

**FOREST WILDLIFE POPULATIONS**

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# GROUSE SURVEYS IN MINNESOTA DURING SPRING 2012

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## SUMMARY OF FINDINGS

Surveys for ruffed grouse (*Bonasa umbellus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) were conducted during April and May 2012. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.0 (95% confidence interval = 0.8–1.1) drums per stop (dps). That was significantly less than mean counts from the previous 4 years, indicating that the grouse population is in the declining phase of its 10-year cycle. The most recent peak in drum counts was the 2.0 (1.8–2.3) dps observed during 2009.

During the spring 2012 survey 1,404 sharp-tailed grouse were observed at 154 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 6.3 (5.4–7.3) in the East Central survey region, 10.7 (9.3–12.3) in the Northwest region, and 9.2 (8.2–10.3) statewide. Counts among dancing grounds observed during both 2011 and 2012 declined 22% (12–31%), but the statewide index value for 2012 was similar to the long-term average observed since 1980.

## INTRODUCTION

### Index Surveys

The purpose of surveys of grouse populations in Minnesota is to monitor changes in the densities of grouse over time. Estimates of density, however, are difficult and expensive to obtain. Simple counts of animals, on the other hand, are convenient and, assuming that changes in density are the major source of variation in counts among years, they can provide a reasonable index to long-term trends in populations. Other factors, such as weather and habitat conditions, observer ability, and grouse behavior, vary over time and also affect simple counts of animals. These other factors make it difficult to make inferences about potential changes in wildlife populations over short periods of time (e.g., a few annual surveys) or from small changes in index values. Over longer periods of time or when changes in index values are large, assumptions upon which grouse surveys in Minnesota depend are more likely to be valid, thereby making inferences about grouse populations more valid. For example, index values from the ruffed grouse drumming count survey have documented what is believed to be true periodic fluctuations in ruffed grouse densities (i.e., the 10-year cycle).

### Ruffed Grouse

The ruffed grouse (*Bonasa umbellus*) is Minnesota's most popular game bird. It occurs throughout the forested regions of the state. Annual harvest varies from approximately 150,000 to 1.4 million birds and averages >500,000 birds. Information derived from spring drumming counts and hunter harvest statistics indicates that ruffed grouse populations fluctuate cyclically at intervals of approximately 10 years.

During spring there is a peak in the drumming behavior of male ruffed grouse. Ruffed grouse drum to communicate to other grouse the location of their territory. The purpose is to attract females for breeding and deter encroachment by competing males. Drumming makes male ruffed grouse much easier to detect, so counts of drumming males is a convenient basis for surveys to monitor changes in the densities of ruffed grouse. Ruffed grouse were first surveyed in Minnesota during the mid-1930s. Spring drumming counts have been conducted annually since the establishment of the first survey routes in 1949.

## **Sharp-tailed Grouse**

Sharp-tailed grouse (*Tympanuchus phasianellus*) in Minnesota occur in brushlands, which often form transition zones between forests and grasslands. Sharp-tailed grouse are considered a valuable indicator of the availability and quality of brushlands for wildlife. Although sharp-tailed grouse habitat was more widely distributed in Minnesota during the early- and mid-1900s, the range of sharp-tailed grouse is now limited to areas in the Northwest (NW) and East Central (EC) portions of the state (Figure 1). Since the early-1990s annual harvest of sharp-tailed grouse by hunters has varied between 6,000 and 22,000 birds, and the number of hunters has varied between 5,000 and 10,000.

During spring male sharp-tailed grouse gather at dancing grounds, or leks, in grassy areas and fields where they defend small territories and make displays to attract females for breeding. Surveys of sharp-tailed grouse populations are based on counts of grouse at dancing grounds. The first surveys of sharp-tailed grouse in Minnesota were conducted between the early 1940s and 1960. The current sharp-tailed grouse survey was initiated in 1976.

## **METHODS**

### **Ruffed Grouse**

Roadside routes consisting of 10 semipermanent stops approximately 1.6 km (1 mile) apart have been established. Routes were originally located along roads with little automobile traffic that were also near apparent ruffed grouse habitat. Therefore, route locations were not selected according to a statistically valid spatial sampling design, which means that data collected along routes is not necessarily representative of the larger areas (e.g., counties, regions) in which routes occur. Approximately 50 routes were established by the mid-1950s, and approximately 70 more were established during the late-1970s and early-1980s.

Observers from the Department of Natural Resources (DNR) Area Wildlife Offices and a variety of other organizations drove along each survey route once just after sunrise during April or May. Observers were not trained but often were experienced with the survey. At each designated stop along the route the observer listened for 4 minutes and recorded the number of ruffed grouse drums (not necessarily the number of individual grouse) he or she heard. Attempts were made to conduct surveys on days near the peak of drumming activity that had little wind and no precipitation.

The survey index value was the number of drums heard during each stop along a route. The mean number of drums per stop (dps) was calculated for each of 4 survey regions and for the entire state (Figure 2). As an intermediate step to summarizing survey results by region, I

calculated the mean number of dps for each route. Mean index values for survey regions were calculated as the mean of route-level means for all routes occurring within the region. Some routes crossed regional boundaries, so data from those routes were included in the means for both regions. The number of routes within regions was not proportional to any meaningful characteristic of the regions or ECS section upon which they were based. Therefore, mean index values for the Northeast region and the state were calculated as the weighted mean of index values for the 4 and 7 ECS sections, respectively, that they included. The weight for each section mean was the geographic area of the section (i.e., AAP = 11,761 km<sup>2</sup>, MOP = 21,468 km<sup>2</sup>, NSU = 24,160 km<sup>2</sup>, DLP = 33,955 km<sup>2</sup>, WSU = 14,158 km<sup>2</sup>, MIM = 20,886 km<sup>2</sup>, and PP = 5,212 km<sup>2</sup>). Only approximately half of the Minnesota and Northeast Iowa Morainal (MIM) and Paleozoic Plateau (PP) sections were within the ruffed grouse range, so the area used to weight drum index means for those sections was reduced accordingly using subsection boundaries.

Stops along survey routes are a small sample of all possible stops within the range of ruffed grouse in Minnesota. Survey index values based on the sample of stops are not the same as they would be if drum counts were conducted at a different sample of stops or at all possible stops. To account for the uncertainty in index values because they are based on a sample, I calculated 95% confidence intervals (CI) for each mean. A 95% confidence interval is a numerical range in which 95% of similarly estimated intervals (i.e., from different hypothetical samples) would contain the true, unknown mean. I used 10,000 bootstrap samples of route-level means to estimate percentile CIs for mean index values for survey regions and the whole state. Limits of each CI were defined as the 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles of the bootstrap frequency distribution. I calculated mean index values and CIs for all years since 1982. Data from earlier years were not analyzed because they were not available in a digital form.

## **Sharp-tailed Grouse**

Over time, DNR Wildlife Managers have recorded the locations of sharp-tailed grouse dancing grounds in their work areas. As new dancing grounds were located, they were added to the survey list. Known, accessible dancing grounds were surveyed by Wildlife Area staff and their volunteers between sunrise and 2.5 hours after sunrise during April and early-May to count sharp-tailed grouse. When possible, surveys were conducted when the sky was clear and the wind was <16 km/hr (10 mph). Attempts were made to conduct surveys on >1 day to account for variation in the attendance of male grouse at the dancing ground. Survey data consist of the maximum of daily counts of sharp-tailed grouse at each dancing ground.

The dancing grounds included in the survey were not selected according to a statistically valid spatial sampling design. Therefore, data collected during the survey were not necessarily representative of the larger areas (e.g., counties, regions) in which the dancing grounds occur. It was believed, however, that most dancing grounds within each work area were included in the sample, thereby minimizing the limitations caused by the sampling design.

I calculated the mean number of sharp-tailed grouse per dancing ground (i.e., index value), averaged across dancing grounds within the NW and EC regions and statewide. The number of grouse included those recorded as males and those recorded as being of unknown sex, and only leks with  $\geq 2$  grouse were included when calculating mean index values. It was not valid to compare the full survey data and results from different years because survey effort and success in detecting and observing sharp-tailed grouse was different between years and the survey samples were not necessarily representative of other dancing grounds. To estimate

differences in sharp-tailed grouse index values between 2 consecutive years, therefore, I analyzed separately sets of data that included counts of birds only from dancing grounds that were surveyed during both years. Although the dancing grounds in the separate data sets were considered comparable, the counts of birds at the dancing grounds still were not. Many factors can affect the number of birds counted, so inferences based upon comparisons of survey data between years are tenuous.

To account for the uncertainty in index values because they are based on a sample of dancing grounds rather than all dancing grounds, I calculated 95% confidence intervals (CI) for each mean. I used 10,000 bootstrap samples of dancing ground counts to estimate percentile confidence intervals for mean index values for the NW and EC regions and the whole state.

The current delineation between the NW and EC survey regions was based on ECS section boundaries (Figure 1), with the NW region consisting of the Lake Agassiz & Aspen Parklands, Northern Minnesota & Ontario Peatlands, and Red River Valley sections and the EC region consisting of selected subsections of the Northern Minnesota Drift & Lake Plains, Western Superior Uplands, and Southern Superior Uplands sections. The 2005 Grouse Survey Report detailed the transition from the former to the current delineation of regions.

## **RESULTS & DISCUSSION**

### **Ruffed Grouse**

Observers from 15 cooperating organizations surveyed 126 routes between 29 March and 16 May 2012. Most routes (91%) were run between 17 April and 10 May. The median date this year (25 April) was similar to the median during 2010 when much spring phenology occurred relatively early. The median dates during 2009 and 2011 were 1 May and 3 May, respectively. Observers reported survey conditions as Excellent, Good, and Fair on 55%, 41%, and 4% of 119 routes, respectively. The distribution of survey conditions has been consistent for at least the last 6 years.

Survey cooperators included the DNR Divisions of Fish & Wildlife and Parks & Trails; Chippewa and Superior National Forests (USDA Forest Service); Fond du Lac, Leech Lake, Red Lake, and White Earth Reservations; 1854 Treaty Authority; Agassiz and Tamarac National Wildlife Refuges (U.S. Fish & Wildlife Service); Vermilion Community College; Cass and Beltrami counties; and UPM Blandin Paper Mill.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.0 (95% confidence interval = 0.8–1.1) drums per stop (dps) during 2012. Drum counts by survey region during 2012 were 1.1 (0.9–1.2) dps in the Northeast ( $n = 106$  routes), 0.9 (0.7–1.2) dps in the Northwest ( $n = 8$ ), 0.6 (0.4–0.9) dps in the Central Hardwoods ( $n = 14$ ), and 0.7 (0.3–1.1) dps in the Southeast ( $n = 6$ ) (Figures 3 and 4). Median index values for bootstrap samples were similar to observed means (i.e., within 0.02 dps), so no bias-correction was necessary.

The statewide mean of drum counts this spring was significantly less than the mean counts from the previous 4 years, indicating that the grouse population is in the declining phase of its 10-year cycle. The most recent peak in drum counts was the 2.0 (1.8–2.3) dps observed

during 2009. Given that factors other than changes in grouse density may influence counts and the resulting index values, emphasis when interpreting results from index surveys like the drum count survey should be on large and long-term changes in counts, not on small or short-term changes.

### **Sharp-tailed Grouse**

A total of 1,404 sharp-tailed grouse was observed at 154 dancing grounds with  $\geq 2$  male grouse (or grouse of unknown sex) during spring 2012. Leks with  $\geq 2$  grouse were visited a mean of 1.9 times. There were 334 grouse on 53 leks in the East Central survey region and 1,070 grouse on 101 leks in the Northwest region. Twenty-nine percent fewer leks were observed than during 2011, mostly due to shortages in DNR Wildlife staff in northwestern Minnesota. The index value (i.e., grouse/lek) in both regions declined slightly from 2011 (Table 1), and counts at leks observed during both years declined 22% (12–31%, Table 2).

The statewide index value of 9.2 (8.2–10.3) was near the middle of values observed since 1980 (Figure 5). The peak in population index values for sharp-tailed grouse that occurred in 2009 coincided with the peak in the abundance of ruffed grouse in Minnesota. The spring index values for both species have followed an approximately 10-year cyclical pattern, with peaks in the sharp-tailed grouse index occurring up to 2 years after peaks in the ruffed grouse index.

### **ACKNOWLEDGEMENTS**

I sincerely appreciate the efforts of all the DNR staff, partners, and volunteer cooperators who conducted and helped coordinate the grouse surveys. I thank Laura Gilbert for helping with data entry and archiving and Lou Cornicelli for reviewing a draft of this report. The ruffed grouse survey data for 1982–2004 were entered into a database by Doug Mailhot and another volunteer through a special effort organized by Gary Drotts, John Erb, and Rick Horton. The grouse surveys reported here were funded in part under the Federal Aid in Wildlife Restoration Act.

Table 1. Number of sharp-tailed grouse observed per active lek ( $\geq 2$  males) during spring in Minnesota.

Year	Statewide			Northwest <sup>a</sup>			East Central <sup>a</sup>		
	Mean	95% CI <sup>b</sup>	<i>n</i> <sup>c</sup>	Mean	95% CI <sup>b</sup>	<i>n</i> <sup>c</sup>	Mean	95% CI <sup>b</sup>	<i>n</i> <sup>c</sup>
2004	11.2	10.1–12.3	183	12.7	11.3–14.2	116	8.5	7.2– 9.9	67
2005	11.3	10.2–12.5	161	13.1	11.5–14.7	95	8.8	7.3–10.2	66
2006	9.2	8.3–10.1	161	9.8	8.7–11.1	97	8.2	6.9– 9.7	64
2007	11.6	10.5–12.8	188	12.7	11.3–14.1	128	9.4	8.0–11.0	60
2008	12.4	11.2–13.7	192	13.6	12.0–15.3	122	10.4	8.7–12.3	70
2009	13.6	12.2–15.1	199	15.2	13.4–17.0	137	10.0	8.5–11.7	62
2010	10.7	9.8–11.7	202	11.7	10.5–12.9	132	8.9	7.5–10.5	70
2011	10.2	9.5–11.1	216	11.2	10.2–12.2	156	7.8	6.7–8.9	60
2012	9.2	8.2–10.3	153	10.7	9.3–12.3	100	6.3	5.4–7.3	53

<sup>a</sup> Survey regions; see Figure 1.

<sup>b</sup> 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.

<sup>c</sup> *n* = number of leks in the sample.

Table 2. Difference in the number of sharp-tailed grouse per lek on dancing grounds that were observed during consecutive spring surveys in Minnesota.

Comparison <sup>b</sup>	Statewide			Northwest <sup>a</sup>			East Central <sup>a</sup>		
	Mean	95% CI <sup>c</sup>	<i>n</i> <sup>d</sup>	Mean	95% CI <sup>c</sup>	<i>n</i> <sup>d</sup>	Mean	95% CI <sup>c</sup>	<i>n</i> <sup>d</sup>
2004 - 2005	-1.3	-2.2– -0.3	186	-2.1	-3.5– -0.8	112	0.0	-1.0– 1.1	74
2005 - 2006	-2.5	-3.7– -1.3	126	-3.6	-5.3– -1.9	70	-1.1	-2.6– 0.6	56
2006 - 2007	2.6	1.5– 3.8	152	3.3	1.7– 5.1	99	1.2	0.1– 2.3	53
2007 - 2008	0.4	-0.8– 1.5	166	0.0	-1.6– 1.6	115	1.2	0.1– 2.5	51
2008 - 2009	0.9	-0.4– 2.3	181	1.8	-0.1– 3.8	120	-0.8	-2.1– 0.6	61
2009 - 2010	-0.6	-1.8– 0.6	179	-0.8	-2.6– 1.0	118	-0.1	-1.2– 1.0	61
2010 - 2011	-1.7	-2.7– -0.8	183	-1.8	-3.1– -0.5	124	-1.5	-2.8– -0.3	59
2011 - 2012	-2.0	-2.9– -1.1	170	-1.7	-2.9– -0.4	112	-2.4	-3.3– -1.6	58

<sup>a</sup> Survey regions; see Figure 1.

<sup>b</sup> Consecutive years for which comparable leks were compared.

<sup>c</sup> 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.

<sup>d</sup> *n* = number of dancing grounds in the sample.



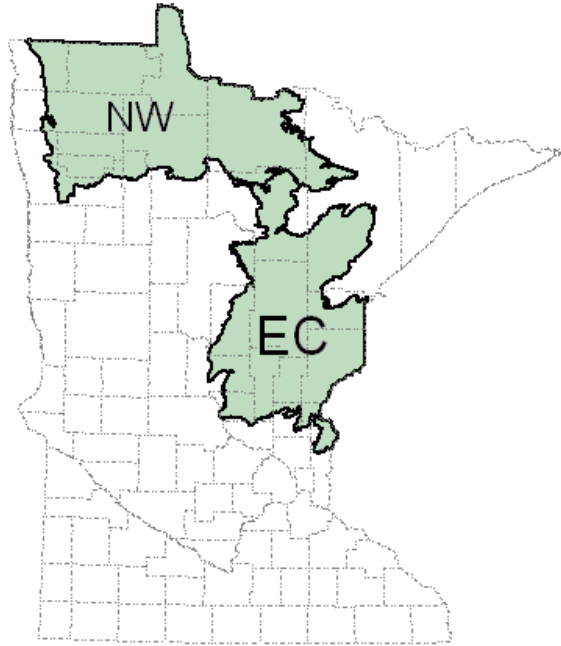


Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** relative to county boundaries in Minnesota. The regions were based largely on boundaries of ECS Subsections.

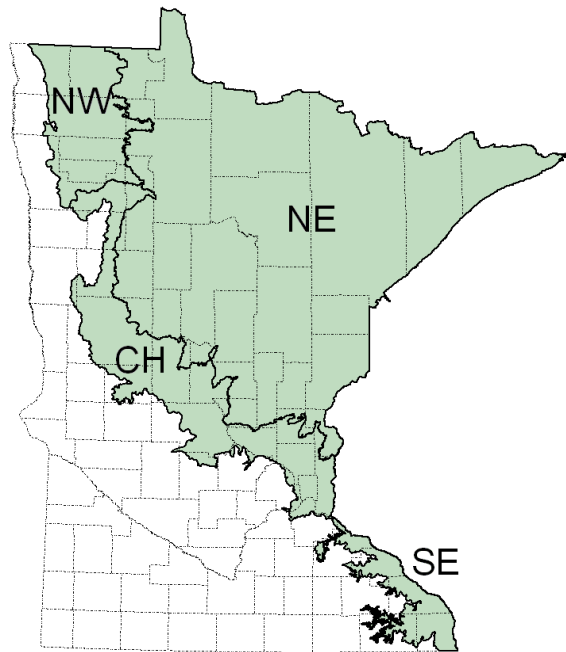


Figure 2. Survey regions for **ruffed grouse** (shaded, curved boundaries) relative to county boundaries (dashed lines) in Minnesota. The regions are based on the Ecological Classification System.

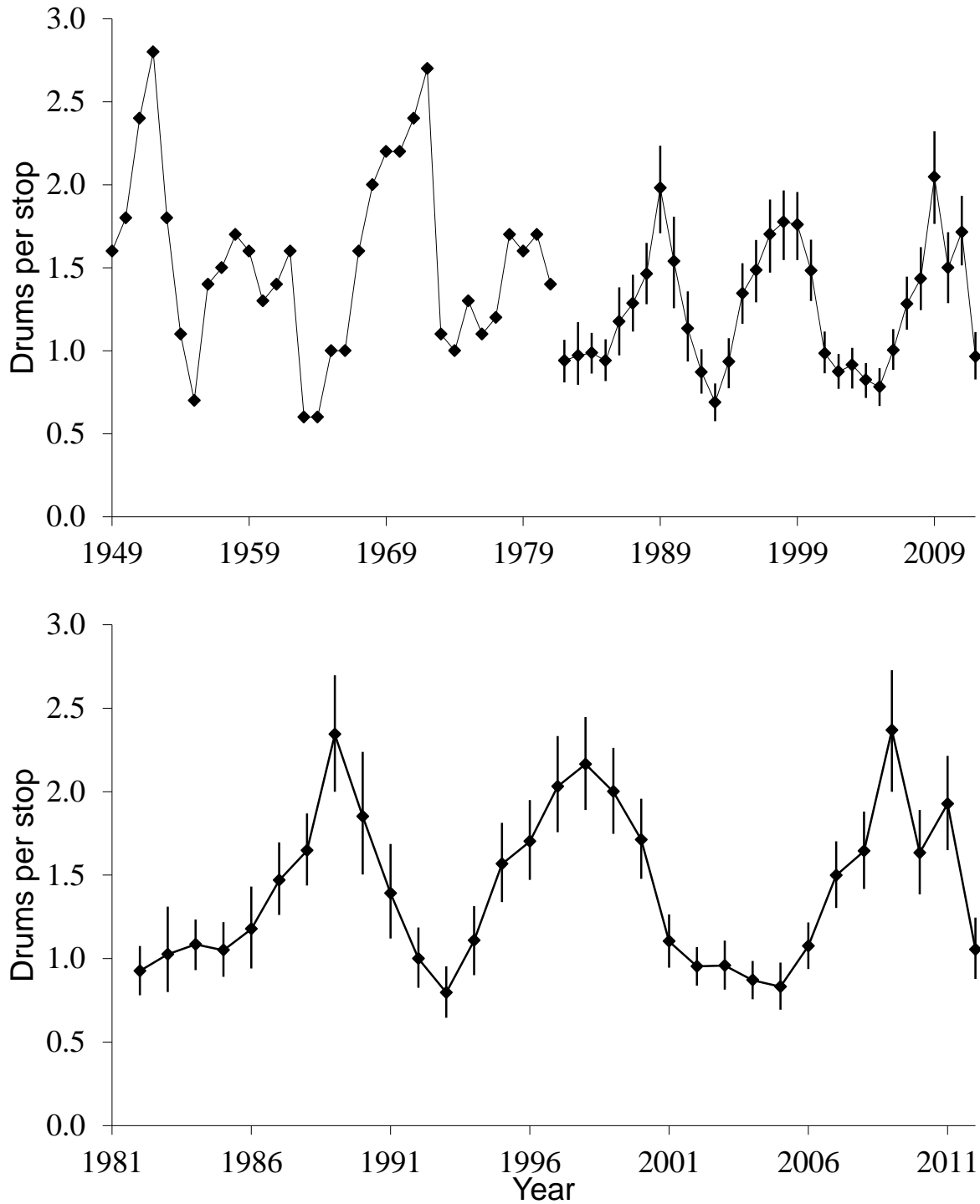


Figure 3. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current weighted average and bootstrapping methods, so confidence intervals were not available. The difference in index values between 1981 and 1982 reflected a real decrease in drums counted, not an artifact of the change in analysis methods.

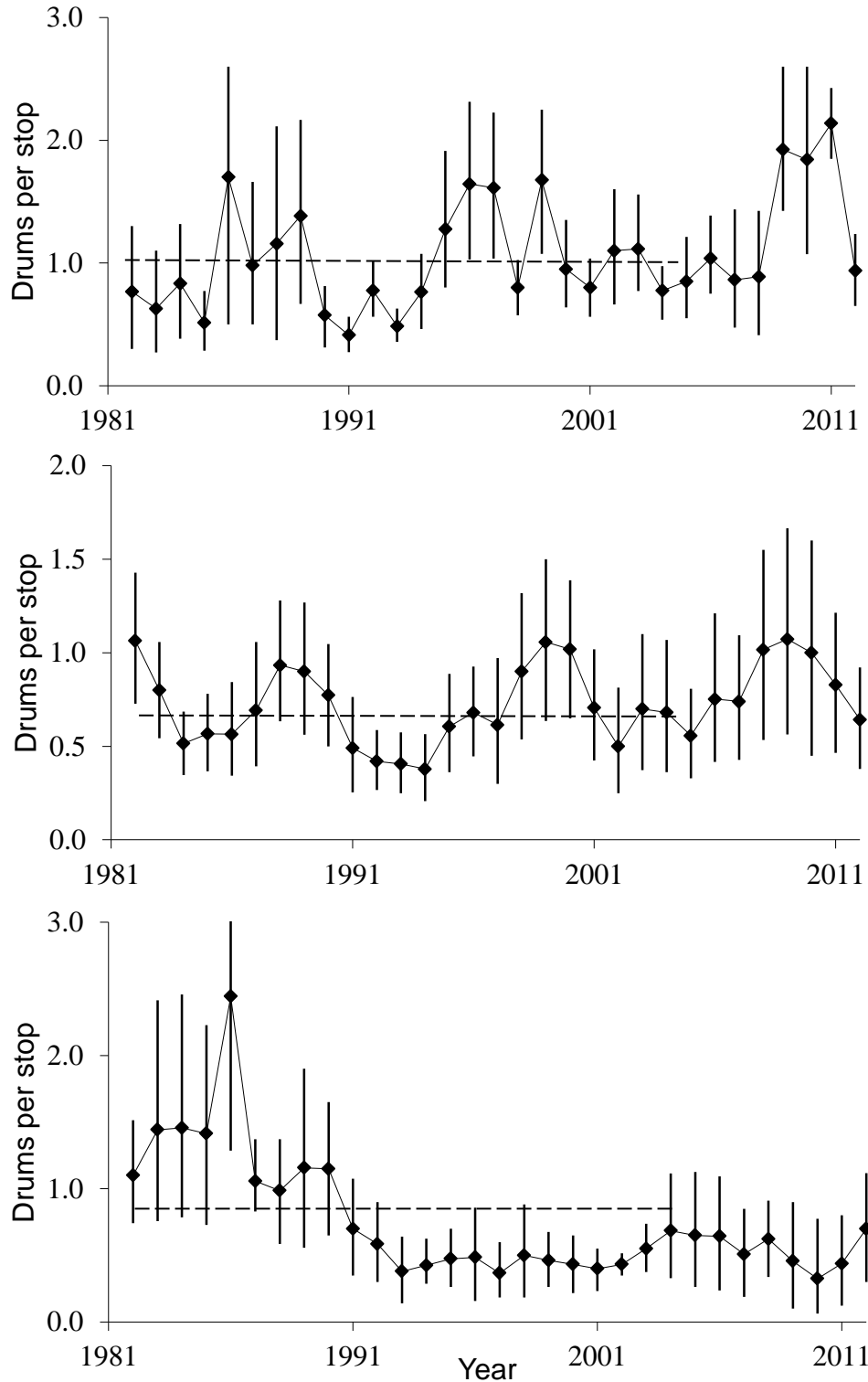


Figure 4. Ruffed grouse drum count index values in the **Northwest** (top), **Central Hardwoods** (middle), and **Southeast** (bottom) survey regions of Minnesota. Dashed horizontal lines indicate the mean from 1984 to 2004. Vertical error bars represent 95% confidence intervals based on bootstrap samples. The highest error bar in the bottom panel was truncated.

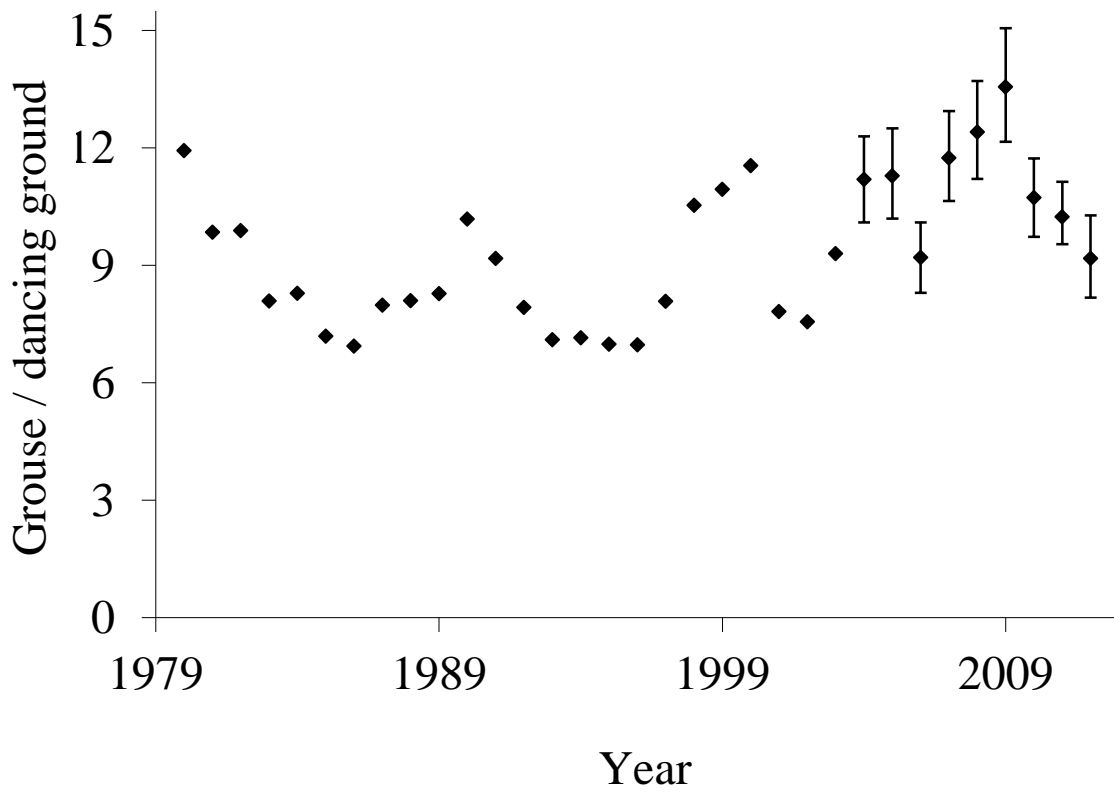


Figure 5. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds, 1980–2012. Vertical error bars, which were calculated only for recent years, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.

# PRAIRIE-CHICKEN SURVEY IN MINNESOTA DURING 2012

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## SUMMARY OF FINDINGS

Surveys for greater prairie-chickens (*Tympanuchus cupido pinnatus*) were conducted in all 17 survey blocks during April and May of 2012. Observers located 128 booming grounds and counted 1,226 male prairie-chickens, including birds of unknown sex, in and near 15 of the survey blocks. Counts from the other 2 survey blocks were not available for analysis at the time of this report. Estimated densities of booming grounds and males/booming ground within the survey blocks were similar to densities during recent years and during the 10 years prior to modern hunting seasons (i.e., 1993–2002).

## INTRODUCTION

### Index Surveys

The purpose of surveys of grouse populations in Minnesota is to monitor changes in the densities of grouse over time. Estimates of density, however, are difficult and expensive to obtain. Simple counts of animals, on the other hand, are convenient and, assuming that changes in density are the major source of variation in counts among years, they can provide a reasonable index to long-term trends in populations. Other factors, such as weather and habitat conditions, observer ability, and grouse behavior, vary over time and also affect simple counts of animals. These other factors make it difficult to make inferences about potential changes in wildlife populations over short periods of time (e.g., a few annual surveys) or from small changes in index values. Over longer periods of time or when changes in index values are large, assumptions upon which grouse surveys in Minnesota depend are more likely to be valid, thereby making inferences about grouse populations more valid. For example, index values from the ruffed grouse drumming count survey have documented what is believed to be true periodic fluctuations in ruffed grouse densities (i.e., the 10-year cycle).

### Greater Prairie-Chickens

During the early 1800s greater prairie-chickens (*Tympanuchus cupido pinnatus*) were present along the southern edge of Minnesota. Their range expanded and contracted dramatically during the next 150 years. Currently, most prairie-chickens in Minnesota occur along the beach ridges of glacial Lake Agassiz in the west (Figure 1). The population of prairie-chickens was expanded southward to the upper Minnesota River valley by a series of relocations during 1998–2006. Hunters in Minnesota have harvested approximately 120 prairie-chickens annually since 2003 when a limited-entry hunting season was opened for the first time since 1942.

During spring male prairie-chickens gather at communal display areas, or leks. The display areas of prairie-chickens are called booming grounds because males make a low-frequency, booming vocalization during their displays. From 1974 to 2003 the Minnesota Prairie Chicken Society coordinated annual counts of prairie-chickens at booming grounds. During

2004 the Minnesota Department of Natural Resources (DNR) began coordinating the annual prairie-chicken surveys, and a standardized survey design was adopted.

## **METHODS**

During the few hours near sunrise from late-March until mid-May cooperating biologists and numerous volunteers counted prairie-chickens at booming grounds in western Minnesota. They attempted to locate and observe multiple times all booming grounds within 17 designated survey blocks (Figure 2). Each block was a square comprising 4 sections of the Public Land Survey (approximately 4,144 ha) and was selected nonrandomly based upon the spatial distribution of booming grounds and the presence of relatively abundant grassland habitat. I separated the survey blocks into 2 groups—core and periphery—based upon densities of prairie-chickens, with a threshold of approximately 1.0 male/km<sup>2</sup> during 2010, and geographic location relative to other survey blocks (Figure 2).

Observations of booming grounds outside the survey blocks were also recorded. They contribute to the known minimum abundance of prairie-chickens and may be of historical significance. These observations, however, were only incidental to the formal survey. Bird counts from areas outside the survey blocks cannot be used to make inferences about the relative abundance of prairie-chickens among different geographic areas (e.g., counties, permit areas) or points in time (e.g., years) because the amount of effort expended to obtain the observations was not standardized or recorded.

Observers counted prairie-chickens at booming grounds from a distance using binoculars. If vegetation or topography obscured the view of a booming ground, the observer attempted to flush the birds to obtain an accurate count. Observed prairie-chickens were classified as male, female, or unknown sex. Male prairie-chickens were usually obvious due to their display behavior. Birds were classified as unknown sex when none of the birds at a booming ground was observed displaying or when the birds had to be flushed to be counted. Most birds classified as unknown likely were males because most birds at booming grounds are males. Although most male prairie-chickens attend booming grounds most mornings, female attendance at booming grounds is much more limited and sporadic. Females are also more difficult to detect because they do not vocalize or display like males. Counts of males and unknowns, rather than females, therefore, were used to make comparisons between core and peripheral ranges and between years.

I summarized counts of booming grounds and prairie-chickens by hunting permit areas and spring survey blocks. Surveys were conducted in all traditional areas, but the counts from several permit areas and survey blocks were not available for analysis at the time of this report. Therefore, I did not calculate densities of booming grounds or prairie-chickens for comparison to estimated densities from previous years.

## **RESULTS & DISCUSSION**

Observers from at least 3 cooperating organizations and many unaffiliated volunteers counted prairie-chickens during April and May 2012. Cooperators included the DNR Division of Fish and Wildlife, the Fergus Falls and Detroit Lakes Wetland Management Districts (U.S. Fish & Wildlife Service), and The Nature Conservancy.

Observers located 128 booming grounds and counted 1,226 male prairie-chickens during 2012 (Table 1). Minimum counts in Table 1 are not comparable among permit areas or years because they included surveys that were conducted outside of the survey blocks and did not follow a predetermined spatial sampling design.

Table 1. Minimum abundance of prairie-chickens within and outside of hunting permit areas in western Minnesota during spring 2012. Counts of booming grounds and birds are not comparable among permit areas or years.

Permit Area	Area (km <sup>2</sup> )	Booming grounds	Males	Unk. <sup>a</sup>
801A	603	0	0	0
802A	826	7	46	1
803A	668	0	0	0
804A	435	0	0	0
805A	267	8	110	0
806A	749	7	49	0
807A	440	31	272	0
808A	417	17	224	0
809A	743	20	217	0
810A	505	12	122	0
811A	704	8	64	37
PA subtotal	6,356	110	1,104	38
Outside PAs <sup>b</sup>	NA <sup>c</sup>	18	122	29
Grand total	NA <sup>c</sup>	128	1,226	67

<sup>a</sup> Unk. = prairie-chickens of unknown sex. It is likely that most were males.

<sup>b</sup> Counts from outside the permit areas (PA).

<sup>c</sup> NA = not applicable. The size of the area outside permit areas was not defined.

Each booming ground was observed on a median of 2 (mean = 1.9) different days, and 38% of booming grounds were observed only once during 2012. Attendance of males at booming grounds varies among days and by time of day. Single counts of males at a booming ground, therefore, may be an unreliable indication of true abundance. Similar counts on multiple days, on the other hand, demonstrate that the counts may be a good indicator of true abundance. Even multiple counts, however, cannot overcome the problems associated with the failure to estimate the probability of detecting booming grounds and individual birds at booming grounds. Without estimates of detection probability, the prairie-chicken survey is an index to, not an estimate of, prairie-chicken abundance within the survey blocks. The credibility of the index for monitoring changes in abundance among years is dependent upon the untested assumption that a linear relationship exists between counts of male prairie-chickens and true abundance. In other words, we assume that (the expected value of) the probability of detection does not change among years.

Within survey blocks we counted 729 males, including birds of unknown sex, on 70 booming grounds during 2012 (Table 2). Booming grounds were defined as having  $\geq 2$  males, so

observations of single males were excluded from summaries by survey block. In the 10 core survey blocks we observed 0.14 (0.10–0.17) booming grounds/km<sup>2</sup> and 10.6 (8.8–12.3) males/booming ground (Table 2, Figure 2). In the 7 peripheral survey blocks we observed 0.04 (0.01–0.08) booming grounds/km<sup>2</sup> and 9.8 (6.7–12.8) males/booming ground. The density of booming grounds observed among all survey blocks during 2012 was slightly less than densities during recent years (Figure 3) but slightly greater than the average of 0.08 (0.06–0.09) booming grounds/km<sup>2</sup> observed during the 10 years before recent hunting seasons (i.e., 1993–2002). The density of males at booming grounds observed among all survey blocks during 2012, however, was similar to densities during recent years but less than the average of 11.5 (10.1–12.9) males/booming ground observed during 1993–2002 (Table 2, Figure 3).

Table 2. Counts of prairie-chickens within survey blocks in Minnesota.

Range <sup>b</sup>	Survey Block	Area (km <sup>2</sup> )	2012		Change from 2011 <sup>a</sup>	
			Booming grounds	Males <sup>c</sup>	Booming grounds	Males <sup>c</sup>
Core	Polk 1	41.2	6	41	-1	-19
	Polk 2	42.0	8	110	0	21
	Norman 1	42.0	3	22	-1	1
	Norman 2	42.2	6	56	0	10
	Norman 3	41.0	9	78	-2	-23
	Clay 1	46.0	6	73	NA <sup>d</sup>	NA <sup>d</sup>
	Clay 2	41.0	2	39	NA <sup>d</sup>	NA <sup>d</sup>
	Clay 3	42.0	8	77	NA <sup>d</sup>	NA <sup>d</sup>
	Clay 4	39.0	3	31	NA <sup>d</sup>	NA <sup>d</sup>
	Wilkin 1	40.0	6	75	1	28
	Core subtotal	415.0	57	602	-3 <sup>e</sup>	18 <sup>e</sup>
Periphery	Mahnomen	41.7	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>
	Becker 1	41.4	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>
	Becker 2	41.7	5	29	NA <sup>d</sup>	NA <sup>d</sup>
	Wilkin 2	41.7	2	32	NA <sup>d</sup>	NA <sup>d</sup>
	Wilkin 3	42.0	3	34	-2	9
	Otter Tail 1	41.0	1	12	0	4
	Otter Tail 2	40.7	2	20	-1	5
		Periphery subtotal	290.6	13 <sup>e</sup>	127 <sup>e</sup>	-3 <sup>e</sup>
Grand total		705.5	70 <sup>e</sup>	729 <sup>e</sup>	-6 <sup>e</sup>	36 <sup>e</sup>

<sup>a</sup> The 2011 count was subtracted from the 2012 count, so a negative value indicates a decline.

<sup>b</sup> Survey blocks were classified as either in the core or periphery of the prairie-chicken range in Minnesota based upon bird densities and geographic location.

<sup>c</sup> Includes birds recorded as being of unknown sex but excludes lone males not observed at a booming ground.

<sup>d</sup> Surveys were conducted in these blocks during both years, but the counts from either 2011 or 2012 were not available for analysis at the time this report was written.

<sup>e</sup> These sums reflect only the blocks for which count data were available.



## ACKNOWLEDGMENTS

I sincerely appreciate the efforts of all the DNR staff and volunteer cooperators who conducted and helped coordinate the prairie-chicken survey. DNR contributions to this survey were funded in part under the Federal Aid in Wildlife Restoration Act, U.S. Fish & Wildlife Service, Minnesota project W-69-S.

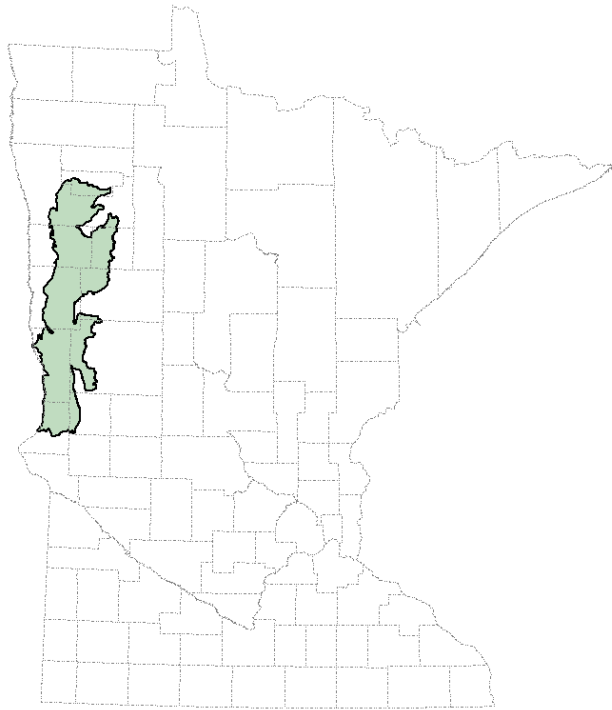


Figure 1. Primary range of greater prairie-chickens (shaded area) relative to county boundaries in Minnesota. This range boundary was based on ECS Land Type Associations and does not include all areas that are known to be occupied by prairie-chickens.

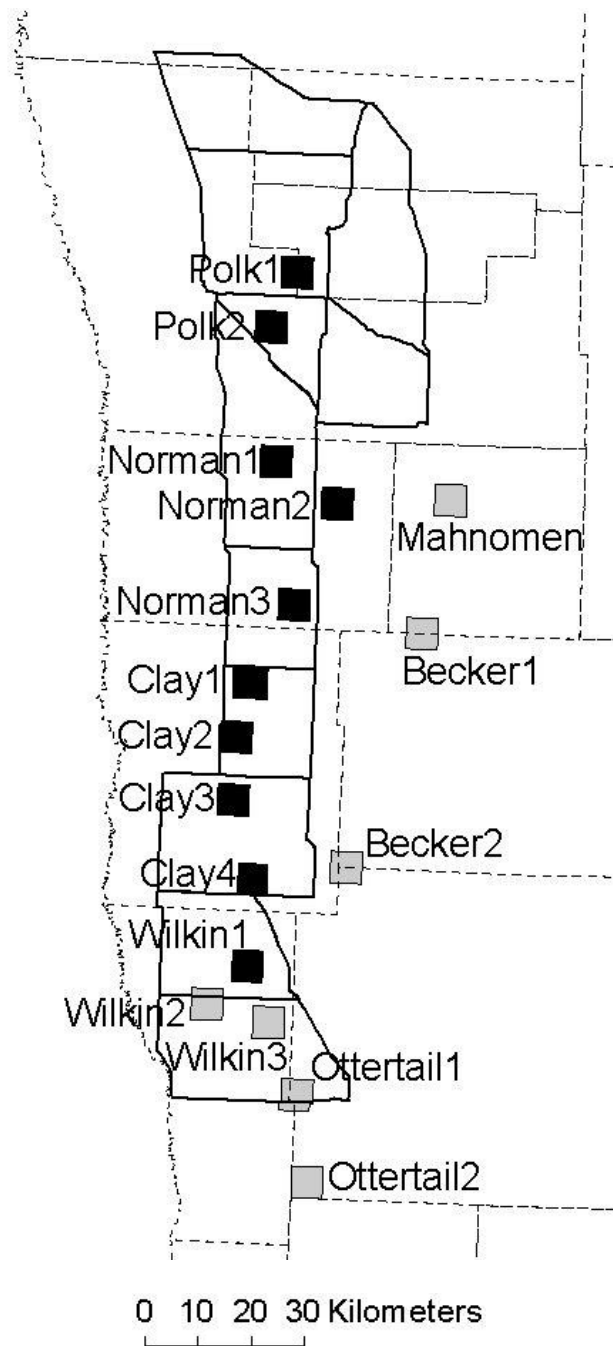


Figure 2. Survey blocks (41 km<sup>2</sup>, labeled squares) and hunting permit area boundaries (solid lines) for prairie-chickens in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which they were primarily located. Permit areas were labeled sequentially from 801A in the north to 811A in the south.

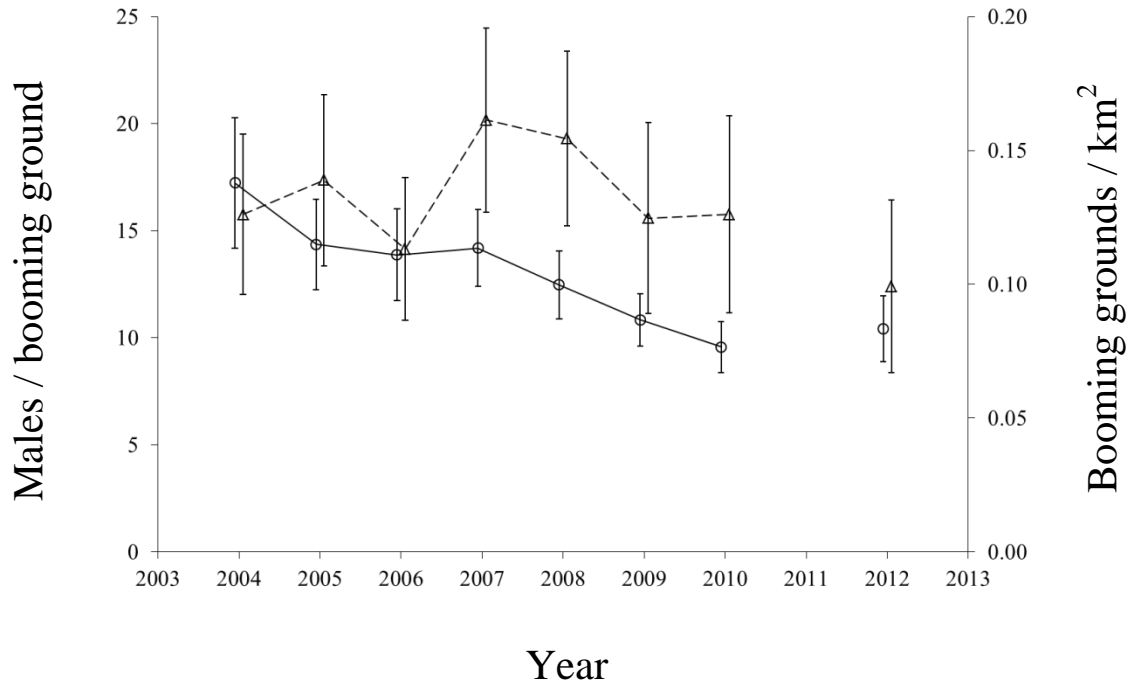
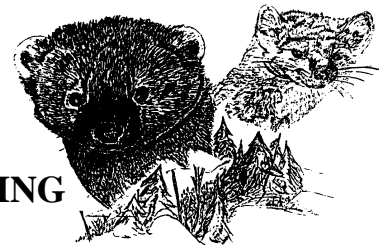


Figure 3. Number of prairie-chicken males/booming ground (circles connected by solid line) and booming grounds/km<sup>2</sup> (triangles connected by dashed line) observed in 17 41-km<sup>2</sup> survey blocks in western Minnesota. Vertical error bars represent 95% confidence intervals. Counts from 2011 for 6 of the survey blocks, including 4 of the 10 blocks in the core, were not available for this report.

# REGISTERED FURBEARER POPULATION MODELING

## 2012 Report



Drawing by Gilbert Proulx

John Erb, Forest Wildlife Populations and Research Group

### INTRODUCTION

For populations of secretive carnivores, obtaining field-based estimates of population size remains a challenging task (Hochachka et al. 2000; Wilson and Delehay 2001; Conn et al. 2004). This is particularly true when one is interested in annual estimates, multiple species, or large areas. Nevertheless, population estimates are desirable to assist in making management or harvest decisions. Population modeling is a valuable tool for synthesizing our knowledge of population demography, predicting outcomes of management decisions, and approximating population size.

In the late 1970s, Minnesota developed population models for 4 species of carnivores (fisher, marten, bobcat, and otter) to help ‘estimate’ population size and track population changes. All are deterministic accounting models that do not currently incorporate density-dependence. However, juvenile survival adjustments are made for bobcats and fisher during cyclic lows in hare abundance and following severe winters, particularly those where northern deer populations decline. For juvenile marten, survival is adjusted downward during apparent lows in small mammal abundance. Modeling projections are interpreted in conjunction with harvest data and results from any annual field-based track surveys.

### METHODS

Primary model inputs include the estimated 1977 ‘starting’ population size, estimates of age-specific survival and reproduction, and sex- and age-specific harvest data. Reproductive inputs are based largely on carcass data collected in the early 1980s, and for bobcats, additional data collected in 1992 and from 2003-present. Initial survival inputs were based on a review of published estimates in the literature, but are periodically adjusted as noted above. In some cases, parameter adjustments for previous years are delayed until additional data on prey abundance trends is available. Hence, population estimates reported in previous reports may not always match those reported in current reports. Obtaining updated Minnesota-specific survival and reproductive estimates is the goal of ongoing research.

Harvest data is obtained through mandatory furbearer registration. A detailed summary of 2011 harvest information is available in a separate report. Bobcat, marten, and fisher age data is obtained via x-ray examination of pulp cavity width or microscopic counts of cementum annuli from teeth of harvested animals. Although the population models only utilize data for the 3 age-classes (juvenile, yearling, adult), cementum annuli counts have periodically been collected for all non-juveniles either to examine age-specific reproductive output (bobcats) or to obtain periodic information on year-class distribution for selected species. In years where age data is not obtained for a given species, harvest age proportions are approximated using averages computed from the most recent period when data was collected.

For comparison to model projections, field-based track survey indices are presented in this report as running 3-year (t-1, t, t+1) averages of the observed track index, with the most recent year's average computed as (2/3\*current index + 1/3\*previous index). More detailed descriptions of scent post and winter track survey methods and results are available in separate reports.

## RESULTS AND DISCUSSION

**Bobcat.** The 2011 registered DNR trapping and hunting harvest reached a new record level (1,711), exceeding last year's record harvest by 70% (Table 1). Total modeled harvest, which includes reported tribal take, was 1,898. The juvenile to adult female ratio in the harvest (0.8; Table 1) was below both the long-term average (1.5) and the recent 10-year average (1.1). A total of 1,626 bobcat carcasses were examined (Table 1), with a mean age of 3.0 for females. Approximately 10% of the harvested female bobcats were  $\geq 6.5$  years old (Figure 1).

Based on examination of reproductive tracts, 13% of yearling females produced a litter in 2011, the lowest since data collection resumed in 2003 (Figure 2). Average litter size for pregnant yearlings was 2.5, slightly above the previous 8-year average of 2.2. Pregnancy rate for 2+ year olds was 73%, similar to the previous 8-year mean (74%). Mean litter size for pregnant adults was 2.8 (8-year mean = 2.8). For both yearlings and adults, pregnancy rates appear to fluctuate more than average litter size, though neither has shown significant variability or trend since data collection resumed in 2003.

Based on the recently recalibrated bobcat population model, 35% of the 2011 fall population was harvested. As a result of the record harvest, population modeling projects a 12% decline in the bobcat population (Figure 3), with an estimated 2012 spring population size of ~ 3,400 (Figure 3). Both track indices remain at record levels (Figure 3).

**Fisher.** For the past 4 years, the fisher harvest season was reduced from 16 days to 9 days. In addition, the fisher limit was reduced the past 2 seasons from 5 to 2. Fisher harvest this year under the DNR framework increased 63% to 1,473 (Table 2). Modeled harvest, which includes reported tribal take, was 1,651.

Fisher carcass collections were resumed in 2010 to collect current information on age distribution. A total of 1,314 carcasses were collected in 2011 (Table 2). The juvenile:adult female ratio was 3.0, below last year's estimate of 4.3, and well below the 1977-1994 average of 6.6 (Table 2). Average age of harvested males and females was 1.4 and 1.8, respectively. Very few fishers over the age of 2.5 were harvested (Figures 4 and 5).

Based on projections from the fisher population model, 21% of the fall fisher population was harvested during the 2011 season. Although the conservative seasons in recent years appeared to have stabilized the previous decline, this year's harvest may have exceeded current sustainable levels, and the 3-year-averaged winter track index for fisher once again declined, though not significantly (Figure 6). Modeling projects a 7% decrease in the population, with an estimated 2012 spring population size of ~ 6,000 fishers (Figure 6).

**Marten.** As with fisher, the marten harvest season the last 4 years was shortened from 16 days to 9 days, though the marten limit has remained unchanged. Harvest this year under the

DNR framework was 2,525, up 37% from last year (Table 3). Modeled harvest, which includes reported tribal take, was 2,744. Age-class information was obtained from a sample of 70% of the carcasses collected this year. Juveniles comprised 39% of the total harvest, slightly below the recent 10-year average (46%), and well below the longer-term average of 55% (Table 3; Figure 7). The juvenile:adult female ratio (2.6) in the harvest was below both the recent 10-year average (4.6) and the longer-term average (7.6; Table 3).

Based on projections from the marten population model, 22% of the fall marten population was harvested. After declining for ~ 8 years, the 3-year-averaged winter track index has been rebounding after implementing more conservative harvest seasons. However, the higher than expected harvest this year appears to have dampened the recovery (Figure 8). Modeling projects a 6% decline in the population from last year (Figure 3), with an estimated 2012 spring population size of ~ 9,000 martens.

**Otter.** From 1977 - 2007, otter harvest was only allowed in the northern part of the state. From 2007-2009, otter harvest was allowed in 2 separate zones with differing limits (4 otter in the north zone, 2 in the southeast zone). Beginning in 2010, otter harvest was allowed statewide, with a consistent limit of 4 otter per trapper. Statewide harvest in 2011 under the DNR framework increased 26% to 2,294 (Table 4), of which approximately 50 (2%) were taken in the former southeast zone and 90 (4%) in the recently opened SC/SW portion of the state.

Modeled statewide otter harvest, which includes tribal take, was 2,490 (Table 4). An estimated 17% of the fall population was harvested. Carcass collections ended in 1986, so no age or reproductive data are available. After the population declined for several years as a result of high fur prices (harvests) and then rebounded to previous levels as fur prices (harvests) declined, modeling indicates that this year's harvest had a stabilizing effect on the population (Figure 7). The 2012 spring population is estimated to be ~ 12,300, essentially unchanged from last year.

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Table 1. Bobcat harvest data, 1982 to 2011.

Year	DNR Harvest	Modeled Harvest <sup>1</sup>	% Autumn Pop. Taken <sup>2</sup>	Carcasses Examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	Overall % males	Mean Pelt Price <sup>3</sup>
1982	274	320	15	261	35	15	50	1.3	47	49	47	48	\$66
1983	208	212	10	205	37	26	37	1.5	54	53	30	45	\$61
1984	280	288	15	288	37	13	50	1.4	52	66	44	51	\$76
1985	119	121	6	99	33	19	48	1.2	41	41	43	42	\$70
1986	160	160	8	132	26	17	57	0.9	53	32	51	51	\$120
1987	214	229	12	163	33	16	51	1.4	44	52	48	48	\$101
1988	140	143	7	114	40	18	42	1.7	58	62	46	54	\$68
1989	129	129	6	119	39	17	44	2	49	53	56	53	\$48
1990	84	87	4	62	20	34	46	0.8	58	80	44	59	\$43
1991	106	110	5	93	35	33	32	3.6	59	55	70	61	\$37
1992	167	167	7	151	28	22	50	1.2	55	45	53	53	\$28
1993	201	210	8	161	32	20	48	1.4	51	45	52	50	\$43
1994	238	270	11	187	26	16	58	0.8	64	43	45	50	\$36
1995	134	152	6	96	31	15	54	2.7	57	71	79	71	\$32
1996	223	250	10	164	35	20	45	1.5	51	30	49	46	\$33
1997	364	401	17	270	35	16	49	1.2	60	37	43	48	\$30
1998	103	107	5	77	29	26	45	1.6	59	60	60	60	\$28
1999	206	228	8	163	18	24	58	0.8	55	59	62	60	\$24
2000	231	250	8	183	31	26	43	1.5	54	59	50	53	\$33
2001	259	278	9	213	30	21	49	1.3	52	51	53	52	\$46
2002	544	621	16	475	27	25	48	1	66	49	46	52	\$72
2003	483	518	14	425	25	13	62	0.9	61	46	53	54	\$96
2004	631	709	16	524	28	34	38	1.6	51	40	54	49	\$99
2005	590	638	14	485	25	13	62	0.8	51	48	46	48	\$96
2006	890	983	20	813	26	17	57	1.1	61	50	58	57	\$101
2007	702	758	16	633	34	14	52	1.2	55	60	47	52	\$93
2008	853	928	18	714	26	25	49	1.1	56	52	51	52	\$75
2009	884	942	18	844	23	22	55	0.9	57	46	54	53	\$43
2010	1012	1042	19	955	38	16	46	1.4	62	55	43	52	\$71
2011	1711	1898	35	1626	23	21	56	0.8	61	73	47	56	\$98

<sup>1</sup>Includes DNR and Tribal harvests

<sup>2</sup>Estimated from population model; includes estimated non-reported harvest of 10%.

<sup>3</sup>Average pelt price based on a survey of in-state fur buyers only.

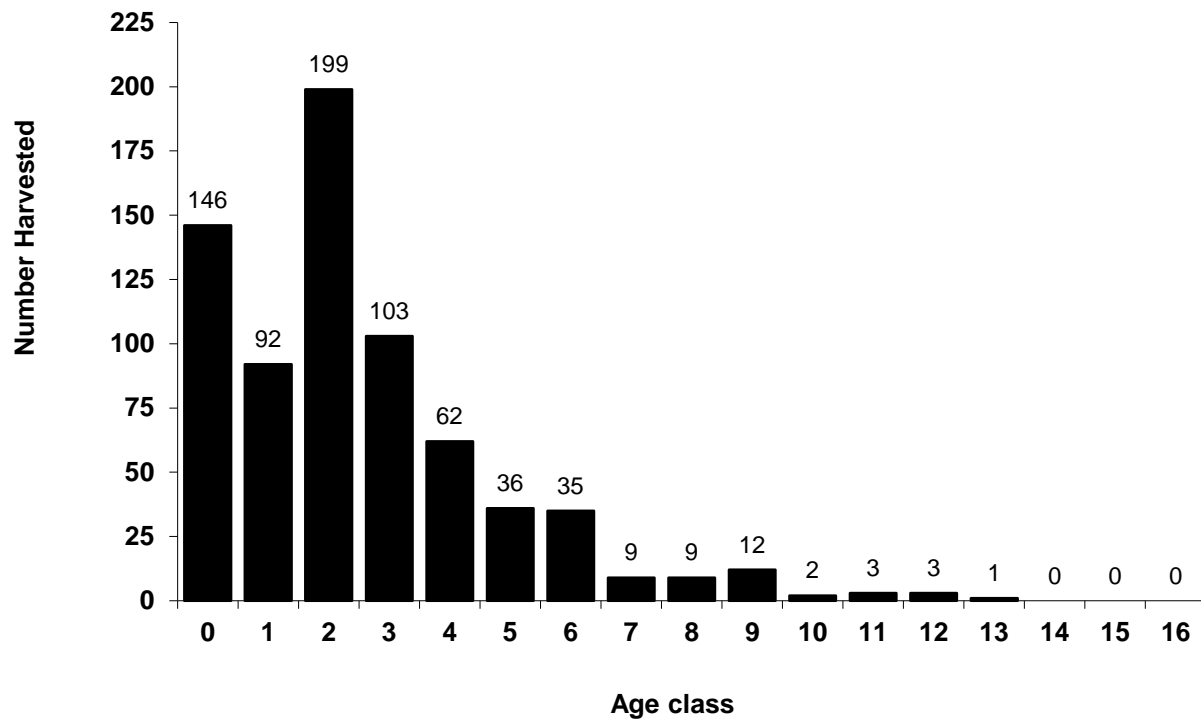


Figure 1. Age structure of female bobcats in the 2011-12 harvest.

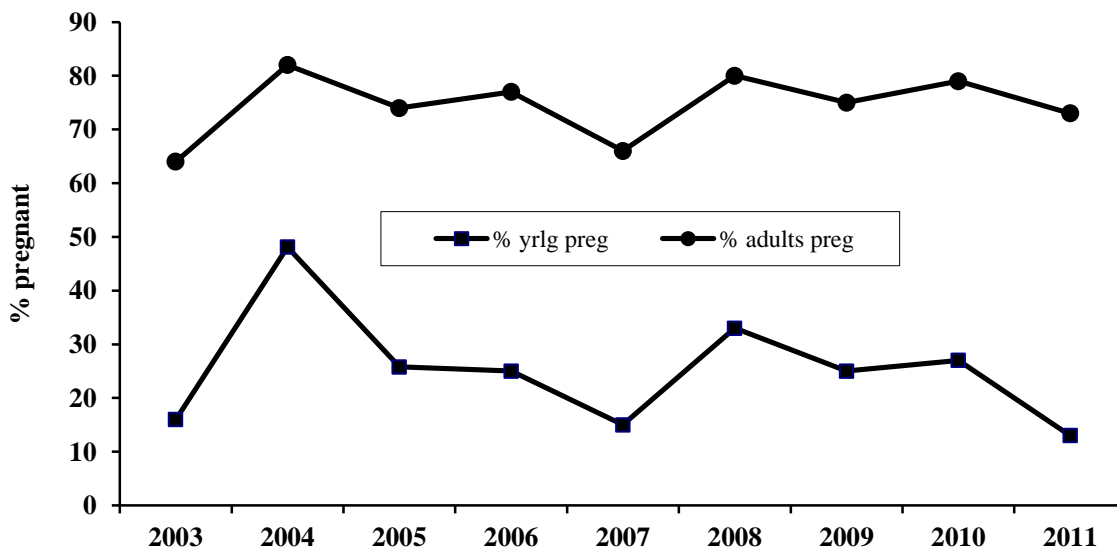


Figure 2. Pregnancy rates for yearling and adult bobcats in Minnesota, 2003-2011.



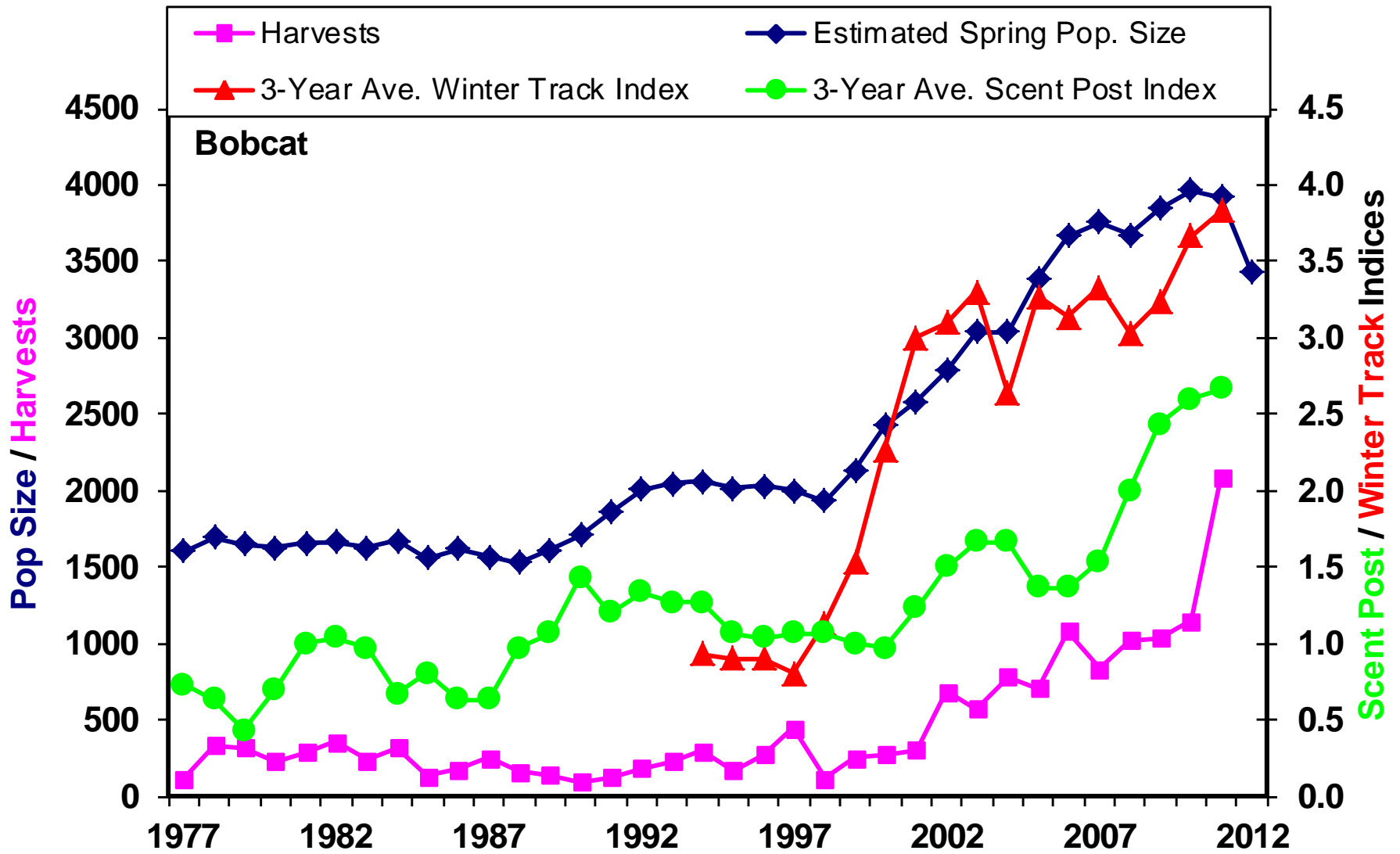


Figure 3. Bobcat populations, harvests, and survey indices, 1977-2012. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1982 to 2011.

Year	DNR harvest	Modeled Harvest <sup>1</sup>	% Autumn Pop. Harvested <sup>2</sup>	Carcasses examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males <sup>3</sup>	Pelt price Females <sup>3</sup>
1982	912	1073	16	1073	66	19	15	9.4	46	41	52	46	\$70	\$99
1983	631	735	11	662	69	18	13	8.8	45	40	40	44	\$71	\$121
1984	1285	1332	18	1270	63	20	17	7.2	52	45	45	49	\$70	\$122
1985	678	735	10	712	63	20	18	5.4	46	40	34	43	\$74	\$130
1986	1068	1186	16	1186	59	24	18	5.3	48	50	37	46	\$84	\$162
1987	1642	1749	23	1534	63	15	22	4.7	46	40	37	43	\$84	\$170
1988	1025	1050	15	805	70	15	15	6.8	48	45	33	45	\$54	\$100
1989	1243	1243	17	1024	64	19	17	5.8	47	47	36	45	\$26	\$53
1990	746	756	10	592	65	14	21	4.5	44	55	30	43	\$35	\$46
1991	528	528	6	410	66	21	13	7.8	50	52	35	48	\$21	\$48
1992	778	782	8	629	58	21	21	4.9	42	55	45	46	\$16	\$29
1993	1159	1192	11	937	59	22	19	5.3	47	37	42	44	\$14	\$28
1994	1771	1932	16	1360	56	18	26	4	47	54	44	48	\$19	\$30
1995	942	1060	9	-	-	-	-	-	-	-	-	45	\$16	\$25
1996	1773	2000	15	-	-	-	-	-	-	-	-	45	\$25	\$34
1997	2761	2974	22	-	-	-	-	-	-	-	-	45	\$31	\$34
1998	2695	2987	23	-	-	-	-	-	-	-	-	45	\$19	\$22
1999	1725	1880	16	-	-	-	-	-	-	-	-	45	\$19	\$20
2000	1674	1900	15	-	-	-	-	-	-	-	-	45	\$20	\$19
2001	2145	2362	19	-	-	-	-	-	-	-	-	54	\$23	\$23
2002	2660	3028	24	-	-	-	-	-	-	-	-	54	\$27	\$25
2003	2521	2728	22	-	-	-	-	-	-	-	-	55	\$27	\$26
2004	2552	2753	23	-	-	-	-	-	-	-	-	52	\$30	\$27
2005	2388	2454	22	-	-	-	-	-	-	-	-	52	\$36	\$31
2006	3250	3500	33	-	-	-	-	-	-	-	-	51	\$76	\$68
2007	1682	1811	21	-	-	-	-	-	-	-	-	51	\$63	\$48
2008	1712	1828	22	-	-	-	-	-	-	-	-	52	\$22	\$37
2009	1259	1323	17	-	-	-	-	-	-	-	-	53	\$35	\$34
2010	903	951	12	759	52	25	23	4.3	54	53	49	52	\$38	\$37
2011	1473	1651	21	1314	46	28	26	3	56	50	39	50	\$48	\$40

<sup>1</sup> Includes DNR and Tribal harvests

<sup>2</sup> Estimated from population model, includes estimated non-reported harvest of 22% 1977-1992, and 10% from 1993-present.

<sup>3</sup> Average pelt price based on a survey of in-state fur buyers only.

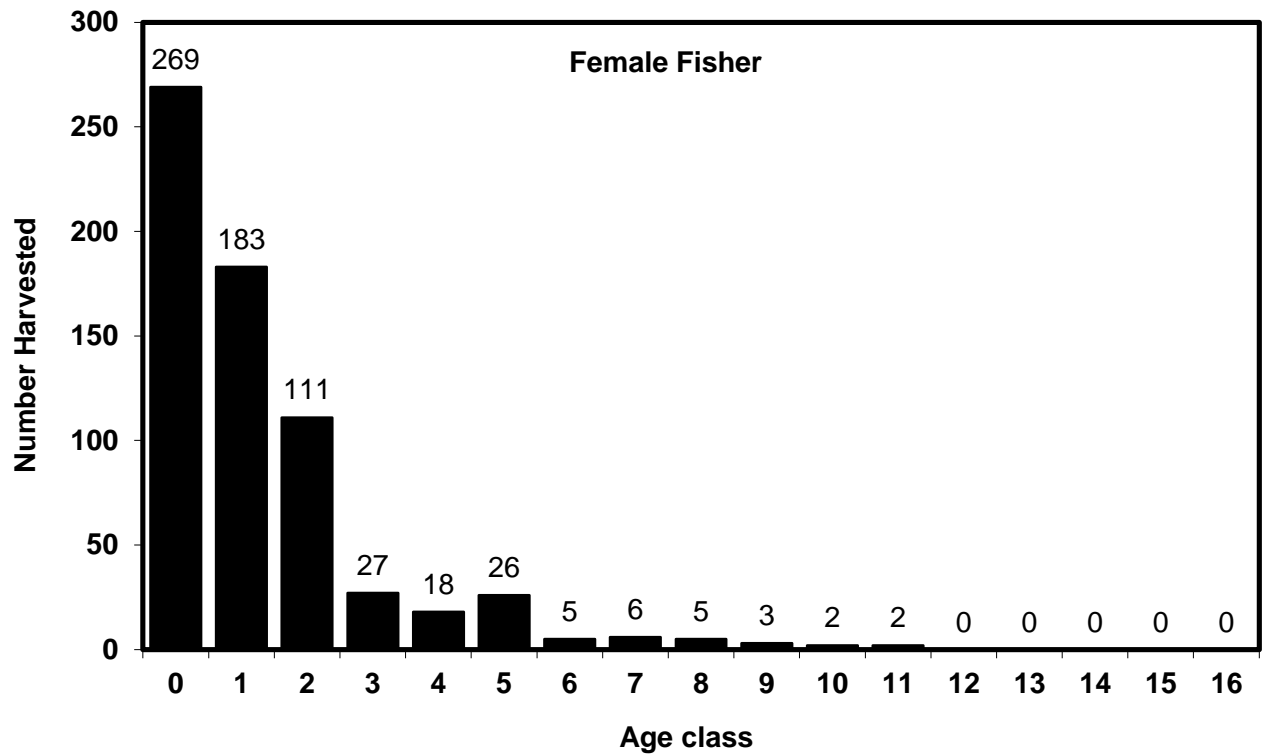


Figure 4. Age structure of female fishers in the 2011 harvest.

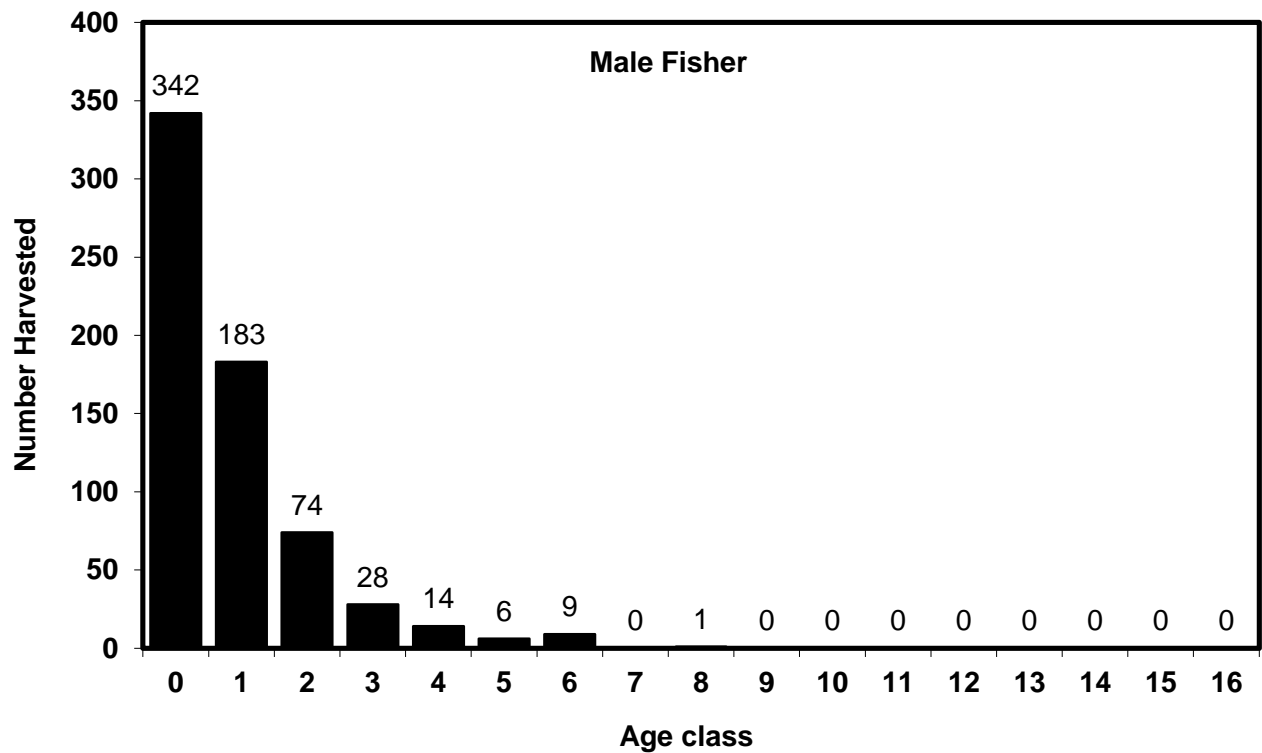


Figure 5. Age structure of male fishers in the 2011 harvest.

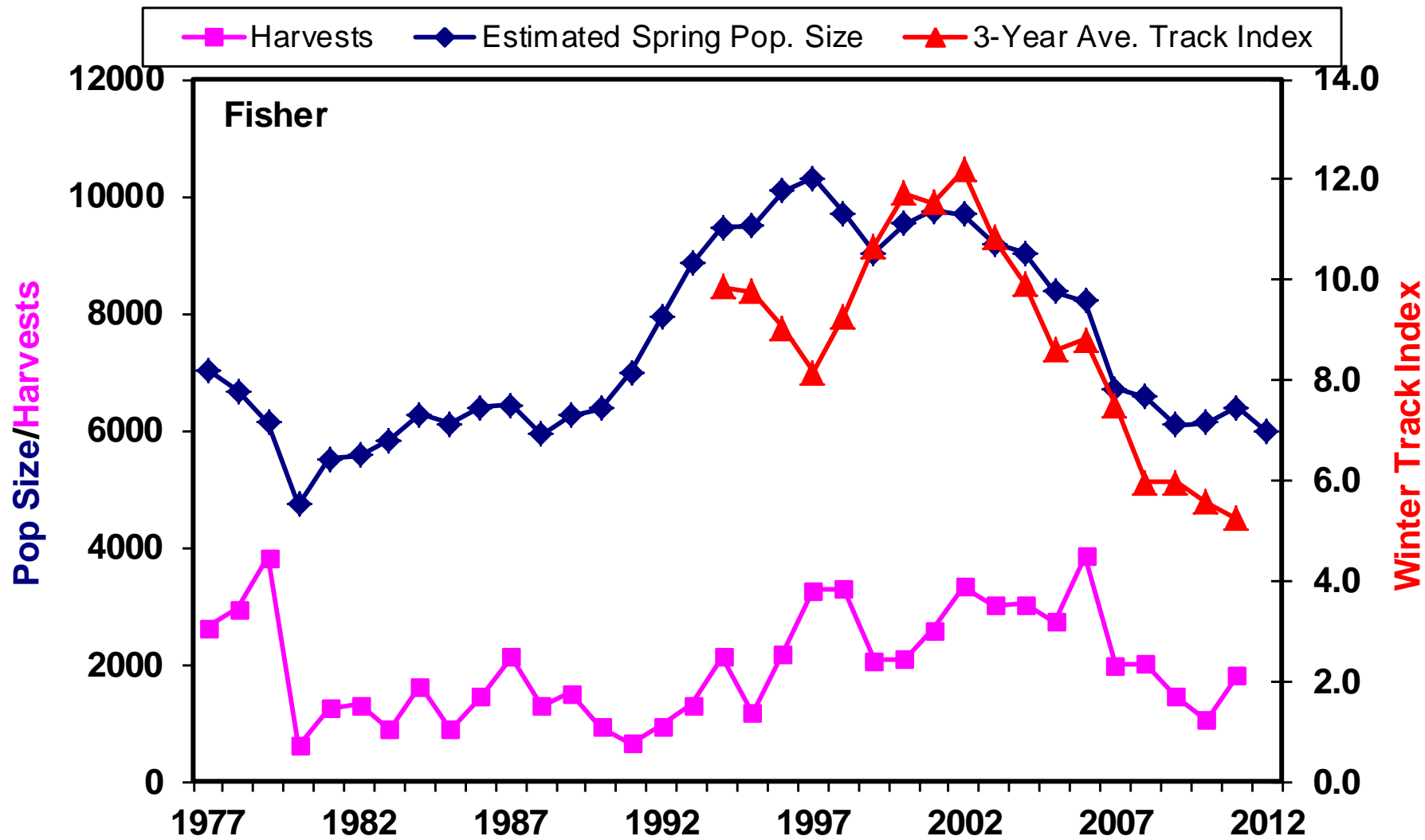


Figure 6. Fisher populations, harvests, and survey indices, 1977-2012. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2011.

Year	DNR harvest	Modeled Harvest <sup>1</sup>	% Autumn Pop. Harvested <sup>2</sup>	Carcasses Examined <sup>3</sup>	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males <sup>4</sup>	Pelt price Females <sup>4</sup>
1985	430	430	5	507	73	18	9	17.2	69	68	82	70	\$30	\$28
1986	798	798	9	884	64	21	15	12.3	65	71	81	69	\$36	\$27
1987	1363	1363	13	1754	66	18	16	11.2	65	67	75	67	\$43	\$39
1988	2072	2072	17	1977	66	11	23	8.6	58	50	66	59	\$50	\$43
1989	2119	2119	17	1014	68	12	20	9.7	57	63	65	59	\$48	\$47
1990	1349	1447	12	1375	48	18	34	3.6	59	54	61	59	\$44	\$41
1991	686	1000	9	716	74	9	17	16.1	69	71	72	70	\$40	\$27
1992	1602	1802	13	1661	65	18	17	15.1	63	70	75	66	\$28	\$25
1993	1438	1828	13	1396	57	20	23	7.5	61	71	67	64	\$36	\$30
1994	1527	1846	13	1452	58	15	27	6.4	62	76	67	66	\$34	\$28
1995	1500	1774	12	1393	60	18	22	8.2	63	68	66	65	\$28	\$21
1996	1625	2000	13	1372	48	22	30	4.8	62	69	67	65	\$34	\$29
1997	2261	2762	18	2238	61	13	26	6.2	60	60	63	61	\$28	\$22
1998	2299	2795	18	1577	57	18	25	6.6	62	66	65	63	\$20	\$16
1999	2423	3000	18	2013	67	12	21	9.8	65	66	67	66	\$25	\$21
2000	1629	2050	12	1598	56	25	19	8.9	62	69	66	64	\$28	\$21
2001	1940	2250	12	1895	62	15	23	11	66	73	75	69	\$24	\$23
2002	2839	3192	18	2451	39	30	31	3.1	57	63	61	60	\$28	\$27
2003	3214	3548	20	2391	48	17	35	4	57	65	66	62	\$30	\$27
2004	3241	3592	22	2776	26	28	46	1.3	52	64	57	58	\$31	\$27
2005	2653	2873	19	1992	53	16	31	4.9	64	63	65	64	\$37	\$32
2006	3788	4120	28	1914	64	17	20	9.2	66	67	65	66	\$74	\$66
2007	2221	2481	20	1355	30	29	41	1.5	56	64	50	56	\$59	\$50
2008	1823	1953	16	1095	40	21	39	2.1	58	60	53	56	\$31	\$28
2009	2073	2250	18	1252	55	16	29	4.9	65	46	61	61	\$27	\$30
2010	1842	1977	16	1202	47	29	25	4.1	69	54	60	63	\$40	\$37
2011	2525	2744	22	1615	39	25	36	2.6	63	63	59	62	\$42	\$39

<sup>1</sup> Includes DNR and Tribal harvests

<sup>2</sup> Estimated from population model; includes estimated non-reported harvest of 40% in 1985-1987 and 1991, 20% in 1988-1990 and 1992-1998, and 10% from 1999-present.

<sup>3</sup> Starting in 2005, the number of carcasses examined represents a random sample of ~ 70% of the carcasses collected in each year.

<sup>4</sup> Average pelt price based on a survey of in-state fur buyers only

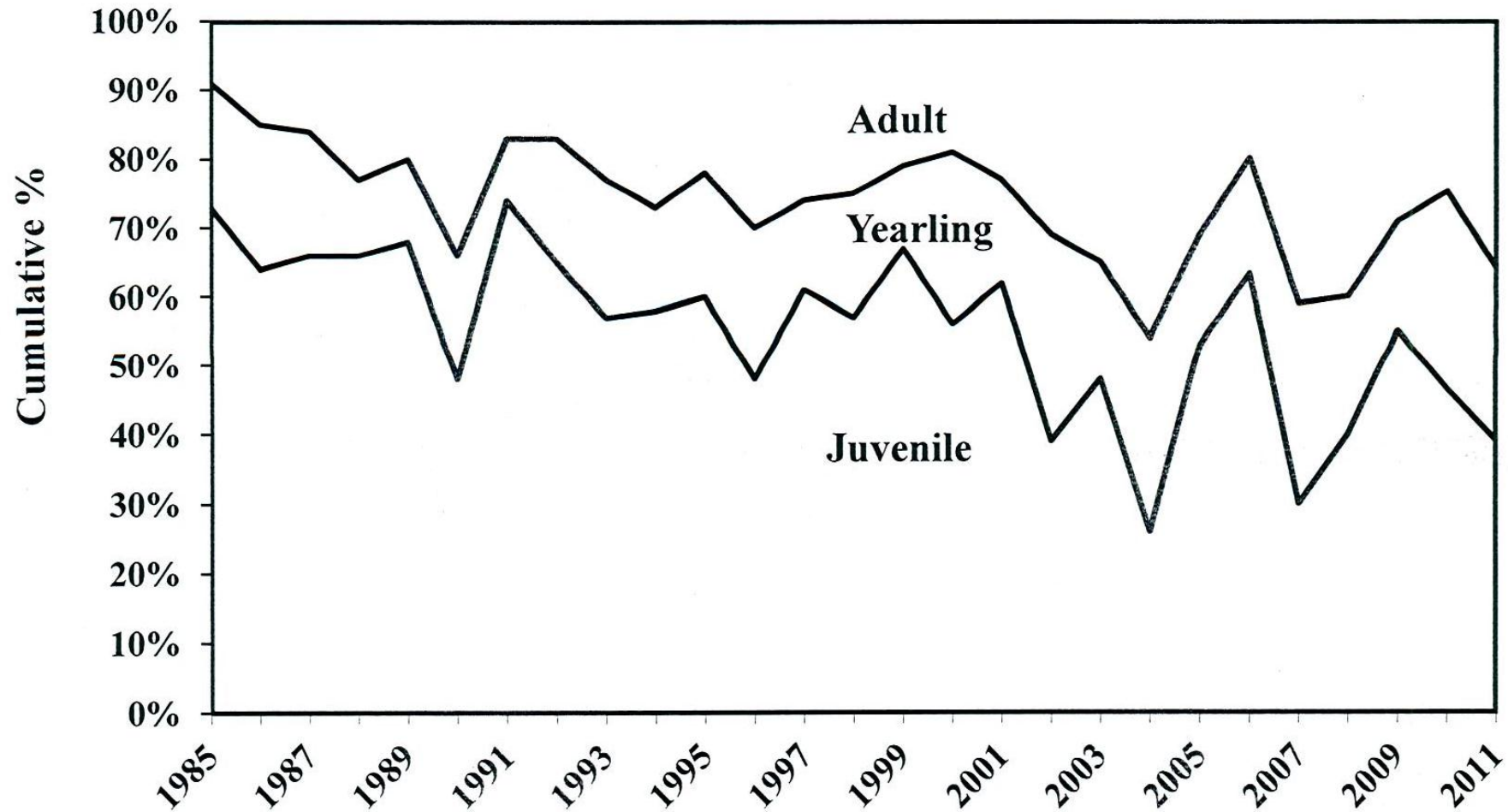


Figure 7. Marten harvest age-class proportions, 1985-2011.

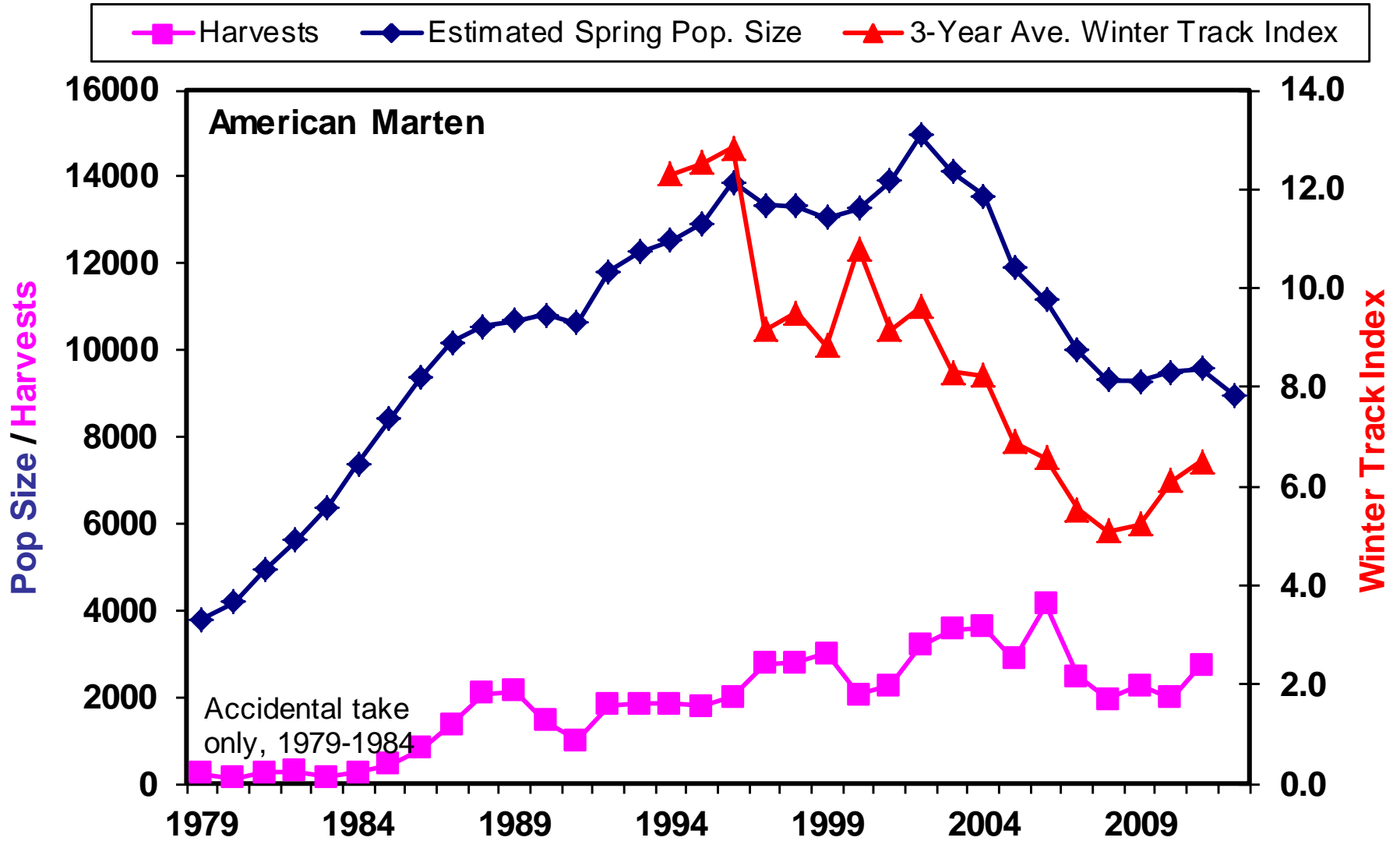


Figure 8. American marten populations, harvests, and survey indices, 1979-2012. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data<sup>1</sup>, 1982 to 2011. Carcasses were only collected from 1980-86.

Year	DNR harvest	Modeled Harvest <sup>1</sup>	% Autumn Pop. Harvested <sup>2</sup>	Carcasses examined	% juveniles	% yearlings	% adults	Juv:ad. females	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Otter <sup>3</sup>	Pelt price Beaver <sup>3</sup>
1982	385	625	9	389	51	26	23	6	57	65	65	60	\$26	\$11
1983	408	604	8	433	42	31	27	3.7	56	57	57	56	\$25	\$12
1984	529	561	7	549	48	23	29	3.2	47	50	49	49	\$22	\$12
1985	559	572	7	572	43	23	34	2.2	53	50	43	51	\$21	\$15
1986	777	777	8	745	45	23	32	2.7	45	48	46	47	\$24	\$20
1987	1386	1484	15	-	-	-	-	-	-	-	-	52	\$23	\$17
1988	922	922	9	-	-	-	-	-	-	-	-	52	\$22	\$14
1989	1294	1294	12	-	-	-	-	-	-	-	-	52	\$22	\$12
1990	888	903	8	-	-	-	-	-	-	-	-	52	\$24	\$9
1991	855	925	8	-	-	-	-	-	-	-	-	51	\$25	\$9
1992	1368	1365	10	-	-	-	-	-	-	-	-	52	\$30	\$7
1993	1459	1368	10	-	-	-	-	-	-	-	-	52	\$43	\$10
1994	2445	2708	19	-	-	-	-	-	-	-	-	52	\$48	\$14
1995	1435	1646	12	-	-	-	-	-	-	-	-	52	\$39	\$12
1996	2219	2500	18	-	-	-	-	-	-	-	-	52	\$39	\$19
1997	2145	2313	17	-	-	-	-	-	-	-	-	52	\$40	\$17
1998	1946	2139	16	-	-	-	-	-	-	-	-	52	\$34	\$13
1999	1635	1717	13	-	-	-	-	-	-	-	-	52	\$41	\$11
2000	1578	1750	13	-	-	-	-	-	-	-	-	52	\$51	\$14
2001	2301	2531	18	-	-	-	-	-	-	-	-	57	\$46	\$13
2002	2145	2390	16	-	-	-	-	-	-	-	-	59	\$61	\$10
2003	2766	2966	20	-	-	-	-	-	-	-	-	57	\$85	\$12
2004	3450	3700	25	-	-	-	-	-	-	-	-	56	\$87	\$14
2005	2846	3018	22	-	-	-	-	-	-	-	-	58	\$89	\$15
2006	2720	2873	22	-	-	-	-	-	-	-	-	56	\$43	\$17
2007	1861	1911	15	-	-	-	-	-	-	-	-	55	\$29	\$16
2008	1938	1983	15	-	-	-	-	-	-	-	-	59	\$24	\$12
2009	1544	1578	12	-	-	-	-	-	-	-	-	59	\$36	\$13
2010	1814	1830	13	-	-	-	-	-	-	-	-	57	\$35	\$13
2011	2294	2490	17	-	-	-	-	-	-	-	-	58	\$51	\$17

<sup>1</sup> Includes DNR and Tribal harvests

<sup>2</sup> Estimated from population model. Incl. estimated non-reported harvest of 30% to 1991, 22% from 1992-2001, and 10% from 2002-present.

<sup>3</sup> Weighted average of spring (beaver only) and fall prices based on a survey of in-state fur buyers.



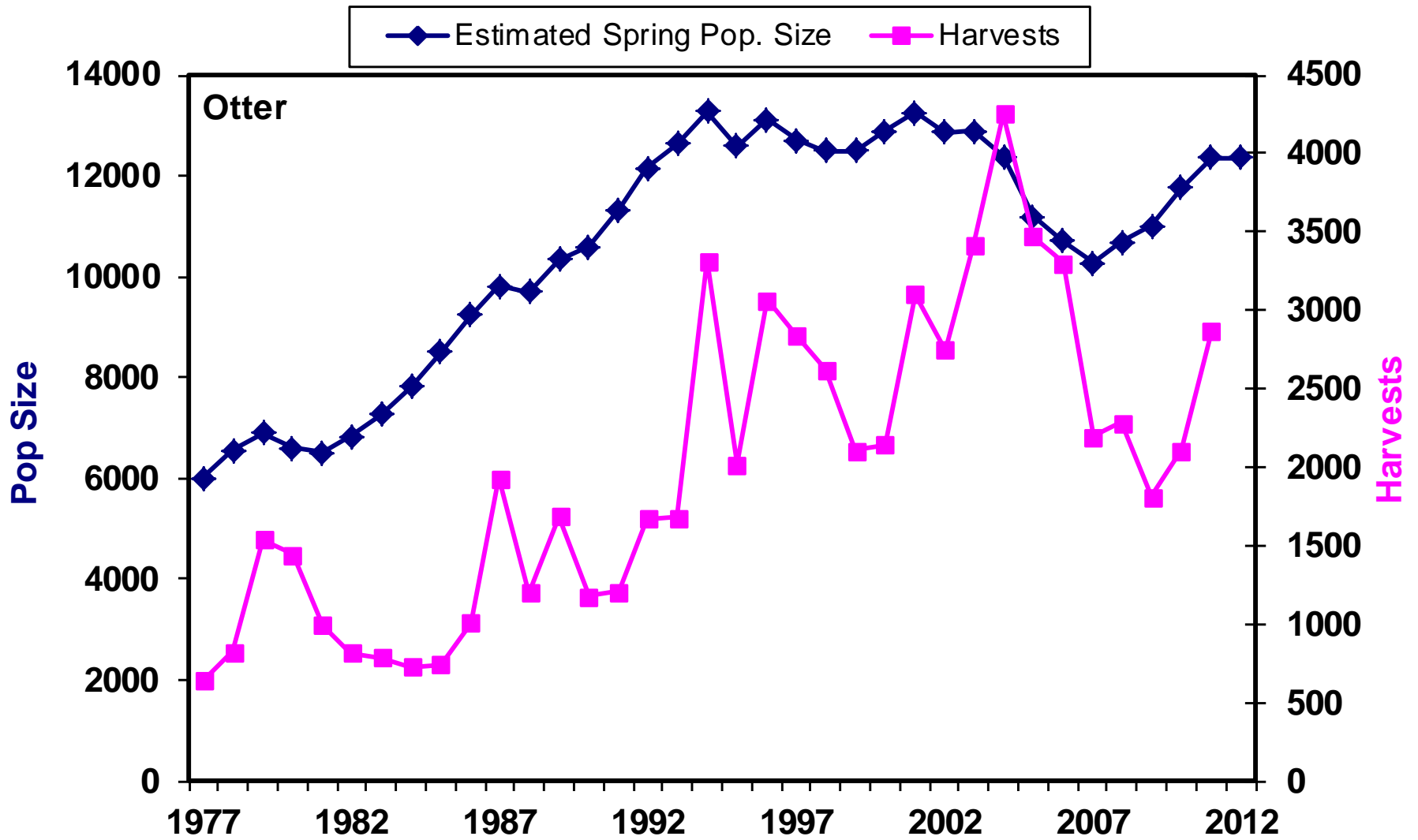


Figure 9. Otter populations and harvests, 1977-2012. Harvests include an estimate of non-reported take.

# 2012 AERIAL MOOSE SURVEY

Mark S. Lenarz, Forest Wildlife Populations and Research Group

## 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 to determine population trends and set the harvest quota for the subsequent hunting season

## 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 2009. 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 (OH-58) helicopters used to conduct the survey. We sexed moose using the presence of antlers and or presence of a vulval patch (Mitchell 1970), and identified calves on the basis of size and behavior. We used the program DNRSurvey on Toughbook<sup>®</sup> tablet style computers to record survey data. DNRSurvey allowed us to display transect lines superimposed on a background of aerial photography, observe the aircraft's flight path over this background in real time, and record data using a tablet pen with a menu-driven data entry form.

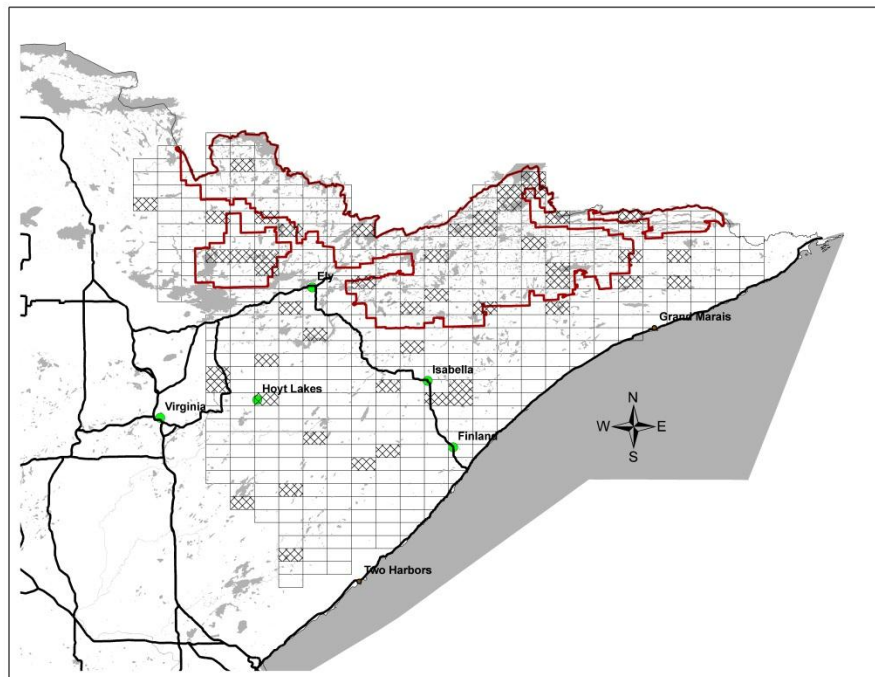


Figure 1. Northeast moose survey area and sample plots (cross hatching) flown in the 2012 aerial moose survey. The red line delineates the boundary of the Boundary Waters Canoe Area Wilderness.

In previous years, we used 3 strata based on expected moose density in an effort to optimize precision of our survey estimates. In 2012, we added a 4<sup>th</sup> stratum to represent a series of 9 plots that have undergone disturbance (wild fire, prescribed burning, timber harvest). Each year, these same 9 plots will be surveyed in an effort to evaluate the effect of disturbance on moose density.

We accounted for visibility bias by using a sightability model (Giudice et al. 2012). 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 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 (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, VO was based on the first moose sighted. We used uncorrected estimates (no visibility bias correction) of bulls, cows, and calves to calculate the bull:cow and calf:cow ratios.

Recent research indicated that variance calculations used in earlier analyses underestimated the total variance of survey estimates (Fieberg in press). We reanalyzed survey data 2004-2011 using the package SightabilityModel in Program R (Fieberg in press, R Development Core Team 2011) to recalculate confidence intervals. Based on this approach, confidence intervals are asymmetrical around the estimates. Minor corrections to our sightability model also modified population estimates slightly (0-4%) from those reported in previous reports.

## RESULTS AND DISCUSSION

We initiated the survey on 26 January and completed it on 9 February. Normally the survey begins in early January but the start was delayed because of insufficient snow on the ground in western portions of the survey area. Observers rated survey conditions as “marginal” (low rank) on 17 plots, and “good” (highest rank) on 32 plots. Snow conditions for the survey were <8” on 7 plots, between 8” and 16” on 26 plots, and >16” on 16 plots. During the survey flights, observers located 344 moose on the 49 plots (653 mi<sup>2</sup>) including 144 bulls, 140 cows, 55 calves, and 5 unidentified moose. After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 4,230 (3,190 – 5,600) animals (Table 1). Estimates of the calf:cow and bull:cow ratios were 0.36 and 1.08, respectively (Table 1).

Table 1. Estimated moose numbers, 90% confidence interval, calves:cow, % calves, % cows with twins, and bulls:cow from aerial surveys in northeastern Minnesota.

Survey	Estimate	90% Confidence Interval	Calves: Cow	% Calves	% Cows w/ twins	Bulls: Cow
2005	8,160	5,960 – 11,170	0.52	19	9	1.04
2006	8,840	6,670 – 11,710	0.34	13	5	1.09
2007	6,860	5,230 – 9,000	0.29	13	3	0.89
2008	7,890	5,970 – 10,420	0.36	17	2	0.77
2009	7,840	6,190 – 9,910	0.32	14	2	0.94
2010	5,700	4,480 – 7,250	0.28	13	3	0.83
2011	4,900	3,810 – 6,290	0.24	13	1	0.64
2012	4,230	3,190 – 5,600	0.36	15	6	1.08

The 2012 population estimate was 14% lower than the 2011 estimate but the overlap in confidence intervals (Table 1, Figure 2) indicates no statistical difference between the two estimates. Gasaway and Dubois (1987) indicated that even with precise survey estimates, a change of 20% may be required to detect a significant change in population size. Time series analysis of estimates since 2005 indicates a significant downward trend (Figure 2,  $P = 0.004$ ). This corroborates several data sets that suggest the northeastern Minnesota moose population is declining. Lenarz et al, (2010), for example, used simulation modeling to integrate survival and reproductive rates measured between 2002 and 2008 and found that the population was decreasing approximately 15% per year over the long term.

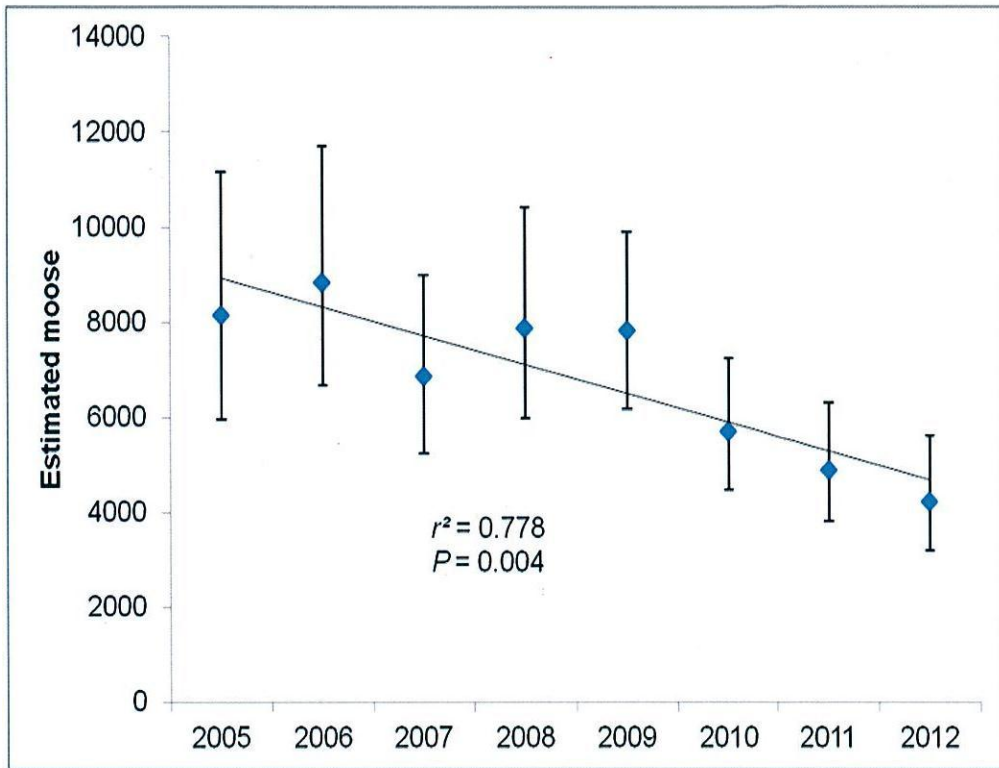


Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2012.

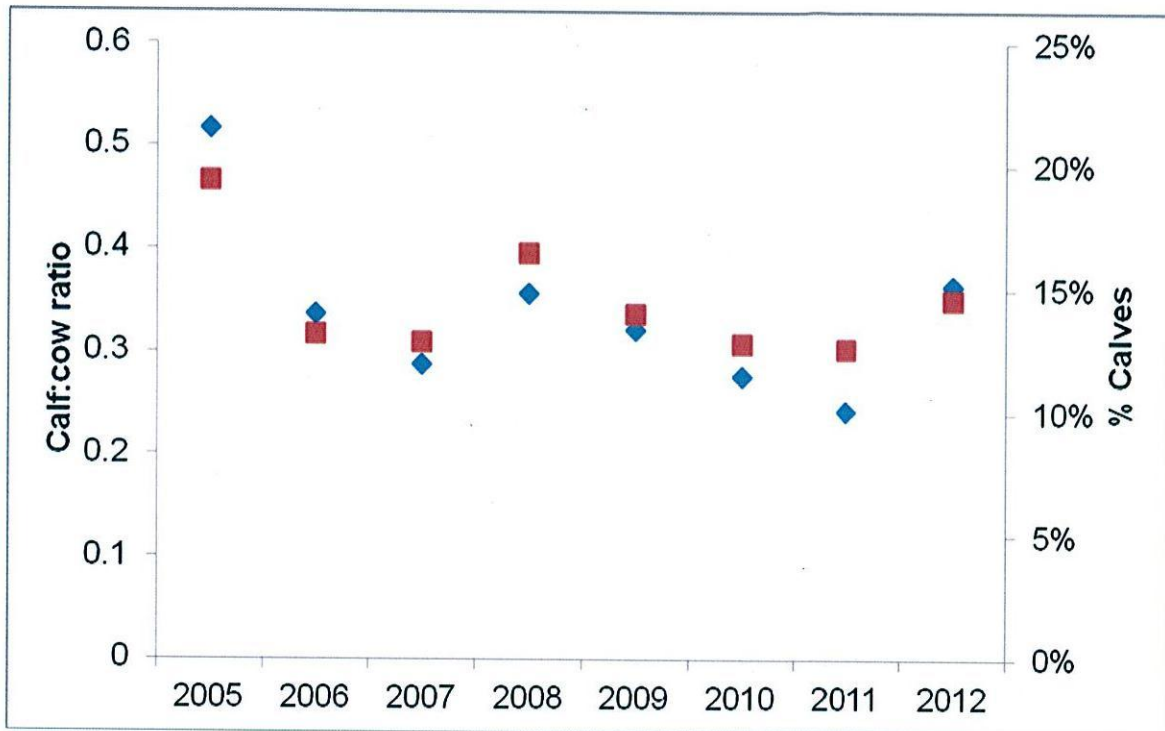


Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota.

Estimated recruitment from this year's survey was the highest it has been since 2005 (Table 1). The calf:cow ratio in early February was 0.36 and calves represented 15% of the total moose observed (Table 1). Almost 6% of the cow moose were accompanied by twins (Table 1), up over 5% from 2011. This increase undoubtedly contributed to this year's increased recruitment and it is likely that survival of single calves increased as well. The close agreement between calf:cow ratio and % calves (Figure 3,  $r = 0.94$ ,  $P < 0.001$ ) suggests that classification of adult moose to sex is accurate. Despite the improvement to recruitment, it is important to note, that adult survival is much more important to the population growth rate than calf survival (Lenarz et al. 2010).

The estimated bull:cow ratio (Table 1; Figure 4) increased considerably since 2011 and this suggests that numbers of adult males and females were roughly equal. This year's survey was delayed approximately 3½ weeks and fewer than normal antlered bulls were observed (<10% vs. 20-30%). It is unlikely that the absence of antlers biased the bull:cow ratio higher because cows would have had to be misclassified as bulls, an unlikely consequence of the absence of antlers. Moreover, the close agreement between calf:cow ratio and % calves (Figure 3) suggests that cows were correctly classified.

Several authors have indicated that moose move into thicker conifer cover as the winter progresses and are more difficult to observe (Gasaway et al 1986, Peterson and Page 1993). During the 2012 survey, however, the mean VO was 36 which was within the range observed in previous years (30 – 44). Presumably the moose have not shifted into the thicker cover because of a warmer than normal winter with lower snow depths. Our use of a sightability model should

correct for sightability bias even if the moose had shifted to denser conifer cover. It is unlikely, therefore, that the late start of this year's survey biased the population estimates.

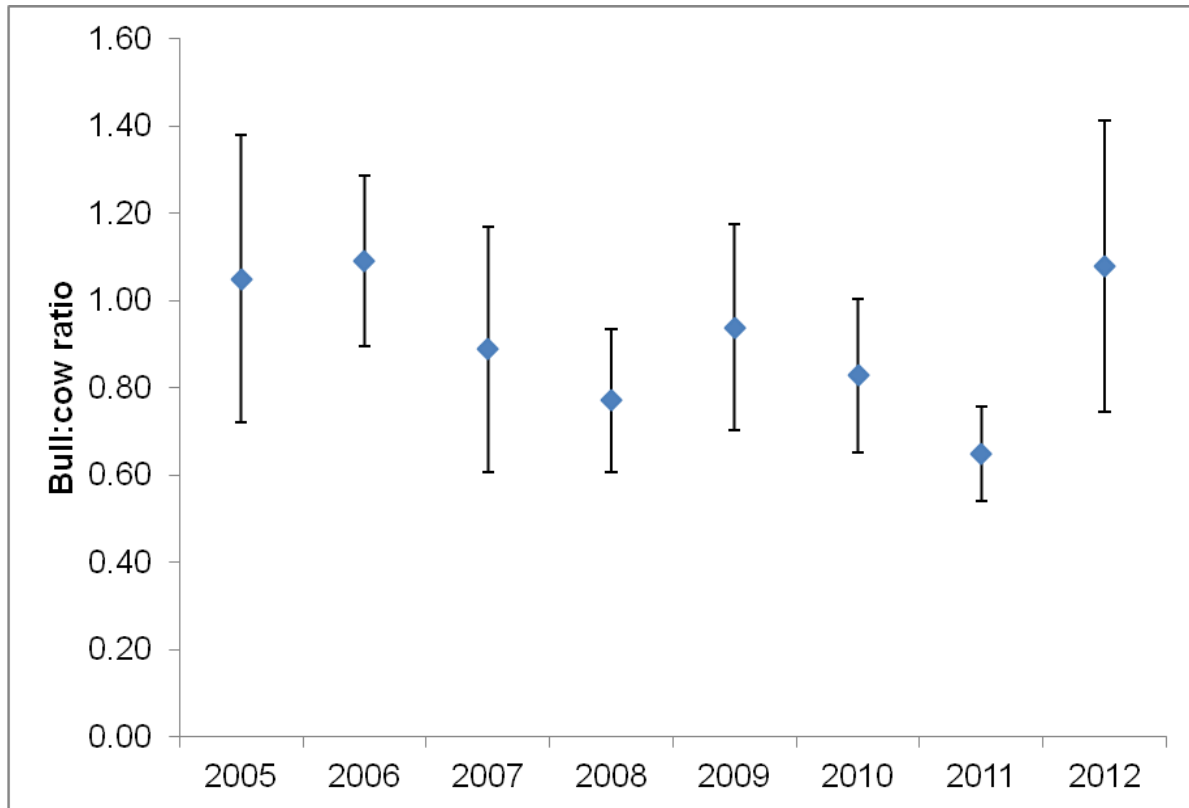


Figure 4. Estimated bull:cow ratio from aerial moose surveys in northeastern Minnesota.

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