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Short note

Second extinction of capercaillie (*Tetrao urogallus*) in Scotland?

R. Moss *

Centre for Ecology and Hydrology, Banchory, Kincardineshire AB31 4BY, UK

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Abstract

The capercaillie (*Tetrao urogallus* L.), a large forest gamebird reintroduced into Scotland in the 1830s, has been declining since the 1970s. This has been attributed to a reduced reproductive rate associated with climate change, and deaths of full-grown birds flying into forest fences. Here, three independent estimates are combined to show that in the 1990s the mean annual rate of decline for adult hens was 18% (S.E. 5%). Without fence deaths, it is calculated that the hen population could have increased at an annual rate of 6% (S.E. 10%). If recent trends persist, the bird will soon be extinct again in Scotland, but without forest fences it would probably survive. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Capercaillie; Scotland; Decline; Extinction; Fence strikes

1. Introduction

The capercaillie (*Tetrao urogallus*), largest gamebird of Western Palearctic boreal and montane forests, is culturally important and regarded as an indicator of healthy forest ecosystems (Storch, 2000). It still occupies much of its original range, but serious declines in western and central Europe have resulted in local extinctions. In Scotland, where it is a charismatic symbol of remnant Caledonian forest, it became extinct in the late eighteenth century, but was successfully reintroduced in the 1830s (Lever, 1977). The Scottish population is now declining, due to a reduced reproductive rate (Moss et al., 2000) associated with climate change (Moss et al., 2001), and deaths of full-grown birds flying into forest fences (Baines and Summers, 1997). Here I document its rate of decline during the 1990s and project future population trends with and without fence deaths.

2. Methods

The analysis focuses on hens because they are the productive sex and suffer higher mortality than cocks (Moss et al., 2000). The rate of hen population change was calculated from three independent estimates. First, the mean rate of change of hen numbers in seven forests from 1992–1997 (Moss et al., 2000) was −0.21 hens/hen/year (S.E. 0.07), that is a rate of decline of 21% per year. Second, data from Moss et al. (2000) were used to calculate the difference between the mortality and recruitment rates of radio-tagged hens.

The third estimate was calculated from the difference between two line transect estimates of the total number of hens in Scotland, in 1992–1994 (1700, 95% confidence limits (CL) 980–2900, Catt et al., 1998) and 1998–1999 (580, 95% CL 250–1050, N.I. Wilkinson, R.H.W. Langston, R.D. Gregory, R.W. Summers, D.W. Gibbons and M. Marquiss, personal communication). Log-normal distributions for each estimate were reconstructed (SAS, 1996; RANNOR function), from the natural logarithms of the quoted means and 95% confidence limits. The standard error of each mean was calculated as the confidence interval divided by four. A random sample was then taken from each of the two reconstructed distributions: the difference divided by the interval between them was a simulated rate of population change. From 1000 such simulations, the mean rate of population change and its standard error were estimated.

The three independent estimates were then combined, using Bayesian inference (Box and Tiao, 1973) accord-

* Corresponding author. Fax: +44-1330-823303.
E-mail address: rmoss@ceh.ac.uk

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ing to Eqs. (4)–(7) in Ellison (1996), to give a combined mean rate of population change and its standard error.

The method of competing risks (Gulland, 1983) was used to calculate what population change would have been without fence deaths, as detailed in Moss et al. (2000). For present purposes, I made small adjustments to the mean parameter values used by Moss et al. (2000), such that the difference between recruitment and mortality became equal to the combined mean rate of population change. Standard errors were kept unchanged.

Population sizes, based on rates of population change with and without fence deaths, were then projected, beginning in 1998–1999. Starting points for each of 1000 simulations were chosen randomly from the reconstructed lognormal distribution for the 1998–1999 line transect estimate of population size. Each constituent parameter estimate in each calculation of the rate of population change was also taken at random from normal distributions reconstructed from their means and standard errors. The distribution of each set of 1000 simulated population projections was then equivalent to the probability distribution of projected population size.

There is likely to be a minimum viable population (MVP) below which demographic and genetic effects cause irreversible decline to extinction (Westemeier et al., 1998). The main Scottish reintroduction involved 13 cock capercaillie and 29 hens from Sweden (Lever, 1977), reinforced by subsequent releases. An isolated population of greater prairie chickens (*Tympanachus cupido pinnatus)* in Illinois showed reduced fitness and genetic diversity when a declining population had reached 50–100 displaying cocks (Westemeier et al., 1998) and presumably a similar number of hens. Also, when exotic bird species were introduced to New Zealand, the chances of successful establishment were much higher when more than 100 individuals were released (Green, 1987). Hence I assumed that the minimum viable population of capercaillie was 50–100 hens, and modelled it as a uniform random variate between lower and upper bounds of 50 and 100 hens, respectively.

3. Results

The combined mean rate of population change in the 1990s, from the three independent estimates of −0.21 (S.E. 0.07), −0.10 (S.E. 0.10) and −0.20 (S.E. 0.08), was −0.18 (S.E. 0.05) hens/hen/year. Without fence deaths, I calculated that this would have been +0.06 (S.E. 0.10).

The most recent estimate of hen population size in Scotland was about 580 in 1998–1999 (N.I. Wilkinson et al. personal communication). Simulations using projected rates of population change, with and without fence deaths respectively, provided probability distributions of projected hen population sizes (Fig. 1). These were probabilistic because the calculations allowed for error in the underlying parameter estimates.

After 15 years with the documented proportion of fence deaths (Moss et al., 2000), the most probable projected hen population in 2014 was about 40, with a 0.59 probability that numbers would be below the MVP. This probability reached 0.95 in 2024.

Without fence deaths, the most probable projected population of hens in 2014 was about 1300 and the probability that it would be below the MVP only 0.02. The projections do not include density dependence,

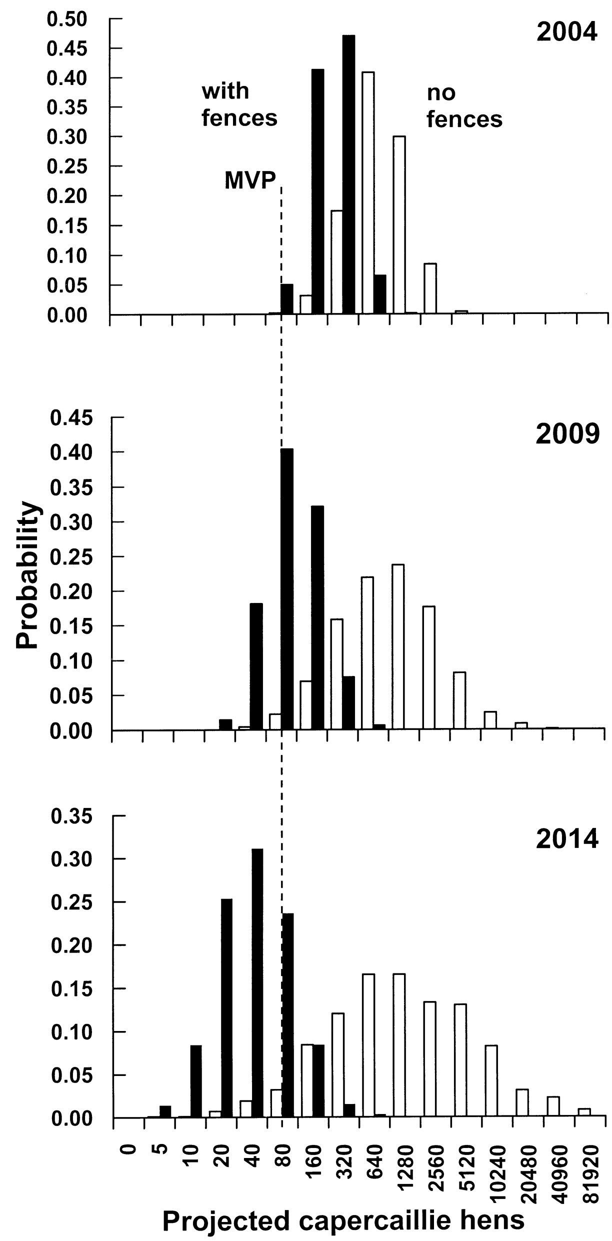

Fig. 1. Simulated probability distributions for the number of hen capercaillie in Scotland with (black columns) and without (white columns) fence deaths, projected from 1999. Numbers are the midpoints for each bar. The vertical dashed line indicates approximately the minimum viable population (MVP).

which would cause increases in numbers to be less at high densities. Hence, the upper tails of the probability distributions (Fig. 1) may be unrealistically high.

4. Discussion

The results were expressed as probabilities because the underlying parameter estimates had standard errors. The analysis is not a stochastic population viability analysis (PVA) in which it is assumed that the true values of the mean demographic rates are known and a model is run to estimate the probability of extinction (Ginzburg et al., 1982). I did not do a PVA because there were no good estimates of annual variability in some crucial parameters. It is, however, unlikely that conclusions from a PVA would be much different.

The primary reason for the decline of capercaillie in Scotland is a reduced reproductive rate, and there is no evidence that mortality due to fence strikes has increased since the 1970s. However, with fewer potential recruits the population can no longer withstand the same rate of fence deaths. Even so, the projections in Fig. 1 suggests that the bird's extinction could be avoided were forest fences to be removed.

Fences are used to prevent deer from browsing young trees. Control of deer without fences, by shooting, is feasible (Rose, 1995) and would help to avoid a second extinction of the capercaillie in Scotland.

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