FOREST WILDLIFE POPULATIONS

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Grouse Surveys In Minnesota During Spring 2007

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SUMMARY OF FINDINGS

Surveys for ruffed grouse (*Bonasa umbellus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and greater prairie-chickens (*Tympanuchus cupido pinnatus*) were conducted during April and May 2007. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.3 (95% confidence interval = 1.1–1.5) drums/stop (dps). That was significantly greater than the 1.0 (0.9–1.1) dps observed during 2006.

During the spring 2007 survey 2,114 sharp-tailed grouse were observed at 180 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 9.4 (8.0–11.0) in the East Central survey region, 12.9 (11.4–14.5) in the Northwest region, and 11.7 (10.6–12.9) statewide. Index values in both regions were significantly greater during 2007 than during 2006, and the statewide index value was as high as any year since 1980.

We counted 3,294 male prairie-chickens and located 263 booming grounds. Within survey blocks we observed 0.42 (0.33–0.51) leks/mi^2 and 14.5 (12.0–17.0) males/lek. Approximately 45% more leks and males were counted in survey blocks during spring 2007 than during spring 2006. Means of annual densities observed during 1993–2002 were 0.2 leks/mi^2 and 11.5 males/lek.

INTRODUCTION

Index Surveys

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

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.

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 there was expanded southward to the upper Minnesota River valley by a series of relocations during 1998–2006. Hunters in Minnesota have harvested approximately 100 prairie-chickens annually since 2003 when a limited-entry hunting season was opened for the first time since 1942.

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

METHODS

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 2.5th and 97.5th percentiles of the bootstrap frequency distribution. I calculated mean index values and CIs for 1982–2007. 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 and 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 2007. 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 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. I used a separate data set of comparable leks to calculate the mean difference in the number of birds counted per dancing ground between 2006 and 2007.

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.

Greater Prairie-Chickens

During the few hours near sunrise from late-March until mid-May cooperating biologists and numerous volunteers counted prairie-chickens at leks in western Minnesota. They attempted to locate and observe multiple times all prairie-chicken leks within 17 designated survey blocks (Figure 3). Each block was approximately 4 miles × 4 miles square (4,144 ha) and was selected nonrandomly based upon the spatial distribution of leks and the presence of relatively abundant grassland habitat. Ten survey blocks were located in what was considered the core of the prairie-chicken range in Minnesota. The other 7 blocks were located in the periphery of the range. The permit areas for the fall hunting season roughly coincide with the core of the range (Figure 3).

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

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

RESULTS & DISCUSSION

Ruffed Grouse

Observers from 15 cooperating organizations surveyed 131 routes between 10 April and 14 May 2007. Most routes (52%) were run between 23 and 29 April. There was a secondary peak of survey effort (15% of routes) during 8–9 May. Cooperators included the DNR Divisions of Fish & Wildlife and Ecological Services; Chippewa and Superior National Forests (USDA Forest Service); Fond du Lac, Grand Portage, Leech Lake, Red Lake, and White Earth Reservations; Agassiz and Tamarac National Wildlife Refuges (U.S. Fish & Wildlife Service); Vermilion Community College; Beltrami and Cass County Land Departments; and UPM Blandin Paper Mill. Observers reported survey conditions as Excellent, Good, and Fair on 62%, 34%, and 4% of 124 routes, respectively. Survey conditions during 2006 were Excellent, Good, and Fair on 52%, 35%, and 13% of routes, respectively.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.3 (95% confidence interval = 1.1–1.5) drums/stop (dps) during 2007. That was significantly greater than the 1.0 (0.9–1.1) dps observed last year and similar to the long-term mean between low and high points in the population cycle (Figure 4). The Northeast survey region was the only one in which counts increased. Drum counts during 2007 by survey region were 1.5 (1.3–1.7) dps in the Northeast (*n* = 107 routes), 0.9 (0.5–1.4) dps in the Northwest (*n* = 8), 0.8 (0.4–1.1) dps in the Southwest (*n* = 14), and 0.5 (0.2–0.9) dps in the Southeast (*n* = 8) (Figures 4 & 5). Median index values for bootstrap samples were similar to observed means, so no bias-correction was necessary.

Based upon the drum count index, ruffed grouse densities in northeastern Minnesota during spring 2007 were likely greater than spring densities during 2001–2006. It appears that this is the second year of a cyclical increase in the population. The lack of changes in drum counts in the periphery of ruffed grouse range in Minnesota, however, indicates that the increase will not be noticeable in all areas.

Sharp-tailed Grouse

A total of 2,114 sharp-tailed grouse was observed at 180 dancing grounds with ≥2 male grouse (or grouse of unknown sex) during spring 2007. The resulting index value (11.7 grouse/lek) was greater than any index value since 1980 (Figure 6). Index values in both survey regions increased from 2006 to 2007 (Table 1). Among dancing grounds visited both years, index values in the NW and EC regions increased by 37% (95% CI = 18–60%) and 17% (95% CI = 1–37%), respectively. Leks with ≥2 grouse were visited a mean of 1.8 times, and 151 historic lek sites with ≤1 male were also surveyed at least once.

Table 1. Number of sharp-tailed grouse observed per dancing ground in Minnesota during spring.

	Statewide			Northwest[a]			Eastcentral[a]		
Year[b]	Mean	95% CI[c]	*n*[d]	Mean	95% CI[c]	*n*[d]	Mean	95%CI[c]	*n*[d]
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	11.7	10.6–12.9	180	12.9	11.4–14.5	120	9.4	8.0–11.0	60
$\text{Difference}_{04\text{-}05}$	-1.3	-2.2– -0.3	186	-2.1	-3.5– -0.8	112	0.0	-1.0– 1.1	74
$\text{Difference}_{05\text{-}06}$	-2.5	-3.7– -1.3	126	-3.6	-5.3– -1.9	70	-1.1	-2.6– 0.6	56
$\text{Difference}_{06\text{-}07}$	2.6	1.5– 3.8	152	3.3	1.7– 5.1	99	1.2	0.1– 2.3	53

[a] Survey regions; see Figure 1.
[b] Year or consecutive years for the mean difference between comparable leks.
[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.

Greater Prairie-Chickens

Observers from at least 3 cooperating organizations and several unaffiliated volunteers counted prairie-chickens during spring 2007. Cooperators included the DNR Division of Fish and Wildlife, Fergus Falls and Detroit Lakes Wetland Management Districts (U.S. Fish & Wildlife Service), and The Nature Conservancy. Observers located 263 booming grounds and counted 3,294 male prairie-chickens (Table 2). Within hunting permit areas we observed 0.09 leks/mi^2 (0.03 leks/km^2) and 13.7 males/lek. Minimum counts in Table 2 and the densities calculated from them are not comparable among permit areas or years because they included surveys that were conducted outside of the survey blocks and did not follow a spatial sampling design.

Table 2. Minimum abundance of prairie-chickens within and outside of hunting permit areas in western Minnesota during spring 2007. Counts of leks and birds are not comparable among permit areas or years.

Permit Area	Area (sq. mi.)	Leks	Males	Unk.[a]
801A	233	0	0	0
802A	319	19	157	0
803A	258	11	98	0
804A	168	0	0	0
805A	103	28	474	0
806A	289	17	172	6
807A	170	32	372	33
808A	161	34	579	0
809A	287	27	466	0
810A	195	26	400	0
811A	272	16	165	54
PA subtotal[b]	2,454	210	2,883	93
Outside PAs[c]	NA[d]	53	411	51
Grand total	NA	263	3,294	144

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

Each booming ground was observed on a median of 2 (mean = 1.9) different days, but 46% of leks were observed only once. Attendance of males at prairie-chicken leks varies among days and by time of day. Single counts of males at a booming ground, therefore, may be an unreliable indication of true abundance. Similar counts on multiple days, on the other hand, demonstrate that the counts may be a good indicator of true abundance. Even multiple counts, however, cannot overcome the problems associated with the failure to estimate the probability of detecting leks and individual birds at leks. Without estimates of detection probability, the prairie-chicken survey is an index to, not an estimate of, prairie-chicken abundance within the survey blocks. The credibility of the index for monitoring changes in abundance among years is dependent upon the untested assumption that a linear relationship exists between counts of male prairie-chickens and true abundance. In other words, we assume that (the expected value of) the probability of detection does not change among years.

Within survey blocks we counted 1,618 males (includes birds of unknown sex) on 114 leks (Table 3). That was 46% more males and 43% more leks than were counted in survey blocks during spring 2006 (Figure 7). Leks were defined as having ≥2 males, so observations of single males were excluded from summaries by survey block. During spring 2007 we observed 0.41 (0.30–0.53) leks/mi^2 and 17.4 (15.2–19.6) males/lek in survey blocks in the core of the range, whereas we observed 0.43 (0.28–0.58) leks/mi^2 and 10.3 (7.1–13.6) males/lek in peripheral blocks (Table 3). The densities of prairie-chickens observed during 2007 were greater than the means of 0.2 leks/mi^2 and 11.5 males/lek observed in survey blocks from 1993 until 2002.

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

Range[b]	Survey Block	Area (miles^2)	2007 Leks	2007 Males[c]	Change from 2006[a] Leks	Change from 2006[a] Males[c]
Core	Polk 2	16.2	9	143	5	78
	Norman 1	16.1	2	19	-1	-23
	Norman 3	16.0	9	154	3	64
	Clay 1	17.6	9	182	0	27
	Clay 2	16.0	4	91	2	-10
	Clay 3	16.1	9	157	0	14
	Clay 4	14.9	5	91	0	34
	Wilkin 1	15.4	9	161	0	68
	Wilkin 3	16.1	8	122	2	51
	Otter Tail 1	15.9	2	40	-1	10
	Core subtotal	160.2	66	1,160	10	313
Periphery	Polk 1	15.9	11	101	7	53
	Norman 2	16.3	9	59	4	-3
	Mahnomen	16.1	7	97	4	49
	Becker 1	16.0	10	82	7	58
	Becker 2	16.1	3	56	-1	14
	Wilkin 2	16.1	3	25	1	9
	Otter Tail 2	15.7	5	38	2	15
	Periphery subtotal	112.2	48	458	24	195
Grand total		272.4	114	1,618	34	508

[a] The 2006 count was subtracted from the 2007 count, so a negative value indicates a decline.

[b] Survey blocks were classified as either mostly within the original (i.e., 2003–2005) hunting permit areas (core) or mostly outside those permit areas (periphery).

[c] Includes birds recorded as being of unknown sex but excludes lone males not observed at a booming ground.

ACKNOWLEDGEMENTS

I sincerely appreciate the efforts of all the DNR staff and volunteer cooperators who conducted and helped coordinate the 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 for reviewing earlier drafts of this report.

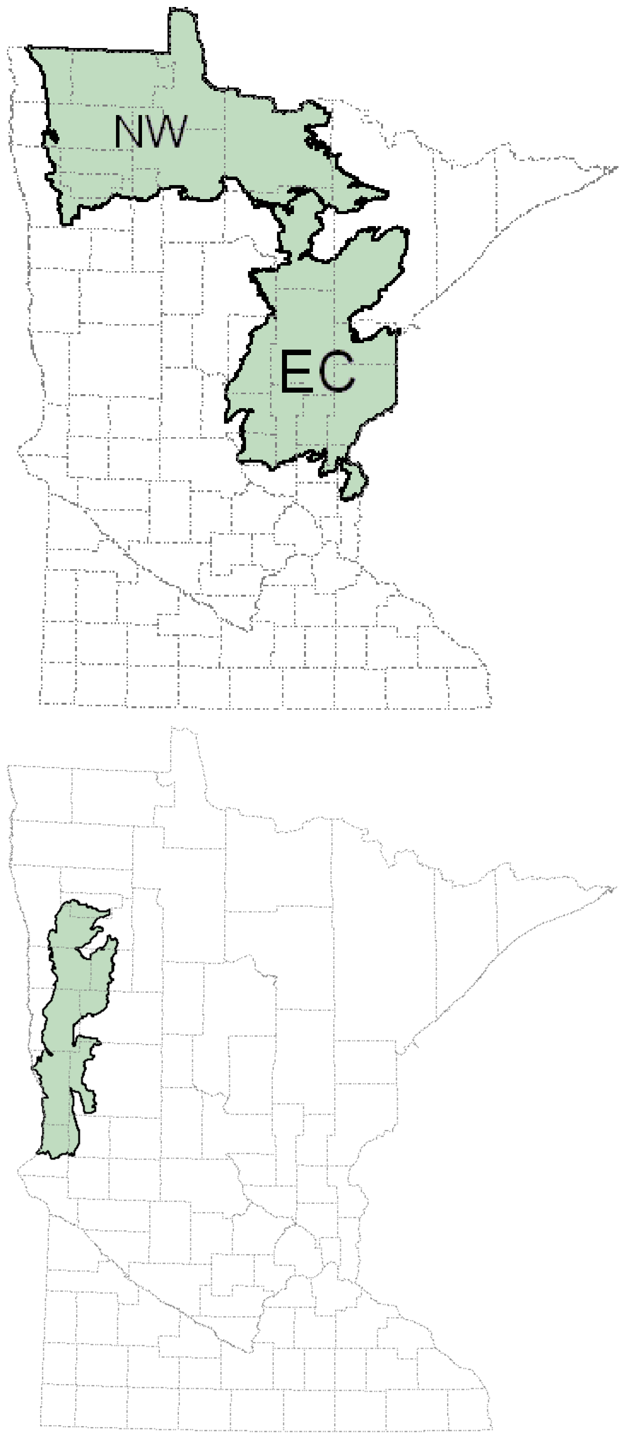


Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** (top panel) and primary range of **greater prairie-chickens** (bottom panel) relative to county boundaries in Minnesota. The sharp-tailed grouse regions were based largely on boundaries of ECS Subsections, whereas the prairie-chicken range was based on ECS Land Type Associations.

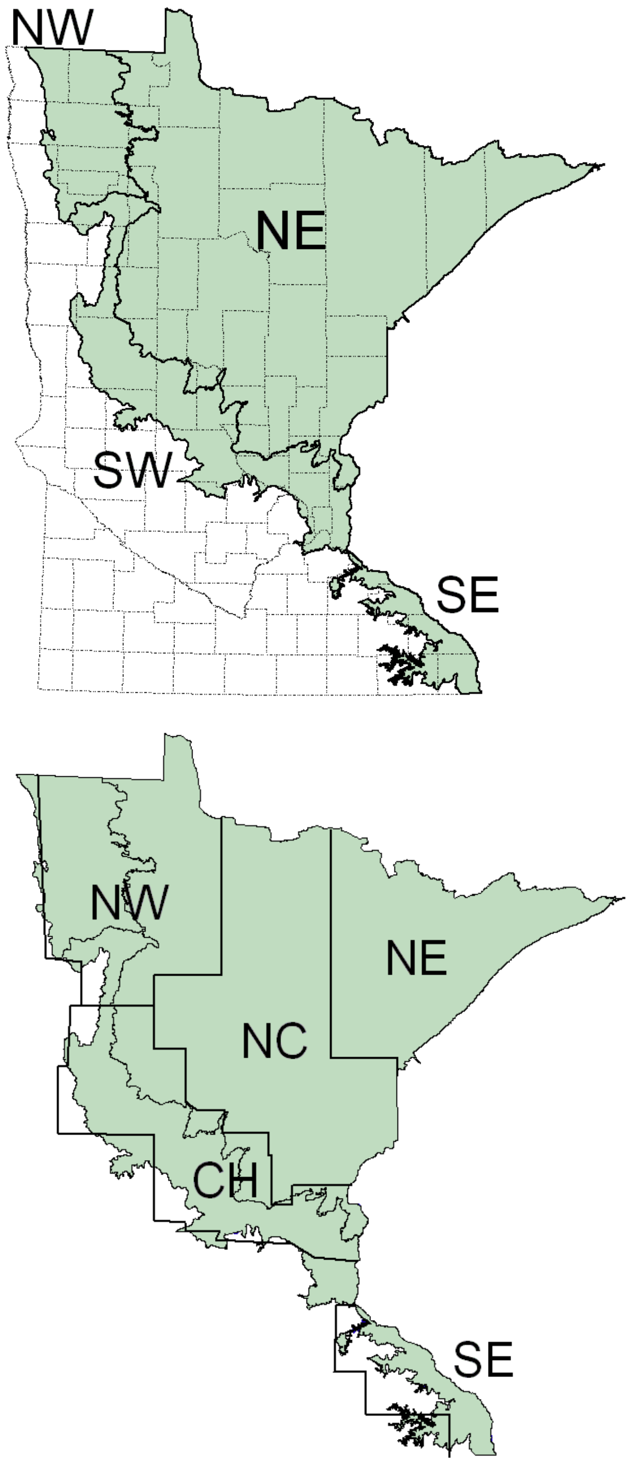


Figure 2. **Ruffed grouse** survey regions (shaded, curved boundaries) are based on the Ecological Classification System. Top panel: regions are labeled and overlaid on counties (dashed lines). Bottom panel: former survey zones (straight boundaries) are labeled and overlaid on regions.

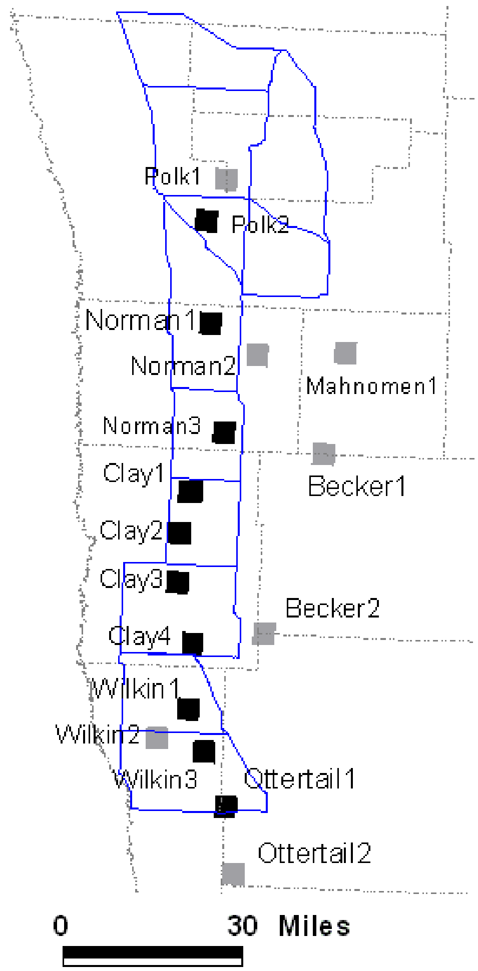
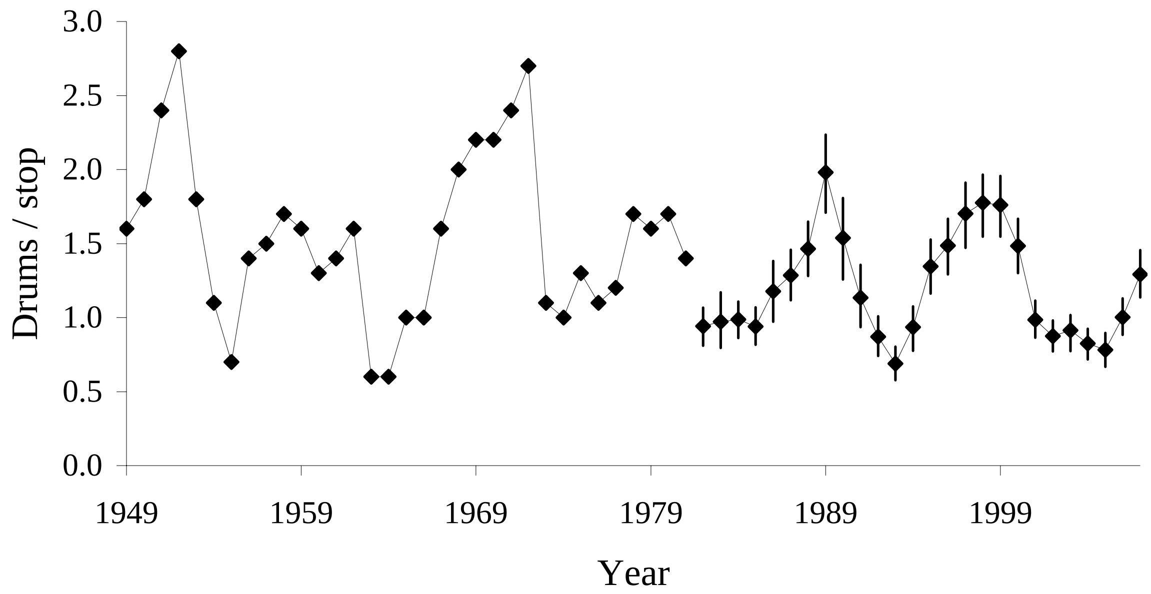


Figure 3. Survey blocks (labeled squares) and hunting permit area boundaries (solid lines) for **prairie-chickens** in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which they were primarily located. Permit areas were labeled sequentially from 801A in the north to 811A in the south.



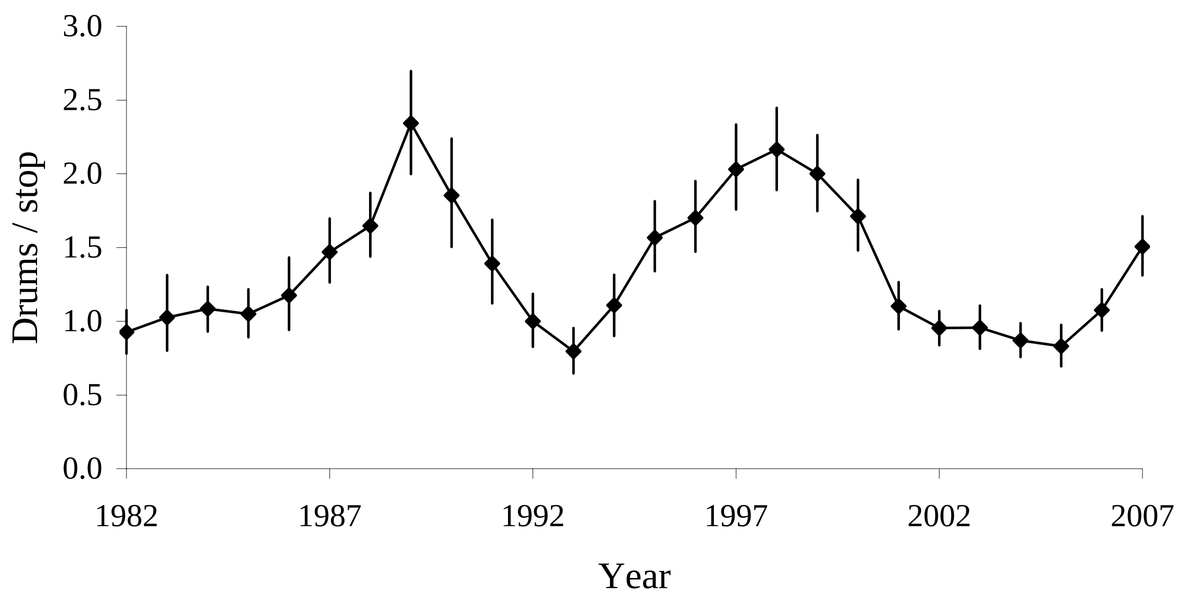


Figure 4. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current methods, so confidence intervals were 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.

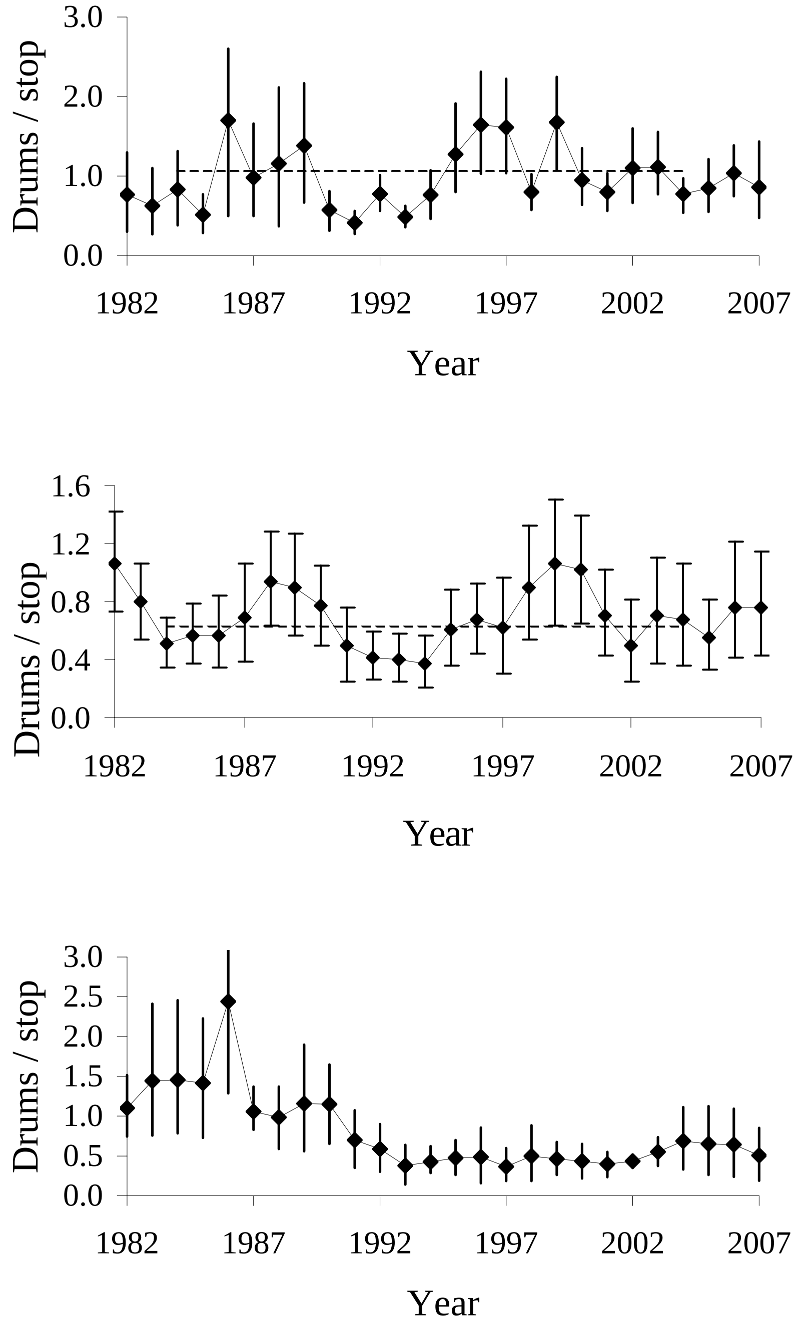


Figure 5. Ruffed grouse drum count index values in the **Northwest** (top), **Southwest** (middle), and **Southeast** (bottom) survey regions of Minnesota. Dashed horizontal lines indicate the mean from 1984 to 2004. Vertical error bars represent 95% confidence intervals based on bootstrap samples. One error bar in the bottom panel was truncated.

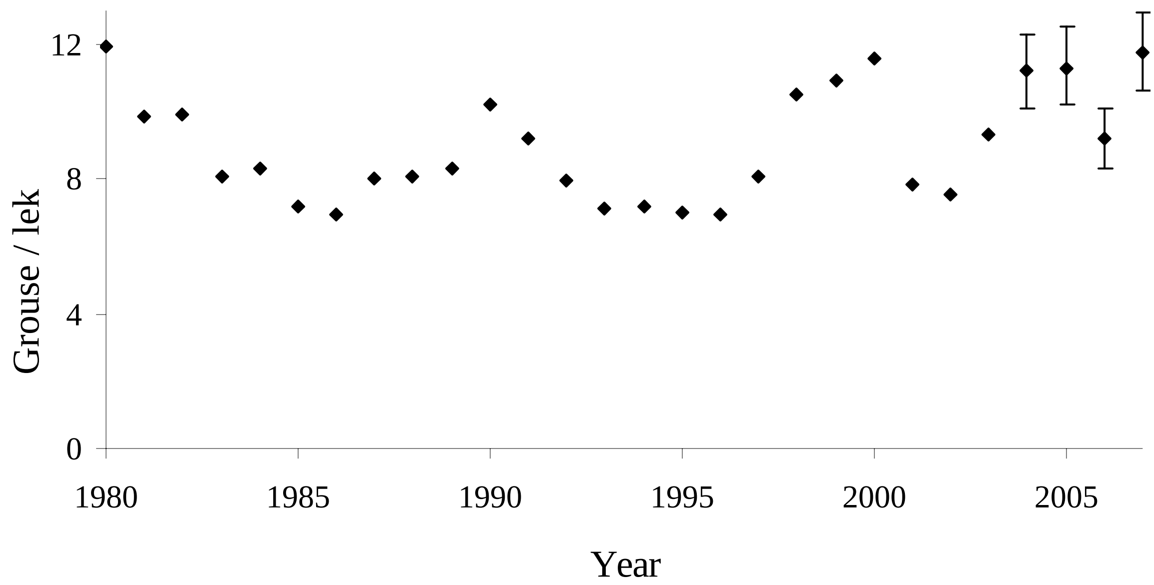


Figure 6. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds, 1980–2007. Vertical error bars, which were calculated only for recent years, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.

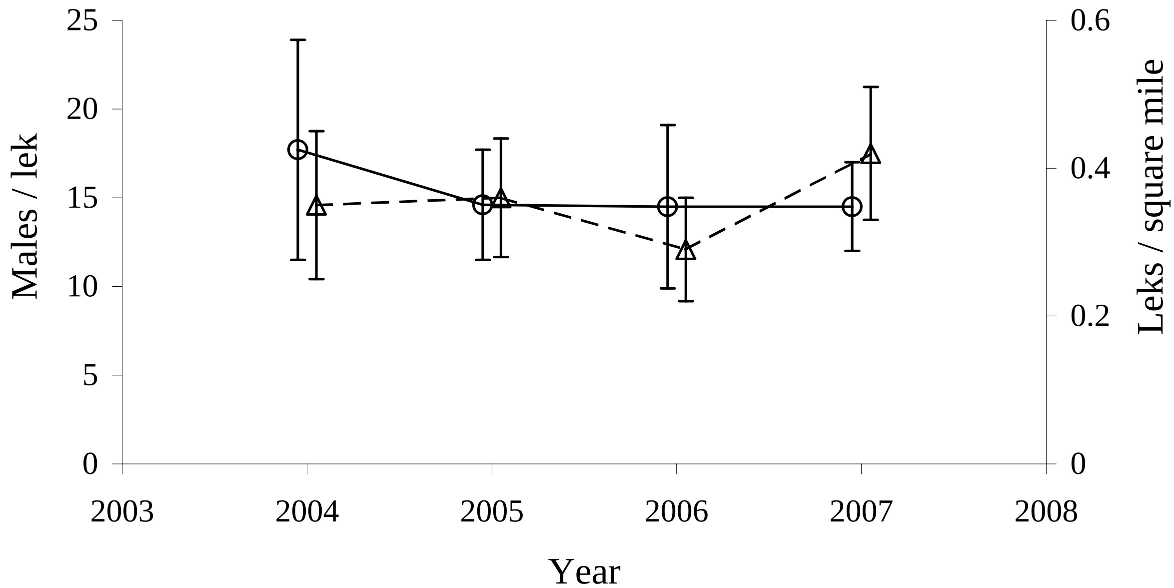
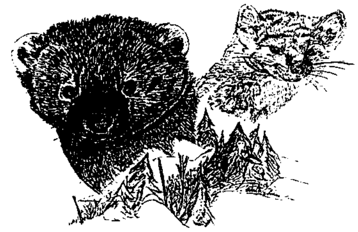


Figure 7. Number of **prairie-chicken** males/lek (circles) and leks/mi^2 (triangles) observed in western Minnesota. Vertical error bars represent 95% confidence intervals based on n = 17 survey blocks.



Registered Furbearer Population Modeling

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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/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 2006 harvest information is available in a separate report. Bobcat and pine marten year-class data is obtained via a combination of x-ray examination of pulp cavity width and 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. 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 2006 registered DNR trapping and hunting harvest was 890, up 51% from last year, and setting a new record (Table 1). Trapping harvest increased 79%, while hunting harvest decreased 25%. Modeled harvest, which includes reported tribal take, was 983. Based on population modeling estimates, 26% of the fall population was harvested. The juvenile to adult female ratio in the harvest (1.1; Table 1) was below the long-term average (1.5), but similar to the recent 10-year average (1.2). A total of 813 bobcat carcasses were examined (Table 1), with a mean age of 2.7 for both females and males, identical to the 4-year mean for both sexes. Approximately 8% of the harvested bobcats were 6.5+ years old. The 2006-07 harvest age distribution is shown in Figure 1.

Based on examination of reproductive tracts, pregnancy rate of yearlings was estimated at 25%, and has ranged from 16 to 48% the last 4 years (4-year mean = 29%). Average litter size for pregnant yearlings was 2.2. Pregnancy rate for 2+ year olds averaged 77%, with a mean litter size of 2.9.

With the record harvest, modeling predicts a 6% decline in this spring's bobcat population (Figure 2), though the estimated population remains well above pre-1998 levels. While (averaged) fall scent station indices have declined slightly the past 2 years, averaged winter track counts have increased. The estimated 2007 spring population is ~ 2,650.

Fisher: Harvest under the DNR framework was 3,250, up 33% from last year (Table 2) and setting a new record. Modeled harvest, which includes reported tribal take, was 3,500. An estimated 30% of the fisher population was harvested this past winter, the highest such estimate since 1979. Carcass collections ended in 1994, so no current age or reproductive data are available. While winter track indices improved slightly this year, the trend in population projections and averaged winter track indices is slowly downward since ~ 2001 (Figure 3). Modeling estimates a 9% decline in the spring population, currently estimated at ~7,900.

Marten: With the exception of 2005, marten harvests have increased over the past 6 years, setting a new record this year. Harvest under the DNR framework was 3,788, up 43% from last year (Table 3). Modeled harvest, which includes reported tribal take, was 4,120. A total of 1914 marten carcasses were examined this year. Although juveniles clearly predominate in the harvest, older marten are evident as well (Figure 4). However, the maximum age observed has declined slightly in each of the last 4 years for females (13, 12, 11, and 10), with a similar pattern for males (13, 12, 11, 11). Over the last 3 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. The percent juveniles (64%) and the juvenile:adult female ratio (9.2) in the harvest both increased this year (Table 3).

Based on modeling, a record 28% 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 (mean annual decline = 5%). The current spring population is estimated to be ~10,400 (Figure 5), a decline of 6% from last year.

Otter: After several years of record harvests, the otter harvest declined the past 2 years. Harvest under the DNR framework was 2,720, down 4% from last year (Table 3). Modeled harvest, including reported tribal take, was 2,872 (Table 4). An estimated 22% of the fall population was harvested. Carcass collections ended in 1986, so no age or reproductive data are available. Modeling indicates the population has declined in each of the past 4 years (mean annual decline ~ 5%; Figure 6). No independent otter survey data are currently available for comparison. The current estimated spring population is ~ 10,300, down 4% from last year.

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Table 1. Bobcat harvest data, 1978 to 2006.

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]
1978	12/1-1/31	5	304	304	15	113	54	15	31	4.4	61	53	60	59	$164
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	$102

[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.

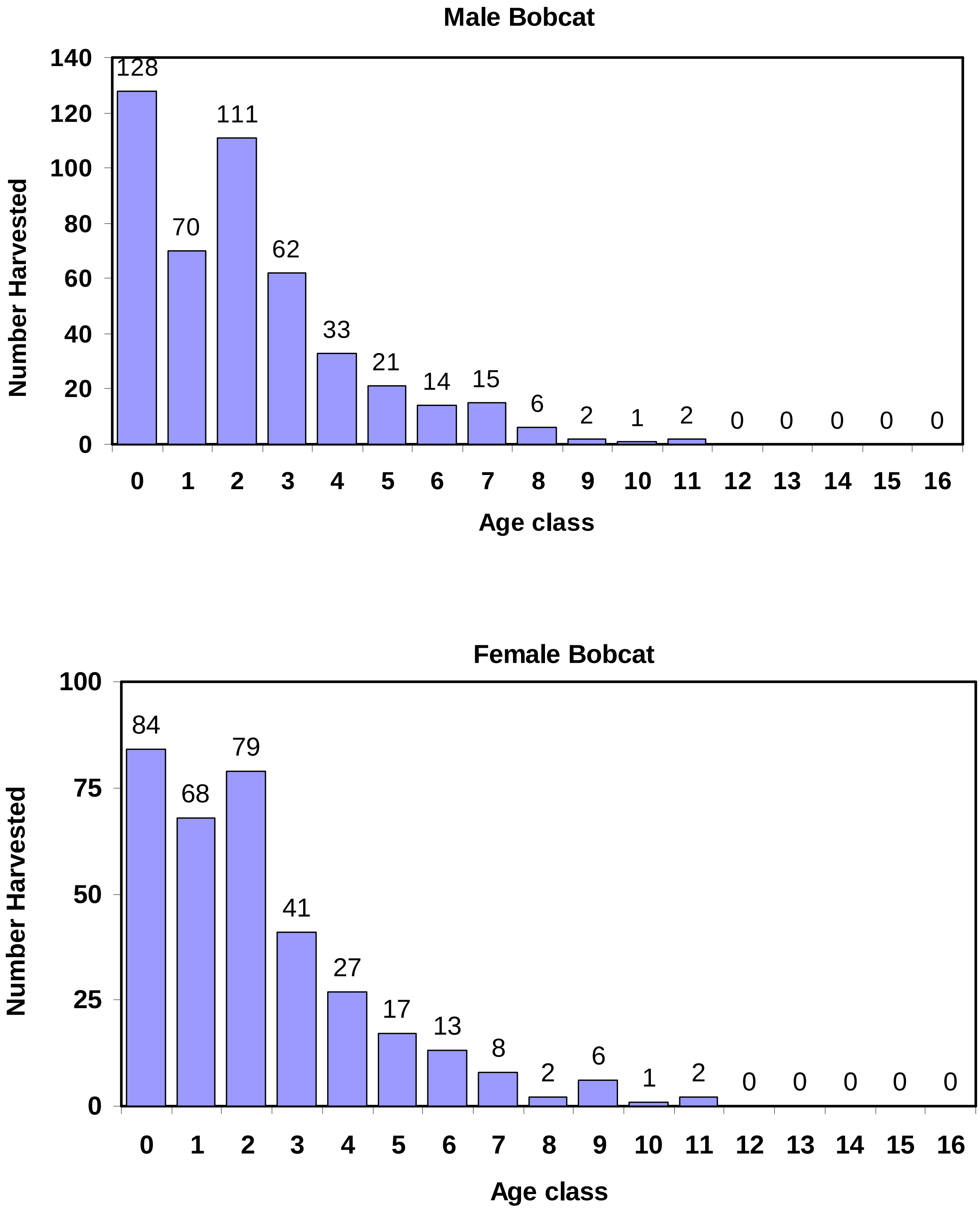

Figure 1. Age structure of male and female bobcats in the 2006-07 harvest.

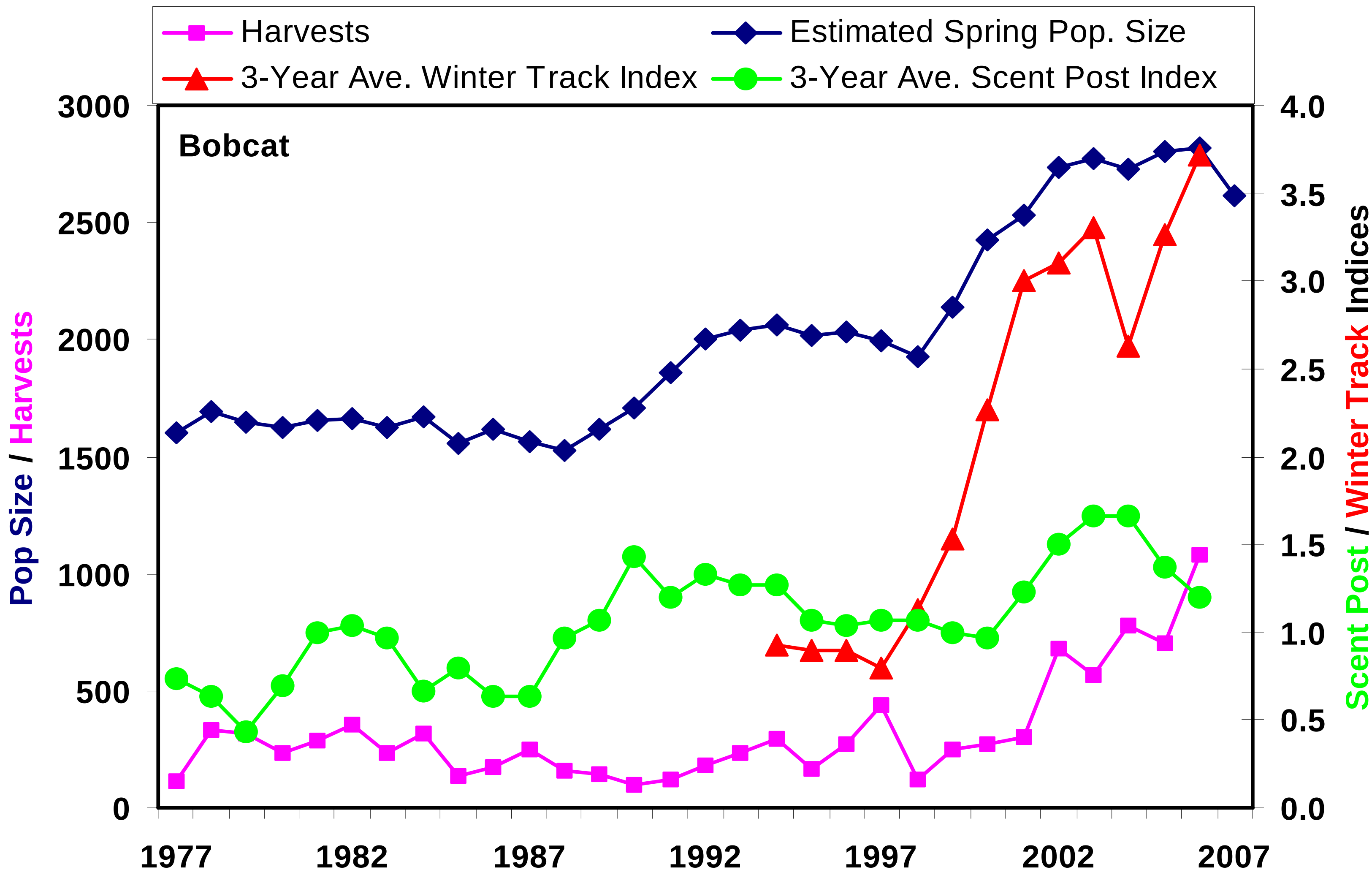

Figure 2. Bobcat populations, harvests, and survey indices, 1977-2006. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1978 to 2006. 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]
1978	12/1-1/31	3	2426	2426	29	577	70	16	14	7.1	44	35	28	40	$132	$147
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	$77	$69

[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.

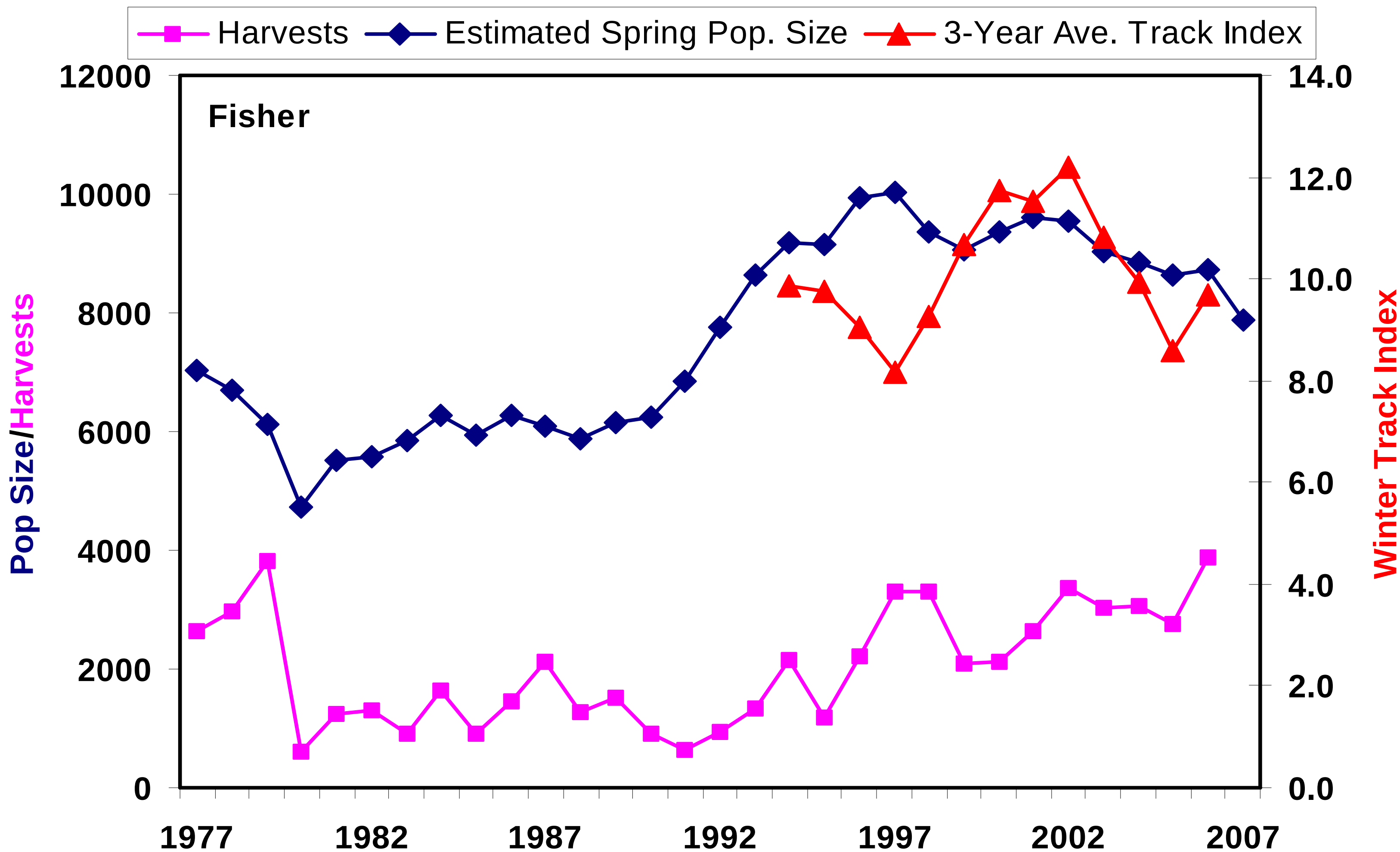

Figure 3. Fisher populations, harvests, and survey indices, 1977-2006. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2006.

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

[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.

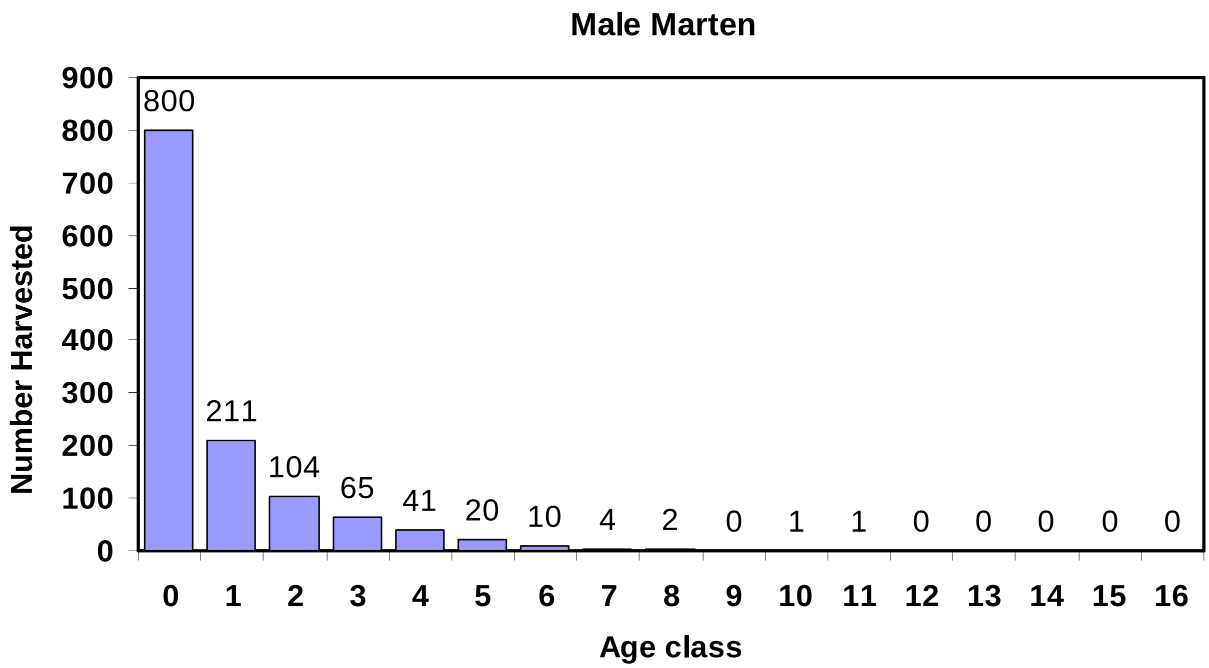

Figure 4. Age structure of male and female marten in the 2006-07 harvest.

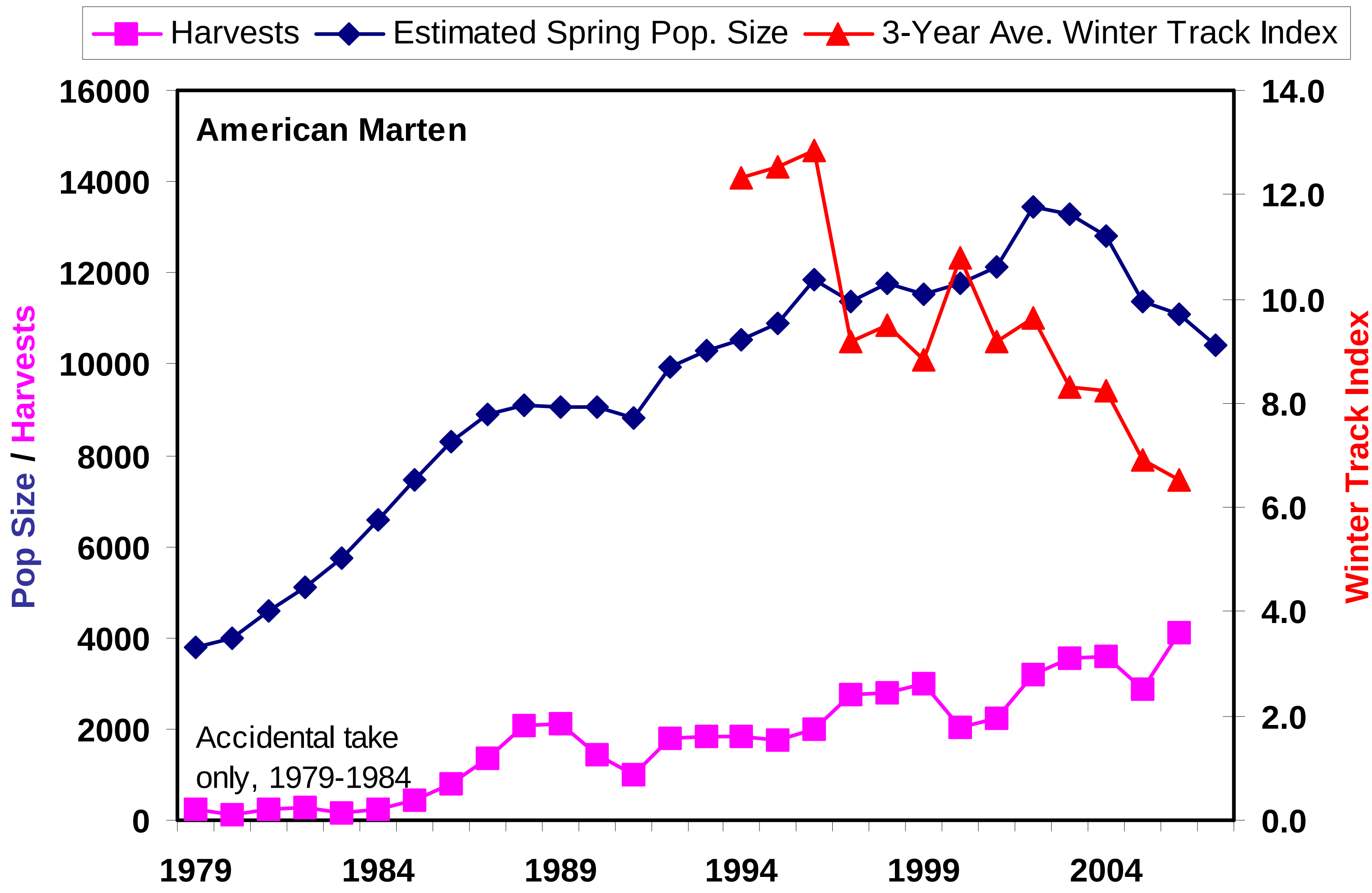

Figure 5. American marten populations, harvests, and survey indices, 1979-2007. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data, 1978 to 2006. 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]
1978	12/1-12/15	3	636	636	10	-	-	-	-	-	-	-	-	52	$59	$22
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	$42	$15

[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.

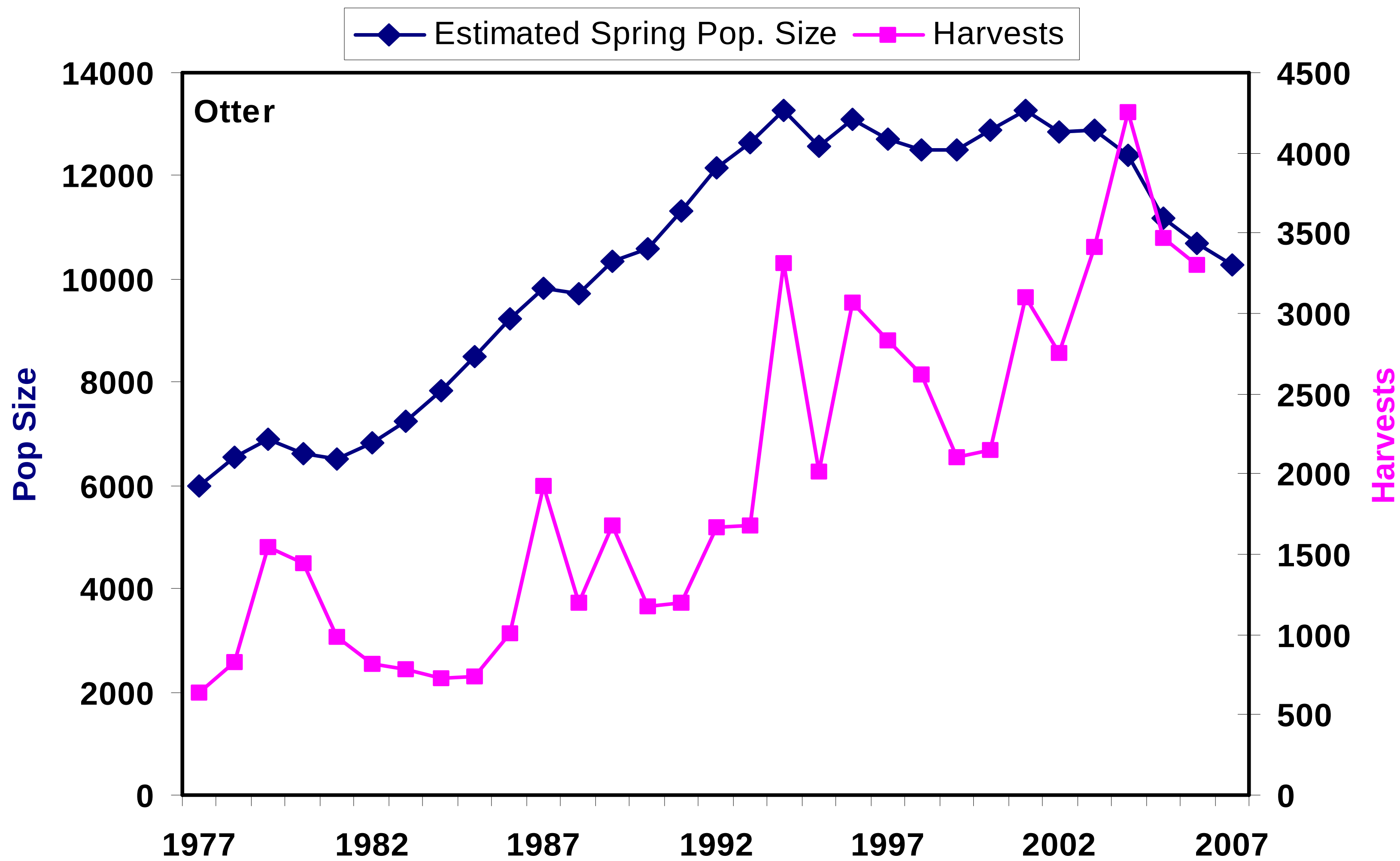

Figure 6. Otter populations and harvests, 1977-2006. Harvests include an estimate of non-reported take.

Population Trends Of White-Tailed Deer In The Forest Zone – 2007

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 2006 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.

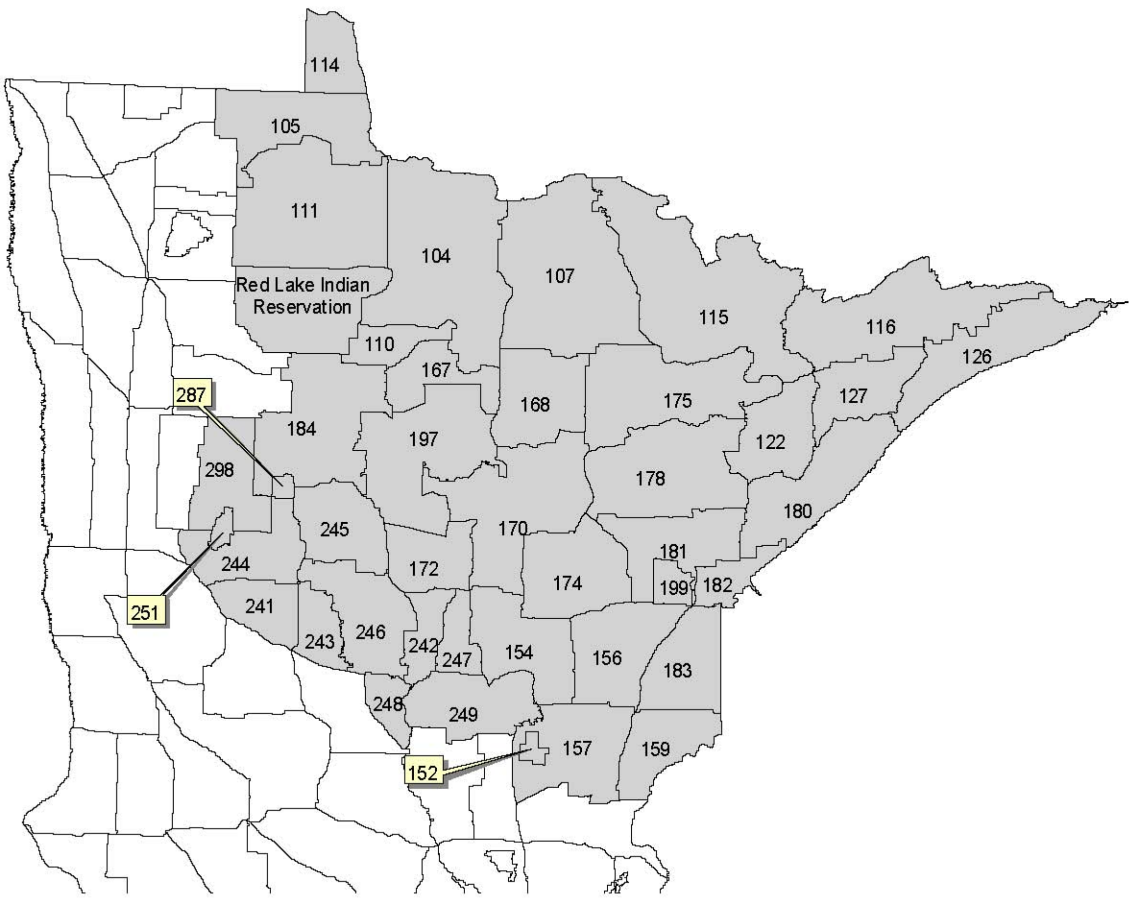

Figure 1. Permit areas in the forested zone, 2007. Permit areas 114, 152, 182, 287, and Red Lake Indian Reservation were not modeled.

HARVEST

In 2006, hunters registered 270,808 deer, the 2nd highest harvest ever recorded in Minnesota. Of that number, 51% or 137,963 deer were harvested in the forested zone (Figure 1, Table 1). The 2006 forest zone harvest increased 6% from the 2005 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 (Table 2, Figure 2). Most of the decrease in buck harvest occurred in the northern tier of permit areas and those in the south-central portion of the forest zone. The total forest zone buck harvest declined only 1% compared with an 11% decline the previous year (Table 2).

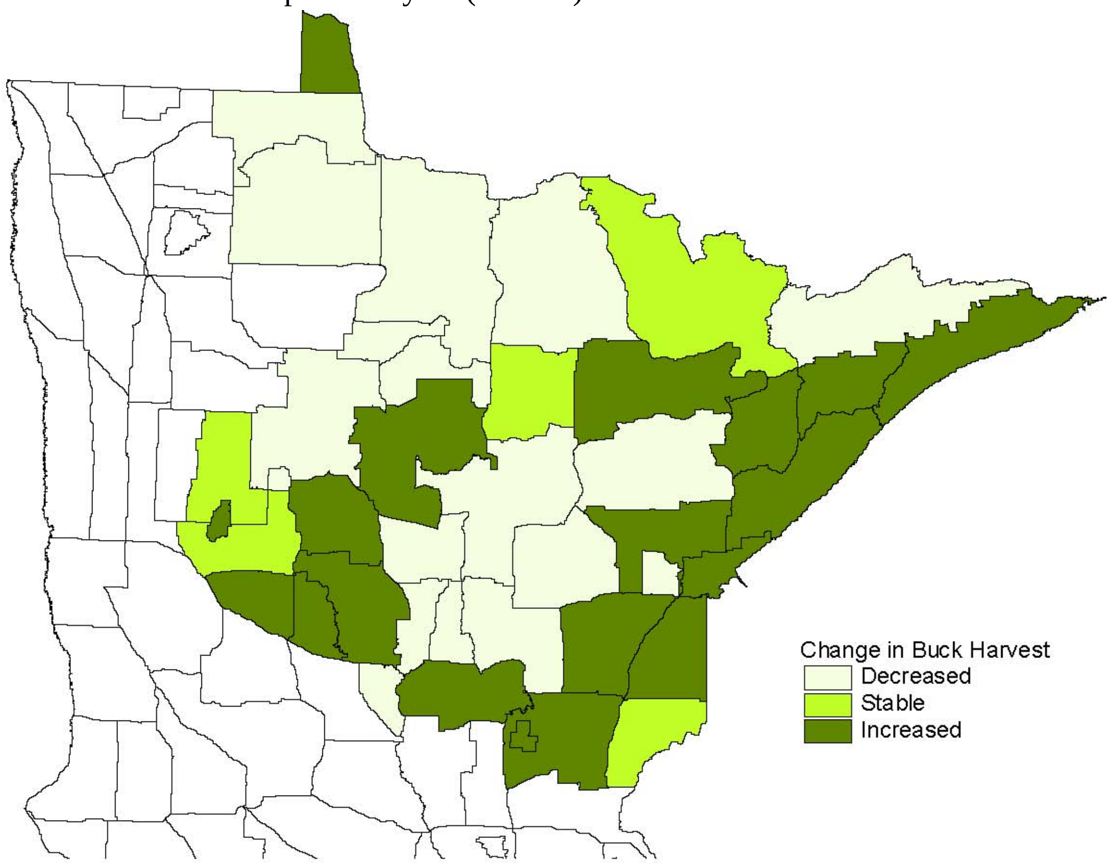

Figure 2. Change in buck harvest in forest zone permit areas between 2005 and 2006.

The antlerless harvest increased in 34 of the 42G permit areas (Table 3) and the total antlerless harvest increased 17%. The greatest increases occurred in permit areas that shifted from “lottery” into the “managed” category (mean=150%, range 91-308%), 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 = 28%, range 21-49%). Permit areas that remained in the “managed” category saw an average change of 6% (-22% to 21%) and permit areas that remained “intensive” averaged a 5% change (-21% to 26%).

The proportion of bucks in the harvest (forest-wide) dropped to 40%, the lowest proportion in recent history. This decline was expected because of the increased opportunity to harvest antlerless harvest. The buck hunter success in the forest also declined but calculation of this variable is becoming increasingly confounded by the increase in “All Season Licenses” which allows hunters the option of hunting outside Zones 1 and 2.

The archery harvest in the forest zone has steadily increased in recent years. Between 1992 and 1999, the archery harvest increased 12% to 2,954, an average of less than 2% per year. Since 1999, the archery harvest increased 225% to 9,598, an average of 32% per year. The muzzleloader harvest has made similar increases. In 1999, the muzzleloader harvest in the forest zone was only 420 deer. Since 1999, the muzzleloader harvest has increased 665% to 3,212. In both cases, the increases are the result of the introduction and steady increased sales of “All Season Licenses” that allow a hunter to kill deer during the archery, regular firearms, and muzzleloader seasons. Both the archery and muzzleloader harvests are linearly related to the number of All Season Licenses (archery: r^2=0.927, $P<0.001$; muzzleloader: r^2=0.652, $P=0.028$)

POPULATION TRENDS AND MODEL PROJECTIONS

Based on the winter severity index (WSI), the winter of 2006-07 was again mild throughout the forest zone with an average index of 45 (22 to 73). Sub zero temperatures occurred throughout the winter but were concentrated in February. Snow depths were generally below the 15” threshold until early March when 2 significant snowstorms occurred. Snow depths dropped below the threshold in mid to late March.

Simulation modeling was used in 38 permit areas (Figures 1 and Table 4) to approximate deer density, identify trends, and project the effect of the 2007-hunting season. To better summarize the results for this report, permit areas were lumped in to one of 5 regions (Figures 3 and 4). Deer density varied according to region with the lowest densities occurring in the Northeast (NE) and Northwest (NW). Highest densities occurred in the West Central (WC). 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, the declines in the South (S) and WC were a response to the high antlerless harvest. Although the antlerless harvest density in the central (C) permit areas increased 20% in 2006, it was well below that documented in the S and WC. This lower harvest explains, in part, why deer numbers in the central permit areas remained stable. The antlerless harvest in the NE and NW remained low and deer numbers, according to the model, are gradually increasing.

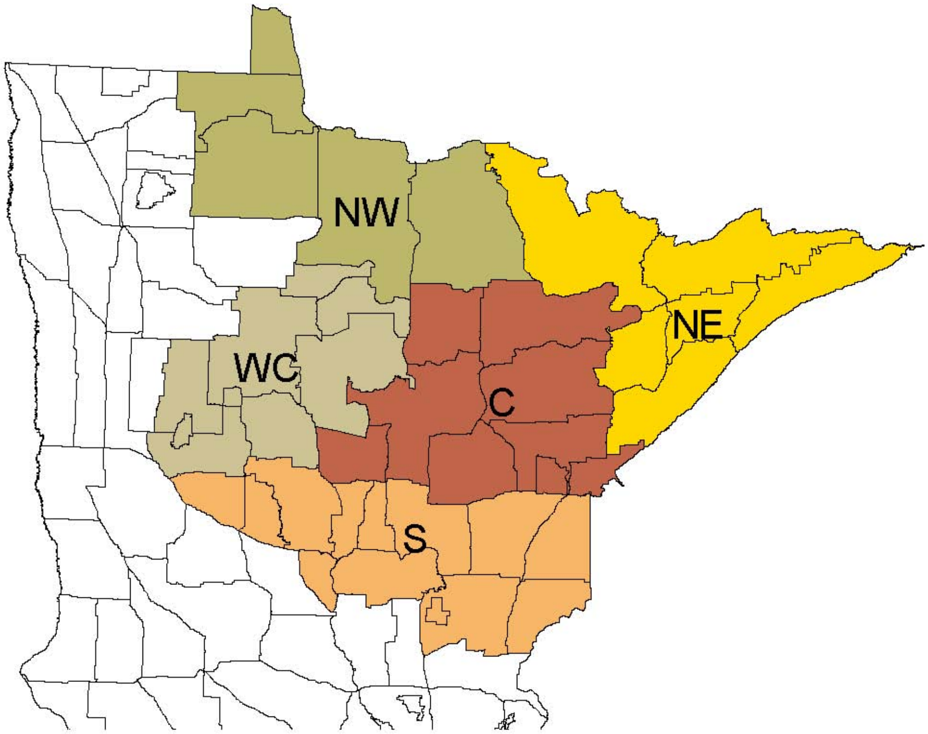

Figure 3. Permit areas grouped for summary discussion.

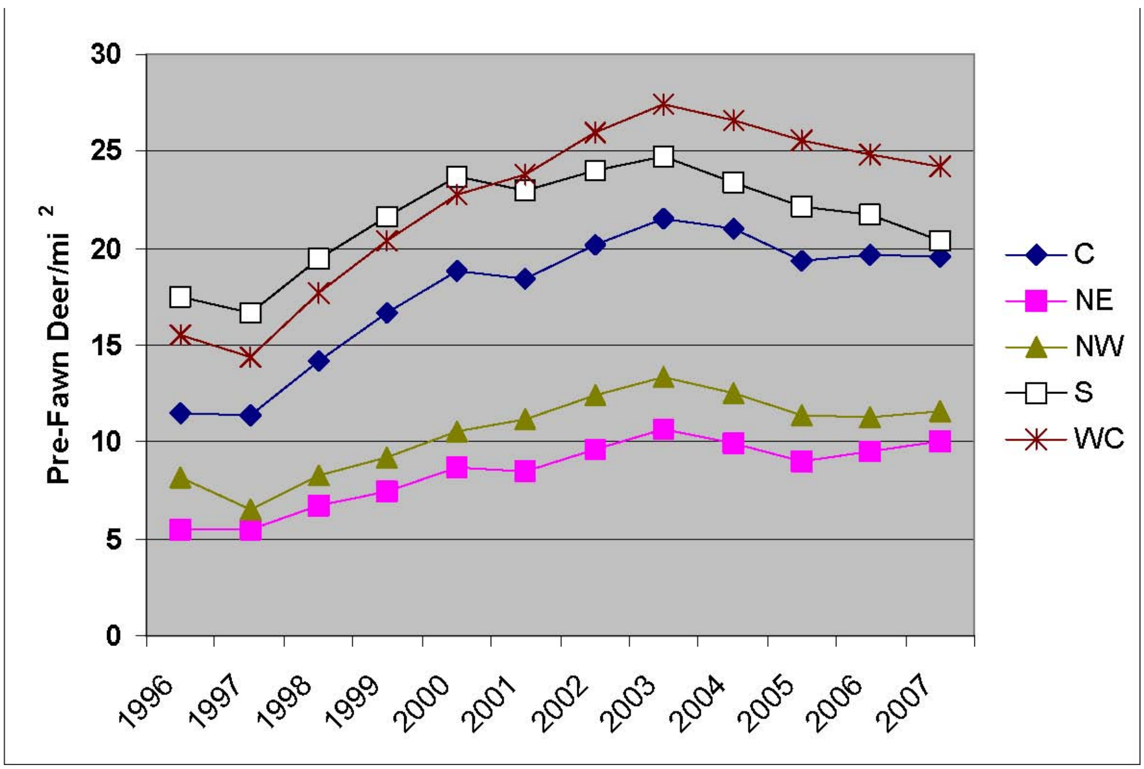

Figure 4. Population trends of deer in forest zone. Trend lines represent the groups of permit areas as illustrated in figure 3. Density represents pre-fawn density.

Based on density targets set during the 2005 and 2006 goal setting processes, the 2007 pre-fawn deer density was above goal over much of the forest zone (Figure 5). 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.

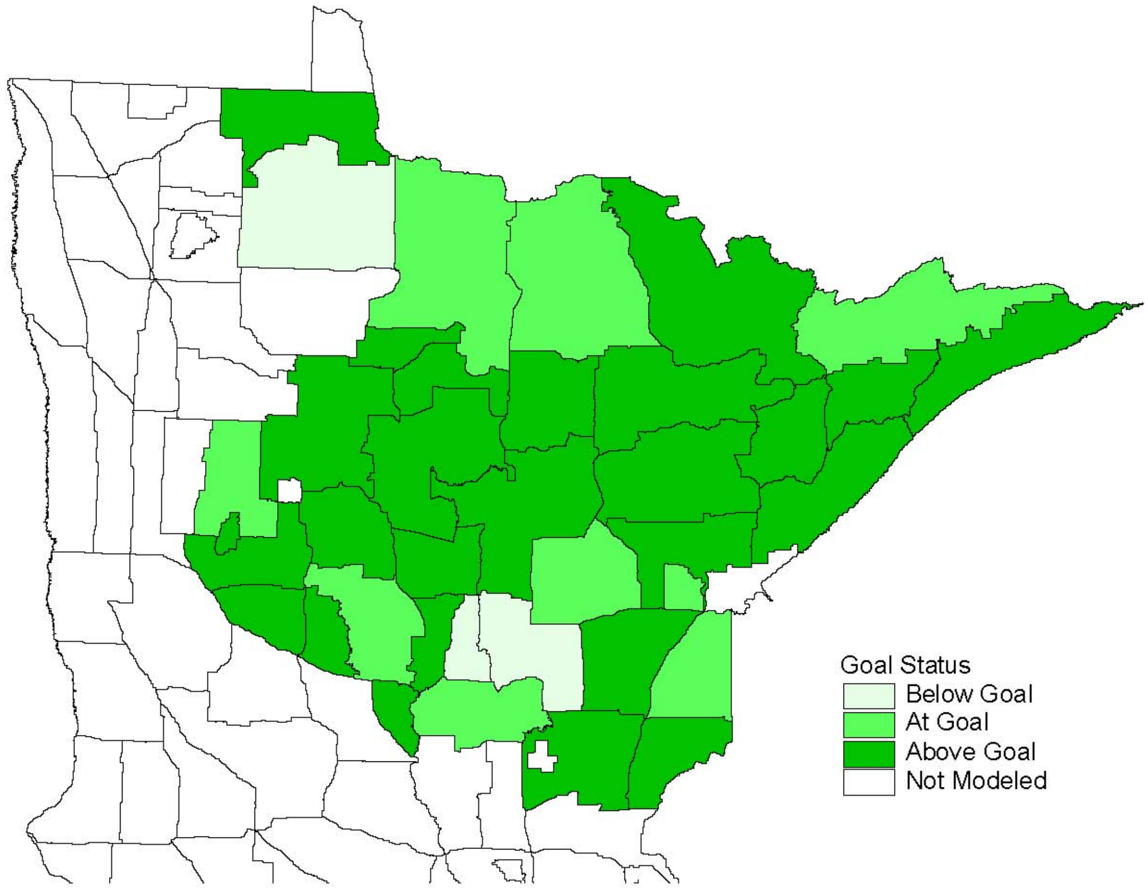

Figure 5. Deer density expressed relative to pre-fawn population goals.

Final classifications of permit areas for the 2007 season were based primarily on the absolute difference between the 2007 pre-fawn density and that prescribed by the goal setting process. Only 2 permit areas were classified as “Lottery” where hunters must apply for the limited number of antlerless permits. Twenty-one permit areas were classified as “Managed” where hunters may take up to 2 antlerless deer. Thirteen permit areas were classified as “Intensive” where hunters are allowed to harvest up to 5 antlerless deer and 6 additional permit areas were “Intensive” and include an early antlerless season in October.

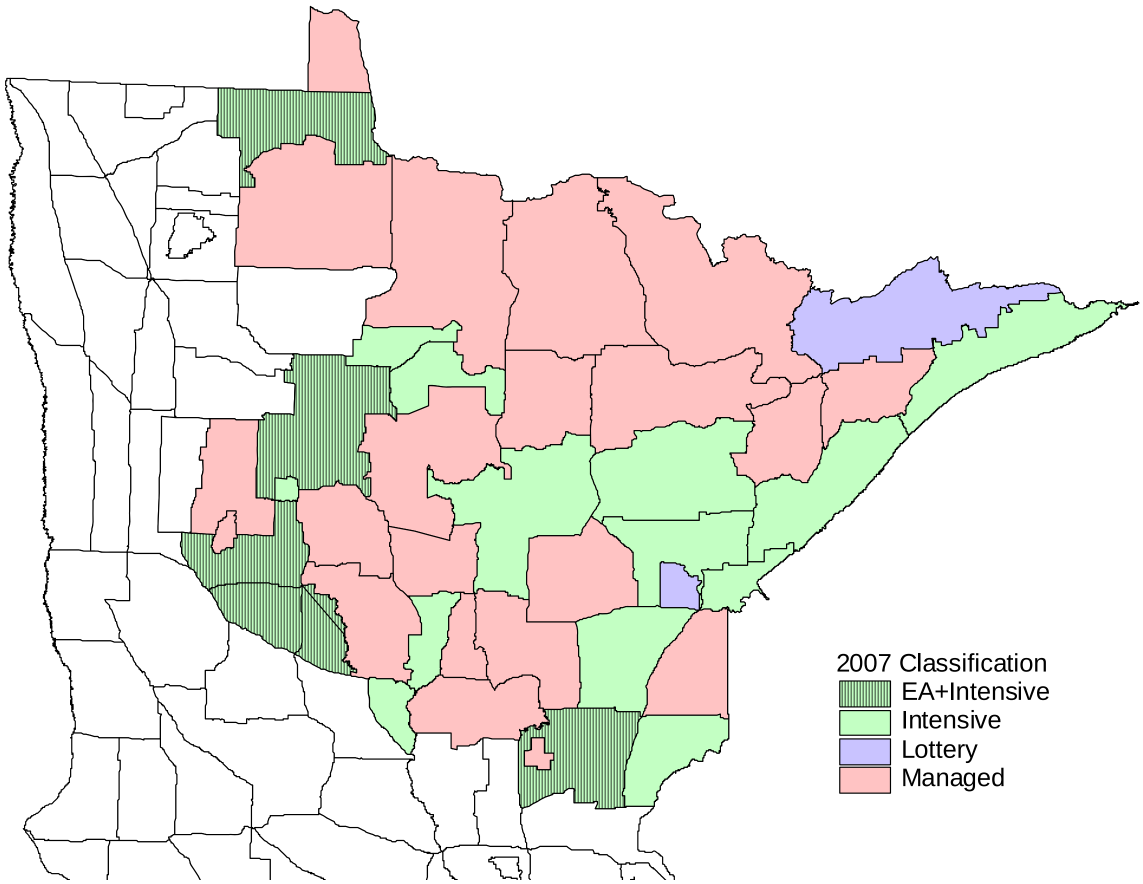

Figure 6. Final classification of permit areas in the 2007 hunting season.

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	Change
104	567	897	1,372	1,837	1,940	2,253	3,421	2,902	2,483	2,631	6%
105	876	1153	1,389	1,821	1,962	2,385	3,740	3,106	3,557	3,196	-10%
107	948	1,176	1,994	2,846	3,550	3,499	5,206	4,027	3,936	3,825	-3%
110	397	571	1,678	1,719	1,745	1,940	2,744	2,869	1,945	1,910	-2%
111	580	733	1,198	1,861	2,353	2,264	3,064	2,621	2,687	2,814	5%
114	52	39	40	55	72	80	96	110	123	174	41%
115	1,029	1,347	2,334	3,170	3,589	3,815	5,373	4,417	4,365	4,472	2%
116	100	146	138	150	162	157	264	295	261	276	6%
122	251	457	296	551	622	564	685	716	657	1067	62%
126	197	268	306	445	470	595	690	837	901	977	8%
127	63	83	176	81	99	108	146	165	148	188	27%
152	143	213	225	283	264	217	235	246	271	330	22%
154	1,370	1,952	2,977	4,415	4,168	5,032	5,717	5,176	4,571	4,533	-1%
156	1,546	2,109	2,646	3,753	3,036	3,246	4,935	4,583	4,466	4,750	6%
157	3,293	4,709	5,385	6,985	7,196	7,727	9,001	7,606	6,901	7,989	16%
159	2,312	3,493	3,971	5,070	4,167	3,934	5,028	3,871	3,672	3,603	-2%
167	338	599	1,452	1,601	1,971	2,488	1,572	1,463	1,257	1,738	38%
168	552	988	2,410	2,686	2,379	3024	3,218	3,978	2,521	3,622	44%
170	1,143	2,220	2,857	4,938	4,833	4,716	8,460	7,154	7,221	6,951	-4%
172	979	1,443	2,960	4,253	4,624	4,910	7,004	5,490	5,227	5,359	3%
174	754	1,371	1,927	2,436	2,141	2,678	3,811	3,346	3,091	3,152	2%
175	2,685	2,686	2,320	3,029	3,339	3184	5,034	4,254	3,103	4,458	44%
178	1,532	2,190	2,344	3,064	3,343	3,650	5,486	5,267	5,363	5,473	2%
180	550	932	927	1,471	1,654	1,811	3,030	2,278	2,802	3,495	25%
181	703	1,186	1,780	2,362	2,457	2,419	3,599	3,544	3,755	4,475	19%
182	240	405	614	827	862	869	1,309	1,206	1,256	1,460	16%
183	598	1,003	2,147	2,748	2,743	2,771	3,960	3,533	3,449	4,006	16%
184	1,977	2,777	5,803	6,940	7,389	8,424	12,488	11,560	11,482	10,261	-11%
197	407	597	933	1,372	1,167	1,413	1,652	1,723	1,594	2,471	55%
199	58	87	130	169	166	164	140	172	188	167	-11%
241	3568	2919	2651	4284	3927	3857	4549	4449	4,288	4,372	2%
242	1,112	1,316	1,572	1,849	2,069	2,426	2,767	2,244	2,116	2,170	3%
243	1,268	1,602	1,908	2,634	2,864	3,238	4,131	3,684	3,165	3,429	8%
244	2,034	2,396	2,952	3,862	4,841	5,805	7,452	6,702	6,162	6,192	0%
245	1,021	1,657	3,524	4,838	5,056	5,626	8,231	6,377	5,737	6,115	7%
246	2,254	2,847	3,358	4,760	5,150	5,149	7,530	6,782	5,835	6,389	9%
247	1,139	1,348	1,611	1,894	2,119	2101	2,744	2,582	2,115	2,393	13%
248	564	943	850	1,039	881	1,352	1,897	1,864	1,670	1,280	-23%
249	1,110	1,514	2,217	2,826	3,149	3,238	4,223	3,800	3,211	3,643	13%
251	231	255	246	326	254	298	470	387	325	299	-8%
287	313	314	368	376	460	470	529	425	280	305	9%
298	326	516	704	803	826	932	1988	1733	1664	1727	4%
Forested Zone	41,179	55,458	76,689	102,429	106,060	114,829	157,619	139,544	129,821	138,137	6%

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	Change
104	565	887	1,137	1,240	1,266	1,332	1,589	1,586	1,250	1,176	-6%
105	484	730	846	945	813	1,138	1,489	1,326	1,364	1,122	-18%
107	942	1,160	1,706	1,948	2,174	2,119	2,523	2,277	1,861	1,725	-7%
110	372	511	818	904	926	914	1,089	1,119	694	658	-5%
111	552	719	1,113	1,350	1,474	1,463	1,467	1,408	1,312	1,149	-12%
114	52	39	40	43	56	63	55	55	72	95	32%
115	1,009	1,316	1,898	2,036	2,145	2,371	2,894	2,663	2,254	2,235	-1%
116	100	144	138	150	156	157	238	249	230	188	-18%
122	242	447	293	415	452	441	490	567	534	565	6%
126	183	250	306	390	417	493	582	587	594	606	2%
127	62	81	176	80	82	93	126	145	126	147	17%
152	89	127	173	191	182	130	106	152	141	158	12%
154	984	1,437	2,017	2,304	2,142	2,169	2,071	2,049	1,783	1,674	-6%
156	1,081	1,531	1,836	2,066	1,680	1,645	1,989	1,996	1,793	1,871	4%
157	1,988	2,675	3,099	3,327	3,143	3,047	3,207	3,030	2,745	2,916	6%
159	1,428	1,867	1,980	2,412	1,773	1,605	1,916	1,514	1,467	1,479	1%
167	327	585	906	1,036	968	1,211	821	819	709	692	-2%
168	543	973	1,579	1,653	1,454	1,675	1,698	1,889	1,432	1,439	0%
170	1,135	2,109	1,609	3,106	2,787	2,611	3,435	3,233	2,987	2,920	-2%
172	896	1,175	1,820	2,292	2,260	2,200	2,359	2,147	1,853	1,803	-3%
174	702	1,224	1,234	1,446	1,255	1,361	1,541	1,596	1,367	1,304	-5%
175	810	1,273	1,917	2,107	2,072	2,113	2,463	2,319	2,072	2,190	6%
178	895	1,363	1,945	2,052	2,012	2,212	2,638	2,756	2,698	2,500	-7%
180	497	854	922	1,169	1,325	1,357	1,775	1,781	1,664	1,799	8%
181	625	1,060	1,351	1,596	1,562	1,590	1,943	1,940	1,779	1,998	12%
182	214	364	484	577	564	568	685	684	511	520	2%
183	537	902	1,633	1,919	1,650	1,575	1,661	1,654	1,514	1,634	8%
184	1,873	2,421	3,680	3,952	3,673	4,095	4,287	4,542	4,161	3,554	-15%
197	403	585	923	1,142	953	998	1,040	1,143	999	1,090	9%
199	58	87	91	137	123	132	104	130	151	119	-21%
241	1008	1175	1030	1382	1396	1477	1559	1621	1,460	1,507	3%
242	583	704	880	1,071	959	824	912	740	721	692	-4%
243	752	957	1,082	1,192	1,169	1,247	1,343	1,217	1,066	1,142	7%
244	1,159	1,452	1,848	2,105	2,040	2,300	2,540	2,390	2,170	2,154	-1%
245	973	1,480	2,216	2,492	2,180	2,430	2,743	2,449	2,036	2,230	10%
246	1,338	1,701	1,954	2,300	2,041	2,384	2,599	2,527	2,082	2,178	5%
247	598	722	902	1,098	982	948	1,047	955	861	848	-2%
248	176	365	541	550	430	720	694	739	641	466	-27%
249	668	1,045	1,310	1,590	1,479	1,429	1,479	1,327	1,261	1,281	2%
251	94	110	129	134	152	132	176	183	128	145	13%
287	70	127	167	189	201	184	207	182	106	104	-2%
298	326	492	601	648	685	654	952	894	810	799	-1%
Forested Zone	27,393	39,226	50,331	58,736	55,254	57,607	64,532	62,580	55,459	54,872	-1%

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	Change
104	2	10	235	597	674	921	1,832	1,316	1,233	1,455	18%
105	392	423	543	876	1,149	1,247	2,251	1,780	2,193	2,074	-5%
107	6	16	288	898	1,376	1,380	2,683	1,750	2,075	2,100	1%
110	26	60	860	815	819	1,026	1,655	1,750	1,251	1,252	0%
111	28	14	85	511	879	801	1,597	1,213	1,375	1,665	21%
114	0	0	0	12	16	17	41	55	51	79	55%
115	20	31	436	1,134	1,444	1,444	2,479	1,754	2,111	2,237	6%
116	392	423	543	876	1,149	1,247	2,251	1,780	2,193	2,074	-5%
122	9	10	3	136	170	123	195	149	123	502	308%
126	14	18	0	55	53	102	108	250	307	371	21%
127	1	2	0	1	17	15	20	20	22	41	86%
152	54	86	52	92	82	87	129	94	130	172	32%
154	386	515	960	2,111	2,026	2,863	3,646	3,127	2,788	2,859	3%
156	465	578	810	1,687	1,356	1,601	2,946	2,587	2,673	2,879	8%
157	1,305	2,034	2,286	3,658	4,053	4,680	5,794	4,576	4,156	5,073	22%
159	884	1,626	1,991	2,658	2,394	2,329	3,112	2,357	2,205	2,124	-4%
167	11	14	546	565	1,003	1,277	751	644	548	1,046	91%
168	9	15	831	1,033	925	1,349	1,520	2,089	1,089	2,183	100%
170	8	111	1,248	1,832	2,046	2,105	5,025	3,921	4,234	4,031	-5%
172	83	268	1,140	1,961	2,364	2,710	4,645	3,343	3,374	3,556	5%
174	52	147	693	990	886	1,317	2,270	1,750	1,724	1,848	7%
175	1,875	1,413	403	922	1,267	1,071	2,571	1,935	1,031	2,268	120%
178	637	827	399	1,012	1,331	1,438	2,848	2,511	2,665	2,973	12%
180	53	79	5	302	329	454	1,255	497	1,138	1,696	49%
181	78	126	429	766	895	829	1,656	1,604	1,976	2,477	25%
182	26	41	130	250	298	301	624	521	745	940	26%
183	62	101	513	829	1,093	1,197	2,299	1,879	1,935	2,372	23%
184	103	356	2,123	2,988	3,716	4,329	8,201	7,018	7,321	6,707	-8%
197	4	12	10	230	214	415	612	580	595	1,381	132%
199	0	0	39	32	43	32	36	42	37	48	30%
241	2,560	1,744	1,621	2,902	2,531	2,380	2,990	2,828	2,828	2,865	1%
242	528	612	692	778	1,110	1,602	1,855	1,504	1,395	1,478	6%
243	516	645	826	1,442	1,695	1,991	2,788	2,467	2,099	2,287	9%
244	875	944	1,104	1,757	2,801	3,505	4,912	4,312	3,992	4,038	1%
245	48	177	1,308	2,346	2,876	3,196	5,488	3,928	3,701	3,885	5%
246	916	1,146	1,404	2,460	3,109	2,765	4,931	4,255	3,753	4,211	12%
247	541	626	709	796	1,137	1,153	1,697	1,627	1,254	1,545	23%
248	388	578	309	489	451	632	1,203	1,125	1,029	814	-21%
249	442	469	907	1,236	1,670	1,809	2,744	2,473	1,950	2,362	21%
251	137	145	117	192	102	166	294	204	197	154	-22%
287	243	187	201	187	259	286	322	243	174	201	16%
298	0	24	103	155	141	278	1,036	839	854	928	9%
Forested Zone	13,778	16,204	25,835	42,198	48,750	54,922	88,546	73,852	71,023	83,265	17%

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	Change
104	2,078	6.3	6.4	7.3	7.8	8.7	9.4	8.6	7.9	7.9	8.1	3%
105	766	20.5	23.5	27.2	30.2	33.9	36.9	37.1	34.8	34.8	36.0	3%
107	1,895	8.9	10.5	12.0	11.9	13.0	14.0	12.6	10.9	11.1	11.5	4%
110	300	19.5	23.2	24.4	24.8	26.9	28.2	27.7	26.1	24.9	24.0	-4%
111	1,707	4.5	4.8	5.6	6.1	6.5	6.9	6.2	5.5	5.2	4.8	-8%
115	1,872	9.7	11.2	13.2	13.0	14.8	16.3	14.5	13.0	14.2	15.2	7%
116	1,158	2.2	2.2	2.6	2.4	2.8	3.2	3.2	2.8	2.8	3.2	14%
122	620	4.6	5.0	5.8	5.7	6.5	7.2	6.7	6.0	6.7	7.1	6%
126	941	8.2	8.3	9.3	8.6	9.7	10.9	10.7	9.2	8.8	9.6	9%
127	561	4.6	5.0	5.8	5.7	6.5	7.2	6.7	6.0	6.7	7.1	6%
154	760	13.3	15.5	17.2	17.0	17.7	17.4	16.1	14.9	14.2	13.1	-8%
156	826	14.2	15.6	16.9	16.6	17.8	19.0	18.2	17.5	17.0	15.7	-8%
157	889	18.4	20.3	22.6	22.5	23.2	23.2	21.6	20.7	20.7	19.2	-7%
159	568	21.3	22.6	23.4	21.1	21.2	21.7	20.2	20.1	20.2	20.1	0%
167	432	19.3	19.5	21.0	21.5	22.0	20.9	19.6	18.2	18.7	18.6	-1%
168	724	13.6	15.9	16.7	15.6	16.8	17.0	16.8	14.8	15.5	14.9	-4%
170	1,315	16.4	19.2	22.2	21.6	23.6	25.6	24.7	23.5	23.5	23.7	1%
172	451	24.2	30.5	35.2	34.4	36.8	38.3	34.8	31.5	29.9	27.4	-8%
174	836	10.7	12.3	13.7	13.3	14.7	15.5	14.8	13.6	13.6	13.5	-1%
175	1,276	10.6	12.3	13.7	13.2	14.1	14.9	14.3	12.9	13.7	13.8	1%
178	1,267	12.8	15.3	17.7	17.9	20.1	22.0	22.4	20.8	21.4	22.3	4%
180	982	7.7	8.7	10.2	10.5	11.6	12.8	12.5	12.0	12.4	12.2	-2%
181	856	16.6	19.0	21.5	21.3	23.3	25.3	25.3	23.1	23.7	23.2	-2%
183	663	18.6	21.4	23.2	22.3	23.8	25.1	23.8	21.1	20.8	19.3	-7%
184	1,232	16.7	20.4	23.4	25.0	27.9	30.3	29.3	28.3	26.4	25.5	-3%
197	975	12.1	12.9	13.8	13.6	14.8	15.3	15.7	15.5	15.7	15.1	-4%
241	417	32.4	35.2	40.1	39.8	42.4	44.7	45.4	45.2	45.9	47.4	3%
242	215	26.0	28.4	30.7	29.5	30.6	30.6	28.0	25.9	24.6	21.9	-11%
243	314	28.4	32.4	36.8	36.3	38.9	39.8	37.7	35.9	35.3	33.2	-6%
244	586	24.1	27.9	32.3	35.0	38.3	40.0	38.9	37.3	36.3	35.8	-1%
245	583	22.5	27.4	31.1	32.3	34.7	36.2	32.9	30.7	29.4	27.3	-7%
246	772	21.0	23.4	25.8	24.5	24.9	25.9	24.2	22.6	22.1	20.1	-9%
247	231	26.0	28.4	30.7	29.5	30.6	30.6	28.0	25.9	24.6	21.9	-11%
248	212	19.5	21.1	22.9	21.4	23.1	24.4	23.4	21.9	20.9	18.6	-11%
249	502	13.8	15.8	17.4	16.7	17.4	17.8	16.3	14.9	14.5	12.8	-12%
251	55	16.0	17.5	19.2	19.0	20.7	22.2	20.6	19.8	20.0	21.0	5%
298	619	16.0	17.6	19.4	20.3	22.3	25.0	25.0	24.8	25.3	26.4	4%
Forest Zone	30,456	13.1	14.9	16.7	16.7	18.1	19.2	18.3	17.1	17.1	16.8	-1%

2007 Aerial Moose Survey

Mark S. Lenarz, Forest Wildlife Populations and Research Group

INTRODUCTION

Each year, we conduct one or more aerial surveys in northern 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. These data are subsequently used in simulation model(s) to identify population trends and the harvestable surplus.

NORTHEAST

METHODS

Moose numbers and age/sex ratios were estimated by flying transects within a stratified random sample of survey plots (Figure 1). As in 2006, all survey plots were rectangular (5 x 2.67 mi.) and all transects were oriented east to west. The survey was conducted using Bell Jet Ranger and Enstrom helicopters flown by DNR Enforcement pilots. Moose were sexed using the presence of antlers, size and shape of the bell, nose color and/or vulval patch (Mitchell 1970), and calves were identified on the basis of size and behavior. UTM coordinates for all moose observed within the plots were recorded. A suite of covariates was recorded each time moose were located, including environmental variables (temperature, snow depth, wind speed), group size, cover type, and the amount of visual obstruction.

Moose observations were "corrected" using a sightability model (Ackerman 1988, Anderson and Lindzey 1996, Otten et al. 1993, Quayle et al. 2001, Samuel et al. 1987). The model was based on moose that were radio-collared as part of research on the population dynamics of the northeastern moose population. These radio-collared moose were periodically located during the survey using fixed-wing aircraft. Test plots (one-half of a rectangular plot) were then identified that contained 1 or more radio-collared moose. The test plots were surveyed with the helicopter using the same protocol as on regular survey plots. If radio-collared moose known to be in the test plot were not observed from transects, they were located using telemetry following completion of the plot. Each time a radio-collared moose was located, the aforementioned suite of covariates was collected. Logistic regression was used to revise the sightability model each year between 2004 and 2007 with the incorporation of that year's data. The revised sightability model for 2007 was used to recalculate the population estimates, bull:cow and calf:cow ratios from the 2004, 2005, and 2006 surveys.

RESULTS

The survey was initiated on 8 January and completed on 24 January. Survey conditions were rated as "Good" (highest rank) on 22 plots, "Marginal" on 17 plots, and "Poor" on 1 plot. Snow conditions for the survey were marginal and only 3 plots had more than 8" of snow on the ground. During the survey flights, 420 moose were located on the 40 plots (532 mi^2) and included 166 bulls, 190 cows, 52 calves, and 12 unidentified moose.

Forty-nine radio-collared moose were located in 38 test plots; 19 were observed from transects and 30 were located using telemetry. These data were combined with data from 2004-2006 to revise the sightability model. The model with the highest predictive reliability incorporated a single covariate, the amount of visual obstruction (VOC) (Giudice and Fieberg, unpubl.). The inverse of the detection probability calculated with this model (theta) was used to "correct" the number of moose every time that moose were observed during the survey.

Based on the moose observed on the survey plots and "corrected" by the sightability model, the estimated moose population in northeastern Minnesota numbered 6,460±1,698 (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.29 and 0.85, respectively (Table 1).

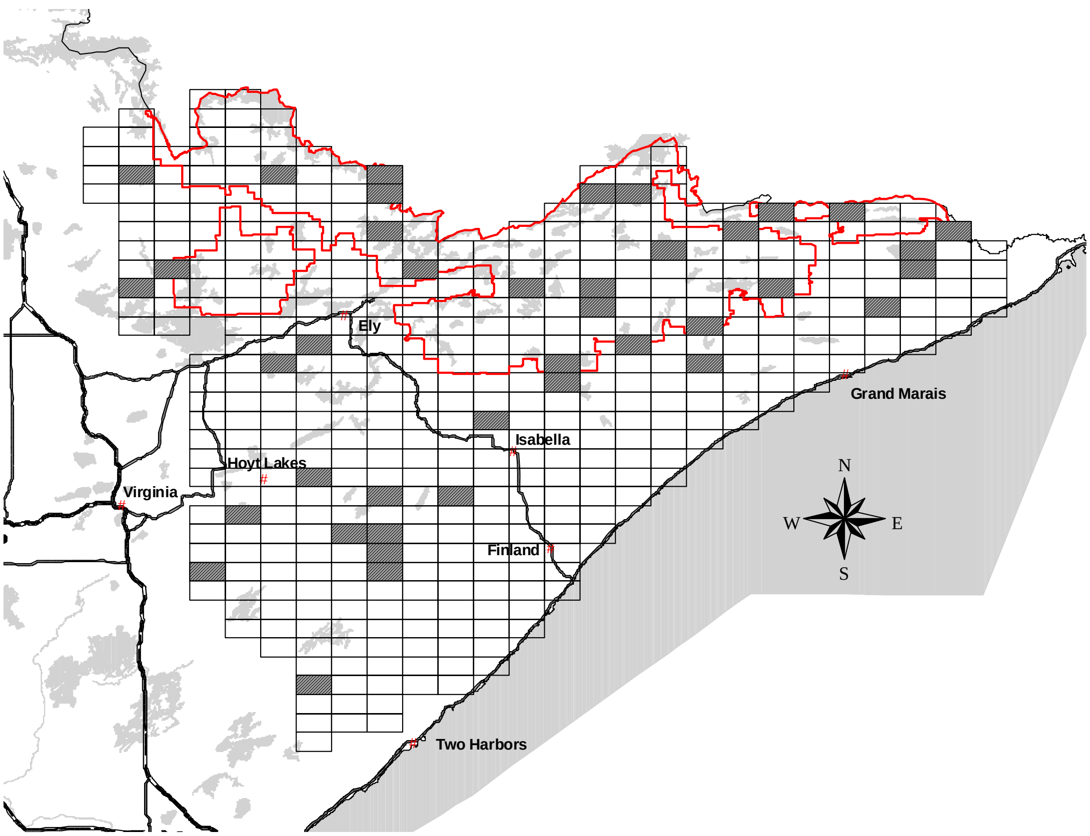

Figure 1. Northeast moose survey area and sample plots (diagonal lines) flown in the 2007 aerial moose survey.

DISCUSSION

We have used the sightability model approach for 4 years to estimate 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=24.2, *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 in 2005, 2006, and 2007 and as a result, population estimates were more comparable. Because of this bias, estimates for 2004 are not included in subsequent analyses.

Prior to 2004, a sightability correction factor (SCF, Gasaway et al. 1986) was used to correct the population estimates. During the period 1997-2003, SCF averaged 1.35 (1.14 to 1.87). In the last 3 years, the mean value for theta (the inverse of the detection probability and a number equivalent to SCF) averaged 1.91 (1.72-2.07). The difference between the pre-sightability model SCF values and estimates of theta implies that some portion of the moose were missed in the intensive surveys used to calculate SCF and that moose population estimates prior to 2004 were likely biased low.

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
1997	3,960 ±35%	0.49	1.57	1
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	13,137±37%	0.41	1.24	4
2005	7,815±31%	0.52	1.05	9
2006	8,382±28%	0.34	1.09	5
2007	6,460±26%	0.29	0.85	3

The 2007 population estimate was 23% lower than the 2006 estimate. It is tempting to infer that this decline reflects the 34% annual mortality as measured in the telemetry study in 2006 (Lenarz unpublished). The overlap in confidence intervals (Table 1, Figure 2), however, indicates that there was no statistical difference between the 2006 and 2007 point estimates.

The calf:cow ratio estimated from the 2007 survey (Table 1) was significantly lower than the average estimated in the previous 21 years ($\bar{x}$ = 0.57, *t*=8.02, *P*<0.001). The calf:cow ratios since 2004 when we changed to a sightability model were significantly lower than previous estimates (*t*=2.43, *P*=0.024). This change is not likely an artifact of the sightability model. If cows without calves were located at sites with higher VOC, their numbers would be inflated relative to numbers of cows with calves and the ratio would decline. There was, however, no difference (F=1.87, *P*=0.155) in VOC between cows with or without calves in any year

The perception of reduced cow:calf ratios was likely an artifact of switching to a helicopter on the survey. The inherent maneuverability of the helicopter allows observers a much better opportunity to classify moose. As a result, the proportion of unclassified moose dropped significantly (t=8.07, P<0.001) since we began using a helicopter. Prior to 2004, an average of 13% moose were not classified; in the last 3 years, the average had dropped to only 3%. If the cow:calf ratio is recalculated under the assumption that unclassified animals were evenly split between cows and bulls, the pre-2004 estimates decline an average of 0.12. There was no difference (t=1.43, P=0.167) between pre and post 2004 recalculated values of cow:calf ratio.

The proportion of cows accompanied by twins was significantly lower ($\bar{x}$=3.2%, t =3.4, P=0.002) in 2007. Even when 50% of unclassified moose were included as cows in the calculation of the proportion twins, the values for 2007 remained significantly lower ($\bar{x}$=3.1%, t =2.8, P=0.006). 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 average estimated for the previous 21 years($\bar{x}$ = 1.19, t=4.99, P<0.001). This is true, even when recalculated after splitting the unclassified moose. The hunter harvest has been heavily biased towards bulls in recent years (Lenarz, unpubl.), but the 2006 bull harvest (169) represented less than 7% of the estimated number of bulls in the population in most years. This level of bull harvest should have little impact on estimates of bull:cow ratio at the population level. It has been speculated that reproduction would decline if the bull:cow ratio declines below some unspecified level (e.g. Rausch 1974). Thompson (1991), however, found no relationship between calf:cow and bull:cow ratios. With a bull:cow ratio consistently near 1 as has been estimated for northeastern Minnesota, it is likely that there should be sufficient numbers of bulls to breed all cows.

In the January survey, 11% of the moose exhibited hair loss, which is indicative of infestation with the winter tick (*Dermacentor albipictus*). In 2006, only 3% 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.

NORTHWEST

METHODS

As in the northeast, moose numbers and age/sex ratios were estimated by flying transects within a stratified random sample of survey plots (Figure 2). All survey plots were rectangular (5 x 2.67 mi.) and transects were oriented east to west. Prior to the survey, DNR Wildlife managers identified all plots thought to contain moose and only those plots were sampled. The survey was conducted using a Cessna 185 flown by a DNR Enforcement pilot. Moose were sexed using the presence of antlers, shape of the bell, nose color and/or vulval patch (Mitchell 1970), and calves were identified on the basis of size and behavior. UTM coordinates for all moose observed within the plots were recorded. Population estimates were "corrected" using a SCF (Gasaway et al. 1986). The SCF is the ratio of moose observed during intensive surveys of 2 mi^2 subplots to moose observed during the standard search.

RESULTS

The northwest survey was delayed by a lack of snow and did not begin until 10 March and was completed on 13 March. Snow depth was moderate with at least 8 inches on the ground with 100% coverage. The survey was flown with 1 airplane and survey crew and survey conditions were classified as marginal (23 plots) to poor (2 plots). During the survey flights, only 18 moose were located on 25 plots (333 mi^2) and included 2 bulls, 6 cows, 4 calves, and 6 unidentified moose. Based on the moose density observed on these plots, the estimated population in the northwest was 84 ± 48 moose (Table 2). The survey estimated ratios of 0.67 calves/cow and 0.33 bulls/cow (Table 2). Circular subplots on 11 of 25 survey plots were re-surveyed and the estimated SCF was 1.00 ± 0%.

DISCUSSION

This year's survey estimated a total of 84 moose within the northwest survey area (Figure 2, Table 2). This estimate is down 69% from the 2003 survey. The fact that so few moose (18) were observed in plots thought to contain moose implies that this decline is real. Survey plots were fairly evenly spread throughout the area (Figure 2) and with the exception of 3 moose located on Agassiz NWR, all remaining moose were located on the western half of the survey area.

Precision of the survey estimate improved over that calculated for the 2003 survey. This improvement was likely the result of restratification prior to the survey. When so few survey plots contain moose, it would be difficult to improve precision, especially when moose are clustered onto only a few plots.

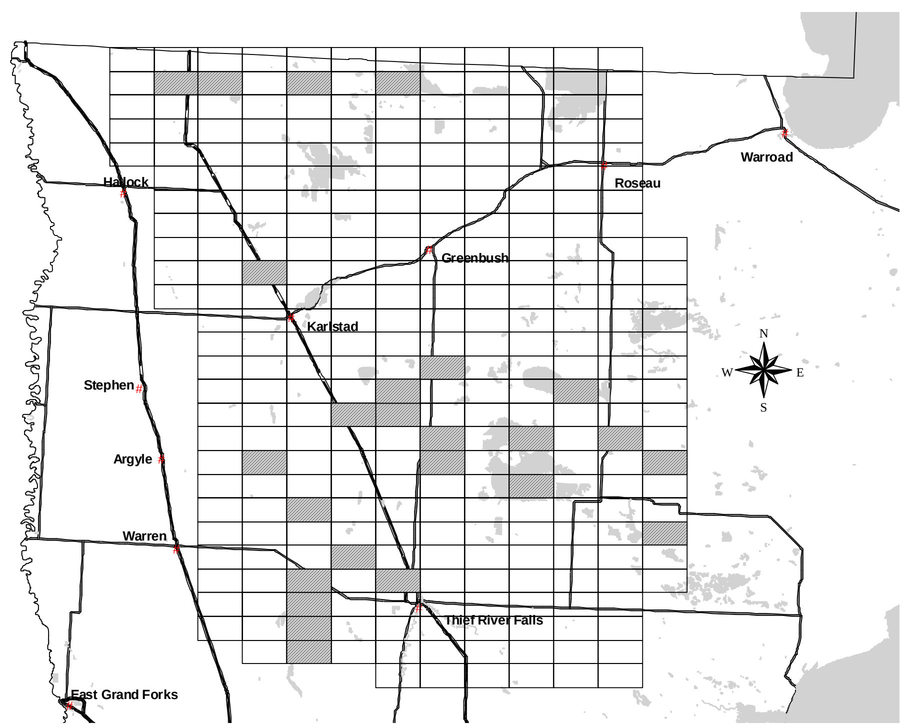

Figure2. Northwest moose survey area and sample plots (diagonal lines) flown in the 2007 aerial moose survey.

Table 2. Estimated moose numbers, calves/ cow, and bulls/cow from aerial surveys in northwestern Minnesota.

Survey	Estimate	Calves:Cow	Bulls:Cow	% Cows w/ Twins
1997	1170 ± 31%	0.80	0.87	11
1998	No Survey			
1999	1160 ± 33%	0.48	1.29	8
2000	560 ± 42%	0.48	1.18	0
2001	883 ± 29%	0.48	1.65	3
2002	No Survey			
2003	237 ± 73%	0.47	1.69	0
2004	No Survey			
2005	No Survey			
2006	No Survey			
2007	84 ± 58%	0.67	0.33	0

The calf:cow ratio (Table 2) increased from previous surveys but is likely biased high by the high proportion of moose that were not classified (33%). If we assume that half of the unclassified moose were cows, the calf:cow ratio drops to 0.44, a number very similar to previous surveys.

Over the past 13 surveys, twin calves accompanied an average of 6% of the cows observed in the northwest survey. In this year's survey, no twins were observed.

The bull:cow ratio (Table 2) in this year's survey was the lowest ever recorded for northwestern Minnesota. Even if unclassified moose were evenly split between bulls and cows, the bull cow ratio increases to only 0.55, a value well below historical estimates.

Considering the low moose population in northwestern Minnesota, I recommend that we stop conducting a formal aerial survey unless anecdotal information suggests a major increase in numbers.

ACKNOWLEDGMENTS

These surveys would not be possible without the excellent partnership between the Division of Enforcement, the Division of Fish and Wildlife, the Fond du Lac Band and the 1854 Treaty Authority. In particular, I would like to thank Mike Trenhom for coordinating all of the aircraft and pilots; Dan Litchfield (northeast) and Marshall Deters (northwest) for coordinating flights and survey crews; and Mike Schrage (Fond du Lac) and Andy Edwards (1854 Treaty Authority) for securing supplemental survey funding from their respective groups. I want to thank Enforcement pilots Mike Trenholm, John Heineman, Brad Maas, Al Buchert, and Tom Buker for their skill in piloting aircraft during the surveys. I also want to thank Dan Litchfield, Tom Rusch, Andy Edwards, Mike Schrage, Kevin Carlisle, Marshall Deters, Christine Reisz, Doug Franke and Eric Nelson who flew as observers; it takes dedication and a strong stomach. I thank John Fieberg and John Giudice for their analyses in creating and applying the sightability model. Finally, I want to thank Barry Sampson for the creating the process to generate the GIS survey maps and GPS coordinates.

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