2010 Aerial Moose Survey

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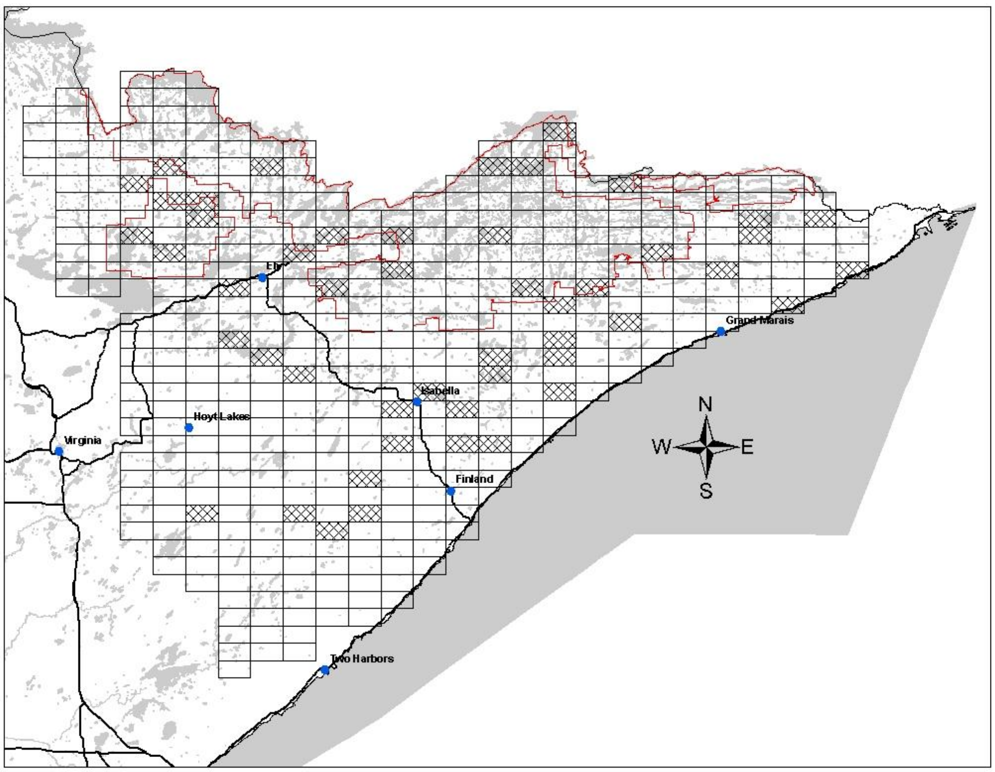
Introduction

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 in a simulation model to identify population trends and the harvestable surplus.

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 helicopters used to conduct the survey. We sexed moose using the presence of antlers, size and shape of the bell, nose color and/or presence of a vulval patch (Mitchell 1970), and identified calves on the basis of size and behavior. We recorded UTM coordinates and the percent visual obstruction (VOC) for all moose observed within the plots. We defined visual obstruction 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.

Figure 1. Northeast moose survey area and sample plots (cross hatching) flown in the 2010 aerial moose survey.



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 visual obstruction was the most important covariate in determining whether radiocollared moose were observed. We used uncorrected estimates (no visibility bias correction) of bulls, cows, and calves to calculate the bull:cow and calf:cow ratios.

Results

We initiated the survey on 4 January and completed it on 12 January. Observers rated survey conditions as "good" (middle rank) on 39 plots and "excellent" on 1 plot. Snow conditions for the survey were <8" on 1 plot, between 8" and 16" on 36 plots, and >16" on 3 plots. During the survey flights, observers located 379 moose on the 40 plots (533 mi^2) including 140 bulls, 179 cows, 48 calves, and 12 unidentified moose. After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 5,528±1,318 animals (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.28 and 0.83, respectively (Table 1).

Discussion

We have used the sightability model approach for 7 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 significantly higher estimates of VOC (Kruskal Wallis AOV, F=16.7, P<0.001). As a result, the 2004 population estimate was biased high (Table 1). Pairwise comparison of the remaining years indicated that mean VOC did not differ among years 2005 -2010 and as a result, population estimates were more comparable. Because of this bias, the population estimate for 2004 was not included in subsequent analyses. Survey estimates prior to 2004 were based on fixed-wing aircraft surveys and are not comparable to estimates based on post 2003 helicopter surveys.

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

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

The 2010 population estimate was substantially lower than those from previous years but the overlap in confidence intervals (Table 1, Figure 2) indicates no statistical difference between the 2009 and 2010 point estimates. At current levels of precision (±24%) the point estimate would have had to decline to at least 4,750 for it to be significantly lower than the 2009 estimate. Survey estimates were relatively imprecise and even with unlimited resources it would be difficult to measurably improve the precision.

The negative slope of the trend line (Figure 2) also was not significant (P = 0.126). The lack of a significant downward trend among survey estimates was likely an artifact of the small sample size (n=6). Several data sets suggest that the northeastern Minnesota moose population is declining. Simulation modeling that integrated survival and reproductive rates measured between 2002 and 2008 indicated that the population was declining by approximately 15% per year over the long term (Lenarz et al. In press). This inference is reinforced by 2 measures of recruitment measured during the survey. Estimates of calf:cow ratio and the % calves in the moose population were not affected by the switch from fixed-wing aircraft to helicopters and we can compare the trend in these statistics over a longer time period. Over the past 13 years, the cow:calf ratio has exhibited a significant decline (Figure 3; P = 0.001). During the same time period, the % calves has also declined (Figure 3; P = 0.006). In addition, the proportion of cows accompanied by twins has steadily declined since 2002 (Table 1; P = 0.010). Independent of the aerial survey, hunter success rates have steadily declined since 2001, for both either sex hunting (P = 0.001) and for bulls-only hunting (P <0.001).

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2010.

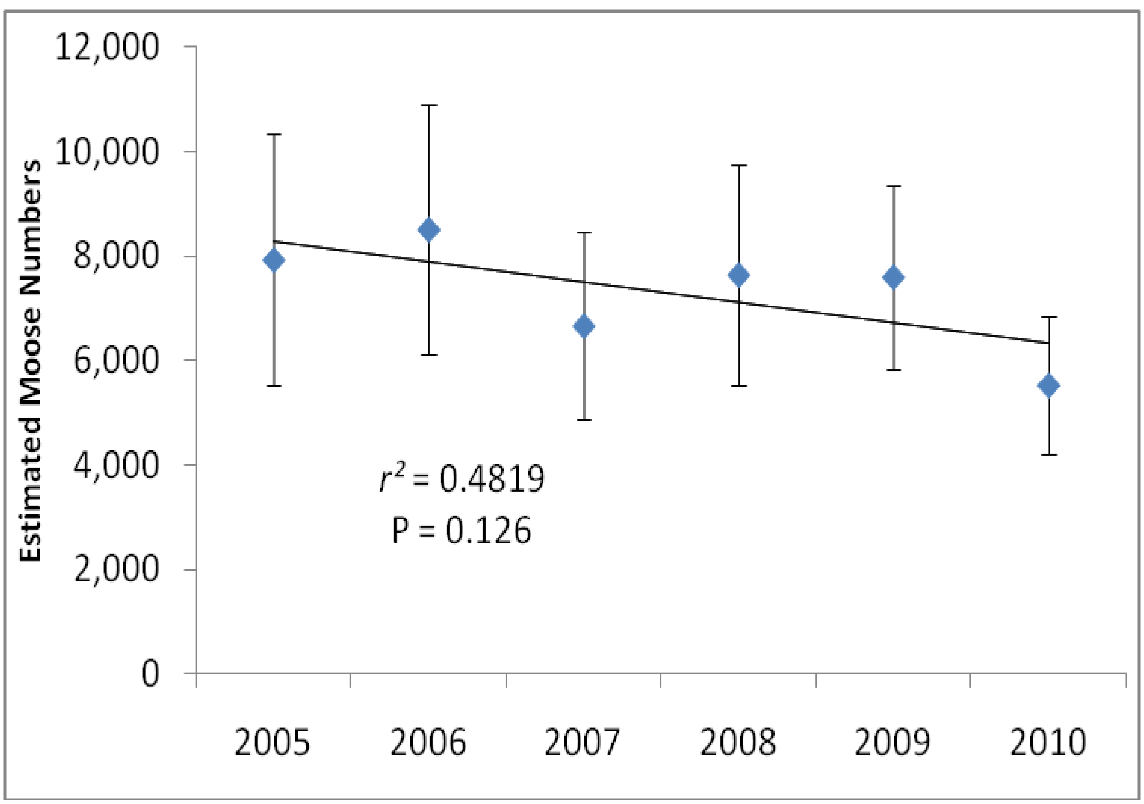


Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota. The % calves is less biased than the calf:cow ratio because it isn't dependent on adult cow moose being correctly classified. The calf:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.

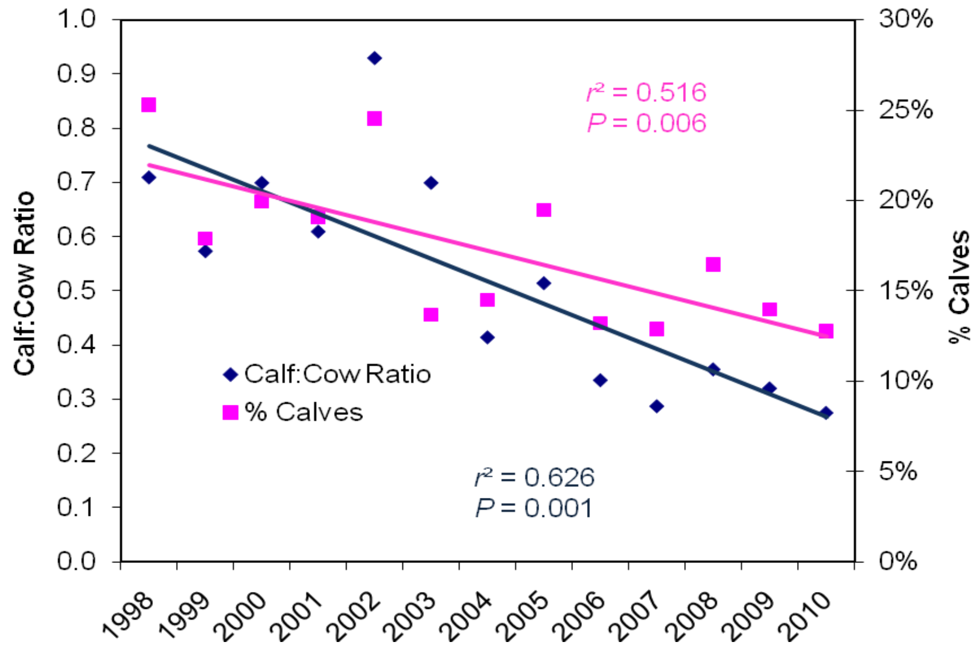
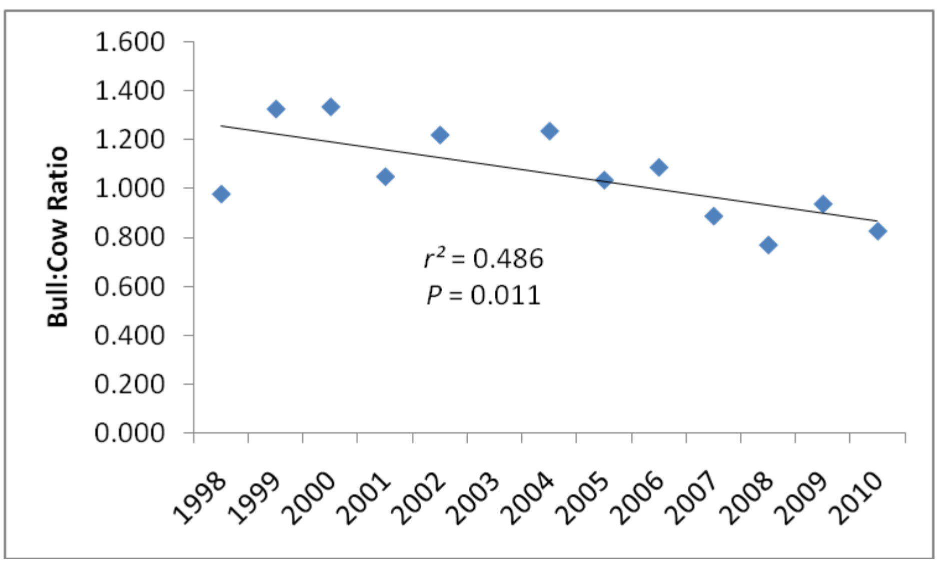


Figure 4. Estimated bull:cow ratio from aerial moose surveys in northeastern Minnesota. The bull:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.



The estimated bull:cow ratio (Table 1; Figure 4) continued to decline. When the 2003 estimate (2.01) was excluded from analysis (this estimate was biologically impossible considering estimates in 2002 and 2004) there was a negative trend in this statistic (r^2 = 0.486, P = 0.011). This trend implies that bull moose have a higher mortality than cow moose. Survival estimates from radiocollared moose between 2002 and 2008 indicated no difference in survival between sexes (Lenarz et al. 2009). Harvest of moose by State hunters has been restricted to bull moose since 2007. It is unlikely that harvest is the cause of the decline in the bull:cow ratio because a low number of bull moose are harvested each year (e.g. 137 in 2009) and the bull:cow ratio has been declining since at least 1999.

Acknowledgments

These surveys would not be possible without the excellent partnership between the Division of Enforcement, the Division of Fish and Wildlife, the Fond du Lac Band and the 1854 Treaty Authority. In particular, I would like to thank Mike Trenholm for coordinating all of the aircraft and pilots; Dan Litchfield for coordinating flights and survey crews; and Mike Schrage (Fond du Lac) and Andy Edwards (1854 Treaty Authority) for securing supplemental survey funding from their respective groups. I want to thank Enforcement pilots Brad Maas and John Heineman, for their skill in piloting aircraft during the surveys. I also want to thank Dan Litchfield, Tom Rusch, Andy Edwards, Mike Schrage, Kevin Carlisle, Nancy Gellerman, and Lance Overland who flew as observers; it takes dedication and a strong stomach. Finally, I want to thank Barry Sampson for the creating the process to generate the GIS survey maps and GPS coordinates.

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