

# 2009 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 2004. 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 and Enstrom 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.

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

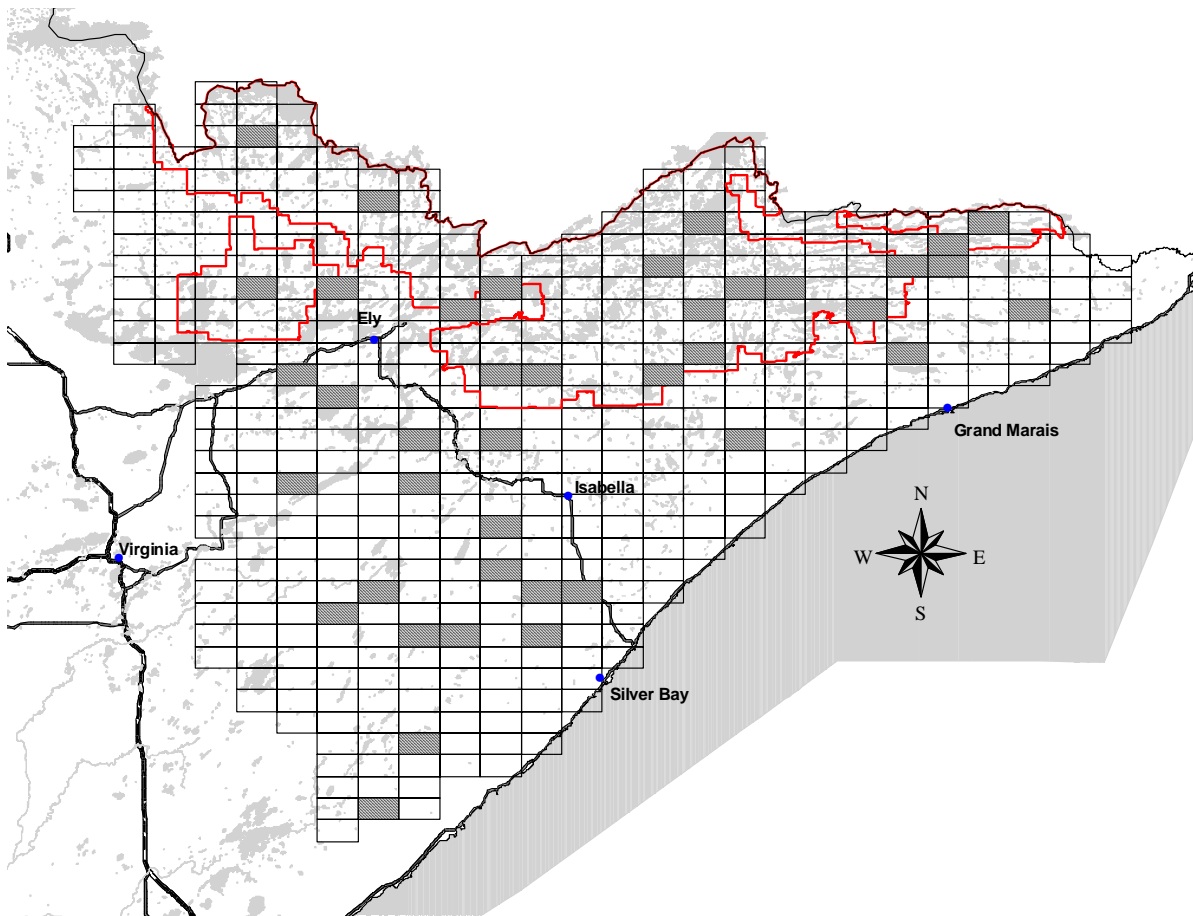
We initiated the survey on 5 January and completed it on 24 January. Observers rated survey conditions as "good" (highest rank) on 38 plots and "marginal" on 2 plots. Snow conditions for the survey were excellent and always exceeded 16" in depth. During the survey flights, observers located 474 moose on the 40 plots (532 mi<sup>2</sup>) including 208 bulls, 197 cows, 63 calves, and 6 unidentified moose.

After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained  $7,593 \pm 1761$  animals (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.32 and 0.94, respectively (Table 1).

## Discussion

We have used the sightability model approach for 6 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 -2009 and as a result, population estimates were more comparable. Because of this bias, the population estimate for 2004 was not included in subsequent analyses.

**Figure 1.** Northeast moose survey area and sample plots (diagonal lines) flown in the 2009 aerial moose survey.

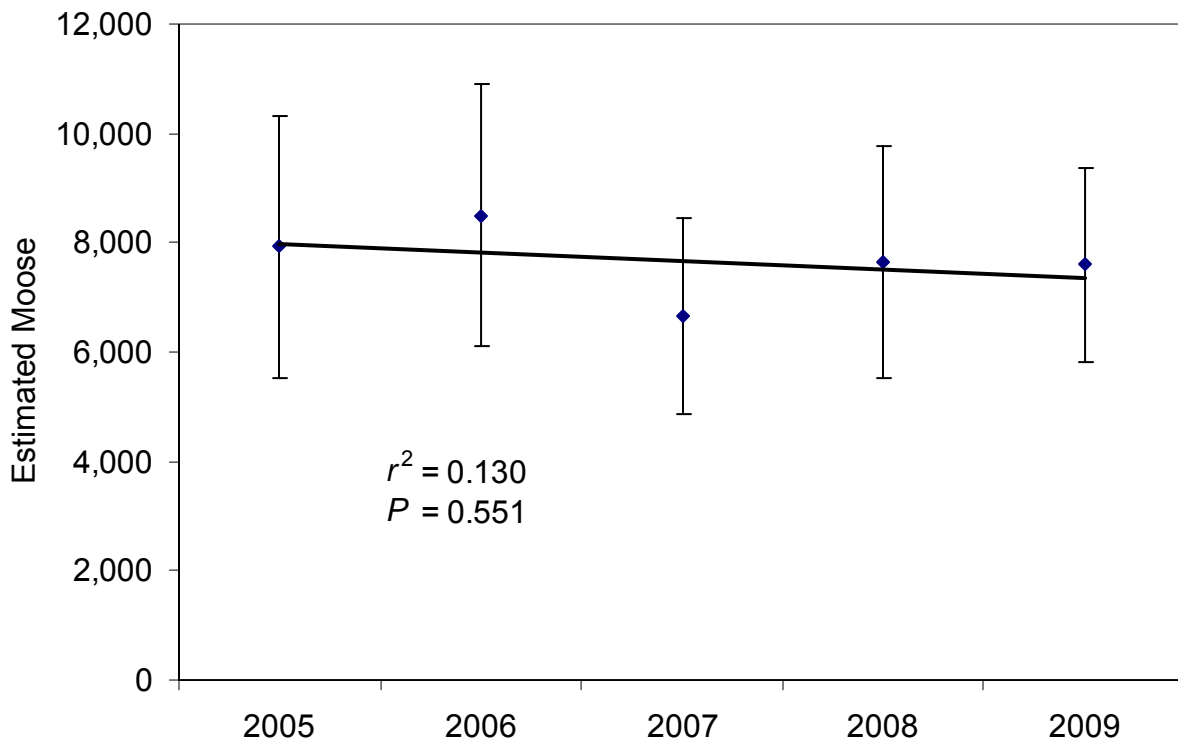


**Table 1.** Estimated moose numbers, calves:cow, percent calves, percent cows with twins, and bulls:cow from aerial surveys in northeastern Minnesota.

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

The 2009 population estimate was almost identical to the 2008 estimate. As would be expected, the overlap in confidence intervals (Table 1, Figure 2) indicates that there was no statistical difference between the 2008 and 2009 point estimates. There was no trend in survey estimates collected in the last 5 years ( $P=0.551$ ), which suggests that the population has been stable. Several data sets, however, suggest that this population is in fact declining and the lack of a downward trend in the survey estimates is an artifact of the small sample size ( $n=5$ ). Survey estimates prior to 2004 were based on fixed-wing aircraft surveys and are not comparable to estimates based on post 2003 helicopter surveys.

**Figure 2.** Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2009.



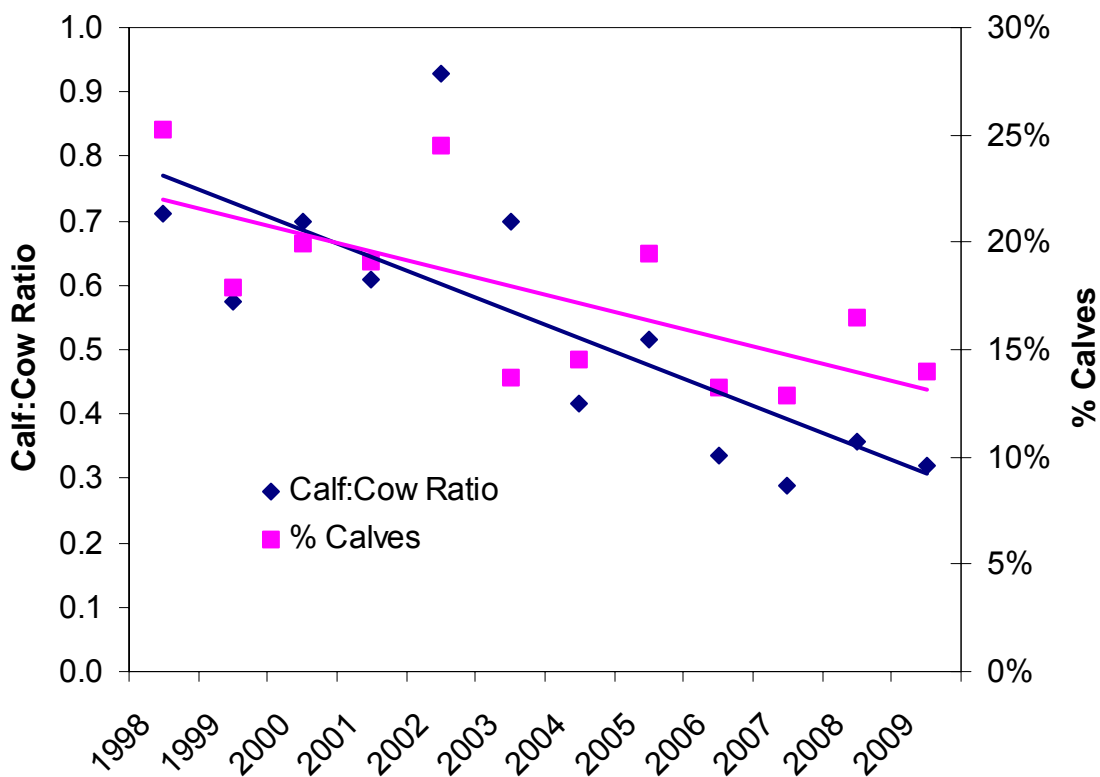
The calf:cow ratio, for example, is an important measure of the number of calves recruited into the population. Over the past 12 years, this ratio has exhibited a significant decline (Figure 3;  $P = 0.004$ ). If only the last 5 years of calf:cow ratio data are included in the analysis, however, the trend is not significant ( $P = 0.227$ ). A similar measure, the % calves observed on the survey displays a significant trend over 12 years ( $P = 0.015$ ) but non-significant trend over 5 years ( $P = 0.456$ ). In addition, the proportion of cows accompanied by twins has steadily declined since 2002 (Table 1,  $P = 0.009$ ).

Independent of the aerial survey, hunter success rates have steadily declined since 2001, for both either sex hunting ( $P = 0.001$ ; Figure 4) and for bulls-only hunting ( $P < 0.001$ ). Prior to 2007, moose hunters were allowed to harvest moose of either sex, but beginning in 2007, hunters were restricted to harvesting antlered bulls.

Annual non-hunting mortality of both bull and cow moose in a sample of 116 radiocollared moose in northeastern Minnesota has been substantially higher than elsewhere in North America (Lenarz et al. 2007). Over a 6-year period, annual non-hunting mortality has averaged 21%; a figure identical to that found for moose in northwestern moose (Murray et al.

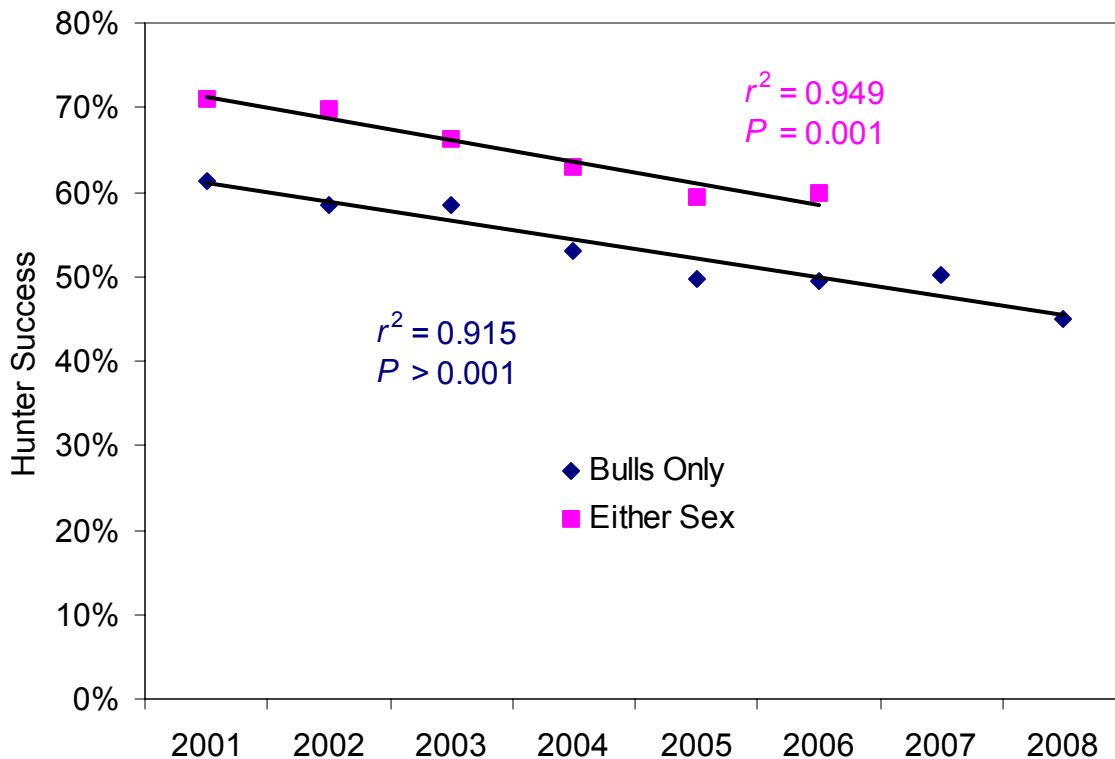
2006). Elsewhere in North America, non-hunting mortality normally falls in the 8 to 12% range (Lenarz et al. 2007). When combined with estimates of age specific fertility into a matrix population model (Caswell 2001), annual estimates of the finite rate of increase ( $\lambda$ ) ranged from 0.69 to 0.97 ( $\bar{x} = 0.85$ ). A finite rate of increase = 1 implies that the population is stable and values below 1 indicate that the population is declining. A mean  $\lambda$  of 0.85 implies that the radio collared moose population has declined an average of 15% per year in the last 6 years (Lenarz et al. in prep.). Unless the radiocollared population is not representative of the population at large, it is likely that the entire northeastern moose population has been declining.

**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.



The estimated bull:cow ratio (Table 1) was significantly lower than the mean bull:cow ratio estimated for the previous 11 years ( $\bar{x} = 1.17$ ,  $t=2.38$ ,  $P=0.039$ ). Although there was a negative trend in this statistic, the slope of the line was not significant ( $P=0.234$ ). If the estimate for 2003 (2.01) is omitted, however, the trend was significant ( $P = 0.039$ ). The departure indicated by the 2003 estimate is biologically impossible if estimates for 2002 and 2004 are accurate.

**Figure 4.** Hunter success rates in northeastern Minnesota, 2001-2008. Prior to 2007, hunters were allowed to harvest moose of either sex. Beginning in 2007, hunters were restricted to taking an antlered bull.



In the January survey, only 2% of the moose exhibited hair loss, which is indicative of infestation with the winter tick (*Dermacentor albipictus*). In 2008, 4% were observed with hair loss. Moose will often rub off patches of hair when high numbers of the tick begin to engorge. Normally, hair loss associated with winter ticks doesn't become noticeable until later in the winter.

**Acknowledgments**

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