MICHIGAN DEPARTMENT OF NATURAL RESOURCES
Wildlife Report No. 3615
January 2014

2013 WESTERN UPPER PENINSULA MOOSE SURVEY

Dean E. Beyer, Jr., Erin Largent, and H. William Scullon

ABSTRACT

We conducted an aerial survey to estimate moose abundance in the western Upper Peninsula of Michigan from January 2 to February 2, 2013. We observed 187 moose during the survey and estimated a population of 451 animals using a sightability correction model. The 95% confidence limits of the 2013 estimate overlap those from the 2006, 2007, 2009, and 2011 surveys indicating no statistical difference among these estimates. Fitting an exponential growth model to survey data from 2009-2013 suggests the population grew, on average, about 2% per year. Given the slow population growth and the Moose Hunting Advisory Council's recommendation to only allow hunting if the population maintains a growth rate of ≥ 3%, we do not recommend implementing a harvest at this time. Recommendations for future surveys include continuing the strategy of surveying all high-density plots, periodic assessment of plot stratum assignments, and mandatory training of observers.

A contribution of Federal Aid in Wildlife Restoration, Michigan Project W-147-R

INTRODUCTION

Moose (*Alces alces*) are native to Michigan and occurred throughout all but the southwestern part of the Lower Peninsula prior to European settlement (Verme 1984, Baker 1983). The Lower Peninsula is at the southern edge of moose range in North America and moose probably were never abundant in this region of the state (Dodge 2002). The influx of settlers resulted in increased hunting pressure and habitat changes, which caused moose numbers to decline. By the early 1880s, these factors resulted in extirpation of moose from the Lower Peninsula and declining numbers in the Upper Peninsula (Wood and Dice 1923). The state granted moose full legal protection in 1889 but the protection did not lead to long-term recovery.

The historical record is not clear on whether settlers extirpated moose from the Upper Peninsula. It is possible that a small remnant population persisted in the Upper Peninsula, although moose could have died out and then reestablished through immigration from Ontario (Dodge 2002). The State attempted to reintroduce moose to the Upper Peninsula in the mid-1930s by releasing 63 moose from Isle Royale in various parts of the Upper Peninsula. Initially, moose numbers appeared to be increasing based on the number and distribution of sighting records. However, by the mid-1940s, the population had again declined and wildlife managers judged the reintroduction a failure.

In 1985, the Michigan Department of Natural Resources (DNR) released 29 moose originating from Algonquin Provincial Park, Ontario, Canada into the north central Upper Peninsula in an attempt to reestablish a herd. Two years later, the DNR released 30 additional animals from Algonquin in the same general area. The goal of these reintroductions was to produce a self-sustaining population of free-ranging moose. The DNR hoped that the population would reach 1,000 animals by the year 2000; however, the population did not reach that objective.

Monitoring moose abundance is important for assessment of the population's status. In addition, any consideration for a hunting season requires reliable abundance estimates collected over multiple years. Moose are on the list of Michigan game species and Public Act 366 of 2010 authorized the Natural Resources Commission (NRC) to establish the first moose hunting season since the late 1800s if it so chooses. Public Act 366 also created the Moose Hunting Advisory Council (MHAC) to make recommendations to the NRC on expanding moose hunting, evaluate the economics of moose hunting, and propose season dates and quotas. Population trend data were critical to MHAC's deliberations and they presented their recommendations in September, 2011 (http://www.michigan.gov/documents/dnr/Moose_Council_Final_Report_Sept_2011_363489_7.pdf). MHAC believed that a moose hunt was conceptually viable; however, the council recommended that management priority should be the continued growth of the population. Specifically, MHAC suggested the DNR manage for a long-term annual growth rate of $\geq$ 3%. Members of MHAC wanted to "assure that moose hunting would occur only if hunting did not reduce the continued presence and expansion of the Michigan moose herd." Given the prominence of the MHAC in the legislation establishing the authority to initiate a hunting season and the importance of public support for conservation and management of moose, the Council's recommendations warrant close consideration.

The DNR's current strategy is to estimate moose abundance every other year using a fixed-wing aircraft survey in conjunction with a sightability model to correct the counts for animals that survey observers miss. This report summarizes the results of a moose population survey conducted in January and February 2013 in the western Upper Peninsula.

SURVEY AREA

The 1985 and 1987 moose reintroductions occurred in western Marquette County (Fig. 1). Since their release, the moose population in the western Upper Peninsula has expanded in number and distribution and now range over approximately 3,550 km^2 (~1,370 mi^2) in portions of Marquette, Baraga, and Iron counties. We based our knowledge of the distribution or range of moose in the western Upper Peninsula on the movements of radio-collared animals, as well as air and ground reconnaissance and aerial survey work.

Moose occur within two physiographic regions of the western Upper Peninsula. The north and northeastern portion of the range falls within the Michigamme Highlands (Subsection IX.2) and the south and southwestern portion occurs within the Upper Wisconsin/Michigan Moraines (Subsection IX.3; Albert 1995). Granite bedrock at or near the ground surface with many lakes and swamps in the glacially formed depressions in the bedrock characterizes the Michigamme Highlands subsection. End and ground moraines and several types of wetlands characterize the Upper Wisconsin/Michigan Moraines subsection.

Upland areas supporting northern hardwoods forests occur throughout the moose range. White pine (*Pinus strobus*), red pine (*Pinus resinosa*), and trembling aspen (*Populus tremuloides*) are found on rocky ridges. Balsam fir (*Abies balsamea*), black ash (*Fraxinus nigra*), eastern hemlock (*Tsuga canadensis*), northern white cedar (*Thuja occidentalis*), red maple (*Acer rubrum*), trembling aspen, white spruce (*Picea glauca*), and yellow birch (*Betula alleghaniensis*) are found on moderately to poorly drained sites and may occur in pure or mixed stands. Wetlands such as bogs, hardwood or conifer swamps and speckled alder (*Alnus incana*) occur in areas where the bedrock is near the surface. Willow (*Salix spp.*), an important food for moose, only occurs in scattered patches.

The climate of the area is continental with seasonally variable temperatures. Winter temperatures in the moose range are often 9–12 ºC (16–22 ºF) colder than temperatures near Lake Superior. From 1951–1980, the mean daily low temperature in January measured at Champion, which is located on the east side of the moose range, was -17.5 ºC (0 ºF). The mean daily maximum temperature was -6.0 ºC (21 ºF). Also, for the same time period and location, the mean daily minimum and maximum temperatures in July were 10.0 ºC (50 ºF) and 25.8 ºC (78 ºF), respectively. Mean annual snowfall was 350 cm (138 in) and mean annual rainfall was 85 cm (33 in) (Berndt 1988).

METHODS

The density of moose varies across the moose range, with the core range (~1,743 km^2; 673 mi^2) having about 19 moose/100 km^2 (49 moose/100 mi^2) in 2007. Surrounding this core area is a peripheral area (1,805 km^2; 697 mi^2) of relatively low moose density (~1 moose/100 km^2 in 2007

[3 moose/100 mi^2]; Figure 1). Using past survey results and field reconnaissance, we allocated portions of the moose range into high and low moose density strata.

We divided the high and low-density strata into 29 high-density and 28 low-density survey plots. For the 2013 survey, we changed 2 plots from the high-density stratum to the low-density stratum based on previous survey results and pre-survey flights that indicated decreased moose abundance in these areas. The survey plots were rectangular and typically 3.2 km wide and 19.3 km long (2 miles wide and 12 miles long), although a few plots were larger or smaller. Seventy-nine percent of survey plots were oriented North-South. Survey transects were established for each plot using Global Positioning System (GPS) coordinates. Transects were spaced every 0.4 km (0.25 miles) to allow the entire survey plot to be searched. A pilot and 2 observers conducted the surveys using Cessna 182 aircraft with the wheel covers removed. The pilot did not attempt to spot moose. Observers collected data from the back seat of the plane to mimic the setup used during development of the sightability model. Transects were flown at speeds of 80 to 90 knots (92 to 104 mph) and an altitude of about 152 m (500 ft).

We conducted all survey flights in January 2013 and the first two days in February 2013. Surveys were not conducted when wind speed exceeded 24 km/hr or during periods of heavy snowfall. We conducted all flights between 0900–1600 hours to take advantage of good light conditions and minimize shadow effects. We only conducted flights when pilots deemed conditions safe.

Weather conditions, including percent cloud cover, presence or absence of precipitation, temperature, wind speed, and wind direction as well as snow age and snow cover on the ground and on conifers were recorded when each plot was surveyed. We recorded light conditions, including type (bright or flat) and intensity (high, medium, and low) for each plot. Because light conditions often change throughout a survey, we recorded the conditions observed throughout the majority of the survey. We reviewed these data to ensure that we conducted each survey under suitable conditions.

For each moose or group of moose observed, we determined their activity (bedded, standing, or running; activity of the most active moose was recorded), an ocular estimate of visual obstruction (to the nearest 5%) in a 10 m radius surrounding the first moose spotted, and number of moose in the group.

We also attempted to classify the sex and age class (adult or calf) of each moose observed. Bulls with antlers were assigned to one of three antler classes; cervicorn (class 1), palmated-small (class 2), or palmated-large (class 3; Oswald 1982). We recorded a GPS location for each moose group observed. We checked these locations after each flight to ensure that each moose group observed was located within the surveyed plot. Each observer collected independent estimates of vegetative cover and light conditions.

Because moose density is relatively low, we surveyed a high proportion of the range to reduce variance surrounding the population estimate. We planned to survey all 29 of the high-density plots and 15 of the 28 low-density plots. We surveyed plots near the center of the high-density stratum first, and then we proceeded outward towards both sides of the high-density stratum. We surveyed low-density plots after the high-density plots were completed.

Abundance estimates for each stratum were determined by correcting the aerial counts with a sightability model. A sightability model is a logistic regression model used to adjust counts of animals directly observed to account for the probability of detection (Steinhorst and Samuel 1989). We then summed stratum estimates to estimate total population size. The sightability model contained covariates believed to influence the probability of observers sighting a moose group. We developed the sightability model specifically for the western Upper Peninsula moose population (T. D. Drummer, unpublished data) as follows:

$$\text{logit(Detection)} = 0.64 - 1.26*\text{Visual Obstruction} + 0.5*\text{Group Size}$$

The sightability model has two covariates: group size and visual obstruction. We averaged the estimates of visual obstruction for each moose group made independently by each observer and classified the result into one of three levels (< 33%, 34-66%, and > 66%).

Results and Discussion

We conducted the 2013 western Upper Peninsula moose survey from January 2 through February 2. We surveyed all 29 plots in the high-density stratum and a random selection of 14 of 28 plots in the low-density stratum. We completed the survey in 9 days of flying, similar previous surveys (Table 1). Initially survey conditions were good, but warm weather eliminated the necessary snow cover requiring a suspension of flights for 11 days. Once snow cover conditions improved, we canceled flights on 10.5 days due to weather conditions unsuitable for flying. We re-surveyed 4 plots after we discovered that a survey crew was incorrectly assessing visual obstruction. These logistical challenges necessitated a higher-than-normal survey effort on weekends (Table 1). The number of observers increased again this year, and we used staff from other Divisions as spotters on a number of flights. Table 1 shows a detailed accounting of survey effort.

We observed 187 moose on the survey plots, down from the 219 animals observed in 2011 (Table 1, Fig. 2), although we did survey 3 fewer plots in 2013. Using the sightability model, we estimate a population of 451 moose with a mean percent error of ± 24%. The 95% confidence limits of the 2013 estimate overlap those from the 2006, 2007, 2009 and 2011 surveys indicating no statistical difference among these estimates (Fig. 2). The estimate for the high-density stratum continues to have reasonable precision (i.e., ± 21%; Table 1). The estimate of the number of moose in the low-density stratum remained low, as did the precision of this estimate.

The overall population estimate increased slightly. The estimate for the low-density stratum increased, while the estimate for the high-density stratum declined (Table 1).

Fitting an exponential growth model to the estimates from 2009-2013 suggests the moose population is growing at an annual rate of about 2% (P = 0.0002; Fig. 3). Collectively, the survey results suggest that the 10% growth estimated from 1997 to 2007 has slowed to about 2%

from 2009 to 2013. The southwestern (Tracy Creek area) and northeastern (Silver Lake Basin area) parts of the high-density stratum continue to support the greatest numbers of moose.

Based on the moose observed, we estimate there were 57 calves/100 cows. This ratio is similar to the 2011 survey, however; the twinning rate decreased from 23% in 2011 to 12% in 2013. The twinning rate is still within the range observed with radio-collared cows from 1999-2005. The percent calves in the population, perhaps a less biased metric than the calf:cow ratio, was also similar to the previous surveys (Table 1) and has averaged 21% over the last 5 surveys. The estimate of the bull:cow ratio was 89 bulls/100 cows and was consistent with our understanding of adult moose survival rates.

The sightability correction model consists of two components: group size and visual obstruction. In 2013, the average group size was 1.9, the smallest observed since 2006 (1.9 in 2006, 3.7 in 2007, 2.3 in 2009, and 2.2 in 2011). The distribution of moose observations assigned to the three visual obstruction classes was similar to the 2006, 2007, and 2011 surveys (Fig. 4).

Although post-survey stratification is not an appropriate technique to produce an estimate, it does provide a means to evaluate the effect of an outlier count within a given strata. Of the 14 low-density plots surveyed, we counted 10 moose on 1 plot (plot 45) and a combined total of 11 moose on the remaining 13 plots. If we had classified plot 45 as high density, the low-density estimate would drop by 40 animals and the overall estimate would decline to 432 animals. This post-hoc analysis demonstrates the importance of carefully considering pre-survey stratification designations.

RECOMMENDATIONS

1. Given the slow population growth and the Moose Hunting Advisory Council's recommendation to maintain a growth rate of $\geq$ 3%, we do not recommend implementing a harvest at this time.
2. Biologists should continue to conduct pre-survey flights to assess the need to revise the plot stratum assignments.
3. Future surveys should continue to cover all high-density plots even if the number of plots in this stratum increases.
4. Increasing the sample size of low-density plots flown may improve the precision of the estimate.
5. Attendance at the pre-survey training session should continue to be required of all observers.
6. Observers should participate in pre-survey flights to become familiar with the proper sight picture for moose and method for estimating visual obstruction. These pre-survey flights should pair experienced observers with less experienced observers to attempt to standardize visual obstruction estimation.

Literature Cited

Albert, D. A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: a working map and classification. General Technical Report. NC-178. St. Paul, Minnesota: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 250 pp.

Berndt, L. W. 1988. Soil survey of Baraga county area, Michigan. United States Department of Agriculture, Soil Conservation Service. 306 pp.

Baker, R. H. 1983. Michigan mammals. Michigan State University Press. East Lansing, Michigan. 642 pp.

Dodge, Jr., W. B. 2002. Population dynamics of moose in the western Upper Peninsula of Michigan, 1999-2001. Thesis, Michigan State University, East Lansing, USA.

Oswald, K. 1982. A manual for aerial observers of moose. Ontario Ministry of Natural Resources report. 103 pp.

Steinhorst, R.K. and M.D. Samuel. 1989. Sightability adjustment methods for aerial surveys of wildlife populations. Biometrics 45:415–425.

Verme, L. J. 1984. Some background on moose in Upper Michigan. Michigan Department of Natural Resources, Wildlife Division Report 2973, Lansing, Michigan. 6 pp.

Wood, N. A., and L. R. Dice. 1923. Records of the distribution of Michigan mammals. Michigan Academy of Science, Arts and Letters 3:425–469.

Table 1. Survey effort and results of the 2006, 2007, 2009, 2001, and 2013 Western Upper Peninsula moose surveys.

Variable	2006	2007	2009	2011	2013
Survey Effort					
Number of days scheduled	28	28	25	27	32
Number of days flown	11	11	9	11	9
Number of flights scheduled	59	63	47	60	90
Number of flights completed	21	22	18	22	29
Number of high density plots completed	28	28	28	31	29
Number of low density plots completed	10	10	10	15	14
Total plots completed	38	38	38	46	43
Plots completed on weekends	19	7	9	14	21
Plots/flight	1.8	1.7	2.1	2.1	1.6*
Number of pilots	4	3	3	3	4
Number of observers	7	9	12	16	23
Days cancelled due to weather	17	6	13	12	10.5
Days cancelled due to survey conditions	0	11	0	4	11
Survey Results					
Bulls					
Number of class 1 bulls			13	29	20
Number of class 2 bulls			19	29	9
Number of class 3 bulls			16	19	6
Number of unknown class bulls			13	17	31
Number of cows			64	77	74
Number of calves			41	43	42
Number of cows of unknown age			4	0	2
Number of moose of unknown sex and age			5	5	3
Total number of moose observed	133	155	175	219	187
Population estimate	347	356	420	433	451
95% confidence limits	238–456	258–454	259–581	322–544	345–557
Percent error	31	28	38	26	24
Calves/100 cows			64	56	57
Twinning rate (%)			16	23	12
Percent calves	21	20	23	20	22
Bulls/100 cows			95	122	89
Survey Results by Stratum					
High density population estimate	305	332	339	378	353
High density 95% confidence limits	227–383	249–415	269–409	316–442	279–427
High density percent error	26	25	21	17	21
High density percent of total population	88	93	81	87	78
Low density population estimate	42	24	81	55	98
Low density 95% confidence limits	0–103	0–63	0–172	8–102	22–174
Low density percent error	145	163	112	85	78
Low density percent of total population	12	7	19	13	22

*(includes 4 plots re-surveyed)

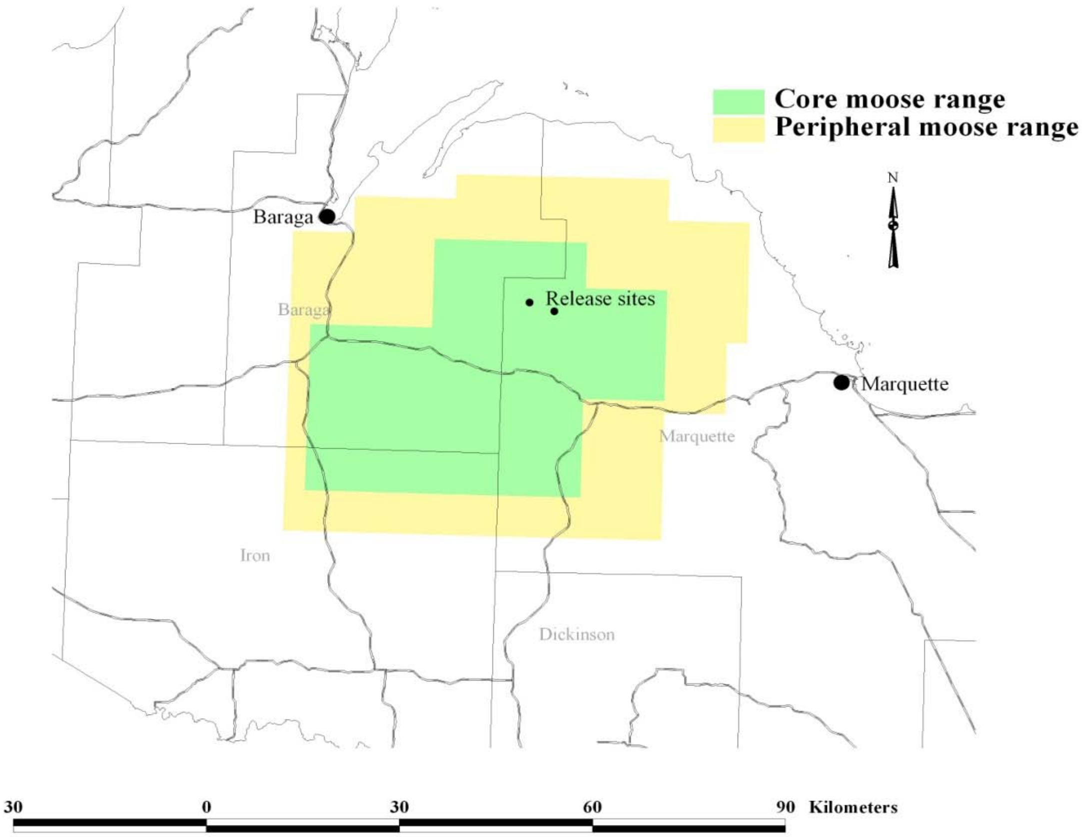

Figure 1. Core (high-density) and peripheral (low-density) moose range in the western Upper Peninsula of Michigan.

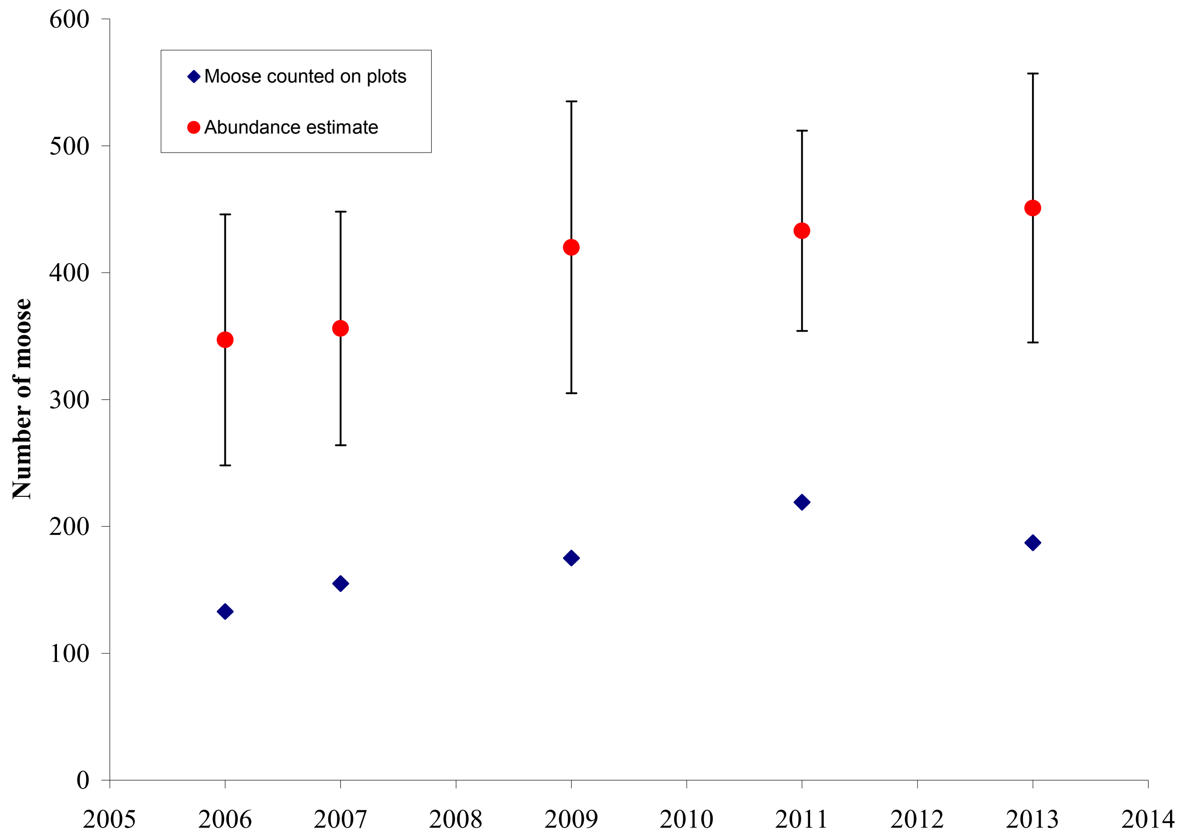

Figure 2. Number of moose counted on survey plots and abundance estimates based on aerial survey counts corrected for visibility bias with a sightability model for the Western Upper Peninsula of Michigan during 2006, 2007, 2009, 2011 and 2013. The number of plots surveyed was the same in 2006–2009 (n=28 high-density and 10 low-density). In 2011, 3 plots were added to the high-density stratum (n=31; all surveyed) and 15 of 26 low-density plots were surveyed. In 2013, 2 high-density plots were switched to the low-density stratum (n=29; all surveyed) and 14 of the 28 low-density plots were surveyed. The error bars on the abundance estimates represent the 95% confidence intervals.

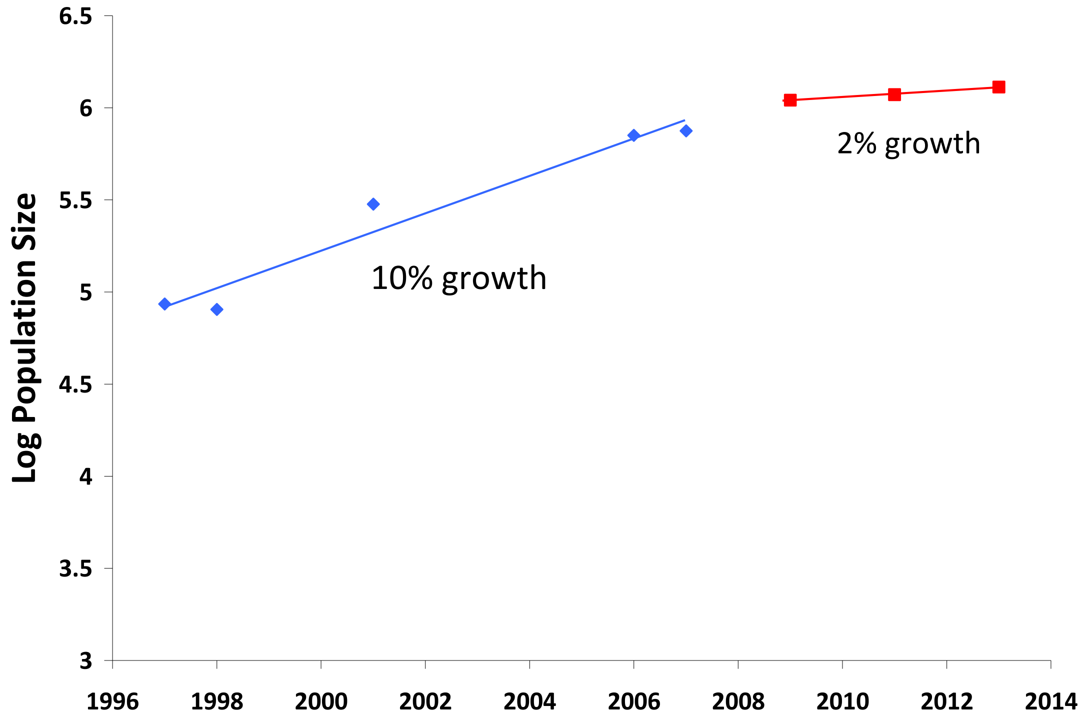

Figure 3. Exponential growth models (logarithmic form) fitted to moose abundance estimates (aerial counts corrected for visibility bias) from the Western Upper Peninsula of Michigan, 1997–2007 and 2009–2013.

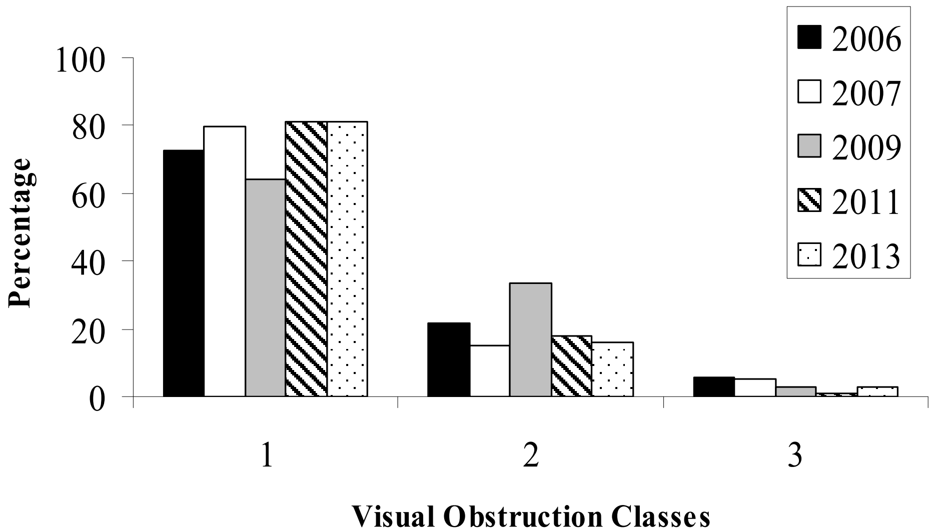

Figure 4. Percentage of moose observations in three visual obstruction classes (class 1 = 0–33%; class 2 = 34–66%; and class 3= 67–100%) during surveys conducted in the Western Upper Peninsula of Michigan in 2006, 2007, 2009, 2011, and 2013.