FOREST WILDLIFE POPULATIONS

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GROUSE SURVEYS IN MINNESOTA DURING SPRING 2011

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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 2011. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.7 (95% confidence interval = 1.5–1.9) drums per stop (dps). That was between the mean counts of 2.0 (1.8–2.3) and 1.5 (1.3–1.7) dps observed during 2009 and 2010, respectively, indicating that densities of ruffed grouse likely remain high relative to the 10-year population cycle in Minnesota.

During the spring 2011 survey 2,212 sharp-tailed grouse were observed at 216 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 7.8 (6.7–8.9) in the East Central survey region, 11.2 (10.2–12.2) in the Northwest region, and 10.2 (9.5–11.1) statewide. Counts among dancing grounds observed during both 2010 and 2011 declined 17% (8–25%), but the statewide index value for 2011 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^2, MOP = 21,468 km^2, NSU = 24,160 km^2, DLP = 33,955 km^2, WSU = 14,158 km^2, MIM = 20,886 km^2, and PP = 5,212 km^2). 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^{th} and 97.5^{th} 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 ≥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 125 routes between 12 April and 17 May 2011. Most routes (95%) were run between 21 April and 11 May. The median date this year (3 May) was 10 days later than during 2010 but only 2 days later than during 2009, which was consistent with much spring phenology occurring relatively early during 2010. Observers reported survey conditions as Excellent, Good, and Fair on 60%, 34%, and 6% of 124 routes, respectively. The distribution of survey conditions has been consistent for at least the last 5 years. Survey cooperators included the DNR Divisions of Fish & Wildlife, Forestry, and Parks and 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 1.7 (95% confidence interval = 1.5–1.9) drums per stop (dps) during 2011. Drum counts by survey region during 2011 were 1.9 (1.6–2.2) dps in the Northeast (n = 104 routes), 2.1 (1.9–2.4) dps in the Northwest (n = 8), 0.8 (0.5–1.2) dps in the Central Hardwoods (n = 14), and 0.4 (0.1–0.8) dps in the Southeast (n = 7) (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 between the mean counts of 2.0 (1.8–2.3) and 1.5 (1.3–1.7) dps observed during 2009 and 2010, respectively, indicating that the grouse population likely remains high relative to the 10-year population cycle. Similar inconsistent fluctuations in drum counts during years near the peak of the population cycle have occurred in the past (e.g., late-1950s and late-1970s; Figure 3). 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.

Observations from 8 weeks of daily surveys of drumming grouse for a research project in northern Minnesota during the springs of 2009 and 2010 provided additional insight about survey conditions and the status of the grouse population during those years. The research observations indicated that during the unusually warm weather of April 2010 drumming activity declined during weeks when typically it would be high (Meadow Kouffeld, University of Minnesota, unpublished data). That could have resulted in a lower proportion of male grouse being detected during DNR surveys in 2010 compared to other years. The estimated densities of male grouse on the study area was lower during 2010 than 2009, but the difference was not statistically significant. Estimates of ruffed grouse harvest from the Small Game Hunter Survey, when they are available in late-summer, also may provide insights about the relative status of the grouse population during 2010 compared to 2009.

Sharp-tailed Grouse

A total of 2,212 sharp-tailed grouse was observed at 216 dancing grounds with ≥2 male grouse (or grouse of unknown sex) during spring 2011. Leks with ≥2 grouse were visited a mean of 1.6 times. There were 468 grouse on 60 leks in the EC survey region and 1,744 grouse on 156 leks in the NW region. The index value (i.e., grouse/lek) in both regions declined slightly from 2010 (Table 1), and counts at leks observed during both years declined 17% (8–25%, Table 2). The statewide index value of 10.2 (9.5–11.1) 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. 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. I also thank Laura Gilbert for helping with data entry and archiving and Glenn DelGiudice and Mark Lenarz for reviewing a draft of this report and suggesting revisions that improved it.

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

	Statewide			Northwest[a]			East Central[a]		
Year	Mean	95% CI[b]	*n*[c]	Mean	95% CI[b]	*n*[c]	Mean	95%CI[b]	*n*[c]
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

[a] Survey regions; see Figure 1.
[b] 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.
[c] *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.

	Statewide			Northwest[a]			East Central[a]		
Comparison[b]	Mean	95% CI[c]	*n*[d]	Mean	95% CI[c]	*n*[d]	Mean	95%CI[c]	*n*[d]
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

[a] Survey regions; see Figure 1.
[b] Consecutive years for which comparable leks were compared.
[c] 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.
[d] *n* = number of dancing grounds in the sample.

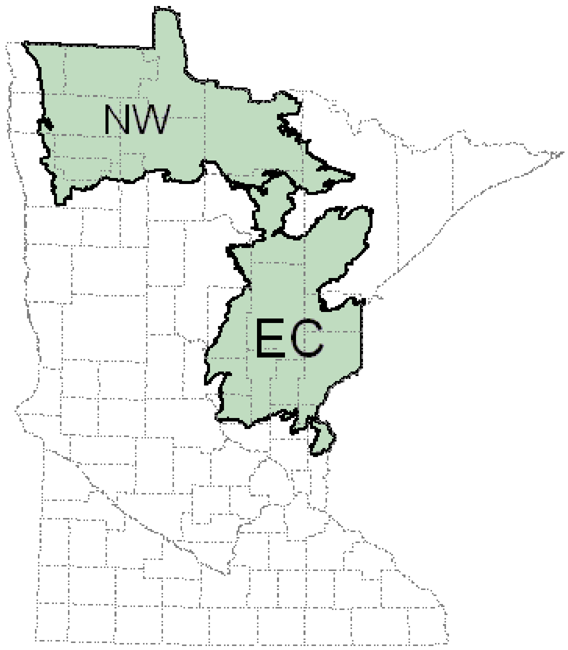

Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** relative to county boundaries in Minnesota. The regions were based largely on boundaries of ECS Subsections.

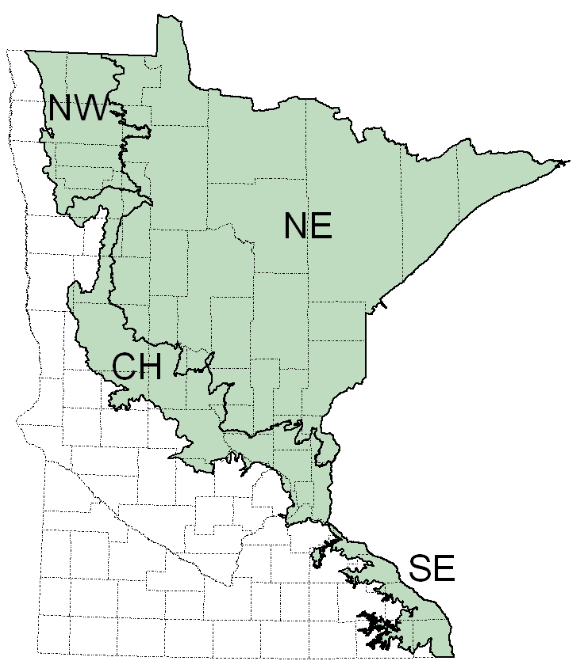

Figure 2. Survey regions for **ruffed grouse** (shaded, curved boundaries) relative to county boundaries (dashed lines) in Minnesota. The regions are based on the Ecological Classification System.

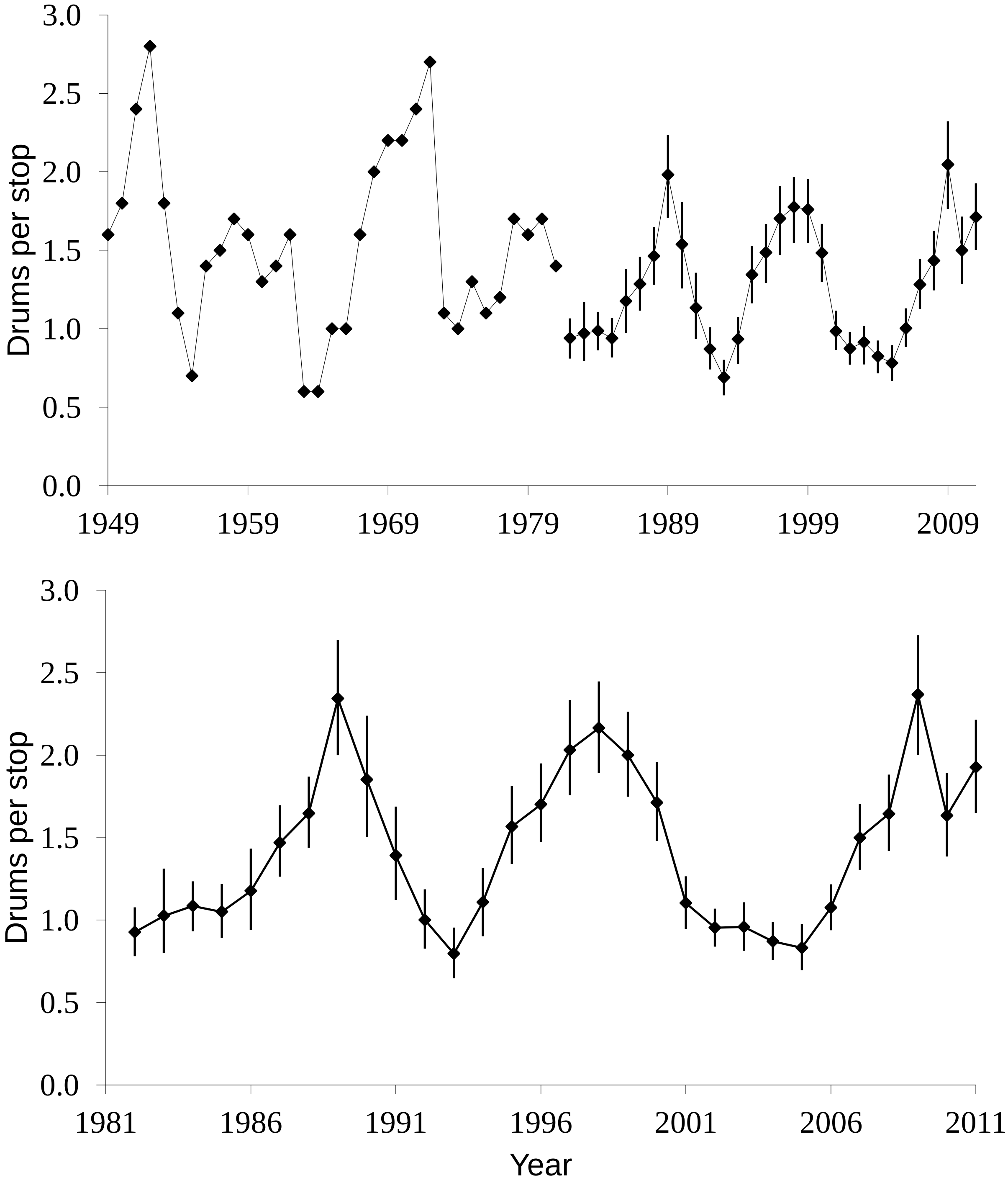

Figure 3. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current weighted average and bootstrapping methods, 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.

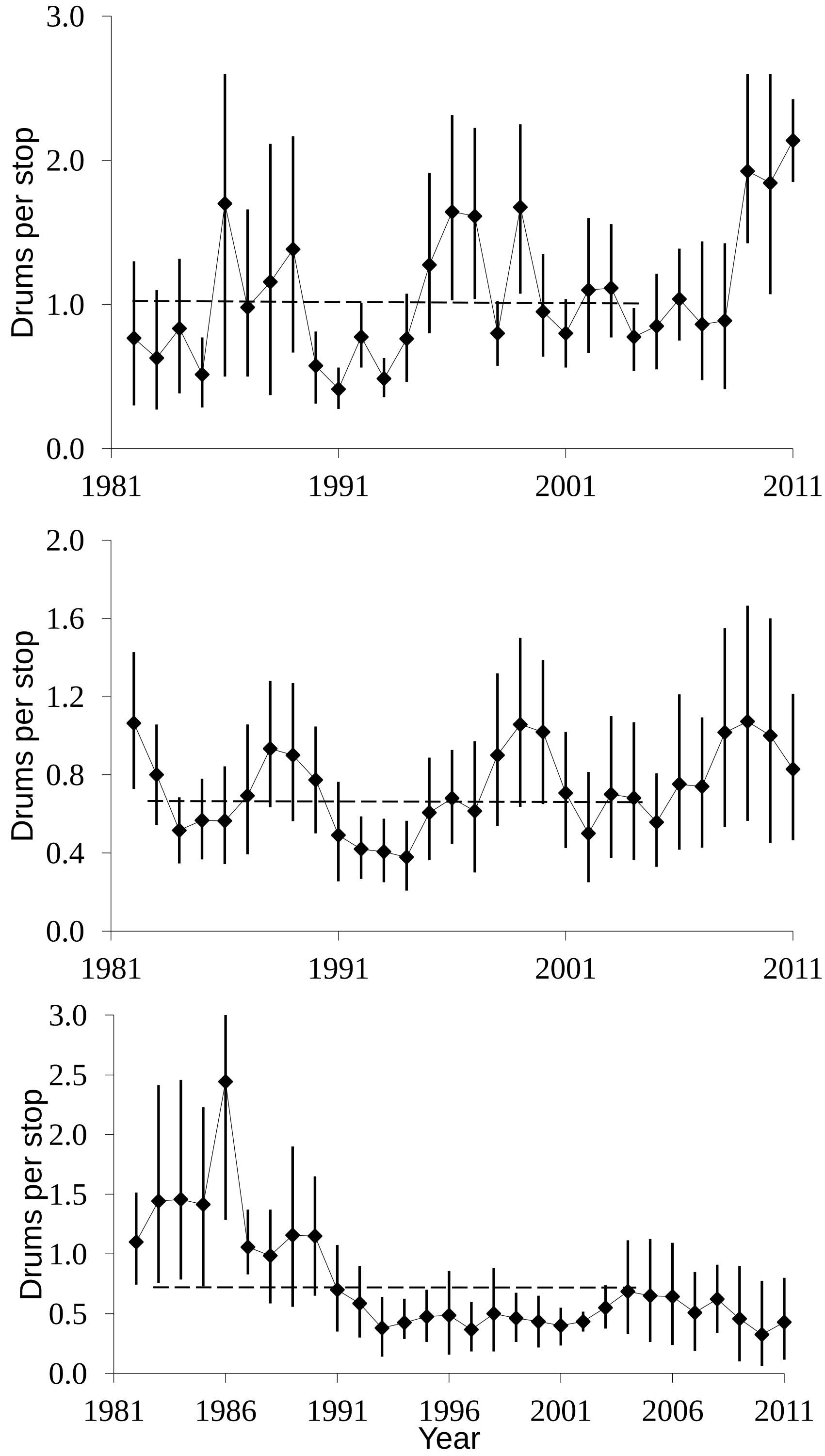

Figure 4. Ruffed grouse drum count index values in the **Northwest** (top), **Central Hardwoods** (middle), and **Southeast** (bottom) survey regions of Minnesota. Dashed horizontal lines indicate the mean from 1984 to 2004. Vertical error bars represent 95% confidence intervals based on bootstrap samples.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

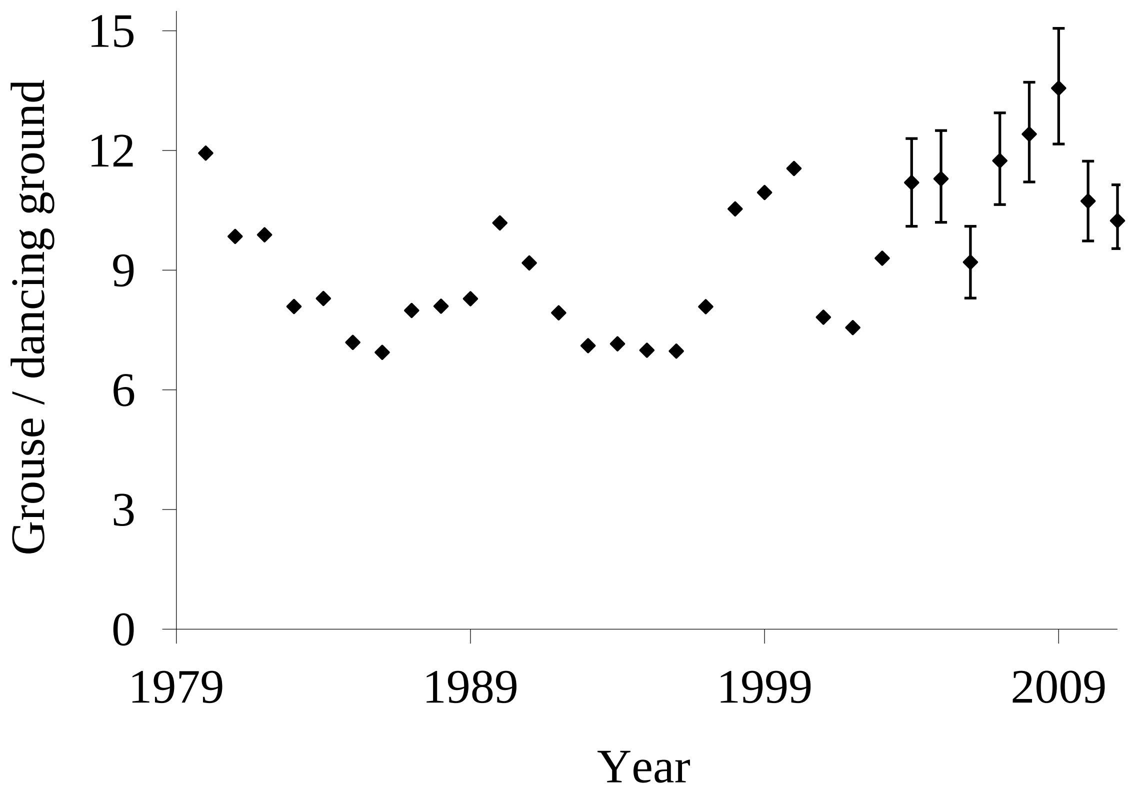

Figure 5. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds, 1980–2011. Vertical error bars, which were calculated only for recent years, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.

PRAIRIE-CHICKEN SURVEY IN MINNESOTA DURING 2011

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SUMMARY OF FINDINGS

Surveys for greater prairie-chickens (*Tympanuchus cupido pinnatus*) were conducted during April and May of 2011. Ditches and many roads within the prairie-chicken range were impassable during April due to a wet fall, high snow accumulation during winter, and rains during early spring. Water levels in many wetland basins were higher than ever, and flooding of homes and farm buildings was not uncommon (Doug Hedtke, MNDNR, and Brian Winter, The Nature Conservancy, personal communications).

Observers located 81 booming grounds and counted 627 male prairie-chickens, including birds of unknown sex. Counts from several survey blocks were not available for analysis at the time of this report, so I did not calculate range-wide densities of booming grounds or prairie-chickens because they would not be comparable to estimates from previous years. Within survey blocks for which counts were available, however, the total numbers of booming grounds and male prairie-chickens were less than they were during 2010.

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^2 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 4 cooperating organizations and many unaffiliated volunteers counted prairie-chickens during April and May 2011. Cooperators included the DNR Division of Fish and Wildlife, the Fergus Falls and Detroit Lakes Wetland Management Districts (U.S. Fish & Wildlife Service), The Nature Conservancy, and the Minnesota Prairie Chicken Society. Ditches and many roads within the prairie-chicken range were impassable during April due to a wet fall, high snow accumulation during winter, and rains during early spring. Water levels in many wetland basins were higher than ever, and flooding of homes and farm buildings was not uncommon (Doug Hedtke, MNDNR, and Brian Winter, The Nature Conservancy, personal communications).

Observers located 81 booming grounds and counted 627 male prairie-chickens during 2011 (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.

Each booming ground was observed on a median of 2 (mean = 2.0) different days, and 35% of booming grounds were observed only once during 2011. 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.

Table 1. Minimum abundance of prairie-chickens within and outside of hunting permit areas in western Minnesota during spring 2011. Counts of booming grounds and birds are not comparable among permit areas or years.

Permit Area	Area (km^2)	Booming grounds	Males	Unk.[a]
801A	603	0	0	0
802A	826	7	61	0
803A	668	0	0	0
804A	435	0	0	0
805A	267	8	89	0
806A	749	9	43	12
807A	440	20	216	0
808A	NA[b]	NA[b]	NA[b]	NA[b]
809A	NA[b]	NA[b]	NA[b]	NA[b]
810A	505	9	74	1
811A	704	7	25	24
PA subtotal[c]	5,197	60	508	37
Outside PAs[d]	NA[e]	21	119	45
Grand total	NA[e]	81	627	82

[a] Unk. = prairie-chickens of unknown sex. It is likely that most were males.
[b] NA = not applicable. Counts were made but not available for this report.
[c] Sum among 9 of the 11 permit areas (PA).
[d] Counts from outside the permit areas (PA).
[e] NA = not applicable. The size of the area outside permit areas was not defined.

Within survey blocks we counted 482 males, including birds of unknown sex, on 58 booming grounds during 2011 (Table 2). Booming grounds were defined as having ≥2 males, so observations of single males were excluded from summaries by survey block. Although comparable estimated densities of booming grounds and prairie-chickens during spring of 2011 are not available at this time, I provided estimates for those indexes for previous years of the survey (Figure 3).

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

			2011		Change from 2010[a]	
Range[b]	Survey Block	Area (km^2)	Booming grounds	Males[c]	Booming grounds	Males[c]
Core	Polk 1	41.2	7	61	0	10
	Polk 2	42.0	8	89	-1	27
	Norman 1	42.0	4	21	1	-7
	Norman 2	42.2	6	46	-1	-11
	Norman 3	41.0	11	101	-2	-4
	Clay 1		NA[d]	NA[d]	NA[d]	NA[d]
	Clay 2		NA[d]	NA[d]	NA[d]	NA[d]
	Clay 3		NA[d]	NA[d]	NA[d]	NA[d]
	Clay 4		NA[d]	NA[d]	NA[d]	NA[d]
	Wilkin 1	40.0	5	47	0	-12
	Core subtotal	248.4[e]	4[e]	365[e]	-27[e]	-282[e]
Periphery	Mahnomen	41.7	4	31	0	-15
	Becker 1	41.4	4	36	-2	-9
	Becker 2		NA[d]	NA[d]	NA[d]	NA[d]
	Wilkin 2		NA[d]	NA[d]	NA[d]	NA[d]
	Wilkin 3	42.0	5	26	2	-19
	Otter Tail 1	41.0	1	9	-1	-7
	Otter Tail 2	40.7	3	15	2	1
	Periphery subtotal	206.8[e]	17[e]	117[e]	-4[e]	-92[e]
Grand total		455.2[e]	58[e]	482[e]	-31[e]	-374[e]

[a] The 2010 count was subtracted from the 2011 count, so a negative value indicates a decline.
[b] 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.
[c] Includes birds recorded as being of unknown sex but excludes lone males not observed at a booming ground.
[d] Surveys were conducted in these blocks, but the counts were not available for analysis at the time this report was written.
[e] These sums reflect only the blocks for which count data were available.

ACKNOWLEDGEMENTS

I sincerely appreciate the efforts of all the DNR staff and volunteer cooperators who conducted and helped coordinate the prairie-chicken survey. I thank Wes Bailey and Mark Lenarz for reviewing a draft of this report. 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.

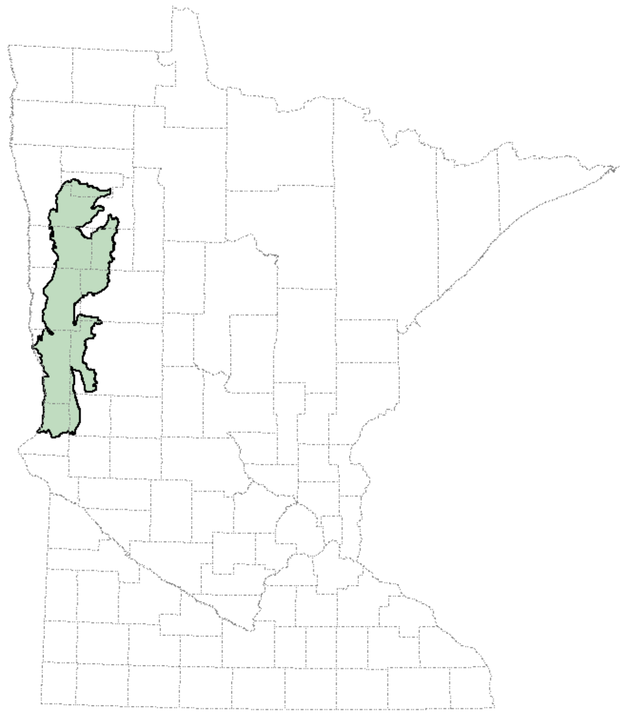

Figure 1. Primary range of greater prairie-chickens (shaded area) relative to county boundaries in Minnesota. This range boundary was based on ECS Land Type Associations and does not include all areas that are known to be occupied by prairie-chickens.

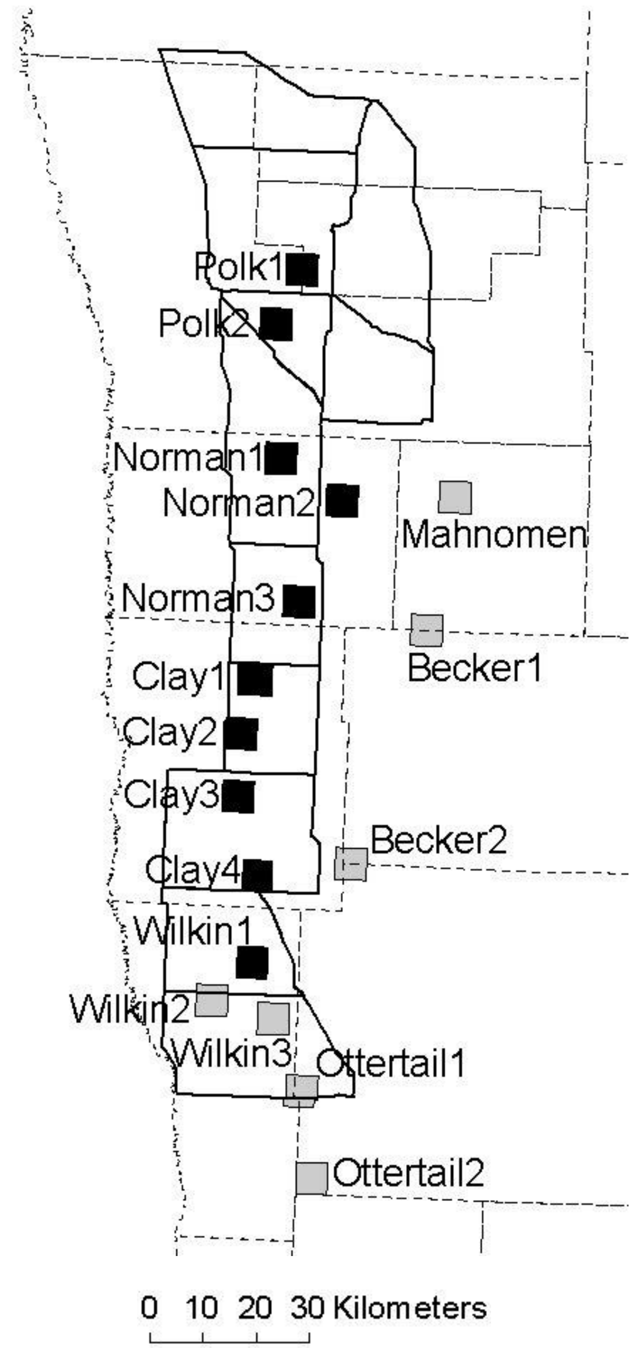

Figure 2. Survey blocks (41 km^2, labeled squares) and hunting permit area boundaries (solid lines) for prairie-chickens in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which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

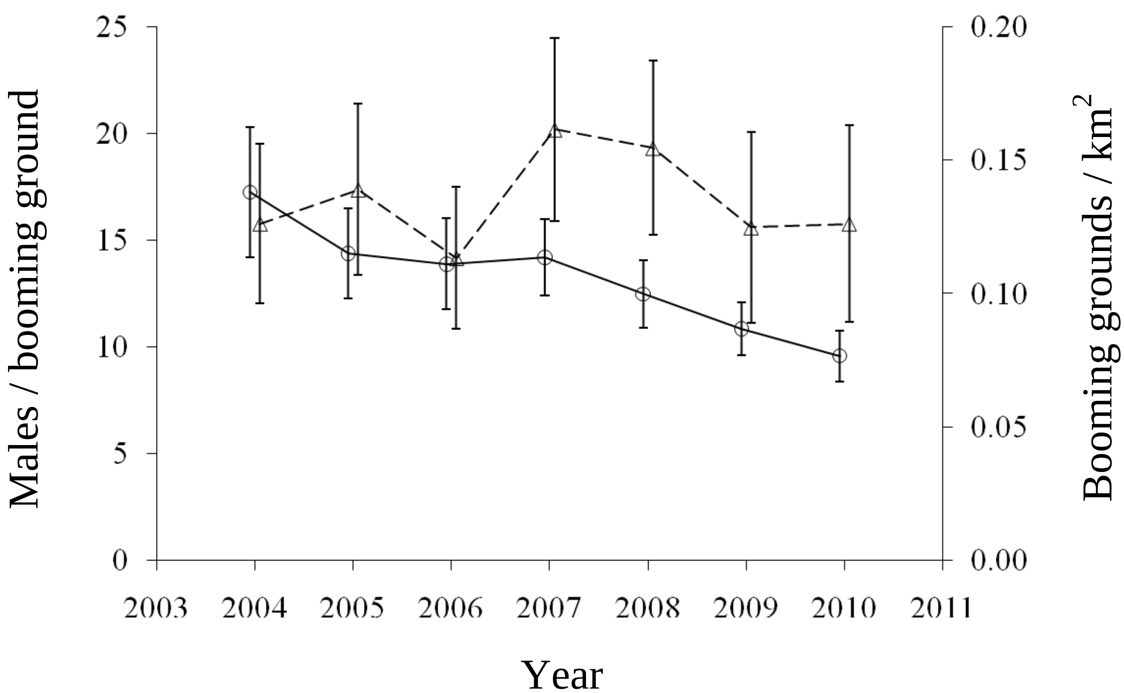

Figure 3. Number of prairie-chicken males/booming ground (circles connected by solid line) and booming grounds/km^2 (triangles connected by dashed line) observed in 17 41-km^2 survey blocks in western Minnesota. Vertical error bars represent 95% confidence intervals. The average densities during the 10 years preceding recent hunting seasons (i.e., 1993–2002) were 11.5 (10.1–12.9) males/booming ground 0.08 (0.06–0.09) booming grounds/km^2.

Drawing by Gilbert Proulx

REGISTERED FURBEARER POPULATION MODELING 2011 REPORT

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 2010 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 2010 registered DNR trapping and hunting harvest reached a new record level (1,012), 14% higher than the previous record in 2006 (890; Table 1). Total modeled harvest, which includes reported tribal take, was 1,042. The juvenile to adult female ratio in the harvest (1.4; Table 1) was near the long-term average (1.5) and higher than the recent 10-year average (1.1). A total of 955 bobcat carcasses were examined (Table 1), with a mean age of 2.7 for females. Approximately 9% of the harvested female bobcats were ≥ 6.5 years old (Figure 1).

Based on examination of reproductive tracts, 27% of yearling females produced a litter in 2010, identical to the 8-year average (Figure 2). Average litter size for pregnant yearlings was 2.1, similar to the recent 8-year average (2.2). Pregnancy rate for 2+ year olds was 79%, slightly above the previous 8-year mean (75%). Mean litter size for pregnant adults was 2.7 (7-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 since data collection resumed in 2003.

Based on the recently recalibrated bobcat population model, 26% of the 2010 fall population was harvested. Due to indications that the 2010-11 winter had a negative impact on bobcats, overwinter survival of kittens was reduced by 10%. As a result of the high harvest and assumed reduction in kitten overwinter survival, population modeling projects an 11% decline in the bobcat population (Figure 3), with an estimated 2011 spring population size of ~ 2,700 (Figure 3). Harvests and both track indices remain at or near record levels (Figure 3).

Fisher. For the past 3 years, the fisher harvest season has been 1 week shorter than 'normal' (i.e., shortened from 16 days to 9 days). In addition, the fisher limit was reduced this season from 5 to 2. Fisher harvest this year under the DNR framework declined 28% to 903, the lowest harvest since 1992 (Table 2). Modeled harvest, which includes reported tribal take, was 951. Prior to 2002, the ratio of fisher to bobcat in the harvest averaged nearly 10:1, but has steadily declined since that time. For the first time since harvest seasons resumed in 1977, the 2010 bobcat harvest exceeded the fisher harvest.

Fisher carcass collections were resumed this year to collect current information on age distribution. A total of 759 carcasses were collected in 2010 (Table 2). Average age of harvested males and females was 1.3 and 1.5, respectively. Very few fishers over the age of 2.5 were harvested (Figures 4 and 5). It remains unclear whether the rapidly truncating age distribution reflects the apparently reduced harvest pressure this year, or changes to natural vital rates affecting recruitment of animals into the upper age classes. The average juvenile to adult (2+) female ratio in the harvest during the most recent 10-year period when data was collected (1985-1994) was 5.5, higher than results from the 2010 harvest (4.3). Similarly, the percentage of juveniles in the harvest from 1985-1994 (62%) was notably higher than this year (52%). Although interpretation of age ratios can be problematic (Caughley 1977, Harris et al. 2008), the differences observed are at least consistent with age structure simulations that incorporate the demographic changes observed from annual population indices and an ongoing research project (i.e., a declining population, with higher than previously assumed natural mortality of adult females with dependent kits). Specifically, holding all other parameters constant, reducing summer survival of adult females and juveniles (based on preliminary research findings) projects a 35% population decline over 8 years, a reduction in the expected percentage of juveniles in the harvest from 61% to 55%, and a reduction in the expected juvenile to adult female harvest ratio from 5.5 to 4.4, reasonably similar in all cases to the observed or estimated changes. However, comparing a previous 10-year average with a single year of current data may mask or ignore the stochastic nature of vital rates and harvest dynamics, which could also explain differences observed in harvest age proportions.

Based on projections from the recently recalibrated fisher population model, 12% of the fall fisher population was harvested during the 2010 season. After declining for ~ 7 years, the 3-year-averaged winter track index for fisher finally increased during winter 2010-11, though not significantly (Figure 6). Modeling projects a 4% increase in the population, with an estimated 2011 spring population size of ~ 6,400 fishers (Figure 6).

Marten. As with fisher, the marten harvest season the last 3 years has been 1 week shorter than 'normal' (i.e., shortened from 16 days to 9 days), though the marten limit has remained unchanged. Harvest this year under the DNR framework was 1,842, down 11% from last year (Table 3). Modeled harvest, which includes reported tribal take, was 1,977. Age-class information was obtained from a sample of 70% of the carcasses collected this year. Juveniles comprised 47% of the total harvest, identical to the recent 10-year average, though below the longer-term average of 55% (Table 3; Figure 7). The juvenile:adult female ratio (4.1) in the harvest was slightly below the recent 10-year average (5.0), and well below the longer-term average (7.8; Table 3).

Based on projections from the recently recalibrated marten population model, 16% of the fall marten population was harvested. After declining for ~ 8 years, the 3-year-averaged winter track index has now increased for 2 years, but remains well below the previous peak (Figure 8). Modeling projects a 2% population increase from last year (Figure 3), with an estimated 2011 spring population size of ~ 9,700 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 2010 under the DNR framework was 1,814 (Table 4), of which approximately 3% (50) were taken in *each* of the former southeast zone and newly opened SC/SW portion of the state. While the southeast zone no longer exists, this year's otter harvest in that area (~50) was similar to levels observed in that zone from 2007-2009 when the otter limit was 2 (range = ~45-60).

When the initial otter population model was parameterized in 1977, it was specific to northern Minnesota. Nevertheless, the model has no explicit spatial boundaries, and given that the otter population in the southern part of the state was extremely low at the time the model was developed, the model is currently assumed to reflect the statewide population (i.e., the projected increase of otter from 1980 – 2000 is assumed to explain most of the expansion of otter range into southern MN). While this assumption is partially flawed (i.e., the southern MN otter expansion was not solely a result of 'spillover' from northern Minnesota, but also undoubtedly influenced by immigration from surrounding states), it is likely a reasonable assumption in this context.

Modeled statewide otter harvest, which includes tribal take, was 1,830 (Table 4). Using the existing population model as a reflection of the statewide population, an estimated 13% of the fall population was harvested. Carcass collections ended in 1986, so no age or reproductive data are available. After declining for several years as a result of high fur prices (harvests), modeling indicates the population has now rebounded to previous levels, with an estimated 5% increase this year (Figure 7). The 2011 spring population is estimated to be ~ 12,300.

No independent statewide otter survey data are currently available for comparison, though otter surveys have periodically been conducted on the Mississippi River (Iowa border to Twin Cities) over the past 10 years. Detection-corrected comparisons of occupancy rates across years will hopefully be completed soon, but will only be possible in a couple years when repeat surveys were conducted. Simple comparison of the number of otter tracks recorded each year suggests the otter population along the

Mississippi River in SE Minnesota has been stable or increased since harvest seasons were initiated in that portion of the state.

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Table 1. Bobcat harvest data, 1981 to 2010.

Year	DNR Harvest	Modeled Harvest[1]	% Autumn Pop. Taken[2]	Carcasses Examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	Overall % males	Mean Pelt Price[3]
1981	260	260	13	230	37	23	40	2.1	59	63	55	58	$73
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	17	475	27	25	48	1	66	49	46	52	$72
2003	483	518	15	425	25	13	62	0.9	61	46	53	54	$96
2004	631	709	17	524	28	34	38	1.6	51	40	54	49	$99
2005	590	638	15	485	25	13	62	0.8	51	48	46	48	$96
2006	890	983	22	813	26	17	57	1.1	61	50	58	57	$101
2007	702	758	19	633	34	14	52	1.2	55	60	47	52	$93
2008	853	928	21	714	26	25	49	1.1	56	52	51	52	$75
2009	884	942	22	844	23	22	55	0.9	57	46	54	53	$43
2010	1012	1042	26	955	38	16	46	1.4	62	55	43	52	$71

[1] Includes DNR and Tribal harvests

[2] Estimated from population model; includes estimated non-reported harvest of 10%.

[3] Average pelt price based on a survey of in-state fur buyers only.

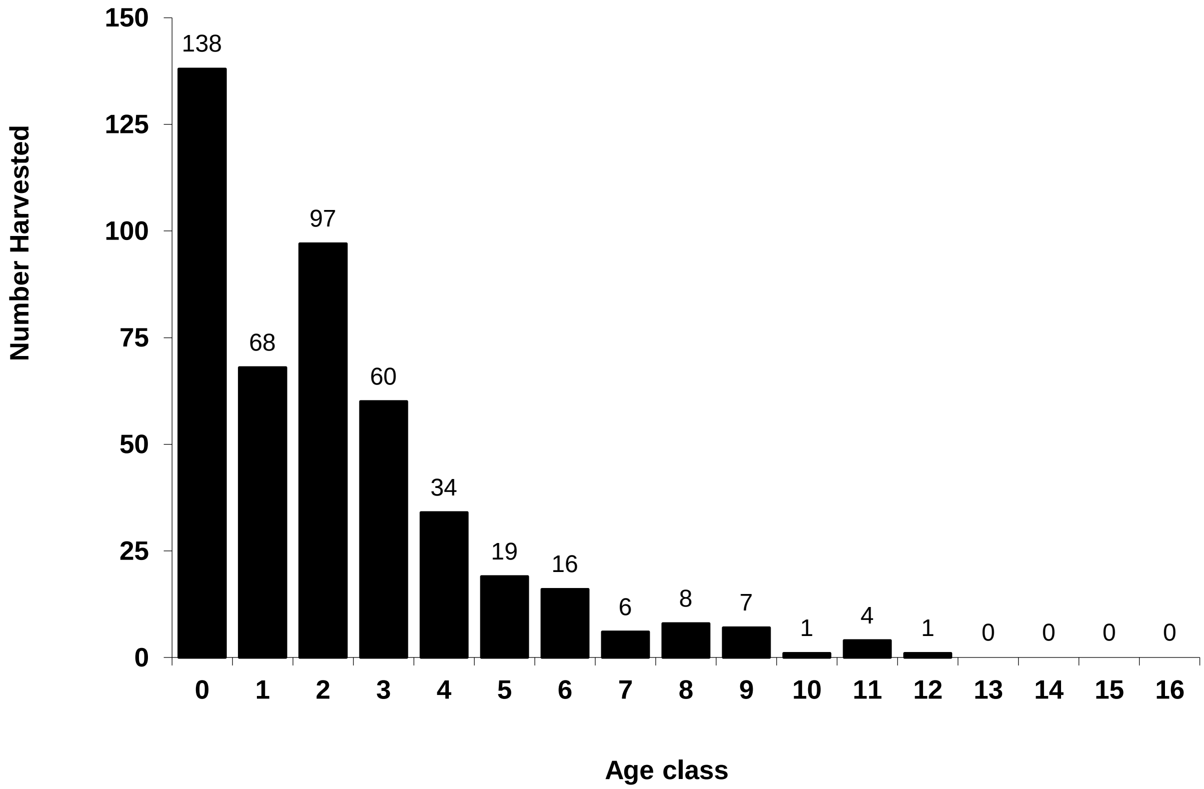

Figure 1. Age structure of female bobcats in the 2010-11 harvest.

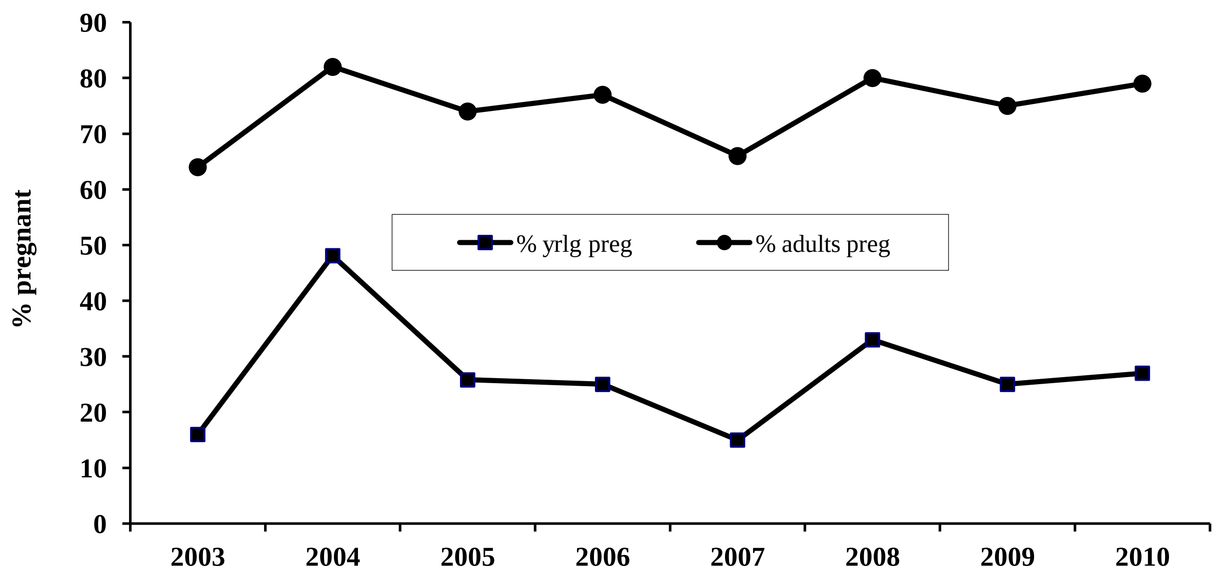

Figure 2. Pregnancy rates for yearling and adult bobcats in Minnesota, 2003-2010.

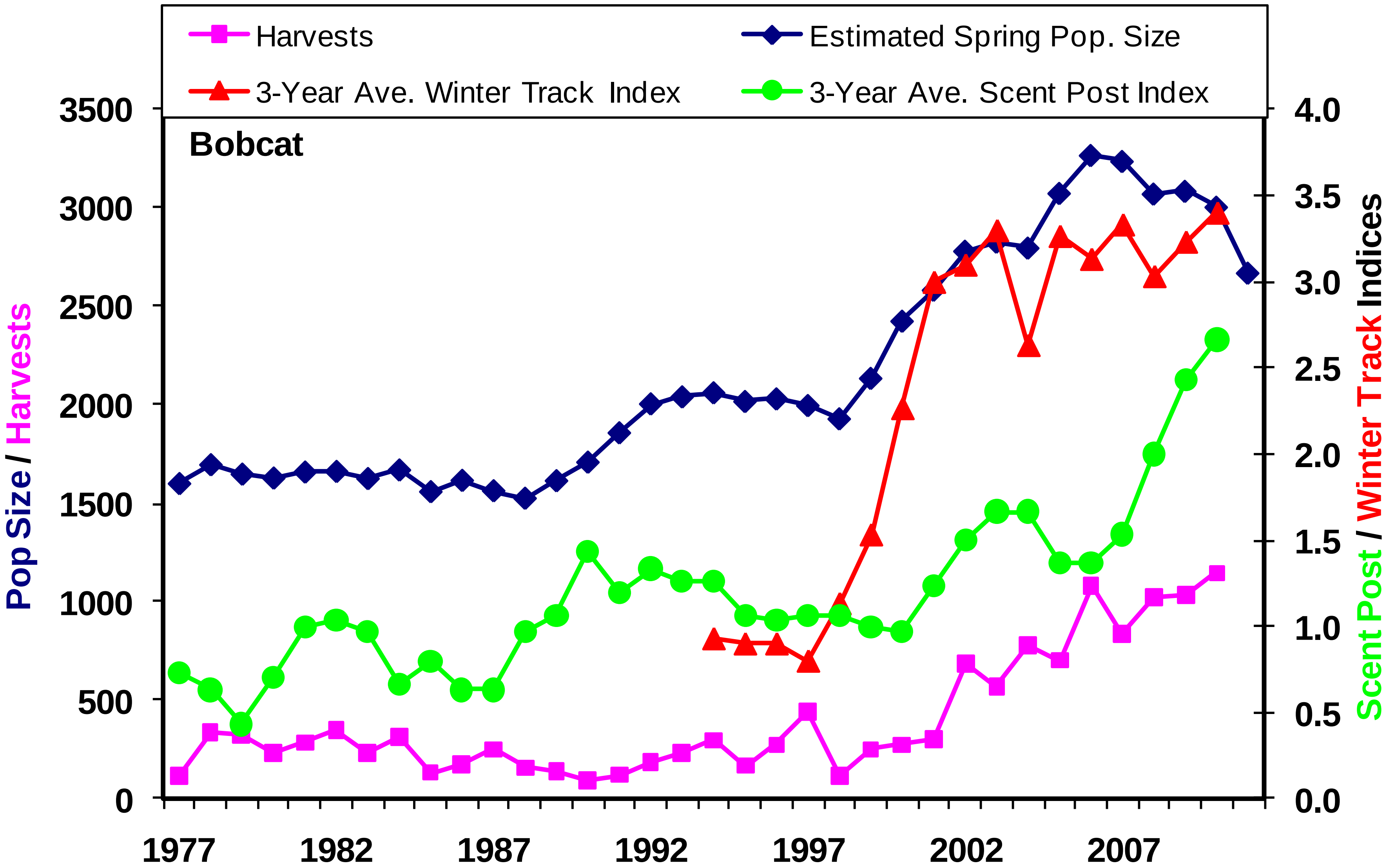

Figure 3. Bobcat populations, harvests, and survey indices, 1977-2011. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1981 to 2010.

Year	DNR harvest	Modeled Harvest[1]	% Autumn Pop. Harvested[2]	Carcasses examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[3]	Pelt price Females[3]
1981	862	1022	16	843	66	24	10	10.5	48	43	37	47	$94	$110
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

[1] Includes DNR and Tribal harvests

[2] Estimated from population model, includes estimated non-reported harvest of 22% 1977-1992, and 10% from 1993-present.

[3] Average pelt price based on a survey of in-state fur buyers only.

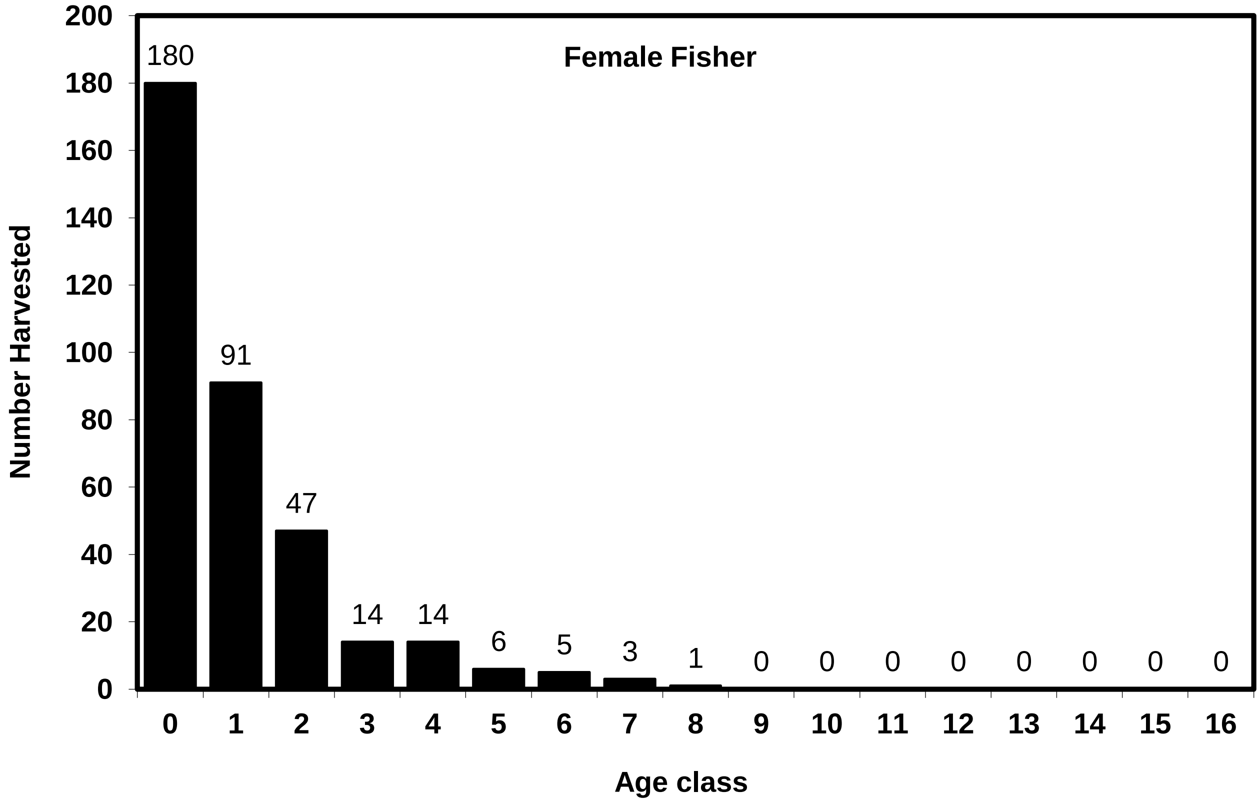

Figure 4. Age structure of female fishers in the 2010 harvest.

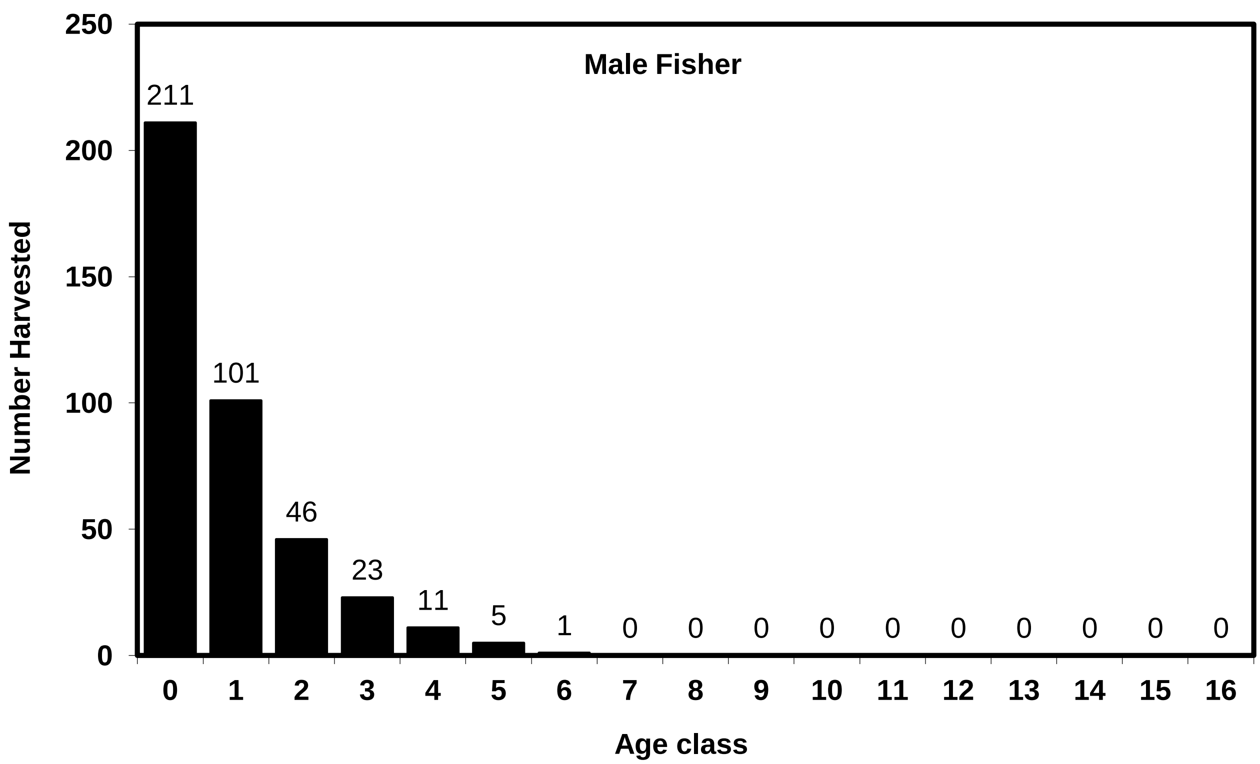

Figure 5. Age structure of male fishers in the 2010 harvest.

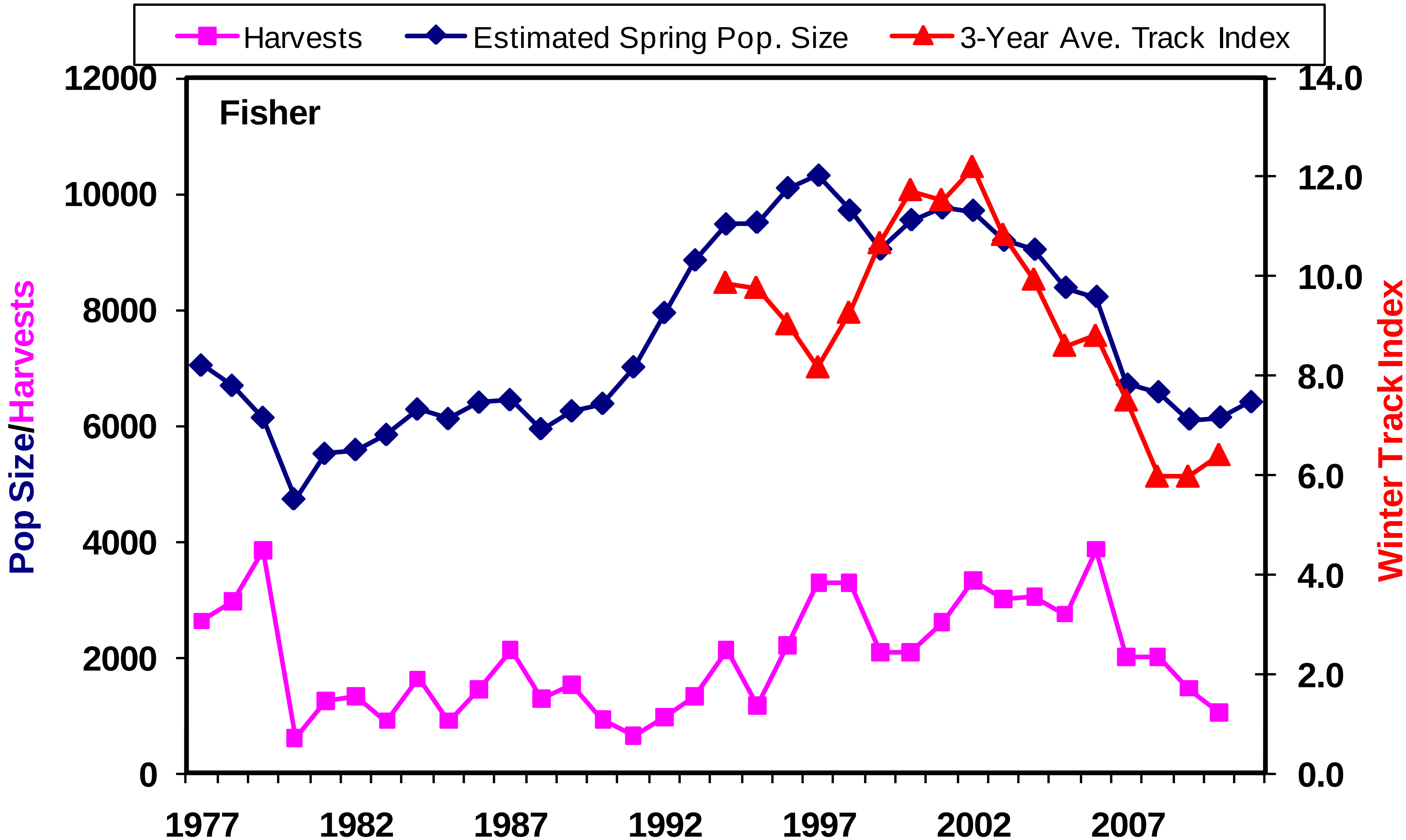

Figure 6. Fisher populations, harvests, and survey indices, 1977-2011. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2010.

Year	DNR harvest	Modeled Harvest[1]	% Autumn Pop. Harvested[2]	Carcasses Examined[3]	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[4]	Pelt price Females[4]
1985	430	430	5	507	73	18	9	17.2	69	68	82	70	$30	$28
1986	798	798	8	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	16	1977	66	11	23	8.6	58	50	66	59	$50	$43
1989	2119	2119	16	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	12	1661	65	18	17	15.1	63	70	75	66	$28	$25
1993	1438	1828	12	1396	57	20	23	7.5	61	71	67	64	$36	$30
1994	1527	1846	12	1452	58	15	27	6.4	62	76	67	66	$34	$28
1995	1500	1774	11	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	16	2238	61	13	26	6.2	60	60	63	61	$28	$22
1998	2299	2795	17	1577	57	18	25	6.6	62	66	65	63	$20	$16
1999	2423	3000	16	2013	67	12	21	9.8	65	66	67	66	$25	$21
2000	1629	2050	11	1598	56	25	19	8.9	62	69	66	64	$28	$21
2001	1940	2250	11	1895	62	15	23	11	66	73	75	69	$24	$23
2002	2839	3192	16	2451	39	30	31	3.1	57	63	61	60	$28	$27
2003	3214	3548	18	2391	48	17	35	4	57	65	66	62	$30	$27
2004	3241	3592	20	2776	26	28	46	1.3	52	64	57	58	$31	$27
2005	2653	2873	18	1992	53	16	31	4.9	64	63	65	64	$37	$32
2006	3788	4120	26	1914	64	17	20	9.2	66	67	65	66	$74	$66
2007	2221	2481	18	1355	30	29	41	1.5	56	64	50	56	$59	$50
2008	1823	1953	15	1095	40	21	39	2.1	58	60	53	56	$31	$28
2009	2073	2250	16	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

[1] Includes DNR and Tribal harvests

[2] 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.

[3] Starting in 2005, the number of carcasses examined represents a random sample of ~ 70% of the carcasses collected in each year.

[4] Average pelt price based on a survey of in-state fur buyers only

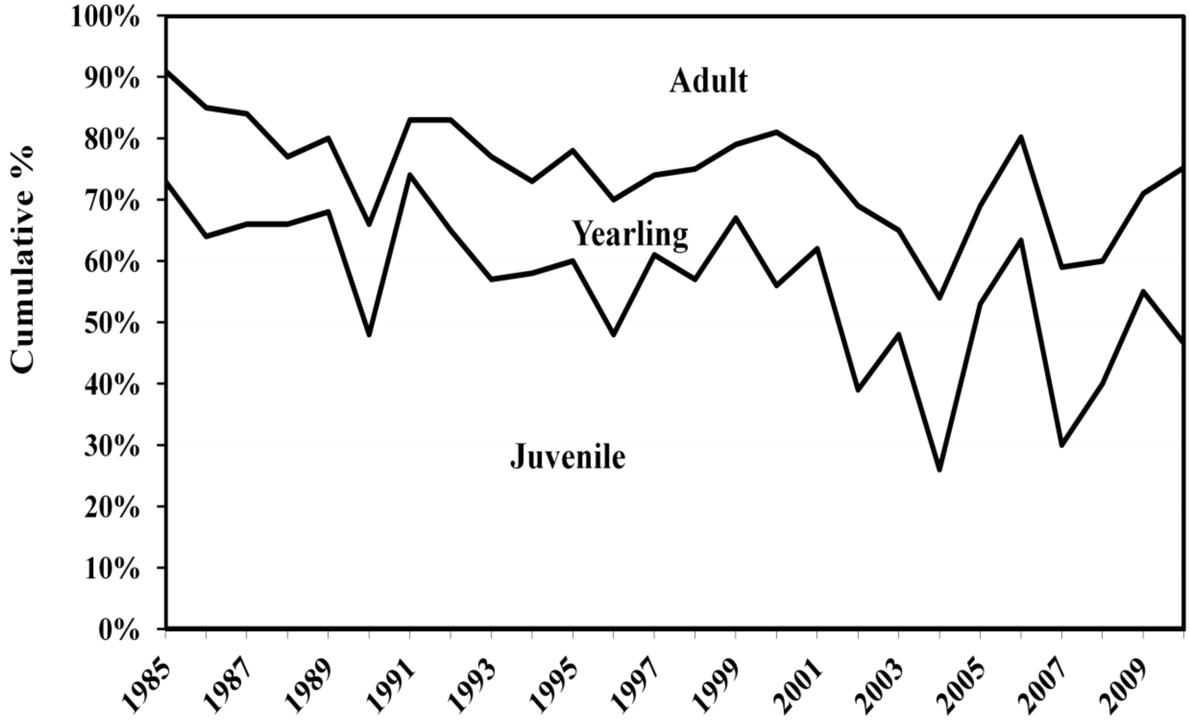

Figure 7. Marten harvest age-class proportions, 1985-2010.

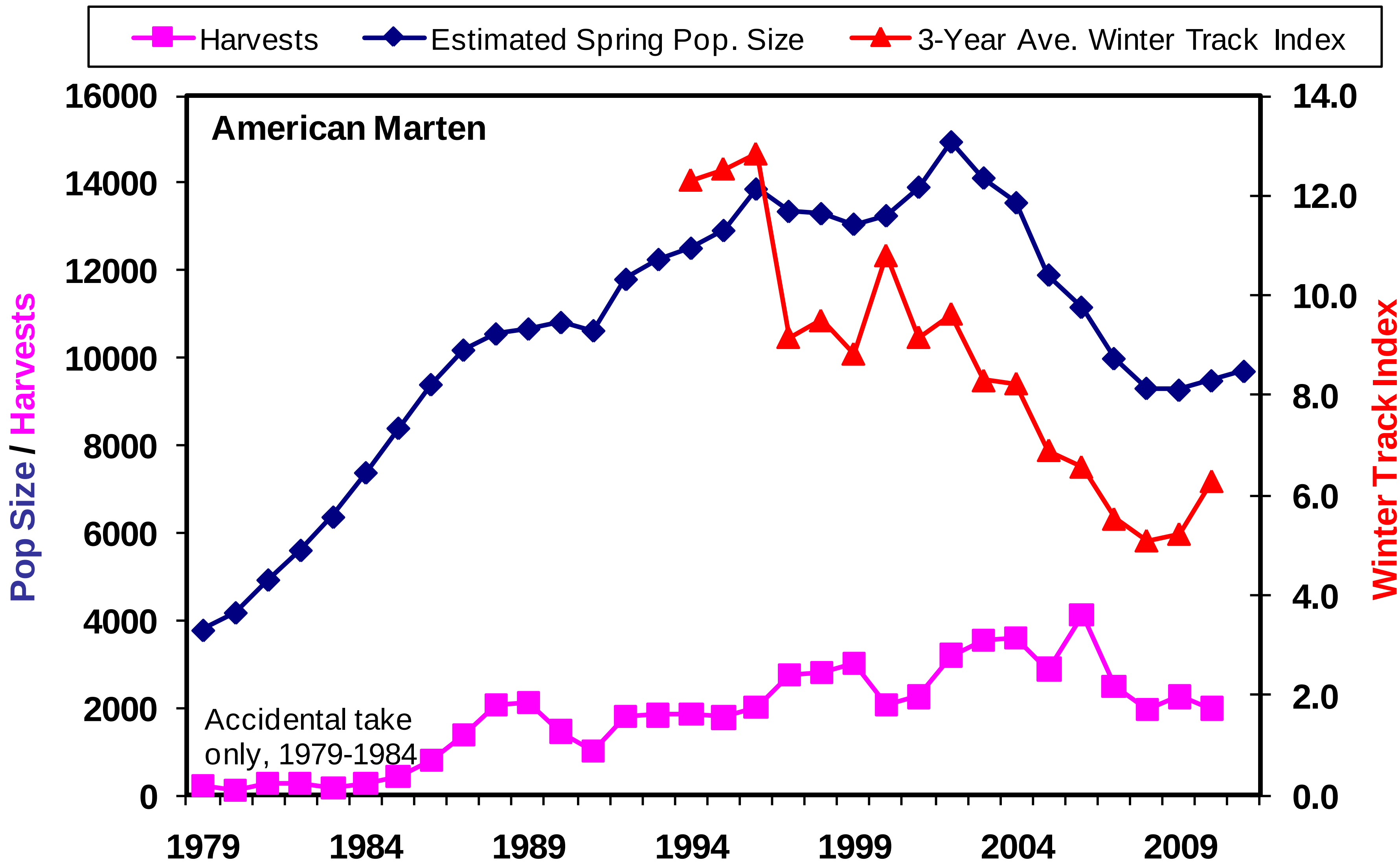

Figure 8. American marten populations, harvests, and survey indices, 1979-2011. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data[1], 1981 to 2010. Carcasses were only collected from 1980-86.

Year	DNR harvest	Modeled Harvest[1]	% Autumn Pop. Harvested[2]	Carcasses examined	% juveniles	% yearlings	% adults	Juv:ad. females	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Otter[3]	Pelt price Beaver[3]
1981	484	762	11	471	55	20	25	4.3	56	53	48	52	$30	$14
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

[1] Includes DNR and Tribal harvests

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

[3] Weighted average of spring (beaver only) and fall prices based on a survey of in-state fur buyers.

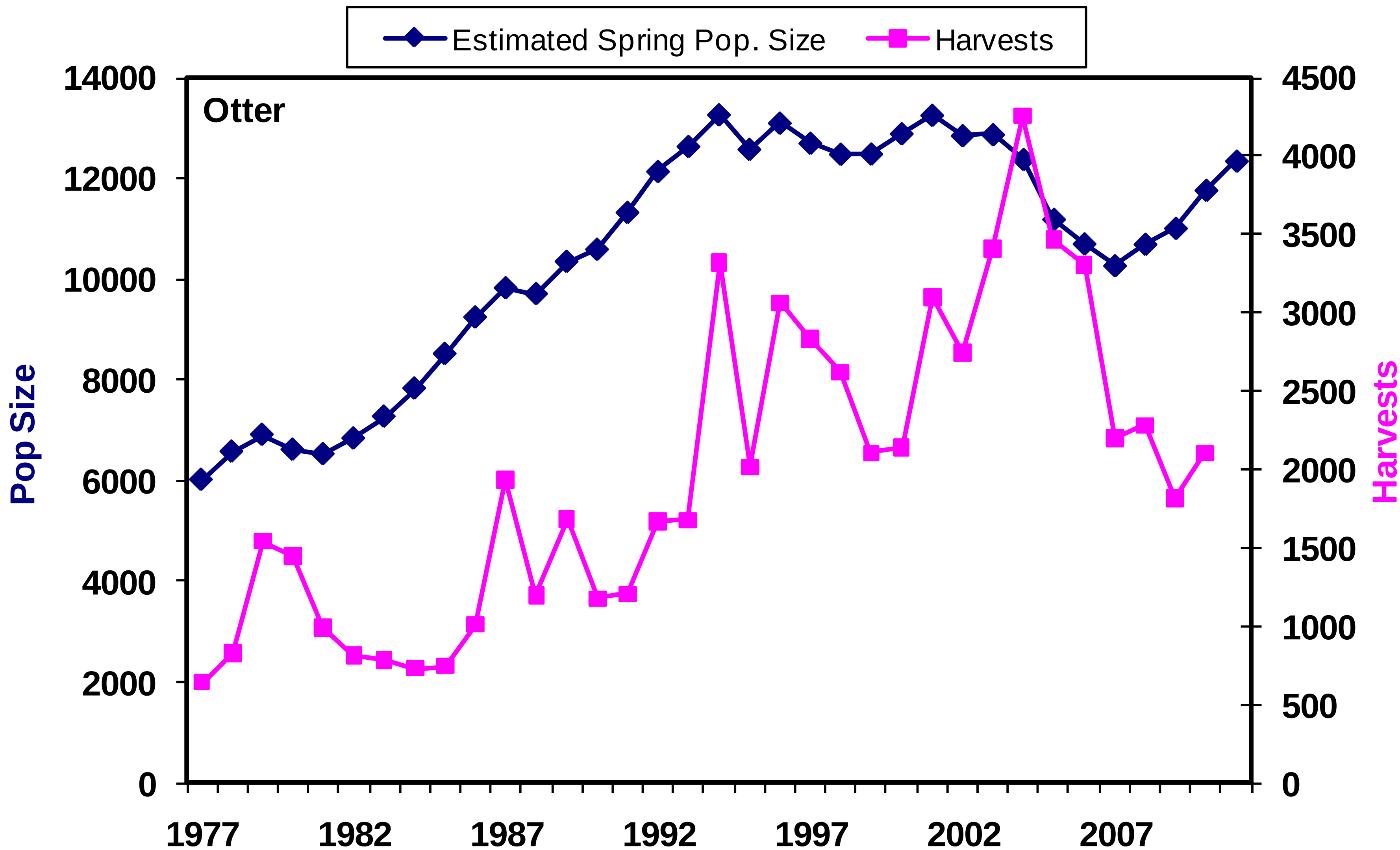

Figure 9. Otter populations and harvests, 1977-2011. Harvests include an estimate of non-reported take.

POPULATION TRENDS OF WHITE-TAILED DEER IN THE FOREST ZONE – 2011

Mark S. Lenarz, Forest Wildlife Populations and Research Group

INTRODUCTION

Deer hunters are required by regulation to register each deer they harvest within 24 hours of the close of the deer-hunting season at an official registration station. Beginning in 2010, hunters were also allowed to register their deer by phone or at the DNR website. Data collected as part of this registration process provides important information on the sex and age of deer killed, population trends, and the effectiveness of current management regulations. The following report presents a brief analysis of the 2010 harvest registration data in the forest zone (Figure 1). This is followed by a discussion of deer population trends and projections in the forest zone based on simulation modeling.

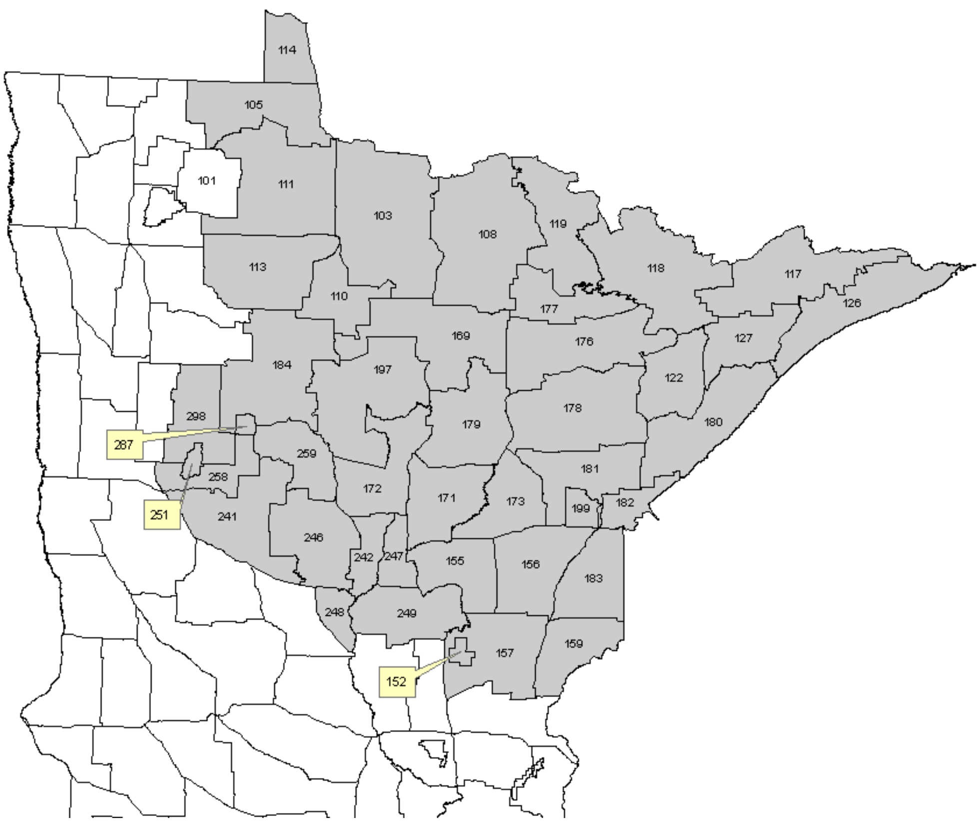

Figure 1. Permit areas in the forested zone, 2010.

HARVEST

In 2010, hunters registered 207,313 deer, up 7% from 2009. Of that number, 48% or 100,131 deer were harvested in the forested zone (Figure 1, Table 1). The 2010 forest zone harvest increased 6% from the 2009 harvest. The following discussion applies to the subset of deer harvested in the forested zone.

The boundaries of almost half (20 of 43) of the forest permit areas changed between 2009 and 2010 and comparisons between the approximate 2009 harvest for each permit area with the 2010 registered harvest may be biased (Tables 1-3). Forest-wide, the buck harvest increased 3% over the 2009 buck harvest. However, the 2010 buck harvest was almost 8% lower than the average over the previous 10 years which implies that we have been successful in reducing deer numbers over the last decade.

The forest-wide antlerless harvest also increased by 3% over 2009 despite a reduced opportunity to harvest antlerless deer (Table 3). In 2009, 37% of the permit areas were listed as "Lottery" with a limited number of antlerless permits. In 2010 this proportion increased to 49% reflecting the belief that deer populations throughout the forest were closer to goal.

The proportion of bucks in the forest zone harvest (total forest bucks/total forest harvest) increased from 49% in 2009 to 51% in 2010. This increase reflected further decreases in the opportunity for hunters to harvest antlerless deer. Forest-wide, the proportion of bucks by permit area ranged from 21% in PA 287 to 86% in PA119.

The archery harvest in the forest zone increased 15% in 2010 and was only 1% lower than the average archery harvest in the previous 10 years. Statewide, the archery harvest represented 11% of the total harvest. Statewide archery license sales were virtually identical to those in 2009.

The muzzleloader harvest increased 19% in the forest zone in 2010 and was 15% higher than the average muzzleloader harvest in the previous 10 years. Statewide, the muzzleloader harvest represented 4% of the total harvest. Statewide muzzleloader license sales declined by 12%.

The firearms, archery, and muzzleloader harvests were higher than expected in many areas. It is possible that the compliance rate (proportion of hunters who registered their deer) increased because of the options to register deer using the internet or telephone. Among stable permit areas in the forest zone (no boundary changes) the registered harvest averaged 4% higher than in 2009. This change was not significantly different from 0 ($n = 20$, $t = 1.32$, $P = 0.203$) and implies that there was no bias associated with the changes to registration.

Population Trends and Model Projections

Based on the winter severity index (WSI), the winter of 2010-11 was generally mild in the southern third of the forest zone (Figure 2). Northern portions of the forest, however experienced WSI values ranging from moderate to severe. The maximum WSI occurred at Poplar Lake with a reading of 193 and 14 stations measured a WSI greater than 100.

Simulation modeling was used in 37 permit areas (Figure 1 and Table 4) to approximate deer density, identify trends, and project the effect of the 2010-hunting season. To better summarize the results for this report, permit areas were pooled into one of 5 regions (Figures 3 and 4). Deer density varied according to region with the lowest densities occurring in the Northeast and Northwest. Highest densities occurred in the West Central and South. The same basic trend occurred in all 5 areas; deer density was at the lowest level in 1997 following the severe winters of the mid-1990's and then steadily increased to peak density in 2003 in response to low (or no) antlerless permits and mild winters. Between 2003 and 2010, there was a steady decline in deer numbers in the South, Central, and West Central in response to the high antlerless harvest. In the past year, deer numbers in all regions continued to drop an average of 9%.

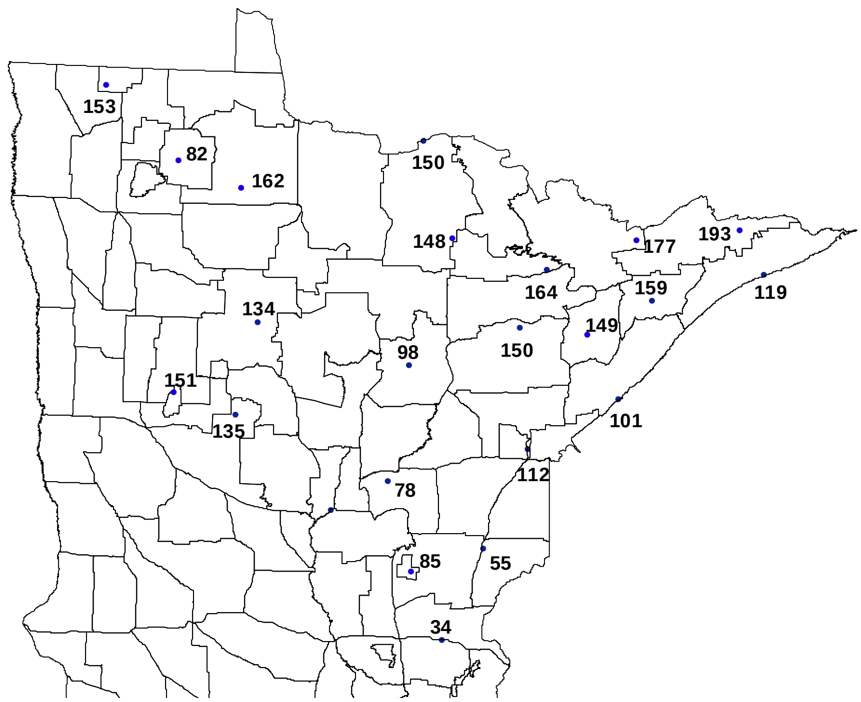

Figure 2. Final WSI values for the forested zone of Minnesota, winter of 2010-2011.

Based on density targets set during the 2005 and 2006 goal setting processes, the 2011 pre-fawn deer density was above goal over much of the forest zone (Figure 5). For purposes here, if deer density was ±10% of the goal, the permit area was listed as being at goal. Deer density in permit areas ranged from 42% below goal to almost 47% above goal.

After discussion at several levels within the Division of Fish and Wildlife, the final designations for the forest zone call for 4 permit area designated as “Lottery”, 19 as “Hunters Choice”, 11 as “Managed”, and 9 as “Intensive” (Figure 6).

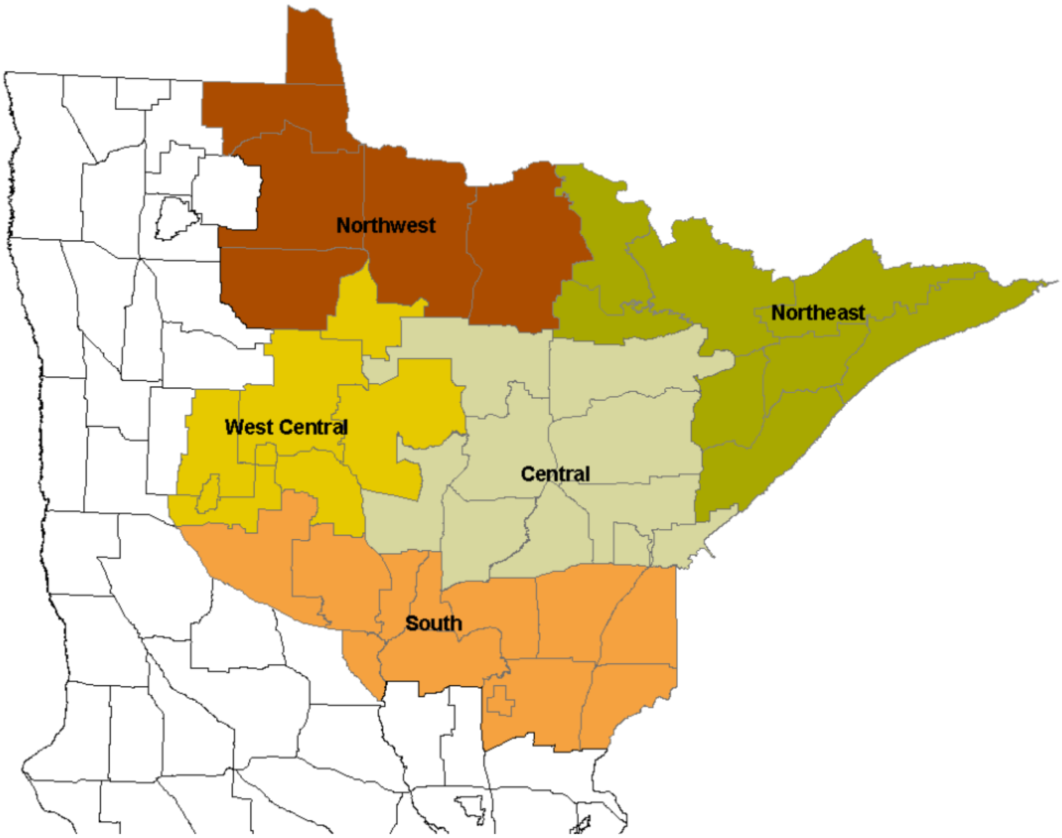

Figure 3. Permit areas grouped for summary discussion.

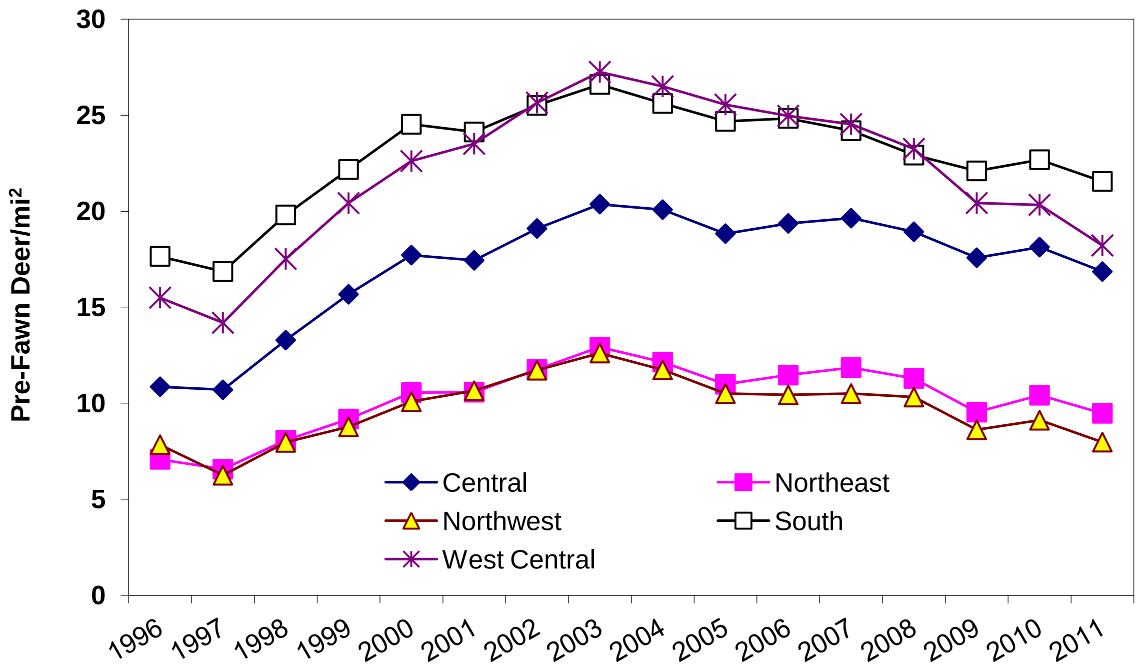

Figure 4. Population trends of deer in forest zone. Trend lines represent the groups of permit areas as illustrated in Figure 3. Density represents pre-fawn density.

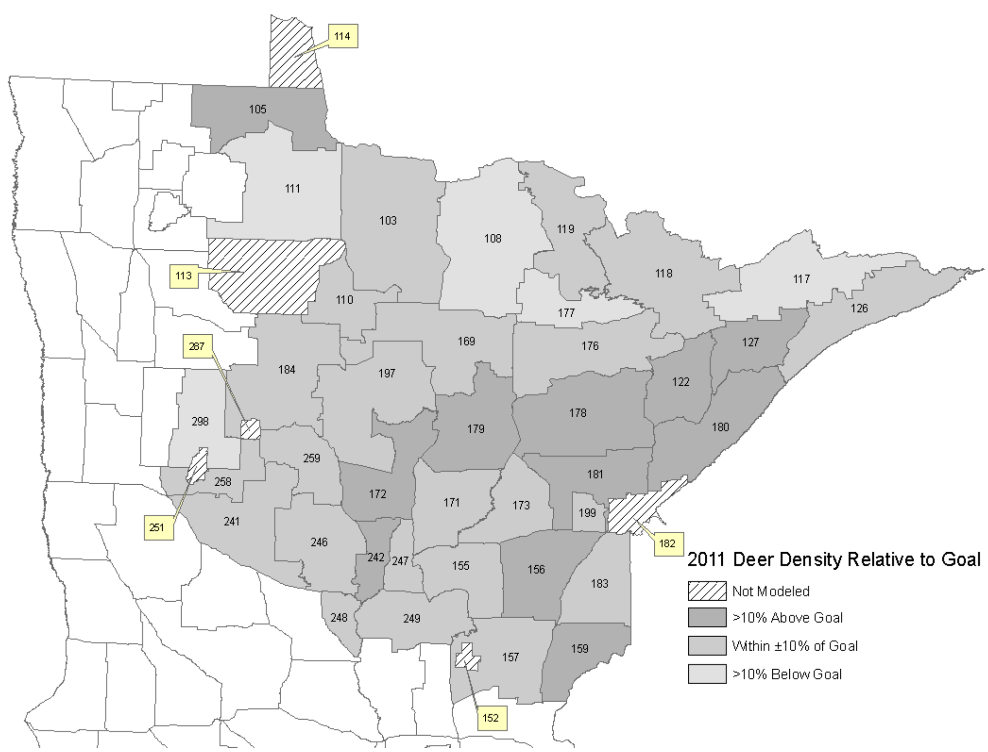

Figure 5. Deer density expressed relative to pre-fawn population goals. Note revised permit area boundaries (and numbers) effective for the 2011 hunting season.

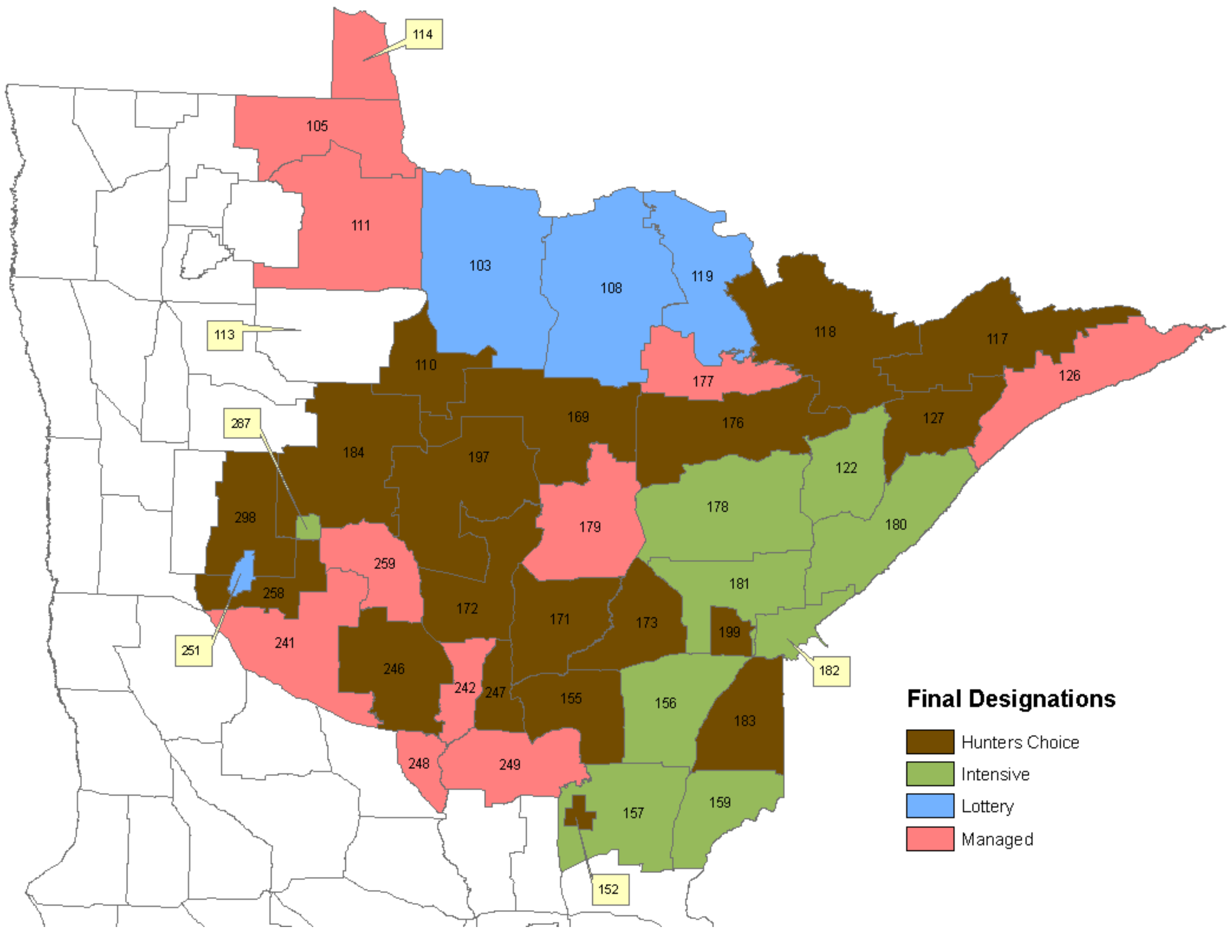

Figure 6. Final designation of permit areas in the Forest Zone for the 2011 hunting season.

Table 1. Total registered deer harvest for Deer Permit Areas in Minnesota's Forested Zone.

Permit Area	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Change
103	1,696	1,971	2,992	2,538	2,172	2,302	2,237	1,838	1,151	1,274 *	11%
105	1,962	2,385	3,740	3,106	3,557	3,210	3,344	2,391	2,020	1,855	-8%
108	3,075	3,033	4,513	3,491	3,412	3,316	3,358	2,734	1,500	1,371 *	-9%
110	1,918	2,233	2,729	2,615	2,368	2,448	2,520	2,391	1,807	2,425 *	34%
111	1,870	1,904	2,577	2,205	2,260	2,365	1,608	1,538	1,364	1,053	-23%
114	72	80	96	110	123	174	127	121	95	94	-1%
117	125	126	212	238	209	216	280	315	136	71 *	-48%
118	1,876	2,003	2,847	2,289	2,305	2,359	2,266	1,856	1,192	926 *	-22%
119	1,533	1,628	2,316	1,843	1,857	1,893	1,811	1,466	943	1,153 *	22%
122	576	536	650	669	614	997	1,054	949	711	990 *	39%
126	470	597	702	841	904	977	1,155	1,009	869	910	5%
127	95	99	146	177	151	188	216	187	132	157	19%
152	264	218	235	246	271	330	377	293	375	234	-38%
155	3,274	3,952	4,490	4,065	3,600	3,571	3,556	2,030	2,194	2,935 *	34%
156	3,055	3,258	4,966	4,594	4,517	4,767	5,180	4,494	4,260	4,584	8%
157	7,194	7,728	9,001	7,606	6,901	7,989	7,828	6,287	5,491	6,568	20%
159	4,180	3,944	5,043	3,788	3,830	3,810	4,090	3,146	3,278	3,512	7%
169	3,802	4,813	4,347	4,916	3,425	4,796	4,735	4,211	3,560	2,804 *	-21%
171	2,545	2,863	4,138	3,605	3,419	3,378	3,690	2,961	2,371	1,841 *	-22%
172	4,156	4,273	6,690	5,422	5,303	5,274	5,500	4,693	3,800	2,640 *	-31%
173	1,515	1,896	2,708	2,370	2,191	2,251	2,297	2,022	1,404	1,730 *	23%
176	2,874	2,784	4,367	3,664	2,674	3,926	3,821	3,726	2,090	2,206 *	6%
177	1,070	1,075	1,606	1,294	1,153	1,324	1,296	1,138	663	2,618 *	295%
178	3,343	3,659	5,509	5,284	5,359	5,473	6,563	5,912	5,056	5,718 *	13%
179	3,141	3,141	5,409	4,700	4,599	4,550	5,359	4,763	3,660	4,750 *	30%
180	1,703	1,867	3,123	2,355	2,837	3,553	3,777	3,408	2,672	3,245	21%
181	2,750	2,779	4,128	4,296	4,071	4,986	5,217	4,687	3,807	4,538	19%
182					1,256	1,460	1,599	1,640	2,339	2,125	-9%
183	2,958	2,991	4,320	3,821	3,505	4,118	3,868	3,086	2,273	2,483	9%
184	7,762	8,811	14,023	12,307	11,482	10,261	11,005	9,311	6,670	4,350	-35%
197	1,167	1,413	1,652	1,723	1,594	2,471	2,248	2,051	1858	1,699	-9%
199	166	164	140	172	188	167	206	218	239	268	12%
241	8,905	9,478	11,994	10,943	10,071	10,432	11,021	8,943	7,831	8,028 *	3%
242	2,072	2,426	2,767	2,244	2,116	2,170	2,259	2,239	1,598	1,907	19%
246	6,741	6,009	8,558	7,694	6,618	7,232	6,268	3,549	4,145	4,256 *	3%
247	2,115	2,101	2,744	2,582	2,115	2,393	2,064	1,247	1,277	1,266	-1%
248	1,231	1,339	1,917	1,864	1,693	1,812	1,878	1,486	1,405	1,568	12%
249	3,148	3,238	4,223	3,800	3,211	3,667	3,321	2,072	2,216	3,613	63%
251	254	298	470	387	325	301	253	143	199	158	-21%
258	2,709	3,249	4,171	3,751	3,449	3,466	3,975	3,079	1,503	1,601 *	7%
259	3,709	4,130	6,042	4,681	4,211	4,489	3,959	3,573	2,045	2,685 *	31%
287	460	446	529	425	280	305	306	249	301	310	3%
298	826	932	1988	1733	1664	1727	1610	1,522	1,585	1,612	2%
Forested Zone	104,357	111,870	154,818	136,454	127,860	136,894	139,102	114,974	94,085	100,131	6%

Note: Some permit area boundaries were changed in 1999 and 2010*. Harvest totals prior to 2010 are estimates that assume an evenly distributed in the old harvest permit areas and may be biased. Harvest in permit area 182 (created in 2005) were calculated in a similar manner.

Table 2. Registered buck harvest for Deer Permit Areas in Minnesota's Forested Zone.

Permit Area	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Change
103	1107	1165	1390	1387	1093	1028	1118	937	825	821 *	0%
105	813	1138	1488	1326	1364	1122	1206	963	807	844	5%
108	1884	1837	2187	1974	1613	1495	1665	1369	1240	1156 *	-7%
110	961	1044	1127	1088	923	880	1040	874	845	1139 *	35%
111	1173	1230	1234	1184	1107	966	830	744	607	572	-6%
114	56	63	55	55	72	95	83	69	54	49	-9%
117	125	126	190	201	184	149	209	175	106	41 *	-61%
118	1135	1254	1548	1429	1210	1191	1202	956	872	797 *	-9%
119	919	1007	1233	1132	952	940	944	750	695	806 *	16%
122	422	419	468	529	499	528	617	553	521	570 *	9%
126	417	495	585	591	595	606	689	527	497	530	7%
127	82	86	126	149	127	147	149	107	106	115	8%
152	182	130	106	152	141	158	149	126	160	134	-16%
155	1682	1703	1626	1609	1405	1317	1501	1157	1338	1620 *	21%
156	1690	1653	2001	2003	1811	1881	2073	1835	1945	2084	7%
157	3144	3048	3207	3030	2745	2916	2832	2340	2466	2960	20%
159	1947	1667	1995	1518	1528	1548	1680	1233	1428	1576	10%
169	2147	2540	2273	2443	1927	1912	2097	1737	1546	1615 *	4%
171	1418	1417	1622	1591	1416	1361	1483	1253	1242	1193 *	-4%
172	2177	2085	2454	2269	2026	1974	2085	1701	1477	1737 *	18%
173	890	965	1091	1130	968	929	991	885	884	1008 *	14%
176	1786	1821	2135	1998	1786	1887	1919	1620	1501	1675 *	12%
177	653	675	806	741	634	633	656	539	496	1064 *	115%
178	2013	2216	2649	2766	2702	2504	2972	2324	2579	2764 *	7%
179	1822	1738	2236	2134	1941	1903	2042	1752	1568	2025 *	29%
180	1358	1398	1831	1833	1692	1829	1888	1598	1566	1434	-8%
181	1717	1781	2186	2363	2077	2279	2327	1970	1923	1955	2%
182					511	520	544	492	788	643	-18%
183	1771	1695	1826	1793	1532	1687	1791	1445	1435	1388	-3%
184	3925	4310	4774	4848	4161	3554	3554	3416	2858	3013	5%
197	953	998	1,040	1,143	999	1,090	1,108	999	882	1055	20%
199	123	132	104	130	151	119	150	119	145	150	3%
241	3475	3740	4046	3913	3470	3598	3444	3153	3025	3278 *	8%
242	885	824	912	740	721	692	688	663	607	732	21%
246	2745	2686	2921	2807	2336	2454	2200	1849	1979	2327 *	18%
247	1056	948	1047	955	861	848	802	657	692	825	19%
248	622	720	714	739	656	638	634	588	584	641	10%
249	1479	1429	1479	1327	1261	1285	1251	1137	1152	1407	22%
251	152	132	176	183	128	147	91	58	63	86	37%
258	1146	1287	1421	1337	1214	1206	1164	1059	863	915 *	6%
259	1599	1783	2013	1797	1494	1636	1418	1391	1113	1556 *	40%
287	201	167	207	182	106	104	92	81	85	64	-25%
298	685	654	952	894	810	799	753	762	699	722	3%
Forested Zone	54,537	56,206	63,481	61,413	54,949	54,555	56,131	47,963	46,264	51,086	10%

Note: Some permit area boundaries were changed in 1999 and 2010*. Harvest totals prior to 2010 are estimates that assume an evenly distributed in the old harvest permit areas and may be biased. Harvest in permit area 182 (created in 2005) were calculated in a similar manner.

Table 3. Registered antlerless deer harvest for Deer Permit Areas in Minnesota's Forested Zone.

Permit Area	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Change
103	589	806	1,602	1,151	1,079	1,274	1,119	901	326	453 *	39%
105	1,149	1,247	2,252	1,780	2,193	2,088	2,138	1,428	1,213	1,011	-17%
108	1,191	1,196	2,326	1,517	1,799	1,821	1,693	1,365	260	215 *	-17%
110	957	1,189	1,602	1,527	1,445	1,568	1,480	1,517	962	1,286 *	34%
111	697	674	1,343	1,021	1,153	1,399	778	794	757	481	-36%
114	16	17	41	55	51	79	44	52	41	45	10%
117	0	0	22	38	25	67	71	140	30	30 *	-1%
118	741	749	1,299	860	1,095	1,168	1,064	900	320	129 *	-60%
119	614	621	1,083	711	905	953	867	716	248	347 *	40%
122	154	117	182	140	115	469	437	396	190	420 *	121%
126	53	102	117	250	309	371	466	482	372	380	2%
127	13	13	20	28	24	41	67	80	26	42	62%
152	82	88	129	94	130	172	228	167	215	100	-53%
155	1,592	2,249	2,864	2,456	2,195	2,254	2,055	873	856	1,315 *	54%
156	1,365	1,605	2,965	2,591	2,706	2,886	3,107	2,659	2,315	2,500	8%
157	4,050	4,680	5,794	4,576	4,156	5,073	4,996	3,947	3,025	3,608	19%
159	2,233	2,277	3,048	2,270	2,302	2,262	2,410	1,913	1,850	1,936	5%
169	1,655	2,273	2,074	2,473	1,498	2,884	2,638	2,474	2,014	1,189 *	-41%
171	1,127	1,446	2,516	2,014	2,003	2,017	2,207	1,708	1,129	648 *	-43%
172	1,979	2,188	4,236	3,153	3,277	3,300	3,415	2,992	2,323	903 *	-61%
173	625	931	1,617	1,240	1,223	1,322	1,306	1,137	520	722 *	39%
176	1,088	963	2,232	1,666	888	2,039	1,902	2,106	589	531 *	-10%
177	417	400	800	553	519	691	640	599	167	1,554 *	831%
178	1,330	1,443	2,860	2,518	2,657	2,969	3,591	3,588	2,477	2,954 *	19%
179	1,319	1,403	3,173	2,566	2,658	2,647	3,317	3,011	2,092	2,725 *	30%
180	345	469	1,292	522	1,145	1,724	1,889	1,810	1,106	1,811	64%
181	1,033	998	1,942	1,933	1,994	2,707	2,890	2,717	1,884	2,583	37%
182					745	940	1,055	1,148	1,551	1,482	-4%
183	1,187	1,296	2,494	2,028	1,973	2,431	2,077	1,641	838	1,095	31%
184	3,837	4,501	9,249	7,459	7,321	6,707	7,451	5,895	3,812	1,337	-65%
197	214	415	612	580	595	1,381	1,140	1,052	976	644	-34%
199	43	32	36	42	37	48	56	99	94	118	26%
241	5,430	5,738	7,948	7,030	6,601	6,834	7,577	5,790	4,806	4,750 *	-1%
242	1,187	1,602	1,855	1,504	1,395	1,478	1,571	1,576	991	1,175	19%
246	3,996	3,323	5,637	4,887	4,282	4,778	4,068	1,700	2,166	1,929 *	-11%
247	1,059	1,153	1,697	1,627	1,254	1,545	1,262	590	585	441	-25%
248	609	619	1,203	1,125	1,037	1,174	1,244	898	821	927	13%
249	1,669	1,809	2,744	2,473	1,950	2,382	2,070	935	1,064	2,206	107%
251	102	166	294	204	197	154	162	85	136	72	-47%
258	1,563	1,962	2,750	2,414	2,235	2,260	2,811	2,020	640	686 *	7%
259	2,110	2,347	4,029	2,884	2,717	2,853	2,541	2,182	932	1,129 *	21%
287	259	279	322	243	174	201	214	168	216	246	14%
298	141	278	1,036	839	854	928	857	760	886	890	0%
Forested Zone	49,820	55,664	91,337	75,042	72,911	82,339	82,971	67,011	47,821	49,045	3%

Note: Some permit area boundaries were changed in 1999 and 2010*. Harvest totals prior to 2010 are estimates that assume an evenly distributed in the old harvest permit areas and may be biased. Harvest in permit area 182 (created in 2005) were calculated in a similar manner.

Table 4. Pre-Fawn deer density (deer/sq.mi.) as simulated from modeling in each permit area in Minnesota's forested zone.

Permit Area	Area (sq. mi.)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change
103	1,818	7	8	9	8	7	7	7	7	6	7	6	-14%
105	766	26	29	31	30	28	27	27	27	23	23	20	-16%
108	1,643	11	13	14	12	11	11	12	11	9	10	9	-6%
110	522	32	34	35	35	33	33	33	31	28	27	24	-9%
111	1,437	6	7	7	6	6	5	5	5	4	4	4	-16%
118	1,202	8	9	9	8	7	8	8	7	6	7	6	-10%
119	799	13	14	15	14	12	13	13	13	10	11	10	-10%
122	600	5	6	6	6	7	7	7	7	7	7	7	-1%
126	941	5	5	6	6	6	6	7	6	5	5	5	-11%
127	587	2	2	2	2	2	2	3	2	2	2	2	-14%
155	597	18	18	18	17	16	16	15	14	15	17	17	4%
156	826	19	21	23	23	23	24	24	23	23	23	22	-3%
157	889	23	24	25	23	23	23	23	21	20	20	18	-8%
159	568	21	22	22	21	21	21	21	20	20	20	19	-4%
169	1,122	15	16	15	15	14	15	14	14	13	13	12	-8%
171	686	17	18	19	18	17	17	17	15	15	15	17	8%
172	695	21	23	25	23	22	21	21	19	18	18	19	6%
173	592	14	15	16	15	14	14	15	14	13	14	15	2%
176	1,099	10	11	12	11	10	10	11	11	9	11	9	-14%
177	504	38	42	45	41	36	37	39	37	30	32	28	-14%
178	1,278	19	22	24	25	24	25	26	26	23	24	21	-15%
179	867	22	24	26	25	24	25	25	24	23	23	21	-8%
180	982	13	15	16	16	15	15	15	15	14	14	14	-3%
181	856	23	26	28	29	27	28	28	27	26	26	23	-9%
183	663	25	26	28	27	25	25	24	23	22	23	23	-2%
184	1,232	25	27	29	28	27	25	25	22	19	19	18	-7%
197	965	15	16	17	17	17	18	17	17	16	15	13	-14%
241	998	35	38	39	39	38	38	38	37	32	32	27	-15%
242	215	32	33	34	32	31	31	30	28	27	27	27	-3%
246	836	26	27	28	26	25	24	23	21	22	23	24	3%
247	230	23	24	24	22	21	20	18	16	18	20	22	11%
248	212	24	26	28	27	27	27	27	25	24	23	22	-8%
249	502	17	18	19	18	17	17	16	15	16	18	16	-7%
258	328	35	38	40	39	37	36	35	32	27	28	26	-8%
259	428	34	36	38	35	34	33	32	31	27	29	26	-10%
298	619	18	19	22	21	20	20	20	20	18	18	15	-16%
Forest Zone	29,159	17	19	20	19	18	18	18	17	16	16	15	-8%

2011 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® 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.

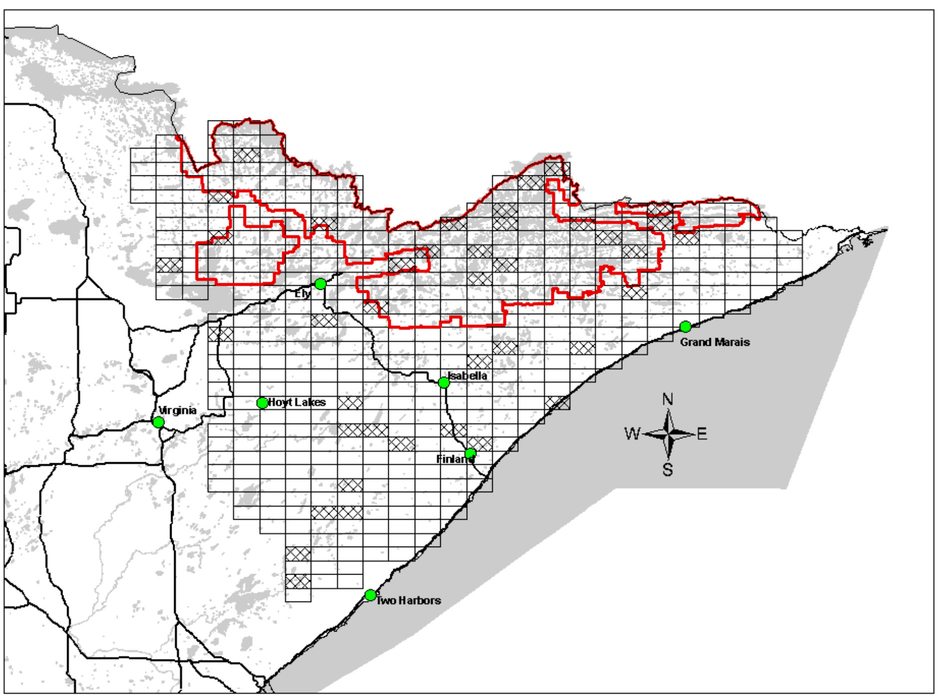

Figure 1. Northeast moose survey area and sample plots (cross hatching) flown in the 2011 aerial moose survey. The red line delineates the boundary of the Boundary Waters Canoe Area Wilderness.

We accounted for visibility bias by using a sightability model (Ackerman 1988, Anderson and Lindzey 1996, Otten et al. 1993, Quayle et al. 2001, Samuel et al. 1987). We developed this model between 2004 and 2007 using moose that were radiocollared as part of research on the population dynamics of the northeastern moose population. Logistic regression indicated that the covariate "visual obstruction" (VOC) was the most important covariate in determining whether radiocollared moose were observed. We defined VOC as the proportion of vegetation within a circle (10m radius or roughly 4 moose lengths) that would prevent you from seeing a moose when circling that spot from an oblique angle. If we observed more than one moose at a location, visual obstruction was based on the first moose sighted. We used uncorrected estimates (no visibility bias correction) of bulls, cows, and calves to calculate the bull:cow and calf:cow ratios.

We have used the sightability model approach for 8 years to account for sightability bias in our estimates of moose numbers in northeastern Minnesota. In 2004, 3 observers equated VOC to crown closure on some observations and this resulted in substantially higher estimates of VOC. As a result, the 2004 population estimate was biased very high (Table 1) and was not included in the following discussion. Population estimates prior to 2004 were based on fixed-wing aircraft surveys and are not comparable to estimates based helicopter surveys which began in 2004.

RESULTS AND DISCUSSION

We initiated the survey on 5 January and completed it on 19 January. Observers rated survey conditions as "fair" (middle rank) on 15 plots and "good" (high rank) on 25 plots. Snow conditions for the survey were between 8" and 16" on 2 plots, and >16" on 38 plots. During the survey flights, observers located 375 moose on the 40 plots (533 mi^2) including 121 bulls, 199 cows, 48 calves, and 7 unidentified moose. After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 4,889±1,182 animals (Table 1). Estimates of the calf:cow and bull:cow ratios were 0.24 and 0.64, respectively (Table 1).

The 2011 population estimate was 12% lower than the 2010 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, $P = 0.024$). 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. Two measures of recruitment (calf:cow ratio and % calves) measured during the aerial survey have also declined significantly over the past 14 years (Figure 3). This decrease is explained in part by a significant decline in the proportion of cows accompanied by twins since 2002 (Table 1; $P = 0.010$). A declining population is also indicated by a significant drop in hunter success rates since 2001, for both either-sex hunting (2001-2006, $P < 0.001$) and for bulls-only hunting (2001-2010, $P = 0.006$).

Table 1. Estimated moose numbers, calves:cow, percent calves, percent cows with twins, and bulls:cow from aerial surveys in northeastern Minnesota. Surveys prior to 2004 were conducted using fixed-wing aircraft and population estimates from these surveys are not comparable to the results from helicopter surveys. Ratios and proportions estimated by fixed-wing and helicopter surveys are comparable. Survey estimate from 2004 was biased high because of an error in how visual obstruction covariate was determined. Survey estimates prior to 1998 were not included because they were biased based on starting date and length of survey (Lenarz 1998).

Survey	Estimate	**Calves:Cow**	**% Calves**	**% Cows w/ twins**	**Bulls:Cow**
1998	3,464 ±36%	0.71	25	0	0.98
1999	3,915 ±35%	0.57	18	9	1.30
2000	3,733 ±25%	0.70	20	7	1.34
2001	3,879 ±28%	0.61	19	5	1.05
2002	5,214 ±23%	0.93	25	20	1.22
2003	4,161 ±37%	0.70	14	11	2.01
2004	13,093±40%	0.42	15	4	1.24
2005	7,923±30%	0.52	19	9	1.04
2006	8,501±28%	0.34	13	5	1.09
2007	6,659±27%	0.29	13	3	0.89
2008	7,637±28%	0.36	16	2	0.77
2009	7,593±23%	0.32	14	2	0.94
2010	5,528±24%	0.28	13	3	0.83
2011	4,889±24%	0.24	13	1	0.64

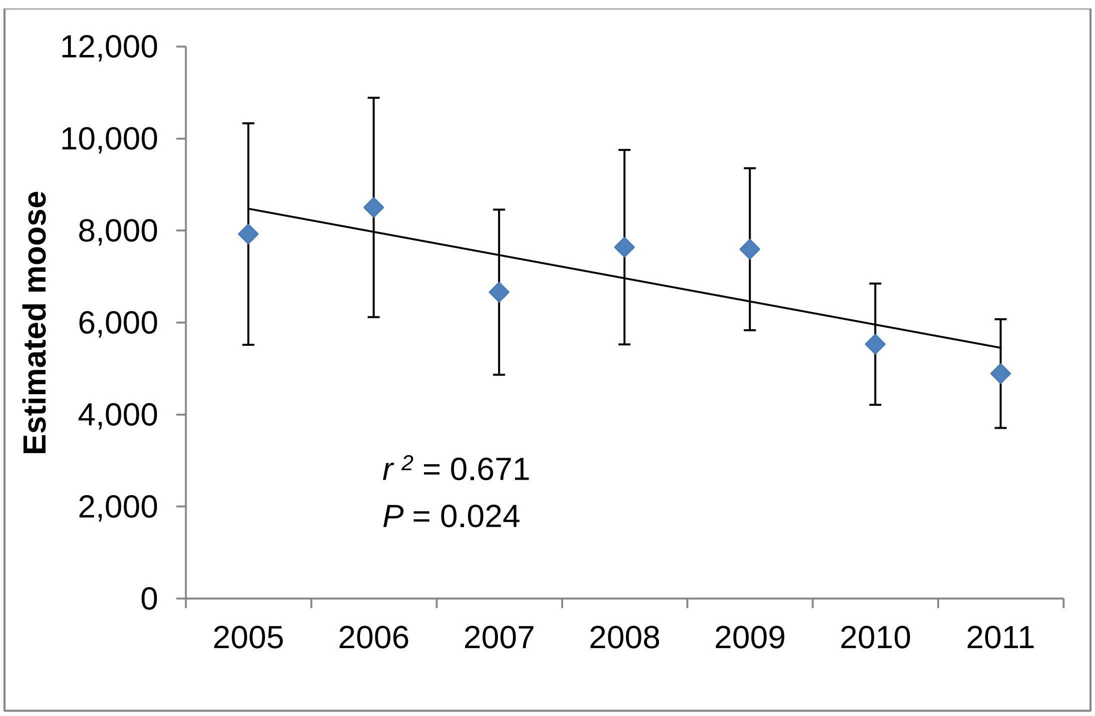

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2011.

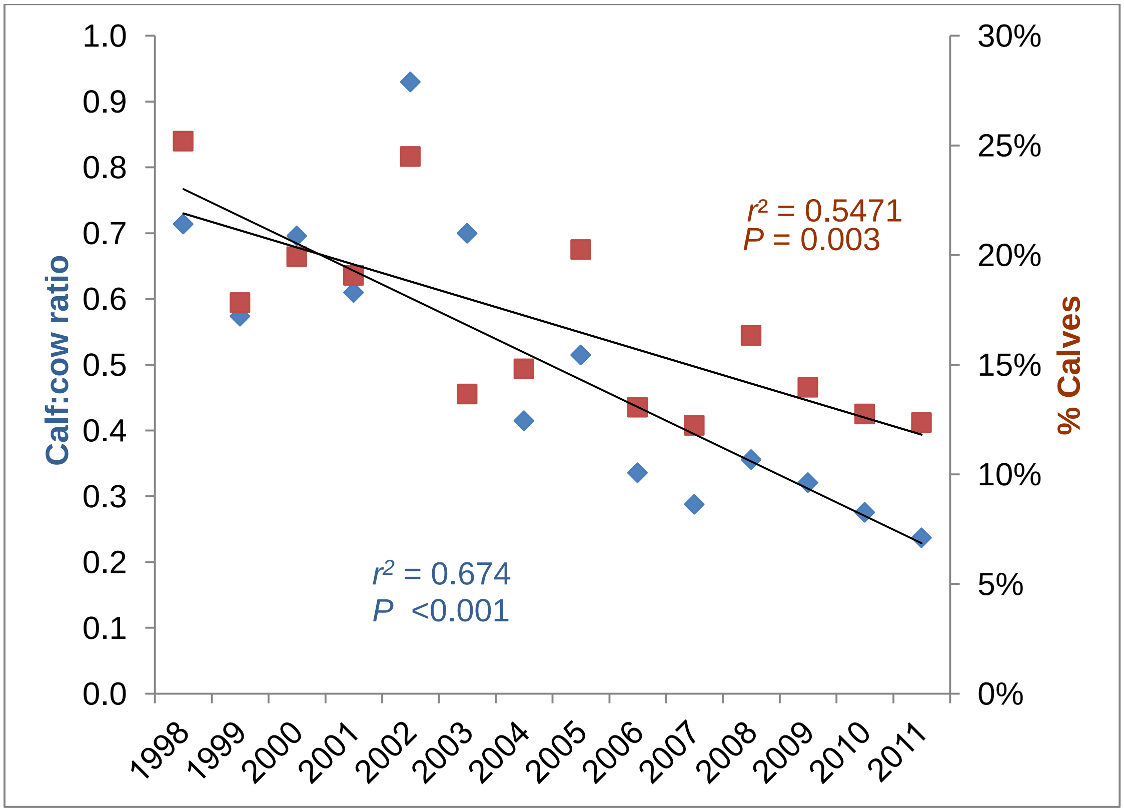

Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota. The % calves is less biased than the calf:cow ratio because it isn't dependent on adult cow moose being correctly classified. The calf:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.

Estimated recruitment from this year's survey was at an all time low. The calf:cow ratio in January was only 0.24 and calves represented only 13% of the total moose observed (Table 1). Only 1% of the cow moose were accompanied by twins (Table 1). An aerial survey of 24 radiocollared cows in late May 2010 indicated a calf:cow ratio of 1.13 calves/cow and 21% of the cow moose were accompanied by twins (M. S. Schrage, unpublished data). By January, the calf:cow ratio among these radiocollared cows was 0.46 and 1 cow (5%) was accompanied by twins. If data from the radiocollared moose was representative of the entire northeastern population, there was substantial calf mortality between May and January. Although disturbing, 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) continued to decline and this year's estimate (0.64) was the lowest value in the last 27 years. When the 2003 estimate (2.01) was excluded from analysis (the 2003 estimate was biologically impossible considering estimates in 2002 and 2004) there was a significant negative trend in the bull:cow ratio (Figure 4, $r^2 = 0.585$, $P = 0.002$). Analysis of non-hunting mortality from radiocollared moose between 2002 and 2008 indicated no difference in survival between sexes (Lenarz et al. 2009, 2010) which suggests that hunting may be contributing to this declining ratio. Since 2005 the combined State and tribal harvest has averaged 153 bull and 19 cow moose per year which represented an average of only 2% of the pre-harvest population. Simulation modeling indicates that even at this low harvest level, a bull biased harvest has the potential to reduce the population's bull:cow ratio especially with higher levels of non-hunting mortality and or reduced recruitment (Lenarz unpublished).

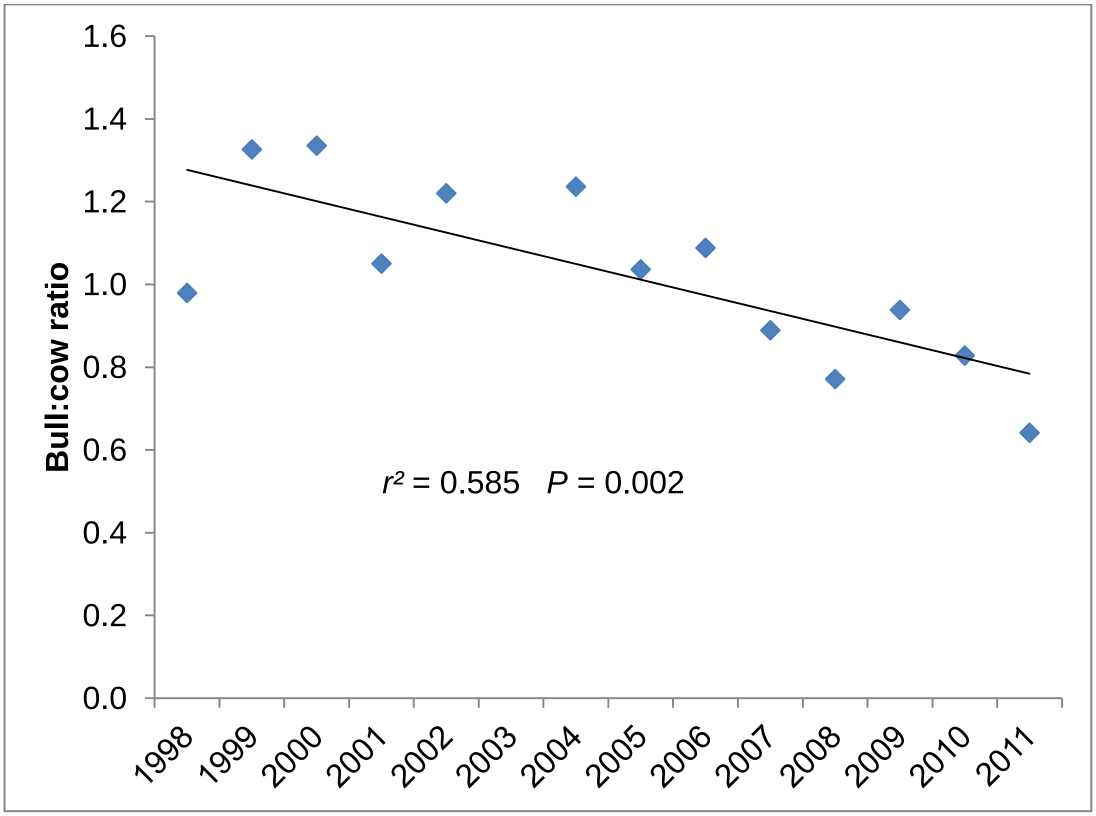

Figure 4. Estimated bull:cow ratio from aerial moose surveys in northeastern Minnesota. The 2003 estimate (2.01) was omitted from this figure because it was biologically impossible considering estimates in 2002 and 2004. The bull:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.

It is generally accepted that productivity of moose decline if the proportion of bulls in the population drops below some threshold (Rausch et al. 1974, Bubenik 1987, Crete et al. 1981, Solberg et al. 2002). However, there are no empirical data to estimate this threshold for moose in Minnesota or eastern Canada. Based on simulation modeling, Crete et al. (1981) recommended maintaining a bull:cow ratio above of 0.67. If the bull:cow ratio in northeastern Minnesota continues to decline, we may witness a decline in productivity.

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