MOOSE POPULATION DYNAMICS IN NORTHEASTERN MINNESOTA

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SUMMARY OF FINDINGS

We captured and radiocollared a total of 116 adult moose (*Alces alces*) (55 bulls and 61 cows) between 2002 and 2005. As of 1 March 2008, 85 collared moose (44 bulls and 41 cows) have died. Annual mortality rates varied among years, and generally were higher than found elsewhere in North America. Regression analysis indicated that a large proportion of the variability in annual and seasonal survival was explained by the frequency and magnitude of days when physiological temperature thresholds were exceeded. Using logistic regression analysis we developed a model to correct for sightability bias on the aerial survey. We found that this bias was substantially larger than previously estimated. The sightability model has now been incorporated into our annual moose survey. Several manuscripts are in preparation or submitted.

INTRODUCTION

Moose formerly occurred throughout much of the forested zone of northern Minnesota, but today are restricted to the northeastern-most counties including all of Lake and Cook counties, and most of northern St. Louis county. Aerial surveys in the late 1990s suggested that the population was relatively stable, despite a conservative harvest. We initiated a research project in 2002 to better understand the dynamics of this population and evaluate the rigor of our aerial survey technique. Fieldwork on the first phase of this projected ended in early 2008 and we are in the process of analyzing data and preparing manuscripts that discuss results of the study. The following report will discuss some of the preliminary findings.

The project was a partnership between the Minnesota Department of Natural Resources (MNDNR), the Fond du Lac Band of Lake Superior Chippewa, and the 1854 Treaty Authority. A second research project was initiated in February 2008 with funding secured by the Fond du Lac band. The Minnesota Department of Natural Resources and 1854 Treaty Authority will provide in-kind support and limited funding for this second phase of research.

METHODS

We captured a total of 116 moose in southern Lake county and southwestern Cook county between 2002 and 2005, attached radiocollars, and collected blood, hair, fecal and tooth samples. We monitored a sample of up to 78 radiocollared moose weekly to determine when mortality occurred and conducted necropsies in an attempt to determine the cause of mortality. We calculated annual non-hunting mortality rates using the Kaplan-Meier procedure (Kaplan and Meier 1958) modified for a staggered-entry design (Pollock et al. 1989) and censored all moose killed by hunters, those that died from capture mortality, and moose still alive as of 1 March 2008. Survival analyses were conducted using Cox Proportional Hazard (CPH) models (Cox 1972, SAS PROC PHREG, SAS Institute 2008).

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We developed a sightability model (Anderson and Lindzey 1996, Quayle et al. 2001), which is used to correct for visibility bias, the number of moose not detected by observers in the survey aircraft. We identified test plots that contained 1 or more radiocollared moose and surveyed these plots using procedures identical to those used in the operational survey. If we observed the collared moose within the plot, we recorded a suite of covariates including environmental conditions, group size, and the amount of visual obstruction. If we didn't observe the collared moose, we located them using telemetry, and recorded the same set of covariates. We used logistic regression to determine which covariates were most important in determining whether moose were observed.

RESULTS AND DISCUSSION

Eighty-five of the 116 radiocollared moose (44 bulls and 41 cows) died by 1 March 2008. In addition, 1 moose slipped its collar and we lost contact with another one. Moose that died within 2 weeks of capture (5) were designated as capture mortality. Hunters killed 15 moose, 2 were poached, and 8 were killed in collisions with vehicles (cars, trucks, or trains). The remaining mortality (55) was considered to be non-anthropogenic and causes included wolf predation (5), bacterial meningitis (1), or unknown (49).

The unknown mortality appeared to be largely non-traumatic. In 50% of the cases, the intact carcass was found with only minor scavenging by small mammals or birds. Wolves and bears were the primary scavengers in 35% of the remaining cases. We were unwilling to attribute predation as the cause of death in these cases because there was little evidence that a struggle had preceded death. In 14% of the cases, we were unable to examine the carcasses or only found a collar with tooth-marks.

Annual non-hunting mortality rates for adult bull and cow moose averaged 18% (SE=6, *n*=6, 0 to 35%) and 22% (SE=4, *n*=6, 6 to 34%), respectively. In both sexes, non-hunting mortality was substantially higher than documented for populations outside of Minnesota (generally 8 to 12%) (Peterson 1977, Mytton and Keith 1981, Bangs 1989, Larsen et al. 1989, Ballard, 1991, Kufeld and Bowden 1996, Bertram and Vivion 2002) and similar to that observed for adult moose in northwestern Minnesota (Murray et al. 2006). The CPH model indicated that sex did not contribute to the prediction of survival (X^2_1=0.01, P=0.92), which implies that there was no difference in survival rates (non-hunting) between adult bull and cow moose. A more complete analysis of moose survival is underway for a manuscript in preparation.

Moose increase their metabolic rate when ambient temperatures increase beyond a seasonally dependent upper critical temperature (Renecker and Hudson 1986). We hypothesized that moose survival would be a function of the frequency and magnitude that summer and winter threshold temperatures were exceeded. Using regression analyses we found that January temperatures consistently explained a high proportion of the variability in both annual and seasonal survival. Models based on late spring temperatures also were important in explaining survival during the subsequent fall. A manuscript discussing these analyses and results has been submitted to the Journal of Wildlife Management.

A total of 171 radiocollared moose were located on test plots during 4 annual surveys between 2004 and 2007. Eighty-six moose were observed from transects in the test plots and the remaining 85 had to be located using telemetry. Logistic regression indicated that the best model to estimate the probability of detection (π) included only 1 covariate, the amount of visual obstruction. Theta (θ) is the inverse of π and is used to correct each moose observation during the helicopter surveys. The mean annual value for θ approximates the sightability correction factor (SCF), which was used prior to 2004 as a measure of sightability bias. Between 1998 and 2003 the mean SCF was 1.4, which implies that 40% of the moose were not detected by observers. In contrast, the mean annual θ for surveys from 2005 to 2007 ranged from 1.70 to 2.10 ($\bar{x}$ =1.9), which implies that moose numbers were approximately 90% higher than the number detected. The sightability model created from these analyses was used in the 2008 aerial survey. Manuscripts discussing the sightability model and assessing the switch to using helicopters for moose surveys are in preparation.

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