Human impact on the spatiotemporal dynamics of red fox in the boreal forests of SE Norway

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Introduction

Human impact on biodiversity may arise from complex and unpredictable effects of disturbances on natural community structure. In Scandinavian boreal forests, an increase in the abundance of a generalist predator, the red fox, is believed to have had cascade effects on lower trophic levels, leading to suppression of populations of small game species and smaller predators. In our study, we evaluated the importance of different factors with the potential of influencing red fox populations in Hedmark county, Norway, using snow-tracking based indices of fox abundance.

Methods

Hedmark county (Fig. 1.) is located in southeastern Norway. Forests are mainly coniferous, and the distribution of the human population and agriculture land is relatively sparse, with a clear north-south gradient. From 2004-2007, data on fox track abundance had been collected annually from 234 snow track index lines (linear and 3 km long). With linear mixed effects models, we investigated how different variables reflecting fox resource abundance (see below) affected the variation among transect lines in recorded red fox tracks, both with regard to the number of tracks (ABUNDANCE) and temporal variation (STABILITY)

Linear Mixed Effects models of red fox distribution in Hedmark county, Norway

Response variables:

- ABUNDANCE: Index of red fox abundance. The average number of red fox tracks per transect line divided by the number of days since last snowfall during 2004-2007
- STABILITY: Index of red fox population stability. Coefficients of variation (CV) of the number of red fox tracks for each of the transect line among the 4 years of survey.

Predictor variables:

- NPP: An index of Net Primary Productivity. Above-ground biomass was estimated based on the Normalised Difference Vegetation Index (NDVI) from the GIMMS data set[4]. NDVI was summed over the vegetation growing season, and above-ground biomass calculated following Dong et al. (2003)[5].
- AGR: Index of landscape composition (agriculture). Using digitized habitat maps, we converted polygons of agricultural land to location data by overlaying a 500m*500m grid. UTM coordinates of grid corners in agricultural fields formed the basis of Fixed Kernel analyses, where the output maps reflected distribution and intensity of agriculture throughout Hedmark county. Kernel density values were assigned to each of the fox transect lines.
- HPD: Index of human population distribution: Kernel density values were assigned to each transect line by using a method similar as described above. However, the Kernel analyses were based on point locations of residential houses
- MOOSE: The number average number of moose shot during the four years of survey in the municipality where the fox transect line was located.

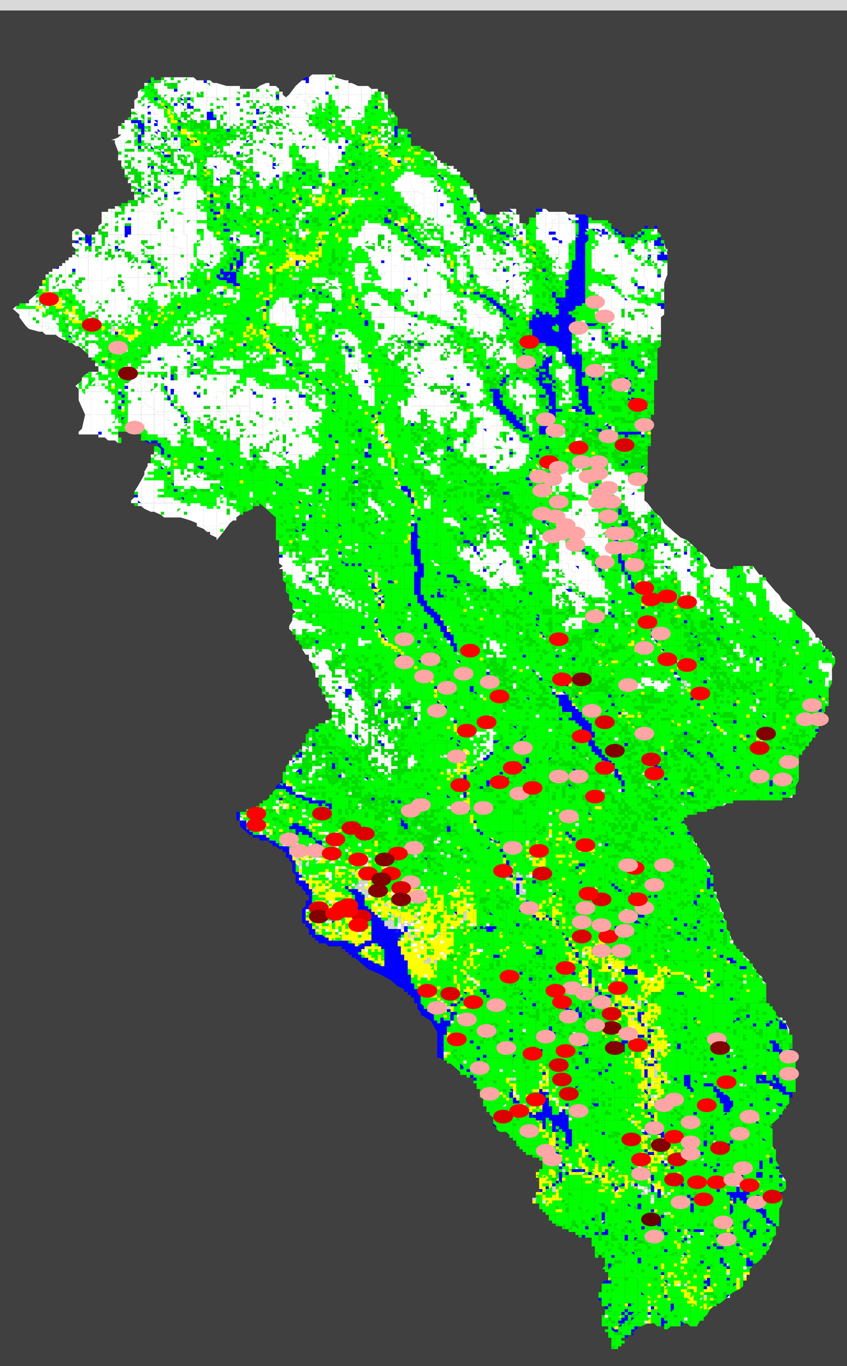

Fig 1. Map of Hedmark county, SE Norway , indicating forests (green), alpine areas (white), agricultural fields (yellow) and locations of red fox transect lines (graduated color reflects red fox track densities – dark red = high density)

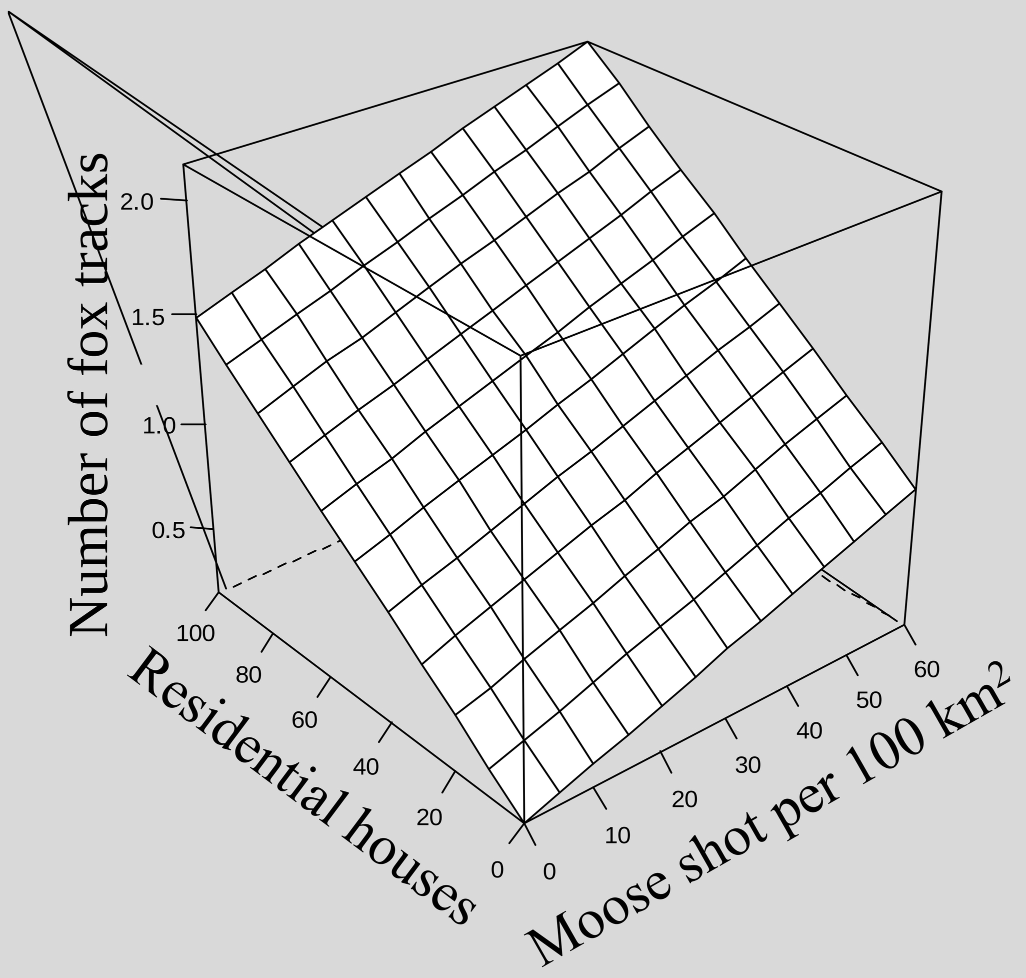

Fig 2. Number of red fox tracks (ABUNDANCE) predicted based on lme models including the terms residential houses (HPD) and the numbers of moose shot annually in the municipality (MOOSE)

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Why have red fox densities increased?

The literature suggests several - but not mutually exclusive - explanations to the increase in red fox abundance, including both top-down and bottom-up processes. The decimation of large carnivores in the early 20th century initiated a mesopredator release effect benefitting red fox[1], whereas enhanced scavenging opportunities may have occurred due to an increase in human living standards (more garbage) and an increase in ungulate population densities[2]. Furthermore, it has been suggested the carrying capacity of the red fox has increased due to an increase in the abundance of Microtus voles following changes in forestry practices[3].

Results

Among 13 candidate linear mixed effects models of red fox ABUNDANCE, the best model (Fig 2) included two terms, the number of moose shot (MOOSE) and the human population distribution index (HPD). The second best model included only MOOSE. Among the models of red fox population STABILITY, the covariate MOOSE was the only term in the best model, whereas the second best model included MOOSE + HPD. The number of moose shot and the human population distribution index were positively related to both ABUNDANCE and STABILITY.

Discussion

Among the 4 predictor variables, MOOSE and HPD probably reflected resource availability of red foxes in the form of carcasses and human garbage, while NPP and AGR may have been related to live prey density and diversity. Foxes cannot kill moose, which are only available as carcasses and leftovers from the autumn hunt. An average of 7229 moose were shot annually in Hedmark county during 2004-2007, and fox track numbers were both high and temporally stable in areas where larger numbers of moose had been shot. Availability of moose carcasses may have increased the carrying capacity of red fox populations, and buffered population declines in periods with low availability of other resources. The presence of houses probably had a similar effect.

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