

MOOSE POPULATION DYNAMICS IN NORTHEASTERN MINNESOTA

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SUMMARY OF FINDINGS

We captured and radiocollared a total of 150 adult moose (*Alces alces*; 55 adult males and 95 adult females) between 2002 and 2008. As of 1 April 2009, 100 collared moose (46 adult males and 54 adult females) have died. Annual mortality rates varied among years, and generally were higher than found elsewhere in North America. Estimates of fertility for this population were also low compared with other North American moose populations. Data analyses from this research are progressing and 1 manuscript was published and 2 other manuscripts were submitted for publication.

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. We initiated a research project in 2002 to better understand the dynamics of this population. Fieldwork on the first phase of this project ended in early 2008 and we are in the process of analyzing data and preparing manuscripts that discuss results from the first phase. The following report will discuss preliminary findings.

The project was a partnership between the Minnesota Department of Natural Resources, the Fond du Lac Band of Lake Superior Chippewa, the 1854 Treaty Authority, and the U. S. Geological Survey. 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. See Lenarz et al. (2009) for greater detail on the study area and research methods. In February 2008, we captured and sampled an additional 34 moose and attached radiocollars. We monitored a sample of up to 78 radiocollared moose weekly to determine when mortality occurred. We calculated annual non-hunting mortality rates ($1 - \text{survival}$) 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, moose that had emigrated from the study area, and apparent transmitter failure. We used a Cox Proportional Hazard (CPH) model (Cox 1972, SAS PROC PHREG, SAS Institute 2008) to test for a difference in annual survival between sexes. Beginning in 2004, we used helicopter surveys in late May – early June (MJ) to estimate fertility of radiocollared females and additional surveys in late April – early May (AM) to estimate survival of calves born the previous spring.

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RESULTS AND DISCUSSION

As of 1 April 2009, 100 of the 150-radiocollared moose (46 adult males and 54 adult females) have died. In addition, 1 moose slipped its collar, 1 moose moved out of the study area, and we lost contact (apparent transmitter failure) with 4 moose. Moose that died within 2 weeks of capture (6) were designated as capture mortality. Hunters killed 16 moose, 2 were poached, and 11 were killed in collisions with vehicles (cars, trucks, or trains). The remaining mortality (65) was considered to be non-anthropogenic and causes included wolf predation (6), bacterial meningitis (1), or unknown (58).

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 40% 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 10% of the cases, we were unable to examine the carcasses or only found a collar with tooth-marks.

Annual non-hunting mortality rates (1 June to 31 May) for adult moose averaged 21% for males (7 to 40%, SE = 5, $n = 6$) and 21% for females (5 to 30%, SE = 4, $n = 6$; Table 1). Sex did not contribute to the prediction of survival ($\chi^2 = 0.001$, $P = 0.98$), which implies that there was no difference in survival rates (non-hunting) between adult male and female moose. Non-hunting mortality was substantially higher than documented for populations outside of Minnesota (generally 8 to 12%; Ballard, 1991, Bangs 1989, Bertram and Vivion 2002, Kufeld and Bowden 1996, Larsen et al. 1989, Mytton and Keith 1981, Peterson 1977) and similar to that observed for adult moose in northwestern Minnesota (Murray et al. 2006).

Serum samples from 91 radiocollared adult female moose were collected and analyzed using radioimmunoassay for levels of serum progesterone between 2002 and 2008. Using a pregnancy threshold of 2.0 ng/ml progesterone, annual pregnancy rate varied from 55 to 100% ($\bar{x} = 80\%$, SE = 8, $n = 5$). Boer (1992), in his review of moose reproduction in North America found that adult pregnancy rate across North America averaged 84%. Although pregnancy rate of yearling moose is reduced (Schwartz 1968), our sample included only 1 yearling moose. Our estimates may be biased low because 4 cows that tested negative in 2003 (55% pregnancy rate) were subsequently observed with a calf.

Between 2004 and 2008, 161 radiocollared adult females gave birth to a minimum of 131 calves (76 singles, 26 twins, and 1 set of triplets; Schrage unpublished). The annual ratio of calves: radiocollared females ranged from 0.53 to 0.96 ($\bar{x} = 0.79$, SE = 0.07, $n = 5$). These estimates were biased low because in 3 of 4 years, radiocollared females not accompanied by calves during the MJ survey were subsequently observed to be accompanied by a single calf (4 in 2004, 2 in 2005, 1 in 2007). It is also possible that post natal mortality occurred prior to the MJ survey. Nonetheless, these estimates are low compared with other locations in North America. Boer (1992), for example, reported estimates ranging from 0.88 to 1.24 calves/adult female, in moose populations above and below carrying capacity, respectively.

During the past year, 3 manuscripts discussing the results of this research have been prepared for publication. The first, entitled "Temperature mediated moose survival in northeastern Minnesota" was published in the May 2009 issue of the Journal of Wildlife Management. A second manuscript, entitled "Assessing winter body condition of moose (*Alces alces*) in a declining population in northeastern Minnesota" has been submitted to the Journal of Mammalogy. The final manuscript, entitled "Dynamics of a Minnesota moose population in a warming climate" has been submitted to the Journal of Animal Ecology. At least 2 additional manuscripts are planned from the data collected during the first phase of this research.

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LITERATURE CITED

- Ballard, W. B., J. S. Whitman, and D. J. Reed. 1991. Population dynamics of moose in south-central Alaska. *Wildlife Monograph* 114.
- Bangs, E. E., T. N. Bailey, and M. F. Portner. 1989. Survival rates of adult female moose on the Kenai Peninsula, Alaska. *Journal of Wildlife Management* 53:557-563.
- Bertram, M. R., and M. T. Vivion. 2002. Moose mortality in eastern interior Alaska. *Journal of Wildlife Management* 66:747-756.
- Boer, A. H. 1992. Fecundity of North American moose (*Alces alces*): a review. *Alces* (Supplement) 1:1-10.
- Cox, D. R. 1972. Regression models and life tables. *Journal of the Royal Statistical Society, Series B* 20:187-220.
- Kaplan, E. L. and O. Meier. 1958. Non-parametric estimation from incomplete observations. *Journal of the American Statistical Association* 53:457-481.
- Kufeld, R. C., and D. C. Bowden. 1996. Survival rates of Shiras moose (*Alces alces shirasi*) in Colorado. *Alces* 32: 9-13.
- Larsen, D. G., D. A. Gauthier, and R. L. Markel. 1989. Cause and rate of moose mortality in the southwest Yukon. *Journal of Wildlife Management* 53:548-557.
- Lenarz, M. S., M. E. Nelson, M. W. Schrage, and A. J. Edwards. Temperature mediated moose survival in northeastern Minnesota. *Journal of Wildlife Management* 73: in press.
- Murray, D. L., E. W. Cox, W. B. Ballard, H. A. Witlaw, M. S. Lenarz, T. W. Custer, T. Barnett, and T. K. Fuller. 2006. Pathogens, nutritional deficiency, and climate influences on a declining moose population. *Wildlife Monographs* 166.
- Mytton, W. R., and L. B. Keith. 1981. Dynamics of moose populations near Rochester, Alberta, 1975-1978. *Canadian Field-Naturalist* 95:39-49.
- Peterson, R. O. Wolf ecology and prey relationships on Isle Royale. National Park Service Scientific Monograph. 88. Washington, D.C., USA.
- Pollock, K. H., S.R. Winterstein, C.M. Bunck, and P.D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. *Journal of Wildlife Management* 53:7-15.
- Schwartz, C. C. 1997. Reproduction, natality and growth. Pages 141-172 in A. W. Franzmann and C. C. Schwartz, editors. *Ecology and management of North American moose*. Smithsonian Institution Press, Washington, D. C., USA.
- SAS Institute. 2008. Version 9.1, SAS Institute, Cary, North Carolina, USA.

Table 1. Annual adult mortality of moose in northeastern Minnesota, USA. Estimates censored for hunting, capture mortality, and apparent transmitter failure. Mortality calculated for period 1 June to 31 May.

Year	Male	Female	Combined
2002 ¹	7% (25) ²	30% (29)	23% (54)
2003	25% (21)	20% (34)	21% (55)
2004	8% (32)	5% (42)	6% (74)
2005	24% (21)	29% (30)	26% (51)
2006	40% (10)	27% (22)	31% (32)
2007	20% (8)	19% (49)	18% (57)
Mean	21%	21%	21%

¹ Period: 1 June 2002 – 31 May 2003.

² Sample size as of 31 May.