2012 Aerial Moose Survey

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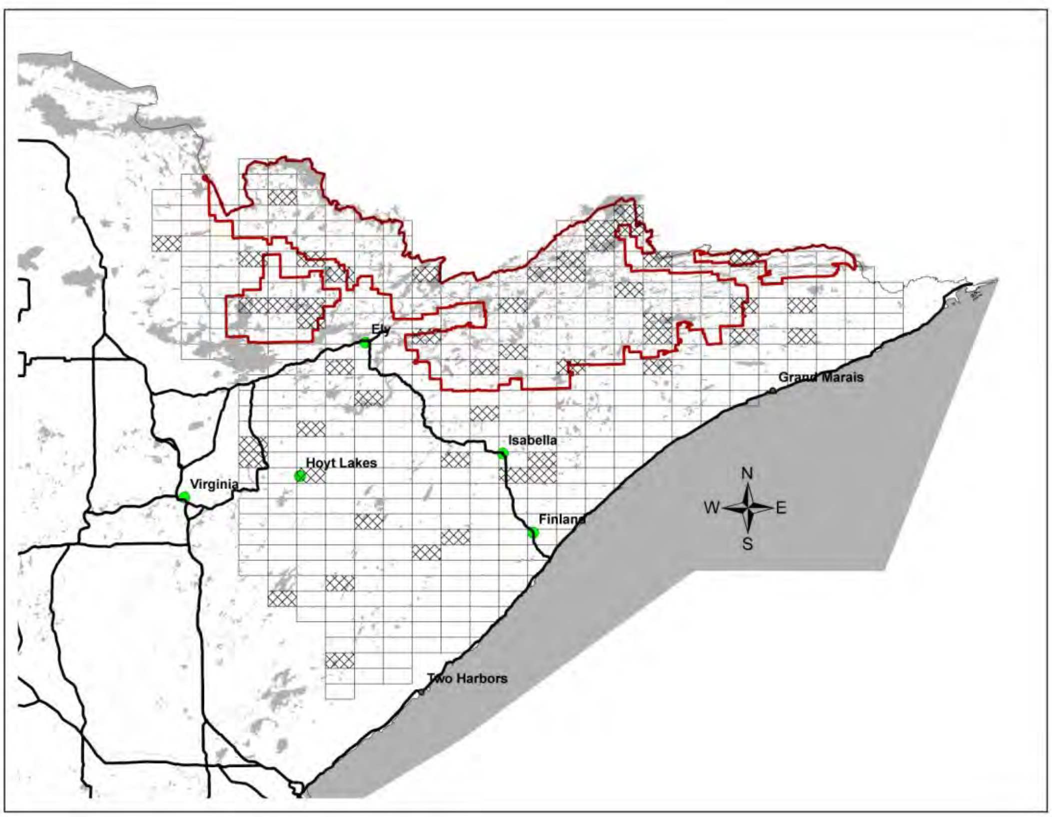
Introduction

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 2012 aerial moose survey. The red line delineates the boundary of the Boundary Waters Canoe Area Wilderness.



In previous years, we used 3 strata based on expected moose density in an effort to optimize precision of our survey estimates. In 2012, we added a 4th stratum to represent a series of 9 plots that have undergone disturbance (wild fire, prescribed burning, timber harvest). Each year, these same 9 plots will be surveyed in an effort to evaluate the effect of disturbance on moose density.

We accounted for visibility bias by using a sightability model (Giudice et al. 2012). 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" (VO) was the most important covariate in determining whether radiocollared moose were observed. We defined VO 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, VO 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.

Recent research indicated that variance calculations used in earlier analyses underestimated the total variance of survey estimates (Fieberg in press). We reanalyzed survey data 2004-2011 using the package SightabilityModel in Program R (Fieberg in press, R Development Core Team 2011) to recalculate confidence intervals. Based on this approach, confidence intervals are asymmetrical around the estimates. Minor corrections to our sightability model also modified population estimates slightly (0-4%) from those reported in previous reports.

Results and Discussion

We initiated the survey on 26 January and completed it on 9 February. Normally the survey begins in early January but the start was delayed because of insufficient snow on the ground in western portions of the survey area. Observers rated survey conditions as "marginal" (low rank) on 17 plots, and "good" (highest rank) on 32 plots. Snow conditions for the survey were <8" on 7 plots, between 8" and 16" on 26 plots, and >16" on 16 plots. During the survey flights, observers located 344 moose on the 49 plots (653 mi^2) including 144 bulls, 140 cows, 55 calves, and 5 unidentified moose. After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 4,230 (3,190 – 5,600) animals (Table 1). Estimates of the calf:cow and bull:cow ratios were 0.36 and 1.08, respectively (Table 1).

Table 1. Estimated moose numbers, 90% confidence interval, calves:cow, % calves, % cows with twins, and bulls:cow from aerial surveys in northeastern Minnesota.

Survey	Estimate	90% Confidence Interval	Calves: Cow	% Calves	% Cows w/ twins	Bulls: Cow
2005	8,160	5,960 – 11,170	0.52	19	9	1.04
2006	8,840	6,670 – 11,710	0.34	13	5	1.09
2007	6,860	5,230 – 9,000	0.29	13	3	0.89
2008	7,890	5,970 – 10,420	0.36	17	2	0.77
2009	7,840	6,190 – 9,910	0.32	14	2	0.94
2010	5,700	4,480 – 7,250	0.28	13	3	0.83
2011	4,900	3,810 – 6,290	0.24	13	1	0.64
2012	4,230	3,190 – 5,600	0.36	15	6	1.08

The 2012 population estimate was 14% lower than the 2011 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 = 0.004). 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.

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2012.

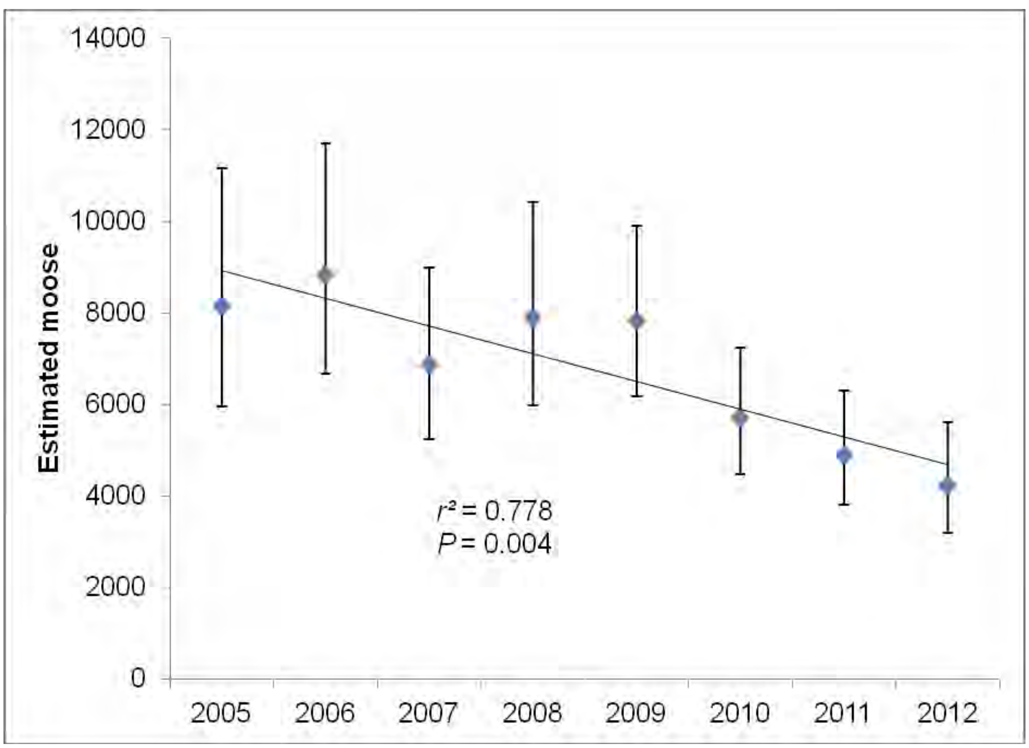
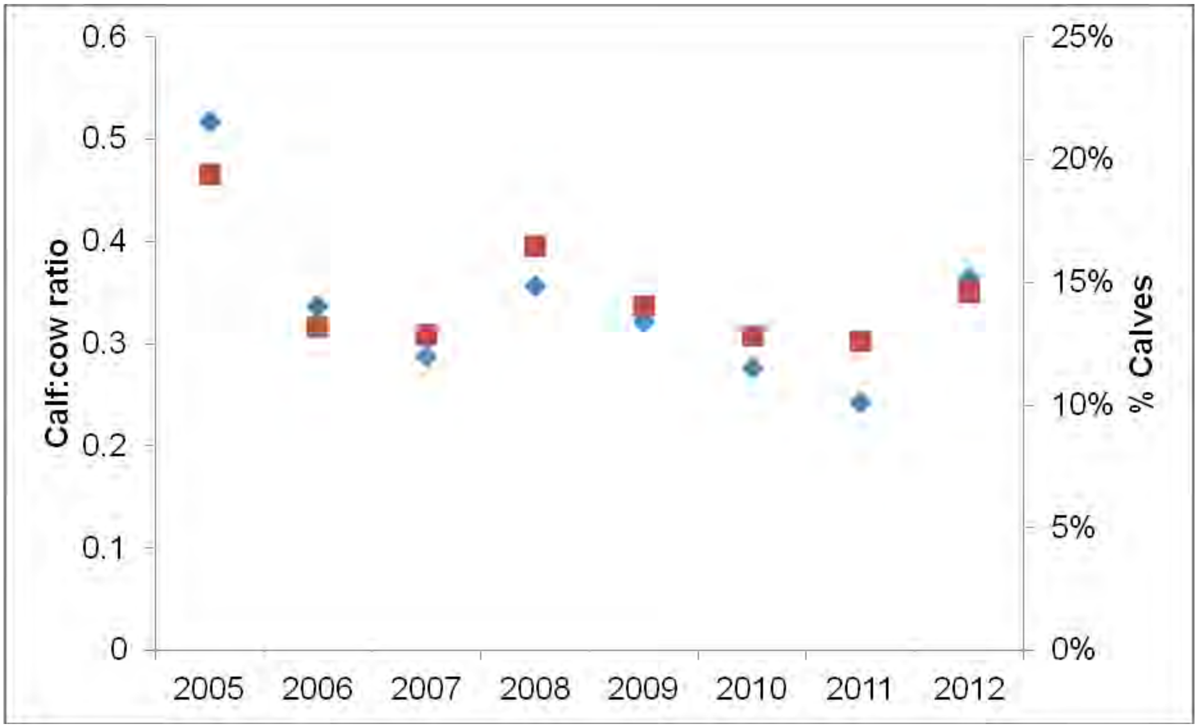


Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota.

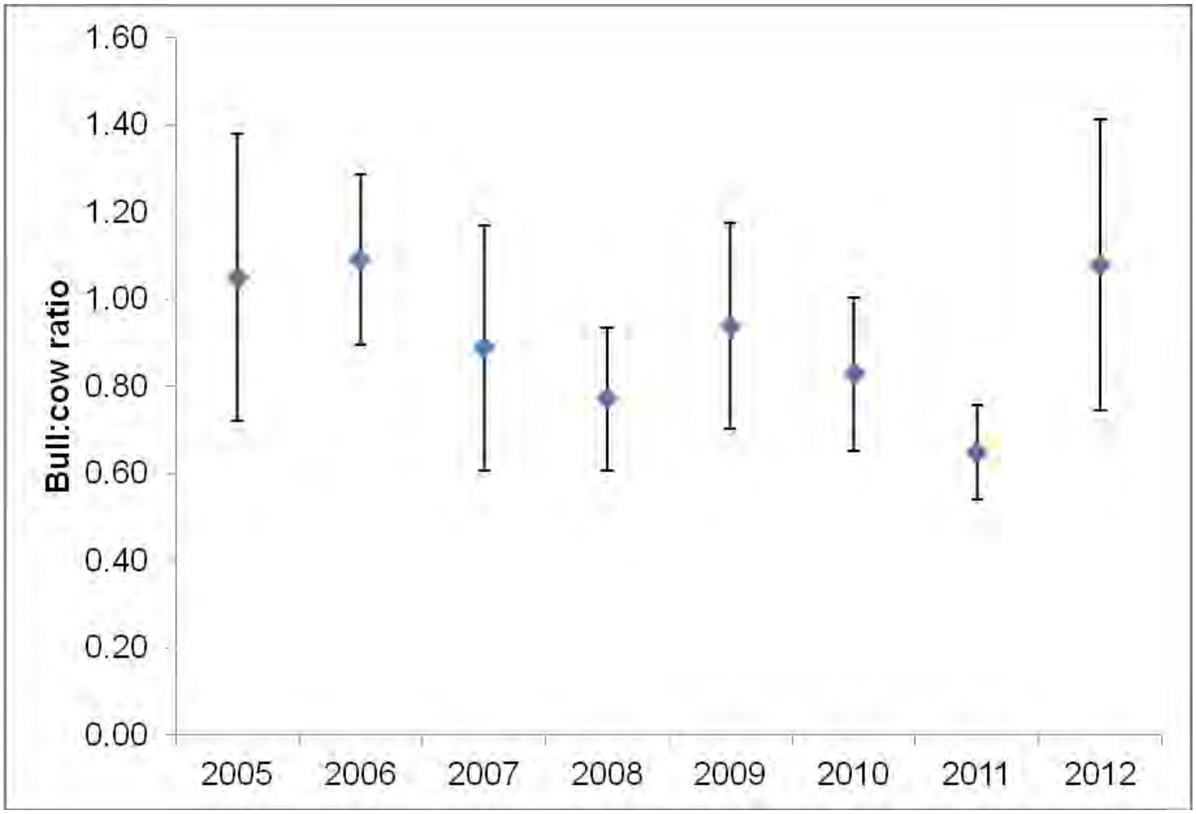


Estimated recruitment from this year's survey was the highest it has been since 2005 (Table 1). The calf:cow ratio in early February was 0.36 and calves represented 15% of the total moose observed (Table 1). Almost 6% of the cow moose were accompanied by twins (Table 1), up over 5% from 2011. This increase undoubtedly contributed to this year's increased recruitment and it is likely that survival of single calves increased as well. The close agreement between calf:cow ratio and % calves (Figure 3, $r = 0.94$, $P < 0.001$) suggests that classification of adult moose to sex is accurate. Despite the improvement to recruitment, 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) increased considerably since 2011 and this suggests that numbers of adult males and females were roughly equal. This year's survey was delayed approximately 3½ weeks and fewer than normal antlered bulls were observed (<10% vs. 20-30%). It is unlikely that the absence of antlers biased the bull:cow ratio higher because cows would have had to be misclassified as bulls, an unlikely consequence of the absence of antlers. Moreover, the close agreement between calf:cow ratio and % calves (Figure 3) suggests that cows were correctly classified.

Several authors have indicated that moose move into thicker conifer cover as the winter progresses and are more difficult to observe (Gasaway et al 1986, Peterson and Page 1993). During the 2012 survey, however, the mean VO was 36 which was within the range observed in previous years (30 – 44). Presumably the moose have not shifted into the thicker cover because of a warmer than normal winter with lower snow depths. Our use of a sightability model should correct for sightability bias even if the moose had shifted to denser conifer cover. It is unlikely, therefore, that the late start of this year's survey biased the population estimates.

Figure 4. Estimated bull:cow ratio from aerial moose surveys in northeastern Minnesota.



Acknowledgments

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