FOREST WILDLIFE POPULATIONS

Forest Wildlife Populations and Research Group
1201 East Highway 2
Grand Rapids, MN 55744
(218) 327-4432

GROUSE SURVEYS IN MINNESOTA DURING SPRING 2008

Michael A. Larson, Forest Wildlife Populations and Research Group

SUMMARY OF FINDINGS

Surveys for ruffed grouse (*Bonasa umbellus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) were conducted during April and May 2008. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.4 (95% confidence interval = 1.2–1.6) drums/stop (dps). That was similar to the 1.3 (1.1–1.5) dps observed during 2007 but consistent with a positive trend since 2005. The slight increase between 2007 and 2008 was similar to the third year of increases during the last 2 population cycles (1987–1988 and 1995–1996).

During the spring 2008 survey 2,383 sharp-tailed grouse were observed at 192 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 10.4 (8.7–12.3) in the East Central survey region, 13.6 (12.0–15.3) in the Northwest region, and 12.4 (11.2–13.7) statewide. Index values in the East Central region were 14% (1–31%) greater during 2008 than during 2007. Index values in the Northwest region were similar to last year, but were as high as any year 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 2008. 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 13 cooperating organizations surveyed 125 routes between 8 April and 15 May 2008. Most routes (78%) were run between 29 April and 9 May. The median date this year (5 May) was 6 days later than the most recent 10-year average (29 April). Cooperators included the DNR Section of Wildlife; Chippewa and Superior National Forests (USDA Forest Service); Fond du Lac, Leech Lake, Red Lake, and White Earth Reservations; 1854 Treaty Authority; Agassiz and Tamarac National Wildlife Refuges (U.S. Fish & Wildlife Service); Vermilion Community College; Cass County Land Department; and UPM Blandin Paper Mill. Observers reported survey conditions as Excellent, Good, and Fair on 63%, 36%, and 1% of 123 routes, respectively. Survey conditions during 2007 were very similar.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.4 (95% confidence interval = 1.2–1.6) drums/stop (dps) during 2008. That was similar to the 1.3 (1.1–1.5) dps observed last year (Figure 3), but mean drum counts increased 0.03–0.28 dps (3–37%) in all survey regions. Drum counts during 2008 by survey region were 1.6 (1.4–1.9) dps in the Northeast (n = 104 routes), 0.9 (0.4–1.4) dps in the Northwest (n = 8), 1.0 (0.5–1.6) dps in the Central Hardwoods (n = 12), and 0.6 (0.3–0.9) dps in the Southeast (n = 8) (Figures 3 and 4). Median index values for bootstrap samples were similar to observed means, so no bias-correction was necessary.

Although increases in the drum count index this year were not significant, they are consistent with a positive trend in the spring population of males since 2005. The results are also similar to the third year of increases during the previous 2 population cycles (1987–1988 and 1995–1996). Reports from hunters during 2007 indicated that recruitment of juvenile birds into the fall population may have been poor. If so, it appears to have not substantially affected the size of this spring's breeding population.

Sharp-tailed Grouse

A total of 2,383 sharp-tailed grouse was observed at 192 dancing grounds with ≥2 male grouse (or grouse of unknown sex) during spring 2008. Leks with ≥2 grouse were visited a mean of 1.7 times. There were 726 grouse on 70 leks in the EC survey region and 1,657 grouse on 122 leks in the NW region. The index values for the Northwest region and statewide range (Table 1) were greater than they have been since 1980 (Figure 5), but they did not change substantially from 2007 (Table 2). For the subset of dancing grounds that were surveyed during both 2007 and 2008, index values in the EC region increased 14% (95% CI = 1–31%, Table 2) to a mean value that is similar to those observed during 1998–2000.

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

[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

[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

I sincerely appreciate the efforts of all the DNR staff and volunteer cooperators who conducted and helped coordinate the grouse surveys. The ruffed grouse survey data for 1982–2004 were entered into a database by Doug Mailhot and another volunteer through a special effort organized by Gary Drotts, John Erb, and Rick Horton. I also thank Laura Gilbert for helping with data entry and archiving and Mark Lenarz and Wes Bailey for reviewing earlier drafts of this report.

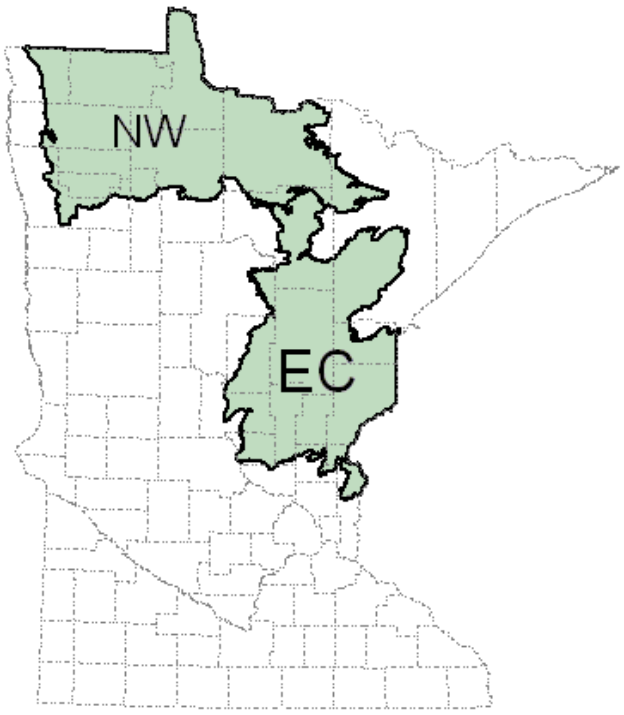


Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** relative to county boundaries in Minnesota. The regions were based largely on boundaries of ECS Subsections.

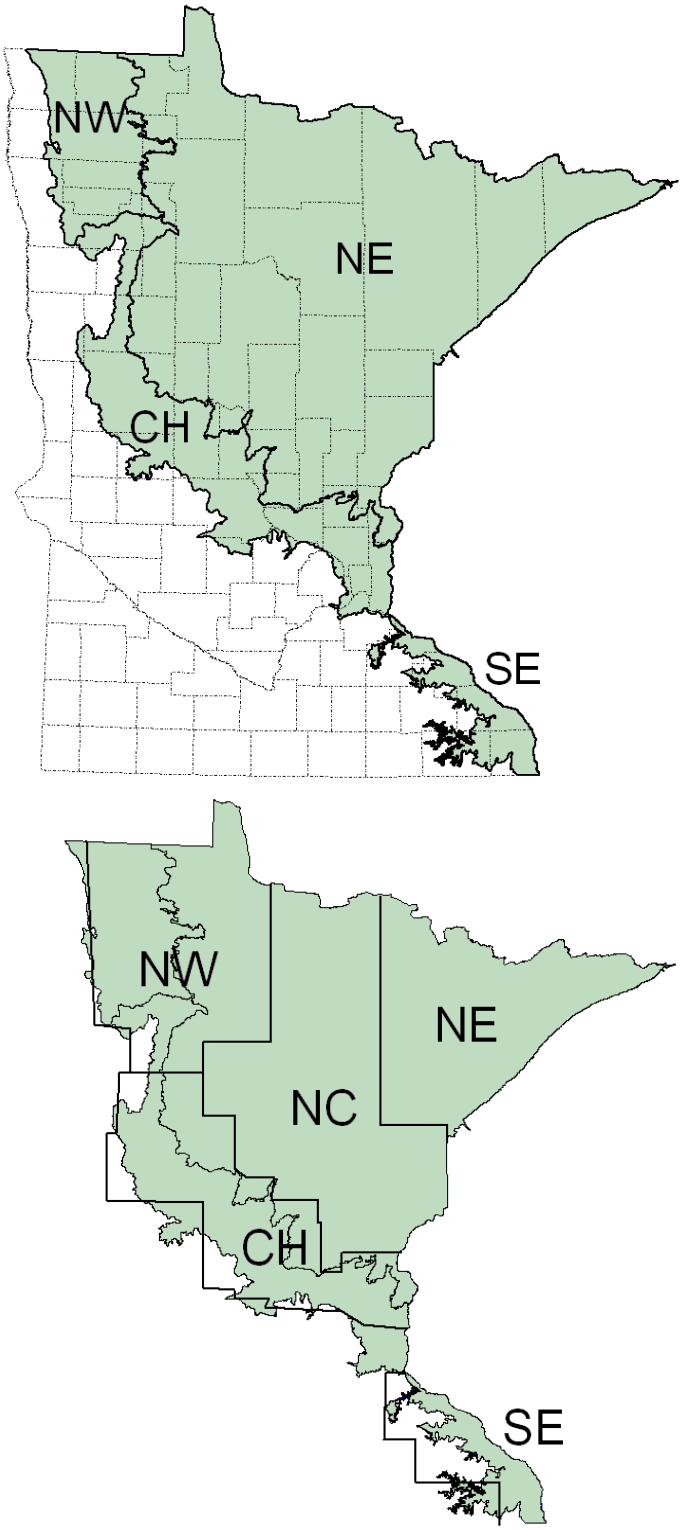


Figure 2. **Ruffed grouse** survey regions (shaded, curved boundaries) are based on the Ecological Classification System. Top panel: regions are labeled and overlaid on counties (dashed lines). Bottom panel: former survey zones (straight boundaries) are labeled and overlaid on regions.

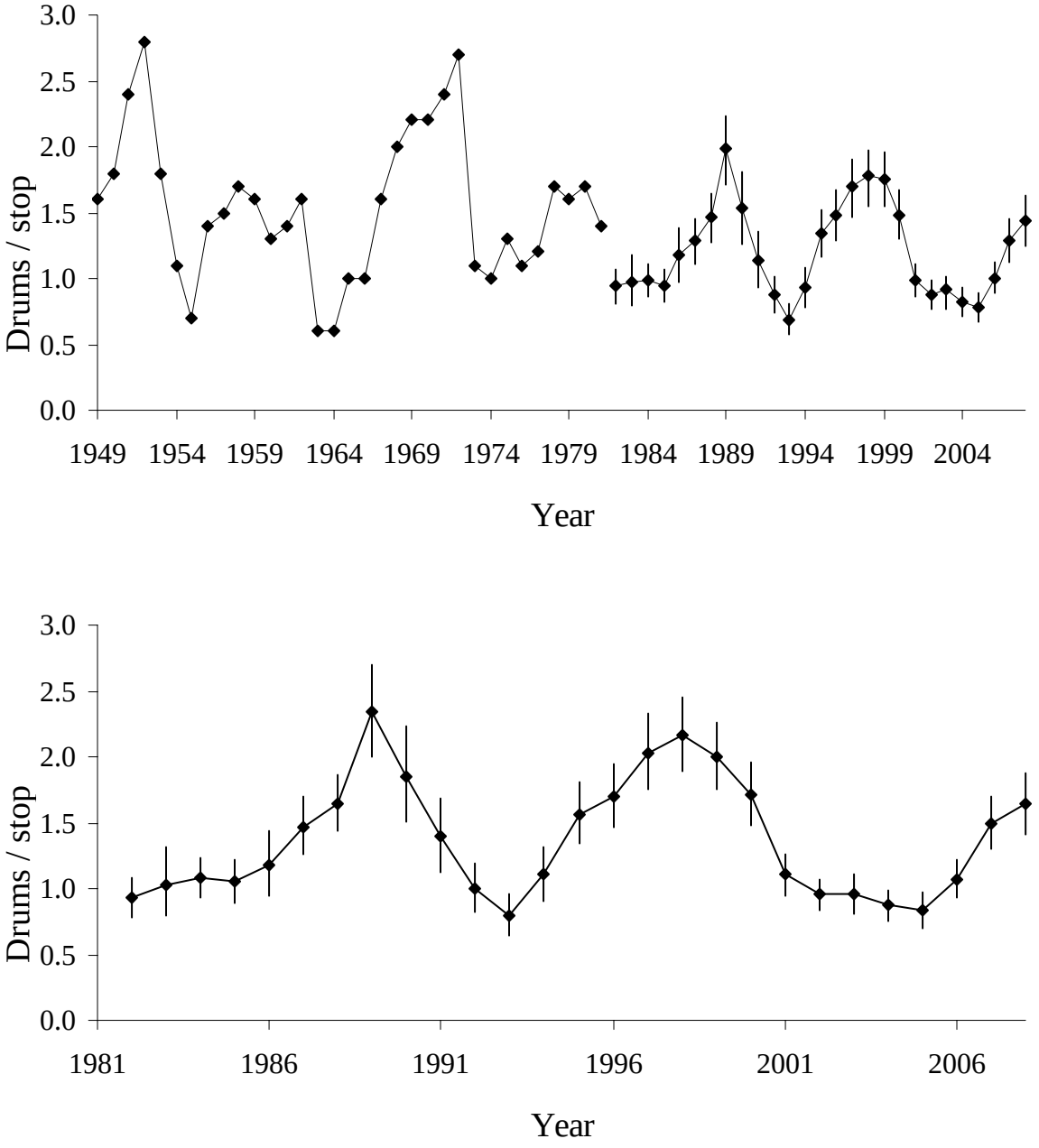


Figure 3. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current methods, so confidence intervals were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

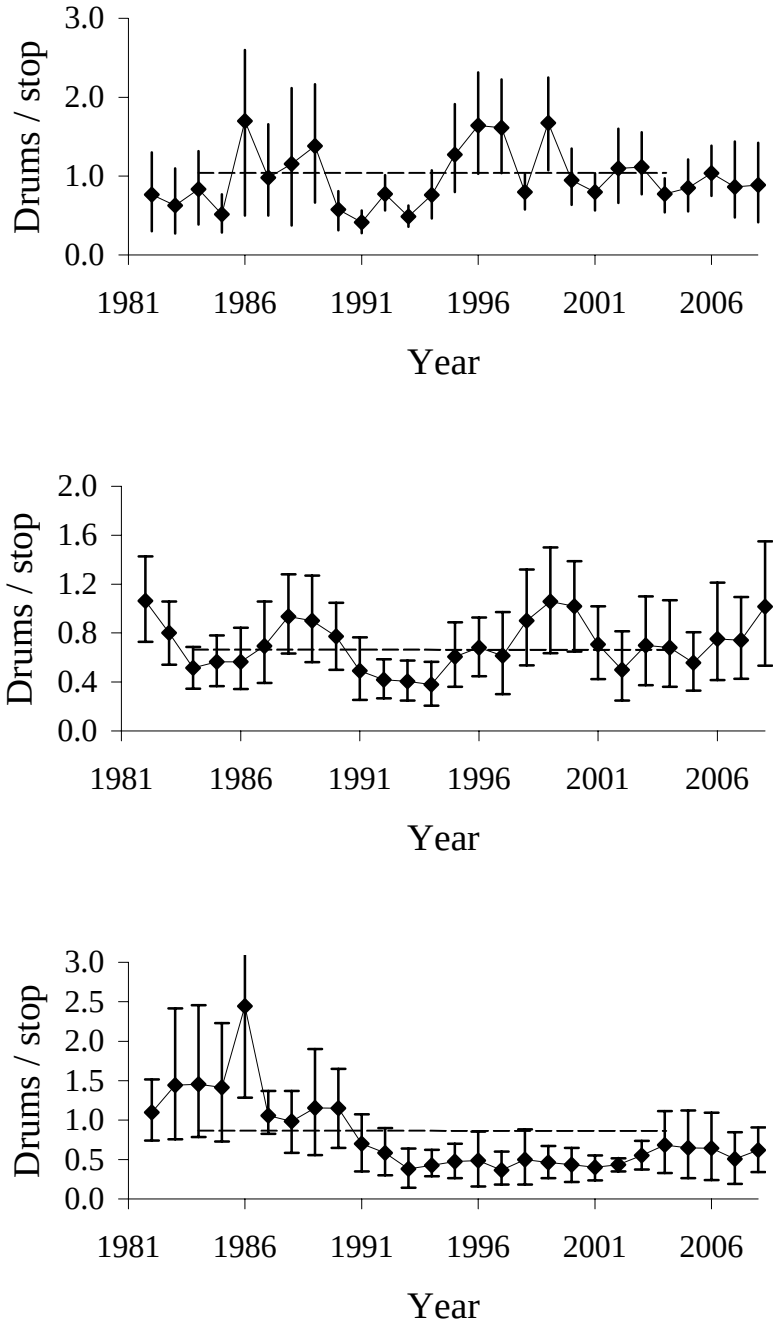


Figure 4. Ruffed grouse drum count index values in the **Northwest** (top), **Central Hardwoods** (middle), and **Southeast** (bottom) survey regions of Minnesota. Dashed horizontal lines indicate the mean from 1984 to 2004. Vertical error bars represent 95% confidence intervals based on bootstrap samples.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

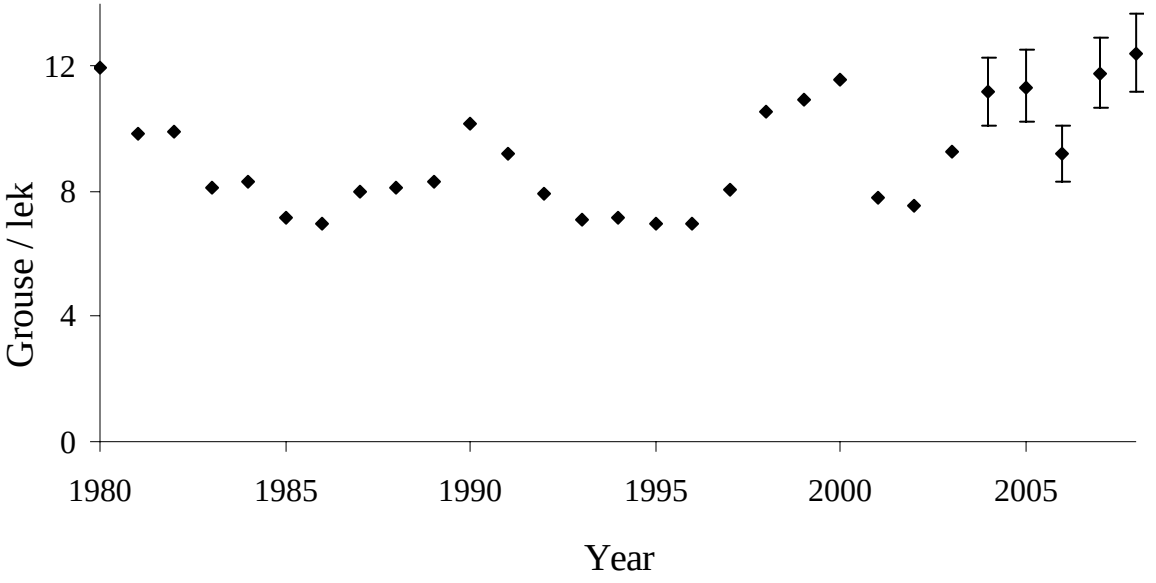
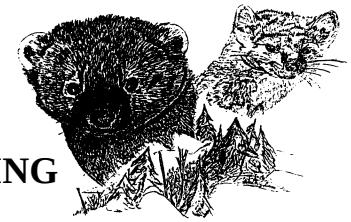


Figure 5. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds, 1980–2008. Vertical error bars, which were calculated only for recent years, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.



REGISTERED FURBEARER POPULATION MODELING
2008 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 estimates remains a goal for future research.

Harvest data is obtained through mandatory furbearer registration. A detailed summary of 2007 harvest information is available in a separate report. Bobcat and pine 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. This year, marten teeth were classified only into age-classes (juvenile, yearling, adult), while all 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 2007 registered DNR trapping and hunting harvest was 702, down 21% from last year (Table 1). Trapping harvest declined 33%, though still accounting for 75% of the total harvest. Hunting harvest increased 60% to 178, setting a new record. Total modeled harvest, which includes reported tribal take, was 758. Based on population modeling estimates, 24% of the fall population was harvested. The juvenile to adult female ratio in the harvest (1.2; Table 1) was below the long-term average (1.5), but similar to the recent 10-year average (1.2). A total of 633 bobcat carcasses were examined (Table 1), with a mean age of 2.8 and 2.4 for females and males, respectively. Approximately 9% of the harvested bobcats were 6.5+ years old (Figure 1).

Based on examination of reproductive tracts, 15% of yearling females produced a litter in 2007, less than the 5-year average of 26% (Figure 2). Average litter size for pregnant yearlings was 2.0, similar to the 5-year average of 2.1. Pregnancy rate for 2+ year olds was 66%, also below the 5-year mean (73%). Mean litter size for pregnant adults was 2.7 (5-year mean = 2.8). For both yearlings and adults, pregnancy rate has generally declined since a 'peak' in 2004 (Figure 2).

Population modeling predicts a 14% decline in this spring's bobcat population (Figure 3), though the estimated population remains above pre-1998 levels. While 3-year-averaged fall scent station indices have declined slightly the past 2 years, averaged winter track counts have remained stable. The estimated 2008 spring population is ~ 2,200.

Fisher. In 2007, the fisher harvest season was shortened 44% from 16 days to 9 days. Harvest under the DNR framework was 1,682, down 48% from last year (Table 2). Modeled harvest, which includes reported tribal take, was 1,811. An estimated 17% of the fisher population was harvested this past winter. Carcass collections ended in 1994, so no current age or reproductive data are available. In spite of the reduced harvest, the fisher winter track index did not increase this winter, with the 3-year-averaged track index continuing its recent downward trend (Figure 4). However, population modeling projects a 3% increase in the spring population, currently estimated at ~8,000.

Marten. In 2007, the marten harvest season was also shortened 44% from 16 days to 9 days. Harvest under the DNR framework was 2,221, down 41% from last year (Table 3). Modeled harvest, which includes reported tribal take, was 2,481. A total of 1,355 marten carcasses were examined this year. In spite of a reduction in harvest pressure, juveniles comprised only 30% of the total harvest, well below the long-term average of 57% (Figure 5). While year-class data was not collected this year, the maximum age observed had declined slightly in each of the previous 4 years for females (13, 12, 11, and 10), with a similar pattern for males (13, 12, 11, 11). Similarly, over the last 4 years the mean age of female marten harvested has declined from 2.6 to 1.4, while the mean age of male marten harvested has declined from 2.4 to 1.3. This year's juvenile:adult female ratio (1.5) in the harvest was the second lowest since data collection began (Table 3).

Based on modeling, 18% of the fall population was harvested. Corresponding in time with recent record harvests, both modeling projections and averaged winter track counts suggest the population has been declining the past 5 years. Track survey results from this past winter were stable compared to last year, though the 3-year-averaged track index continues to suggest a slight decline. The population model projects a 2% increase to a 2008 spring population of ~ 10,600 (Figure 6).

Otter. The north otter-trapping zone was expanded southward this year. Harvest under the DNR framework in the north zone was 1,847, of which ~ 55 were harvested in the expanded portion of the north zone. Total harvest in the north zone was down 32% from last year (Table 4). Modeled harvest, including reported tribal take, was 1,955 (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 projected declines, modeling this year indicates the population increased by ~ 4% (Figure 7). No independent otter survey data are currently available for comparison. The current estimated spring population in the north zone is ~ 10,600.

A new otter-trapping zone was also established in southeast Minnesota. A total of ~ 45 otter were harvested in the southeast zone. While we have established an otter survey in this region to assist with population monitoring, weather conditions and pilot scheduling conflicts did not allow us to complete the survey this winter. 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, 1979 to 2007.

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]
1979	12/1-1/31	5	291	291	14	75	37	12	51	1.6	54	44	53	52	$118
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	

[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.

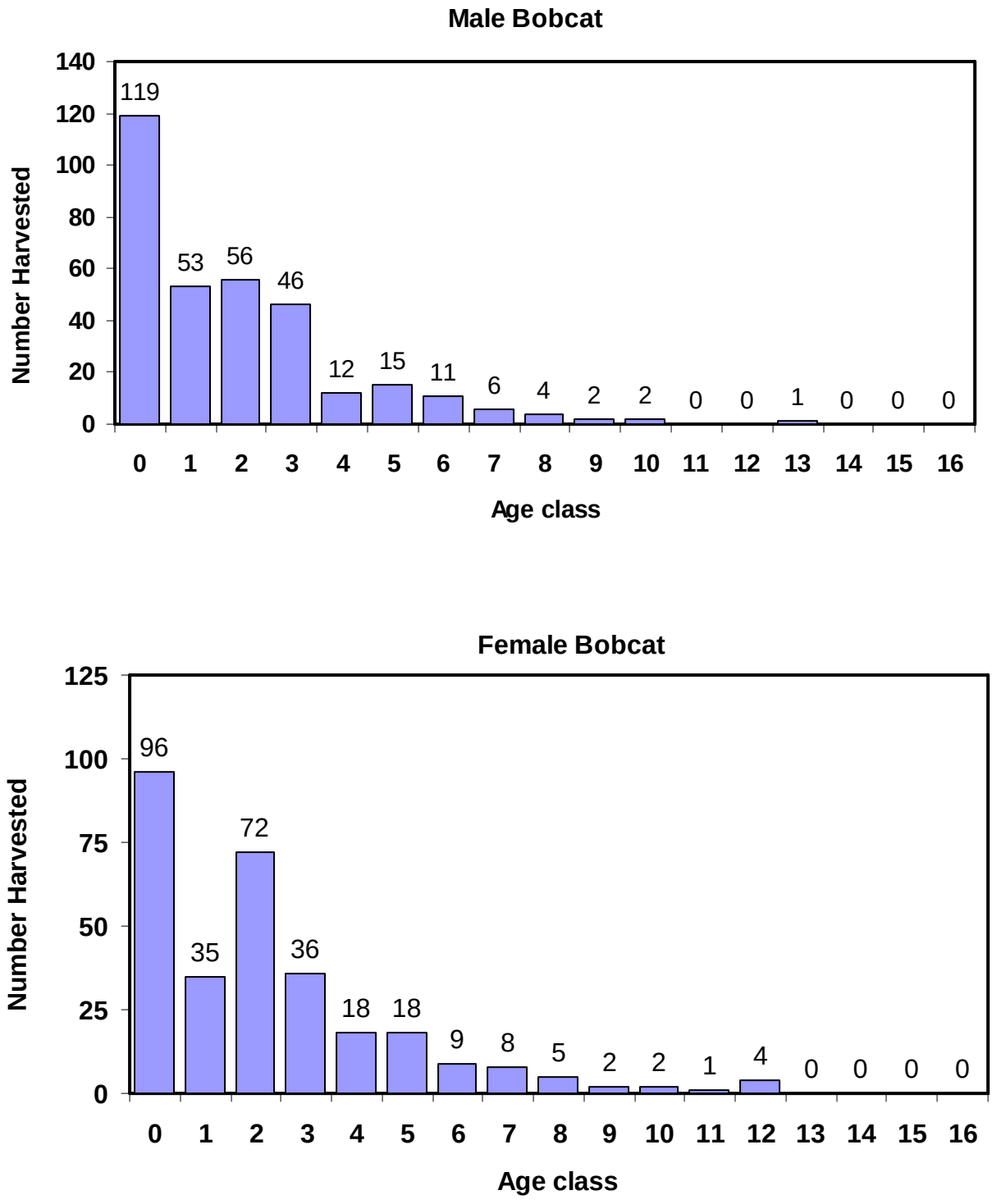


Figure 1. Age structure of male and female bobcats in the 2007-08 harvest.

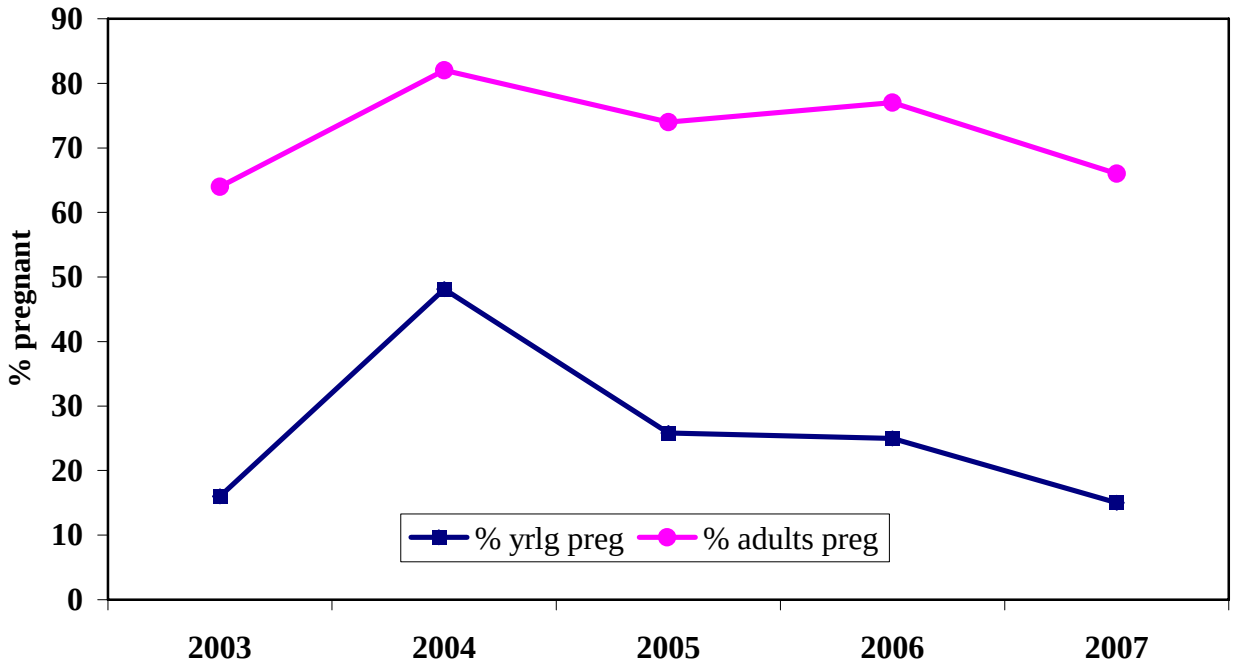


Figure 2. Pregnancy rates for yearling and adult bobcats in Minnesota, 2003-2007.

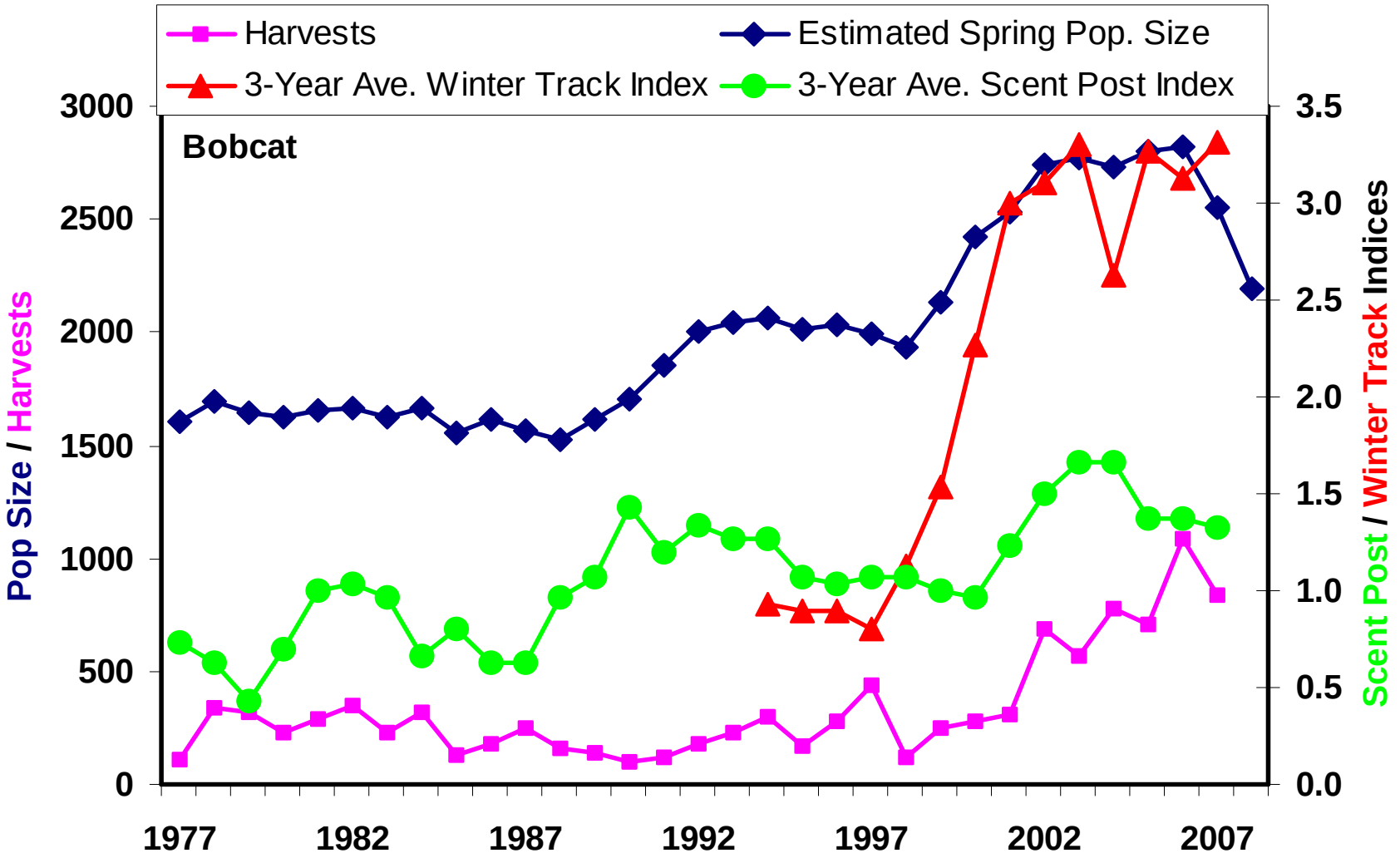


Figure 3. Bobcat populations, harvests, and survey indices, 1977-2007. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1979 to 2007. 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]
1979	12/1-1/31	3	3032	3032	41	467	65	15	21	5.6	54	46	44	50	$108	$128
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	11/29-12/4	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	$19
2002	11/30-12/15	5	2660	3028	24	-	-	-	-	-	-	-	-	54	$23	$23
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		

[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% in 1993-1999

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

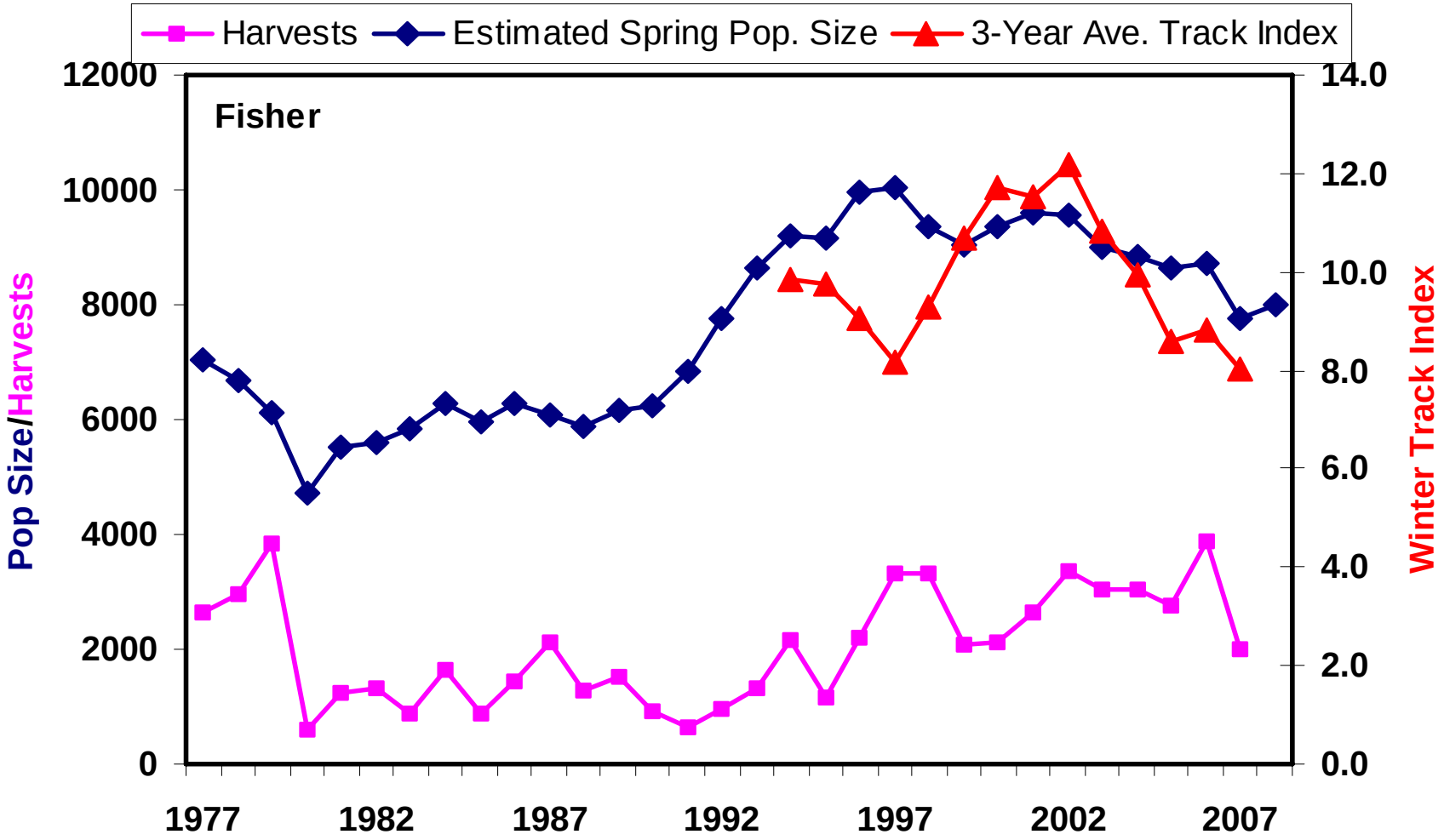


Figure 4. Fisher populations, harvests, and survey indices, 1977-2007. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2007.

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	$28	$21
2002	11/30-12/15	5	2839	3192	19	2451	39	30	31	3.1	57	63	61	60	$24	$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		

[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

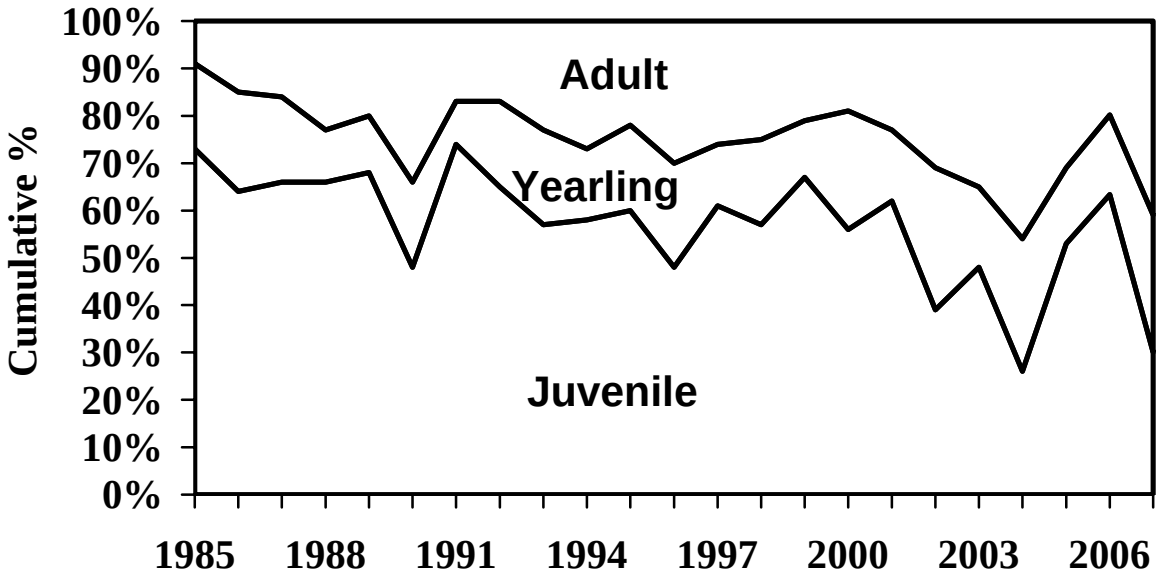


Figure 5. Marten age-class proportions in the harvest, 1985-2007.

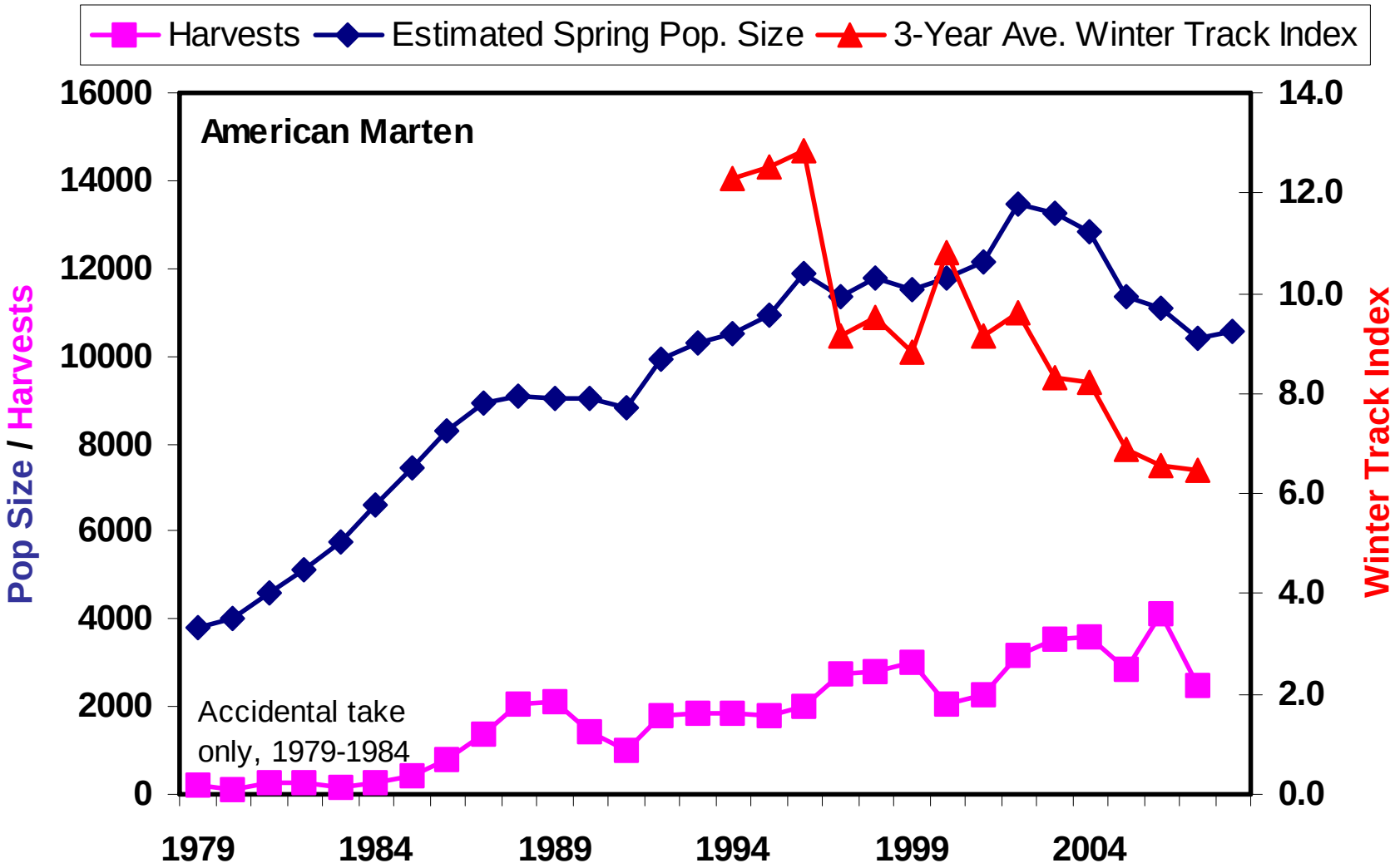


Figure 6. American marten populations, harvests, and survey indices, 1979-2007. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data, 1979 to 2007. 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]
1979	11/15-1/29	3	1186	1186	17	-	-	-	-	-	-	-	-	52	$63	$29
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		

[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% after 2001.

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

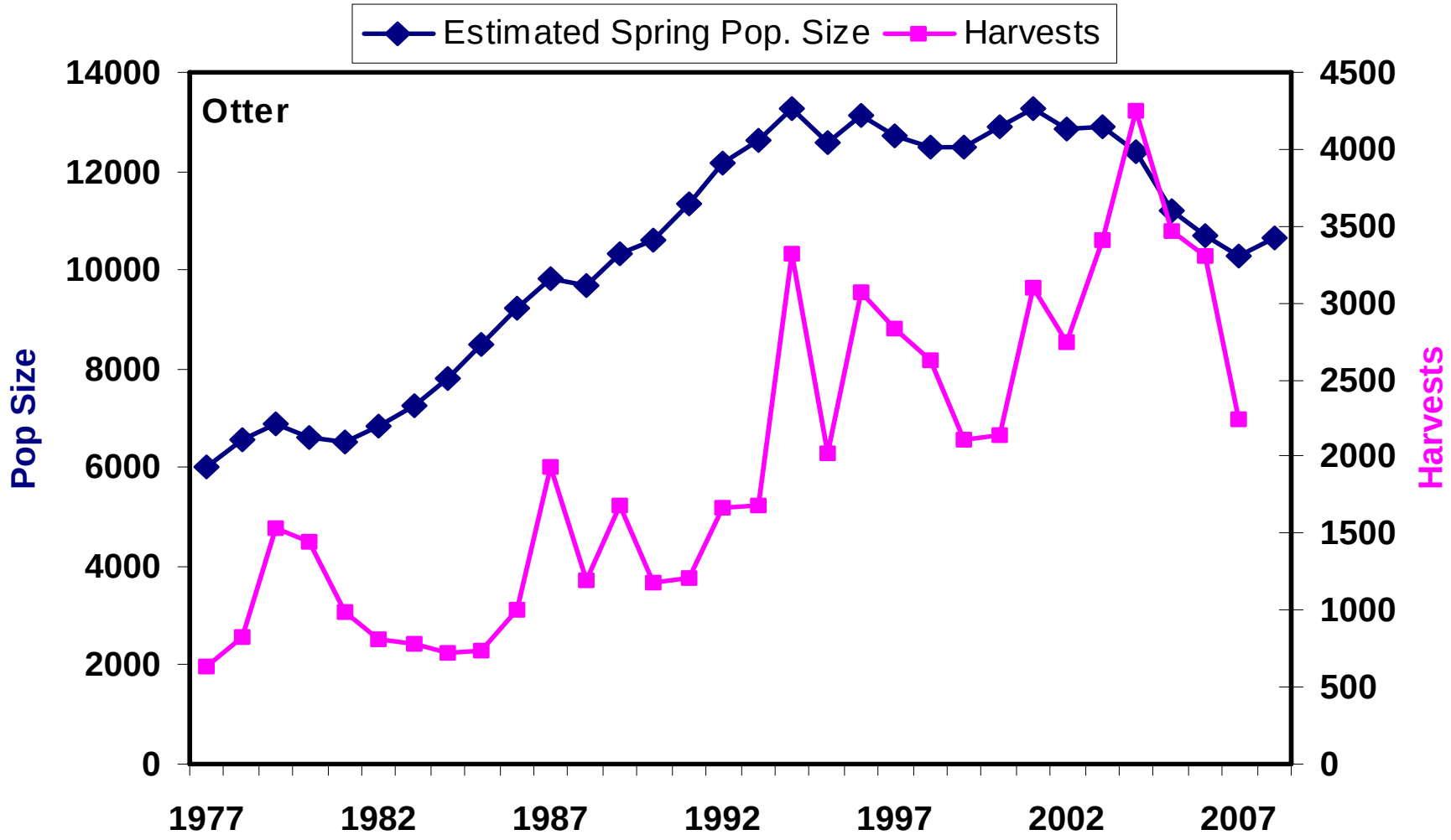


Figure 7. Otter populations and harvests, 1977-2007. Harvests include an estimate of non-reported take.

POPULATION TRENDS OF WHITE-TAILED DEER IN THE FOREST ZONE – 2008

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 2007 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.

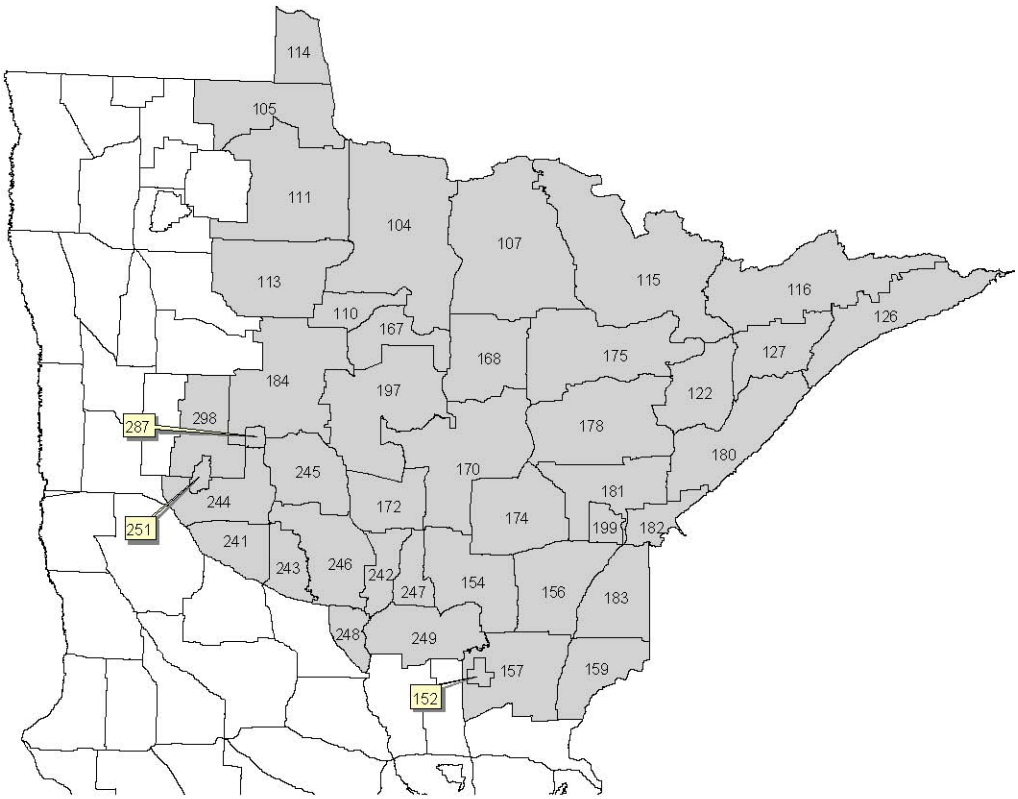


Figure 1. Permit areas in the forested zone, 2007. Permit areas 114, 152, 182, 287, and Red Lake Indian Reservation were not modeled.

HARVEST

In 2007, hunters registered 260,434 deer, the 4th highest harvest ever recorded in Minnesota. Of that number, 54% or 141,121 deer were harvested in the forested zone (Figure 1, Table 1). The 2007 forest zone harvest increased 2% from the 2006 harvest. The following discussion applies to the subset of deer harvested in the forest zone.

The buck harvest decreased in 16 of the 42 permit areas (Figure 2, Table 2). Most of the decrease in buck harvest occurred in the west central and southern portions of the forest zone (Figure 3). The total buck harvest declined 3% compared with a 1% decline the previous year (Table 2).

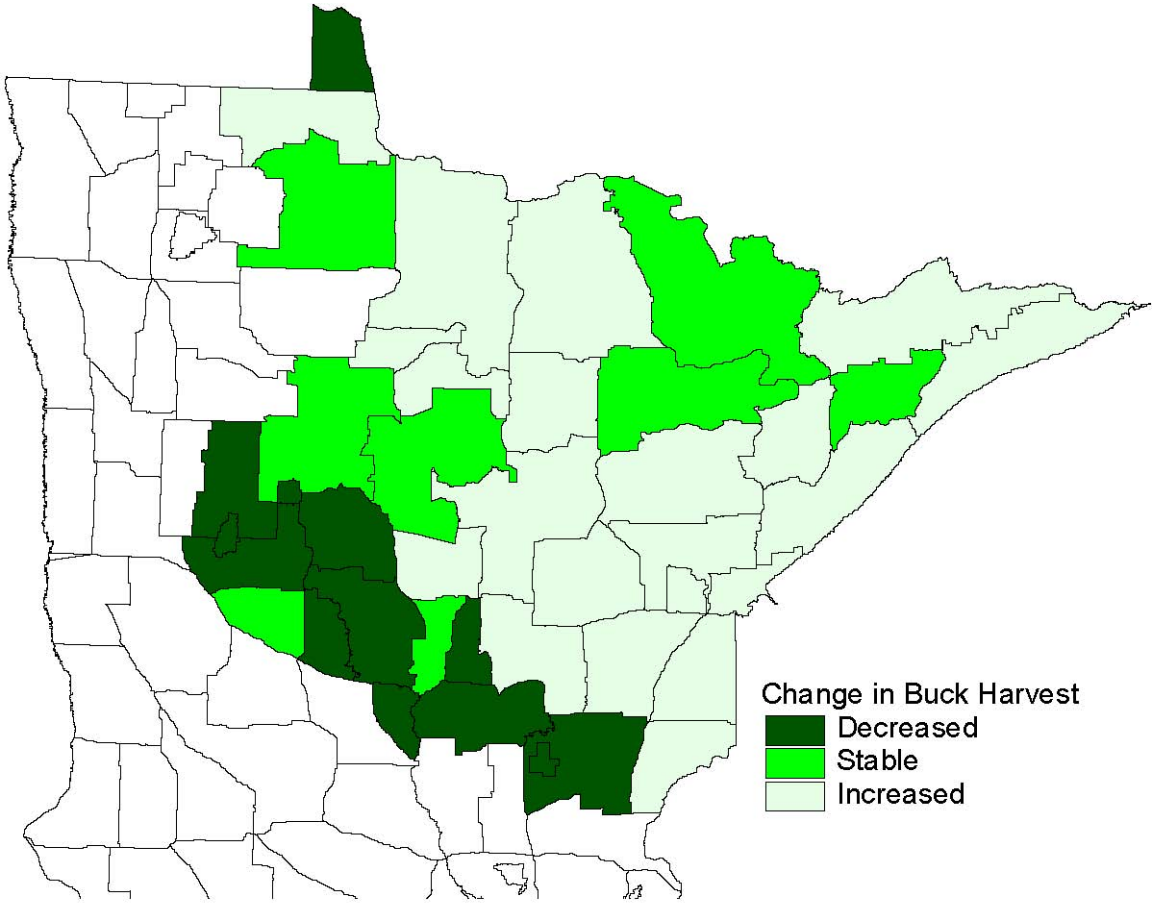


Figure 2. Change in buck harvest in forest zone permit areas between 2006 and 2007.

The antlerless harvest increased in 22 of the 42 permit areas (Table 3) but the total antlerless harvest increased by only 1%. The greatest increases occurred in permit areas that shifted from "lottery" into the "managed" category (mean=49%, n = 2, range 33-66%), which allowed all hunters the option of harvesting 2 antlerless deer. Permit areas that shifted from "managed" into the "intensive" category, which allowed hunters to harvest up to 5 antlerless deer, also experienced increased antlerless harvests (mean = 21%, n = 4, range 11-29%). Permit areas that stayed "intensive", but added an early antlerless hunt had a 9% (-2% to 24%, n = 6) increase in the antlerless harvest. Permit areas that remained in the "managed" category saw an average change of -12% (-44% to 5%, n = 15) and permit areas that remained "intensive" averaged a 7% change (-8% to 12%, n = 9). Finally, the opportunity to harvest antlerless deer was reduced in 4 permit areas (i.e. changed from "intensive" to "managed") and the harvest declined an average of 25% (-11 to –53%).

The proportion of bucks in the harvest (forest-wide) was stable at 40%, the lowest proportion in recent history. This decline was expected because of the increased opportunity to harvest antlerless deer.

The archery harvest in the forest zone declined 5% in 2007, the first decline since 2001. Between 1992 and 1999, the archery harvest increased 12% to 2,954, an average of less than 2% per year. Between 1999 and 2006, the archery harvest increased 225%, an average of 32% per year. The archery harvest is a linear function of the number of "All Season Licenses" sold ($r^2 = 0.94$, $P<0.001$).

The muzzleloader harvest appears to have leveled out. In 2007, the muzzleloader harvest increased 28% to 4,105 deer but this was still 4% lower that the record harvest in 2005. The muzzleloader harvest increased dramatically with the introduction of the "All Season License" in 2003 and is a linear function of the number of licenses sold ($r^2 = 0.74$, $P=0.006$). Statewide sales of this license increased by only 1% in 2007.

POPULATION TRENDS AND MODEL PROJECTIONS

Based on the winter severity index (WSI), the winter of 2007-08 was "mild" throughout most of the forest zone (43 to 86, Figure 3). In northeastern Minnesota, however, the WSI was generally "moderate" (116-158), or even "severe" (189). Deep snow between early January and mid-April combined with cold temperatures resulted in the higher than normal WSI indices. In the remainder of the forest zone, the WSI was based primarily on cold temperatures with an average of 10 days with deep snow.

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 2008-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, 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 and West Central in response to the high antlerless harvest. Deer density in the Central region declined 5% since last year but the decline since 2003 has not been as steady as that in the South or West Central regions. The antlerless harvest in the NW remained low and deer numbers, according to the model, are gradually increasing. Antlerless harvest in the Northeast region was essentially flat and the decline was a response to the moderate-severe winter.

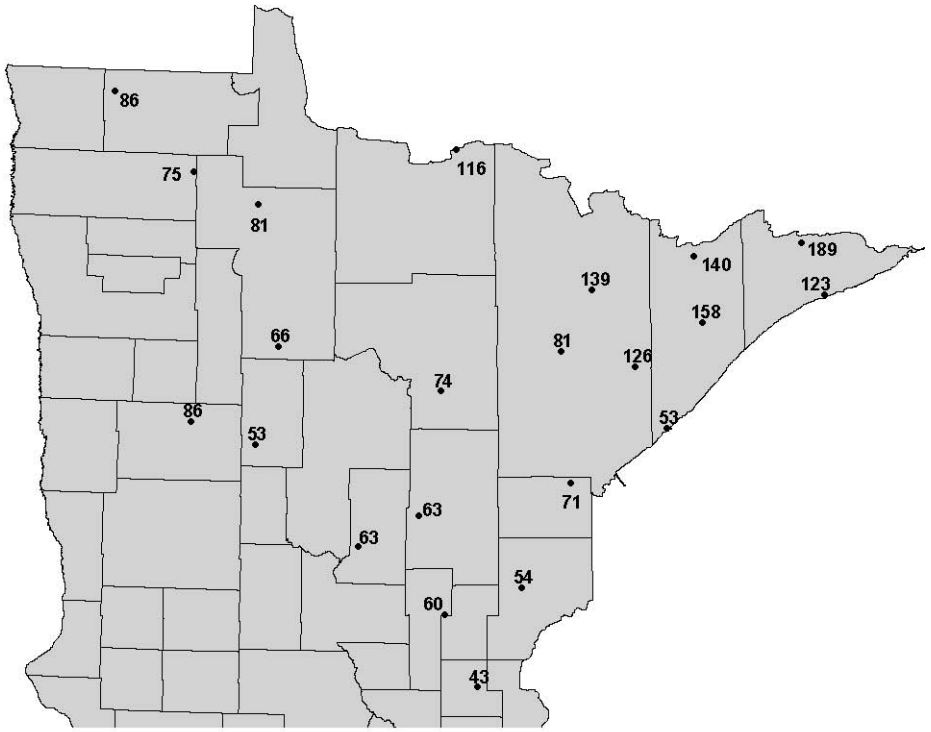


Figure 3. Final WSI values for the forested zone of Minnesota, winter of 2007-2008.

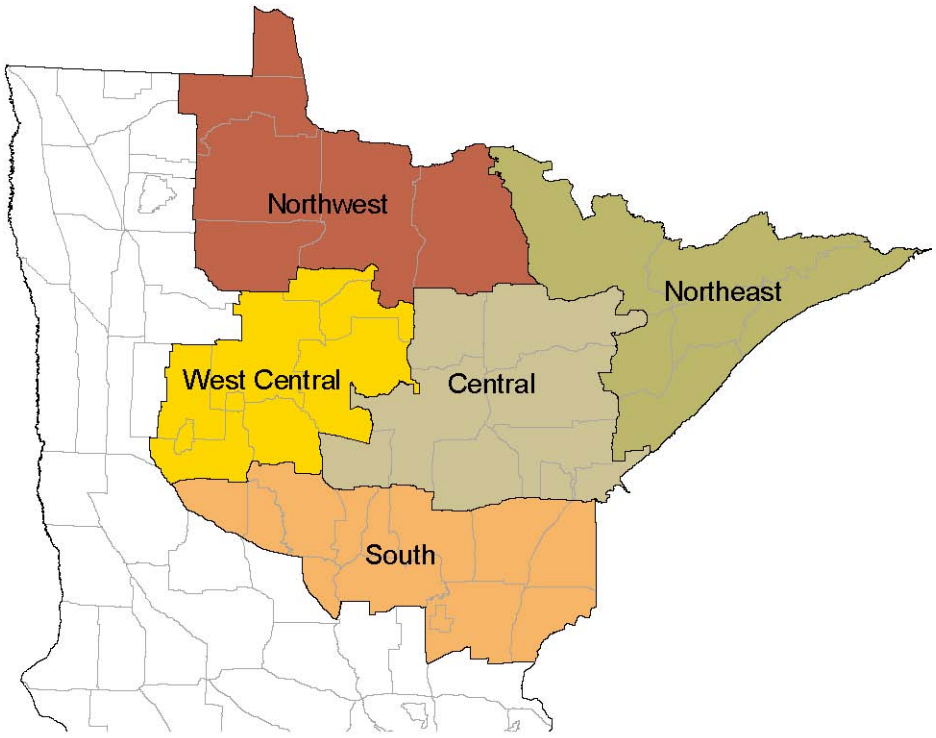


Figure 4. Permit areas grouped for summary discussion.

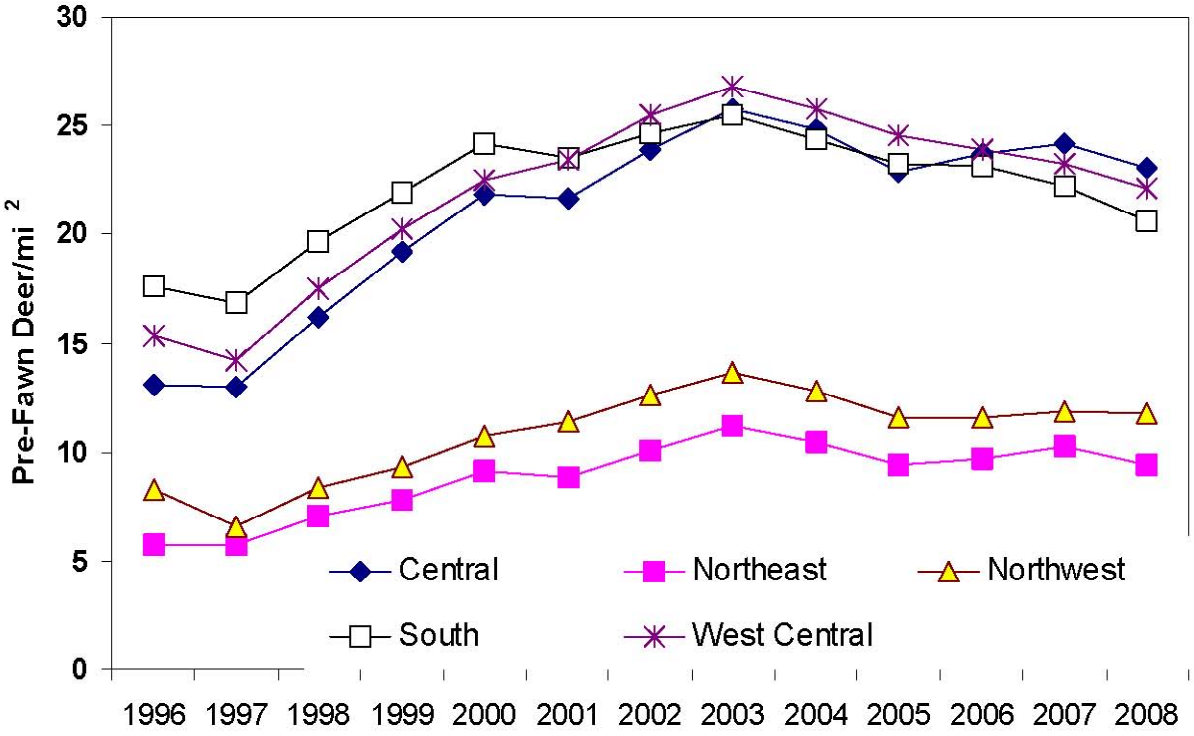


Figure 5. Population trends of deer in forest zone. Trend lines represent the groups of permit areas as illustrated in Figure 4. Density represents pre-fawn density.

Base on density targets set during the 2005 and 2006 goal setting processes, the 2008 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 2 deer/mi^2 below goal to as much as 19 deer/mi^2 above goal.

Final classifications of permit areas for the 2008 season (Figure 7) were based primarily on the absolute difference between the 2008 pre-fawn density and that prescribed by the goal setting process. Four permit areas were classified as "Lottery" where hunters must apply for the limited number of antlerless permits. Seventeen permit areas were classified as "Managed" where hunters may take up to 2 antlerless deer. Eleven permit areas were classified as "Intensive" where hunters are allowed to harvest up to 5 antlerless deer and 10 additional permit areas were "Intensive" and include an early antlerless season in October.

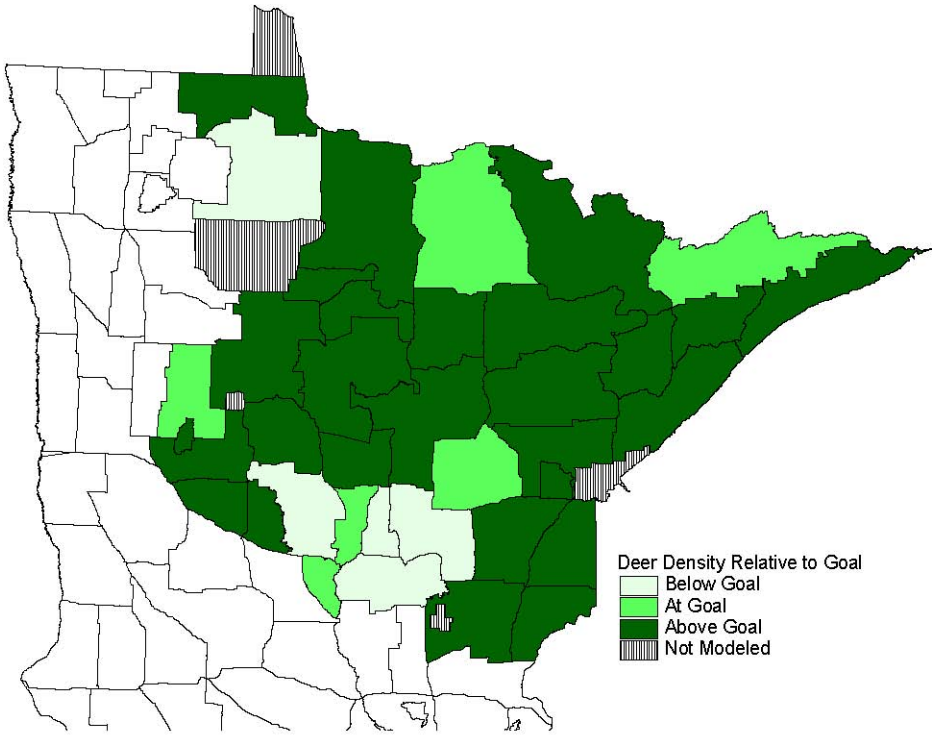


Figure 6. Deer density expressed relative to pre-fawn population goals.

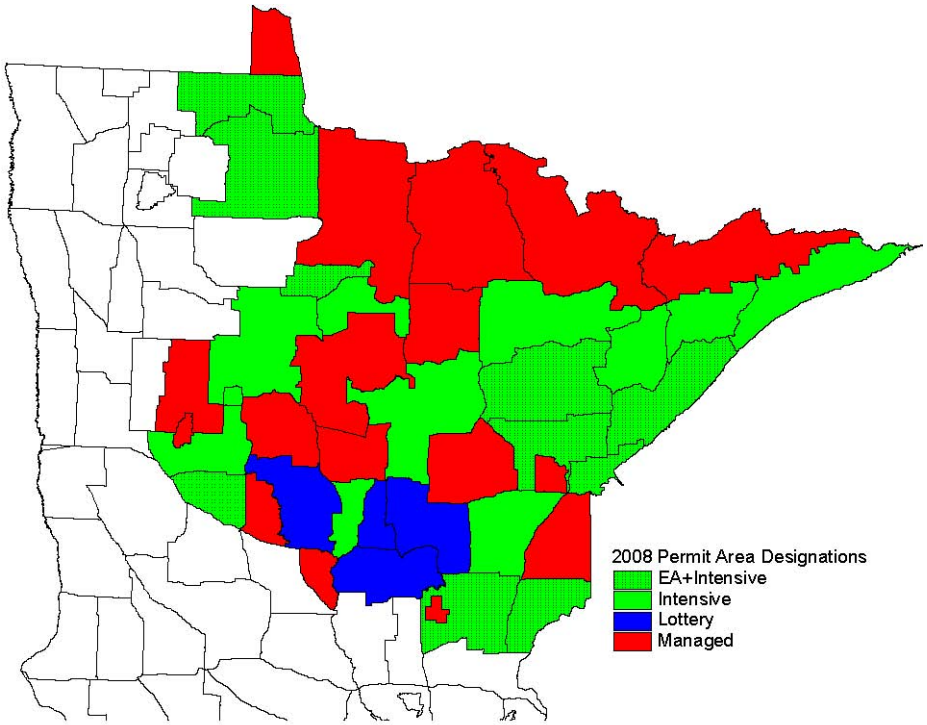


Figure 7. Final designation of permit areas in the Forest Zone for the 2008 hunting season.

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

Permit Area	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Change
104	567	897	1,372	1,837	1,939	2,253	3,421	2,902	2,483	2,632	2,557	-3%
105	876	1153	1,389	1,821	1,962	2,385	3,740	3,106	3,557	3,210	3,344	4%
107	948	1,176	1,994	2,846	3,547	3,499	5,206	4,027	3,936	3,825	3,874	1%
110	297	433	1,511	1,376	1,371	1,553	2,180	2,122	1,945	1,910	1,935	1%
111	540	683	1,169	1,644	2,223	2,264	3,064	2,621	2,687	2,812	2,530	-10%
114	52	39	40	55	72	80	96	110	123	174	127	-27%
115	1,029	1,347	2,334	3,174	3,586	3,815	5,431	4,333	4,378	4,480	4,250	-5%
116	100	146	138	150	156	157	265	298	261	270	350	30%
122	251	457	296	556	617	574	696	716	657	1067	1118	5%
126	260	351	306	445	470	597	702	841	904	977	1150	18%
127	63	83	176	81	95	99	146	177	151	188	215	14%
152	143	213	225	283	264	217	235	246	271	330	377	14%
154	1,370	1,952	2,978	4,418	4,169	5,032	5,717	5,176	4,583	4,546	4,526	0%
156	1,546	2,109	2,643	3,795	3,055	3,258	4,966	4,594	4,517	4,767	5,164	8%
157	3,293	4,709	5,385	6,990	7,194	7,728	9,001	7,606	6,901	7,989	7,828	-2%
159	2,553	3,751	4,371	5,311	4,459	4,153	5,207	3,887	3,968	3,905	4,165	7%
167	338	599	1,452	1,601	1,967	2,488	1,572	1,463	1,257	1,738	1,977	14%
168	552	988	2,410	2,686	2,376	3024	3,218	3,978	2,534	3,627	3,357	-7%
170	1,143	2,220	2,880	4,938	4,829	4,716	8,460	7,154	7,221	6,951	8,346	20%
172	979	1,443	2,961	4,253	4,621	4,910	7,004	5,489	5,227	5,345	4,877	-9%
174	754	1,371	1,927	2,438	2,140	2,678	3,825	3,347	3,095	3,180	3,245	2%
175	828	1,308	2,326	3,035	3,338	3233	5,071	4,254	3,103	4,559	4,419	-3%
178	912	1,401	2,351	3,050	3,347	3,666	5,523	5,297	5,373	5,476	6,562	20%
180	561	951	946	1,540	1,703	1,867	3,123	2,355	2,837	3,553	3,755	6%
181	703	1,186	1,780	2,362	2,457	2,419	3,599	3,544	3,755	4,475	5,005	12%
182	240	405	614	827	862	869	1,309	1,206	1,256	1,460	1,599	10%
183	598	1,003	2,147	2,748	2,743	2,771	3,960	3,533	3,449	4,006	3,747	-6%
184	1,822	2,558	5,970	7,283	7,762	8,811	14,023	12,307	11,482	10,261	11,005	7%
197	407	597	933	1,372	1,167	1,413	1,652	1,723	1,594	2,471	2,248	-9%
199	58	87	130	169	166	164	140	172	188	167	206	23%
241	3568	2919	2651	4284	3927	3857	4549	4449	4,288	4,369	4,787	10%
242	1,095	1,325	1,552	1,820	2,072	2,426	2,767	2,244	2,116	2,170	2,259	4%
243	1,268	1,602	1,907	2,634	2,864	3,238	4,131	3,684	3,165	3,429	3,458	1%
244	2,034	2,396	2,956	3,771	4,841	5,805	7,452	6,702	6,162	6,192	7,102	15%
245	1,021	1,657	3,524	4,695	5,053	5,626	8,231	6,377	5,737	6,115	5,393	-12%
246	2,761	3,447	4,075	5,599	6,090	5,149	7,530	6,782	5,835	6,389	5,339	-16%
247	1,155	1,407	1,631	1,923	2,115	2101	2,744	2,582	2,115	2,393	2,064	-14%
248	564	943	850	1,039	881	1,352	1,897	1,864	1,670	1,280	1,387	8%
249	1,110	1,514	2,217	2,826	3,148	3,238	4,223	3,800	3,211	3,667	3,305	-10%
251	188	208	246	326	254	298	470	387	325	301	253	-16%
287	313	314	368	376	460	470	529	425	280	305	306	0%
298	326	516	704	803	826	932	1988	1733	1664	1727	1610	-7%
Forested Zone	39,186	53,864	77,834	103,180	107,189	115,185	159,063	139,613	130,261	138,688	141,121	2%

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	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Change
104	567	897	1,137	1,240	1,266	1,332	1,589	1,586	1,250	1,176	1,279	9%
105	484	730	846	945	813	1,138	1,488	1,326	1,364	1,122	1,206	7%
107	948	1,174	1,706	1,948	2,174	2,119	2,523	2,277	1,861	1,725	1,921	11%
110	296	417	685	732	674	699	852	813	694	658	784	19%
111	540	683	1,088	1,168	1,395	1,463	1,467	1,408	1,316	1,149	1,155	1%
114	52	39	40	43	56	63	55	55	72	95	83	-13%
115	1,025	1,337	1,898	2,038	2,145	2,376	2,915	2,679	2,262	2,242	2,228	-1%
116	100	145	138	150	156	157	238	251	230	186	261	40%
122	248	455	293	417	452	449	501	567	534	565	658	16%
126	248	340	306	390	417	495	585	591	595	606	686	13%
127	62	83	176	80	82	86	126	149	127	147	148	1%
152	89	127	173	191	182	130	106	152	141	158	149	-6%
154	1,014	1,489	2,018	2,305	2,142	2,169	2,071	2,049	1,789	1,677	1,911	14%
156	1,116	1,590	1,836	2,084	1,690	1,653	2,001	2,003	1,811	1,881	2,068	10%
157	2,088	2,768	3,009	3,327	3,144	3,048	3,207	3,030	2,745	2,916	2,832	-3%
159	1,540	2,083	2,121	2,431	1,947	1,667	1,995	1,518	1,528	1,548	1,674	8%
167	336	597	906	1,036	968	1,211	821	819	709	692	821	19%
168	552	988	1,579	1,653	1,454	1,675	1,698	1,889	1,435	1,439	1,525	6%
170	1,143	2,174	1,621	3,106	2,786	2,611	3,435	3,233	2,987	2,920	3,285	13%
172	910	1,210	1,821	2,292	2,259	2,200	2,359	2,147	1,853	1,799	1,866	4%
174	725	1,268	1,234	1,448	1,257	1,363	1,542	1,597	1,367	1,313	1,400	7%
175	824	1,298	1,923	2,108	2,074	2,115	2,480	2,320	2,074	2,192	2,223	1%
178	908	1,390	1,946	2,059	2,013	2,218	2,651	2,767	2,704	2,503	2,966	18%
180	526	902	941	1,215	1,358	1,398	1,831	1,833	1,692	1,829	1,878	3%
181	625	1,060	1,351	1,596	1,562	1,590	1,943	1,940	1,779	1,998	2,240	12%
182	214	364	484	577	564	568	685	684	511	520	544	5%
183	537	902	1,633	1,919	1,650	1,575	1,661	1,654	1,514	1,634	1,745	7%
184	1,873	2,421	3,813	4,124	3,925	4,310	4,774	4,848	4,161	3,554	3,553	0%
197	403	585	923	1,142	953	998	1,040	1,143	999	1,090	1,108	2%
199	58	87	91	137	123	132	104	130	151	119	150	26%
241	1008	1175	1030	1382	1396	1477	1559	1621	1,460	1,506	1,498	-1%
242	586	743	812	988	885	824	912	740	721	692	688	-1%
243	760	991	1,081	1,192	1,169	1,247	1,343	1,217	1,066	1,142	1,066	-7%
244	1,195	1,491	1,848	2,014	2,048	2,300	2,540	2,390	2,170	2,155	2,080	-3%
245	1,019	1,527	2,216	2,350	2,179	2,430	2,743	2,449	2,036	2,229	1,932	-13%
246	1,639	2,113	2,355	2,784	2,479	2,384	2,599	2,527	2,082	2,178	1,935	-11%
247	700	887	970	1,181	1,056	948	1,047	955	861	848	802	-5%
248	272	534	641	778	622	720	714	739	656	638	487	-24%
249	706	1,104	1,310	1,590	1,479	1,429	1,479	1,327	1,261	1,285	1,246	-3%
251	95	112	129	134	152	132	176	183	128	145	91	-37%
287	70	127	167	189	201	184	207	182	106	104	92	-12%
298	326	492	601	648	685	654	952	894	810	799	753	-6%
Forested Zone	28,428	40,899	50,896	59,131	56,033	57,736	65,014	62,682	55,612	55,174	57,017	3%

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	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Change
104	0	0	235	597	673	921	1,832	1,316	1,233	1,456	1,278	-12%
105	392	423	543	876	1,149	1,247	2,252	1,780	2,193	2,088	2,138	2%
107	0	2	288	898	1,373	1,380	2,683	1,750	2,075	2,100	1,953	-7%
110	1	16	826	644	697	854	1,328	1,309	1,251	1,252	1,151	-8%
111	0	0	81	476	828	801	1,597	1,213	1,371	1,663	1,375	-17%
114	0	0	0	12	16	17	41	55	51	79	44	-44%
115	4	10	436	1,136	1,441	1,439	2,516	1,654	2,116	2,238	2,022	-10%
116	0	1	0	0	0	0	27	47	31	84	89	6%
122	3	2	3	139	165	125	195	149	123	502	460	-8%
126	12	11	0	55	53	102	117	250	309	371	464	25%
127	1	0	0	1	13	13	20	28	24	41	67	63%
152	54	86	52	92	82	87	129	94	130	172	228	33%
154	356	463	960	2,113	2,027	2,863	3,646	3,127	2,794	2,869	2,615	-9%
156	430	519	807	1,711	1,365	1,605	2,965	2,591	2,706	2,886	3,096	7%
157	1,205	1,941	2,376	3,663	4,050	4,680	5,794	4,576	4,156	5,073	4,996	-2%
159	1,013	1,668	2,250	2,880	2,512	2,486	3,212	2,369	2,440	2,357	2,491	6%
167	2	2	546	565	999	1,277	751	644	548	1,046	1,156	11%
168	0	0	831	1,033	922	1,349	1,520	2,089	1,099	2,188	1,832	-16%
170	0	46	1,259	1,832	2,043	2,105	5,025	3,921	4,234	4,031	5,061	26%
172	69	233	1,140	1,961	2,362	2,710	4,645	3,342	3,374	3,546	3,011	-15%
174	29	103	693	990	883	1,315	2,283	1,750	1,728	1,867	1,845	-1%
175	4	10	403	927	1,264	1,118	2,591	1,934	1,029	2,367	2,196	-7%
178	4	11	405	991	1,334	1,448	2,872	2,530	2,669	2,973	3,596	21%
180	35	49	5	325	345	469	1,292	522	1,145	1,724	1,877	9%
181	78	126	429	766	895	829	1,656	1,604	1,976	2,477	2,765	12%
182	26	41	130	250	298	301	624	521	745	940	1,055	12%
183	62	101	513	829	1,093	1,197	2,299	1,879	1,935	2,372	2,002	-16%
184	-51	137	2,157	3,159	3,837	4,501	9,249	7,459	7,321	6,707	7,452	11%
197	4	12	10	230	214	415	612	580	595	1,381	1,140	-17%
199	0	0	39	32	43	32	36	42	37	48	56	17%
241	2,560	1,744	1,621	2,902	2,531	2,380	2,990	2,828	2,828	2,863	3,289	15%
242	509	582	740	832	1,187	1,602	1,855	1,504	1,395	1,478	1,571	6%
243	508	611	826	1,442	1,695	1,991	2,788	2,467	2,099	2,287	2,392	5%
244	839	905	1,108	1,757	2,793	3,505	4,912	4,312	3,992	4,037	5,022	24%
245	2	130	1,308	2,345	2,874	3,196	5,488	3,928	3,701	3,886	3,461	-11%
246	1,122	1,334	1,720	2,815	3,611	2,765	4,931	4,255	3,753	4,211	3,404	-19%
247	455	520	661	742	1,059	1,153	1,697	1,627	1,254	1,545	1,262	-18%
248	292	409	209	261	259	632	1,183	1,125	1,014	642	900	40%
249	404	410	907	1,236	1,669	1,809	2,744	2,473	1,950	2,382	2,059	-14%
251	93	96	117	192	102	166	294	204	197	156	162	4%
287	243	187	201	187	259	286	322	243	174	201	214	6%
298	0	24	103	155	141	278	1,036	839	854	928	857	-8%
Forested Zone	10,759	12,965	26,938	44,049	51,156	57,449	94,049	76,931	74,649	83,514	84,104	1%

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. 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.)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Change
104	2,078	6	6	7	8	9	9	9	8	8	8	8	2%
105	766	21	24	27	30	34	37	37	35	35	36	37	2%
107	1,895	9	11	12	12	13	14	13	11	11	12	11	-4%
110	300	20	24	25	26	28	30	30	28	28	27	26	-4%
111	1,707	5	5	6	7	7	8	7	6	6	6	6	-5%
115	1,872	9	10	12	12	13	15	13	11	12	13	12	-4%
116	1,158	1	1	1	1	2	2	2	1	2	2	2	-6%
122	620	6	7	8	8	9	10	10	9	8	9	8	-9%
126	941	10	10	12	11	12	14	14	12	11	12	11	-12%
127	561	6	7	8	8	9	10	10	9	8	9	8	-9%
154	760	14	16	18	18	19	19	18	17	17	16	15	-6%
156	826	14	16	18	17	19	21	20	20	20	19	18	-9%
157	889	19	21	23	23	24	24	22	21	22	20	18	-10%
159	568	21	23	23	21	21	22	20	20	20	20	19	-6%
167	432	20	20	22	22	23	22	21	19	20	20	19	-4%
168	724	14	16	17	16	17	17	17	15	16	15	15	-6%
170	1,315	17	20	23	22	24	26	26	24	25	25	24	-6%
172	451	25	31	36	35	38	40	37	34	33	31	29	-8%
174	836	11	13	14	14	15	16	15	14	14	14	14	-4%
175	1,276	19	23	26	26	29	32	29	25	28	29	27	-8%
178	1,267	13	16	19	19	22	24	24	23	24	25	25	-1%
180	982	8	10	11	12	13	14	14	14	15	15	13	-10%
181	856	18	21	23	23	26	28	29	27	28	28	27	-3%
183	663	20	23	25	24	26	28	27	24	25	24	22	-5%
184	1,232	17	21	23	25	27	30	28	27	26	25	23	-8%
197	975	12	13	13	13	14	15	15	15	15	14	13	-6%
241	417	32	35	40	39	42	44	44	44	44	45	44	-1%
242	215	26	29	31	30	31	32	29	28	27	25	21	-13%
243	314	28	32	37	36	39	40	38	36	35	33	29	-12%
244	586	24	28	32	34	38	39	38	36	35	34	30	-10%
245	583	23	28	31	33	35	37	33	31	30	28	26	-6%
246	772	21	24	26	25	25	26	25	23	23	21	20	-6%
247	231	26	29	31	30	31	32	29	28	27	25	21	-13%
248	212	20	22	24	22	24	25	25	24	23	21	18	-15%
249	502	14	16	18	17	18	19	17	16	16	15	14	-9%
251	55	15	17	18	17	19	20	18	16	15	15	16	5%
298	619	15	16	17	18	19	22	21	20	20	20	23	12%
Forest Zone	30,456	14	16	18	18	19	20	19	18	18	18	17	-5%

2008 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 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

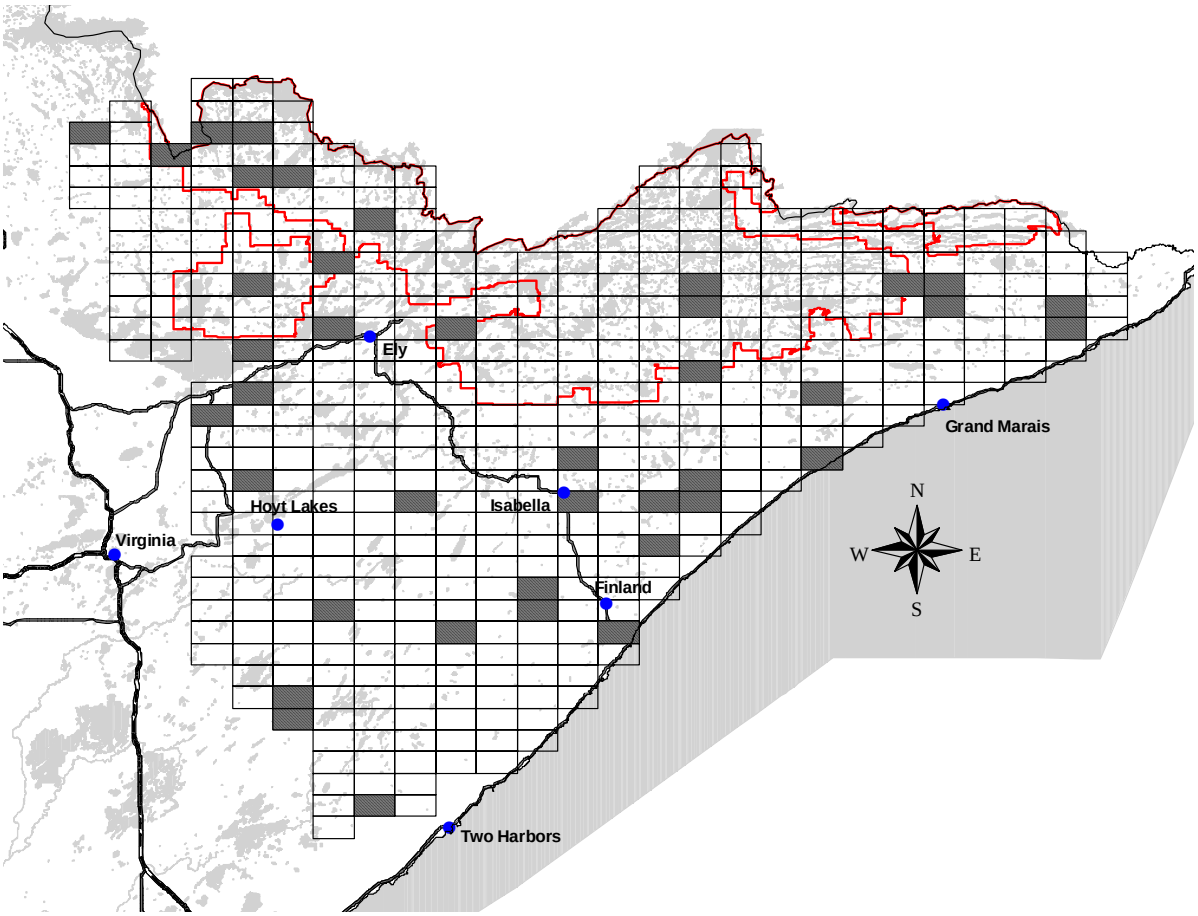
We initiated the survey on 2 January and completed it on 17 January. Observers rated survey conditions as "good" (highest rank) on 35 plots and "marginal" on 5 plots. Snow conditions for the survey were excellent and generally exceeded 16"in depth. During the survey flights, observers located 416 moose on the 40 plots (532 mi^2) including 155 bulls, 192 cows, 64 calves, and 5 unidentified moose.

After adjusting for sampling and sightability, we estimated that the moose population in northeastern Minnesota contained 7,637±2114 animals (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.36 and 0.77, respectively (Table 1).

DISCUSSION

We have used the sightability model approach for 5 years to account for sightability bias in our estimates of moose numbers in northeastern Minnesota. In the first year, 3 observers equated VOC to crown closure on some observations and this resulted in significantly higher estimates of VOC (Kruskal Wallis AOV, F=20.3, $P<0.01$). 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 - 2008 and as a result, population estimates were more comparable. Because of this bias, estimates for 2004 were not included in subsequent analyses.

Figure 1. Northeast moose survey area and sample plots (diagonal lines) flown in the 2008 aerial moose survey.



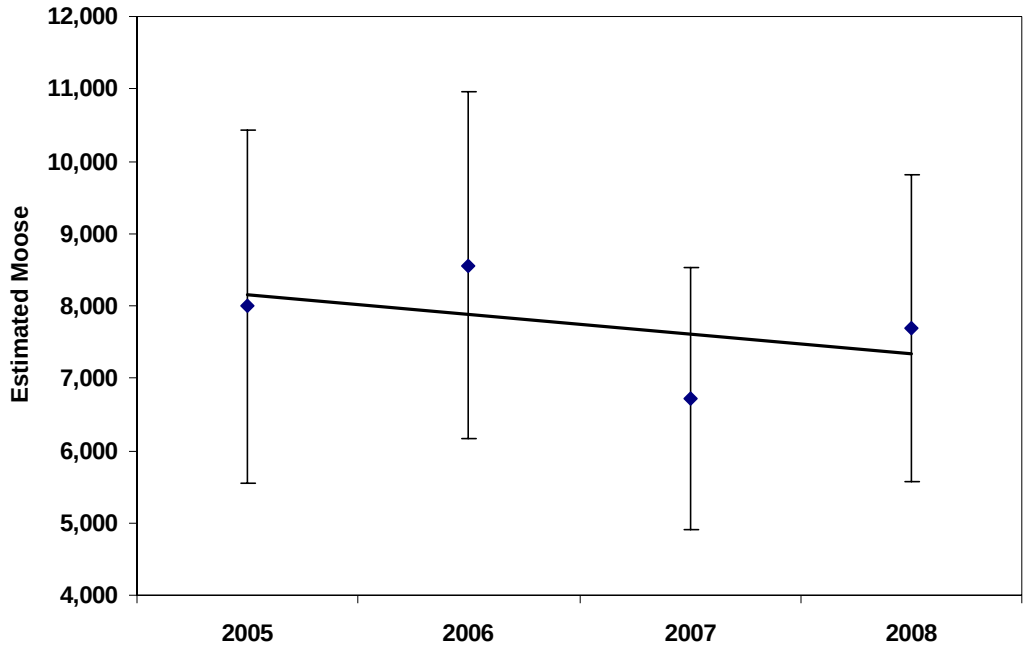
Prior to 2004, we used double sampling to calculate a sightability correction factor (SCF, Gasaway et al. 1986) to account for visibility bias. During the period 1997-2003, SCF averaged 1.35 (1.14 to 1.87). In the last 4 years, the mean theta value (a number equivalent to SCF) averaged 1.94 (1.78-2.09). The difference between estimates for SCF and theta implies that we missed a substantial proportion of the moose in the double sampling used to calculate SCF. Moreover, this difference implies that moose population estimates prior to 2004 were biased low. These inferences are corroborated by research conducted in Alaska (Gasaway et al. 1986) where they found that double sampling missed a larger proportion of moose if surveys were conducted in mid to late winter.

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

Survey	Estimate	Calves:Cow	Bulls:Cow	% Cows w/ Twins
1998	3,464 ±36%	0.71	0.98	0
1999	3,915 ±35%	0.57	1.30	9
2000	3,733 ±25%	0.70	1.34	7
2001	3,879 ±28%	0.61	1.05	5
2002	5,214 ±23%	0.93	1.22	20
2003	4,161 ±37%	0.70	2.01	11
2004	13,093±40%	0.42	1.24	4
2005	7,923±30%	0.52	1.04	9
2006	8,501±28%	0.34	1.09	5
2007	6,659±27%	0.29	0.89	3
2008	7,637±28%	0.36	0.77	2

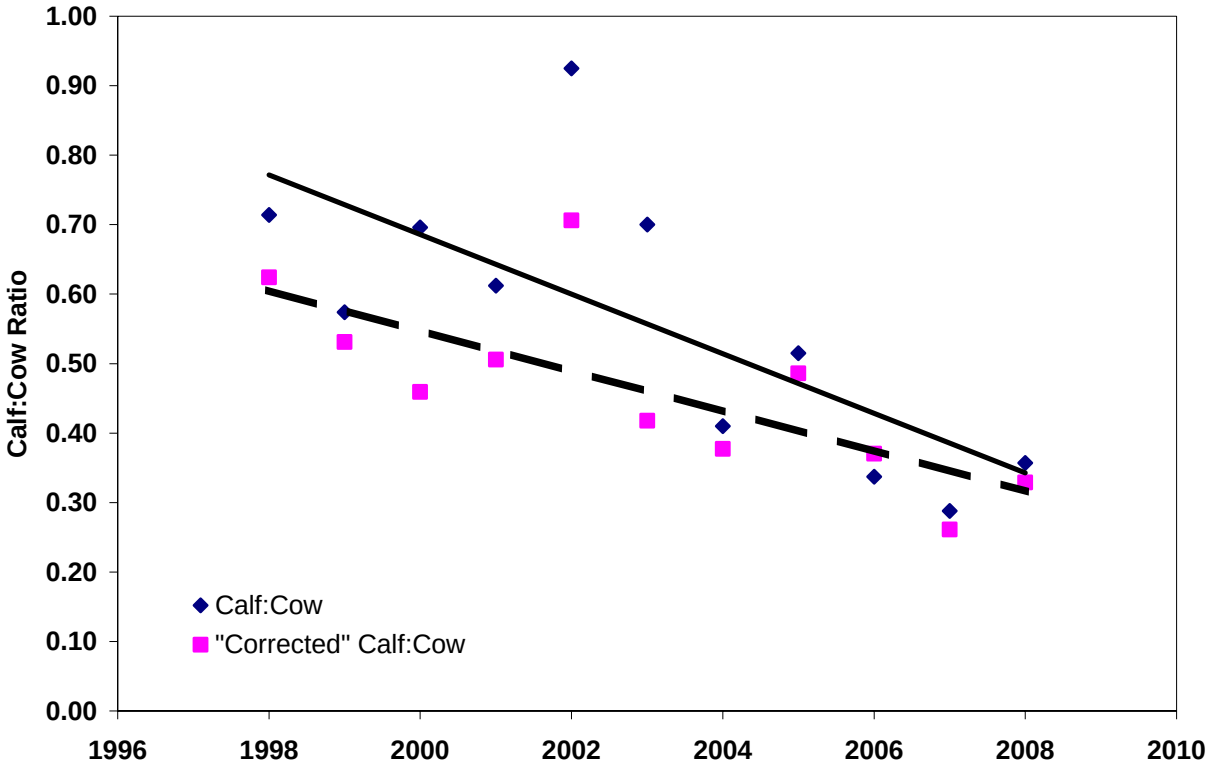
The 2008 population estimate was almost 15% higher than the 2007 estimate. The overlap in confidence intervals (Table 1, Figure 2), however, indicates that there was no statistical difference between the 2007 and 2008 point estimates. The population trend has a negative slope suggestive of a declining population. This inference is reinforced by the low calf:cow ratio (Table 1) and continued high mortality observed in research on radiocollared moose within the northeast population (Lenarz unpublished). citation.

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



The calf:cow ratio estimated from the 2008 survey (Table 1) was significantly lower than the mean estimated in the previous 10 years ($\bar{x}$ = 0.58, t=3.56, P=0.003). Although slightly higher than in 2007, the calf:cow ratio has steadily declined in recent years (F=9.82, P=0.012; Figure 3.). Even if the cow:calf ratio is "corrected" by assuming that half of the unclassified moose were cows, there is still a significant decline in this important parameter (F=10.94, P=0.009). Ratio estimates (bull:cow and calf:cow) were not adjusted for sightability and hence, can be compared with estimates prior to adoption of the sightability model.

Figure 3. Estimates of calf:cow ratio of moose in northeastern Minnesota. Diamonds represent estimates adjusted for sampling and squares represent estimates "corrected" by assuming that half of the unclassified moose were cows. The solid and dashed lines represent the uncorrected and corrected trends, respectively.



The proportion of cows accompanied by twins was significantly lower ($\bar{x}$=7.2%, t =2.96, P=0.008) in 2008. Even when 50% of unclassified moose were included as cows in the calculation of the proportion twins, the values for 2008 remained significantly lower ($\bar{x}$=5.8%, t =2.87, P=0.009). Twinning rates vary widely across North America, and may be related to habitat quality and the relationship between a moose population and the carrying capacity of its habitat (Gasaway et al. 1992).

The estimated bull:cow ratio (Table 1) was significantly lower than the mean bull:cow ratio estimated for the previous 10 years($\bar{x}$ = 1.22, t=4.49, P<0.001). This is true, even when recalculated with the assumption that 50% of the unclassified moose were adult bulls ($\bar{x}$ = 1.15, t=5.74, P<0.001). Although there is a negative trend in this statistic, the slope of the line is not significant (P=0.077). The hunter harvest has been heavily biased towards bulls in recent years (Lenarz, unpubl.), but the 2007 bull harvest (154) represented less than 6% of the estimated number of bulls in the 2007 population. This level of bull harvest is insufficient to have caused the decline in the bull:cow ratio observed between the 2007 and 2008 surveys. It has been speculated that reproduction would decline if the bull:cow ratio declines

below some unspecified level (e.g. Rausch 1974). Unless the bull:cow ratio drops to very low levels, there should be sufficient numbers of bulls to breed all cows.

In the January survey, 4% of the moose exhibited hair loss, which is indicative of infestation with the winter tick (*Dermacentor albipictus*). In 2007, 11% 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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