FOREST WILDLIFE POPULATIONS

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GROUSE SURVEYS IN MINNESOTA DURING SPRING 2010

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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 2010. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.5 (95% confidence interval = 1.3–1.7) drums/stop (dps). That was 27% lower than the mean of 2.0 (1.8–2.3) dps observed during 2009, which was likely the peak in abundance during the population cycle of ruffed grouse in Minnesota.

During the spring 2010 survey 2,096 sharp-tailed grouse were observed at 195 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 8.9 (7.5–10.5) in the East Central survey region, 11.8 (10.4–13.1) in the Northwest region, and 10.7 (9.8–11.8) statewide. Index values (i.e., grouse/lek) declined slightly from 2009 in the Northwest region and remained approximately the same in the East Central region. The statewide index value was similar to those from 2003–2007 and the long-term average 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 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 125 routes between 2 April and 18 May 2010. Most routes (90%) were run between 16 April and 6 May. The median date this year (23 April) was 8 days earlier than during 2009 and 6 days earlier than the 2000–2009 average (29 April), which was consistent with much spring phenology occurring relatively early during 2010. Observers reported survey conditions as Excellent, Good, and Fair on 63%, 33%, and 4% of 123 routes, respectively. The distribution of survey conditions has been consistent for at least the last 4 years. Survey cooperators included the DNR Divisions of Fish & Wildlife and Forestry; 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.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.5 (95% confidence interval = 1.3–1.7) drums/stop (dps) during 2010. Drum counts by survey region during 2010 were 1.6 (1.4–1.9) dps in the Northeast (n = 104 routes), 1.8 (1.1–2.6) dps in the Northwest (n = 7), 1.0 (0.5–1.6) dps in the Central Hardwoods (n = 14), and 0.3 (0.1–0.8) dps in the Southeast (n = 8) (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.

Declines in counts from 2009 to 2010 in the Northeast (31%) and statewide (27%) were statistically significant. Counts declined in the 3 peripheral regions also (4–29%), but the wide confidence intervals precluded definitive inferences about the 1-year change in counts. It appears that the peak in abundance during the population cycle of ruffed grouse in Minnesota occurred during 2009.

Sharp-tailed Grouse

A total of 2,096 sharp-tailed grouse was observed at 195 dancing grounds with ≥2 male grouse (or grouse of unknown sex) during spring 2010. Leks with ≥2 grouse were visited a mean of 1.7 times. There were 626 grouse on 70 leks in the EC survey region and 1,470 grouse on 125 leks in the NW region. The index value (i.e., grouse/lek) for the NW region declined slightly from 2009, and the index value for the EC region remained approximately the same (Tables 1 and 2). The statewide value of 10.7 (9.8–11.8) was similar to values from 2003–2007 and the long-term average 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.

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	9.8–11.8	195	11.8	10.4–13.1	125	8.9	7.5–10.5	70

[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

[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.

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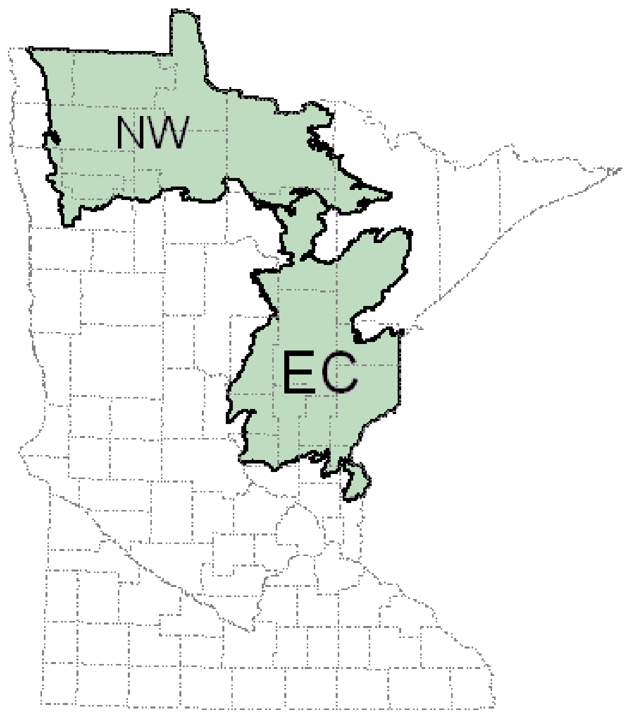


Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** relative to county boundaries in Minnesota. The regions were based largely on boundaries of ECS Subsections.

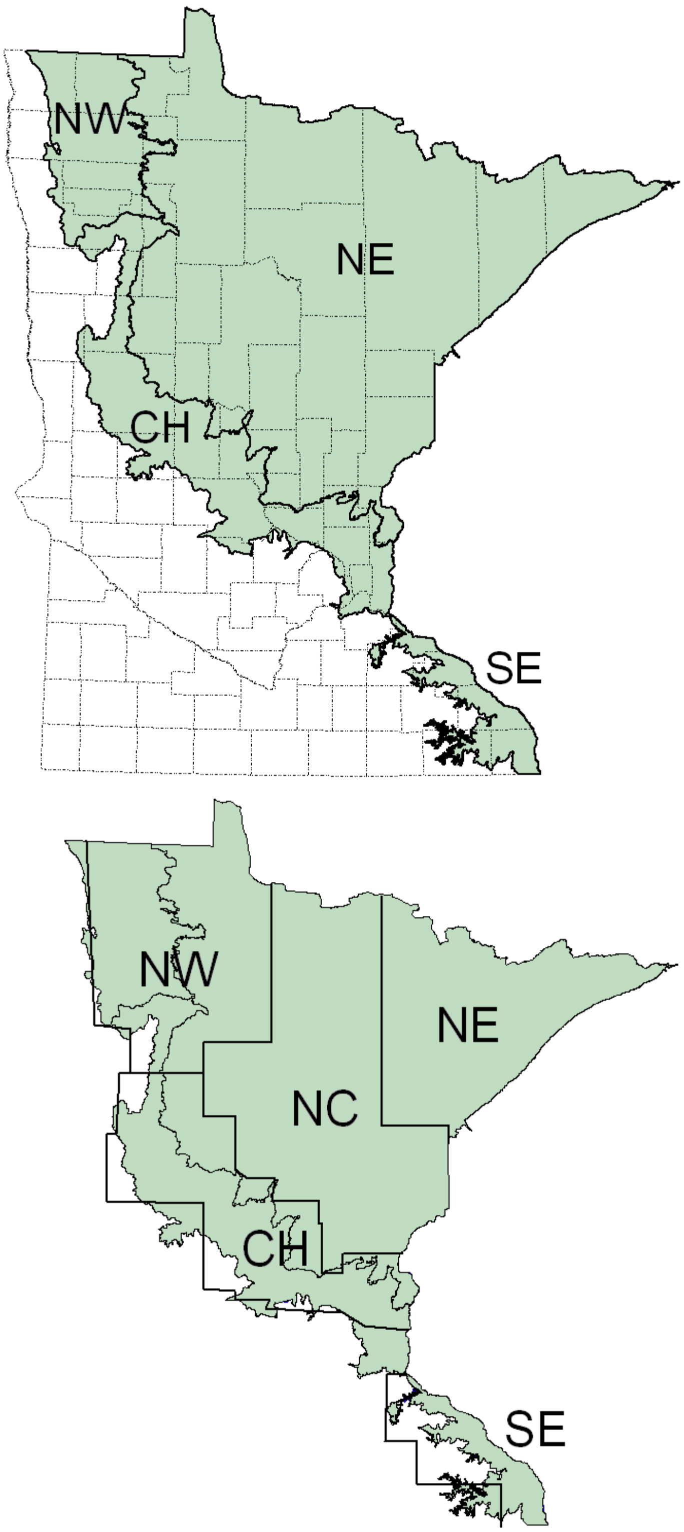


Figure 2. **Ruffed grouse** survey regions (shaded, curved boundaries) are based on the Ecological Classification System. Top panel: regions are labeled and overlaid on counties (dashed lines). Bottom panel: former survey zones (straight boundaries) are labeled and overlaid on regions.

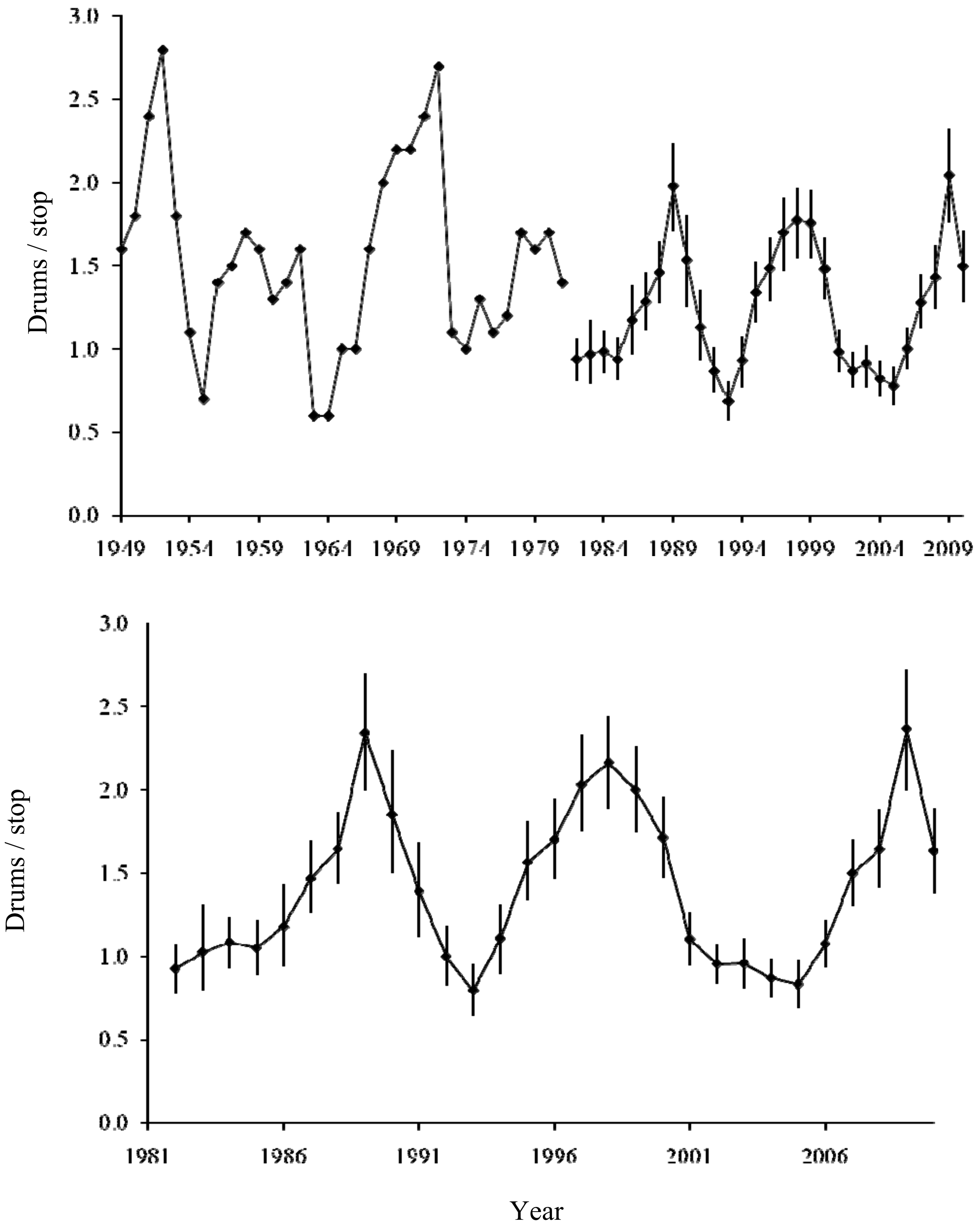
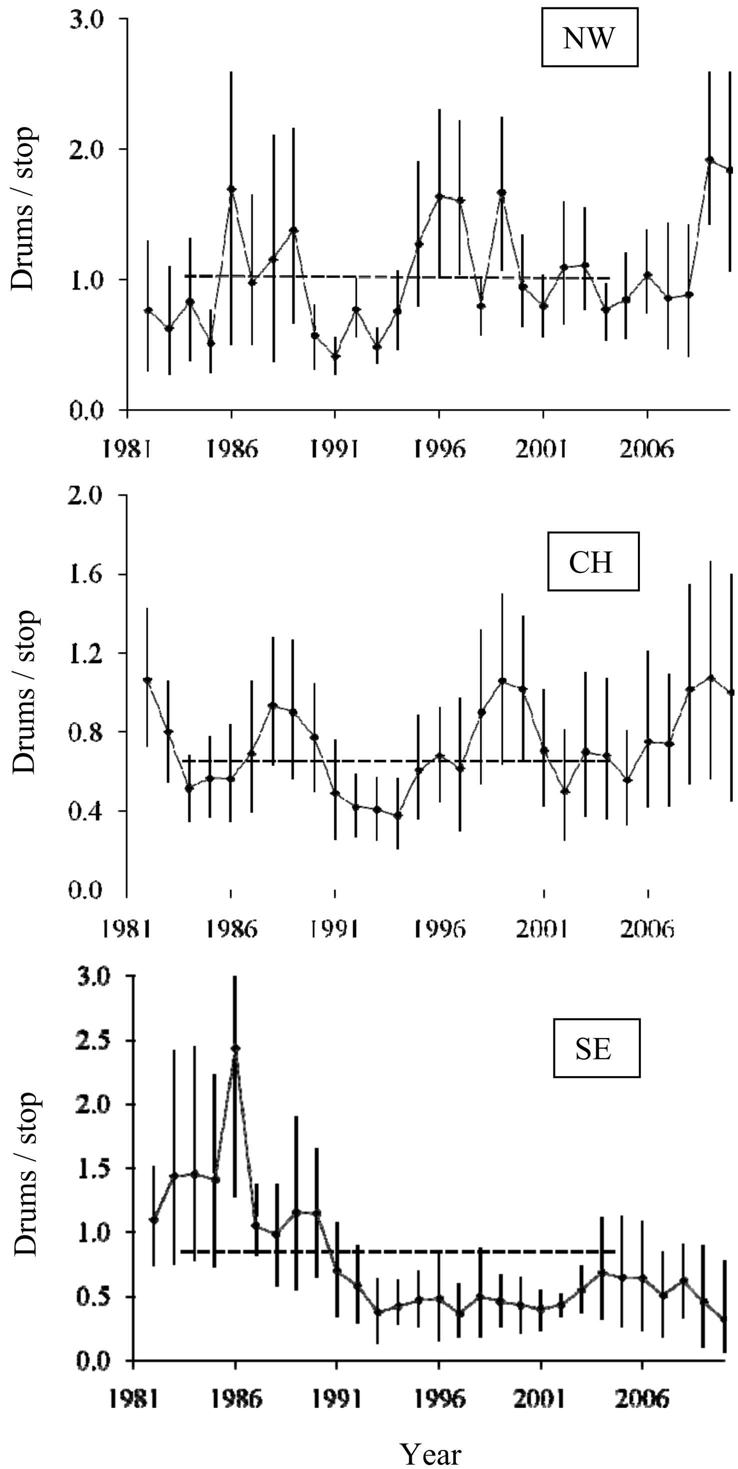


Figure 3. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current methods, so confidence intervals were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



. Ruffed grouse drum count index values in the **Northwest** (NW), **Central Hardwoods** (CH), and **Southeast** (SE) 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.

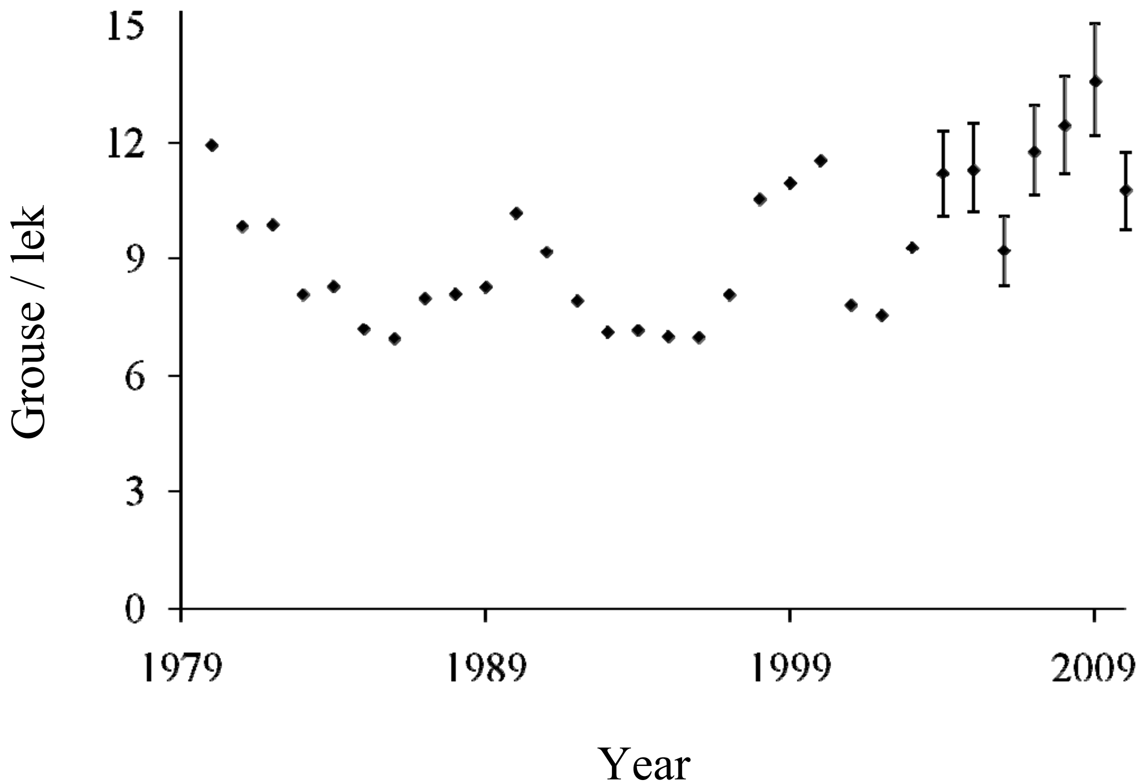


Figure 5. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds, 1980–2010. Vertical error bars, which were calculated only for recent years, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.

PRAIRIE-CHICKEN SURVEY IN MINNESOTA DURING 2010

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SUMMARY OF FINDINGS

Surveys for greater prairie-chickens (*Tympanuchus cupido pinnatus*) were conducted during April and May of 2010. We located 152 booming grounds where males gather for breeding displays, and we counted 1,499 male prairie-chickens, including birds of unknown sex. Within the 17 41-km^2 survey blocks we observed 0.13 (95% confidence interval = 0.09–0.16) booming grounds/km^2 and 9.6 (8.4–10.8) males/booming ground. The density of booming grounds was greater than the average of 0.08 (0.06–0.09) booming grounds/km^2 observed during the 10 years before recent hunting seasons (i.e., 1993–2002), whereas the density of males at booming grounds was less than the average of 11.5 (10.1–12.9) males/booming ground observed during 1993–2002.

INTRODUCTION

Index Surveys

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

Greater Prairie-Chickens

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

During spring male prairie-chickens gather at communal display areas, or leks. The display areas of prairie-chickens are called booming grounds because males make a low-frequency, booming vocalization during their displays. From 1974 to 2003 the Minnesota Prairie Chicken Society coordinated annual counts of prairie-chickens at booming grounds. During 2004 the Minnesota Department of Natural Resources (DNR) began coordinating the annual prairie-chicken surveys, and a standardized survey design was adopted.

METHODS

During the few hours near sunrise from late-March until mid-May cooperating biologists and numerous volunteers counted prairie-chickens at booming grounds in western Minnesota. They attempted to locate and observe multiple times all booming grounds within 17 designated survey blocks (Figure 2). Each block was a square comprising 4 sections of the Public Land Survey (approximately 4,144 ha) and was selected non-randomly 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. I calculated confidence intervals for the mean of estimated densities using the standard deviation of density estimates among survey blocks. I compared densities from the current year to estimates from the 10 years before recent hunting seasons (i.e., 1993–2002). Such comparisons should be made cautiously because prior to 2004 there was less emphasis on standardization of effort and timing of surveys. Survey protocols were similar in the past, however, and the current survey blocks were located in areas surveyed regularly since the mid-1970s. Also, sex-specific counts were not recorded prior to 2000 and they likely included females, so counts from those years were reduced by the proportion of females observed in 2004 to make them more comparable to current counts of males and birds of unknown sex.

RESULTS & DISCUSSION

Observers from at least 4 cooperating organizations and many unaffiliated volunteers counted prairie-chickens during April and May 2010. 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 University of Minnesota-Crookston. Observers located 152 booming grounds and counted 1,499 male prairie-chickens during 2010 (Table 1). Within hunting permit areas we observed 0.02 booming grounds/km^2 and 10.4 males/booming ground during 2010. Minimum counts in Table 1 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 predetermined spatial sampling design.

Each booming ground was observed on a median of 2 (mean = 2.0) different days, and 43% of booming grounds were observed only once during 2010. Attendance of males at booming grounds varies among days and by time of day. Single counts of males at a booming ground, therefore, may be an unreliable indication of true abundance. Similar counts on multiple days, on the other hand, demonstrate that the counts may be a good indicator of true abundance. Even multiple counts, however, cannot overcome the problems associated with the failure to estimate the probability of detecting booming grounds and individual birds at booming grounds. Without estimates of detection probability, the prairie-chicken survey is an index to, not an estimate of, prairie-chicken abundance within the survey blocks. The credibility of the index for monitoring changes in abundance among years is dependent upon the untested assumption that a linear relationship exists between counts of male prairie-chickens and true abundance. In other words, we assume that (the expected value of) the probability of detection does not change among years.

Within survey blocks we counted 852 males, including birds of unknown sex, on 89 booming grounds during 2010 (Table 2). Booming grounds were defined as having ≥2 males, so observations of single males were excluded from summaries by survey block. In the 10 core survey blocks we observed 0.16 (0.12–0.21) booming grounds/km^2 and 9.5 (8.2–10.9) males/booming ground (Table 2, Figure 2). In the 7 peripheral survey blocks we observed 0.07 (0.04–0.10) booming grounds/km^2 and 9.8 (7.1–12.4) males/booming ground. The density of booming grounds observed among all survey blocks during 2010 was greater than the average of 0.08 (0.06–0.09) booming grounds/km^2 observed during the 10 years before recent hunting seasons (i.e., 1993–2002), whereas the density of males at booming grounds observed among all survey blocks during 2010 was less than the average of 11.5 (10.1–12.9) males/booming ground observed during 1993–2002 (Table 2, Figure 3).

Table 1. Minimum abundance of prairie-chickens within and outside of hunting permit areas in western Minnesota during spring 2010. 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	51	0
803A	668	0	0	0
804A	435	0	0	0
805A	267	9	62	0
806A	749	9	68	18
807A	440	29	350	29
808A	417	24	298	0
809A	743	20	217	0
810A	505	13	152	0
811A	704	10	58	30
PA subtotal[b]	6,356	121	1,256	77
Outside PAs[c]	NA[d]	31	243	75
Grand total	NA	152	1,499	152

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

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

			2010		Change from 2009[a]	
Range[b]	Survey Block	Area (km^2)	Booming grounds	Males[c]	Booming grounds	Males[c]
Core	Polk 1	41.2	7	51	0	-12
	Polk 2	42.0	9	62	0	-39
	Norman 1	42.0	3	28	1	7
	Norman 2	42.2	7	57	1	-15
	Norman 3	41.0	13	105	2	-15
	Clay 1	46.0	10	115	0	25
	Clay 2	41.0	2	39	0	11
	Clay 3	42.0	7	73	-1	-16
	Clay 4	39.0	5	58	-1	-5
	Wilkin 1	40.0	5	59	-3	-31
	Core subtotal	415.0	68	647	-1	-90
Periphery	Mahnomen	41.7	4	46	1	12
	Becker 1	41.4	6	43	4	30
	Becker 2	41.7	3	32	0	-12
	Wilkin 2	41.7	2	11	-1	-6
	Wilkin 3	42.0	3	44	-1	-22
	Otter Tail 1	41.0	2	16	1	9
	Otter Tail 2	40.7	1	13	-2	-23
	Periphery subtotal	290.6	21	205	2	-12
Grand total		705.5	89	852	1	-102

[a] The 2009 count was subtracted from the 2010 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.

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 Wes Bailey and Mark Lenarz for reviewing a draft of this report.

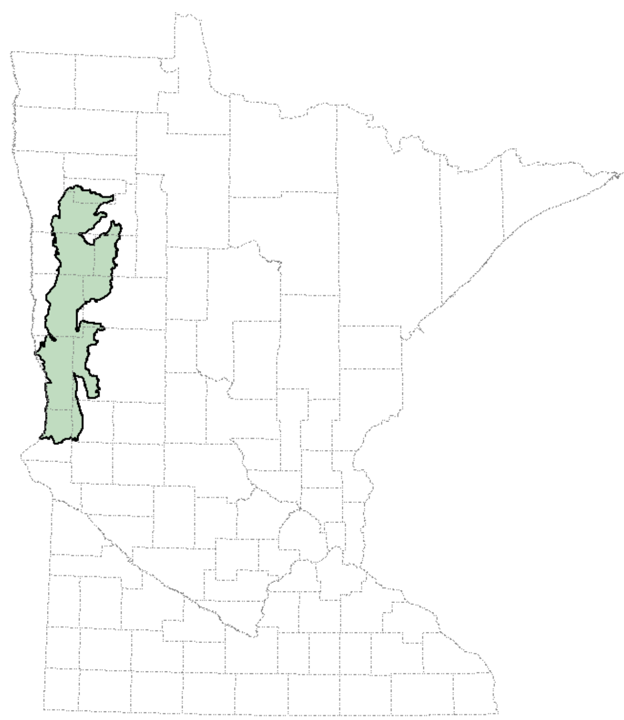

Figure 1. Primary range of greater prairie-chickens (shaded area) relative to county boundaries in Minnesota. This range boundary was based on ECS Land Type Associations and does not include all areas that are known to be occupied by prairie-chickens.

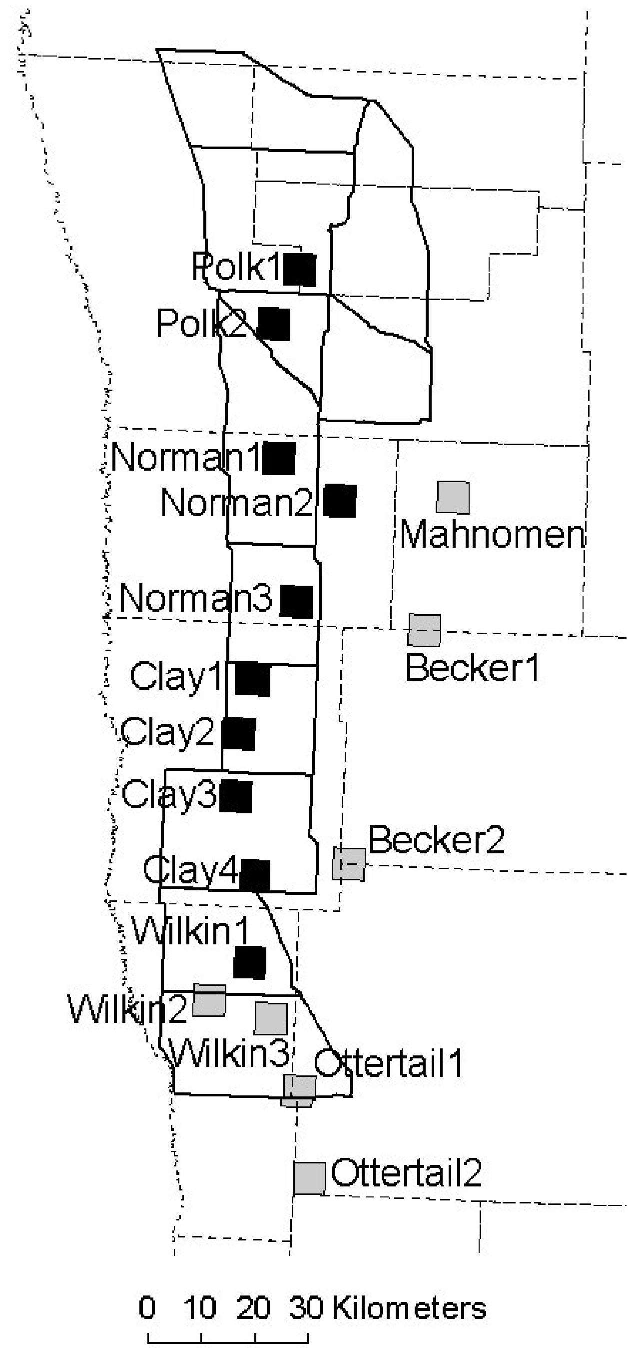

Figure 2. Survey blocks (41 km^2, labeled squares) and hunting permit area boundaries (solid lines) for prairie-chickens in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which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

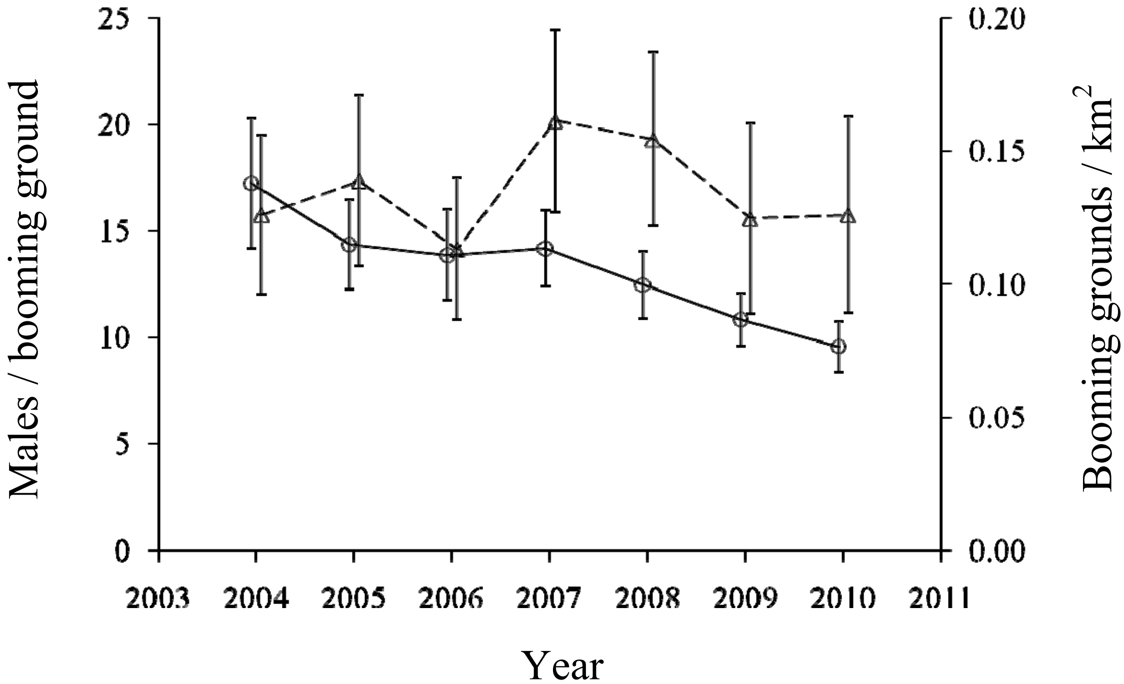

Figure 3. Number of prairie-chicken males/booming ground (circles connected by solid line) and booming grounds/km^2 (triangles connected by dashed line) observed in 17 41-km^2 survey blocks in western Minnesota. Vertical error bars represent 95% confidence intervals. The average densities during the 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
2010 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, 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 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 2009 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 periodically been collected for all non-juveniles to facilitate interpretation of reproductive data (bobcats) and to obtain current information on year-class distribution for both species. However, in recent years, 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 2009 registered DNR trapping and hunting harvest was 884, a slight increase from last year, and nearly matching the record harvest observed in 2006 (890; Table 1). Total modeled harvest, which includes reported tribal take, was 942. The juvenile to adult female ratio in the harvest (0.9; Table 1) was slightly below both the long-term average (1.5) and the recent 10-year average (1.1). A total of 844 bobcat carcasses were examined (Table 1), with a mean age of 2.5 for females. Approximately 6% of the harvested female bobcats were ≥ 6.5 years old (Figure 1).

Based on examination of reproductive tracts, 25% of yearling females produced a litter in 2009, slightly below the 7-year average of 27% (Figure 2). Average litter size for pregnant yearlings was 2.5, above the 7-year average of 2.2. Pregnancy rate for 2+ year olds was 75%, below last year (80%), but similar to the previous 7-year mean (74%). Mean litter size for pregnant adults was 2.7 (7-year mean = 2.8). For both yearlings and adults, pregnancy rates appear to fluctuate much more than average litter size.

As a result of a recent but continuing discordance between population modeling projections and field evidence (i.e., track surveys, harvests, field observations), numerous inputs to the bobcat population model were modified this year. Because we currently collect empirical data on reproductive parameters, the model was recalibrated primarily via adjustment of post-2001 survival parameters. While the magnitude of parameter changes was based on professional judgment, the preponderance of evidence clearly suggests the population model was underestimating the size of the bobcat population. The changes made to the input parameters resulted in a 65% increase in the projected 2009 spring population. Based on projections from the recalibrated model, 22% of the 2009 fall population was harvested. Population modeling predicts a 3% decline in the bobcat population (Figure 3), with an estimated 2010 spring population size of ~ 3,000 (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). Fisher harvest this year under the DNR framework declined 30% to 1,259 (Table 2). Modeled harvest, which includes reported tribal take, was 1,323. Carcass collections ended in 1994, so no current age or reproductive data are available. The fisher winter track survey index continued to decline, once again reaching a new low since the survey began (Figure 4).

With the availability of both reproductive and survival data collected as part of an ongoing fisher research project, as well as some discordance between recent model projections and field sign, numerous model parameters were adjusted in accordance with preliminary research findings. The changes made to the input parameters resulted in a 27% decrease in the projected 2009 spring population. Based on projections from the recalibrated model, 17% of the fall fisher population was harvested. Modeling projects negligible population change from last year (Figure 3), with an estimated 2010 spring population size of ~ 6,100 fishers.

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). Harvest this year under the DNR framework was 2,073, up 14% from last year (Table 3). Modeled harvest, which includes reported tribal take, was 2,250. Age-class information was obtained from a sample of 70% of the carcasses collected this year. Juveniles comprised 55% of the total harvest, above the recent 10-year average (48%), though similar to the longer-term average of 56% (Table 3; Figure 5). The juvenile:adult female ratio (4.9) in the harvest was above last year (2.1), but below the long-term average (Table 3).

With the availability of reproductive, survival, and sex ratio data collected as part of an ongoing marten research project, numerous model parameters were adjusted in accordance with preliminary research findings. The changes made to the input parameters resulted in a 13% decrease in the projected 2009 spring population, as well as a shift toward a more balanced adult sex ratio (previously very female biased). Based on projections from the recalibrated model, 18% of the fall marten population was harvested. Modeling projects a 2% population increase from last year (Figure 3), with an estimated 2010 spring population size of ~ 9,500 martens.

Otter. In the north otter-trapping zone, harvest under the DNR framework declined 21% to 1,484 (Table 4), likely a result of reduced fur prices and trapper effort. Modeled harvest, including reported tribal take, was 1,578 (Table 4). An estimated 12% of the fall population was harvested. Carcass collections ended in 1986, so no age or reproductive data are available. After several years of decline, modeling suggests the population has increased the past 3 years, with a projected 7% increase this year (Figure 7). No independent otter survey data are currently available for comparison in the northern zone. The current estimated spring population in the north zone is ~ 11,700.

A new otter-trapping zone was also established in southeast Minnesota starting in 2007. The otter harvest in the southeast zone has increased slightly in each of the 3 years, from 44 the first year to 60 this year. While we have established protocol for an otter occupancy survey in this region to assist with population monitoring, weather conditions or scheduling conflicts have not allowed us to consistently fly repeat surveys (or any surveys in some years) that would allow for detection-corrected comparisons of occupancy rate across years. Acknowledging this limitation, approximately 40% more otter sign was recorded during this past winter's aerial survey compared to a similar survey flown in 2006 (i.e., the year prior to the first harvest season). The preponderance of evidence suggests that since the harvest season was established 3 years ago, the otter population has likely continued to increase. Efforts to develop a population model specific to the southeast zone are continuing, though initial projections are not yet available.

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Table 1. Bobcat harvest data, 1980 to 2009.

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]
1980	210	210	10	48	31	33	36	1.9	80	69	56	66	$79
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

[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.

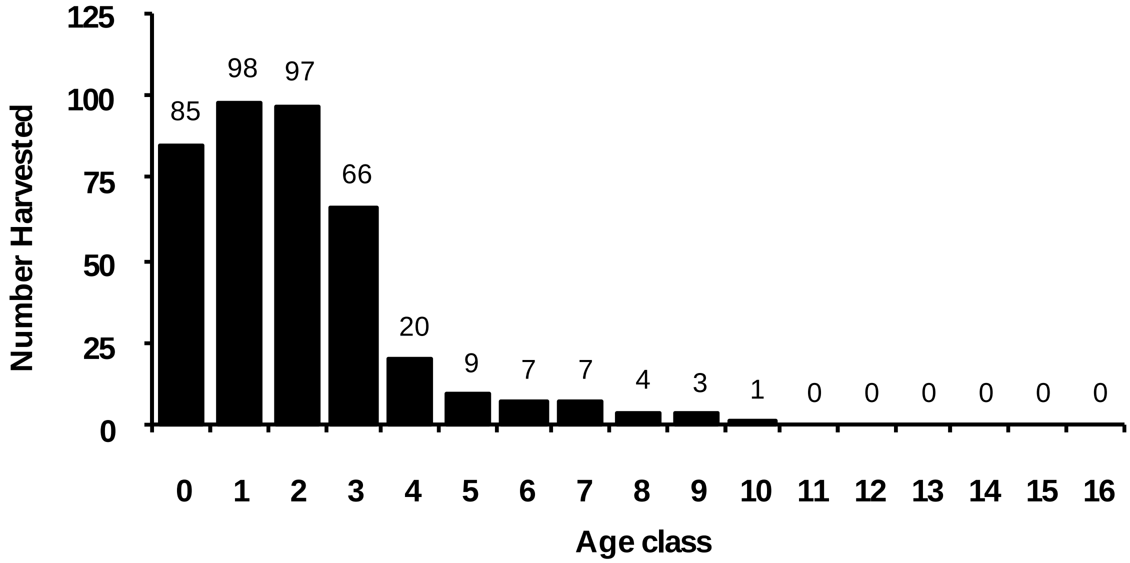

Figure 1. Age structure of female bobcats in the 2009-10 harvest.

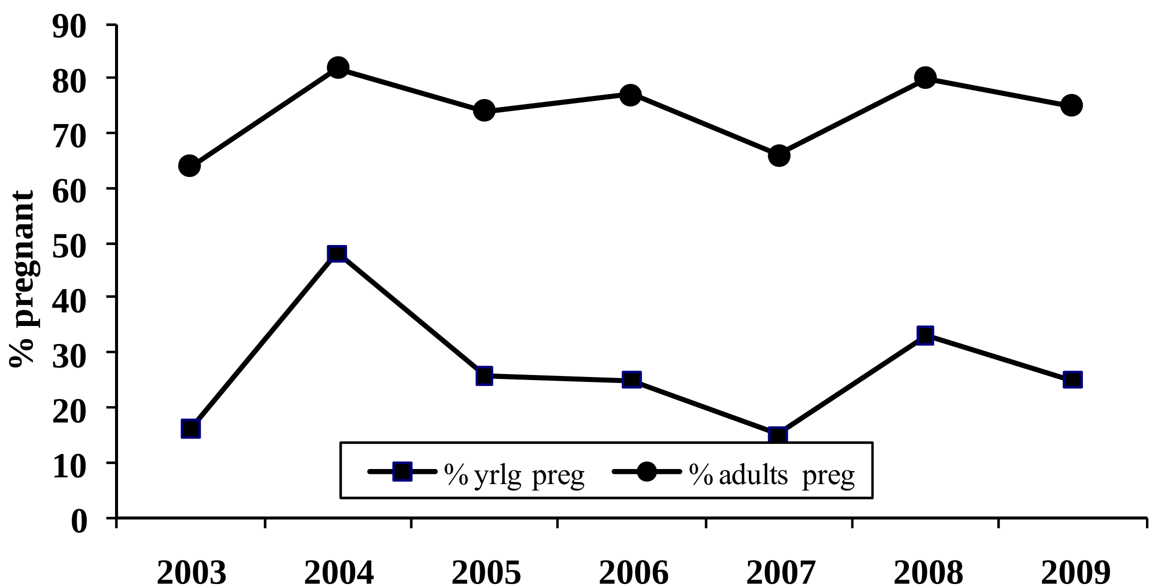

Figure 2. Pregnancy rates for yearling and adult bobcats in Minnesota, 2003-2009.

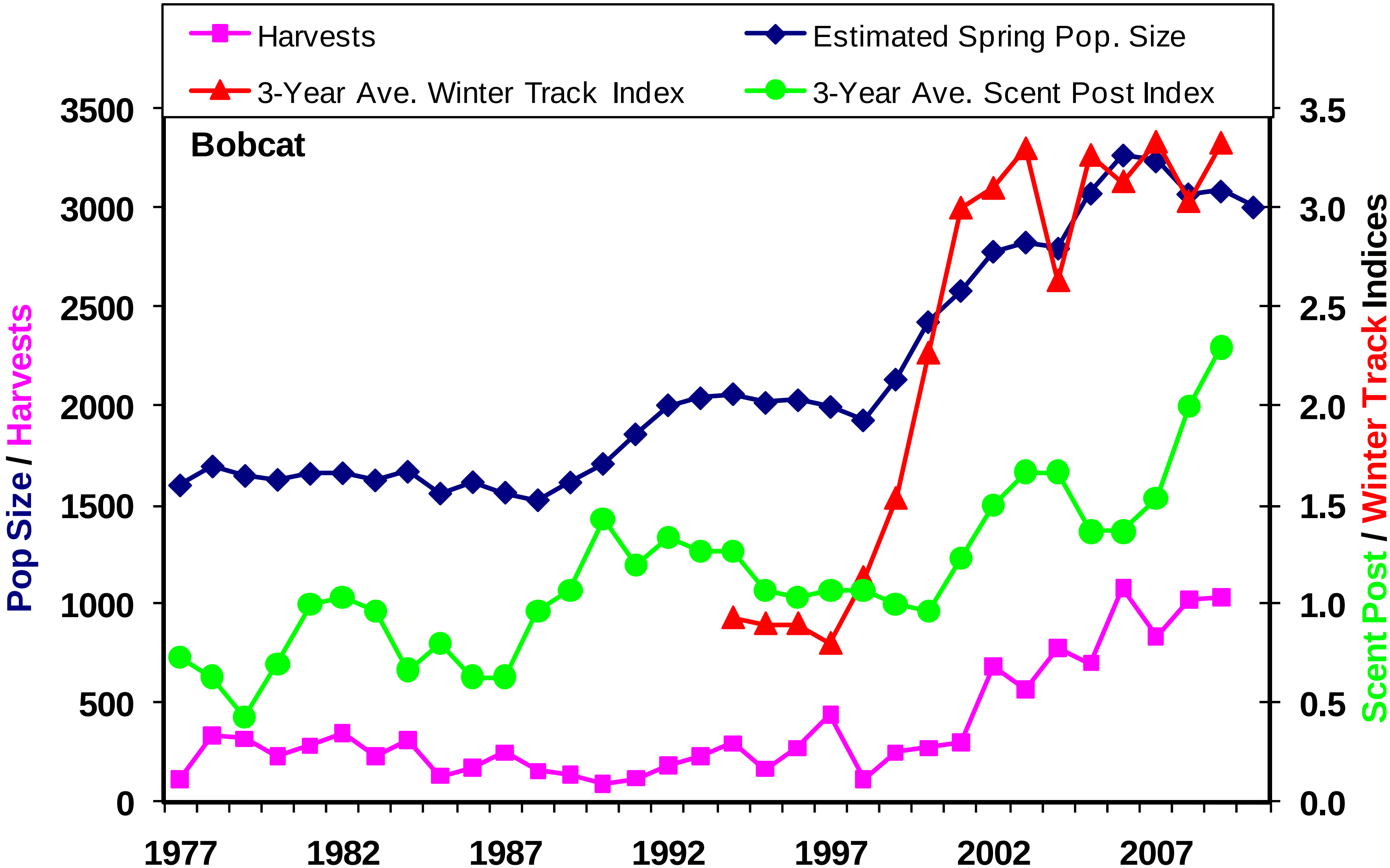

Figure 3. Bobcat populations, harvests, and survey indices, 1977-2010. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1980 to 2009. Carcass collections ended in 1994.

Year	DNR harvest	Modeled Harvest[2]	% Autumn Pop. Harvested[3]	Carcasses examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[4]	Pelt price Females[4]
1980	CLOSED													
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	$34	$35

[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 10% from 1993-present.

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

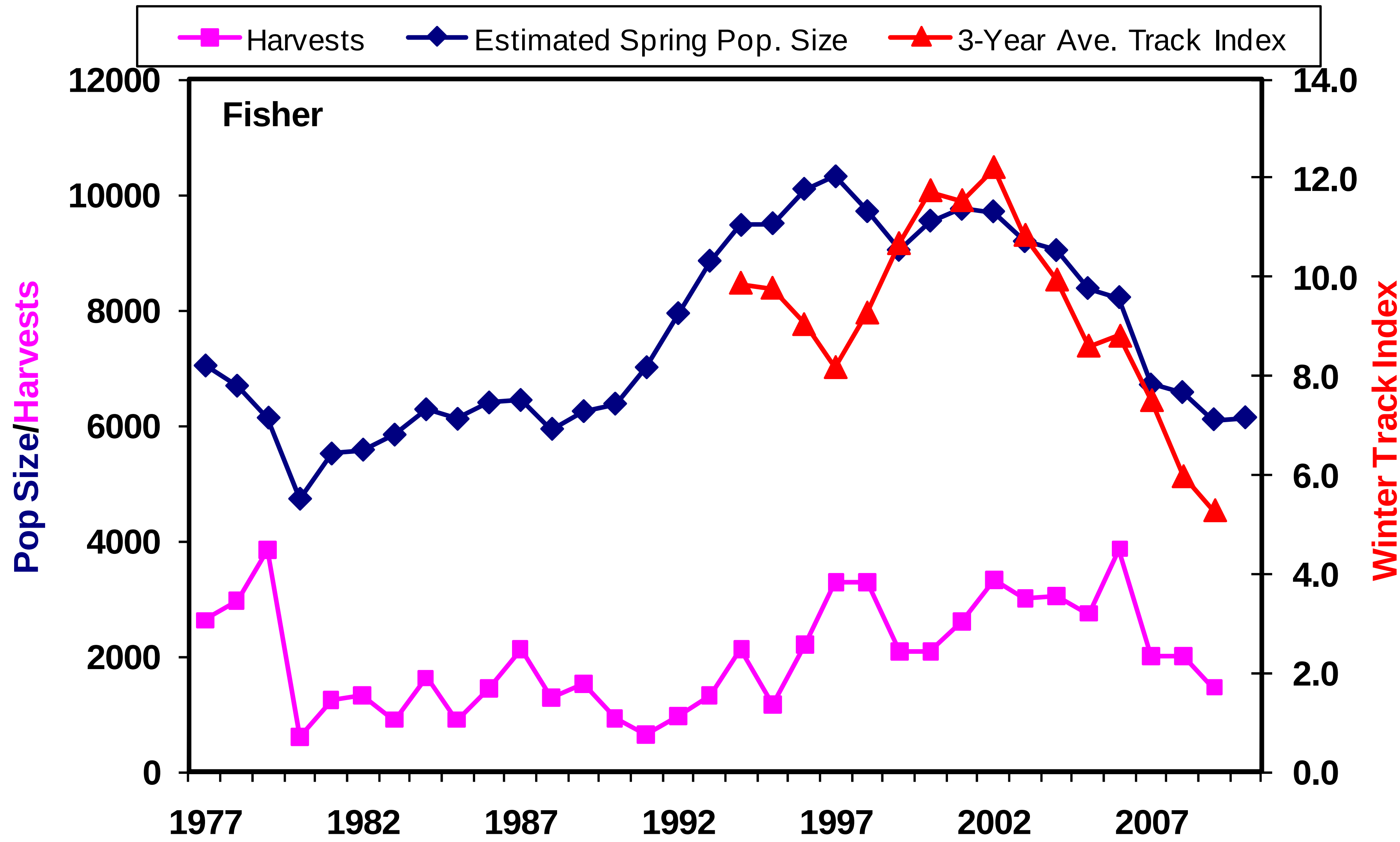

Figure 4. Fisher populations, harvests, and survey indices, 1977-2010. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2009.

Year	DNR harvest	Modeled Harvest[2]	% Autumn Pop. Harvested[3]	Carcasses examined	% 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

[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 10% 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

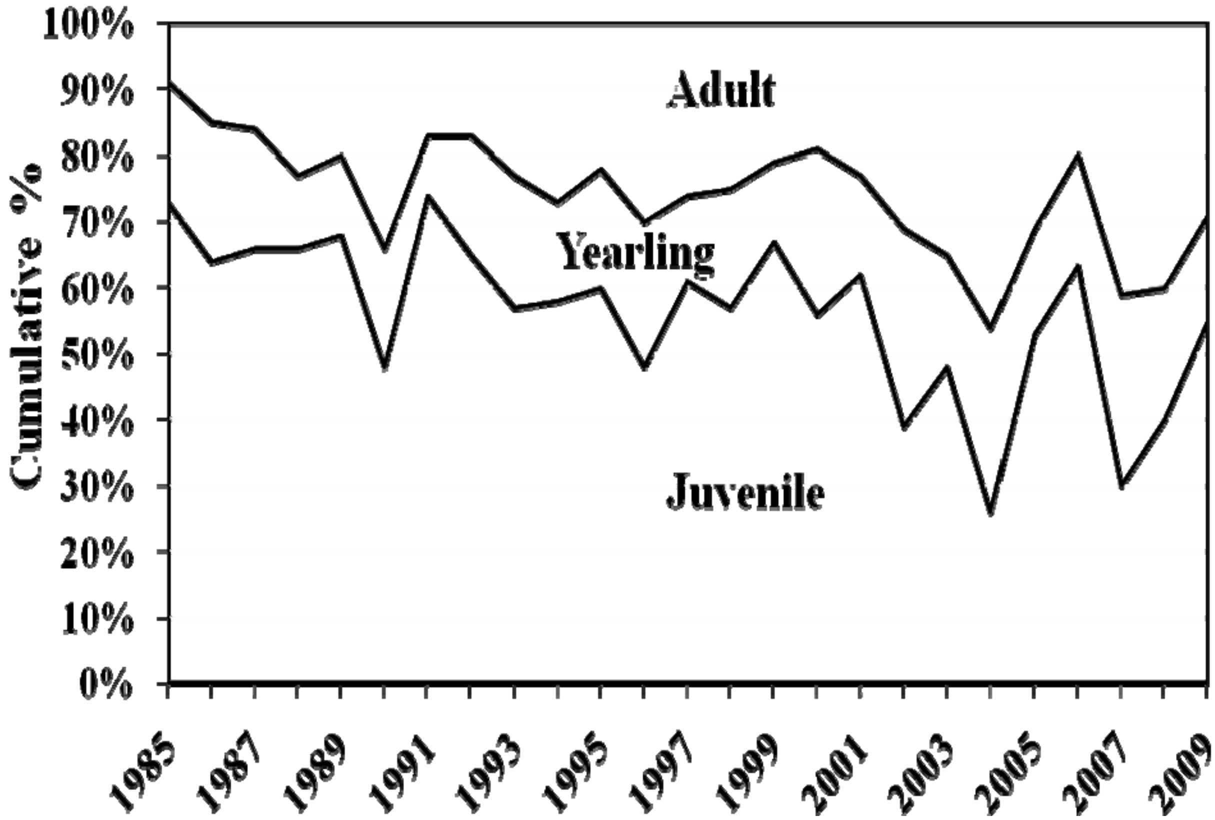

Figure 5. Marten harvest age-class proportions, 1985-2009.

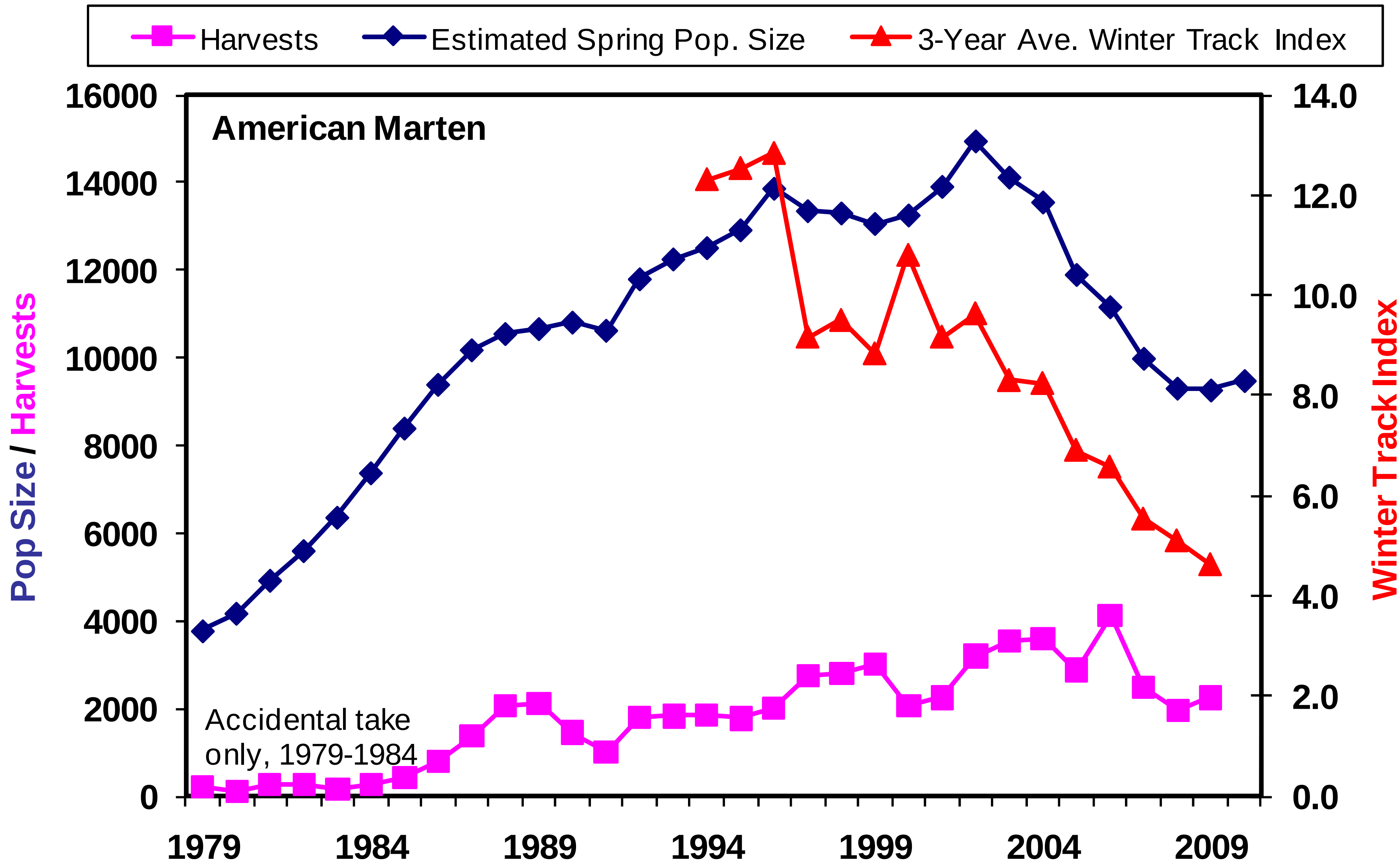

Figure 6. American marten populations, harvests, and survey indices, 1979-2010. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data[1], 1980 to 2009. Carcasses were only collected from 1980-86.

Year	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 Otter[4]	Pelt price Beaver[4]
1980	1111	1111	16	88	55	15	30	3.4	40	62	56	48	$33	$18
1981	485	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	614	8	433	42	31	27	3.7	56	57	57	56	$25	$12
1984	513	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	1368	10	-	-	-	-	-	-	-	-	52	$30	$7
1993	1459	1646	10	-	-	-	-	-	-	-	-	52	$43	$10
1994	2445	2708	19	-	-	-	-	-	-	-	-	52	$48	$14
1995	1435	1466	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	2323	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	2884	22	-	-	-	-	-	-	-	-	58	$89	$15
2006	2720	2872	22	-	-	-	-	-	-	-	-	56	$43	$17
2007	1803	1911	15	-	-	-	-	-	-	-	-	55	$29	$16
2008	1884	1983	15	-	-	-	-	-	-	-	-	59	$24	$12
2009	1484	1578	12	-	-	-	-	-	-	-	-		$36	$13

[1] Excludes harvest in new trapping zone in SE MN that opened in 2007.

[2] Includes DNR and Tribal harvests

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

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

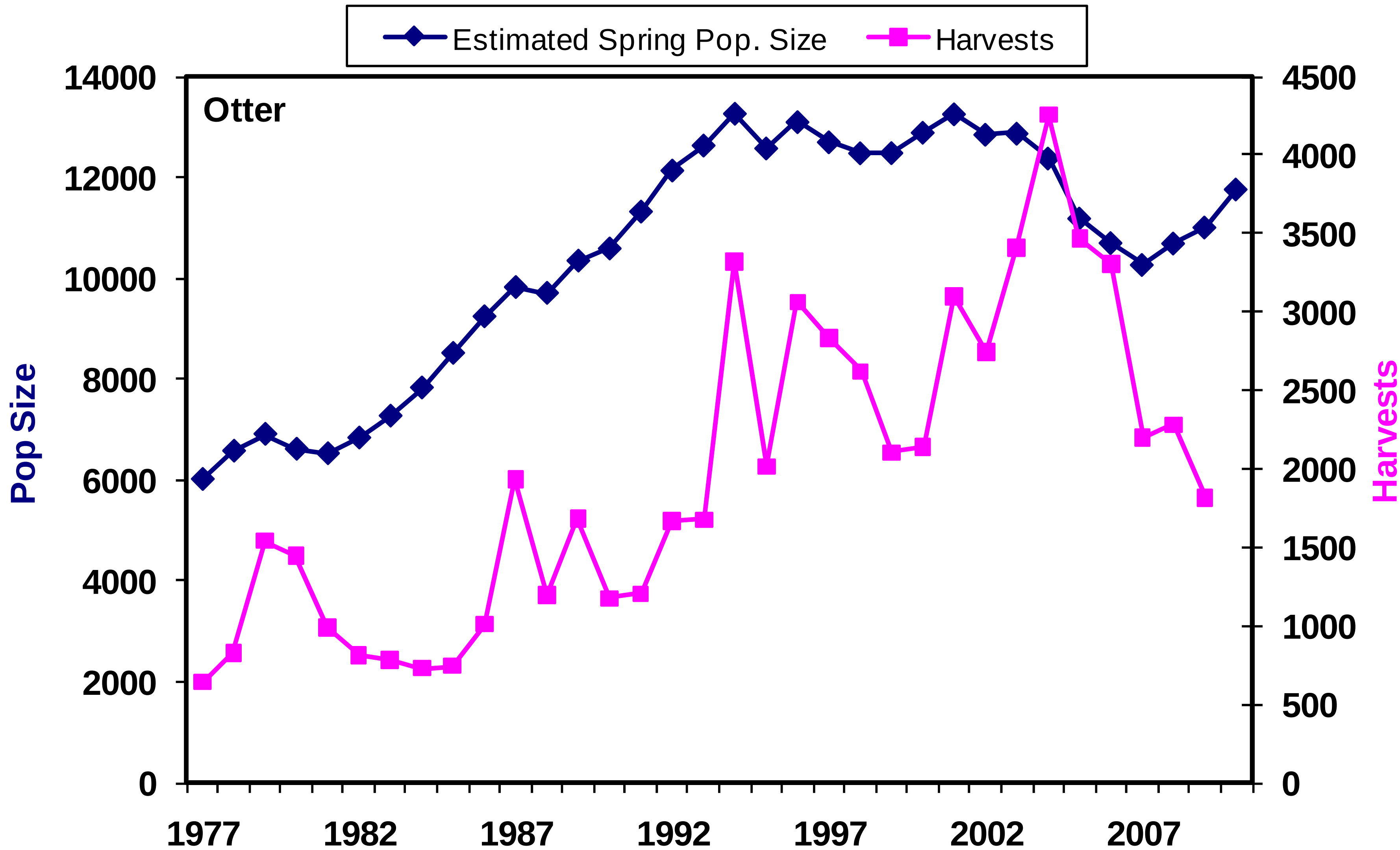

Figure 7. Otter populations and harvests, 1977-2010. Harvests include an estimate of non-reported take.

POPULATION TRENDS OF WHITE-TAILED DEER IN THE FOREST ZONE – 2010

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 2009 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.

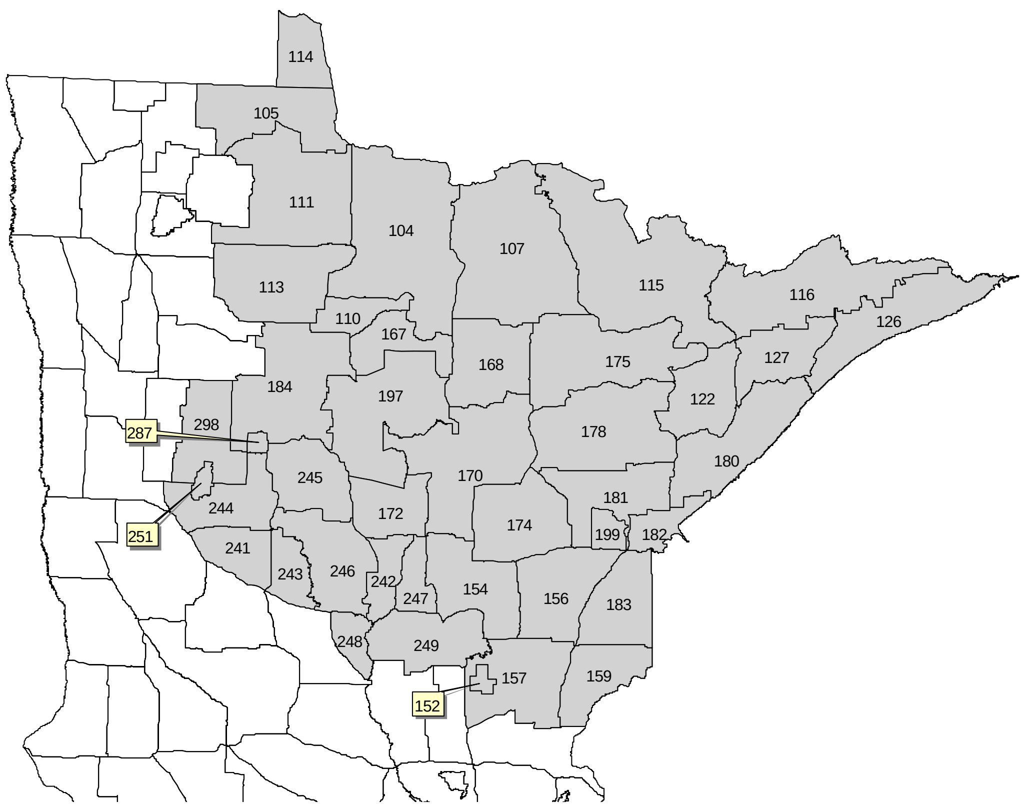

Figure 1. Permit areas in the forested zone, 2009.

HARVEST

In 2009, hunters registered 194,186 deer, down 12% from 2008. Of that number, 48% or 94,089 deer were harvested in the forested zone (Figure 1, Table 1). The 2009 forest zone harvest decreased 19% from the 2008 harvest. The following discussion applies to the subset of deer harvested in the forested zone.

The buck harvest decreased in 25 of the 42 permit areas yet this represented a decline of only 3% from the 2008 buck harvest (Table 2). Last year, the 2008 buck harvest was down 15% from the preceding year. The minor change in the 2009 buck harvest likely reflects the fact that deer populations in most permit areas were near goal. There were fewer opportunities to harvest antlerless deer in 2009 and hunters likely hunted longer to harvest a buck.

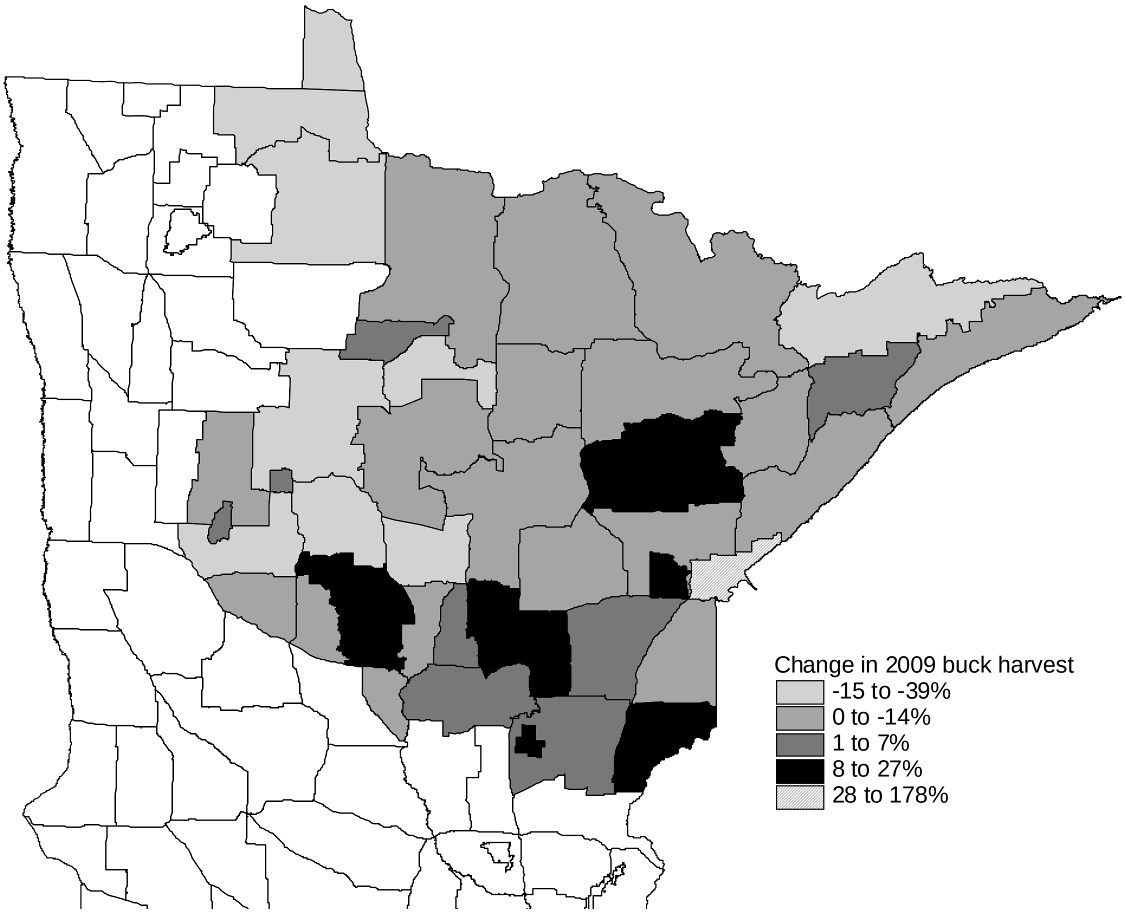

Figure 2. Change in buck harvest in forest zone permit areas between 2008 and 2009.

The antlerless harvest decreased in 33 of the 42 permit areas (Table 3) and the total antlerless harvest decreased by 29%. The greatest decreases occurred in 11 permit areas that shifted from managed or intensive into the lottery category ($\bar{x}$ = -63%, n = 11, range -36 to -81%; Table 4). Under the lottery category, only hunters with an either-sex permit (based on a lottery) are allowed to kill an antlerless deer. In permit areas that remained within their respective category (i.e. stayed lottery, managed, etc), the antlerless harvest increased ($\bar{x}$ = 21%, n = 17, range -7 to 270%; Table 4).

The proportion of bucks in the forest zone harvest (total forest bucks/total forest harvest) increased 8% from last year to 49%. This increase reflected the decreased 2009 antlerless harvest. Forest-wide, the proportion of bucks by permit area ranged from 28 to 83%.

The archery harvest in the forest zone declined 35% in 2009. Change in the archery harvest was correlated with change in the total forest deer harvest (r^2 = 0.795, P < 0.001) which suggests that the decline was in part, the result of reduced deer numbers. State wide archery license sales increased <1% from 2008.

The muzzleloader harvest declined 20% in the forest zone in 2009. Unlike archery, the change in muzzleloader harvest was not related to change in the total forest harvest. Muzzleloader license sales declined by 2%.

POPULATION TRENDS AND MODEL PROJECTIONS

Based on the winter severity index (WSI), the winter of 2009-10 was generally mild with only 2 stations in the “moderate” range (Figure 3). Maximum WSI occurred at Isabella with a reading of 114 and International Falls recorded a reading of 105.

In an attempt to make permit areas more homogeneous in regards to ownership and habitat, we altered the boundaries of 21 permit areas (Figure 6). The numbering of some of these permit areas was changed to prevent confusion with the earlier numbering system (Figure 6). Because we aggregated some permit areas and split others, the forested zone now includes 43 permit areas, up from the 42 in 2009.

Simulation modeling was used in 37 permit areas (Figure 1 and Table 5) 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 pooled into 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. Between 2003 and 2009, 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 continued to drop slightly (1%) in the West Central region but increased from 1 to 10% in the remaining regions.

Based on density targets set during the 2005 and 2006 goal setting processes, the 2010 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. Deer density in permit areas ranged from 5 deer/mi^2 below goal to almost 10 deer/mi^2 above goal.

After discussion at several levels within the Division of Fish and Wildlife, the final designation of permit areas for the 2010 hunting season call for 20 permit areas to be listed as Lottery, 18 permit areas as Managed, 5 permit areas as Intensive, and 2 of the latter will also have an early antlerless season (Figure 7).

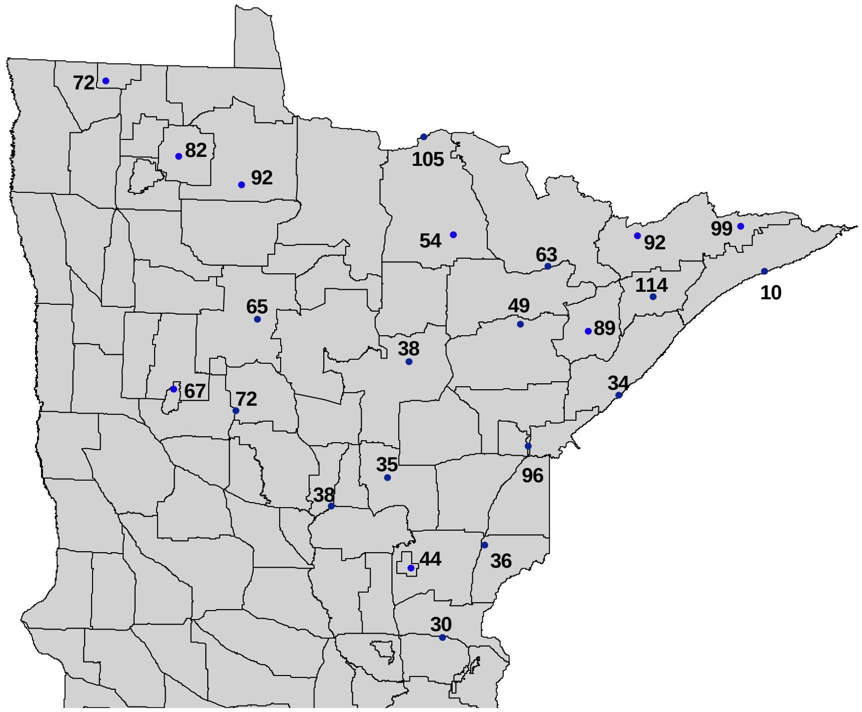

Figure 3. Final WSI values for the forested zone of Minnesota, winter of 2008-2009.

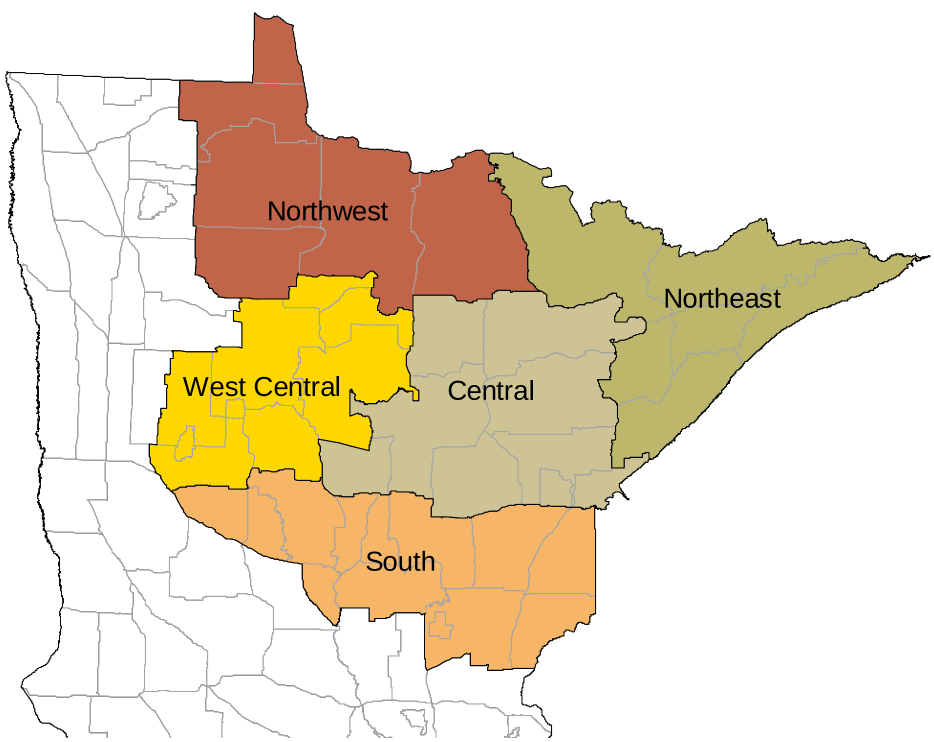

Figure 4. Permit areas grouped for summary discussion.

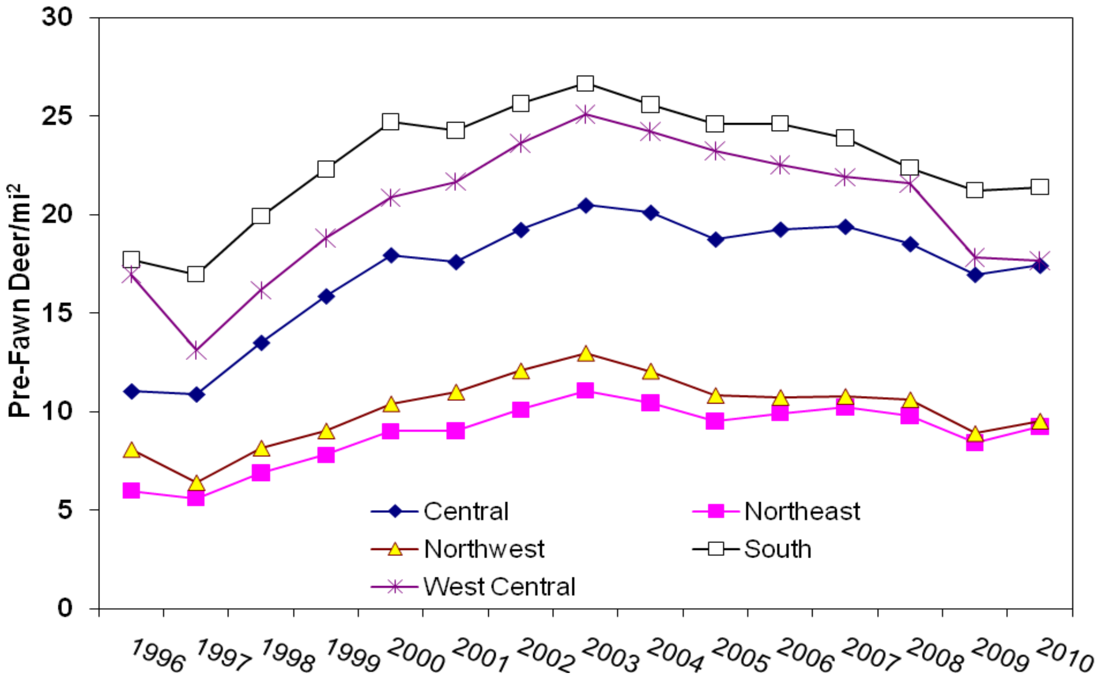

Figure 5. Population trends of deer in forest zone. Trend lines represent the groups of permit areas as illustrated in figure 4. Density represents pre-fawn density.

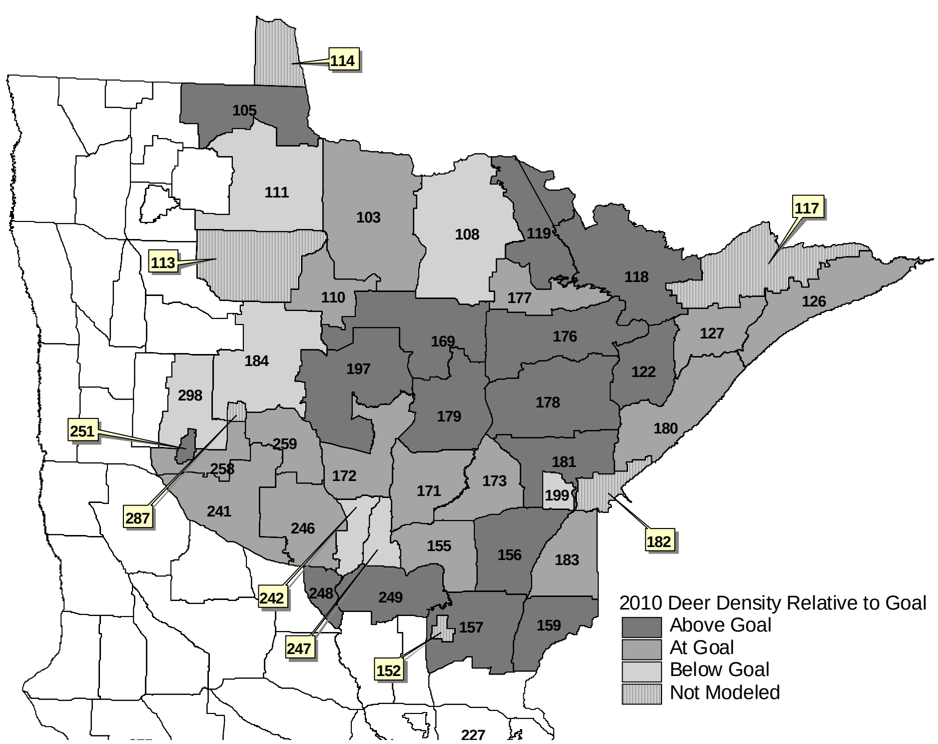

Figure 6. Deer density expressed relative to pre-fawn population goals. Note revised permit area boundaries (and numbers) effective for the 2010 hunting season.

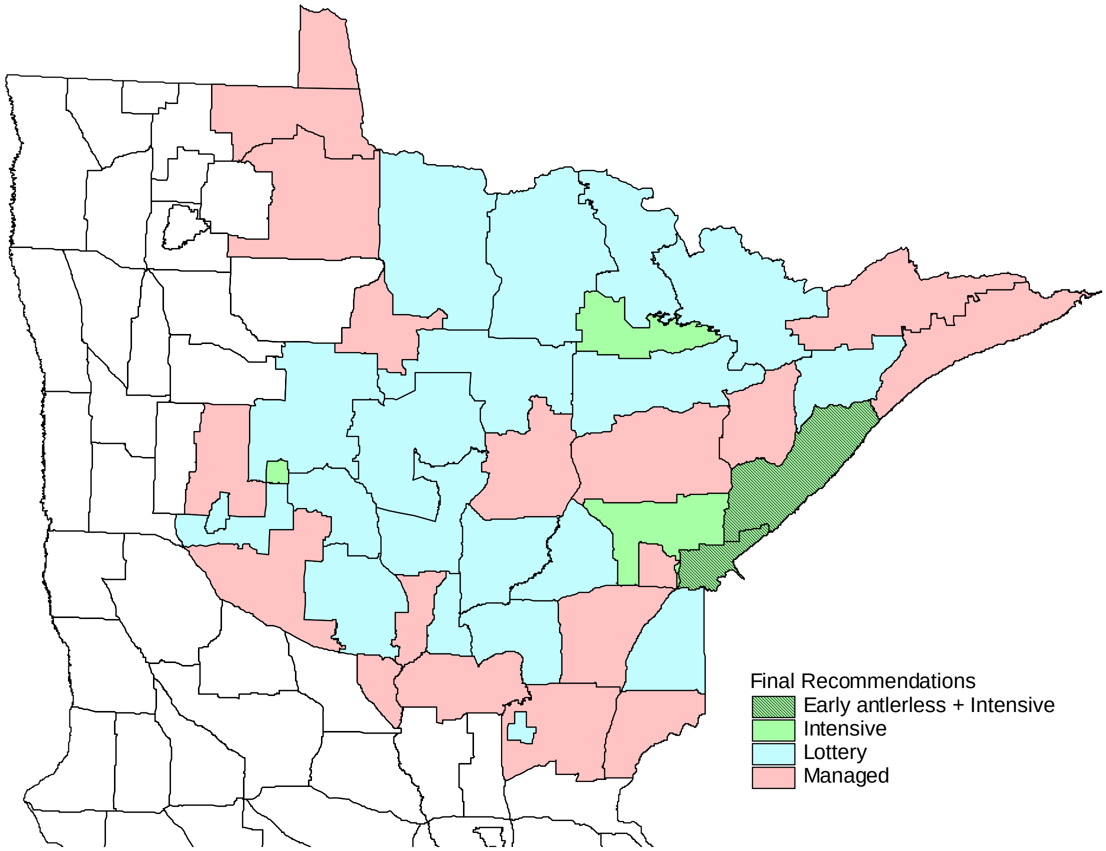

Figure 7. Final designation of permit areas in the Forest Zone for the 2010 hunting season.

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	2009	Change
104	1,372	1,837	1,939	2,253	3,421	2,902	2,483	2,632	2,557	2,100	1,316	-37%
105	1,389	1,821	1,962	2,385	3,740	3,106	3,557	3,210	3,344	2,391	2,006	-16%
107	1,994	2,846	3,547	3,499	5,206	4,027	3,936	3,825	3,874	3,148	1,731	-45%
110	1,511	1,376	1,371	1,553	2,180	2,122	1,945	1,910	1,935	1,865	1,438	-23%
111	1,169	1,644	2,223	2,264	3,064	2,621	2,687	2,812	1,608	1,558	1,364	-12%
114	40	55	72	80	96	110	123	174	127	120	96	-20%
115	2,334	3,174	3,586	3,815	5,431	4,333	4,378	4,480	4,250	3,438	2,214	-36%
116	138	150	156	157	265	298	261	270	350	394	170	-57%
122	296	556	617	574	696	716	657	1067	1118	1,014	753	-26%
126	306	445	470	597	702	841	904	977	1150	990	861	-13%
127	176	81	95	99	146	177	151	188	215	181	132	-27%
152	225	283	264	217	235	246	271	330	377	292	375	28%
154	2,978	4,418	4,169	5,032	5,717	5,176	4,583	4,546	4,526	2,578	2,767	7%
156	2,643	3,795	3,055	3,258	4,966	4,594	4,517	4,767	5,164	4,486	4,241	-5%
157	5,385	6,990	7,194	7,728	9,001	7,606	6,901	7,989	7,828	6,276	5,491	-13%
159	4,371	5,311	4,459	4,153	5,207	3,887	3,968	3,905	4,165	3,205	3,030	-5%
167	1,452	1,601	1,967	2,488	1,572	1,463	1,257	1,738	1,977	1,812	1,334	-26%
168	2,410	2,686	2,376	3024	3,218	3,978	2,534	3,627	3,357	2,941	2,695	-8%
170	2,880	4,938	4,829	4,716	8,460	7,154	7,221	6,951	8,346	7,412	5627	-24%
172	2,961	4,253	4,621	4,910	7,004	5,489	5,227	5,345	4,877	3,966	3459	-13%
174	1,927	2,438	2,140	2,678	3,825	3,347	3,095	3,180	3,245	2,856	1965	-31%
175	2,326	3,035	3,338	3233	5,071	4,254	3,103	4,559	4,419	4,318	2410	-44%
178	2,351	3,050	3,347	3,666	5,523	5,297	5,373	5,476	6,562	5,884	5045	-14%
180	946	1,540	1,703	1,867	3,123	2,355	2,837	3,553	3,755	3,366	2600	-23%
181	1,780	2,362	2,457	2,419	3,599	3,544	3,755	4,475	5,005	4,527	3526	-22%
182	614	827	862	869	1,309	1,206	1,256	1,460	1,599	1,621	2335	44%
183	2,147	2,748	2,743	2,771	3,960	3,533	3,449	4,006	3,747	3,060	2194	-28%
184	5,970	7,283	7,762	8,811	14,023	12,307	11,482	10,261	11,005	9,335	6645	-29%
197	933	1,372	1,167	1,413	1,652	1,723	1,594	2,471	2,248	2,051	1858	-9%
199	130	169	166	164	140	172	188	167	206	218	239	10%
241	2651	4284	3927	3857	4549	4449	4,288	4,369	4,787	4,261	4,332	2%
242	1,552	1,820	2,072	2,426	2,767	2,244	2,116	2,170	2,259	2,215	1,598	-28%
243	1,907	2,634	2,864	3,238	4,131	3,684	3,165	3,429	3,458	2,342	2,975	27%
244	2,956	3,771	4,841	5,805	7,452	6,702	6,162	6,192	7,102	5,499	2,686	-51%
245	3,524	4,695	5,053	5,626	8,231	6,377	5,737	6,115	5,393	4,853	2,786	-43%
246	4,075	5,599	6,090	5,149	7,530	6,782	5,835	6,389	5,339	2,847	3,323	17%
247	1,631	1,923	2,115	2101	2,744	2,582	2,115	2,393	2,064	1,230	1,277	4%
248	850	1,039	881	1,352	1,897	1,864	1,670	1,280	1,387	952	917	-4%
249	2,217	2,826	3,148	3,238	4,223	3,800	3,211	3,667	3,305	2,063	2,193	6%
251	246	326	254	298	470	387	325	301	253	145	199	37%
287	368	376	460	470	529	425	280	305	306	250	301	20%
298	704	803	826	932	1988	1733	1664	1727	1610	1,522	1,585	4%
Forested Zone	77,834	103,180	107,189	115,185	159,063	139,613	130,261	138,688	140,199	115,582	94,089	-19%

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	2009	Change
104	1,137	1,240	1,266	1,332	1,589	1,586	1,250	1,176	1,279	1,070	943	-12%
105	846	945	813	1,138	1,488	1,326	1,364	1,122	1,206	964	807	-16%
107	1,706	1,948	2,174	2,119	2,523	2,277	1,861	1,725	1,921	1,576	1,431	-9%
110	685	732	674	699	852	813	694	658	784	653	662	1%
111	1,088	1,168	1,395	1,463	1,467	1,408	1,316	1,149	830	741	607	-18%
114	40	43	56	63	55	55	72	95	83	69	54	-22%
115	1,898	2,038	2,145	2,376	2,915	2,679	2,262	2,242	2,228	1,764	1,633	-7%
116	138	150	156	157	238	251	230	186	261	219	132	-40%
122	293	417	452	449	501	567	534	565	658	587	553	-6%
126	306	390	417	495	585	591	595	606	686	518	495	-4%
127	176	80	82	86	126	149	127	147	148	104	106	2%
152	173	191	182	130	106	152	141	158	149	126	160	27%
154	2,018	2,305	2,142	2,169	2,071	2,049	1,789	1,677	1,911	1,468	1,699	16%
156	1,836	2,084	1,690	1,653	2,001	2,003	1,811	1,881	2,068	1,831	1,938	6%
157	3,009	3,327	3,144	3,048	3,207	3,030	2,745	2,916	2,832	2,334	2,466	6%
159	2,121	2,431	1,947	1,667	1,995	1,518	1,528	1,548	1,674	1,229	1,366	11%
167	906	1,036	968	1,211	821	819	709	692	821	706	585	-17%
168	1,579	1,653	1,454	1,675	1,698	1,889	1,435	1,439	1,525	1,233	1,142	-7%
170	1,621	3,106	2,786	2,611	3,435	3,233	2,987	2,920	3,285	2,698	2,414	-11%
172	1,821	2,292	2,259	2,200	2,359	2,147	1,853	1,799	1,866	1,429	1,203	-16%
174	1,234	1,448	1,257	1,363	1,542	1,597	1,367	1,313	1,400	1,247	1,245	0%
175	1,923	2,108	2,074	2,115	2,480	2,320	2,074	2,192	2,223	1,872	1,734	-7%
178	1,946	2,059	2,013	2,218	2,651	2,767	2,704	2,503	2,966	2,310	2,574	11%
180	941	1,215	1,358	1,398	1,831	1,833	1,692	1,829	1,878	1,579	1,538	-3%
181	1,351	1,596	1,562	1,590	1,943	1,940	1,779	1,998	2,240	1,823	1,806	-1%
182	484	577	564	568	685	684	361	357	372	315	878	179%
183	1,633	1,919	1,650	1,575	1,661	1,654	1,514	1,634	1,745	1,430	1,409	-1%
184	3,813	4,124	3,925	4,310	4,774	4,848	4,161	3,554	3,553	3,433	2,852	-17%
197	923	1,142	953	998	1,040	1,143	999	1,090	1,108	999	882	-12%
199	91	137	123	132	104	130	151	119	150	119	145	22%
241	1030	1382	1396	1477	1559	1621	1,460	1,506	1,498	1,370	1,462	7%
242	812	988	885	824	912	740	721	692	688	656	607	-7%
243	1,081	1,192	1,169	1,247	1,343	1,217	1,066	1,142	1,066	957	927	-3%
244	1,848	2,014	2,048	2,300	2,540	2,390	2,170	2,155	2,080	1,893	1542	-19%
245	2,216	2,350	2,179	2,430	2,743	2,449	2,036	2,229	1,932	1,887	1517	-20%
246	2,355	2,784	2,479	2,384	2,599	2,527	2,082	2,178	1,935	1,595	1753	10%
247	970	1,181	1,056	948	1,047	955	861	848	802	651	692	6%
248	641	778	622	720	714	739	656	638	487	410	406	-1%
249	1,310	1,590	1,479	1,429	1,479	1,327	1,261	1,285	1,246	1,134	1149	1%
251	129	134	152	132	176	183	128	145	91	59	63	7%
287	167	189	201	184	207	182	106	104	92	81	85	5%
298	601	648	685	654	952	894	810	799	753	762	699	-8%
Forested Zone	50,896	59,131	56,033	57,736	65,014	62,682	55,462	55,011	56,520	47,901	46,361	-3%

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	2009	Change
104	235	597	673	921	1,832	1,316	1,233	1,456	1,278	1,030	373	-64%
105	543	876	1,149	1,247	2,252	1,780	2,193	2,088	2,138	1,427	1,199	-16%
107	288	898	1,373	1,380	2,683	1,750	2,075	2,100	1,953	1,572	300	-81%
110	826	644	697	854	1,328	1,309	1,251	1,252	1,151	1,212	776	-36%
111	81	476	828	801	1,597	1,213	1,371	1,663	778	817	757	-7%
114	0	12	16	17	41	55	51	79	44	51	42	-18%
115	436	1,136	1,441	1,439	2,516	1,654	2,116	2,238	2,022	1,674	581	-65%
116	0	0	0	0	27	47	31	84	89	175	38	-78%
122	3	139	165	125	195	149	123	502	460	427	200	-53%
126	0	55	53	102	117	250	309	371	464	472	366	-22%
127	0	1	13	13	20	28	24	41	67	77	26	-66%
152	52	92	82	87	129	94	130	172	228	166	215	30%
154	960	2,113	2,027	2,863	3,646	3,127	2,794	2,869	2,615	1,110	1,068	-4%
156	807	1,711	1,365	1,605	2,965	2,591	2,706	2,886	3,096	2,655	2,303	-13%
157	2,376	3,663	4,050	4,680	5,794	4,576	4,156	5,073	4,996	3,942	3,025	-23%
159	2,250	2,880	2,512	2,486	3,212	2,369	2,440	2,357	2,491	1,976	1,664	-16%
167	546	565	999	1,277	751	644	548	1,046	1,156	1,106	749	-32%
168	831	1,033	922	1,349	1,520	2,089	1,099	2,188	1,832	1,708	1,553	-9%
170	1,259	1,832	2,043	2,105	5,025	3,921	4,234	4,031	5,061	4,714	3,213	-32%
172	1,140	1,961	2,362	2,710	4,645	3,342	3,374	3,546	3,011	2,537	2,256	-11%
174	693	990	883	1,315	2,283	1,750	1,728	1,867	1,845	1,609	720	-55%
175	403	927	1,264	1,118	2,591	1,934	1,029	2,367	2,196	2,446	676	-72%
178	405	991	1,334	1,448	2,872	2,530	2,669	2,973	3,596	3,574	2,471	-31%
180	5	325	345	469	1,292	522	1,145	1,724	1,877	1,787	1,062	-41%
181	429	766	895	829	1,656	1,604	1,976	2,477	2,765	2,704	1,720	-36%
182	130	250	298	301	624	521	339	303	388	394	1,457	270%
183	513	829	1,093	1,197	2,299	1,879	1,935	2,372	2,002	1,630	785	-52%
184	2,157	3,159	3,837	4,501	9,249	7,459	7,321	6,707	7,452	5,902	3,793	-36%
197	10	230	214	415	612	580	595	1,381	1,140	1,052	976	-7%
199	39	32	43	32	36	42	37	48	56	99	94	-5%
241	1,621	2,902	2,531	2,380	2,990	2,828	2,828	2,863	3,289	2,891	2,870	-1%
242	740	832	1,187	1,602	1,855	1,504	1,395	1,478	1,571	1,559	991	-36%
243	826	1,442	1,695	1,991	2,788	2,467	2,099	2,287	2,392	1,385	2,048	48%
244	1,108	1,757	2,793	3,505	4,912	4,312	3,992	4,037	5,022	3,606	1,144	-68%
245	1,308	2,345	2,874	3,196	5,488	3,928	3,701	3,886	3,461	2,966	1,269	-57%
246	1,720	2,815	3,611	2,765	4,931	4,255	3,753	4,211	3,404	1,252	1,570	25%
247	661	742	1,059	1,153	1,697	1,627	1,254	1,545	1,262	579	585	1%
248	209	261	259	632	1,183	1,125	1,014	642	900	542	511	-6%
249	907	1,236	1,669	1,809	2,744	2,473	1,950	2,382	2,059	929	1,044	12%
251	117	192	102	166	294	204	197	156	162	86	136	58%
287	201	187	259	286	322	243	174	201	214	169	216	28%
298	103	155	141	278	1,036	839	854	928	857	760	886	17%
Forested Zone	26,938	44,049	51,156	57,449	94,049	76,931	74,243	82,877	82,840	66,769	47,728	-29%

Table 4. Change in anterless harvest in response to change in harvest strategy between 2008 and 2009 seasons for Deer Permit Areas in Minnesota's forest zone.

Permit Area	L-L	M-L	M-M	M-I	I-L	I-M	I-I	EA-EA	EA-M	EA-I
104		-64%								
105								-16%		
107		-81%								
110									-36%	
111								-7%		
114			-18%							
115		-65%								
116		-78%								
122					-53%					
126						-22%				
127					-66%					
152			30%							
154	-4%									
156						-13%				
157									-23%	
159									-16%	
167						-32%				
168			-9%							
170						-32%				
172			-11%							
174		-55%								
175		-72%								
178									-31%	
180									-41%	
181									-36%	
182								270%		
183		-36%								
184						-36%				
197			-7%							
199			-5%							
241										-1%
242						-36%				
243				48%						
244					-68%					
245		-57%								
246	25%									
247	1%									
248			-6%							
249	12%									
251			58%							
287							28%			
298			17%							
Mean	9%	-64%	5%	48%	-62%	-29%	28%	82%	-31%	-1%
n	4	8	9	1	3	6	1	3	6	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	2010	Change
103	1,818	7	7	8	9	8	7	7	7	7	6	7	8%
105	766	24	26	29	31	31	28	27	27	27	23	24	4%
108	1,643	12	12	13	14	13	11	11	12	11	9	10	11%
110	522	18	18	19	20	20	19	19	19	18	16	16	-1%
111	1,437	6	7	7	8	7	6	6	6	6	5	5	4%
118	1,202	9	9	10	11	10	8	9	9	9	7	8	20%
119	799	13	13	14	15	14	12	12	13	12	10	11	12%
122	600	5	5	6	6	6	7	7	7	7	7	7	6%
126	941	4	4	5	5	6	6	6	6	5	5	5	2%
127	587	2	2	2	2	2	2	2	2	2	2	2	6%
155	597	18	18	18	18	17	16	16	15	14	15	17	9%
156	826	18	18	20	22	22	22	23	22	21	20	20	-2%
157	889	23	23	24	24	23	22	23	21	20	18	18	-2%
159	568	24	21	22	22	21	21	21	21	20	20	20	1%
169	1,122	16	15	16	15	15	14	15	14	14	13	13	2%
171	686	17	17	18	19	18	17	17	17	15	15	15	3%
172	695	21	21	22	24	23	21	21	20	18	17	16	-2%
173	592	14	14	15	16	15	14	14	14	13	13	14	6%
176	1,099	14	13	14	15	15	13	14	14	14	12	13	10%
177	504	17	17	18	20	18	16	16	17	17	13	14	10%
178	1,278	18	19	21	23	24	22	23	24	24	21	22	4%
179	867	22	21	23	25	24	23	23	24	22	21	21	1%
180	982	13	14	15	17	17	16	16	16	16	15	16	7%
181	856	23	23	25	28	28	26	27	27	26	25	25	0%
183	663	25	25	27	28	28	25	25	25	24	23	24	4%
184	1,232	23	24	27	29	28	26	25	24	22	18	18	-4%
197	965	14	14	15	16	16	16	16	16	15	14	13	-4%
241	998	34	35	37	39	38	37	36	36	34	30	29	-3%
242	215	34	33	35	35	33	32	32	31	28	23	20	-12%
246	836	27	26	27	28	26	25	24	23	21	22	23	5%
247	230	32	31	32	33	31	29	29	27	25	23	22	-2%
248	212	24	23	25	27	27	26	27	26	24	22	22	-3%
249	502	18	17	18	19	18	17	17	16	15	16	18	10%
251	55	17	16	17	18	16	14	13	12	12	12	13	5%
258	328	32	35	38	40	39	37	36	35	32	27	28	5%
259	428	32	33	36	37	34	32	31	30	38	24	25	6%
298	619	17	18	19	21	20	19	19	19	19	17	16	-2%
Forest Zone	29,159	16.7	16.8	18.2	19.3	18.5	17.4	17.5	17.3	16.6	14.8	15.3	-11%

2010 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 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 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.

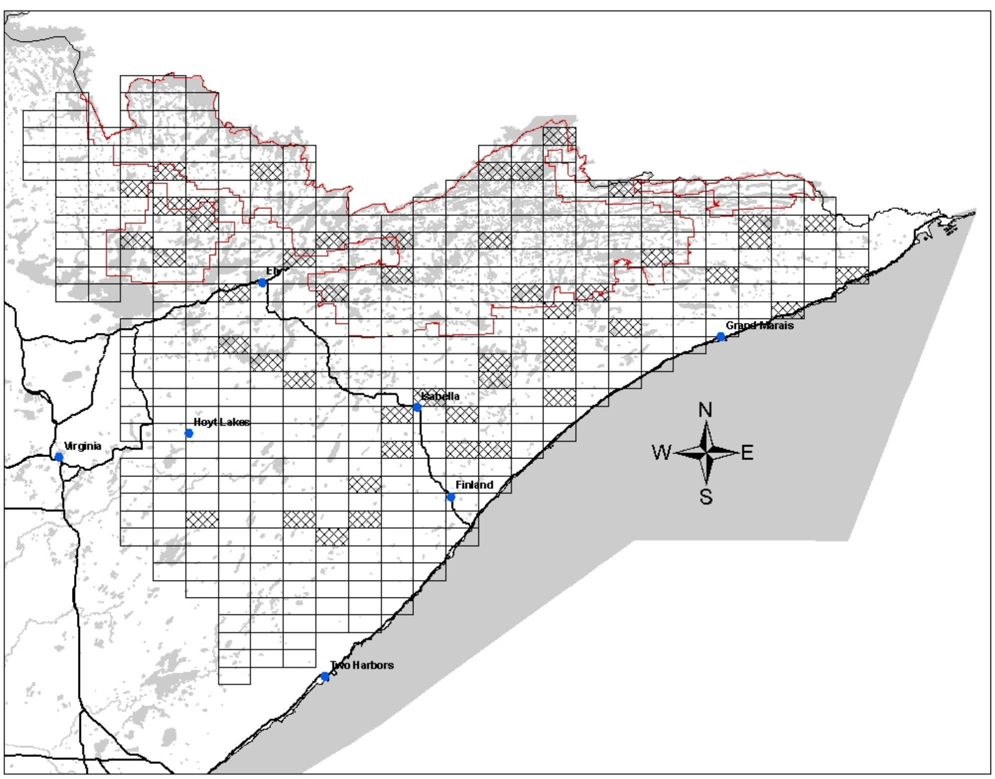

Figure 1. Northeast moose survey area and sample plots (cross hatching) flown in the 2010 aerial moose survey.

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 4 January and completed it on 12 January. Observers rated survey conditions as "good" (middle rank) on 39 plots and "excellent" on 1 plot. Snow conditions for the survey were <8" on 1 plot, between 8" and 16" on 36 plots, and >16" on 3 plots. During the survey flights, observers located 379 moose on the 40 plots (533 mi^2) including 140 bulls, 179 cows, 48 calves, and 12 unidentified moose. After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 5,528±1,318 animals (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.28 and 0.83, respectively (Table 1).

DISCUSSION

We have used the sightability model approach for 7 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 -2010 and as a result, population estimates were more comparable. Because of this bias, the population estimate for 2004 was not included in subsequent analyses. Survey estimates prior to 2004 were based on fixed-wing aircraft surveys and are not comparable to estimates based on post 2003 helicopter surveys.

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
2010	5,528±24%	0.28	13	3	0.83

The 2010 population estimate was substantially lower than those from previous years but the overlap in confidence intervals (Table 1, Figure 2) indicates no statistical difference between the 2009 and 2010 point estimates. At current levels of precision (±24%) the point estimate would have had to decline to at least 4,750 for it to be significantly lower than the 2009 estimate. Survey estimates were relatively imprecise and even with unlimited resources it would be difficult to measurably improve the precision.

The negative slope of the trend line (Figure 2) also was not significant ($P = 0.126$). The lack of a significant downward trend among survey estimates was likely an artifact of the small sample size (n=6). Several data sets suggest that the northeastern Minnesota moose population is declining. Simulation modeling that integrated survival and reproductive rates measured between 2002 and 2008 indicated that the population was declining by approximately 15% per year over the long term (Lenarz et al. In press). This inference is reinforced by 2 measures of recruitment measured during the survey. Estimates of calf:cow ratio and the % calves in the moose population were not affected by the switch from fixed-wing aircraft to helicopters and we can compare the trend in these statistics over a longer time period. Over the past 13 years, the cow:calf ratio has exhibited a significant decline (Figure 3; $P = 0.001$). During the same time period, the % calves has also declined (Figure 3; $P = 0.006$). In addition, the proportion of cows accompanied by twins has steadily declined since 2002 (Table 1; $P = 0.010$). Independent of the aerial survey, hunter success rates have steadily declined since 2001, for both either sex hunting ($P = 0.001$) and for bulls-only hunting ($P < 0.001$).

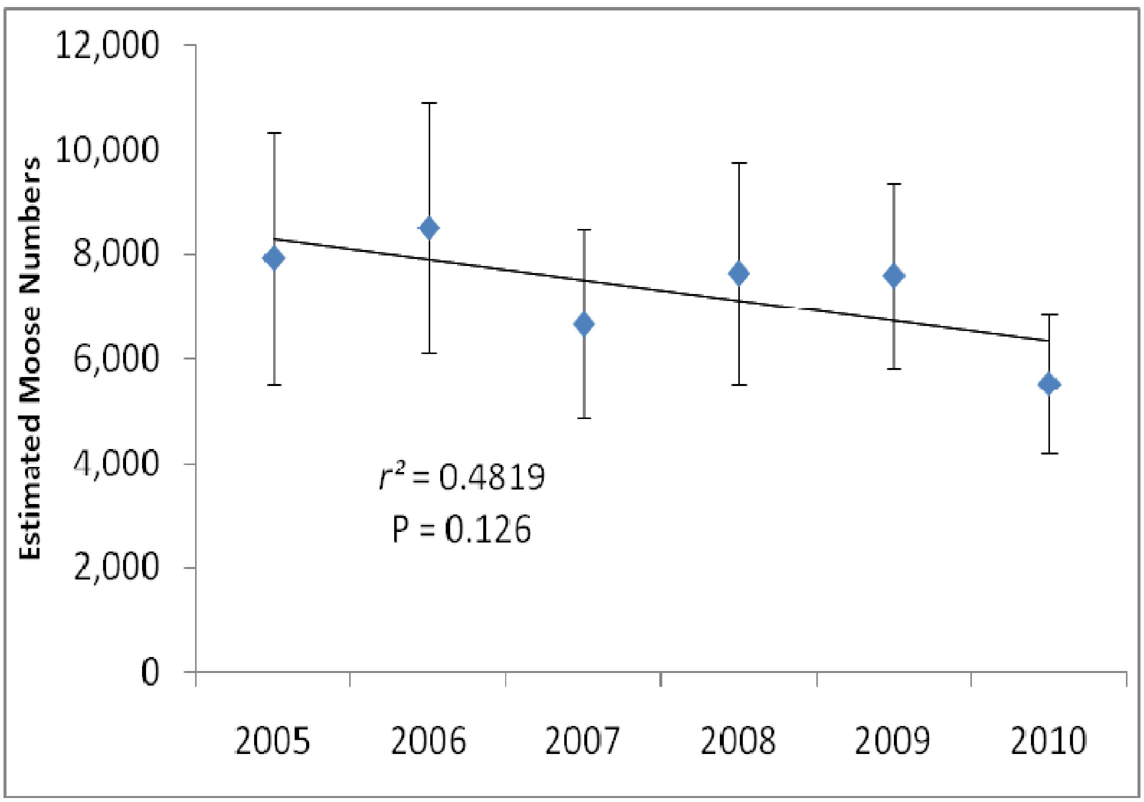

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2010.

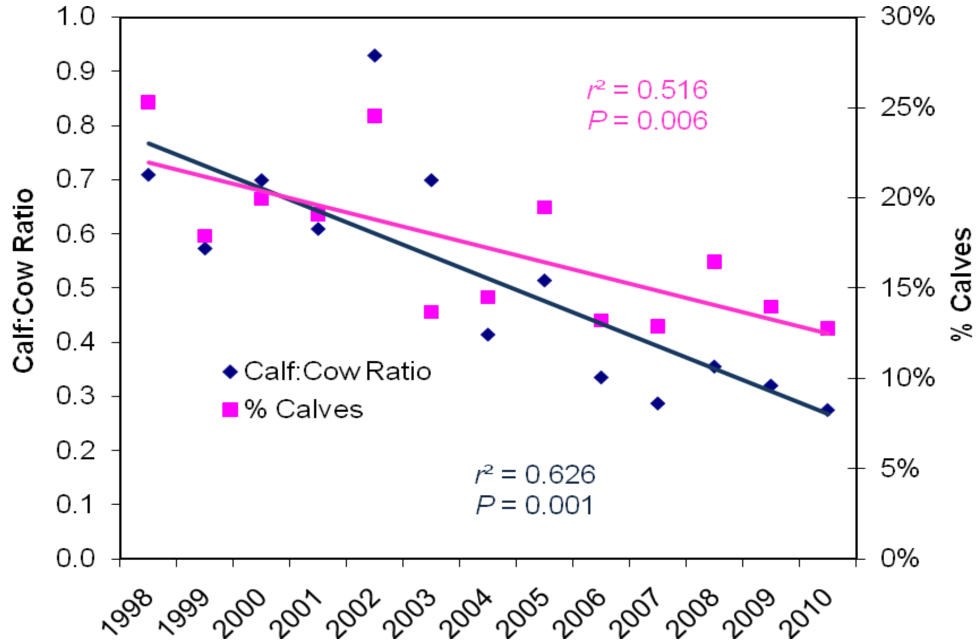

Figure 3. Estimated calf:cow ratio and % calves from aerial moose surveys in northeastern Minnesota. The % calves is less biased than the calf:cow ratio because it is not dependent on adult cow moose being correctly classified. The calf:cow ratio is not adjusted for sightability and can be compared with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

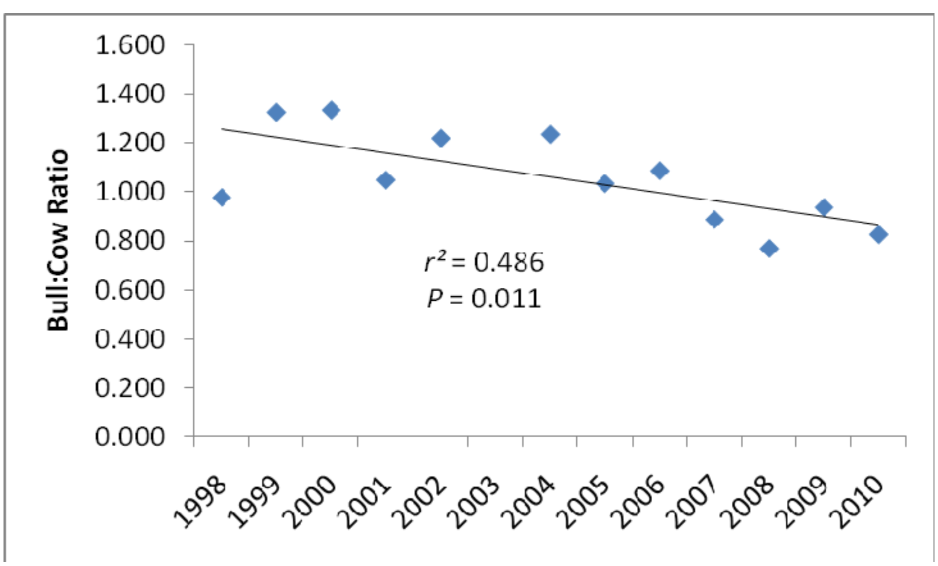

Figure 4. Estimated bull:cow ratio from aerial moose surveys in northeastern Minnesota. The bull:cow ratio is not adjusted for sightability and can be compared with estimates prior to adoption of the sightability model.

The estimated bull:cow ratio (Table 1; Figure 4) continued to decline. When the 2003 estimate (2.01) was excluded from analysis (this estimate was biologically impossible considering estimates in 2002 and 2004) there was a negative trend in this statistic ($r^2 = 0.486$, $P = 0.011$). This trend implies that bull moose have a higher mortality than cow moose. Survival estimates from radiocollared moose between 2002 and 2008 indicated no difference in survival between sexes (Lenarz et al. 2009). Harvest of moose by State hunters has been restricted to bull moose since 2007. It is unlikely that harvest is the cause of the decline in the bull:cow ratio because a low number of bull moose are harvested each year (e.g. 137 in 2009) and the bull:cow ratio has been declining since at least 1999.

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