2013 Aerial Moose Survey Final Results

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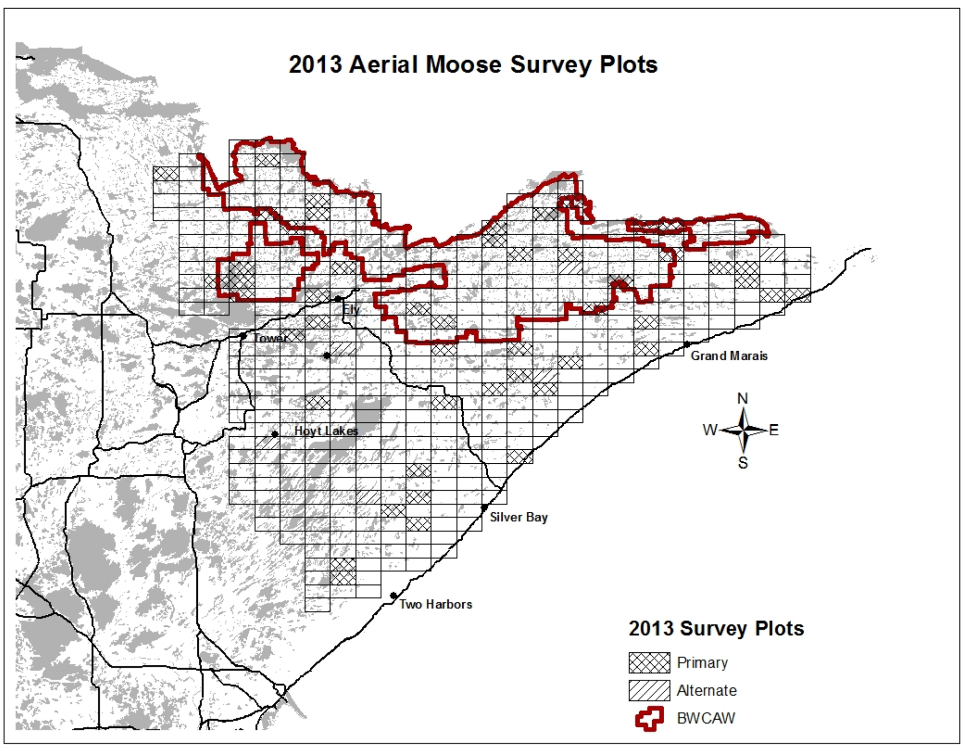
Introduction

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

Methods

We estimated moose numbers, age and sex ratios by flying transects within a stratified random sample of survey plots (Figure 1). Survey plots were last stratified as low, medium, and high moose density 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 or the 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 2013 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 (low, medium, and high) 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 by wild fire, prescribed burning, and timber harvest. Each year, these same 9 plots will be surveyed in an effort to evaluate the effect of disturbance on moose density over time.

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 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 (10-m 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 2012). We reanalyzed survey data from 2004 to 2011 using the package Sightability Model in Program R (R Development Core Team 2011, Fieberg 2012) 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 previously reported.

Results and Discussion

We initiated the survey on 3 January and completed it on 15 January 2013. It consisted of 9 actual survey days. Sixty-seven percent of plots were surveyed under snow conditions classified as "good," 33% as marginal, and 0% as "poor," not dissimilar from the past 2 years' surveys. During the survey flights, observers detected 251 moose for 49 plots (653 mi^2) flown, including 109 bulls, 99 cows, 34 calves, and 9 unidentified moose. Estimates of the calf:cow and bull:cow ratios adjusted for sampling-only were 0.33 and 1.23, respectively (Table 1). In 2012, the first year 49 plots (versus 40 in the previous 5 years) were surveyed, 344 moose were observed, including 144 bulls, 140 cows, 55 calves, and 5 unidentified.

After adjusting for sampling and sightability, we estimated the population in northeastern Minnesota at 2,760 (2,120 – 3,580) moose (Table 1). Based on the log rate of change (-0.427, -0.762, -0.093 [90% confidence limits]), the 2013 population estimate was significantly lower (35%) than the 2012 estimate. Gasaway and Dubois (1987) indicated that even with relatively precise survey estimates, a change of at least 20% may be required to detect a significant change in population size. However, time series analysis of estimates since 2005 indicates a significant downward trend (Figure 2, $P = 0.0005$). This corroborates several data sets which suggest the northeastern Minnesota moose population is declining. Lenarz et al. (2010) had 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. The 2013 estimate indicates a significant (52%) decline in the population since 2010, not inconsistent with that finding (Table 1).

Table 1. Estimated moose numbers, 90% confidence interval, and calves:cow, percent calves, percent cows with twins, and bulls:cow observed from aerial surveys in northeastern Minnesota, 2005-2013.

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
2013	2,760	2,120 – 3,580	0.33	14	3	1.23

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2013. (Note: The 2005 survey was the first to be flown with helicopters, and to include a sightability model and a uniform grid of east-west oriented rectangular 5 x 2.67 mi^2 plots).

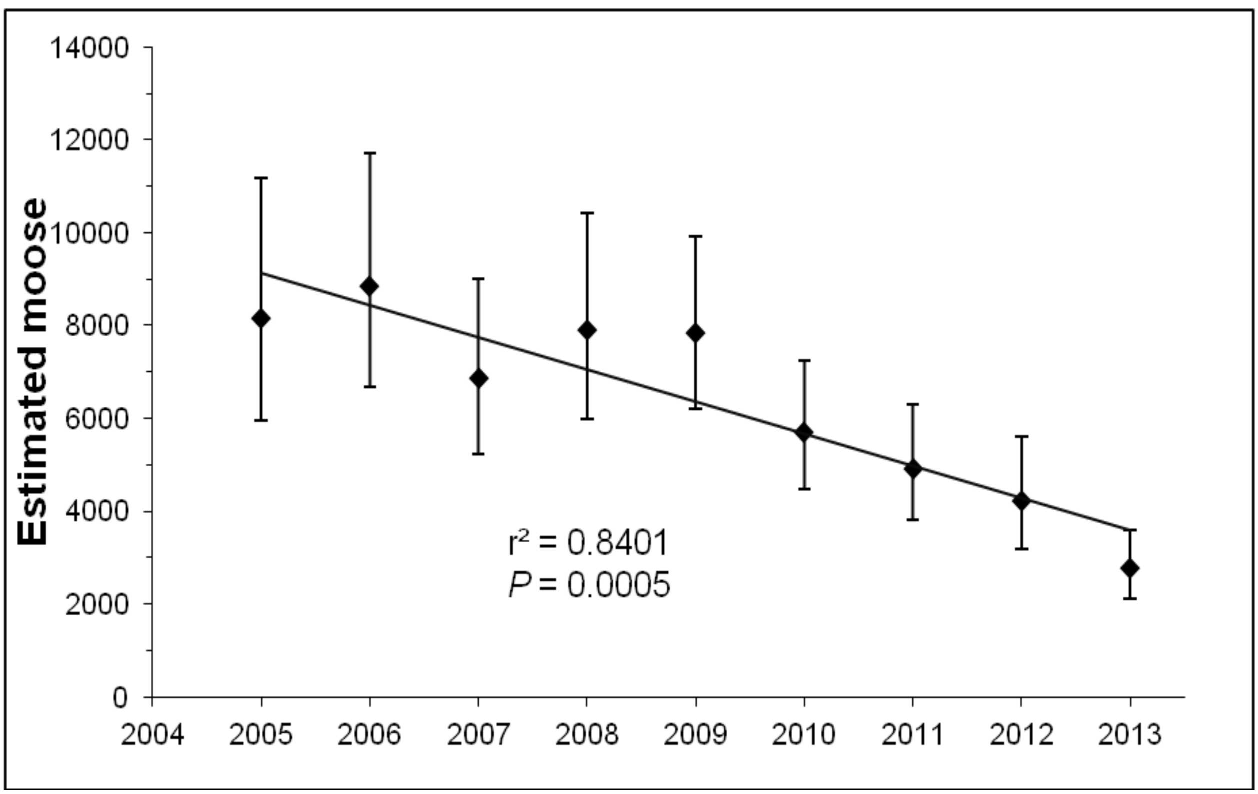
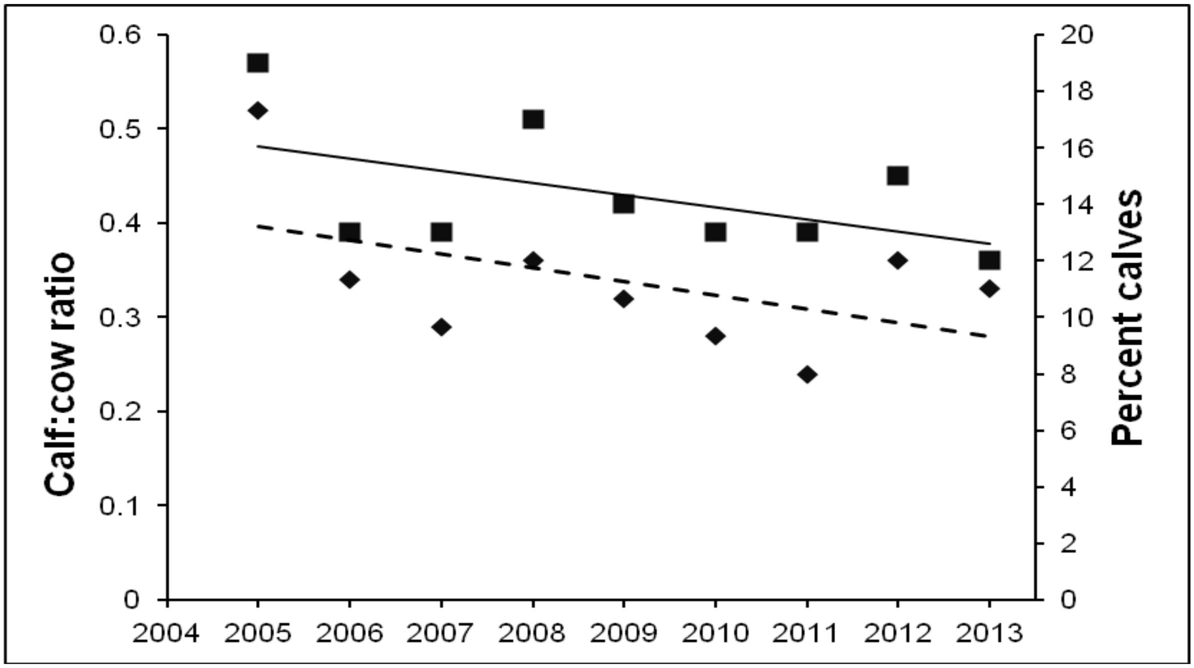


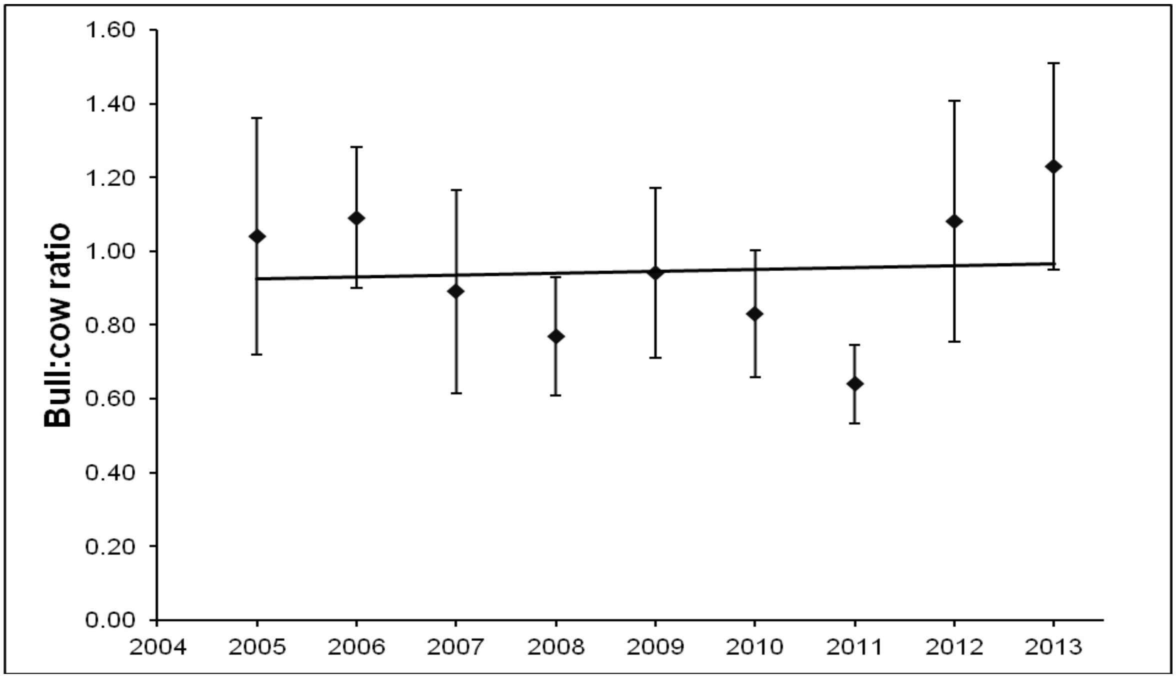
Figure 3. Estimated calf:cow ratios (solid diamonds, dashed trend line) and percent calves (solid squares, solid trend line) from aerial moose surveys in northeastern Minnesota, 2005-2013.



Estimated calf recruitment from this year's survey remained *relatively* high and similar to last year's estimate (Table 1). The calf:cow ratio in mid-January 2013 was 0.33 and calves represented 14% of the total moose observed (Table 1). Only 3% of the cow moose were accompanied by twins (Table 1), down from 6% in 2012. In 2012, the close agreement between calf:cow ratio and % calves ($r = 0.94$, $P < 0.001$) indicated that classification of adult moose to sex is accurate. Despite the apparent stability of calf survival through to the January 2013 survey compared to the 2012 survey, it is important to note that annual adult survival is more important to the population growth rate than calf survival (Lenarz et al. 2010). Further, *annual* recruitment of the calves is not actually determined until the next spring calving season when winter survey-observed calves become yearlings. At this point little is known about the survival rates of moose calves during the period between the annual winter survey and subsequent spring calving.

The estimated bull:cow ratio (Table 1; Figure 4) increased considerably since 2011 and is the highest it's ever been since 2005. Further, this year's estimated bull:cow ratio indicates that adult bulls may somewhat outnumber adult females, although there is a great deal of variability associated with these annual ratio estimates. Consequently, there is no clear upward or downward long-term trend (2005-2013) in bull:cow ratios. Despite the higher bull:cow ratios during this year's survey, the number of bulls observed over 49 survey plots surveyed decreased 24% from last year's (2012) 49 plots flown, and was considerably less (74%) than the average annual number of bulls observed (413) from 2007 to 2011.

Figure 4. Estimated bull:cow ratios, 90% confidence intervals, and trend line from aerial moose surveys in northeastern Minnesota, 2005-2013.



Acknowledgments

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