2011 Aerial Moose Survey

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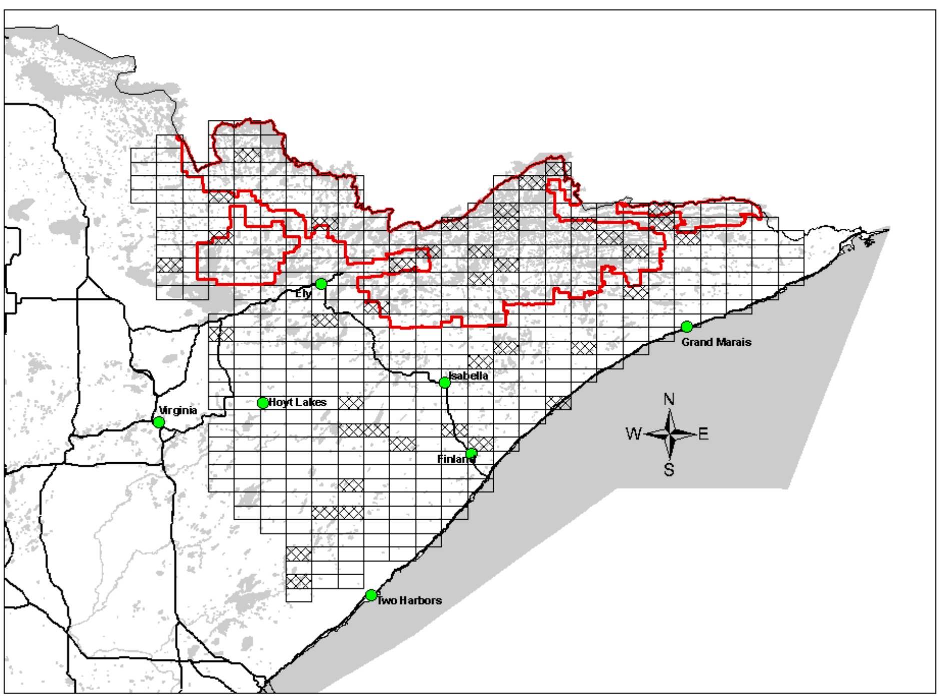
Introduction

Each year, we conduct an aerial survey in northeastern Minnesota in an effort to monitor moose (*Alces alces*) numbers and identify fluctuations in the status of Minnesota's largest deer species. The primary objectives of this annual survey are to estimate moose numbers and determine the calf:cow and bull:cow ratios. We use these data to determine population trends and set the harvest quota for the subsequent hunting season

Methods

We estimated moose numbers and age/sex ratios by flying transects within a stratified random sample of survey plots (Figure 1). Survey plots were last stratified in 2009. As in previous years, all survey plots were rectangular (5 x 2.67 mi.) and all transects were oriented east to west. DNR Enforcement pilots flew the Bell Jet Ranger (OH-58) helicopters used to conduct the survey. We sexed moose using the presence of antlers and or presence of a vulval patch (Mitchell 1970), and identified calves on the basis of size and behavior. We used the program DNRSurvey on Toughbook® tablet style computers to record survey data. DNRSurvey allowed us to display transect lines superimposed on a background of aerial photography, observe the aircraft's flight path over this background in real time, and record data using a tablet pen with a menu-driven data entry form.

Figure 1. Northeast moose survey area and sample plots (cross hatching) flown in the 2011 aerial moose survey. The red line delineates the boundary of the Boundary Waters Canoe Area Wilderness.



We accounted for visibility bias by using a sightability model (Ackerman 1988, Anderson and Lindzey 1996, Otten et al. 1993, Quayle et al. 2001, Samuel et al. 1987). We developed this model between 2004 and 2007 using moose that were radiocollared as part of research on the population dynamics of the northeastern moose population. Logistic regression indicated that the covariate "visual obstruction" (VOC) was the most important covariate in determining whether radiocollared moose were observed. We defined VOC as the proportion of vegetation within a circle (10m radius or roughly 4 moose lengths) that would prevent you from seeing a moose when circling that spot from an oblique angle. If we observed more than one moose at a location, visual obstruction was based on the first moose sighted. We used uncorrected estimates (no visibility bias correction) of bulls, cows, and calves to calculate the bull:cow and calf:cow ratios.

We have used the sightability model approach for 8 years to account for sightability bias in our estimates of moose numbers in northeastern Minnesota. In 2004, 3 observers equated VOC to crown closure on some observations and this resulted in substantially higher estimates of VOC. As a result, the 2004 population estimate was biased very high (Table 1) and was not included in the following discussion. Population estimates prior to 2004 were based on fixed-wing aircraft surveys and are not comparable to estimates based helicopter surveys which began in 2004.

Results and Discussion

We initiated the survey on 5 January and completed it on 19 January. Observers rated survey conditions as "fair" (middle rank) on 15 plots and "good" (high rank) on 25 plots. Snow conditions for the survey were between 8" and 16" on 2 plots, and >16" on 38 plots. During the survey flights, observers located 375 moose on the 40 plots (533 mi^2) including 121 bulls, 199 cows, 48 calves, and 7 unidentified moose. After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 4,889±1,182 animals (Table 1). Estimates of the calf:cow and bull:cow ratios were 0.24 and 0.64, respectively (Table 1).

Table 1. Estimated moose numbers, calves:cow, percent calves, percent cows with twins, and bulls:cow from aerial surveys in northeastern Minnesota. Surveys prior to 2004 were conducted using fixed-wing aircraft and population estimates from these surveys are not comparable to the results from helicopter surveys. Ratios and proportions estimated by fixed-wing and helicopter surveys are comparable. Survey estimate from 2004 was biased high because of an error in how visual obstruction covariate was determined. Survey estimates prior to 1998 were not included because they were biased based on starting date and length of survey (Lenarz 1998).

Survey	Estimate	Calves:Cow	% Calves	% Cows w/ twins	Bulls:Cow
1998	3,464 ±36%	0.71	25	0	0.98
1999	3,915 ±35%	0.57	18	9	1.30
2000	3,733 ±25%	0.70	20	7	1.34
2001	3,879 ±28%	0.61	19	5	1.05
2002	5,214 ±23%	0.93	25	20	1.22
2003	4,161 ±37%	0.70	14	11	2.01
2004	13,093±40%	0.42	15	4	1.24
2005	7,923±30%	0.52	19	9	1.04
2006	8,501±28%	0.34	13	5	1.09

2007	6,659±27%	0.29	13	3	0.89
2008	7,637±28%	0.36	16	2	0.77
2009	7,593±23%	0.32	14	2	0.94
2010	5,528±24%	0.28	13	3	0.83
2011	4,889±24%	0.24	13	1	0.64

The 2011 population estimate was 12% lower than the 2010 estimate but the overlap in confidence intervals (Table 1, Figure 2) indicates no statistical difference between the two estimates. Gasaway and Dubois (1987) indicated that even with precise survey estimates, a change of 20% may be required to detect a significant change in population size. Time series analysis of estimates since 2005 indicates a significant downward trend (Figure 2, $P = 0.024$). This corroborates several data sets that suggest the northeastern Minnesota moose population is declining. Lenarz et al, (2010), for example, used simulation modeling to integrate survival and reproductive rates measured between 2002 and 2008 and found that the population was decreasing approximately 15% per year over the long term. Two measures of recruitment (calf:cow ratio and % calves) measured during the aerial survey have also declined significantly over the past 14 years (Figure 3). This decrease is explained in part by a significant decline in the proportion of cows accompanied by twins since 2002 (Table 1; $P = 0.010$). A declining population is also indicated by a significant drop in hunter success rates since 2001, for both either-sex hunting (2001-2006, $P < 0.001$) and for bulls-only hunting (2001-2010, $P = 0.006$).

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2011.

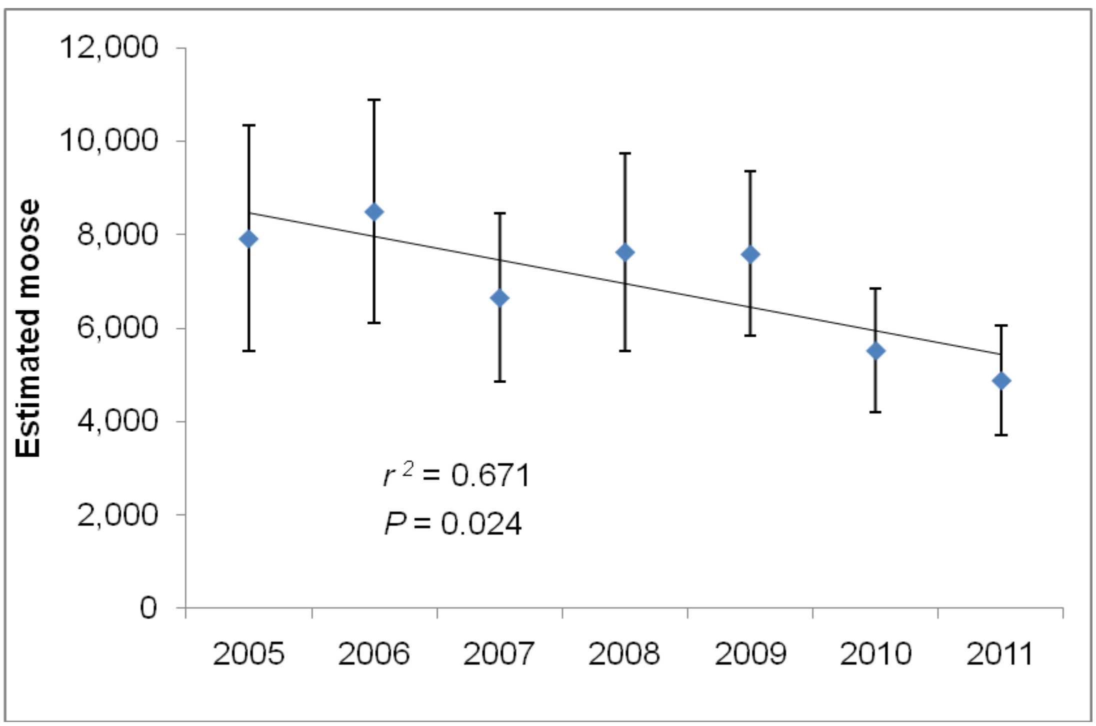
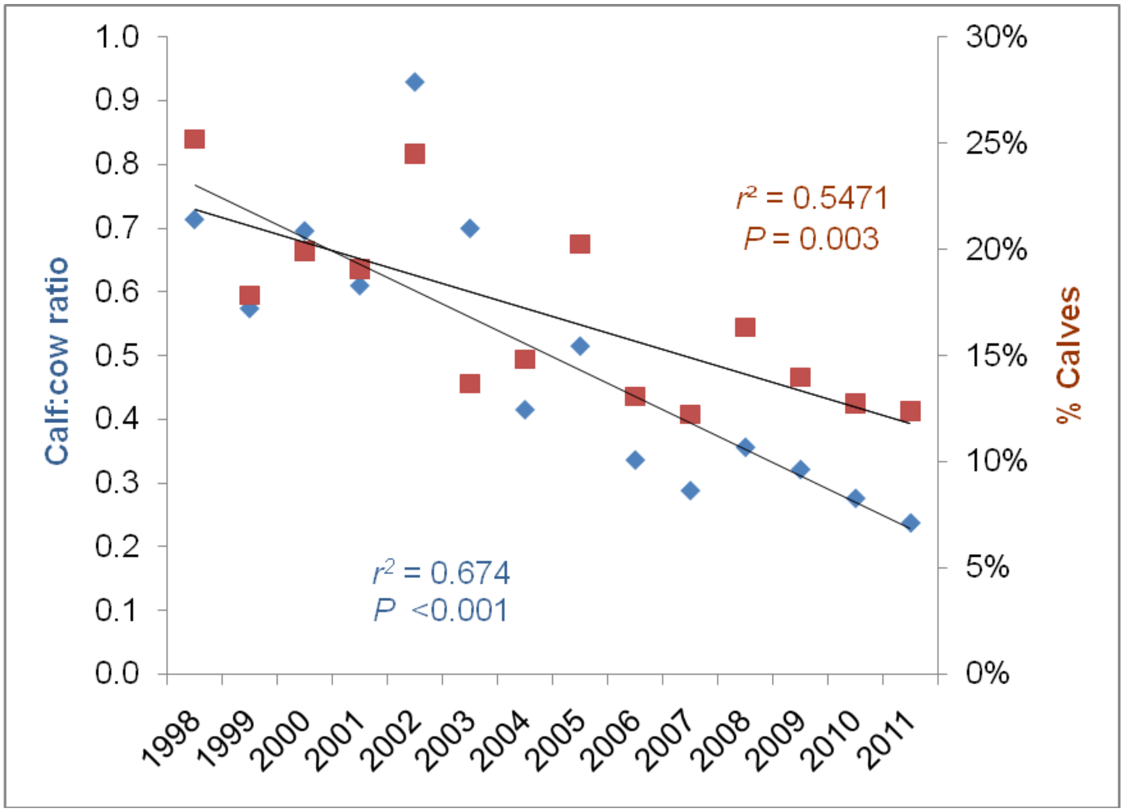


Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota. The % calves is less biased than the calf:cow ratio because it isn't dependent on

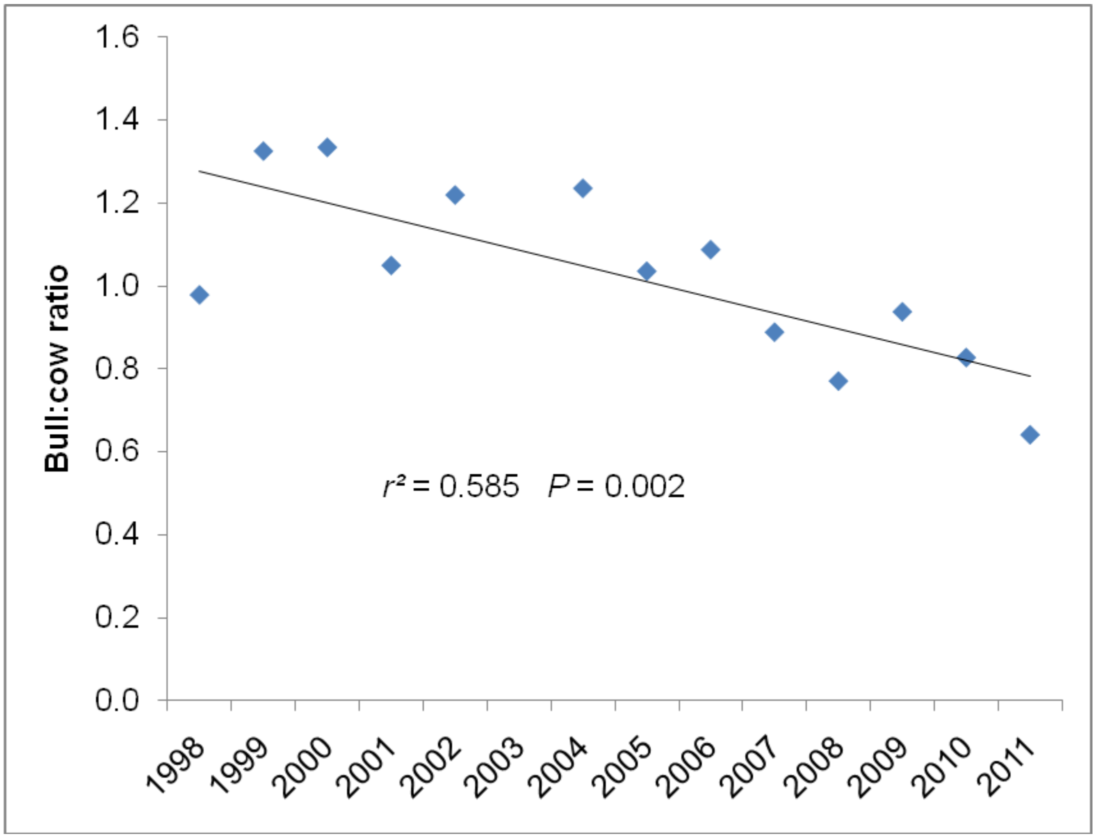
adult cow moose being correctly classified. The calf:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.



Estimated recruitment from this year's survey was at an all time low. The calf:cow ratio in January was only 0.24 and calves represented only 13% of the total moose observed (Table 1). Only 1% of the cow moose were accompanied by twins (Table 1). An aerial survey of 24 radiocollared cows in late May 2010 indicated a calf:cow ratio of 1.13 calves/cow and 21% of the cow moose were accompanied by twins (M. S. Schrage, unpublished data). By January, the calf:cow ratio among these radiocollared cows was 0.46 and 1 cow (5%) was accompanied by twins. If data from the radiocollared moose was representative of the entire northeastern population, there was substantial calf mortality between May and January. Although disturbing, it is important to note that adult survival is much more important to the population growth rate than calf survival (Lenarz et al. 2010).

The estimated bull:cow ratio (Table 1; Figure 4) continued to decline and this year's estimate (0.64) was the lowest value in the last 27 years. When the 2003 estimate (2.01) was excluded from analysis (the 2003 estimate was biologically impossible considering estimates in 2002 and 2004) there was a significant negative trend in the bull:cow ratio (Figure 4, r^2 = 0.585, P = 0.002). Analysis of non-hunting mortality from radiocollared moose between 2002 and 2008 indicated no difference in survival between sexes (Lenarz et al. 2009, 2010) which suggests that hunting may be contributing to this declining ratio. Since 2005 the combined State and tribal harvest has averaged 153 bull and 19 cow moose per year which represented an average of only 2% of the pre-harvest population. Simulation modeling indicates that even at this low harvest level, a bull biased harvest has the potential to reduce the population's bull:cow ratio especially with higher levels of non-hunting mortality and or reduced recruitment (Lenarz unpublished).

Figure 4. Estimated bull:cow ratio from aerial moose surveys in northeastern Minnesota. The 2003 estimate (2.01) was omitted from this figure because it was biologically impossible considering estimates in 2002 and 2004. The bull:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.



It is generally accepted that productivity of moose decline if the proportion of bulls in the population drops below some threshold (Rausch et al. 1974, Bubenik 1987, Crete et al. 1981, Solberg et al. 2002). However, there are no empirical data to estimate this threshold for moose in Minnesota or eastern Canada. Based on simulation modeling, Crete et al. (1981) recommended maintaining a bull:cow ratio above of 0.67. If the bull:cow ratio in northeastern Minnesota continues to decline, we may witness a decline in productivity.

Acknowledgments

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