2015 Aerial Moose Survey

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Introduction

Each year, we conduct an aerial survey in northeastern Minnesota to monitor moose (*Alces americanus*) numbers and fluctuations in the overall status of the state'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 assess the population's long-term trend and composition, set the harvest quota for the subsequent hunting season when applicable, improve our understanding of moose ecology, and otherwise contribute to sound future management strategies.

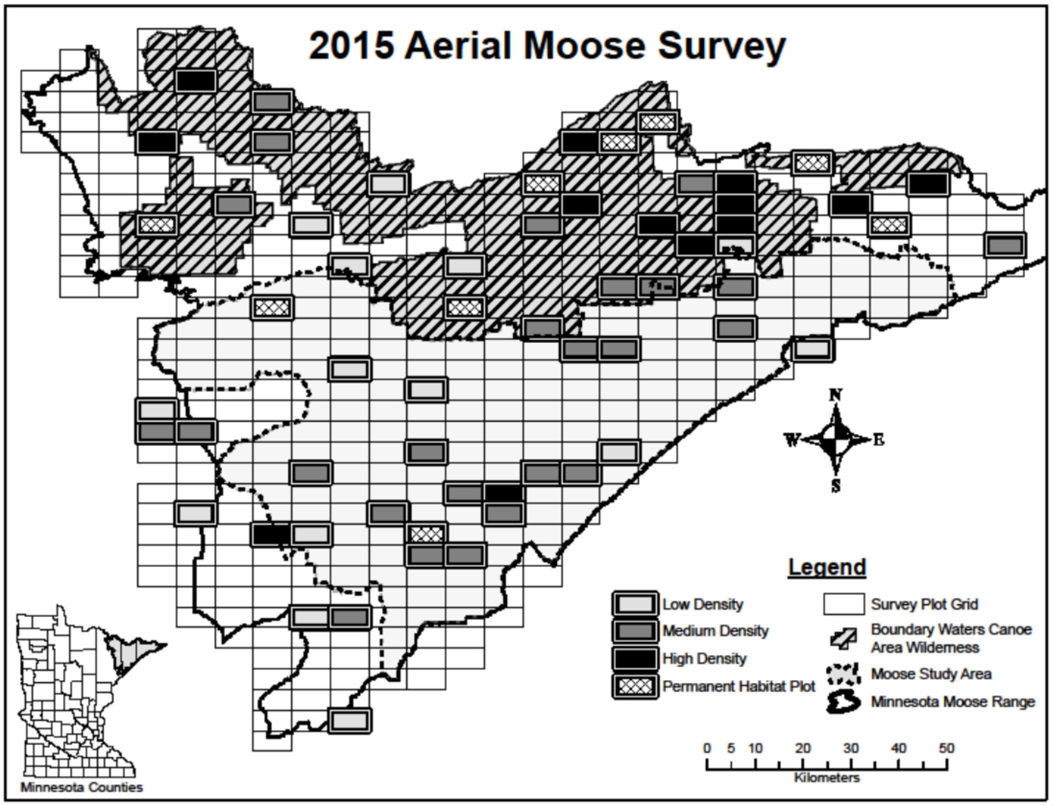
Methods

The survey area is approximately 5,985 mi^2 (Lenarz 1998, Giudice et al. 2012). We estimated moose numbers, age and sex ratios by flying transects within a stratified random sample of the 436 total survey plots (Figure 1). All survey plots are reviewed and re-stratified as low, medium, or high moose density about every 5 years based on past survey observations of moose, locations of harvested moose in past years, and extensive field experience of moose managers and researchers. The most recent re-stratification was conducted in November 2013; survey plots were classified as low, medium, or high based on whether < 2, 3-7, or $\geq$8 moose, respectively, would be expected to occur in a specific plot. Stratification is most important to optimizing precision of our survey estimates. In 2012, we added a 4th stratum represented by a series of 9 plots which have undergone disturbance by wildfire, prescribed burning, and timber harvest. Each year since, these same 9 plots are surveyed in an effort to evaluate the effect of disturbance on moose density over time.

All survey plots of the 436-plot grid (designed in 2005) are rectangular (5 x 2.67 mi.) and oriented east to west with 8 transects spaced about 0.3 miles apart. Minnesota Department of Natural Resources (MNDNR) Enforcement pilots flew the 2 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), nose coloration, bell size and shape, 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 each aircraft's flight path over this background in *real time*, and record data using a tablet pen with a menu-driven data entry form. Two of the primary strengths of this survey are the consistency and standardization of the methods since 2005 and the long-term consistency of the survey team personnel.

We accounted for visibility bias by using a sightability model (Giudice et al. 2012). This model was developed between 2004 and 2007 using moose that were radiocollared as part of a study of survival and its impact on dynamics of the population (Lenarz et al. 2009, 2010). 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 (30'-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 1 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, adjusted for sampling, to calculate the bull:cow and calf:cow ratios (i.e., using the combined ratio estimator; Cochran 1977:165).

Figure 1. Moose survey area and 52 sample plots flown in the 2015 aerial moose survey. The study area for ongoing MNDNR moose research also is shown.



Results and Discussion

The survey was conducted from 13 to 29 January 2015. It consisted of 8 actual survey days, and as in 2014, included 52 survey plots. This year, based on optimal allocation analyses, we surveyed 11 low, 22 medium, and 10 high density plots, and the 9 permanent plots (Giudice 2015). Generally, 8" of snow cover is our minimum threshold depth for conducting the survey. Snow depths were marginal on 6% of the survey plots, but 8-16" and greater than 16" on 92% and 2% of the plots, respectively. Overall, survey conditions were good for 86% and fair for 14% of the plots when surveyed. Average survey intensity was 47 minutes/plot (13.4 mi^2) and ranged from 30 to 65 minutes/plot (Giudice 2015).

This year a total of 392 moose were observed on 34 (65%) of the 52 plots surveyed (694 mi^2), not markedly dissimilar from last year (419 moose on 41 plots), and included 162 bulls, 169 cows, 56 calves, and 5 unclassified moose. This apparent occupancy of plots is lower than the 10-year average of 82%. An average of 11.5 moose were observed per "occupied" plot (range = 1-46 moose) compared to a 10-year average of 12.2 moose. Estimates of the calf:cow and bull:cow ratios were 0.29 and 0.99, respectively. This calf:cow ratio is one of the lowest since 2005 (Table 1).

After adjusting for sampling and sightability, we estimated the population in northeastern Minnesota at 3,450 (2,610–4,770, 90% confidence interval) moose (Table 1, Fig. 2). As can be noted from the 90% confidence limits associated with the population point estimates (Table 1,

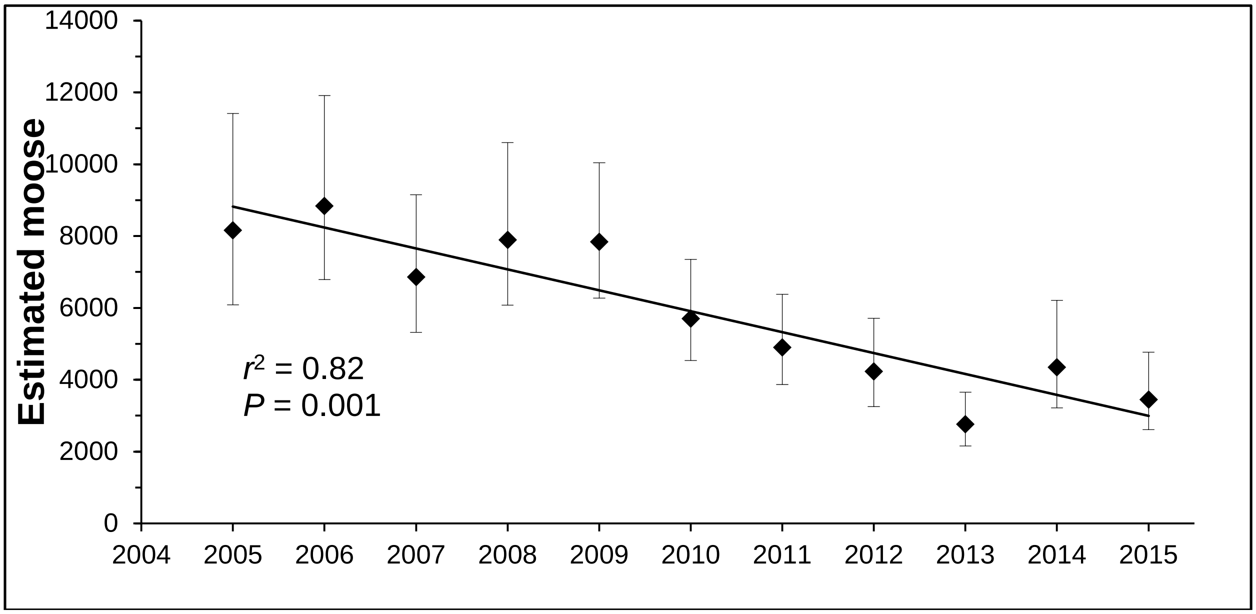
Figure 2), statistical uncertainty inherent in aerial wildlife surveys can be quite large, even when surveying large, dark, relatively conspicuous animals such as moose against a white background during winter. This is attributable to the varied (1) occurrence of dense vegetation, (2) habitat use by moose, (3) behavioral responses to aircraft, (4) effects of annual environmental conditions (e.g., snow depth) on their movements, and (5) interaction of these factors. Short-term, year-to-year statistical comparisons of population estimates are not supported by these surveys, rather they are best suited to establishing long-term trends. Past aerial survey and research results have indicated that the trend of the population in northeastern Minnesota has been declining since 2006 (Lenarz et al. 2010, DelGiudice 2013). This downward trend persists ($r^2 = 0.821$, $P = 0.001$, Figure 2), and the 2015 population estimate of 3,450 indicates a 61% decline since 2006; however, the population estimate is not statistically different from last year.

Table 1. Estimated moose numbers, 90% confidence intervals, and calf:cow ratios, percent calves in the population, percent cows with twins, and bull:cow ratios estimated from aerial surveys in northeastern Minnesota, 2005-2015.

Survey	Estimate	90% Confidence Interval	Calf: Cow	% Calves	% Cows w/ twins	Bull: Cow
2005	8,160	6,090 – 11,410	0.52	19	9	1.04
2006	8,840	6,790 – 11,910	0.34	13	5	1.09
2007	6,860	5,320 – 9,100	0.29	13	3	0.89
2008	7,890	6,080 – 10,600	0.36	17	2	0.77
2009	7,840	6,270 – 10,040	0.32	14	2	0.94
2010	5,700	4,540 – 7,350	0.28	13	3	0.83
2011	4,900	3,870 – 6,380	0.24	13	1	0.64
2012	4,230	3,250 – 5,710	0.36	15	6	1.08
2013	2,760	2,160 – 3,650	0.33	13	3	1.23
2014	4,350	3,220 – 6,210	0.44	15	3	1.24
2015	3,450	2,610 – 4,770	0.29	13	3	0.99

Based on the survey's recorded calf:cow ratio (0.29), estimated calf recruitment in spring of 2015 could be one of the lowest in several years (Table 1, Fig. 3). The calf:cow ratio in mid-January 2015 was 0.29, down markedly compared to last year's survey (0.44) and 17% below the 10- year average of 0.35. Calves were 14% of the total 392 moose actually observed and represented 13% of the estimated population (Table 1, Fig. 3). The sighting of twins with cows, 3% of the 169 cow moose observed, has not been uncommon since 2005 (Table 1). Survey results indicate calf survival to late January 2015 was low. Findings from an ongoing study of GPS-collared moose calves indicate that calf survival was low in 2013-14 and likely in 2014-15 (Severud et al. 2014). Annual recruitment of calves can have a significant influence on the population performance of moose, but it is not actually determined until the next spring's calving season when winter survey-observed calves become yearlings. At this point, little is known about survival of moose calves during the period between the annual winter survey and subsequent spring calving. It also is important to note that adult moose survival has the greatest long-term impact on annual changes in the moose population (Lenarz et al. 2010). For the past year annual mortality of adult moose has been lower (11% vs. 20%; Carstensen et al., unpublished data).

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2015. (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 13.4-mi² plots).



data) than the elevated rates (~21%, Lenarz et al. 2009, 2010) that coincided with the beginning of the population decline.

The estimated bull:cow ratio (Table 1; Figure 4) exhibits an apparent decrease compared to 2013 and 2014, but is similar to the mean of 2005-2015 (0.98). There is a great deal of annual variability associated with the bull:cow ratios, consequently, they exhibited no clear upward or downward long-term trend (2005-2015).

Acknowledgments

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training for survey observers using DNRSurvey. The efforts of all of these people contribute to survey improvements.

Figure 3. Estimated calf:cow ratios (solid diamonds, dashed trend line) and percent calves (solid squares, solid trend line) of the population from aerial moose surveys in northeastern Minnesota, 2005-2015.

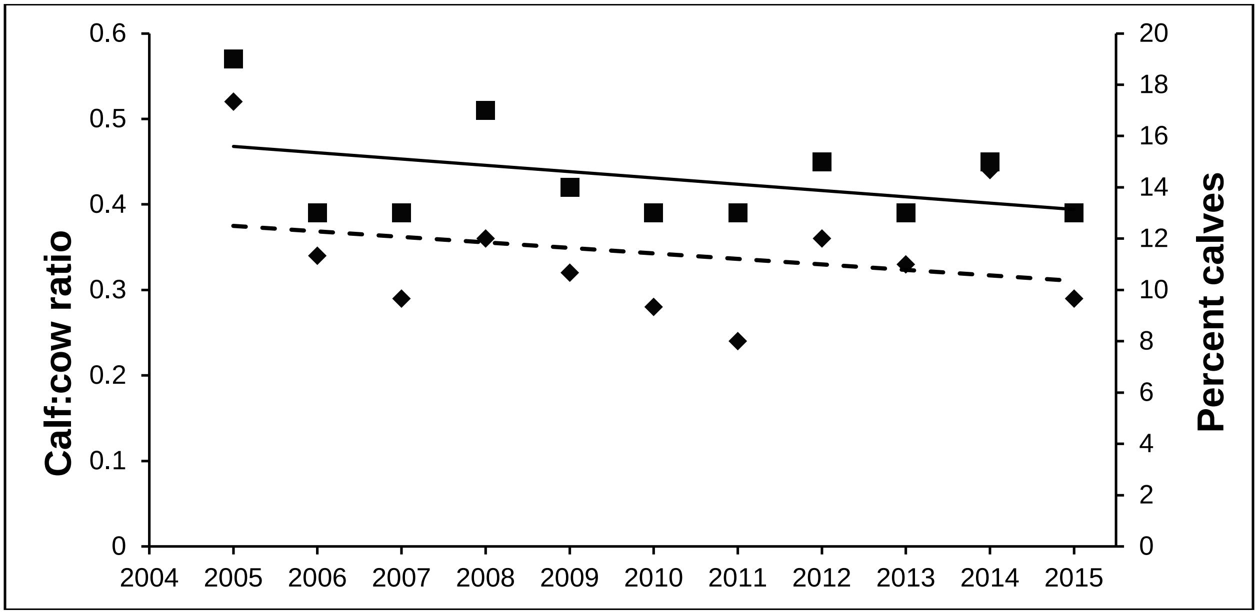
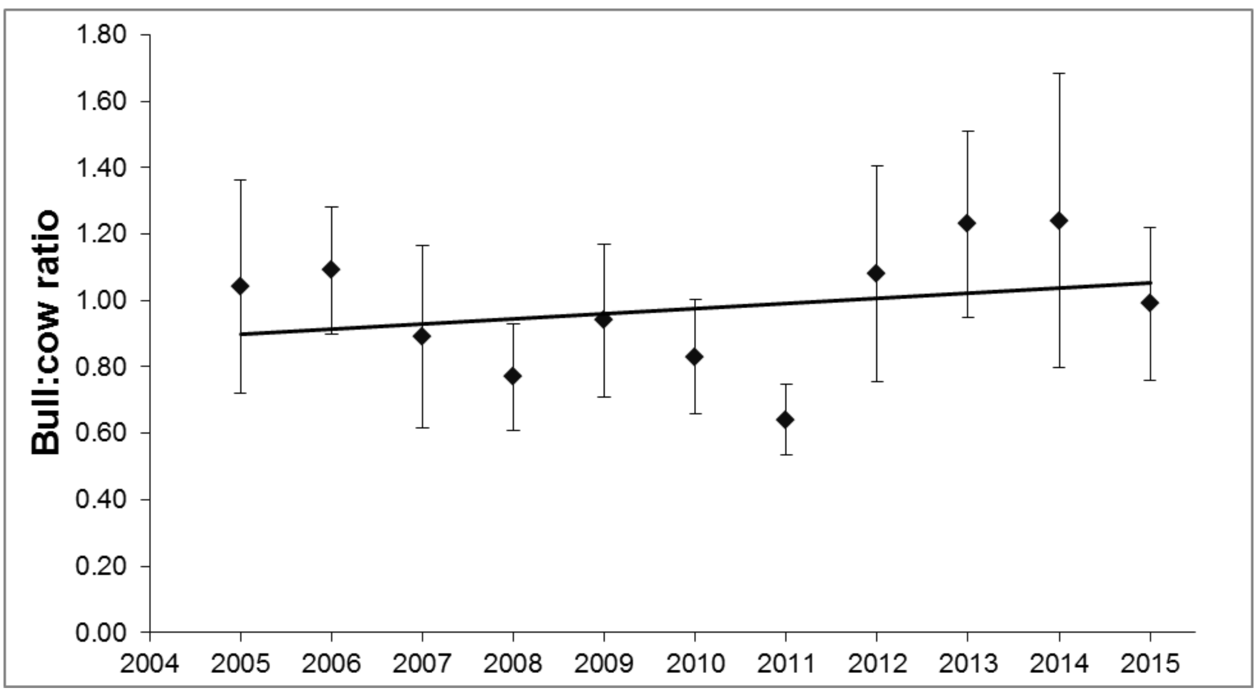


Figure 4. Estimated bull:cow ratios, 90% confidence intervals, and trend line from aerial moose surveys in northeastern Minnesota, 2005-2015.



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