FOREST WILDLIFE POPULATIONS

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GROUSE SURVEYS IN MINNESOTA DURING SPRING 2009

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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 2009. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 2.0 (95% confidence interval = 1.8–2.3) drums/stop (dps). That was 43% higher than the mean of 1.4 (1.2–1.6) dps observed during 2008. It was as high as counts during the last 3 peak years of the long-term population cycle (i.e., 1978, 1989, and 1998).

During the spring 2009 survey 2,699 sharp-tailed grouse were observed at 199 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 10.0 (8.5–11.7) in the East Central survey region, 15.2 (13.4–17.0) in the Northwest region, and 13.6 (12.2–15.1) statewide. Index values in the Northwest region were 15% (-1–34%) greater during 2009 than during 2008, which were greater than during any other year since 1980. Index values in the East Central region declined slightly from 2008 but remained higher than values observed during 25 of the last 27 years.

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 1990 annual harvest of sharp-tailed grouse by hunters has varied from 8,000 to 30,000 birds, and the number of hunters has varied from 6,000 to 13,000.

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/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, 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 1982–2008. 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 for spring 2009. 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 132 routes between 8 April and 15 May 2009. Most routes (83%) were run between 22 April and 8 May. The median date this year (1 May) was similar to the most recent 10-year average (29 April). Cooperators included the DNR Divisions of Fish & Wildlife and Ecological Services; Chippewa and Superior National Forests (USDA Forest Service); Fond du Lac, Grand Portage, 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. Observers reported survey conditions as Excellent, Good, and Fair on 57%, 35%, and 8% of 129 routes, respectively. The distribution of survey conditions was within the range of results from the last 3 years.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 2.0 (95% confidence interval = 1.8–2.3) drums/stop (dps) during 2009. Drum counts by survey region during 2009 were 2.4 (2.0–2.7) dps in the Northeast (*n* = 110 routes), 1.9 (1.4–2.6) dps in the Northwest (*n* = 8), 1.1 (0.6–1.7) dps in the Central Hardwoods (*n* = 15), and 0.5 (0.1–0.9) 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.

Increases in counts from 2008 to 2009 in the Northeast (44%) and Northwest (117%) regions were statistically significant, as was the statewide increase (43%). Changes in counts in the Central Hardwoods (+5%) and Southeast (-27%) regions were not significant. Drum counts during 2009 throughout most of the range of ruffed grouse in Minnesota were as high as counts during the last 3 peak years of the long-term population cycle (i.e., 1978, 1989, and 1998). It is currently the 4th year of an increasing phase of the cycle, which has lasted as few as 4 years and as many as 8 years during the last 4 cycles.

Sharp-tailed Grouse

A total of 2,699 sharp-tailed grouse was observed at 199 dancing grounds with ≥2 male grouse (or grouse of unknown sex) during spring 2009. Leks with ≥2 grouse were visited a mean of 1.8 times. There were 622 grouse on 62 leks in the EC survey region and 2,077 grouse on 137 leks in the NW region. The index values for the NW region and statewide range continued an increasing trajectory since 2006 (Tables 1 and 2) to values greater than they have been since 1980 (Figure 5). Index values in the EC region declined slightly from 2008 (Tables 1 and 2) but remained higher than values observed during 25 of the last 27 years.

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

[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

[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.

ACKNOWLEDGEMENTS

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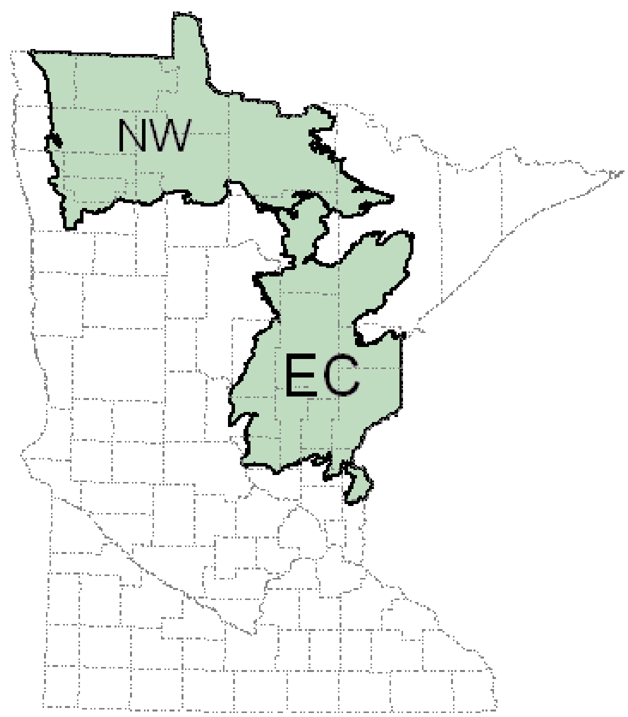


Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** relative to county boundaries in Minnesota. The regions were based largely on boundaries of ECS Subsections.

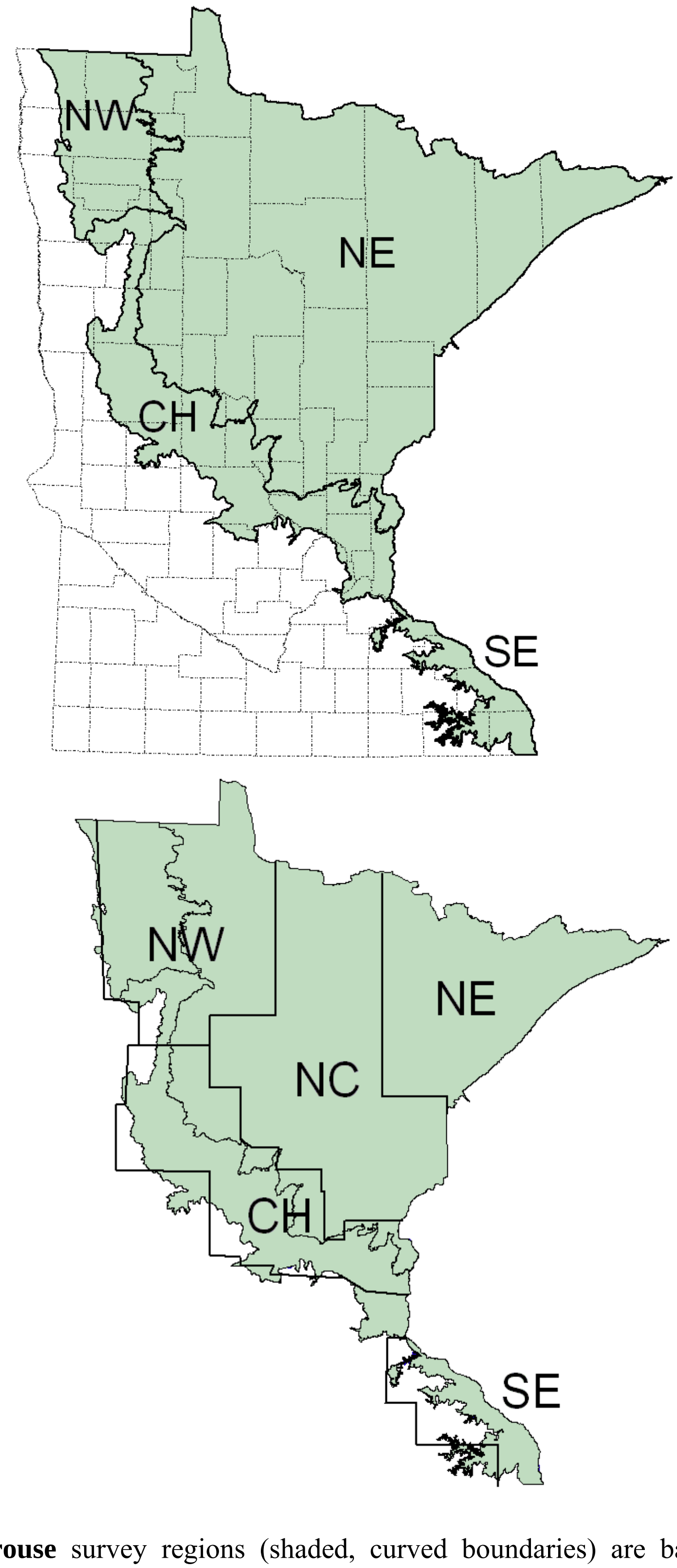
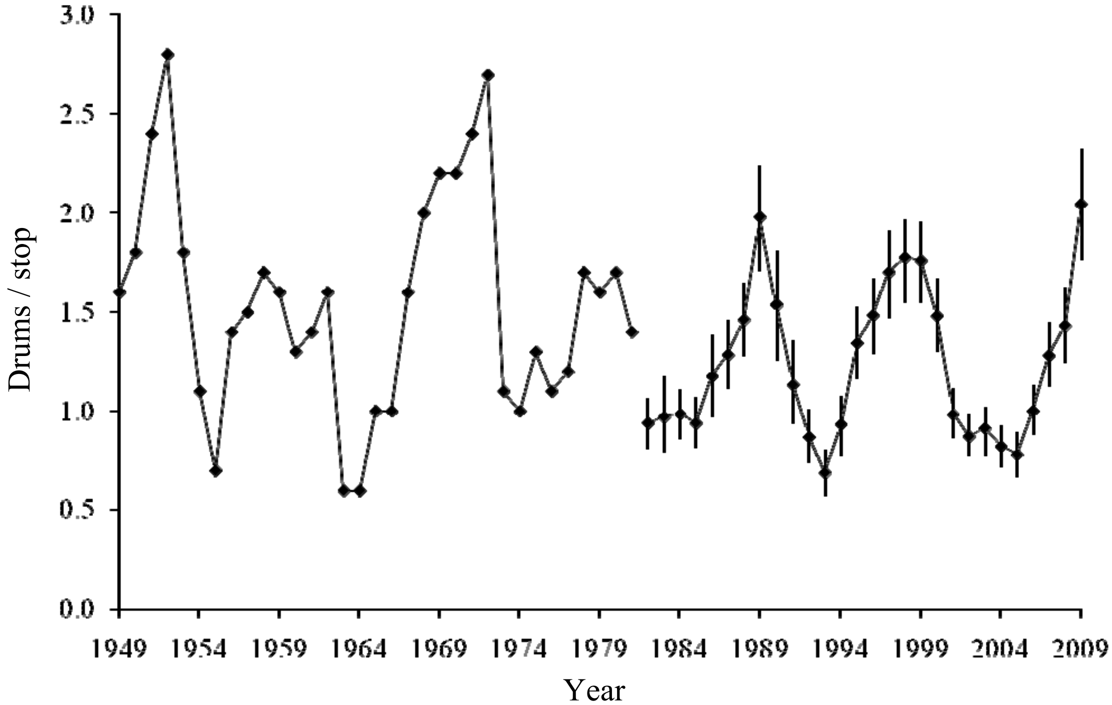


Figure 2. **Ruffed grouse** survey regions (shaded, curved boundaries) are based on the Ecological Classification System. Top panel: regions are labeled and overlaid on counties (dashed lines). Bottom panel: former survey zones (straight boundaries) are labeled and overlaid on regions.



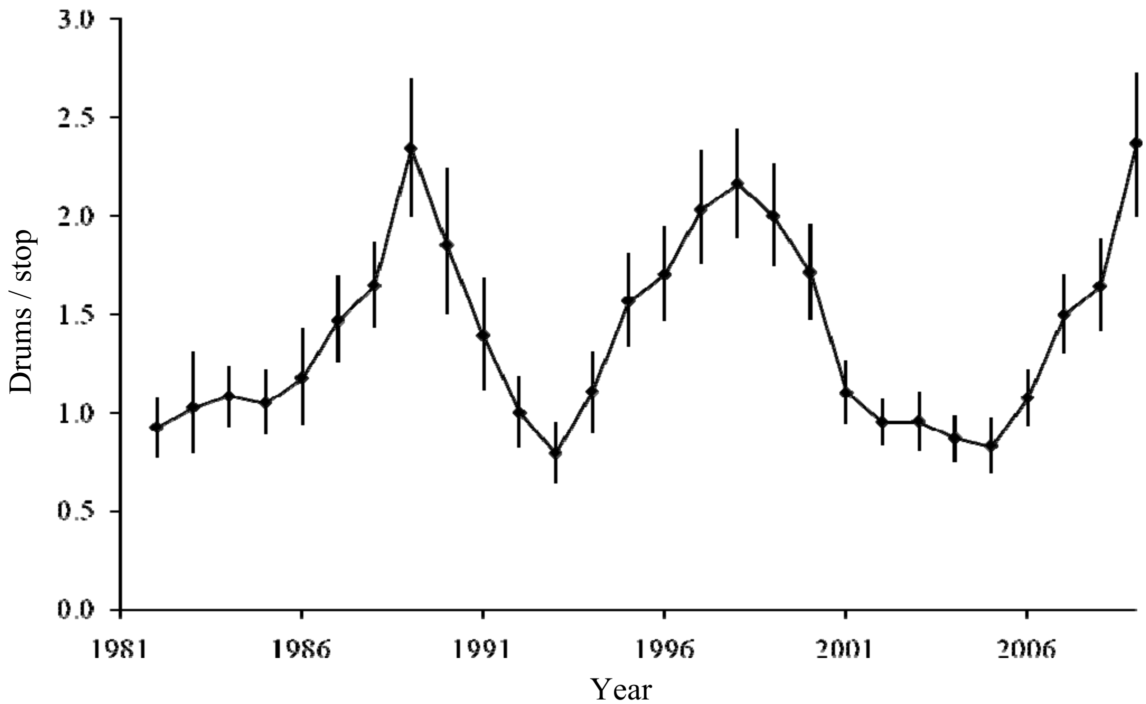


Figure 3. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current methods, so confidence intervals were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

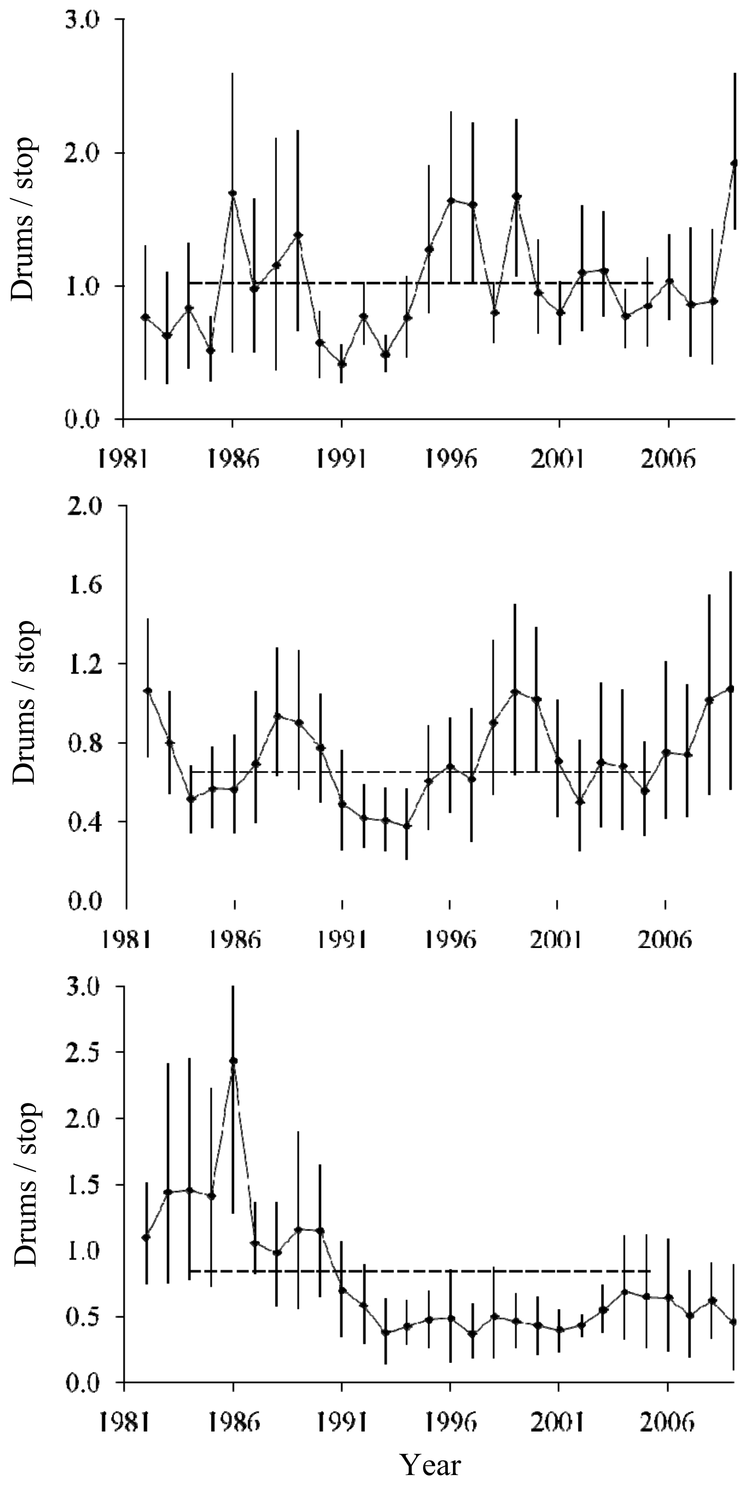


Figure 4. Ruffed grouse drum count index values in the **Northwest** (top), **Central Hardwoods** (middle), and **Southeast** (bottom) survey regions of Minnesota. Dashed horizontal lines indicate the mean from 1984 to 2004. Vertical error bars represent 95% confidence intervals based on bootstrap samples.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

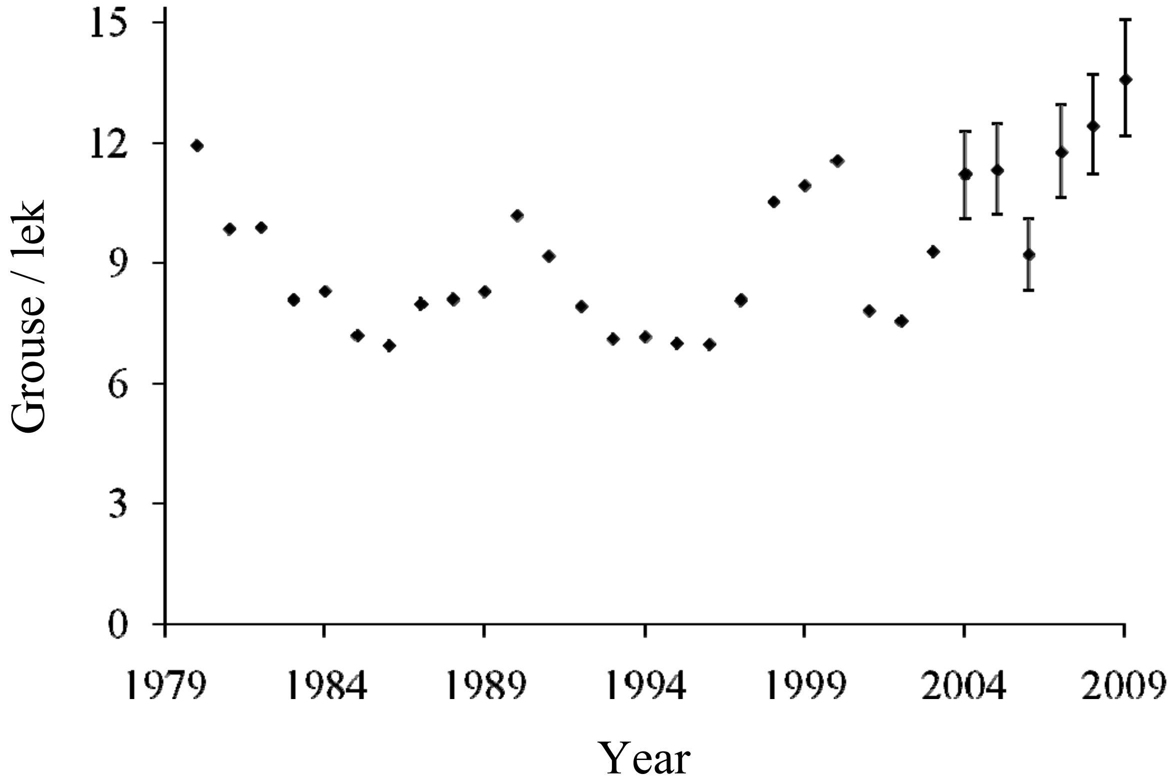


Figure 5. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds, 1980–2009. Vertical error bars, which were calculated only for recent years, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.

PRAIRIE-CHICKEN SURVEY IN MINNESOTA DURING 2008 AND 2009

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SUMMARY OF FINDINGS

Surveys for greater prairie-chickens (*Tympanuchus cupido pinnatus*) were conducted during April and May of 2008 and 2009. During 2009 we counted 1,665 male prairie-chickens (includes birds of unknown sex) and located 151 booming grounds. Within survey blocks we observed 0.32 (0.23–0.42) leks/mi^2 and 10.8 (9.6–12.1) males/lek. Approximately 19% fewer leks and 30% fewer males were counted in survey blocks during spring 2009 than during spring 2008. Averages of annual densities observed during 1993–2002 were 0.2 leks/mi^2 and 11.5 males/lek.

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 100 prairie-chickens annually since 2003 when a limited-entry hunting season was opened for the first time since 1942.

Prairie-chickens, like sharp-tailed grouse, gather at leks during spring. The leks of prairie-chickens are also 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. 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 leks in western Minnesota. They attempted to locate and observe multiple times all prairie-chicken leks within 17 designated survey blocks (Figure 2). Each block was approximately 4 miles × 4 miles square (4,144 ha) and was selected non-randomly based upon the spatial distribution of leks and the presence of relatively abundant grassland habitat. Ten survey blocks were located in what was considered the core of the prairie-chicken range in Minnesota. The other 7 blocks were located in the periphery of the range. The permit areas for the fall hunting season roughly coincide with the core of the range (Figure 2).

Observations of leks 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 leks from a distance using binoculars. If vegetation or topography obscured the view of a lek, 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 lek were 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 leks are males. Although most male prairie-chickens attend leks most mornings, female attendance at leks 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.

RESULTS & DISCUSSION

Observers from at least 3 cooperating organizations and many unaffiliated volunteers counted prairie-chickens during April and May in 2008 and 2009. 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 236 booming grounds and counted 2,863 male prairie-chickens during 2008 (Table 1). Observers located 151 booming grounds and counted 1,566 male prairie-chickens during 2009 (Table 2). Within hunting permit areas we observed 0.08 leks/mi^2 (0.03 leks/km^2) and 12.8 males/lek during 2008 and 0.05 leks/mi^2 (0.02 leks/km^2) and 10.4 males/lek during 2009. Minimum counts in Tables 2 and 3 and the densities calculated from them 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 spatial sampling design.

Each booming ground was observed on a median of 1 (mean = 1.8) and 2 (mean = 2.0) different days during 2008 and 2009, respectively. Fifty-seven percent and 40% of leks were observed only once during 2008 and 2009, respectively. Attendance of males at prairie-chicken leks 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 leks and individual birds at leks. 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 **2008**. Counts of leks and birds are not comparable among permit areas or years.

Permit Area	Area (sq. mi.)	Leks	Males	Unk.[a]
801A	233	0	0	0
802A	319	18	160	0
803A	258	12	108	0
804A	168	10	149	0
805A	103	26	416	0
806A	289	8	114	0
807A	170	30	361	0
808A	161	30	448	0
809A	287	27	337	0
810A	195	22	285	14
811A	272	15	156	24
PA subtotal[b]	2,454	198	2,534	38
Outside PAs[c]	NA[d]	38	329	96
Grand total	NA	236	2,863	134

[a] Unk. = prairie-chickens of unknown sex. It is likely that most were males.
[b] Sum among the 11 permit areas.
[c] Counts from outside the permit areas.
[d] NA = not applicable. The size of the area outside permit areas was not defined.

Table 2. Minimum abundance of prairie-chickens within and outside of hunting permit areas in western Minnesota during spring **2009**. Counts of leks and birds are not comparable among permit areas or years.

Permit Area	Area (sq. mi.)	Leks	Males	Unk.[a]
801A	233	0	0	0
802A	319	8	74	0
803A	258	0	0	0
804A	168	0	0	0
805A	103	10	106	0
806A	289	5	52	0
807A	170	31	370	2
808A	161	23	248	0
809A	287	23	265	0
810A	195	20	179	28
811A	272	11	70	37
PA subtotal[b]	2,454	131	1,364	67
Outside PAs[c]	NA[d]	20	202	32
Grand total	NA	151	1,566	99

[a] Unk. = prairie-chickens of unknown sex. It is likely that most were males.
[b] Sum among the 11 permit areas.
[c] Counts from outside the permit areas.
[d] NA = not applicable. The size of the area outside permit areas was not defined.

Within survey blocks we counted 954 males (includes birds of unknown sex) on 88 leks during 2009 (Table 3). That was 30% fewer males and 19% fewer leks than were counted in survey blocks during spring 2008 (Figure 3). Leks were defined as having ≥2 males, so observations of single males were excluded from summaries by survey block. During spring 2009 we observed 0.38 (0.24–0.52) leks/mi^2 and 11.1 (9.6–12.6) males/lek in survey blocks in the core of the range, whereas we observed 0.24 (0.15–0.33) leks/mi^2 and 10.3 (8.2–12.4) males/lek in peripheral blocks (Table 3). The densities of prairie-chickens observed during 2009 were less than the means observed during 2008 but were similar to the means of 0.2 leks/mi^2 and 11.5 males/lek observed in survey blocks from 1993 until 2002.

Table 3. Counts of prairie-chickens within survey blocks in Minnesota.

Range[b]	Survey Block	Area (miles^2)	2009 Leks	2009 Males[c]	Change from 2008[a] Leks	Change from 2008[a] Males[c]
Core	Polk 2	16.2	9	101	1	-19
	Norman 1	16.1	2	21	-1	-28
	Norman 3	16.0	11	120	2	12
	Clay 1	17.6	10	90	-1	-62
	Clay 2	16.0	2	28	0	-36
	Clay 3	16.1	8	89	-2	-26
	Clay 4	14.9	6	63	1	-5
	Wilkin 1	15.4	8	90	0	-21
	Wilkin 3	16.1	4	66	-3	-26
	Otter Tail 1	15.9	1	7	-1	-31
	Core subtotal	160.2	61	675	-4	-242
Periphery	Polk 1	15.9	7	63	-3	-31
	Norman 2	16.3	6	72	-3	-21
	Mahnomen	16.1	3	34	-2	-66
	Becker 1	16.0	2	13	-5	-54
	Becker 2	16.1	3	44	-1	-1
	Wilkin 2	16.1	3	17	0	-2
	Otter Tail 2	15.7	3	36	-3	12
	Periphery subtotal	112.2	27	279	-17	-163
Grand total		272.4	88	954	-21	-405

[a] The 2008 count was subtracted from the 2009 count, so a negative value indicates a decline.
[b] Survey blocks were classified as either mostly within the original (i.e., 2003–2005) hunting permit areas (core) or mostly outside those permit areas (periphery).
[c] Includes birds recorded as being of unknown sex but excludes lone males not observed at a booming ground.

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 Laura Gilbert for helping with data entry and Mark Lenarz for reviewing a draft of this report.

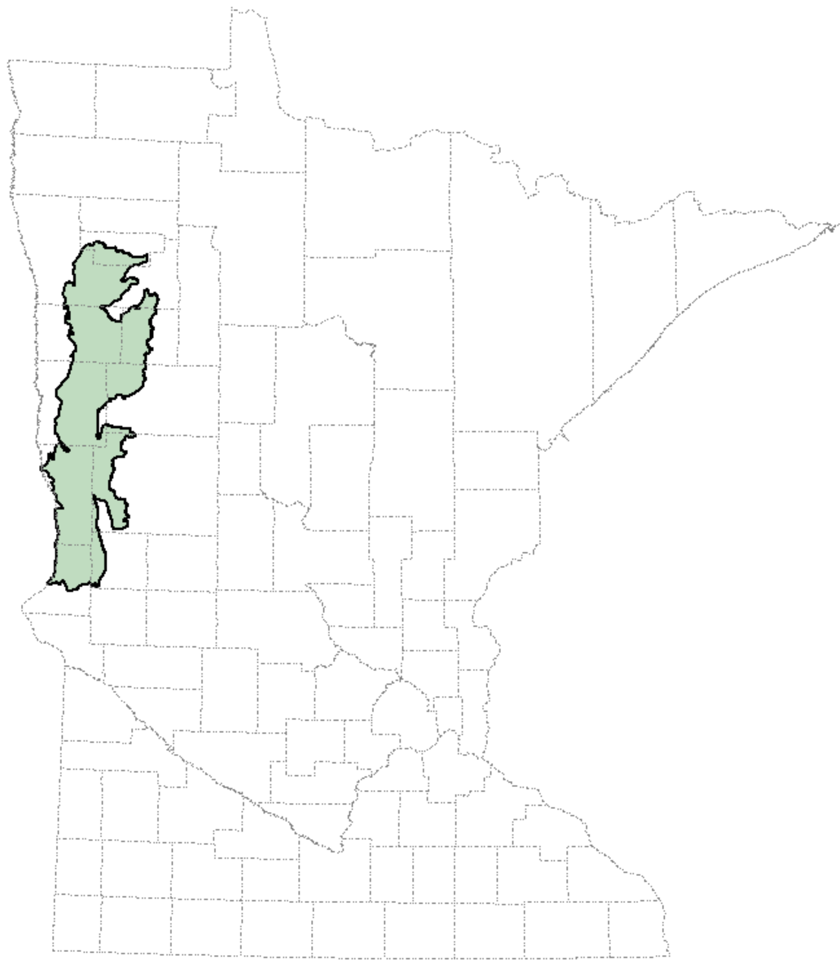

Figure 1. Primary range of greater prairie-chickens (shaded area) relative to county boundaries in Minnesota. The prairie-chicken range was based on ECS Land Type Associations.

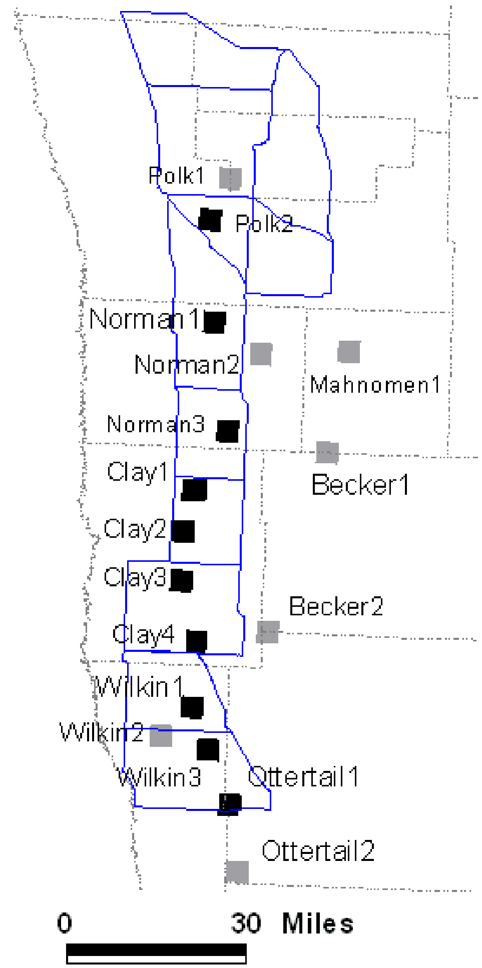

Figure 2. Survey blocks (labeled squares) and hunting permit area boundaries (solid lines) for prairie-chickens in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which they were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

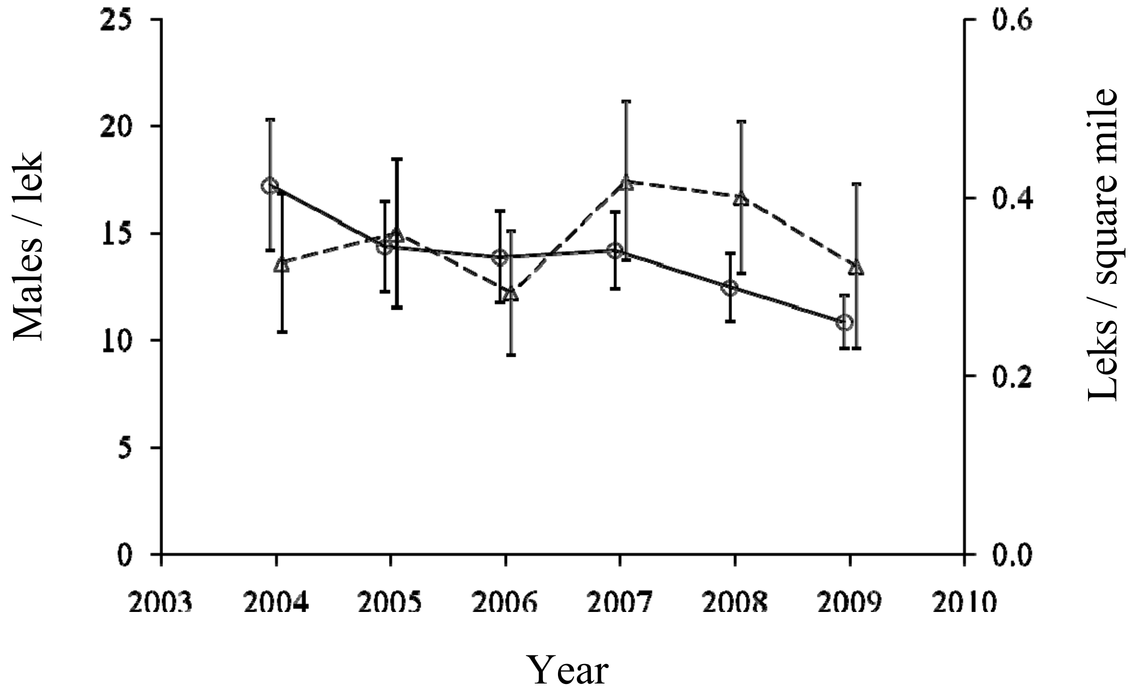

Figure 3. Number of prairie-chicken males/lek (circles) and leks/mi^2 (triangles) observed in western Minnesota. Vertical error bars represent 95% confidence intervals based on *n* = 17 survey blocks.

REGISTERED FURBEARER POPULATION MODELING
2009 REPORT

John Erb, Forest Wildlife Populations and Research Group
Drawing by Gilbert Proulx

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, and/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 annual field-based track surveys, with the exception of otter for which no harvest-independent survey data is currently available for comparison.

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 2008 harvest information is available in a separate report. Bobcat and marten age data is obtained via x-ray examination of pulp cavity width or microscopic counts of cementum annuli from teeth of harvested animals. While the population models only utilize data for the 3 age-classes (juvenile, yearling, adult), marten and bobcat cementum annuli counts have been collected for all non-juveniles in recent years to facilitate interpretation of reproductive data (bobcats) and to obtain current information on year-class distribution for both species. However, this year, all marten teeth and male bobcats were classified only into age-classes (juvenile, yearling, adult), while all female bobcat teeth were sectioned to determine specific year-classes. Current harvest age proportions for fisher and otter are approximated using averages computed from carcass collections obtained during 1980-86 (otter) and 1977-1994 (fisher).

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 2008 registered DNR trapping and hunting harvest was 853, up 22% from last year and near the record harvest observed in 2006 (890; Table 1). Trapping harvest increased 31%, accounting for 81% of the total harvest. Hunting harvest declined 8% to 164. Total modeled harvest, which includes reported tribal take, was 928. Based on population modeling estimates, 30% of the fall population was harvested. The juvenile to adult female ratio in the harvest (1.1; Table 1) was below the long-term average (1.5), but similar to the recent 10-year average (1.2). A total of 714 bobcat carcasses were examined (Table 1), with a mean age of 2.6 for females. Approximately 8% of the harvested female bobcats were 6.5+ years old (Figure 1).

Based on examination of reproductive tracts, 33% of yearling females produced a litter in 2008, above the previous 5-year average of 26% (Figure 2). Average litter size for pregnant yearlings was 2.2, similar to the 5-year average (2.1). Pregnancy rate for 2+ year olds was 80%, also above the previous 5-year mean (73%). Mean litter size for pregnant adults was 2.7 (5-year mean = 2.8). For both yearlings and adults, pregnancy rates appear to fluctuate much more than average litter size.

Population modeling predicts an 18% decline in this spring's bobcat population (Figure 3), with the estimated population size (~ 1,800) now similar to that estimated in the mid-1990's. However, 3-year-averaged scent station indices were at an all-time high last fall, and winter track indices remain comparatively high. Based on these track surveys, as well as additional field sign, I believe the population model is currently underestimating bobcat population size. Given the availability and use of current reproductive data and accurate harvest totals, this implies that non-harvest mortality of bobcats may currently be lower than assumed.

Fisher. For the past 2 years, the fisher harvest season has been 1 week shorter than 'normal' (i.e., shortened from 16 days to 9 days). Harvest this year under the DNR framework was 1,712, similar to last year (Table 2). Modeled harvest, which includes reported tribal take, was 1,828. An estimated 17% of the pre-harvest fisher population was harvested this past winter. Carcass collections ended in 1994, so no current age or reproductive data are available.

Population modeling projects a 5% increase in the spring population, currently estimated at ~8,400. Conversely, and in spite of the reduced harvest the past 2 years, the fisher winter track index has yet to rebound from its recent downward trend (Figure 4). However, as discussed in more detail in a separate track survey report, I believe this year's track survey results may have been biased low, a result of the survey being conducted later than ever before and during one of the most severe winters since the survey began. Hence, it is premature to conclude that the population has not stabilized or slightly increased. Based on multiple sources of information, I believe the fisher population has been declining for several years, but has now stabilized. Nevertheless, if modeling projections further diverge from track survey trends the next couple years, it would suggest that the population model is over-estimating fisher abundance.

Marten. As with fisher, the marten harvest season the last 2 years has been 1 week shorter than 'normal' (i.e., shortened from 16 days to 9 days). Harvest this year under the DNR framework was 1,823, down 18% from last year (Table 3). Modeled harvest, which includes reported tribal take, was 1,953. Age-class information was obtained from a sample of 70% of the carcasses collected this year. Juveniles comprised 40% of the total harvest, below the long-term average of 56% (Table 3; Figure 5). The juvenile:adult female ratio (2.1) in the harvest was also below the long-term average (Table 3).

Based on modeling, 16% of the fall population was harvested. After several years of estimated decline, the population model now projects a stable to slightly increasing population, with an estimated 2009 spring population of ~ 10,600 (Figure 6). Nevertheless, averaged winter track counts continue to suggest a population decline. As noted for fisher, however, I believe this year's track survey results may have been biased low as a result of routes being surveyed later than usual and during a comparatively severe winter. Based on multiple sources of information, I believe the marten population, similar to fisher, has been declining for several years, but has now stabilized. However, if modeling projections further diverge from track survey trends the next couple years, it would suggest that the population model is over-estimating marten abundance.

Otter. In the new north otter-trapping zone (slightly expanded in 2007), harvest under the DNR framework was 1,884, a slight increase from last year (Table 4). Modeled harvest, including reported tribal take, was 1,983 (Table 4). An estimated 16% of the fall population was harvested. Carcass collections ended in 1986, so no age or reproductive data are available. After several years of estimated decline, modeling suggests the population has increased the past 2 years, with an estimated 3% increase this year (Figure 7). No independent otter survey data are currently available for comparison. The current estimated spring population in the north zone is ~ 10,900.

A new otter-trapping zone was also established in southeast Minnesota starting in 2007. A total of ~ 52 otter were harvested this year in the southeast zone, slightly more than during the first year (~ 44). While we have established protocol for an otter survey in this region to assist with population monitoring, weather conditions and scheduling conflicts did not allow us to complete the survey the past 2 winters. I am also currently developing a population model specific to the southeast zone, but initial projections are not yet available.

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Table 1. Bobcat harvest data, 1980 to 2008.

Year	Season	Limit	DNR Harvest	Modeled Harvest[1]	% Autumn Pop. Taken[2]	Carcasses Examined	% juveniles	% yearlings	% adults	Juvs : adult female	% male juveniles	% male yearlings	% male adults	Overall % males	Mean Pelt Price[3]
1980	12/1-1/31	5	210	210	10	48	31	33	36	1.9	80	69	56	66	$79
1981	12/1-1/23	5	260	260	13	230	37	23	40	2.1	59	63	55	58	$73
1982	12/1-1/23	5	274	320	15	261	35	15	50	1.3	47	49	47	48	$66
1983	12/1-1/22	5	208	212	10	205	37	26	37	1.5	54	53	30	45	$61
1984	12/1-1/20	5	280	288	15	288	37	13	50	1.4	52	66	44	51	$76
1985	11/30-1/19	5	119	121	6	99	33	19	48	1.2	41	41	43	42	$70
1986	11/29 -1/3	5	160	160	8	132	26	17	57	0.9	53	32	51	51	$120
1987	11/28-1/3	5	214	229	12	163	33	16	51	1.4	44	52	48	48	$101
1988	11/26-1/1	5	140	143	7	114	40	18	42	1.7	58	62	46	54	$68
1989	12/2-1/7	5	129	129	6	119	39	17	44	2	49	53	56	53	$48
1990	12/1-1/6	5	84	87	4	62	20	34	46	0.8	58	80	44	59	$43
1991	11/30-1/5	5	106	110	5	93	35	33	32	3.6	59	55	70	61	$37
1992	11/28-1/3	5	167	167	7	151	28	22	50	1.2	55	45	53	53	$28
1993	12/4-1/9	5	201	210	8	161	32	20	48	1.4	51	45	52	50	$43
1994	12/3-1/8	5	238	270	11	187	26	16	58	0.8	64	43	45	50	$36
1995	12/2-1/7	5	134	152	6	96	31	15	54	2.7	57	71	79	71	$34
1996	11/30 -1/5	5	223	250	10	164	35	20	45	1.5	51	30	49	46	$33
1997	11/29-1/4	5	364	401	17	270	35	16	49	1.2	60	37	43	48	$30
1998	11/28-12/13	5	103	107	5	77	29	26	45	1.6	59	60	60	60	$28
1999	12/4-1/9	5	206	228	8	163	18	24	58	0.8	55	59	62	60	$24
2000	12/2-1/7	5	231	250	8	183	31	26	43	1.5	54	59	50	53	$33
2001	11/24-1/6	5	259	278	9	213	30	21	49	1.3	52	51	53	52	$35
2002	11/30-1/5	5	544	621	18	475	27	25	48	1	66	49	46	52	$46
2003	11/29-1/4	5	483	518	16	425	25	13	62	0.9	61	46	53	54	$96
2004	11/27 – 1/9	5	631	709	20	524	28	34	38	1.6	51	40	54	49	$99
2005	11/26-1/8	5	590	638	19	485	25	13	62	0.8	51	48	46	48	$96
2006	11/25-1/7	5	890	983	26	813	26	17	57	1.1	61	50	58	57	$101
2007	11/24-1/6	5	702	758	24	633	34	14	52	1.2	55	60	47	52	$93
2008	11/29-1/4	5	853	928	30	714	26	25	49	1.1	56	52	51	52	$75

[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.

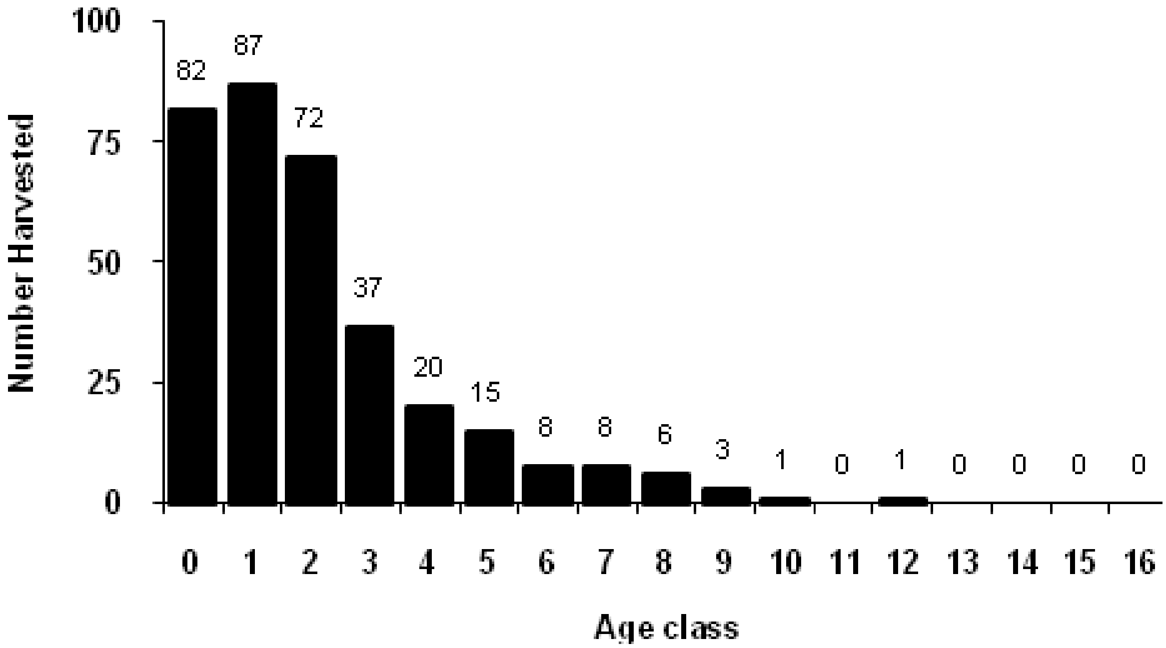

Figure 1. Age structure of female bobcats in the 2008-09 harvest.

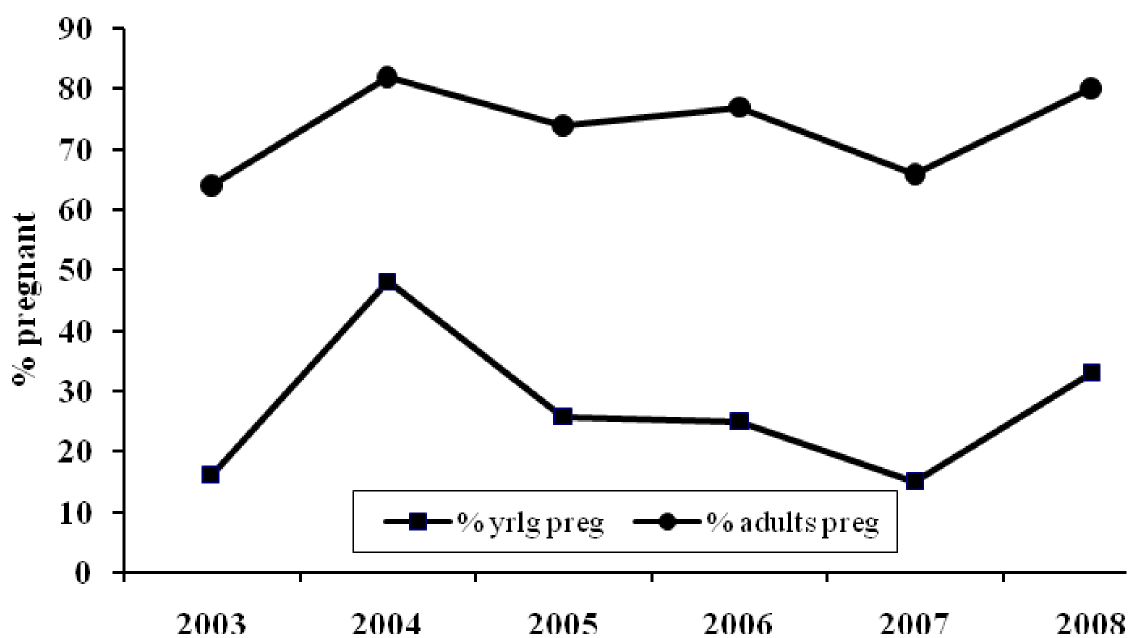

Figure 2. Pregnancy rates for yearling and adult bobcats in Minnesota, 2003-2008.

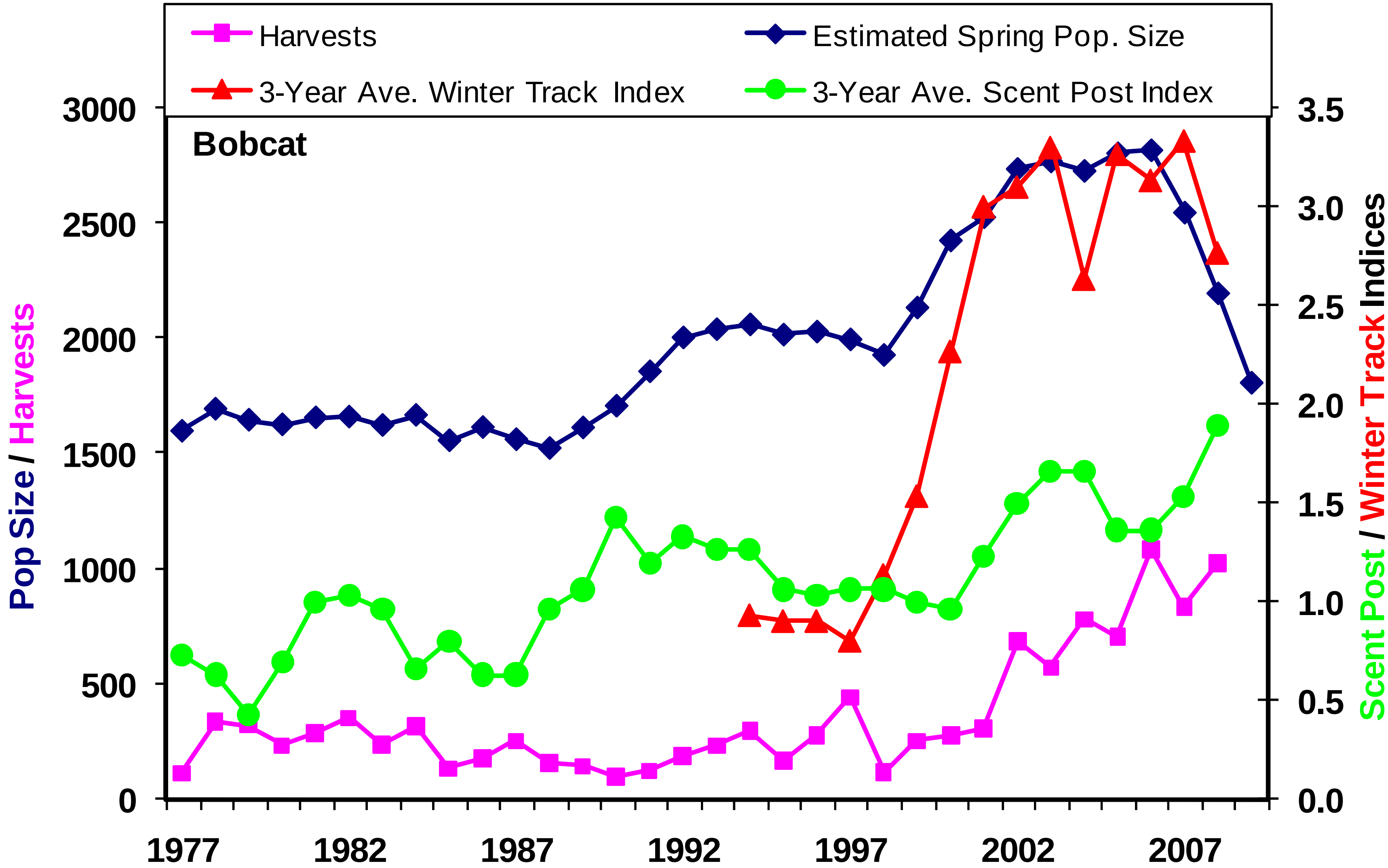

Figure 3. Bobcat populations, harvests, and survey indices, 1977-2008. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1980 to 2008. Carcass collections ended in 1994.

Year	Season	Limit[1]	DNR harvest	Modeled Harvest[2]	% Autumn Pop. Harvested[3]	Carcasses examined	% juveniles	% yearlings	% adults	Juv:ad. females	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[4]	Pelt price Females[4]
1980	CLOSED															
1981	12/1-12/10	1	862	1022	16	843	66	24	10	10.5	48	43	37	47	$94	$110
1982	12/1-12/10	1	912	1073	16	1073	66	19	15	9.4	46	41	52	46	$70	$99
1983	12/1-12/11	1	631	735	11	662	69	18	13	8.8	45	40	40	44	$71	$121
1984	12/1-12/16	1	1285	1332	19	1270	63	20	17	7.2	52	45	45	49	$70	$122
1985	11/30-12/15	1	678	735	11	712	63	20	18	5.4	46	40	34	43	$74	$130
1986	11/29-12/14	1	1068	1186	17	1186	59	24	18	5.3	48	50	37	46	$84	$162
1987	11/28-12/13	1	1642	1749	24	1534	63	15	22	4.7	46	40	37	43	$84	$170
1988	11/26-12/11	1	1025	1050	15	805	70	15	15	6.8	48	45	33	45	$54	$100
1989	12/2-12/17	1	1243	1243	17	1024	64	19	17	5.8	47	47	36	45	$26	$53
1990	12/1-12/16	1	746	756	10	592	65	14	21	4.5	44	55	30	43	$35	$46
1991	11/30-12/15	1	528	528	7	410	66	21	13	7.8	50	52	35	48	$21	$48
1992	11/28-12/13	1	778	782	9	629	58	21	21	4.9	42	55	45	46	$16	$29
1993	12/4-12/19	2	1159	1192	11	937	59	22	19	5.3	47	37	42	44	$14	$28
1994	12/3-12/18	2	1771	1932	16	1360	56	18	26	4	47	54	44	48	$19	$30
1995	12/2-12/17	2	942	1060	9	-	-	-	-	-	-	-	-	45	$16	$25
1996	11/30-12/15	2	1773	2000	16	-	-	-	-	-	-	-	-	45	$25	$34
1997	11/29-12/14	2	2761	2974	23	-	-	-	-	-	-	-	-	45	$31	$34
1998	11/28-12/13	2	2695	2987	24	-	-	-	-	-	-	-	-	45	$19	$22
1999	12/4-12/19	2	1725	1880	16	-	-	-	-	-	-	-	-	45	$19	$20
2000	12/2-12/17	4	1674	1900	16	-	-	-	-	-	-	-	-	45	$20	$19
2001	11/24-12/9	4	2145	2362	19	-	-	-	-	-	-	-	-	54	$20	$23
2002	11/30-12/15	5	2660	3028	24	-	-	-	-	-	-	-	-	54	$23	$25
2003	11/29-12/14	5	2521	2728	23	-	-	-	-	-	-	-	-	55	$27	$26
2004	11/27-12/12	5	2552	2753	23	-	-	-	-	-	-	-	-	52	$30	$27
2005	11/26-12/11	5	2388	2454	21	-	-	-	-	-	-	-	-	52	$36	$31
2006	11/25-12/10	5	3250	3500	30	-	-	-	-	-	-	-	-	51	$76	$68
2007	11/24-12/2	5	1682	1811	17	-	-	-	-	-	-	-	-	51	$63	$48
2008	11/29-12/7	5	1712	1828	17	-	-	-	-	-	-	-	-	52	$22	$37

[1] Combined limit since 1999 of any combination of marten and fisher totaling the specified limit, except in 1999 where fisher portion of limit could only be 2.

[2] Includes DNR and Tribal harvests

[3] Estimated from population model, includes estimated non-reported harvest of 22% 1977-1992, and 11% from 1993-present.

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

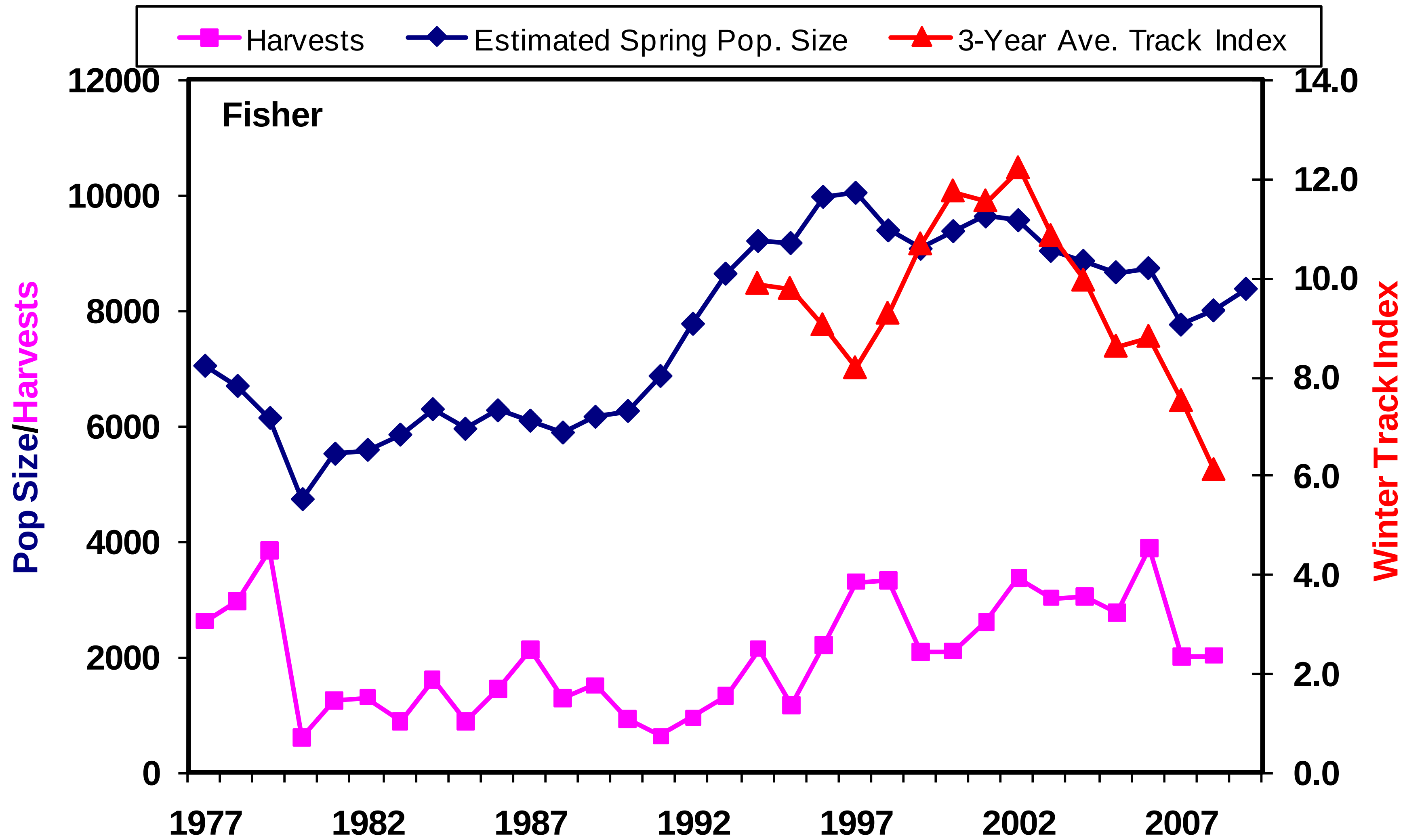

Figure 4. Fisher populations, harvests, and survey indices, 1977-2008. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2008.

Year	Season	Limit[1]	DNR harvest	Modeled harvest[2]	% Autumn Pop. Taken[3]	Carcasses examined[4]	% juveniles	% yearlings	% adults	Juv:ad females	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[5]	Pelt price Females[5]
1985	11/30-12/15	1	430	430	6	507	73	18	9	17.2	69	68	82	70	$30	$28
1986	11/29-12/14	1	798	798	10	884	64	21	15	12.3	65	71	81	69	$36	$27
1987	11/28-12/13	1	1363	1363	15	1754	66	18	16	11.2	65	67	75	67	$43	$39
1988	11/26-12/11	2	2072	2072	19	1977	66	11	23	8.6	58	50	66	59	$50	$43
1989	12/2-12/17	2	2119	2119	20	1014	68	12	20	9.7	57	63	65	59	$48	$47
1990	12/1-12/16	2	1349	1447	15	1375	48	18	34	3.6	59	54	61	59	$44	$41
1991	11/30-12/15	1	686	1000	11	716	74	9	17	16.1	69	71	72	70	$40	$27
1992	11/28-12/13	2	1602	1802	15	1661	65	18	17	15.1	63	70	75	66	$28	$25
1993	12/4-12/19	2	1438	1828	15	1396	57	20	23	7.5	61	71	67	64	$36	$30
1994	12/3-12/18	2	1527	1846	15	1452	58	15	27	6.4	62	76	67	66	$34	$28
1995	12/2-12/17	2	1500	1774	13	1393	60	18	22	8.2	63	68	66	65	$28	$21
1996	11/30-12/15	2	1625	2000	16	1372	48	22	30	4.8	62	69	67	65	$34	$29
1997	11/29-12/14	2	2261	2762	20	2238	61	13	26	6.2	60	60	63	61	$28	$22
1998	11/28-12/13	2	2299	2795	20	1577	57	18	25	6.6	62	66	65	63	$20	$16
1999	12/4-12/19	4	2423	3000	20	2013	67	12	21	9.8	65	66	67	66	$25	$21
2000	12/2-12/17	4	1629	2050	14	1598	56	25	19	8.9	62	69	66	64	$28	$21
2001	11/24-12/9	4	1940	2250	14	1895	62	15	23	11	66	73	75	69	$24	$21
2002	11/30-12/15	5	2839	3192	19	2451	39	30	31	3.1	57	63	61	60	$28	$23
2003	11/29-12/14	5	3214	3548	22	2391	48	17	35	4	57	65	66	62	$30	$27
2004	11/27-12/12	5	3241	3592	24	2776	26	28	46	1.3	52	64	57	58	$31	$27
2005	11/26-12/11	5	2653	2873	20	1992	53	16	31	4.9	64	63	65	64	$37	$32
2006	11/25-12/10	5	3788	4120	28	1914	64	17	20	9.2	66	67	65	66	$74	$66
2007	11/24-12/2	5	2221	2481	19	1355	30	29	41	1.5	56	64	50	56	$59	$50
2008	11/29-12/7	5	1823	1953	16	1095	40	21	39	2.1	58	60	53	56	$31	$28

[1] Combined limit since 1999 of any combination of fisher and marten totaling the specified limit, except in 1999 where fisher portion of limit could only be 2.

[2] Includes DNR and Tribal harvests

[3] Estimated from population model; includes estimated non-reported harvest of 40% in 1985-1987 and 1991, 20% in 1988-1990 and 1992-1998, and 15% from 1999-present.

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

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

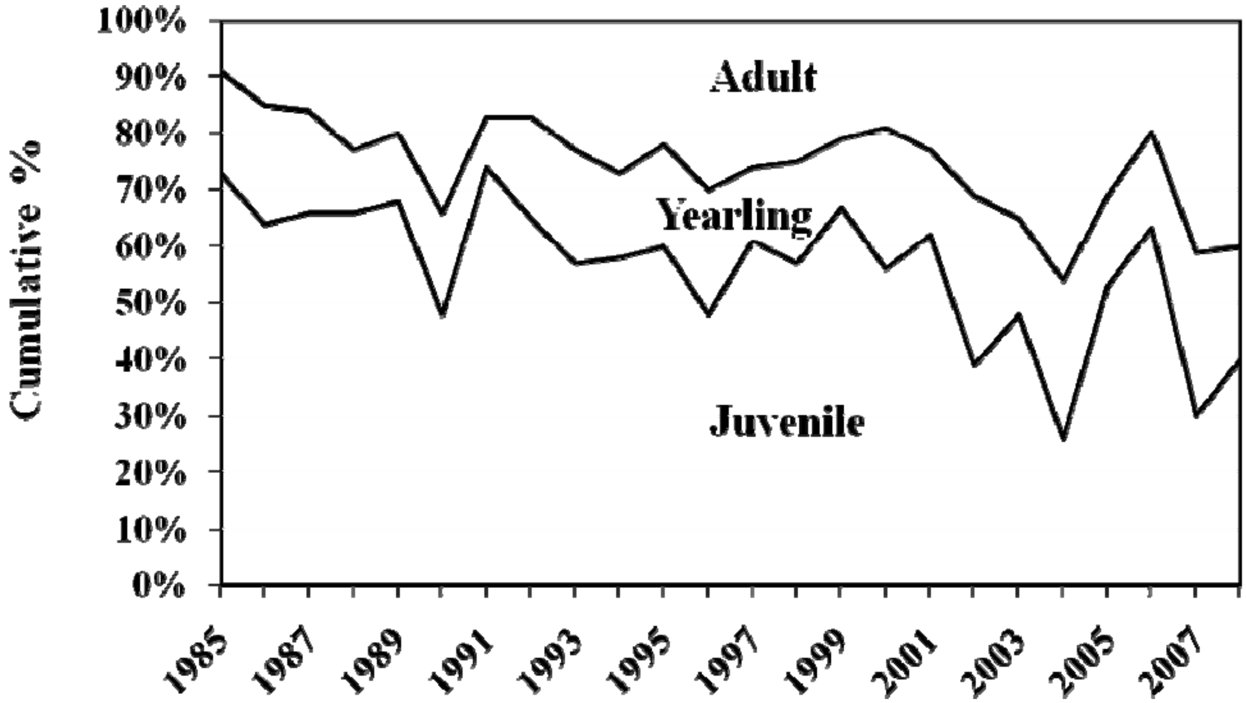

Figure 5. Marten age-class proportions in the harvest, 1985-2008.

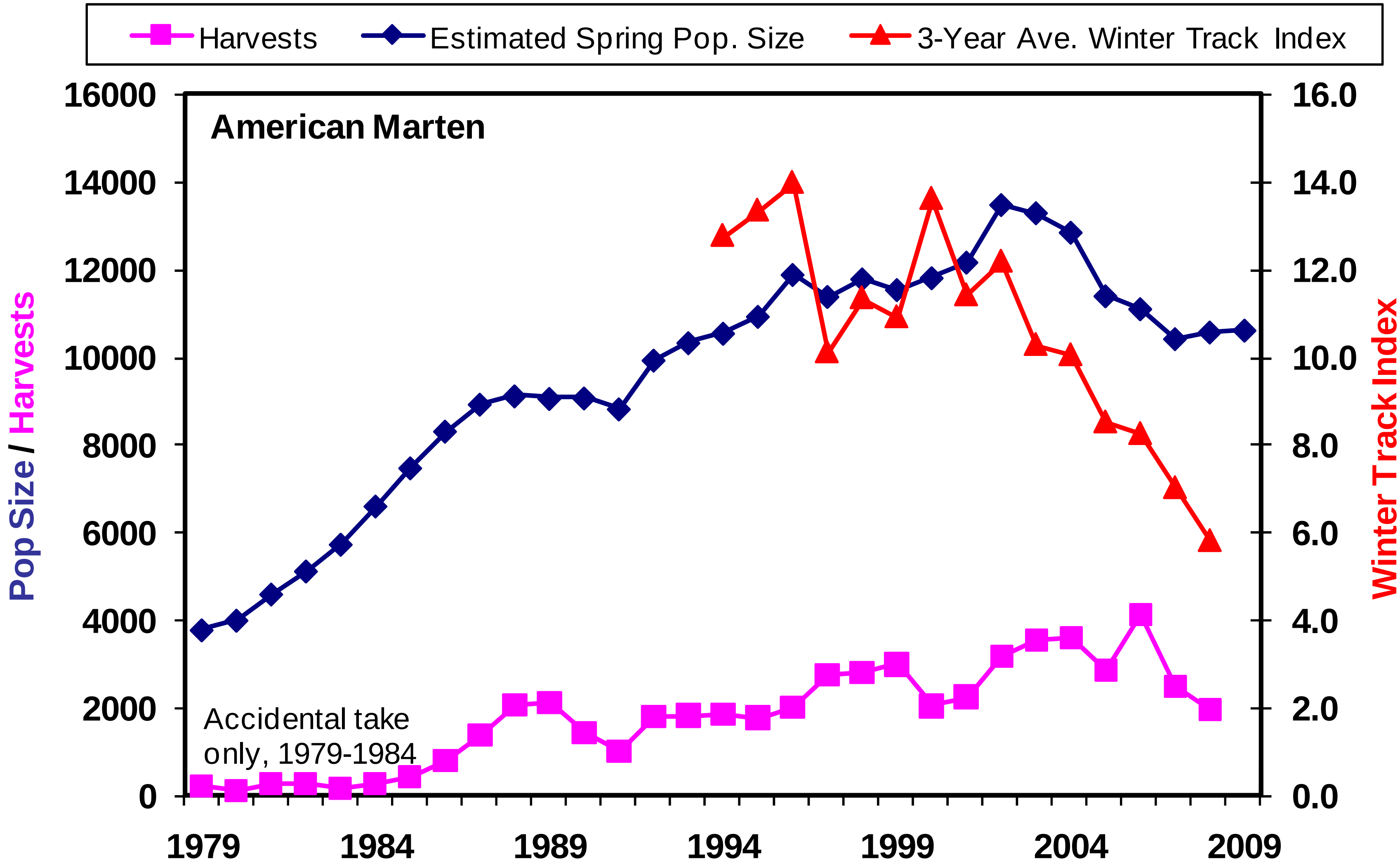

Figure 6. American marten populations, harvests, and survey indices, 1979-2008. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data, 1980 to 2008. Carcasses were only collected from 1980-86.

Year	Season	Limit	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]
1980	11/15-1/29	2	1111	1111	16	88	55	15	30	3.4	40	62	56	48	$33	$18
1981	11/14-1/28	2	485	762	11	471	55	20	25	4.3	56	53	48	52	$30	$14
1982	11/13-1/27	2	385	625	9	389	51	26	23	6	57	65	65	60	$26	$11
1983	11/12-1/26	2	408	614	8	433	42	31	27	3.7	56	57	57	56	$25	$12
1984	11/17-2/01	2	513	561	7	549	48	23	29	3.2	47	50	49	49	$22	$12
1985	11/16-2/15	3	559	572	7	572	43	23	34	2.2	53	50	43	51	$21	$15
1986	10/24-1/29	3	777	777	8	745	45	23	32	2.7	45	48	46	47	$24	$20
1987	10/27-1/29	3	1386	1484	15	-	-	-	-	-	-	-	-	52	$23	$17
1988	10/29-1/27	3	922	922	9	-	-	-	-	-	-	-	-	52	$22	$14
1989	10/28-2/17	3	1294	1294	12	-	-	-	-	-	-	-	-	52	$22	$12
1990	10/27-1/6	3	888	903	8	-	-	-	-	-	-	-	-	52	$24	$9
1991	10/26-1/5	3	855	925	8	-	-	-	-	-	-	-	-	51	$25	$9
1992	10/24-1/3	4	1368	1368	10	-	-	-	-	-	-	-	-	52	$30	$7
1993	10/23-1/9	4	1459	1646	10	-	-	-	-	-	-	-	-	52	$43	$11
1994	10/29-1/8	4	2445	2708	19	-	-	-	-	-	-	-	-	52	$48	$14
1995	10/28-1/7	4	1435	1466	12	-	-	-	-	-	-	-	-	52	$38	$13
1996	10/26-1/5	4	2219	2500	18	-	-	-	-	-	-	-	-	52	$39	$19
1997	10/25-1/4	4	2145	2313	17	-	-	-	-	-	-	-	-	52	$39	$19
1998	10/24-1/3	4	1946	2139	16	-	-	-	-	-	-	-	-	52	$34	$11
1999	10/23-1/9	4	1635	1717	13	-	-	-	-	-	-	-	-	52	$41	$12
2000	10/28-1/7	4	1578	1750	13	-	-	-	-	-	-	-	-	52	$51	$15
2001	10/27-1/6	4	2323	2531	18	-	-	-	-	-	-	-	-	57	$51	$14
2002	10/26-1/5	4	2145	2390	16	-	-	-	-	-	-	-	-	59	$46	$13
2003	10/25-1/4	4	2766	2966	20	-	-	-	-	-	-	-	-	57	$85	$13
2004	10/23-1/9	4	3450	3700	25	-	-	-	-	-	-	-	-	56	$87	$14
2005	10/29-1/8	4	2846	2884	21	-	-	-	-	-	-	-	-	58	$89	$16
2006	10/28-1/7	4	2720	2872	22	-	-	-	-	-	-	-	-	56	$43	$16
2007	10/27-1/6	4	1847	1955	16	-	-	-	-	-	-	-	-	55	$42	$16
2008	10/25-1/4	4	1884	1983	16	-	-	-	-	-	-	-	-	59		

[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 15% from 2002-present.

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

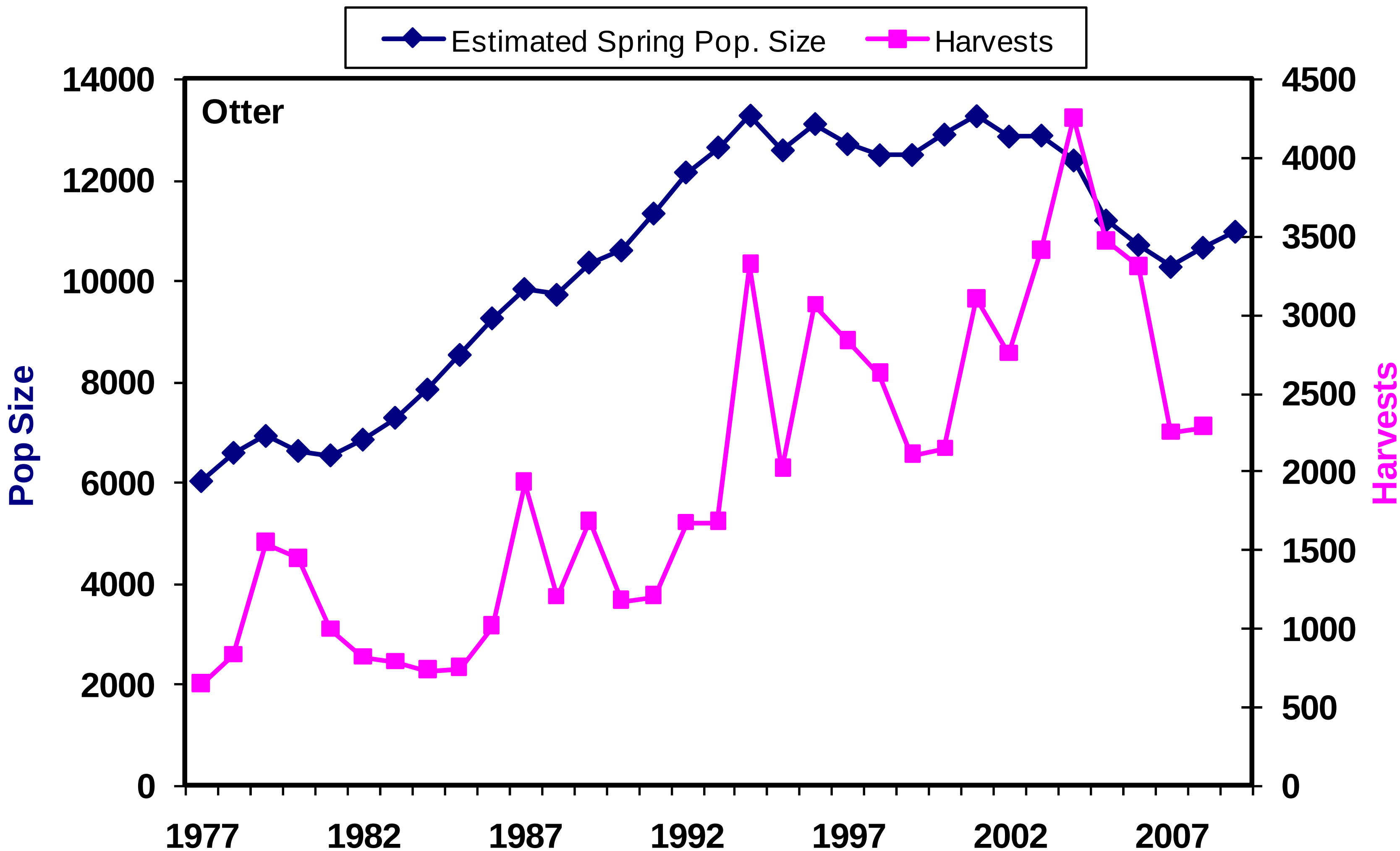

Figure 7. Otter populations and harvests, 1977-2008. Harvests include an estimate of non-reported take.

POPULATION TRENDS OF WHITE-TAILED DEER IN THE FOREST ZONE – 2009

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. Data collected as part of this registration process provide 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 2008 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.

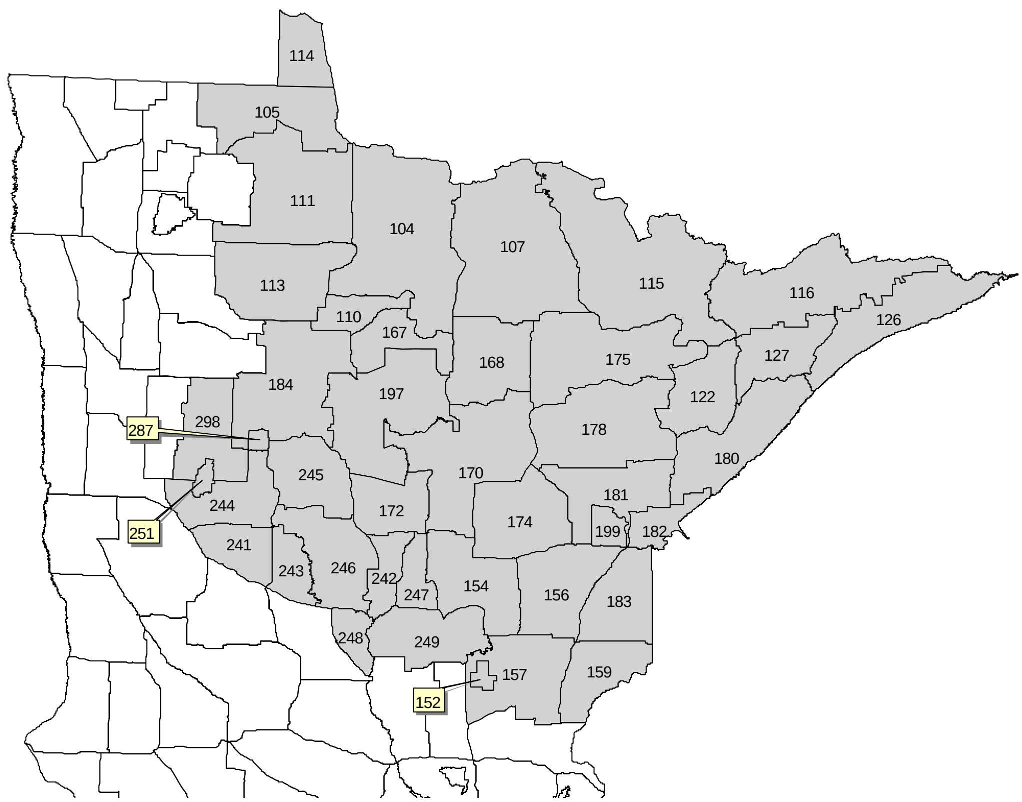

Figure 1. Permit areas in the forested zone, 2008. Permit areas 113, 114, 152, 182, and 287 were not modeled.

HARVEST

In 2008, hunters registered 221,841 deer, the 8th highest harvest ever recorded in Minnesota. Of that number, 44% or 115,582 deer were harvested in the forest zone (Figure 1, Table 1). The 2008 forest zone harvest decreased 18% from the 2007 harvest. The following discussion applies to the subset of deer harvested in the forest zone.

The buck harvest decreased in 41 of the 42 permit areas and only increased 1% in PA298 (Figure 2, Table 2). The total buck harvest declined 15% compared with a 3% decline the previous year (Table 2), an indication that deer density has declined throughout the forest zone.

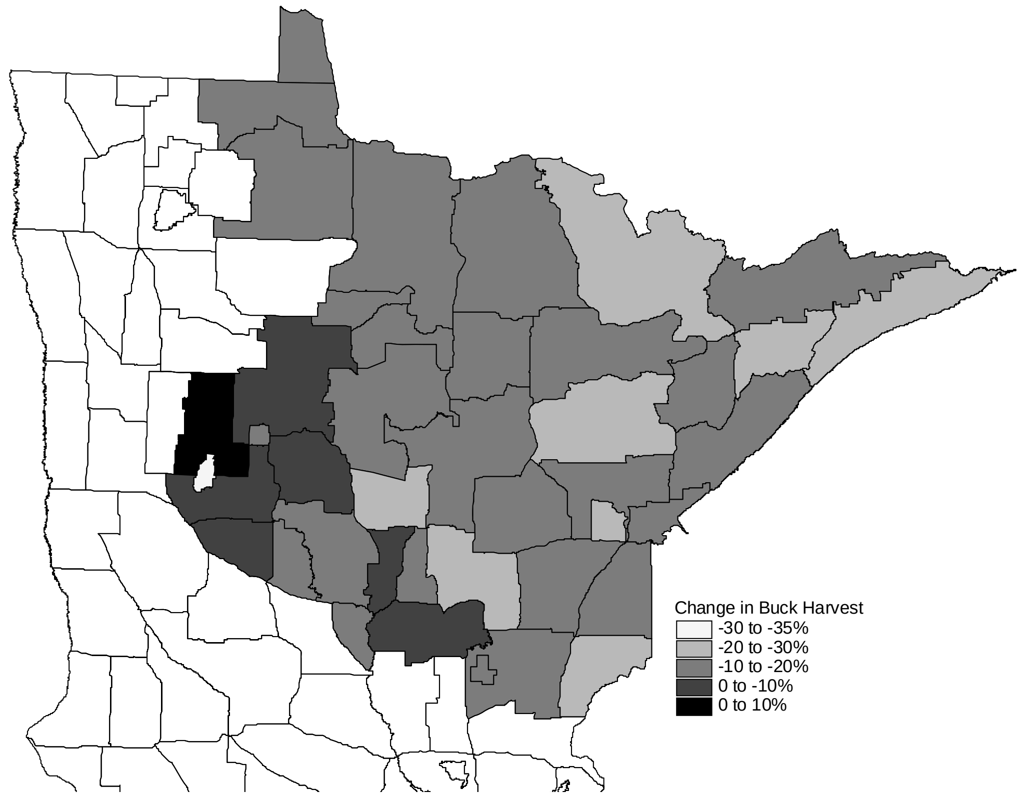

Figure 2. Change in buck harvest in forest zone permit areas between 2007 and 2008.

The antlerless harvest increased in 9 of the 42 permit areas (Table 3) but the total antlerless harvest decreased by 19%. The greatest increases occurred in 2 permit areas that shifted from "lottery" into the "managed" category ($\bar{x}$=87%, n = 2, range 77-97%), which allowed all hunters the option of harvesting 2 antlerless deer (Table 4). The remaining increases in antlerless harvest occurred in permit areas that offered more liberal opportunities to harvest antlerless deer (e.g. "managed" to "intensive"). Decreased antlerless harvest occurred in almost all categories (Table 4).

The proportion of bucks in the forest zone harvest increased 2% from last year to 42%. This increase reflects the decreased 2008 antlerless harvest. Forest-wide, the proportion of bucks in the harvest ranged from 30 to 58%.

The archery harvest in the forest zone declined 13% in 2008. Change in the archery harvest by permit area was correlated with change in the total firearms harvest ($r^2 = 0.45$, $P < 0.001$) which suggests that the decline was in part, the result of reduced deer numbers. Between 2002 and 2006, the archery harvest increased over 200%, presumably because of increased sales of the All Season License. The elimination of this license in 2008 also may have contributed to the decline.

The muzzleloader harvest declined 36% in the forest zone in 2008. Change in the muzzleloader harvest by permit area was correlated with change in the total firearms harvest ($r^2 = 0.35$, $P < 0.001$) which suggest that the decline is related to decreased deer numbers. The elimination of the All Season License also may have contributed to the decline.

POPULATION TRENDS AND MODEL PROJECTIONS

Based on the winter severity index (WSI), the winter of 2008-09 ranged from “mild” to “severe” (Figure 3). Across much of the northern Minnesota the WSI exceeded 150 and 2 locations exceeded 180. Deep snow between late December and early-April combined with colder than normal temperatures resulted in the higher than normal WSI indices. In the west central portion of the forest zone, the WSI exceeded 100, the threshold for a moderate winter.

Simulation modeling was used in 38 permit areas (Figure 1 and Table 4) to approximate deer density, identify trends, and project the effect of the 2009-hunting season. To better summarize the results for this report, permit areas were lumped in to one of 5 regions (Figs. 4 and 5). 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. Since 2003, there has been a steady decline in deer numbers in both the South, Central, and West Central in response to the high antlerless harvest. Deer numbers in both the NW and NE forest dropped 16% and 19%, respectively in the past year, primarily in response to winter severity.

Base on density targets set during the 2005 and 2006 goal setting processes, the 2009 pre-fawn deer density was above goal over much of the forest zone (Figure 6). For purposes here, if deer density was within 1 deer/mi^2 of the goal, the permit area is listed as being at goal. Permit areas ranged from 5 deer/mi^2 below goal to as much as 10 deer/mi^2 above goal.

Final classifications of permit areas for the 2009 season are currently being discussed with wildlife managers throughout the forest zone. Tentative recommendations (Figure 7) call for 15 permit areas to be listed as Lottery, 19 permit areas as Managed, 5 permit areas as Intensive, and 3 permit areas as Intensive with an early antlerless harvest. Final decisions on the status of permit areas will be available in early June.

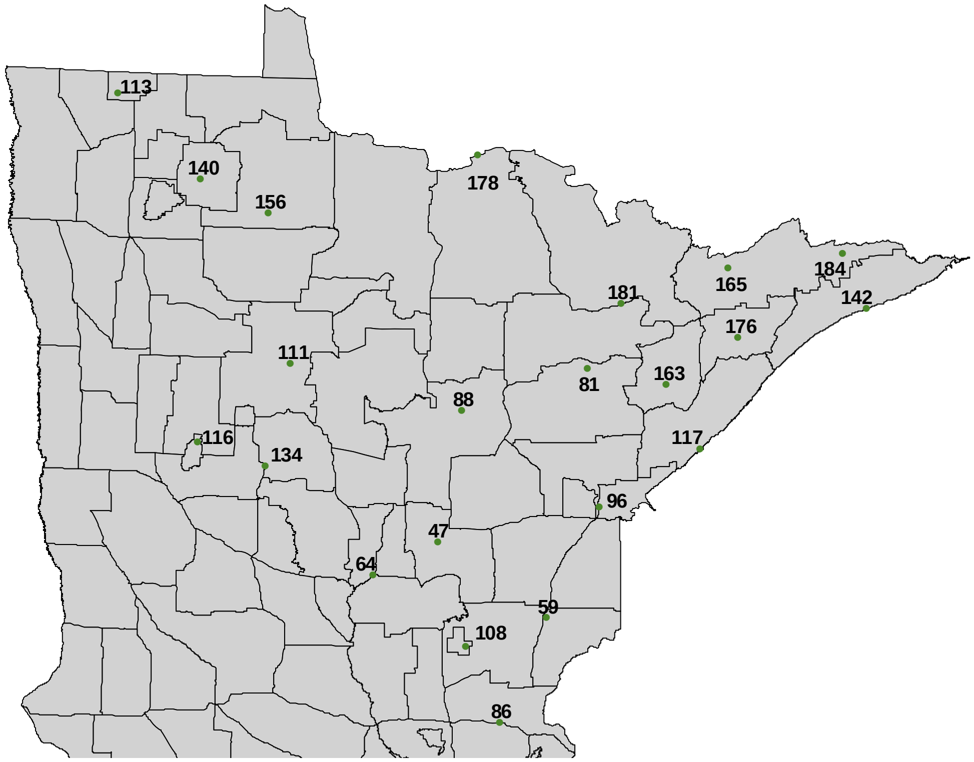

Figure 3. Final WSI values for the forested zone of Minnesota, winter of 2008-2009.

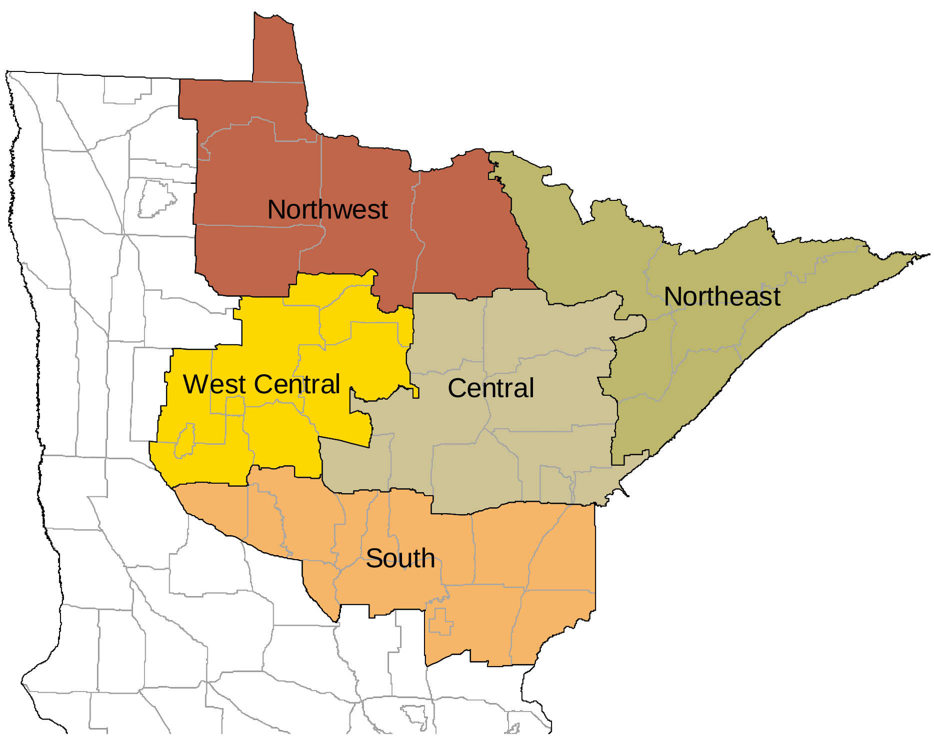

Figure 4. Permit areas grouped for summary discussion.

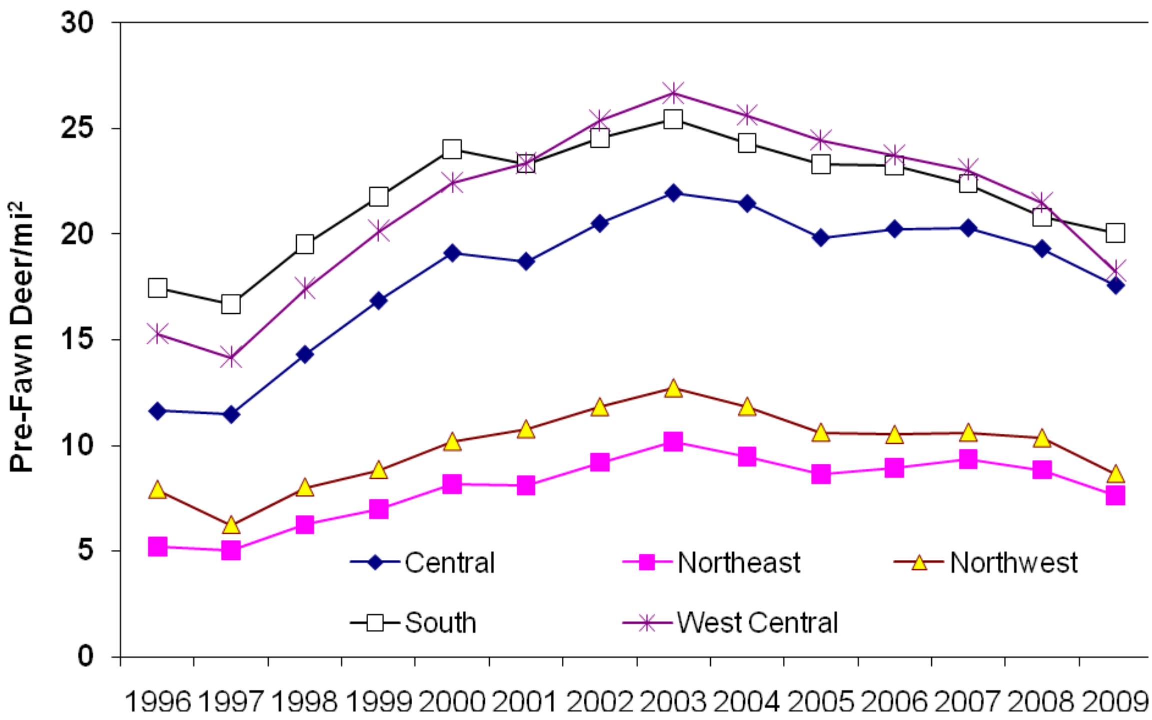

Figure 5. Population trends of deer in forest zone. Trend lines represent the groups of permit areas as illustrated in figure 4. Density represents pre-fawn density.

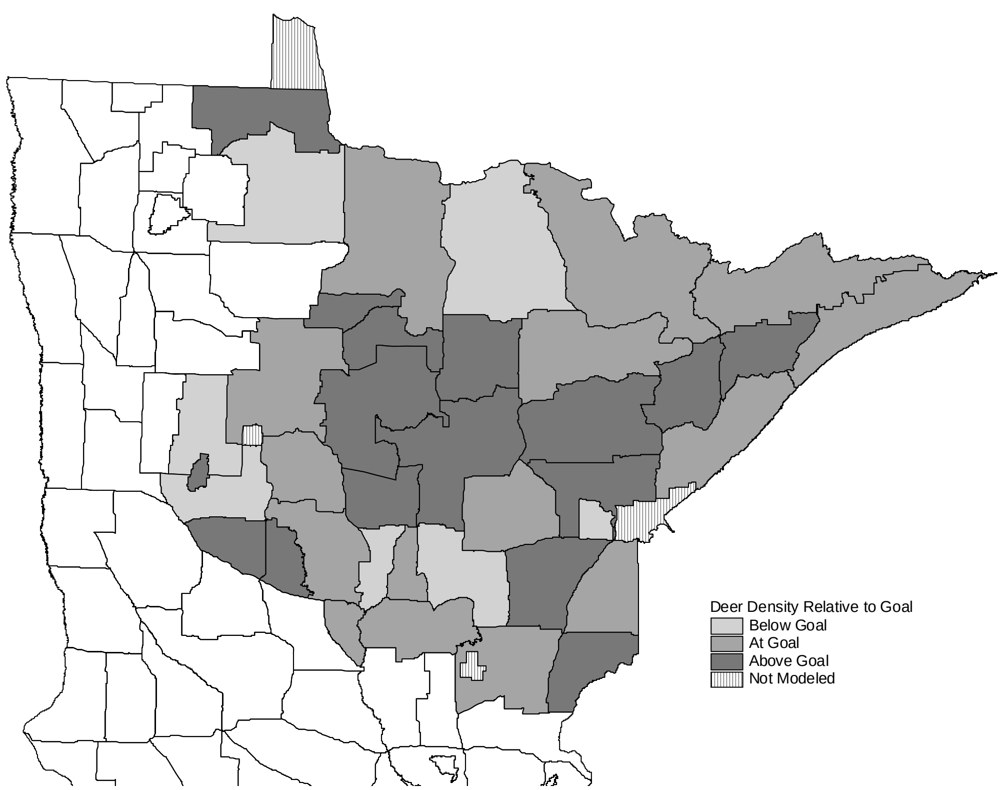

Figure 6. Deer density expressed relative to pre-fawn population goals.

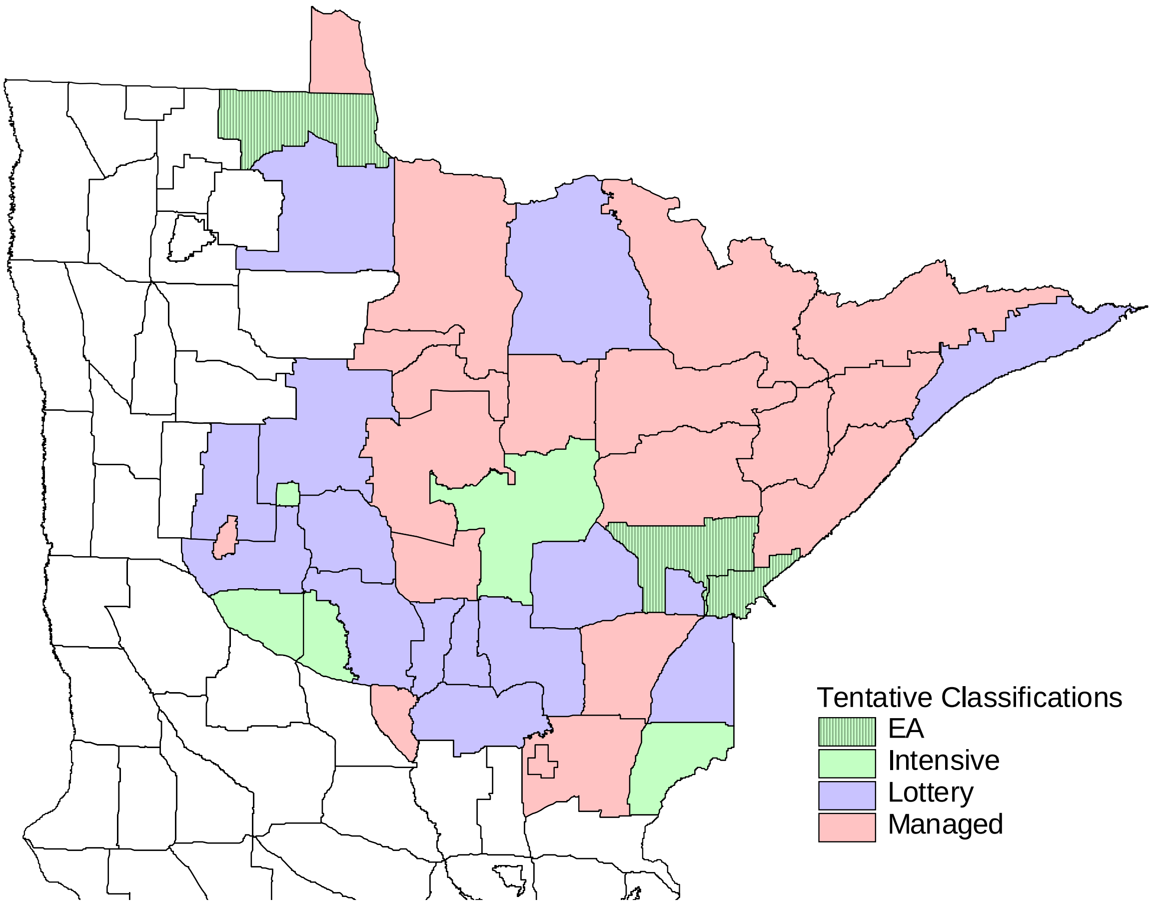

Figure 7. Tentative designation of permit areas in the Forest Zone for the 2009 hunting season.

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

Permit Area	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Change
104	1,372	1,837	1,939	2,253	3,421	2,902	2,483	2,632	2,557	2,100	-18%
105	1,389	1,821	1,962	2,385	3,740	3,106	3,557	3,210	3,344	2,391	-28%
107	1,994	2,846	3,547	3,499	5,206	4,027	3,936	3,825	3,874	3,148	-19%
110	1,511	1,376	1,371	1,553	2,180	2,122	1,945	1,910	1,935	1,865	-4%
111	1,169	1,644	2,223	2,264	3,064	2,621	2,687	2,812	1,608	1,558	-3%
114	40	55	72	80	96	110	123	174	127	120	-6%
115	2,334	3,174	3,586	3,815	5,431	4,333	4,378	4,480	4,250	3,438	-19%
116	138	150	156	157	265	298	261	270	350	394	13%
122	296	556	617	574	696	716	657	1067	1118	1,014	-9%
126	306	445	470	597	702	841	904	977	1150	990	-14%
127	176	81	95	99	146	177	151	188	215	181	-16%
152	225	283	264	217	235	246	271	330	377	292	-23%
154	2,978	4,418	4,169	5,032	5,717	5,176	4,583	4,546	4,526	2,578	-43%
156	2,643	3,795	3,055	3,258	4,966	4,594	4,517	4,767	5,164	4,486	-13%
157	5,385	6,990	7,194	7,728	9,001	7,606	6,901	7,989	7,828	6,276	-20%
159	4,371	5,311	4,459	4,153	5,207	3,887	3,968	3,905	4,165	3,205	-23%
167	1,452	1,601	1,967	2,488	1,572	1,463	1,257	1,738	1,977	1,812	-8%
168	2,410	2,686	2,376	3024	3,218	3,978	2,534	3,627	3,357	2,941	-12%
170	2,880	4,938	4,829	4,716	8,460	7,154	7,221	6,951	8,346	7,412	-11%
172	2,961	4,253	4,621	4,910	7,004	5,489	5,227	5,345	4,877	3,966	-19%
174	1,927	2,438	2,140	2,678	3,825	3,347	3,095	3,180	3,245	2,856	-12%
175	2,326	3,035	3,338	3233	5,071	4,254	3,103	4,559	4,419	4,318	-2%
178	2,351	3,050	3,347	3,666	5,523	5,297	5,373	5,476	6,562	5,884	-10%
180	946	1,540	1,703	1,867	3,123	2,355	2,837	3,553	3,755	3,366	-10%
181	1,780	2,362	2,457	2,419	3,599	3,544	3,755	4,475	5,005	4,527	-10%
182	614	827	862	869	1,309	1,206	1,256	1,460	1,599	1,621	1%
183	2,147	2,748	2,743	2,771	3,960	3,533	3,449	4,006	3,747	3,060	-18%
184	5,970	7,283	7,762	8,811	14,023	12,307	11,482	10,261	11,005	9,335	-15%
197	933	1,372	1,167	1,413	1,652	1,723	1,594	2,471	2,248	2,051	-9%
199	130	169	166	164	140	172	188	167	206	218	6%
241	2651	4284	3927	3857	4549	4449	4,288	4,369	4,787	4,261	-11%
242	1,552	1,820	2,072	2,426	2,767	2,244	2,116	2,170	2,259	2,215	-2%
243	1,907	2,634	2,864	3,238	4,131	3,684	3,165	3,429	3,458	2,342	-32%
244	2,956	3,771	4,841	5,805	7,452	6,702	6,162	6,192	7,102	5,499	-23%
245	3,524	4,695	5,053	5,626	8,231	6,377	5,737	6,115	5,393	4,853	-10%
246	4,075	5,599	6,090	5,149	7,530	6,782	5,835	6,389	5,339	2,847	-47%
247	1,631	1,923	2,115	2101	2,744	2,582	2,115	2,393	2,064	1,230	-40%
248	850	1,039	881	1,352	1,897	1,864	1,670	1,280	1,387	952	-31%
249	2,217	2,826	3,148	3,238	4,223	3,800	3,211	3,667	3,305	2,063	-38%
251	246	326	254	298	470	387	325	301	253	145	-43%
287	368	376	460	470	529	425	280	305	306	250	-18%
298	704	803	826	932	1988	1733	1664	1727	1610	1,522	-5%
Forested Zone	77,834	103,180	107,189	115,185	159,063	139,613	130,261	138,688	140,199	115,582	-18%

Note: Permit area totals prior to 1999 are estimates that assume an evenly distributed harvest in the old permit areas and may be biased. Harvest in permit areas such as 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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Change
104	1,137	1,240	1,266	1,332	1,589	1,586	1,250	1,176	1,279	1,070	-16%
105	846	945	813	1,138	1,488	1,326	1,364	1,122	1,206	964	-20%
107	1,706	1,948	2,174	2,119	2,523	2,277	1,861	1,725	1,921	1,576	-18%
110	685	732	674	699	852	813	694	658	784	653	-17%
111	1,088	1,168	1,395	1,463	1,467	1,408	1,316	1,149	830	741	-11%
114	40	43	56	63	55	55	72	95	83	69	-17%
115	1,898	2,038	2,145	2,376	2,915	2,679	2,262	2,242	2,228	1,764	-21%
116	138	150	156	157	238	251	230	186	261	219	-16%
122	293	417	452	449	501	567	534	565	658	587	-11%
126	306	390	417	495	585	591	595	606	686	518	-24%
127	176	80	82	86	126	149	127	147	148	104	-30%
152	173	191	182	130	106	152	141	158	149	126	-15%
154	2,018	2,305	2,142	2,169	2,071	2,049	1,789	1,677	1,911	1,468	-23%
156	1,836	2,084	1,690	1,653	2,001	2,003	1,811	1,881	2,068	1,831	-11%
157	3,009	3,327	3,144	3,048	3,207	3,030	2,745	2,916	2,832	2,334	-18%
159	2,121	2,431	1,947	1,667	1,995	1,518	1,528	1,548	1,674	1,229	-27%
167	906	1,036	968	1,211	821	819	709	692	821	706	-14%
168	1,579	1,653	1,454	1,675	1,698	1,889	1,435	1,439	1,525	1,233	-19%
170	1,621	3,106	2,786	2,611	3,435	3,233	2,987	2,920	3,285	2,698	-18%
172	1,821	2,292	2,259	2,200	2,359	2,147	1,853	1,799	1,866	1,429	-23%
174	1,234	1,448	1,257	1,363	1,542	1,597	1,367	1,313	1,400	1,247	-11%
175	1,923	2,108	2,074	2,115	2,480	2,320	2,074	2,192	2,223	1,872	-16%
178	1,946	2,059	2,013	2,218	2,651	2,767	2,704	2,503	2,966	2,310	-22%
180	941	1,215	1,358	1,398	1,831	1,833	1,692	1,829	1,878	1,579	-16%
181	1,351	1,596	1,562	1,590	1,943	1,940	1,779	1,998	2,240	1,823	-19%
182	484	577	564	568	685	684	511	520	544	489	-10%
183	1,633	1,919	1,650	1,575	1,661	1,654	1,514	1,634	1,745	1,430	-18%
184	3,813	4,124	3,925	4,310	4,774	4,848	4,161	3,554	3,553	3,433	-3%
197	923	1,142	953	998	1,040	1,143	999	1,090	1,108	999	-10%
199	91	137	123	132	104	130	151	119	150	119	-21%
241	1030	1382	1396	1477	1559	1621	1,460	1,506	1,498	1,370	-9%
242	812	988	885	824	912	740	721	692	688	656	-5%
243	1,081	1,192	1,169	1,247	1,343	1,217	1,066	1,142	1,066	957	-10%
244	1,848	2,014	2,048	2,300	2,540	2,390	2,170	2,155	2,080	1,893	-9%
245	2,216	2,350	2,179	2,430	2,743	2,449	2,036	2,229	1,932	1,887	-2%
246	2,355	2,784	2,479	2,384	2,599	2,527	2,082	2,178	1,935	1,595	-18%
247	970	1,181	1,056	948	1,047	955	861	848	802	651	-19%
248	641	778	622	720	714	739	656	638	487	410	-16%
249	1,310	1,590	1,479	1,429	1,479	1,327	1,261	1,285	1,246	1,134	-9%
251	129	134	152	132	176	183	128	145	91	59	-35%
287	167	189	201	184	207	182	106	104	92	81	-12%
298	601	648	685	654	952	894	810	799	753	762	1%
Forested Zone	50,896	59,131	56,033	57,736	65,014	62,682	55,612	55,174	56,692	48,075	-15%

Note: Permit area totals prior to 1999 are estimates that assume an evenly distributed harvest in the old permit areas and may be biased. Harvest in permit areas such as 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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Change
104	235	597	673	921	1,832	1,316	1,233	1,456	1,278	1,030	-19%
105	543	876	1,149	1,247	2,252	1,780	2,193	2,088	2,138	1,427	-33%
107	288	898	1,373	1,380	2,683	1,750	2,075	2,100	1,953	1,572	-20%
110	826	644	697	854	1,328	1,309	1,251	1,252	1,151	1,212	5%
111	81	476	828	801	1,597	1,213	1,371	1,663	778	817	5%
114	0	12	16	17	41	55	51	79	44	51	16%
115	436	1,136	1,441	1,439	2,516	1,654	2,116	2,238	2,022	1,674	-17%
116	0	0	0	0	27	47	31	84	89	175	97%
122	3	139	165	125	195	149	123	502	460	427	-7%
126	0	55	53	102	117	250	309	371	464	472	2%
127	0	1	13	13	20	28	24	41	67	77	15%
152	52	92	82	87	129	94	130	172	228	166	-27%
154	960	2,113	2,027	2,863	3,646	3,127	2,794	2,869	2,615	1,110	-58%
156	807	1,711	1,365	1,605	2,965	2,591	2,706	2,886	3,096	2,655	-14%
157	2,376	3,663	4,050	4,680	5,794	4,576	4,156	5,073	4,996	3,942	-21%
159	2,250	2,880	2,512	2,486	3,212	2,369	2,440	2,357	2,491	1,976	-21%
167	546	565	999	1,277	751	644	548	1,046	1,156	1,106	-4%
168	831	1,033	922	1,349	1,520	2,089	1,099	2,188	1,832	1,708	-7%
170	1,259	1,832	2,043	2,105	5,025	3,921	4,234	4,031	5,061	4,714	-7%
172	1,140	1,961	2,362	2,710	4,645	3,342	3,374	3,546	3,011	2,537	-16%
174	693	990	883	1,315	2,283	1,750	1,728	1,867	1,845	1,609	-13%
175	403	927	1,264	1,118	2,591	1,934	1,029	2,367	2,196	2,446	11%
178	405	991	1,334	1,448	2,872	2,530	2,669	2,973	3,596	3,574	-1%
180	5	325	345	469	1,292	522	1,145	1,724	1,877	1,787	-5%
181	429	766	895	829	1,656	1,604	1,976	2,477	2,765	2,704	-2%
182	130	250	298	301	624	521	745	940	1,055	1,132	7%
183	513	829	1,093	1,197	2,299	1,879	1,935	2,372	2,002	1,630	-19%
184	2,157	3,159	3,837	4,501	9,249	7,459	7,321	6,707	7,452	5,902	-21%
197	10	230	214	415	612	580	595	1,381	1,140	1,052	-8%
199	39	32	43	32	36	42	37	48	56	99	77%
241	1,621	2,902	2,531	2,380	2,990	2,828	2,828	2,863	3,289	2,891	-12%
242	740	832	1,187	1,602	1,855	1,504	1,395	1,478	1,571	1,559	-1%
243	826	1,442	1,695	1,991	2,788	2,467	2,099	2,287	2,392	1,385	-42%
244	1,108	1,757	2,793	3,505	4,912	4,312	3,992	4,037	5,022	3,606	-28%
245	1,308	2,345	2,874	3,196	5,488	3,928	3,701	3,886	3,461	2,966	-14%
246	1,720	2,815	3,611	2,765	4,931	4,255	3,753	4,211	3,404	1,252	-63%
247	661	742	1,059	1,153	1,697	1,627	1,254	1,545	1,262	579	-54%
248	209	261	259	632	1,183	1,125	1,014	642	900	542	-40%
249	907	1,236	1,669	1,809	2,744	2,473	1,950	2,382	2,059	929	-55%
251	117	192	102	166	294	204	197	156	162	86	-47%
287	201	187	259	286	322	243	174	201	214	169	-21%
298	103	155	141	278	1,036	839	854	928	857	760	-11%
Forested Zone	26,938	44,049	51,156	57,449	94,049	76,931	74,649	83,514	83,507	67,507	-19%

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

Table 4. Change in anterless harvest in response to change in harvest strategy between 2007 and 2008 seasons for Deer Permit Areas in Minnesota's forest zone.

Permit Area	L-M	M-I	I-EA	M-M	I-I	I-M	EA-EA	M-EA	M-L	EA-I	EA-M
104				-19%							
105							-33%				
107				-20%							
110			5%								
111								5%			
114				16%							
115				-17%							
116	97%										
122		-7%									
126					2%						
127		15%									
152				-27%							
154									-58%		
156					-14%						
157							-21%				
159			-21%								
167					-4%						
168				-7%							
170					-7%						
172				-16%							
174				-13%							
175				11%							
178			-1%								
180			-5%								
181			-2%								
182			7%								
183				-19%							
184										-21%	
197				-8%							
199	77%										
241							-12%				
242					-1%						
243											-42%
244										-28%	
245				-14%							
246		-63%									
247		-54%									
248						-40%					
249									-55%		
251				-47%							
287					-21%						
298				-11%							
Mean	87%	-27%	-3%	-14%	-8%	-40%	-22%	5%	-56%	-24%	-42%
n	2	4	6	14	6	1	3	1	2	2	1

L = Lottery, M = Managed, I = Intensive, EA = Intensive+Early Antlerless

Table 5. 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.)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Change
104	2,078	7	7	8	9	8	7	7	7	7	6	-14%
105	766	24	27	30	32	32	29	29	29	29	25	-14%
107	1,895	12	12	13	14	13	11	11	11	11	8	-21%
110	300	25	26	28	30	30	28	28	27	26	23	-11%
111	1,707	6	7	7	8	7	6	6	6	6	5	-16%
115	1,872	11	11	13	14	12	10	11	11	10	8	-19%
116	1,158	1	1	1	2	1	1	2	2	2	1	-20%
122	620	15	15	17	19	18	17	16	18	17	15	-13%
126	941	4	4	5	6	6	6	6	6	6	5	-11%
127	561	1	1	2	2	2	2	2	2	2	1	-13%
154	760	18	18	18	18	17	16	16	15	14	15	6%
156	826	18	18	20	21	21	21	21	21	19	18	-6%
157	889	23	23	24	24	22	21	22	20	18	16	-11%
159	568	23	21	21	22	20	20	20	20	19	18	-4%
167	432	22	22	23	22	21	20	20	20	20	16	-19%
168	724	17	16	17	17	17	15	16	15	15	14	-5%
170	1,315	23	22	24	26	25	24	24	25	23	22	-7%
172	451	36	35	38	40	37	34	33	31	29	27	-6%
174	836	14	13	15	16	15	14	14	14	13	13	-5%
175	1,276	14	13	14	15	14	12	13	13	13	11	-16%
178	1,267	17	18	20	22	22	20	21	22	21	18	-15%
180	982	14	14	16	17	17	16	17	17	17	16	-7%
181	856	23	23	25	28	28	26	27	27	26	25	-5%
183	663	25	25	26	28	27	25	25	24	23	22	-3%
184	1,232	23	24	27	29	27	26	24	23	21	18	-15%
197	975	14	14	15	15	16	15	16	15	14	13	-11%
241	417	39	39	41	43	43	42	42	42	41	35	-14%
242	215	33	33	35	35	32	32	31	30	26	21	-19%
243	314	37	37	40	41	39	38	37	36	33	32	-3%
244	586	32	35	38	40	39	37	36	35	32	26	-18%
245	583	32	33	36	37	34	32	31	30	28	24	-16%
246	772	26	25	25	26	25	23	23	21	20	22	8%
247	231	24	23	24	25	23	21	21	19	18	19	9%
248	212	24	23	25	27	26	25	25	24	21	20	-8%
249	502	18	17	18	19	18	17	17	16	15	16	7%
251	55	17	17	18	19	16	15	14	13	13	14	6%
298	619	17	17	18	20	20	19	18	18	18	15	-13%
Forest Zone	30,456	17	17	18	19	18	17	17	17	16	14	-10%

2009 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 in a simulation model to identify population trends and the harvestable surplus.

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 2004. 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 and Enstrom helicopters used to conduct the survey. We sexed moose using the presence of antlers, size and shape of the bell, nose color and/or presence of a vulval patch (Mitchell 1970), and identified calves on the basis of size and behavior. We recorded UTM coordinates and the percent visual obstruction (VOC) for all moose observed within the plots. We defined visual obstruction 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 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 visual obstruction was the most important covariate in determining whether radiocollared moose were observed. We used uncorrected estimates (no visibility bias correction) of bulls, cows, and calves to calculate the bull:cow and calf:cow ratios.

RESULTS

We initiated the survey on 5 January and completed it on 24 January. Observers rated survey conditions as "good" (highest rank) on 38 plots and "marginal" on 2 plots. Snow conditions for the survey were excellent and always exceeded 16"in depth. During the survey flights, observers located 474 moose on the 40 plots (532 mi^2) including 208 bulls, 197 cows, 63 calves, and 6 unidentified moose.

After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 7,593±1761 animals (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.32 and 0.94, respectively (Table 1).

DISCUSSION

We have used the sightability model approach for 6 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 significantly higher estimates of VOC (Kruskal Wallis AOV, F=16.7, $P<0.001$). As a result, the 2004 population estimate was biased high (Table 1). Pairwise comparison of the remaining years indicated that mean VOC did not differ among years 2005 -2009 and as a result, population estimates were more comparable. Because of this bias, the population estimate for 2004 was not included in subsequent analyses.

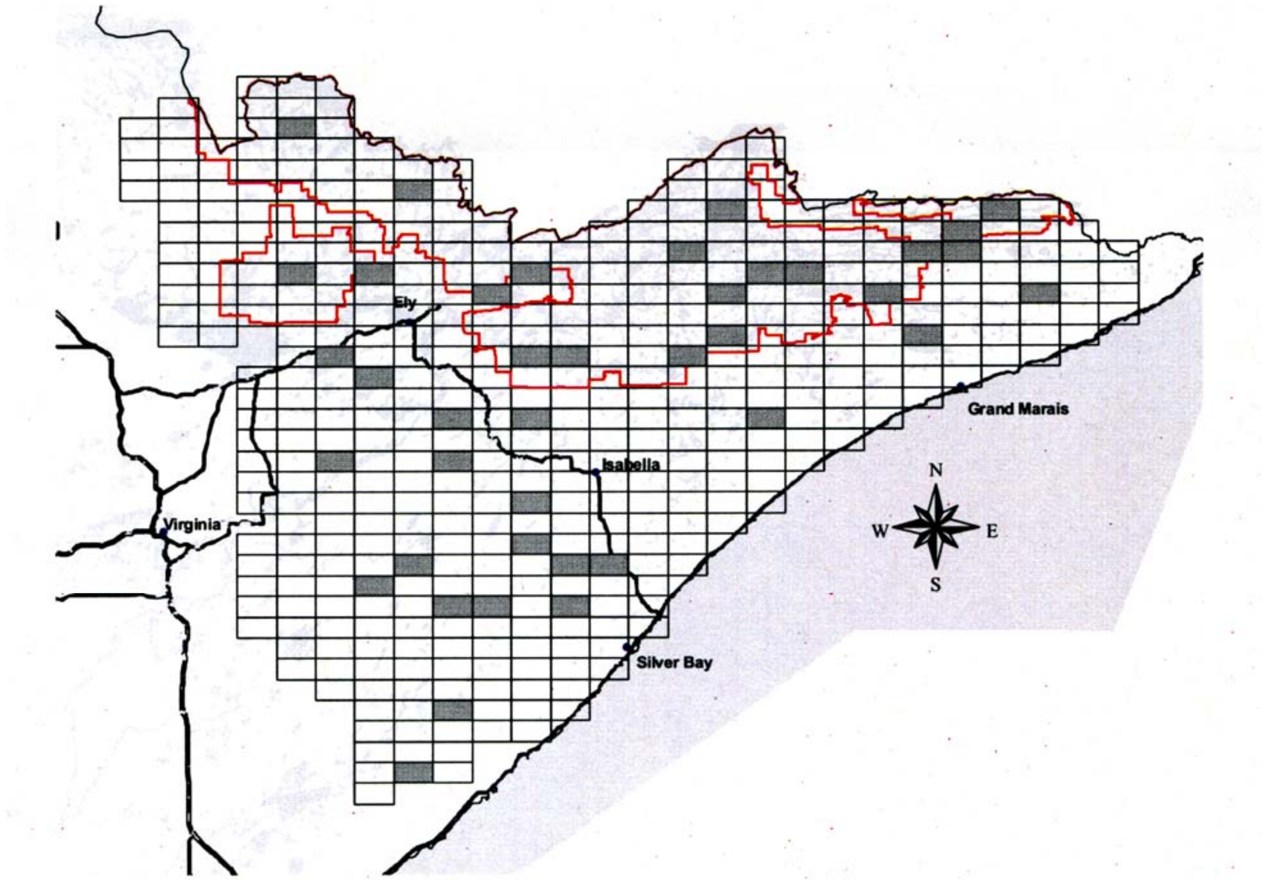

Figure 1. Northeast moose survey area and sample plots (shaded squares) flown in the 2009 aerial moose survey.

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

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

The 2009 population estimate was almost identical to the 2008 estimate. As would be expected, the overlap in confidence intervals (Table 1, Figure 2) indicates that there was no statistical difference between the 2008 and 2009 point estimates. There was no trend in survey estimates collected in the last 5 years (*P*=0.551), which suggests that the population has been stable. Several data sets, however, suggest that this population is in fact declining and the lack of a downward trend in the survey estimates is an artifact of the small sample size (n=5). Survey estimates prior to 2004 were based on fixed-wing aircraft surveys and are not comparable to estimates based on post 2003 helicopter surveys.

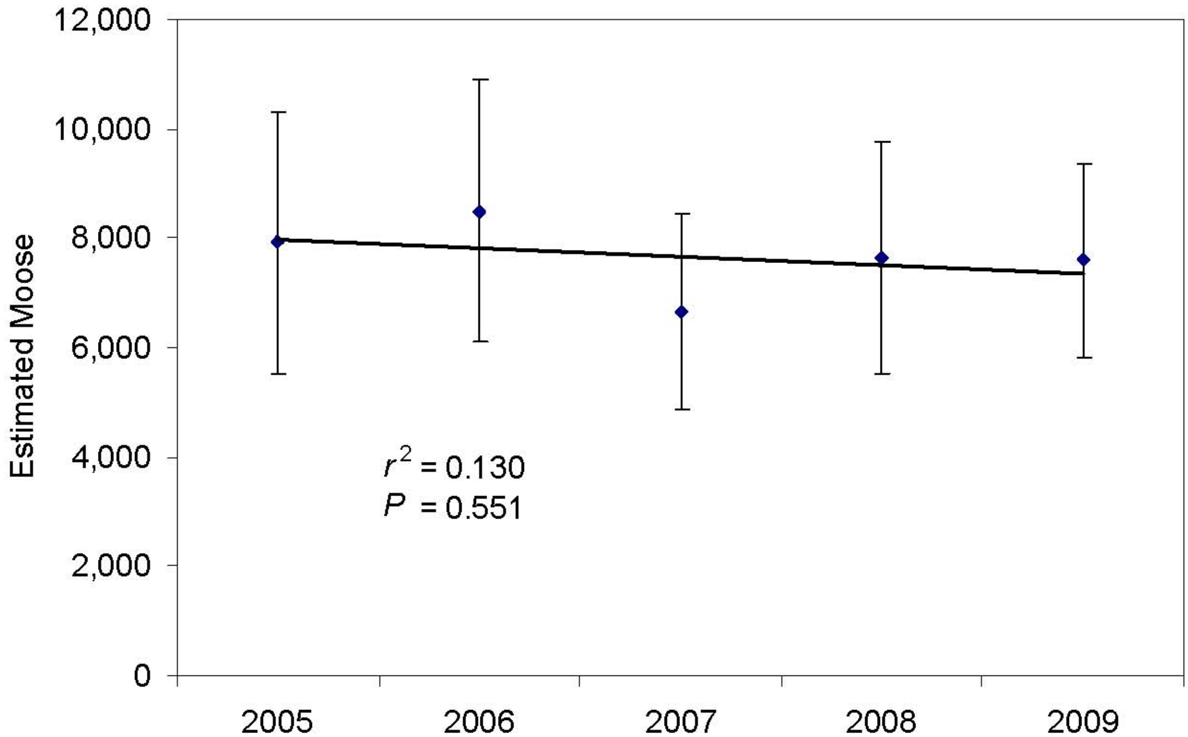

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2009.

The calf:cow ratio, for example, is an important measure of the number of calves recruited into the population. Over the past 12 years, this ratio has exhibited a significant decline (Figure 3; $P = 0.004$). If only the last 5 years of calf:cow ratio data are included in the analysis, however, the trend is not significant ($P = 0.227$). A similar measure, the % calves observed on the survey displays a significant trend over 12 years ($P = 0.015$) but non-significant trend over 5 years ($P = 0.456$). In addition, the proportion of cows accompanied by twins has steadily declined since 2002 (Table 1, $P = 0.009$).

Independent of the aerial survey, hunter success rates have steadily declined since 2001, for both either sex hunting ($P = 0.001$; Figure 4) and for bulls-only hunting ($P < 0.001$). Prior to 2007, moose hunters were allowed to harvest moose of either sex, but beginning in 2007, hunters were restricted to harvesting antlered bulls.

Annual non-hunting mortality of both bull and cow moose in a sample of 116 radiocollared moose in northeastern Minnesota has been substantially higher than elsewhere in North America (Lenarz et al. 2007). Over a 6-year period, annual non-hunting mortality has averaged 21%; a figure identical to that found for moose in northwestern moose (Murray et al. 2006). Elsewhere in North America, non-hunting mortality normally falls in the 8 to 12% range (Lenarz et al. 2007). When combined with estimates of age specific fertility into a matrix population model (Caswell 2001), annual estimates of the finite rate of increase (λ) ranged from 0.69 to 0.97 ($\bar{x}$ = 0.85). A finite rate of increase = 1 implies that the population is stable and values below 1 indicate that the population is declining. A mean λ of 0.85 implies that the radio collared moose population has declined an average of 15% per year in the last 6 years (Lenarz et al. in prep.). Unless the radiocollared population is not representative of the population at large, it is likely that the entire northeastern moose population has been declining.

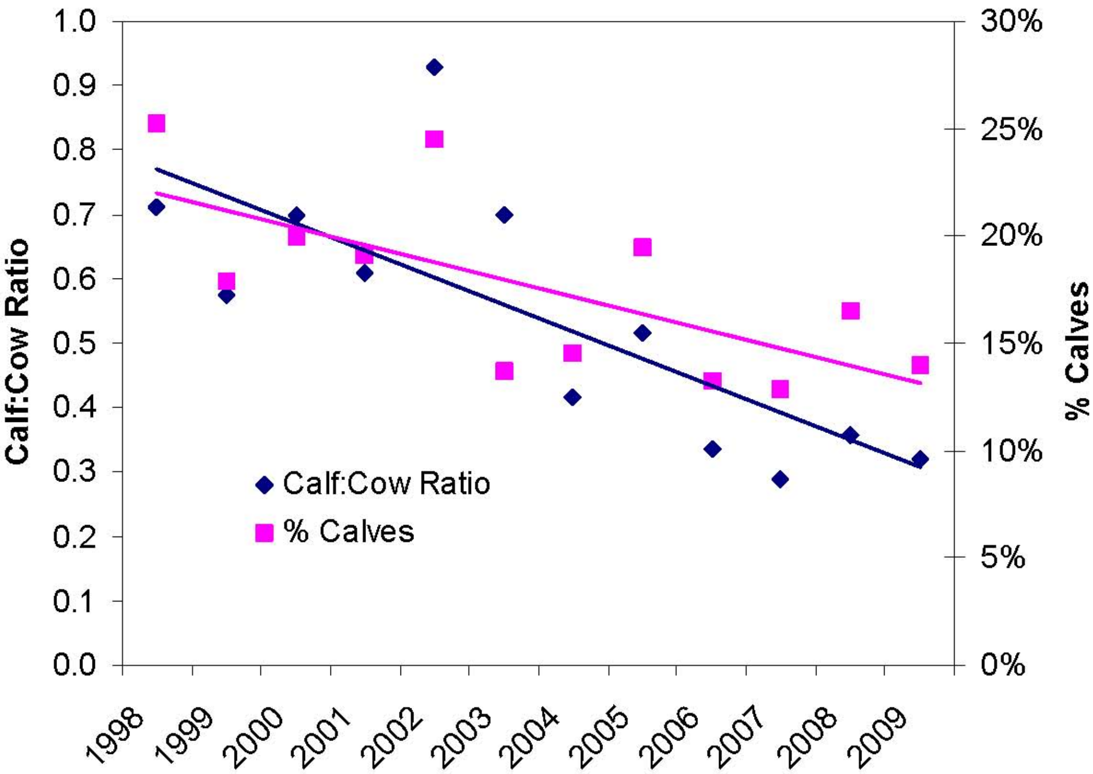

Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota. The % calves is less biased than the calf:cow ratio because it isn't dependent on adult cow moose being correctly classified. The calf:cow ratio is not adjusted for sightability and can be compared with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

The estimated bull:cow ratio (Table 1) was significantly lower than the mean bull:cow ratio estimated for the previous 11 years ($\bar{x}$ = 1.17, t=2.38, P=0.039). Although there was a negative trend in this statistic, the slope of the line was not significant (P=0.234). If the estimate for 2003 (2.01) is omitted, however, the trend was significant (P = 0.039). The departure indicated by the 2003 estimate is biologically impossible if estimates for 2002 and 2004 are accurate.

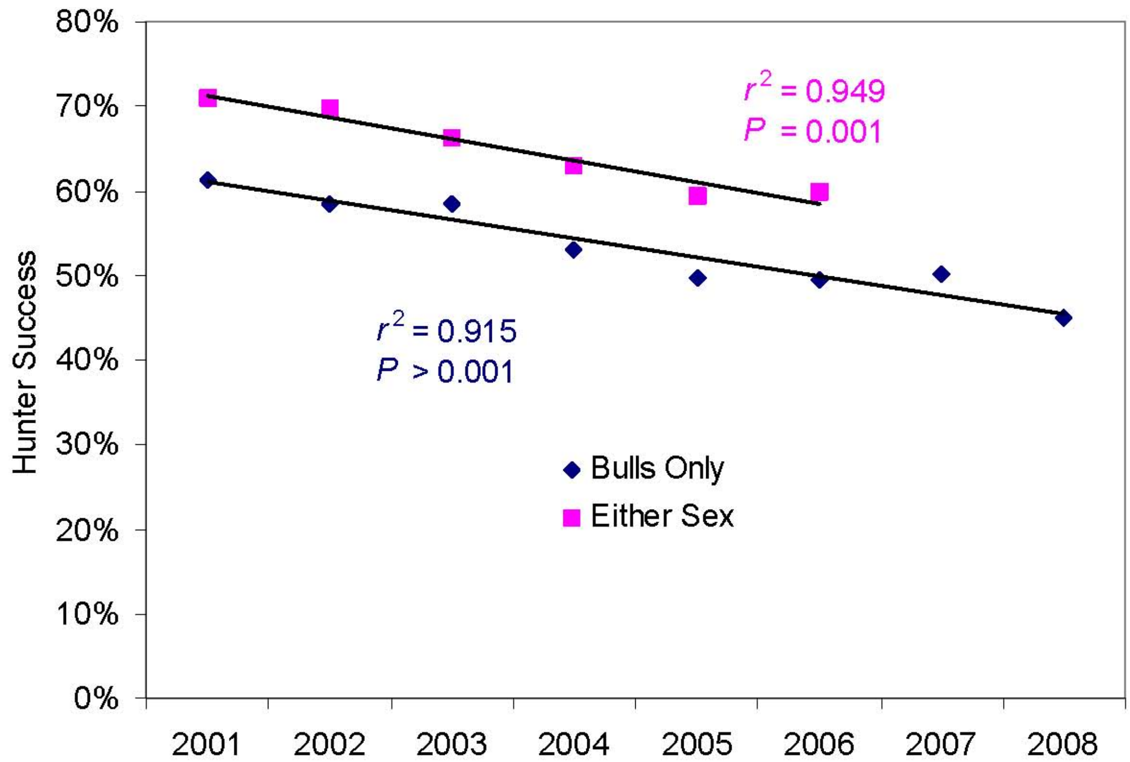

Figure 4. Hunter success rates in northeastern Minnesota, 2001-2008. Prior to 2007, hunters were allowed to harvest moose of either sex. Beginning in 2007, hunters were restricted to taking an antlered bull.

In the January survey, only 2% of the moose exhibited hair loss, which is indicative of infestation with the winter tick (*Dermacentor albipictus*). In 2008, 4% were observed with hair loss. Moose will often rub off patches of hair when high numbers of the tick begin to engorge. Normally, hair loss associated with winter ticks doesn't become noticeable until later in the winter.

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