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# 2015 WESTERN UPPER PENINSULA MOOSE SURVEY

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## ABSTRACT

*From January 2 to January 30, 2015, we conducted an aerial survey to estimate moose abundance in the western Upper Peninsula of Michigan. We observed 187 moose during the survey and estimated a population of 323 animals using a sightability correction model. The 2015 estimate declined about 28% from the estimate in 2013. However, the confidence limits of the two estimates overlap, so we cannot say with statistical confidence that the population decreased. We did observe a decline in the proportion of calves in the population, suggesting a population decline may have occurred. Given the potential decline and the Moose Hunting Advisory Council's recommendation to only allow hunting if a growth rate of ≥ 3% is maintained, 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.*

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## 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 2015 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). In addition, for the same 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 (~1,782 km$^2$; 688 mi$^2$) having about 20 moose/100 km$^2$ (52 moose/100 mi$^2$) in 2013. Surrounding this core area is a peripheral area (1,896 km$^2$; 732 mi$^2$) of relatively low moose density (~5 moose/100 km$^2$ in 2013

[14 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. 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 2015. 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 2015 western Upper Peninsula moose survey from January 2 through January 30. 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 12 days of flying, similar to previous surveys (Table 1). Survey conditions remained good throughout the survey period, however; we cancelled flights on 16 days, primarily due to high winds. The number of observers increased again this year with a number of new wildlife employees that we trained as observers. As in previous years, we used staff from other Divisions as spotters on a number of flights. However, we made an effort to use experienced observers and crew leaders on every flight. Table 1 shows a detailed accounting of survey effort.

We observed 187 moose on the survey plots, the same number observed in 2013 (Table 1, Fig. 2). Using the sightability model, we estimate a population of 323 moose with a mean percent error of ± 19%. The 95% confidence limits of the 2015 estimate overlap those from the 2006, 2007, 2009, 2011 and 2013 surveys indicating no statistical difference among these estimates (Fig. 2). The estimate for the high-density stratum continues to have reasonable precision (i.e., ± 14%; 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 suggests a 28% decline from the 2013 survey; however, due to the overlapping confidence limits we cannot say with statistical confidence that the population decreased. The estimate decreased for both the low-density and high-density strata (Table 1).

Collectively, survey results suggest that the 10% growth estimated from 1997 to 2007 slowed to about 2% from 2009 to 2013 with a potential decline in 2015 (Fig. 3); however, future surveys are necessary to confirm a decline. We observed fewer moose in the southwestern (Tracy Creek area) part of the high-density stratum, which had previously supported the greatest number of moose.

The best evidence supporting an actual population decline comes from our estimates of the calf:cow ratio and the percent calves in the population. Based on the moose observed, we estimate there were 42 calves/100 cows. This ratio is down from the 2013 survey of 57 calves/100 cows and from the 2009, 2011, and 2013-survey average of 59 calves/100 cows. The

2009-2013 ratio estimates were consistent with our estimates of reproduction (0.7 calves/cow) and calf survival (~80% annual) from our intensive radio-collared based study of the population from 1999-2005. The percent calves in the population, perhaps a less biased metric than the calf:cow ratio, was 17%, also down from the 2013 survey (Table 1) and the 21% average from the previous 5 surveys. Possible explanations for a decline in the abundance of calves include: (1) potential effects of back-to-back severe winters on moose condition, reproductive success, and/or calf survival; (2) possible increase in wolf predation resulting from a reduced deer herd following two severe winters; and (3) potential effects of climate change on moose condition, reproductive success, and/or survival.

The observed twinning rate of 11% was similar to 2013 (12%) and was still within the range documented with radio-collared cows from 1999-2005. The estimate of the bull:cow ratio was 101 bulls/100 cows.

The sightability correction model consists of two components: group size and visual obstruction. In 2015, the average group size was 2.3, similar to the average group size observed in 2009 (2.3) and 2011(2.2). The smallest average group size (1.9) was observed in 2006 and 2013, and the largest average group size occurred in 2007 (3.7). The 2015 survey had the highest percentage of moose observed in visual obstruction class 1 and the lowest percentage of moose observed in visual obstruction class 2 when compared to the past 5 surveys. We did not observe any moose in visual obstruction class 3 during the 2015 survey (Fig. 4).

Although we cannot say with statistical confidence that the moose population did in fact decline, the lesser point estimate paired with fewer calves per cow suggests a strong possibility of an actual decline. Future surveys are necessary to determine if the lesser estimate is the beginning of a downward trend.

## RECOMMENDATIONS

1. Given the potential for a decline in the population 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. Pre-survey flights should commence as soon as snow conditions are favorable.

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Table 1. Survey effort and results of the 2006, 2007, 2009, 2011and 2013 Western Upper Peninsula moose surveys.

| Variable | 2006 | 2007 | 2009 | 2011 | 2013 | 2015 |
|---|---|---|---|---|---|---|
| Survey Effort | | | | | | |
| Number of days scheduled | 28 | 28 | 25 | 27 | 32 | 29 |
| Number of days flown | 11 | 11 | 9 | 11 | 11 | 12 |
| Number of flights scheduled | 59 | 63 | 47 | 60 | 90 | 78 |
| Number of flights completed | 21 | 22 | 18 | 22 | 29* | 23 |
| Number of high density plots completed | 28 | 28 | 28 | 31 | 29 | 29 |
| Number of low density plots completed | 10 | 10 | 10 | 15 | 14 | 14 |
| Total plots completed | 38 | 38 | 38 | 46 | 43 | 43 |
| Plots completed on weekends | 19 | 7 | 9 | 14 | 21 | 14 |
| Plots/flight | 1.8 | 1.7 | 2.1 | 2.1 | 1.5 | 1.9 |
| Number of pilots | 4 | 3 | 3 | 3 | 4 | 4 |
| Number of observers | 7 | 9 | 12 | 9 | 17 | 19 |
| Days cancelled due to weather | 17 | 6 | 13 | 12 | 10.5 | 16 |
| Days cancelled due to survey conditions | 0 | 11 | 0 | 4 | 11 | 0 |
| | | | | | | |
| Survey Results | | | | | | |
| Bulls | | | | | | |
| Number of class 1 bulls | | | 13 | 29 | 20 | 30 |
| Number of class 2 bulls | | | 19 | 29 | 9 | 10 |
| Number of class 3 bulls | | | 16 | 19 | 6 | 5 |
| Number of unknown class bulls | | | 13 | 17 | 31 | 30 |
| Number of cows | | | 64 | 77 | 74 | 74 |
| Number of calves | | | 41 | 43 | 42 | 31 |
| Number of cows of unknown age | | | 4 | 0 | 2 | 0 |
| Number of moose of unknown sex and age | | | 5 | 5 | 3 | 7 |
| | | | | | | |
| Total number of moose observed | 133 | 155 | 175 | 219 | 187 | 187 |
| | | | | | | |
| Population estimate | 347 | 356 | 420 | 433 | 451 | 323 |
| 95% confidence limits | 248–446 | 264–447 | 305–535 | 354–513 | 345–557 | 263–383 |
| Percent error | 29 | 26 | 27 | 18 | 24 | 19 |
| | | | | | | |
| Calves/100 cows | | | 64 | 56 | 57 | 42 |
| Twinning rate (%) | | | 16 | 23 | 12 | 11 |
| Percent calves | 21 | 20 | 23 | 20 | 22 | 17 |
| | | | | | | |
| Bulls/100 cows | | | 95 | 122 | 89 | 101 |
| | | | | | | |
| Survey Results by Stratum | | | | | | |
| High density population estimate | 305 | 332 | 339 | 378 | 353 | 285 |
| High density 95% confidence limits | 227–383 | 249–415 | 269–409 | 316–442 | 279–427 | 244–326 |
| High density percent error | 26 | 25 | 21 | 17 | 21 | 14 |
| High density percent of total population | 88 | 93 | 81 | 87 | 78 | 88 |
| | | | | | | |
| Low density population estimate | 42 | 24 | 81 | 55 | 98 | 38 |
| Low density 95% confidence limits | 0–103 | 0–63 | 0–172 | 8–102 | 22–174 | 0–81 |
| Low density percent error | 145 | 162 | 112 | 85 | 78 | 113 |
| Low density percent of total population | 12 | 7 | 19 | 13 | 22 | 12 |

*(including 4 plots re-surveyed)

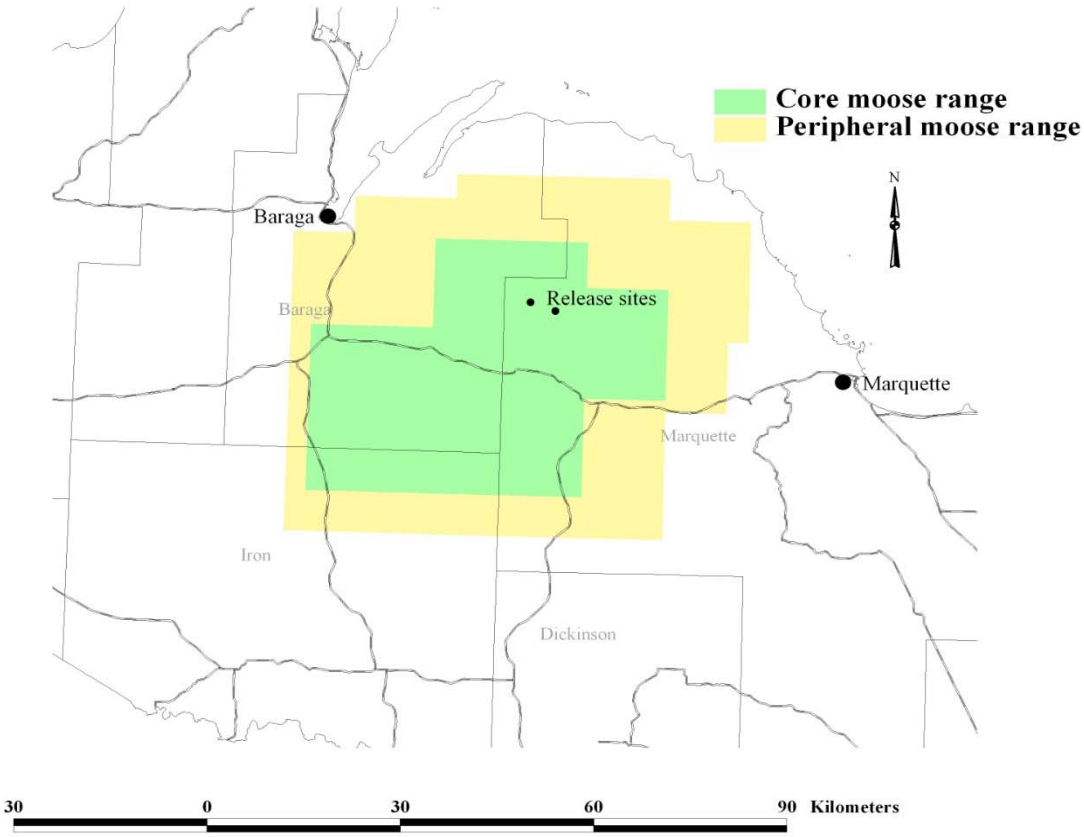


Figure 1. Core (high-density) and peripheral (low-density) moose range in the western Upper Peninsula of Michigan.

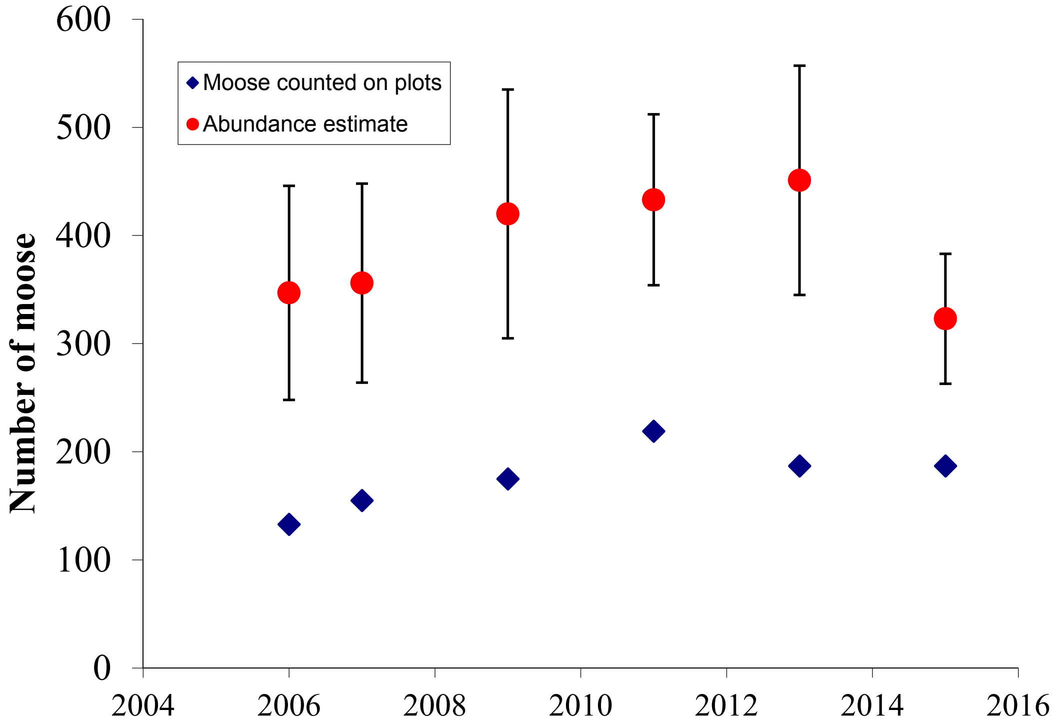


Figure 2. Number of moose counted on survey plots and abundance estimates based on aerial survey counts corrected for visibility bias with a sightability model for the Western Upper Peninsula of Michigan during 2006, 2007, 2009, 2011, 2013 and 2015. The number of plots surveyed was the same in 2006-2009 (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. In 2015, we surveyed all 29 high-density plots and 14 of the 28 low-density plots. The error bars on the abundance estimates represent the 95% confidence intervals.

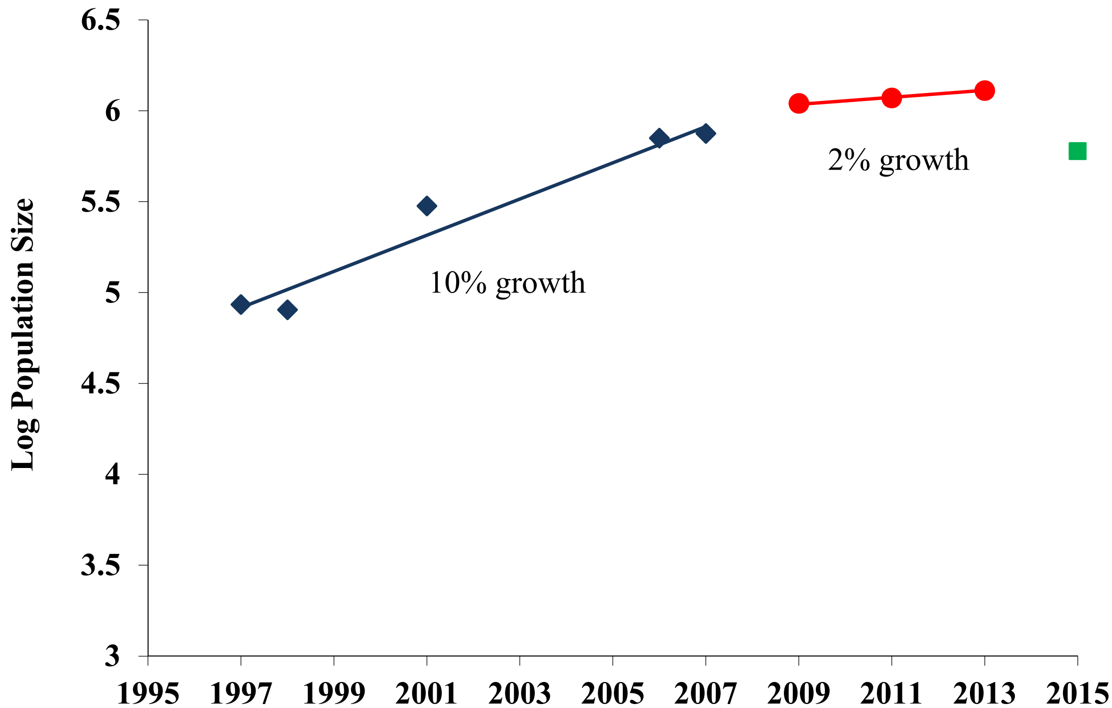


Figure 3. Exponential growth models (logarithmic form) fitted to moose abundance estimates (aerial counts corrected for visibility bias) from the Western Upper Peninsula of Michigan, 1997–2007, 2009–2013 and 2015.

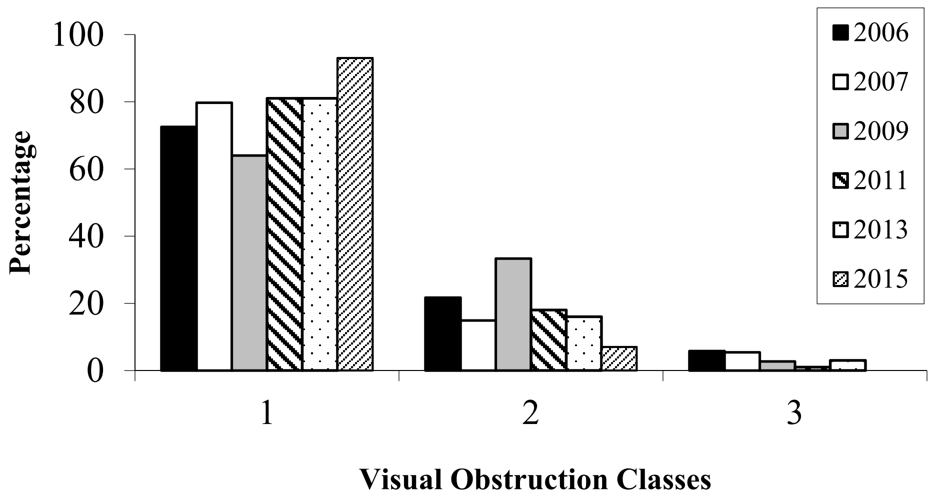


Figure 4. Percentage of moose observations in three visual obstruction classes (class 1 = 0–33%; class 2 = 34–66%; and class 3= 67–100%) during surveys conducted in the Western Upper Peninsula of Michigan in 2006, 2007, 2009, 2011, 2013 and 2015.