

Status of Capercaillie *Tetrao urogallus* in Scotland during winter 2003/04

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Capsule The population estimate was 1980 individuals (95% confidence limits 1284–2758).

Aim To produce a new national population estimate with greater precision than the previous survey, but retaining comparability.

Methods A total of 643, 2-km-long transects were walked at sites throughout the recently occupied range. The survey intensity was high in a 'primary' stratum of woodland where Capercaillie have been recorded since 2000, and lower in a 'secondary' stratum where Capercaillie have been recorded prior to 2000 only. DISTANCE analysis software was used to calculate densities in the two strata and extrapolate to a total population estimate.

Results The population estimate was 1980 individuals (95% confidence limits 1284–2758). Although this value is 84% greater than that from the previous survey in 1998/99 (1073 individuals), it lies within the confidence limits of that estimate (549–2041). A randomization test confirmed that the apparent increase since 1998/99 was not statistically significant. The range of sightings recorded in the survey, and the frequency of Capercaillie sightings in four regions, suggests that the majority of the population is concentrated in Badenoch and Strathspey, with few birds in the south of the range.

Conclusion The revision to the survey design since the 1998/99 survey, along with an increase in survey effort, was successful in producing a more precise population estimate than in previous surveys. However, the imprecision in survey estimates still hampers the power to detect changes in the size of the population. A number of alternative sources of Capercaillie data suggest that there may have been a recent increase in the core areas for Capercaillie, most noticeably in Strathspey.

The Capercaillie *Tetrao urogallus*, the largest species of the grouse family, has a historical range closely associated with the distribution of Scots Pine *Pinus sylvestris* and Blaeberry *Vaccinium myrtillus*, extending from western Europe to north-central Asia (Picozzi *et al.* 1992, Storch 2001). Capercaillie were reintroduced to Scotland in 1837 (Lever 1977), having become extinct the previous century, and from this initial reintroduction of just 42 individuals, with a few subsequent supplementary releases, the population grew rapidly, becoming re-established over a large range. However, following high numbers in the 1960s and early 1970s, the population began to decline again. The first national survey over the winters of 1992/93 and 1993/94 produced an estimate of 2200 birds (95% CL

1500–3200) (Catt *et al.* 1998), followed by a decline to 1073 (95% CL 549–2041) by the time of a repeat survey in 1998/99 (Wilkinson *et al.* 2002). This decrease in numbers since the early 1970s was accompanied by a contraction in range (Gibbons *et al.* 1993). Capercaillie is listed in Annex 1 of the European Council Directive on the Conservation of Wild Birds (79/409/EEC), is on Schedule 1 and 9 of the Wildlife and Countryside Act, 1981 as amended and is red-listed in the UK (Gregory *et al.* 2002).

Recent climate change has been identified as the likely principal cause of the low productivity that has, in part, driven the decline in Capercaillie numbers. In particular, wet weather in June has been implicated in high levels of chick mortality (Summers *et al.* 2004a). Delayed warming in April, which inhibits the growth of food for hens pre-laying, has also been suggested as a driver (Moss *et al.* 2001). This low productivity has

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been exacerbated by habitat loss (Moss *et al.* 1979), the degradation of chick-rearing habitat (Baines *et al.* 1994) and predation (Summers *et al.* 2004a). In addition to decreased productivity, the other major cause of the decline has been high adult mortality in recent years, due to collisions in flight with deer fences (Baines & Summers 1997). The decline between the 1992–94 and 1998/99 surveys was estimated at -0.18 hens/hen/year. If the demographic drivers behind this decrease were to remain unchanged, it has been estimated that the population would decline to 40 hens by 2014, and below the probable minimum viable population (MVP) threshold (Moss 2001).

The high risk of extinction facing Capercaillie, and increasing understanding of the causes of the decline, has led to sustained conservation effort in recent years. Ongoing projects such as the European Union-funded Nature-Life project 'Urgent conservation management for Scottish Capercaillie' (from 2002) and the Scottish Executive-funded Forestry Commission Capercaillie Challenge Fund (from 2001) have been responsible for the removal or marking of hundreds of kilometres of deer fence, predator management and habitat restoration or creation through measures such as careful grazing control, glade creation and plantation thinning.

This paper reports a new national population estimate from a survey over the winter of 2003/04. This survey used the same methods as the previous two surveys, but with minor refinements and an increase in sampling effort designed to increase precision. This survey was the first opportunity to monitor on a national scale the success of the conservation measures implemented to date.

METHODS

Survey design

As with the previous two surveys, the survey was conducted between November and March. This timing exploits the greater detectability of Capercaillie in winter when birds feed in the canopy and are more readily flushed by observers. Winter surveying also avoids disturbance to the birds during the breeding season.

The present range of Capercaillie in Scotland is well recorded, due to ongoing collection of distribution data by conservation programmes. A database of past and present distribution of Capercaillie was compiled from the records of conservation professionals, amateur ornithologists, and landowners and managers, which

was believed to reflect current distribution accurately. However, this knowledge is based primarily upon breeding season records; Capercaillie may disperse in the non-breeding season, sometimes utilizing habitats unlikely to be used for breeding. Therefore, surveying was targeted at two strata: an upper stratum of woodlands that were known to have records of Capercaillie since 2000, and a lower stratum for which there were older records from as far back as 1968. It was assumed that the inclusion of this lower stratum would allow adequate sampling of birds dispersing in winter, as well as any unrecorded breeding sites. Forest areas with no history of Capercaillie presence were excluded from the survey. The two previous surveys used strata based on Capercaillie abundance, but this is no longer tenable as the recent population decline has made it unreliable.

Capercaillie presence in either of the two strata was recorded in a GIS database based on the Forestry Commission's National Inventory of Woodland and Trees (Forestry Commission 2001), which contains polygons for all woodland areas larger than 0.5 ha. Figure 1 shows the distribution of the two Capercaillie survey strata. The area of woodland in the primary

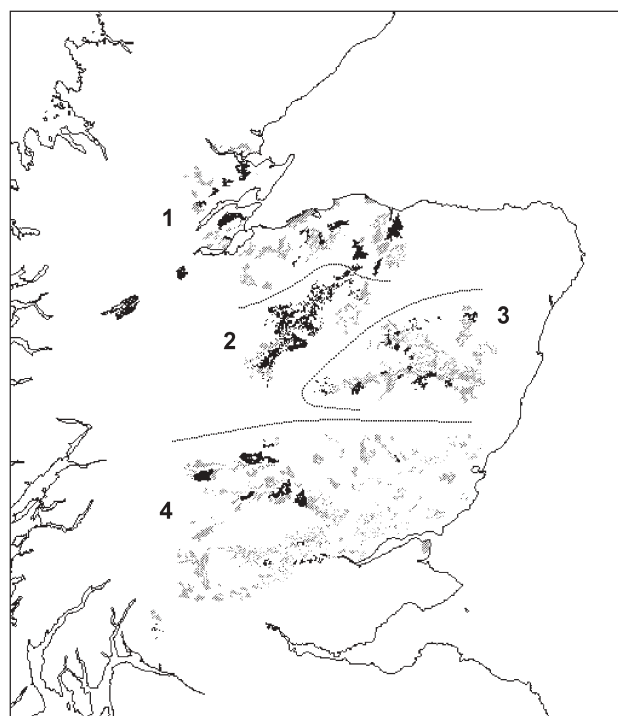


Figure 1. Stratification of survey areas. Woodland plots over 0.5 ha in area are shown. The primary sampling stratum is shown in black, the secondary stratum in grey. Dotted lines and numbers indicate the regions used in analysis: 1, Moray and Easter Ross; 2, Strathspey and Badenoch; 3, Donside and Deeside; 4, Tayside and the Trossachs.

stratum was 81 187 ha, and that in the secondary stratum 130 403 ha.

In order to allow sampling of the primary stratum at a high density, locations for 2-km-long triangular survey transects were selected using a regular 1.5-km grid pattern overlaid on the primary stratum – the smallest scale for sampling possible without transects overlapping. Transects were in the shape of equilateral triangles, with sides 666 m in length. Transects were placed at every grid intersection that fell within primary stratum forest, allowing for 0.44 transects/km² at the maximum density possible. As a regular pattern of sampling could potentially covary with spatial patterns of Capercaillie distribution caused by regular spacing of leks, the orientation of the first leg of each transect was chosen randomly from eight possible directions, as shown in Fig. 2, meaning that the nearest points of neighbouring transects could be between 168 and 1500 m apart. In cases where not all of the 2-km transect was through woodland, either because the transect extended out of the forest block or because there was a gap in the forest cover (greater than 200 m) along a transect leg (smaller gaps were surveyed as they might have been utilized by Capercaillie despite the lack of forest cover), an extension was made at the end of one or more transect legs until 2 km had been walked. If the chosen orientation would not fit within the woodland area even after extension, then a replacement orientation was selected randomly. Transect locations were rejected if it was not possible to fit the transect into the surrounding woodland area regardless of the orientation of the starting leg. Neighbouring transects were not surveyed simultaneously or consecutively, to prevent birds from being flushed from one transect and then recorded in another. If a transect in the primary stratum was not surveyed (due to refusal of access permission) it was not possible to replace it as all possible locations were selected for sampling.

A lower intensity of sampling was used within the secondary stratum. Transect locations were identified as for the primary stratum, and then 35% (183 of 515 of all possible transects) were selected randomly and orientation of the starting leg selected as described for the primary stratum transects. If a transect in the secondary stratum was dropped from the survey for any reason, a replacement was selected randomly. Sampling was distributed evenly between the two sampling strata and four main regions of the survey area throughout the survey period, to avoid any bias arising through particular areas or strata being surveyed earlier or later in the winter than others.

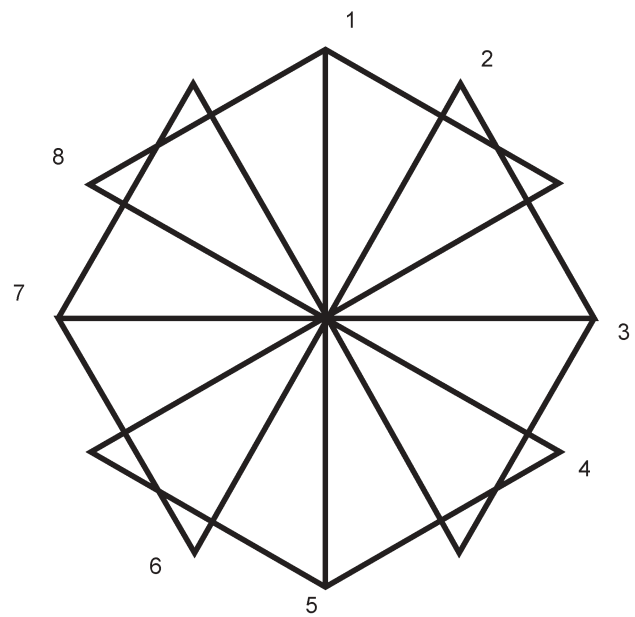


Figure 2. Diagram of the orientation of the eight transect variations. Transects were walked in a clockwise direction, from a starting point at the intersection of a 1.5 km × 1.5 km grid, so the bearing of the initial leg was 0° for transect type 1, 30° for transect type 2, 90° for transect type 3, and so on.

Field methods

Transects were surveyed between November and March (inclusive), although not in adverse weather conditions (persistent rain, snow, wind over Beaufort scale 4, or snow lying on trees). Observers walked along transects in a clockwise direction, following compass bearings, at a steady pace, halting for approximately 5 seconds at 25-m intervals, as this increased the chances of any nearby birds flushing. At this time they also briefly scanned the ground around them for signs of Capercaillie (droppings, feathers or dusting sites). GPS units were used to confirm position at the end of each transect leg and make any minor corrections required to enable the next leg to be started from the correct location. When Capercaillie were recorded the birds were sexed and counted. The bearing and distance of the point of flushing from the observer, the precise grid reference using GPS, and habitat data (see below) were also recorded. The distance of birds from the observer was measured with laser rangefinders, and the bearing was measured by compass, allowing basic trigonometry to be used to calculate the perpendicular distance of the point of flushing from the transect.

Habitat details were recorded at 100-m intervals

along transects (i.e. every fourth pause), giving 20 habitat samples per transect. Observers identified the stand type and dominant tree species within a 5-m radius, along with any ground-cover types occupying over 10% of the ground area (estimated by visual inspection). The recording options within each category are given in Table 1.

Population estimates

The measurements of bearing (relative to transect bearing) and distance of each Capercaillie sighting from the observer allowed distance from the transect line to be calculated. DISTANCE 4.1 (Thomas *et al.* 2004) was used to calculate the effective strip width (ESW) of the transect from the distribution of Capercaillie detections as a function of distance from the transect line. Buckland *et al.* (2001) state that a minimum of 60–80 observations is required in order for DISTANCE to model detection functions successfully and hence produce reliable density estimates. This survey recorded 105 detections. However, there were insufficient Capercaillie encounters within the secondary stratum to allow detection functions to be produced for the two strata separately, so a global detection function was produced from the pooled data.

A number of key assumptions are required to be met for validity of DISTANCE sampling analysis (Buckland *et al.* 2001). We believe that the survey data fulfilled these assumptions: (1) the detection of birds was certain along the transect line; (2) birds did not move in response to the observer before detection (particularly as the great majority were flushed from trees, where movement away from the transect before flushing is impossible); (3) recording of distance from transect was highly accurate; (4) bird detections were independent events; and (5) detection probability was not influenced by group size (nearly all encounters were of single birds).

Buckland *et al.* (2001) recommend truncating data for DISTANCE analysis by removing 5–10% of the largest perpendicular distances. In this case, there was only one obvious outlier, at 122 m from the transect, so this was removed from the data prior to analysis. The truncation distance used was 64 m. Several combinations of key models and adjustments were tested in order to find the best-fitting model. For a given set of model parameters, the model with the lowest Akaike's information criterion (AIC) represents the best fit (Buckland *et al.* 2001). Density estimates were obtained both at the stratum level and globally, where

Table 1. Categories for habitat data collected within a 5-m radius of the observer, at 100-m intervals along transects.

Variable	Categories
Stand type	Restock ^b , Prethicket ^a , Thicket ^a , Unthinned pole ^a , Thinned pole ^b , Mature plantation ^b , Semi-natural ^b , Natural regeneration ^b , Mixed age ^a , Bog pine ^b
Tree species	Scots Pine <i>Pinus sylvestris</i> , Lodgepole Pine <i>P. contorta</i> , Spruce <i>Picea</i> spp., Douglas Fir <i>Pseudotsuga menziesii</i> , Larch <i>Larix</i> spp., Broad-leaved, Mixed species
Ground cover categories	(>10%) Heath (<i>Calluna/Erica</i> spp.), Blaeberry <i>Vaccinium myrtillus</i> , Cowberry <i>V. vitis-idaea</i> , Cotton-grass <i>Eriophorum vaginatum</i> , Bare ground

^aCategorized as 'dense' in DISTANCE analysis with habitat as a covariate. ^bCategorized as 'open'.

the global density estimate was the mean of the stratum estimates weighted by the stratum area.

A second DISTANCE analysis was conducted as before, but using habitat structure (as measured at the location of Capercaillie sightings) as a covariate of detection function in the analysis to test whether this improved the precision of the estimate, following a recent development of the DISTANCE program to allow this (Buckland *et al.* 2001). For this, two simple structure categories were used: 'open' and 'dense', using the stand types as defined in Table 1.

The confidence limits for the final population size and density from both DISTANCE analyses were generated with a boot-strapping procedure, using 999 iterations with replacement. Confidence limits were derived by ranking the boot-strapped estimates and taking the 25th and 975th values as the lower and upper 95% confidence limits, respectively. The change in population since the 1998/99 survey was calculated using a randomization test, generating a mean and confidence limits from 999 ratios between paired boot-strap estimates of population size from the 1998/99 and 2003/04 surveys.

Distribution

The sampling regime was not sufficiently intensive to generate reliable population estimates for any geographical subset of the population. However, an indication of the relative densities of Capercaillie in four main regions (Moray and Easter Ross, Badenoch and Strathspey, Deeside and Donside and Tayside and the Trossachs, Fig. 1) was obtained by calculating the number of birds seen per transect in each.

Habitat use

Jacobs' preference index was used to identify broad habitat preferences, calculated as follows:

$$D = (r - p) / (r + p - 2rp)$$

where r is the proportion of observations in a habitat and p is the proportion of that habitat type in the study area (Jacobs 1974). The index ranges from -1 (complete avoidance) to $+1$ (exclusive use). A further analysis was conducted looking for determinants of Capercaillie distribution; binary logistic regression was used to find significant correlates of presence at the transect level. Habitat variables entered into the model were the percentage (calculated from the 20 habitat recording points on each transect) of each class in the three recording categories (as listed in Table 1): stand type (whether open or closed: categorizations given in Table 1), tree species (percentage Scots Pine etc.) and ground cover (percentage of points with $>10\%$ cover of heath etc.). Non-habitat predictor variables were region (using the four regions as listed above) and month. Forward stepwise logistic regression was performed in SAS 8.0 (SAS 1999), adding the variable that explained the most deviance in Capercaillie occurrence in turn until all significant ($P < 0.05$) variables had been included.

RESULTS

In total, 643 transects were surveyed between November 2003 and March 2004; a further 17 transects were not surveyed, due to the refusal of landowners to grant access permission. Of the transects surveyed, 460 (72%) were in the primary stratum and 183 in the secondary stratum. Coverage was spread as evenly as possible over the survey period, although there was a slight reduction in the rate of coverage in mid-winter due to shorter daylength and a greater incidence of days lost to poor weather. There was no regional or stratum bias in the timing of survey visits.

During the course of the survey 120 Capercaillie were recorded, in 105 separate encounters along 1286 km of

transect (0.093 birds/km). Virtually even numbers of males and females were seen: 52 birds were males, 51 were females, and 17 were unsexed. Birds were recorded on 70 transects, of which only five (7.1%) were in the secondary stratum, and sign of Capercaillie (chiefly droppings) were recorded on a further 49 transects: 119 transects in all. The presence of Capercaillie was recorded (either by sight or the presence of sign) on 112 primary stratum transects (24.3% of those surveyed), and seven secondary stratum transects (3.8%).

Population estimates

Of the various model types fitted to the entire data set, the best fit was given by a half-normal key function with one polynomial adjustment, and without incorporating habitat data as covariates (Table 2, Fig. 3), which gave an ESW of 30.4 m (i.e. 60.8 m for the transect). Using habitat structure as a covariate failed to produce a better fitting model. The optimum model was used to estimate densities in both the strata and globally (Table 3), and then extrapolated to derive a population estimate of 1980 (95% CL 1284–2758): 1645 (95% CL 1064–2337) in the primary stratum area and 335 (95% CL 71–656) in the secondary stratum. This overall population estimate is 84% greater than that from the 1998/99 survey (1073, 95% CL 549–2041), but lies within the confidence limits of that estimate. A randomization test confirmed this increase as non-

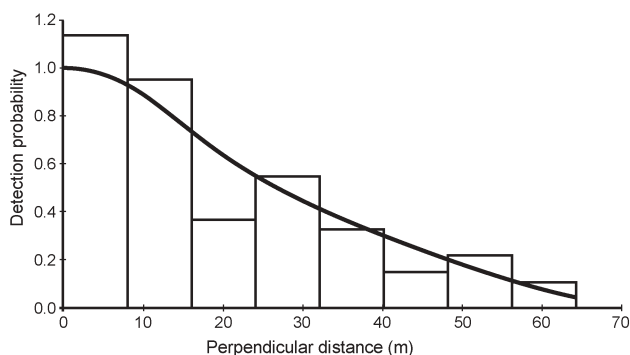


Figure 3. The distribution of perpendicular distances of observed Capercaillie from transect lines in 2003/04 and the fitted global detection curve.

Table 2. Best-fitting DISTANCE model parameters.

Detection	AIC	W (m)	n	χ^2	df	P	Mean cluster size	ESW (m) (95% CL)
Global	821.79	64	104	7.25	5	0.202	1.14	30.4 (26.3–35.1)

Model used: Half-normal + simple polynomial (one adjustment).

Table 3. National population results: global and by stratum (bootstrap CI).

Stratum	Area (km ²)	Bird density (birds/km ²) (95% CI)	Estimate (95% CI)
Global	2115.9	0.94 (0.61–1.30)	1980 (1284–2758)
Primary	811.9	2.03 (1.31–2.87)	1645 (1064–2337)
Secondary	1304	0.26 (0.05–0.50)	335 (71–656)

significant at +78%, but with 95% confidence limits of –17% and +224%.

The increased survey effort and birds seen per transect resulted in an increase in the precision of the results. The mean percentage error reported from the 1998/99 survey was $\pm 57\%$ for the global model (Wilkinson *et al.* 2002). The percentage error for the final estimate on this survey was $\pm 37\%$.

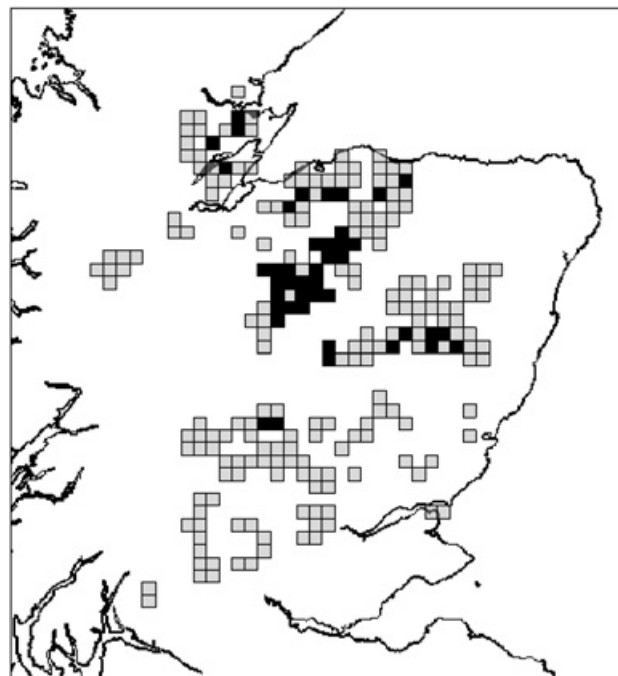
Distribution

Figure 4 shows the distribution of Capercaillie as recorded by the survey. There is an obvious concentration in Badenoch and Strathspey, with 66.6% of all birds recorded (Table 4). The rate of occurrence along transects was 4.3 times higher in Badenoch and Strathspey than in the region with the next highest frequency of encounter, Deeside and Donside, and 27.5 times higher than the region apparently with fewest Capercaillie, Tayside and the Trossachs. A notable concentration was apparent in the Abernethy and Craigmore RSPB reserves, with 30.8% of all birds recorded during the survey being on just 26 transects surveyed there.

There are eight Special Protection Areas designated (at least in part) for Capercaillie conservation: four in Strathspey (Abernethy, Cairngorm, Craigmore and Kinveachy), two in Deeside (Ballochbuie and Glen Tanar), one at Loch Lomond, and one in Easter Ross (Morangie). Sixty-five birds were recorded in these SPAs during the survey (54% of all sightings), suggesting that these SPAs contain a considerable proportion of the national population.

Table 4. Capercaillie sighting frequency by region.

	Primary (km ²)	Secondary (km ²)	Total (km ²)	Transects	Birds	Birds/km
Badenoch and Strathspey	246	16	262	152	80	0.27
Deeside and Donside	105	299	404	107	13	0.06
Moray coast and Easter Ross	304	371	675	227	24	0.05
Tayside and the Trossachs	164	611	775	157	3	0.01

**Figure 4.** The distribution of Capercaillie in Scotland as recorded by the 2003/04 winter survey, reported at a 5 km \times 5 km resolution. Black squares indicate where Capercaillie were recorded, grey squares where surveys were made without recording birds.

Habitat use

Most encounters were of birds flushed from trees, although in some cases the origin of the birds was uncertain. Most birds (101 birds, 84%) seen were flushed from stands of Scots Pine *Pinus sylvestris*, with others from Lodgepole Pine *P. contorta*, spruce *Picea* spp., and mixed stands. Scots Pine was the only tree species for which a positive preference was shown (Table 5). In particular seminatural and thinned pole plantations were preferred.

Capercaillie presence was significantly associated with three predictor variables (Table 6): region, percentage of recording points with Scots Pine as the dominant tree, and percentage of points with over 10% ground cover of Blaeberry. These variables confirm the big differences in density between regions, as well as a

Table 5. Habitat preference indices shown by Capercaillie encountered during the national survey.

Habitat	Jacobs' D	
	Male	Female
Scots Pine, all stand types	0.846	0.676
Scots Pine, semi-natural stands	0.735	0.611
Scots Pine, thinned pole stands	0.563	0.447
Scots Pine, unthinned pole stands	-0.106	0.167

preference for areas of older native pinewood (whether natural or not) in which Scots Pine with Blaeberry understorey is dominant.

DISCUSSION

The 2003/04 national Capercaillie survey produced an estimate of 1980 individuals (95% CL 1284–2758), an increase of 78% since 1998/99 (13% per annum). However, the imprecise nature of the population estimates, particularly that from the 1998/99 survey, means that this apparent increase is not statistically significant. The results do give some cause for optimism, and indicate that there is unlikely to have been any continuation of the rapid decline detected between 1992–94 and 1998/99. The sex ratio, which is close to 1:1, appears to have remained constant since 1998/99.

A number of additional sources of data suggest that Capercaillie may indeed have increased since 1998/99, at least in some regions. Since 2002 numbers of lekking male Capercaillie have been monitored annually in spring at 44 sites within estates covered by the EU Nature-Life project 'Urgent conservation management for Scottish Capercaillie' (K. Kortland pers comm.). Although such monitoring represents a biased sample of the total population, the increase over the three breeding seasons from 135 to 185 males (+37%) does suggest a population increase in the areas covered. A

varying number of lek sites are monitored outwith the project area every year, and although data are patchy, these counts suggest a decrease in numbers, with some leks having been abandoned entirely.

Measures of productivity from brood counts at approximately 20 sites sampled within the EU Nature-Life project area were relatively high in the two breeding seasons preceding the survey, with means of 1.18 chicks/female in 2002 and 0.82 chicks/female in 2003. Both values are above the threshold of 0.62 chicks/female needed for a population to maintain numbers in the absence of elevated adult mortality caused by fence collision deaths (Moss *et al.* 2000), although they are not high in comparison with published reproductive rates (Moss *et al.* 2000). Any increase in population size since 1998/99 may thus reflect a short-term fluctuation due to higher-than-average chick survival in the 2002 and 2003 breeding seasons (compared with a productivity of virtually nil in the two breeding seasons preceding the 1998/99 survey; A. Amphlett unpubl. data). However, it could also be evidence of a genuine change in the population trend due to change in demographic parameter(s). Collision mortality of Capercaillie at deer fences has been identified as one of the two main causes of decline in the 1990s (Baines & Summers 1997), with rates as high as 3.0 birds/km/year (although Capercaillie densities were considerably higher than at present) (Catt *et al.* 1998). Marking fences to increase their visibility to Capercaillie can reduce collision rates by 64% (Baines & Andrew 2003); considerable recent conservation work has therefore been directed at the removal or marking of deer fences in the core Capercaillie range. The Forestry Commission's Capercaillie Challenge Fund (Forestry Commission 2002) has enabled the removal, conversion or marking of 260 km of fencing in the core of the current Capercaillie range, while the EU Nature-Life project has targeted a further 36 km of deer fencing.

In parallel with fence marking and removal, work is

Table 6. Significant determinants of Capercaillie occurrence on transects from binary logistic regression modelling, using both sightings and records of Capercaillie sign from the 2003/04 winter survey.

Variable	Parameter estimate	se	Wald χ^2	df	P
Region			35.5	3	≤0.0001
Tayside and the Trossachs	-2.93	0.281			
Moray and Easter Ross	-2.855	0.249			
Deeside and Donside	-2.539	0.273			
Badenoch and Strathspey	-1.554	0.242			
Percentage Scots Pine	0.015	0.004	12.0	1	≤0.001
Percentage Blaeberry	0.016	0.005	9.3	1	≤0.01

being aimed at increasing Capercaillie productivity in the core range. Capercaillie breeding success increases with increasing Blaeberry cover (up to at least 15–20%) (Baines *et al.* 2004) as the invertebrates that Blaeberry supports are a vital component of chick diet, along with the plant itself (Picozzi *et al.* 1996). The presence of birds encountered on this survey was positively correlated with Blaeberry (as it was in the previous winter survey; Wilkinson *et al.* 2002), although it is not utilized in the winter itself. Forest management to encourage the growth of Blaeberry, and to improve the suitability of habitat in other ways, has been an important component of the ongoing conservation work for Capercaillie. The EU Nature-Life project has targets regarding habitat improvements, many aimed at improving and increasing brood habitat. This includes managing grazing regimes, controlling heather, Bracken *Pteridium aquilinum*, Rhododendron *Rhododendron* spp., Gorse *Ulex europaeus* and Hemlock *Conium maculatum*, and changing drainage (increasing boggy ground to encourage Cotton-grass, *Eriophorum* spp., an important food for hen Capercaillie in the spring; Summers *et al.* 2004b). These improvements may help increase productivity, as may predator control, which is now practised over a wide area. Management trials demonstrated better Capercaillie breeding performance when most Carrion Crows *Corvus corone* and some Foxes *Vulpes vulpes* were controlled (Baines *et al.* 2004; Summers *et al.* 2004a).

The decline of the Scottish Capercaillie population since the 1970s has resulted in a population fragmented into six meta-populations, in Easter Ross, Strathspey, Moray, Donside, Deeside and Tayside. Recent genetic analyses indicate that movement between these populations is restricted (Piertney 2004). Although it was not possible to analyse the survey results at the spatial resolution of these local populations, very few birds were found in some regions (and none in the relatively small sample in Donside). The scarcity of records in all but Strathspey, and to a lesser extent Moray and Deeside, suggests that numbers in other populations are likely to be very low. Given the fragmented nature of suitable habitat and the pressures on the Capercaillie population, recolonization after local extinction may not be feasible. Hence despite the encouraging signs in Strathspey, there must be real concern over the possible extinction of local populations of Capercaillie.

Given the precarious state of the Capercaillie population, and the potential for new threats to the population (e.g. disturbance from increased recreational use of the core range and the potential impacts

of continued climate change), it is recommended that national surveys are maintained at the current frequency (every five to six years). A major problem of such surveys, of elusive species distributed unevenly over a considerable (but uncertain) range, is that they may struggle to produce precise estimates. Without reasonably precise estimates, there is little power to detect even considerable changes in abundance. The 2003/04 Capercaillie survey delivered a population estimate with considerably higher precision than the previous survey. This may be attributed to the increased sampling intensity, with 58% more transects sampled in 2003/04 than during the previous survey, and that a new stratification based on the most recent knowledge of Capercaillie distribution was used. This meant that a greater proportion of transects was in areas still occupied by Capercaillie, whereas in the 1998/99 survey considerable effort was expended in areas in which they had become extinct. Repeating the survey using the same transects as in 2003/04 may give the next survey greater power to detect change, but this should only be done if there is sufficient confidence that there has not been a significant change in range. We would also recommend that thought is given to standardized monitoring of the populations in areas such as Donside and Tayside, which may be close to extinction, and for which a national survey approach such as this cannot deliver accurate local information.

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