Recent trends and harvest in Finland's brown bear population

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Abstract: We examined the occurrence of brown bear (*Ursus arctos*) in Finland by using hunter-provided observations and harvest data for 1992–2004. We calculated a simple index (bears observed/all observation cards) from observation cards filled annually by nearly 5,000 moose hunting clubs. This occurrence index was treated as a dependent variable in a mixed regression model to examine differences between regions and periods. Both region and period effects were significant. The index was highest in the eastern region of Finland, followed by central, northern, and western Finland. Trends provided evidence of population growth during the first 9 years of the study and then a slight decline in all regions. There was no two-way interaction between region and period, suggesting that trends were similar among regions. The observation index was best related to former harvest rate with 3 years' time lag. The levelling off and the recent slight decline in central and western Finland implies that the population has not met the target set by a government working group in 1996 of a substantial increase in these regions. We suggest that harvest rates should be kept at the very low levels of recent years in eastern and central Finland. In particular, females in central Finland will need to be more effectively protected before the goals set by the working group can be achieved.

Key words: brown bear, Finland, harvest, moose hunters, population trend, *Ursus arctos*

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Short-term trends in population size of bears are difficult to detect without comprehensive field data and constant effort, although it is important to know trends when a population is harvested (Garshelis 1990, Miller 1990, Wielgus and Bunnell 1994, Swenson and Sandegren 1996, Mattson 1997). In Finland, the brown bear (*Ursus arctos*) was exterminated from the southern, western, and central parts of the country during the late 1800s (Ermala 2003). In the early 1970s, numbers started to increase in the southeast due to improved protection and continuous dispersal from core areas in Russian Karelia (Pulliainen 1990, 1996, 1997). Kojola and Heikkinen (in press) assumed that yearly λ from 1968 through 1995 was 1.10 in southern Finland. However, in northern Finland λ was only 1.02 owing to substantially higher harvest rates. Changes in population structure with distance from Russian border provided evidence that the Finnish population is at the periphery of the Russian population (Kojola et al. 2003*a*, Kojola and Heikkinen in press). Based on 85 litters from 2004, Kojola and Heikkinen (in press) estimated a minimum population of 810 bears. The Finnish brown bear population is subject to legal, regulated hunting. Until the early 1990s, harvest was concentrated in the northern part of the country, but thereafter most bears were shot in the southeast segment of Finland (Kojola and Heikkinen in press). According to Finnish hunting regulations, females with cubs-of-the-year are protected.

Moose hunting clubs in Finland have recorded brown bear observations within their hunting grounds systematically since 1992 (Nygrén and Nygrén 1994), with relatively constant effort over the years (Kojola et al.

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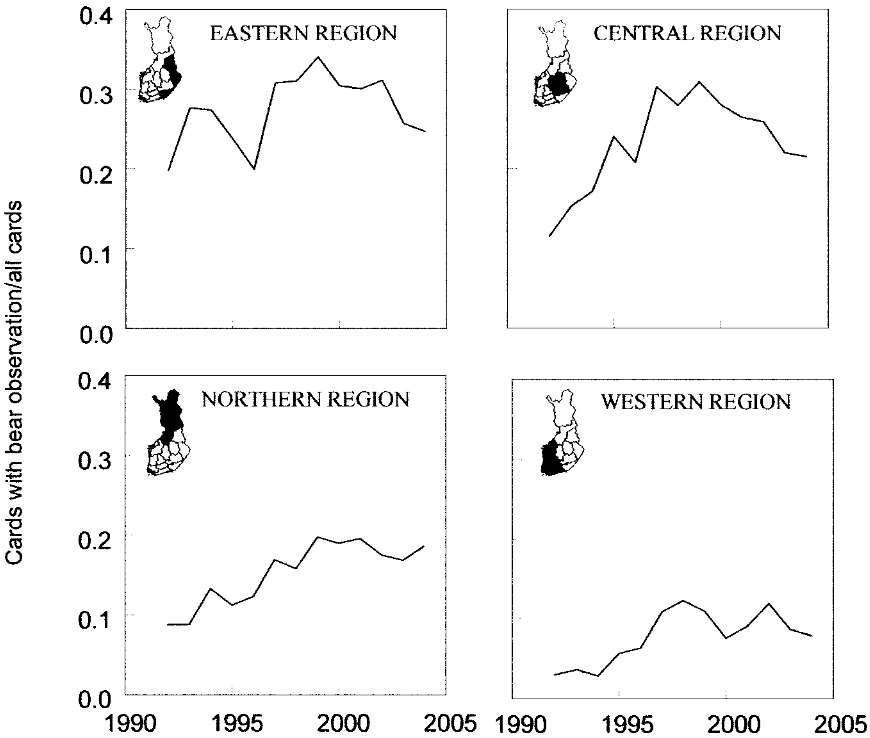

Fig. 1. The frequency of brown bear observations in regions of Finland, 1992–2004.

2003*b*). These countrywide data enabled us to investigate regional trends in the relative abundance of brown bears in Finland.

We examined recent trends in the occurrence of brown bear in regions of Finland via an index derived from these moose hunters. We initially predicted that the bear population would continue to increase in the western segment of Finland, where harvest has been practically absent. We discuss trends relative to a population target set by a government working group in 1996 (Ministry of Agriculture and Forestry 1996) and to harvest policy adopted in different parts of the country.

Methods

Data

We used official harvest data for 1992–2003 and brown bear observations made on moose observation cards (Nygrén and Pesonen 1993) by moose hunting clubs during 1992–2004. There are about 5,000 moose hunting clubs in Finland, and their hunting grounds cover practically all woodland areas of the country (Koskela and Nygrén 2002). Moose hunting clubs were requested annually to report moose and large carnivore observations they made within their hunting ground; 90% of them responded without substantial variation among regions and periods. We accepted both direct sightings and observations of tracks as valid observations of brown bears.

Statistical analysis

We developed a simple index of brown bear occurrence by dividing the number of bear-positive observation cards by the number of completed cards. This response variable was calculated separately for the 15 game management districts and 4 periods (1992–94, 1995–97, 1998–2000, 2001–04). A regression model (procedure MIXED using GLIMMIX macro; SAS Institute, Inc. 2004) assuming a binomial distribution for this occurrence index was used to test the differences between the 4 regions (central, eastern, northern, and western Finland, Fig. 1) and the 4 periods. We tested the interaction terms between periods and districts for significance. We assumed that indices for the 4 periods were correlated within game management districts, and we treated districts as independent variables. The variance structure among the correlated periods was considered as unstructured, thus allowing all the variances

Table 1. Fixed and random effects of the model for the occurrence of brown bear in Finland, 1992–2004. The estimated probability for occurrence (μ) is when other variables are set to their mean values.

Variable	Estimate	SE	*t*-value	*P*	Odds ratio	μ
Intercept	−1.198	0.230	−5.21	0.000	0.302	
Fixed effects						
Region						
Eastern	0.213	0.318	0.67	0.516	1.238	0.27
Western	−0.828	0.331	−2.50	0.030	0.437	0.09
Northern	−0.289	0.399	−0.73	0.484	0.789	0.15
Central	0.000	—	—	—	1.000	0.22
Period						
1: 1992–94	−0.593	0.173	−3.43	0.006	0.553	0.12
2: 1995–97	0.058	0.114	0.51	0.622	1.059	0.17
3: 1998–00	0.259	0.085	3.05	0.011	1.295	0.21
4: 2001–04	0.000	—	—	—	1.000	0.19

and covariances in the matrix to be estimated. All the lowest-level error variances were set in the unstructured variance–covariance matrix. The model can be written as:

$$\text{logit}(\pi_{ij(i)t}) = \log\left(\frac{\pi_{ij(i)t}}{1-\pi_{ij(i)t}}\right) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2t} + \beta_3 x_{1i} * x_{2t} + \vartheta_{j(i)}$$

where, $\pi_{ij(i)k} = s_{ij(i)t}/n_{ij(i)t}$

$s_{ij(i)t}$ = number of cards with bear observation for region i, management district j within region i and period t

$n_{ij(i)t}$ = number of cards for region i, management district j within region i and period t

β_0 = fixed intercept

β_1 = fixed coefficient for region x_{1i}

β_2 = fixed coefficient for time x_{2t}

β_3 = fixed coefficient for interaction of $x_{1i} * x_{2t}$

$\vartheta_{j(i)}$ = random management district effect j nested within region i

Covariance structure within management district effect $\vartheta_{j(i)}$ can be expressed as:

$$\Omega = \begin{bmatrix} \delta_{11}^2 & & & \\ \delta_{12}^2 & \delta_{22}^2 & & \\ \delta_{13}^2 & \delta_{23}^2 & \delta_{33}^2 & \\ \delta_{14}^2 & \delta_{24}^2 & \delta_{34}^2 & \delta_{44}^2 \end{bmatrix}$$

where $\delta_{11}^2, \delta_{22}^2, \delta_{33}^2, \delta_{44}^2$ are variances of periods 1–4, others being covariances between the periods (outside the diagonal). Random management district effects were not estimated, but were used only to describe the covariance structure.

Table 2. Type 3 tests for the fixed effects in the model with brown bear occurrence as a dependent variable, Finland, 1992–2004.

Independent variables	*F*	df	*P*
Region	7.48	3,11	0.005
Period	34.05	3,11	<0.001
Region * period	1.91	9,11	0.155

To examine if the occurrence index was correlated with the number of harvested bears, we modeled time lags of 1, 2, 3, 4, 5, and 6 years, both separately for each region and nationwide. Because we considered bears shot during 1992–2003, the number of years in correlation analyses declined with the growing time lag. Two-tailed probabilities <0.05 were considered statistically significant.

Results

The observation index (proportion of positive observations) increased during the early 1990s and levelled off during late 1990s (Fig. 1). The estimated probability of observation (μ in Table 1) increased from 0.12 to 0.21 during the first three 3-year periods but declined (to 0.19) during the fourth period. This effect was highly significant (Table 2). The probability of bear observation was highest in the eastern region, intermediate in the middle and northern regions, and lowest in the western region (Table 1). The region effect was significant (Table 2), but the interaction of period and region on the probability of bear observation was not, indicating that temporal trends in bear occurrence did not differ among regions. The estimated probability of occurrence (μ) was relatively stable in the eastern region (0.25, 0.25, 0.31, and 0.27), whereas in the 3 other regions it increased from the first to the third period and then leveled off (western: 0.05, 0.09, 0.12, and 012; northern: 0.10, 0.14, 0.18, and 0.18; central 0.14, 0.24, 0.28, and 0.23, respectively). The observation index was correlated among all regions (Pearson correlation analysis, probabilities $P < 0.05$). Indices for the western region was correlated with those of the central region ($r = 0.897$, $P < 0.001$), the eastern region ($r = 0.676$, $P = 0.011$), and the northern region ($r = 0.755$, $P = 0.003$).

Bear harvesting in Finland is based on quotas for each of the 15 game management districts. The number of hunter-killed bears was highest in the eastern region, followed by the northern area and the central regions. There was very little harvest in the western region (Fig. 2).

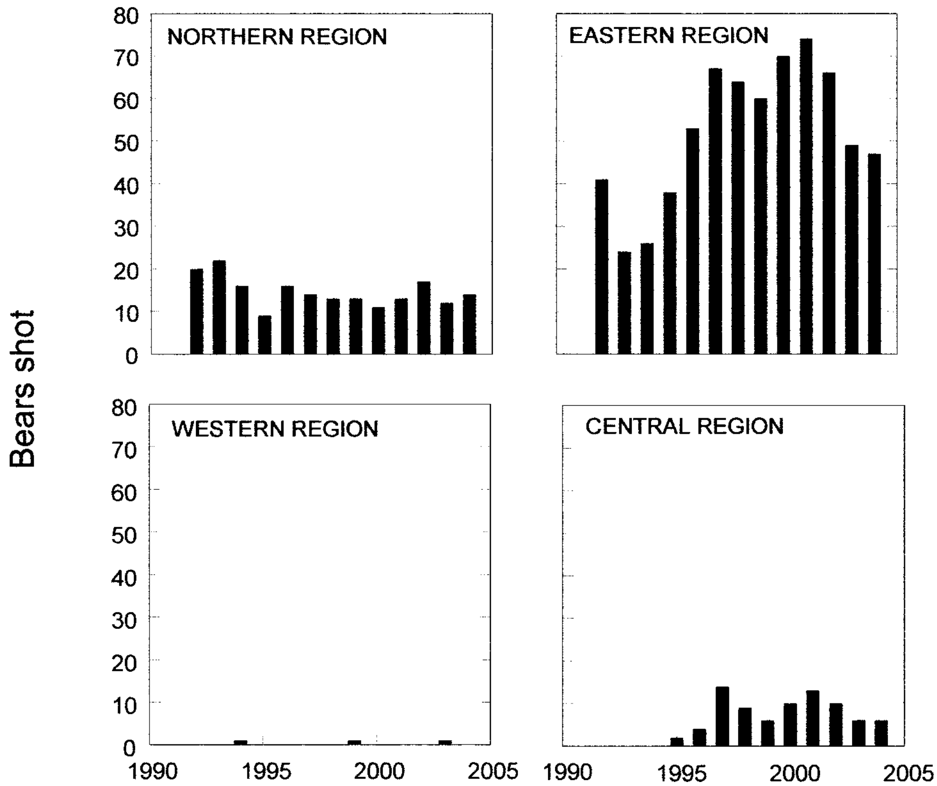

Fig. 2. The number of hunter-killed bears in Finland, 1992–2004.

We found negative correlations between the observation index and harvest at time lags of 1–6 years. Nationwide, this correlation was strongest at a 3-year lag (Fig. 3; $r = -0.640$, $n = 10$, $P = 0.046$). In the eastern and central regions, the number hunter-killed bears and the observation index were most strongly correlated at a 6-year lag (eastern: $r = -0.843$, $n = 7$, $P = 0.017$; central: $r = -0.897$, $n = 7$, $P = 0.015$), and in the northern region with a 1-year lag ($r = -0.660$, $n = 12$, $P = 0.025$). Although the observation index in the western region was correlated with that of the other regions, the index was not correlated with harvest in the other regions ($P > 0.10$).

Discussion

Trends in brown bear occurrence in the western and central regions of Finland did not correspond with those suggested by the government working group ((Ministry of Agriculture and Forestry 1996), which had set a goal of >60% increase in bear numbers for western Finland and a goal of 30–60% increase for central Finland from 1995 through 2014. Occurrence indices in the western and central regions suggested that the number of bears increased in both areas toward the targets set by the working group from the late 1990s, but we did not have evidence of increases in the early 2000s, and the last indices of occurrence (2004) were only slightly higher than those in 1995 (Fig. 2). To reach the target for the eastern region, the maintenance of the population size at the 1995 level (Ministry of Agriculture and Forestry 1996), seems possible in light of the trend in the observation index. The observation index is not fully comparable over years because some changes in hunting practices probably occurred. On the other hand, one of the authors (IK) found that in each region the index was closely correlated with the annual number of bear observations reported by local large carnivore contact persons, a network of 1,500 persons who record observations through entire season when bears are active.

The significant negative correlations we found between harvest and index suggest a cause–effect relationship. For these regions our results indicated a considerable time lag in the effects of harvest on the observation index. No such lag was found in the north.

This can be explained by the relatively even harvest over time (Fig. 3). In the eastern and central regions, in contrast, harvest increased strongly during late 1990s, but decreased when a decrease in the number of bears became evident (Kojola 2003). The lag in the effects of harvest, formerly reported by Swenson et al. (1995) and Swenson and Sandegren (1996) for the Scandinavian brown bear population, increases the difficulty of assessing a sustainable harvest rate. The central and western parts of the Finnish brown bear population are a peripheral population in which the proportion of females is lower than in the eastern region (Kojola et al. 2003*a*), probably owing to male-biased dispersal (Swenson et al. 1998, McLellan and Hovey 2001, Proctor et al. 2004, Støen et al. in press). Subadult males, which are the most mobile bears and most prone to disperse far from their natal grounds, are the predominant category of bears harvested in Finland (Kojola et al. 2003*a*). Therefore, increasing harvest in central and eastern Finland could decrease the number of bears dispersing to the western region (although the occurrence index in the western region was not correlated with harvest in the central region).

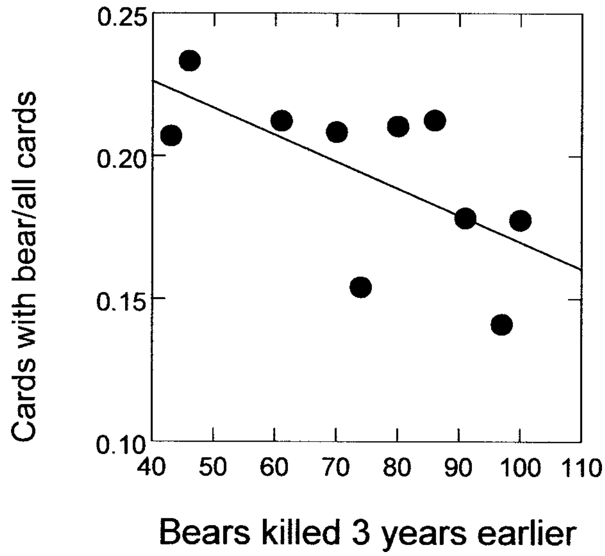

Fig. 3. Relationship between the number of bears shot and the frequency of bear observations 3 years later, Finland, 1992–2004.

Management implications

A major increase in bear numbers in western and central Finland, a goal set by the Large Carnivore Working Group (Ministry of Agriculture and Forestry 1996), would obviously require low harvest levels in the central and eastern regions. The harvest quotas have been declining recently, but they may still be too high to result in an increasing trend in the western region. Some adult females live at the border between the central and the western regions, where two females were translocated from the east during 1980s (Nyholm 1995; I. Kojola, unpublished data). Several females ($\geq$5) were shot in this area during 1994–2003. We recommend that females in the western part of the central region of Finland should be protected from harvest to increase the bear population in the western region. To summarize, we suggest that harvest rates should be kept at the recent lower levels (Fig. 2) in eastern and central Finland and females, especially in central Finland, should be more effectively protected to achieve the goals set by the working group.

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