

## 2008 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 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

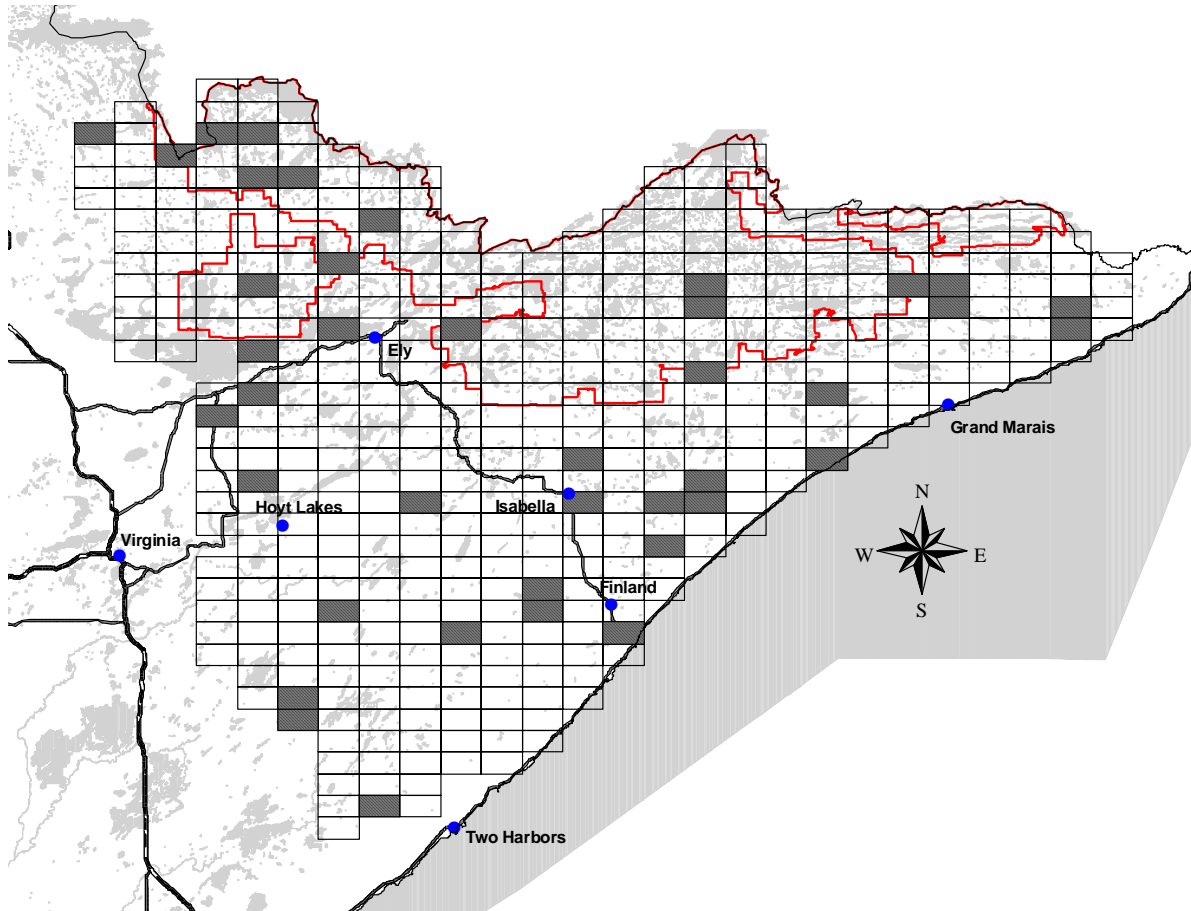
We initiated the survey on 2 January and completed it on 17 January. Observers rated survey conditions as "good" (highest rank) on 35 plots and "marginal" on 5 plots. Snow conditions for the survey were excellent and generally exceeded 16" in depth. During the survey flights, observers located 416 moose on the 40 plots (532 mi<sup>2</sup>) including 155 bulls, 192 cows, 64 calves, and 5 unidentified moose.

After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained  $7,637 \pm 2114$  animals (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.36 and 0.77, respectively (Table 1).

### Discussion

We have used the sightability model approach for 5 years to account for sightability bias in our estimates of moose numbers in northeastern Minnesota. In the first year, 3 observers equated VOC to crown closure on some observations and this resulted in significantly higher estimates of VOC (Kruskal Wallis AOV,  $F=20.3$ ,  $P<0.01$ ). 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 -2008 and as a result, population estimates were more comparable. Because of this bias, estimates for 2004 were not included in subsequent analyses.

**Figure 1.** Northeast moose survey area and sample plots (diagonal lines) flown in the 2008 aerial moose survey.



Prior to 2004, we used double sampling to calculate a sightability correction factor (SCF, Gasaway et al. 1986) to account for visibility bias. During the period 1997-2003, SCF averaged 1.35 (1.14 to 1.87). In the last 4 years, the mean theta value (a number equivalent to SCF) averaged 1.94 (1.78-2.09). The difference between estimates for SCF and theta implies that we missed a substantial proportion of the moose in the double sampling used to calculate SCF. Moreover, this difference implies that moose population estimates prior to 2004 were biased low. These inferences are corroborated by research conducted in Alaska (Gasaway et al. 1986) where they found that double sampling missed a larger proportion of moose if surveys were conducted in mid to late winter.

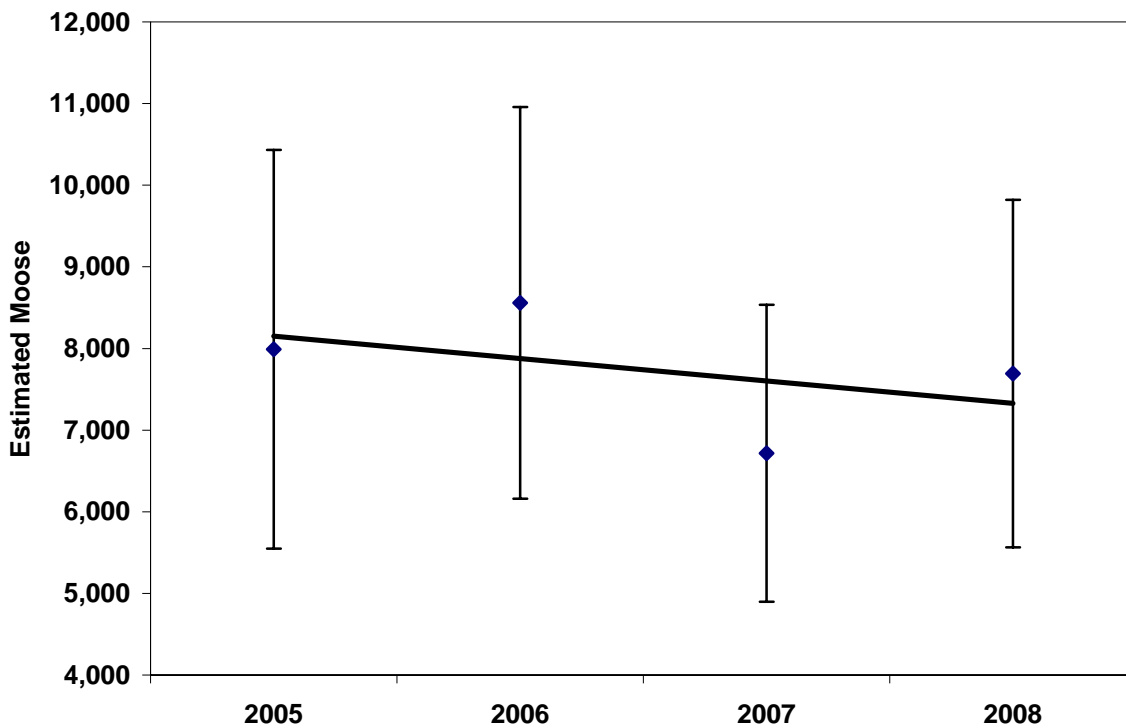
**Table 1.** Estimated moose numbers, calves:cow, bulls:cow, and percent cows with twins from aerial surveys in northeastern Minnesota.

Survey	Estimate	Calves:Cow	Bulls:Cow	% Cows w/ Twins
1998	3,464 $\pm$ 36%	0.71	0.98	0
1999	3,915 $\pm$ 35%	0.57	1.30	9
2000	3,733 $\pm$ 25%	0.70	1.34	7
2001	3,879 $\pm$ 28%	0.61	1.05	5
2002	5,214 $\pm$ 23%	0.93	1.22	20

<b>2003</b>	4,161 ±37%	0.70	2.01	11
<b>2004</b>	13,093±40%	0.42	1.24	4
<b>2005</b>	7,923±30%	0.52	1.04	9
<b>2006</b>	8,501±28%	0.34	1.09	5
<b>2007</b>	6,659±27%	0.29	0.89	3
<b>2008</b>	7,637±28%	0.36	0.77	2

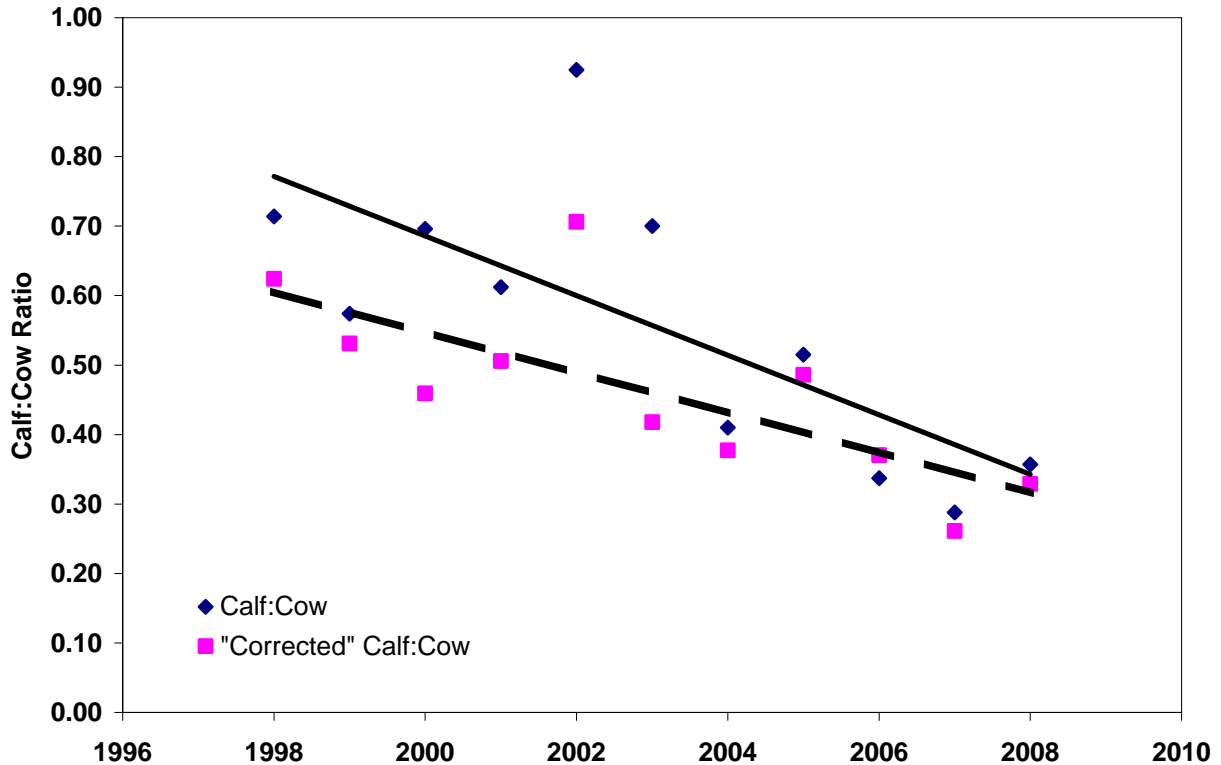
The 2008 population estimate was almost 15% higher than the 2007 estimate. The overlap in confidence intervals (Table 1, Figure 2), however, indicates that there was no statistical difference between the 2007 and 2008 point estimates. The population trend has a negative slope suggestive of a declining population. This inference is reinforced by the low calf:cow ratio (Table 1) and continued high mortality observed in research on radiocollared moose within the northeast population (Lenarz unpublished). citation.

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



The calf:cow ratio estimated from the 2008 survey (Table 1) was significantly lower than the mean estimated in the previous 10 years ( $\bar{x} = 0.58$ ,  $t=3.56$ ,  $P=0.003$ ). Although slightly higher than in 2007, the calf:cow ratio has steadily declined in recent years ( $F=9.82$ ,  $P=0.012$ ; Figure 3.). Even if the cow:calf ratio is “corrected” by assuming that half of the unclassified moose were cows, there is still a significant decline in this important parameter ( $F=10.94$ ,  $P=0.009$ ). Ratio estimates (bull:cow and calf:cow) were not adjusted for sightability and hence, can be compared with estimates prior to adoption of the sightability model.

**Figure 3.** Estimates of calf:cow ratio of moose in northeastern Minnesota. Diamonds represent estimates adjusted for sampling and squares represent estimates “corrected” by assuming that half of the unclassified moose were cows. The solid and dashed lines represent the uncorrected and corrected trends, respectively.



The proportion of cows accompanied by twins was significantly lower ( $\bar{x}=7.2\%$ ,  $t=2.96$ ,  $P=0.008$ ) in 2008. Even when 50% of unclassified moose were included as cows in the calculation of the proportion twins, the values for 2008 remained significantly lower ( $\bar{x}=5.8\%$ ,  $t=2.87$ ,  $P=0.009$ ). Twinning rates vary widely across North America, and may be related to habitat quality and the relationship between a moose population and the carrying capacity of its habitat (Gasaway et al. 1992).

The estimated bull:cow ratio (Table 1) was significantly lower than the mean bull:cow ratio estimated for the previous 10 years ( $\bar{x} = 1.22$ ,  $t=4.49$ ,  $P<0.001$ ). This is true, even when recalculated with the assumption that 50% of the unclassified moose were adult bulls ( $\bar{x} = 1.15$ ,  $t=5.74$ ,  $P<0.001$ ). Although there is a negative trend in this statistic, the slope of the line is not significant ( $P=0.077$ ). The hunter harvest has been heavily biased towards bulls in recent years (Lenarz, unpubl.), but the 2007 bull harvest (154) represented less than 6% of the estimated number of bulls in the 2007 population. This level of bull harvest is insufficient to have caused the decline in the bull:cow ratio observed between the 2007 and 2008 surveys. It has been speculated that reproduction would decline if the bull:cow ratio declines below some unspecified level (e.g. Rausch 1974). Unless the bull:cow ratio drops to very low levels, there should be sufficient numbers of bulls to breed all cows.

In the January survey, 4% of the moose exhibited hair loss, which is indicative of infestation with the winter tick (*Dermacentor albipictus*). In 2007, 11% 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**

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 Trenhom for coordinating all of the aircraft and pilots; Dan Litchfield (northeast) 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 Mike Trenholm 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, who flew as observers; it takes dedication and a strong stomach. I thank John Fieberg and John Giudice for their analyses in creating and applying the sightability model. 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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