FOREST WILDLIFE POPULATIONS

Forest Wildlife Populations & Research Group
1201 E. Hwy 2
Grand Rapids, MN 55744
(218) 327-4432

Ruffed grouse and sharp-tailed grouse surveys in Minnesota during spring 2005

Mike Larson, Ph.D., Forest Wildlife Populations & Research Group

ABSTRACT

Drum count surveys for ruffed grouse and count surveys of sharp-tailed grouse at dancing grounds were conducted during April and May 2005. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 0.8 (95% confidence interval = 0.7–0.9) drums/stop (dps), which was the same as during 2004. Drum counts by survey zone were 1.2 (0.9–1.5) dps in the Northwest, 0.8 (0.6–1.0) dps in the North Central, 0.5 (0.3–0.6) dps in the Northeast, 0.6 (0.4–0.8) dps in the Central Hardwoods, and 0.7 (0.3–1.1) dps in the Southeast. Mean drum counts were also calculated for 7 sections of the Ecological Classification System (ECS). Index values by zone and by ECS section were all essentially the same as they were during 2004.

During the spring 2005 survey 1,824 sharp-tailed grouse were observed at 193 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 7.6 (6.3–8.9) in the East Central range, 11.4 (9.6–13.2) in the Northwest range, and 9.5 (8.3–10.6) statewide. Means were also calculated for re-defined ranges based on aggregations of ECS sections. The mean number of birds per dancing ground during 2005 was not different than during 2004 for dancing grounds where birds were counted during both years. The difference statewide was -0.6 (-1.4–0.3) birds per dancing ground, or -6 (-13–3)%.

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. The NW range consists primarily of Roseau, Marshall, Beltrami, Lake of the Woods, and Koochiching counties. The EC range consists primarily of Pine, Aitkin, Carlton, and St. Louis counties. 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 where they defend small territories and make displays to attract females for breeding. Surveys of sharp-tailed grouse populations are based on counts of males 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 the 5 ruffed grouse survey zones, each of 7 sections of the Ecological Classification System (ECS) in Minnesota, and for the entire state (Figure 1). As an intermediate step, the mean number of dps was calculated for each route. Mean index values for survey zones and ECS sections were calculated as the mean of route-level means for all routes occurring within the zone or section. Some routes crossed boundaries of ECS sections, so data from those routes were included in the means for both sections. The number of routes within zones and sections was not proportional to any meaningful characteristic of zones or sections. Therefore, the statewide mean index value was calculated as the weighted mean of index values for the ECS sections. 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; see Figure 1 caption for full section names). Only approximately half of the Minnesota and Northeast Iowa Morainal section and Paleozoic Plateau section were within the ruffed grouse range, so the area used to weight drum index means for those sections was reduced accordingly.

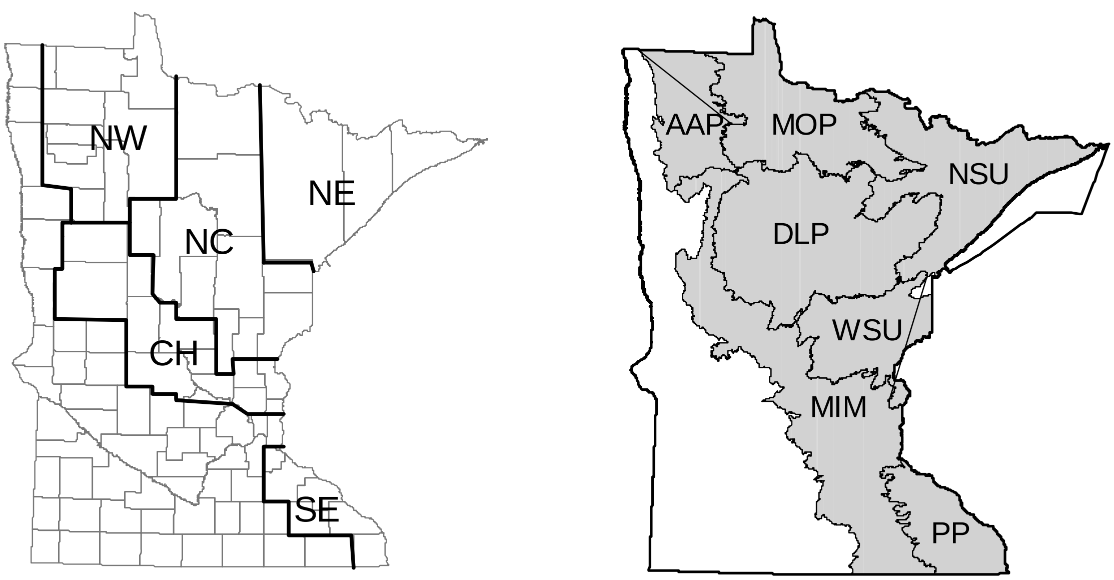


Figure 1. Ruffed grouse survey zones overlaid on county boundaries (left panel) and forested Sections of the Ecological Classification System (right panel) in Minnesota. Zones: NW = Northwest, NC = North Central, NE = Northeast, CH = Central Hardwoods, and SE = Southeast. ECS Sections: AAP = Lake Agassiz & Aspen Parklands, MOP = Northern Minnesota & Ontario Peatlands, NSU = Northern Superior Uplands, DLP = Northern Minnesota Drift & Lake Plains, WSU = Western Superior Uplands (including a small portion of the Southern Superior Uplands in eastern Carlton County), MIM = Minnesota and Northeast Iowa Morainal (only the northern half of which is surveyed for ruffed grouse), and PP = Paleozoic Plateau.

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 confidence intervals for mean index values for survey zones, ECS sections, and the whole state.

I calculated mean index values and CIs for 1982–2005. Data from earlier years were not analyzed because they have not been entered into an electronic database. Annual index values for 1949–1981 are available in the DNR's 2004 Grouse and Hares report.

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 Managers and their volunteers between sunrise and 2.5 hours after sunrise during April 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 was 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.

The index value of interest was the mean number of sharp-tailed grouse per dancing ground, averaged across dancing grounds within the NW and EC ranges and statewide. I calculated range and statewide means for all dancing grounds surveyed during 2004 and all dancing grounds surveyed during 2005. 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 years, therefore, I analyzed separately a set of data that included counts of birds only from dancing grounds that were successfully surveyed during both years. Although the dancing grounds in the separate data set 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 the separate data set to calculate the difference in the mean number of birds counted per dancing ground between 2004 and 2005 and the percent difference in the total number of birds counted on the comparable dancing grounds.

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 ranges and the whole state.

I used 2 different definitions, or classifications, of range boundaries to summarize the sharp-tailed grouse survey results (Figure 2). I referred to the NW and EC ranges, as they were defined in the past for previous DNR Grouse and Hare reports, as the “former” classification. I defined “new” ranges by reclassifying the DNR’s International Falls wildlife work area and the northwestern portion of the Tower wildlife work area to be in the NW range (formerly, they were included in the EC range). The Eveleth (i.e., southern) portion of the Tower area remained in the EC range under the new classification. The new range delineation was based on ECS section boundaries (Figure 1), with the NW range consisting of the Lake Agassiz & Aspen Parklands and Northern Minnesota & Ontario Peatlands sections and the EC range consisting of portions of the Northern Minnesota Drift & Lake Plains, Western Superior Uplands, and Southern Superior Uplands sections.

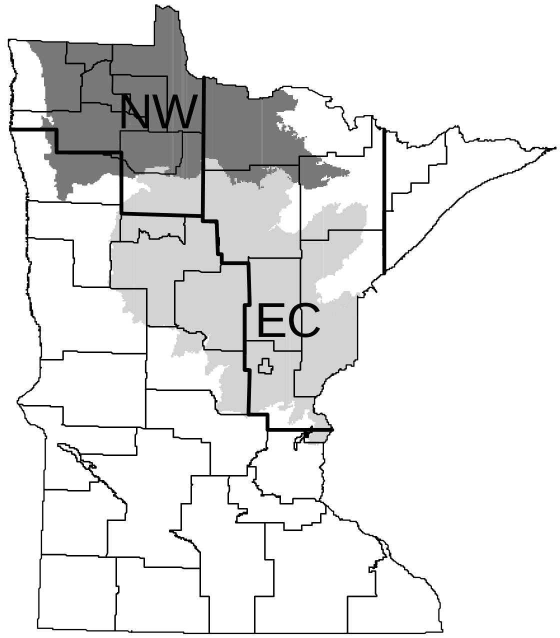


Figure 2. Northwest (NW) and East Central (EC) ranges of sharp-tailed grouse in Minnesota. The heavy lines, based largely on DNR Wildlife Work Area boundaries (light lines), represent the former range boundaries. The dark and light gray shading represent the new range boundaries, based on ECS section boundaries (see Figure 1 for ECS labels).

RESULTS

Ruffed Grouse

Observers from 22 cooperating organizations surveyed 124 routes between 14 April and 23 May 2005. Most routes (82%) were run between 20 April and 10 May. The cooperators included the DNR Division of Fisheries & Wildlife; Chippewa and Superior National Forests (USDA Forest Service); 1854 Authority; Fond du Lac, Grand Portage, Leech Lake, Red Lake, and White Earth Reservations; Agassiz and Tamarac National Wildlife Refuges (U.S. Fish & Wildlife Service); Central Lakes College and Vermilion Community College; Beltrami and Cass County Land Departments; UPM Blandin Paper Mill; and Gull Lake Recreation Area (U.S. Army Corps of Engineers). Observers reported survey conditions as Excellent, Good, and Fair on 48%, 39%, and 12% of routes, respectively. Survey conditions were similar during 2004.

Median index values for bootstrap samples were within 0.03 drums/stop (dps) of the 120 survey means by zone and 0.06 dps of the 168 survey means by ECS section for all annual estimates since 1982. Furthermore, bootstrap medians were within 0.02 dps of 89% of the survey means by ECS section. Therefore, no bias-correction was necessary, and CI limits were defined as the 2.5^{th} and 97.5^{th} percentiles of the bootstrap frequency distribution.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 0.8 (95% CI = 0.7–0.9) drums/stop (dps) during 2005. The statewide drum index has remained unchanged since 2002 at a level similar to the last time the ruffed grouse population was at a low point in its cycle (i.e., 1992–1994; Figure 3). Drum counts during 2005 in the 5 survey zones (Table 1, Figures 1 & 4–8) and the 7 ECS sections (Table 2, Figures 1 & 8–14) were all essentially the same as they were during 2004 (i.e., the CIs overlap considerably).

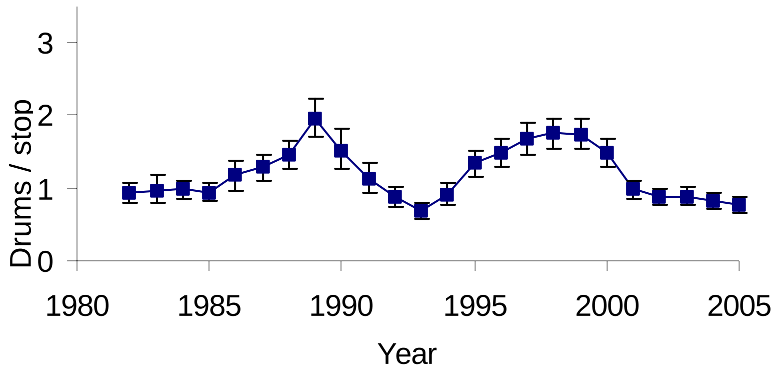


Figure 3. **Statewide** ruffed grouse drum count index values in Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

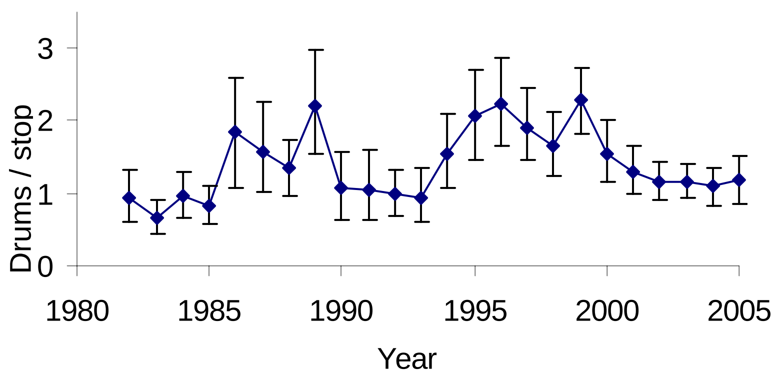


Figure 4. Ruffed grouse drum count index values in the **Northwest** survey zone of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

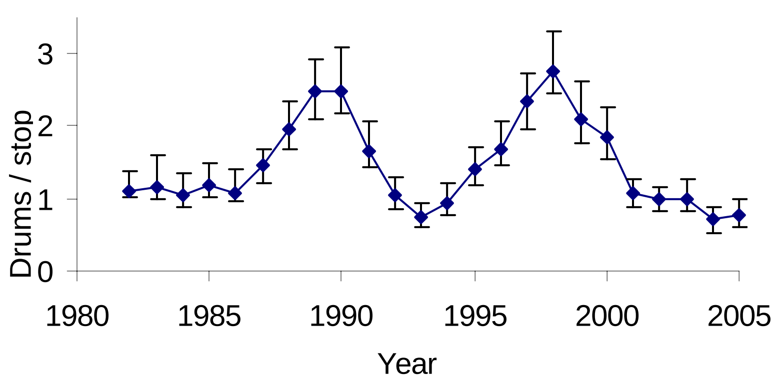


Figure 5. Ruffed grouse drum count index values in the **North Central** survey zone of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

Table 1. Ruffed grouse survey index values (drums/stop) by survey zone in Minnesota during the springs of 2004 and 2005.

	NW[a]		NC		NE		CH		SE	
Year	Mean	95% CI[b]	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
2004	1.1	0.8-1.4	0.7	0.5-0.9	0.6	0.5-0.9	0.7	0.5-1.1	0.7	0.3-1.1
2005	1.2	0.9-1.5	0.8	0.6-1.0	0.5	0.3-0.6	0.6	0.4-0.8	0.7	0.3-1.1

[a] NW = North West, NC = North Central, NE = North East, CH = Central Hardwoods, SE = South East, as defined by county boundaries.
[b] 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.

Table 2. Ruffed grouse survey index values (drums/stop) by ECS Section[a] in Minnesota during the springs of 2004 and 2005.

	AAP[b]		MOP		NSU		DLP		WSU		MIM	
Year	Mean	95% CI[c]	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
2004	0.8	0.5-1.0	1.4	1.1-1.7	0.6	0.4-0.8	0.7	0.6-0.9	0.8	0.5-1.1	0.7	0.4-1.1
2005	0.9	0.6-1.2	1.4	1.0-1.9	0.5	0.4-0.7	0.8	0.6-1.0	0.6	0.4-0.7	0.6	0.3-0.8

[a] ECS = Ecological Classification System.
[b] AAP = Lake Agassiz & Aspen Parklands, MOP = Northern Minnesota & Ontario Peatlands, NSU = Northern Superior Uplands, DLP = Northern Minnesota Drift & Lake Plains, WSU = Western Superior Uplands, and MIM = Minnesota and Northeast Iowa Morainal. The Paleozoic Plateau is the same area as the Southeast Zone (see Table).
[c] 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.

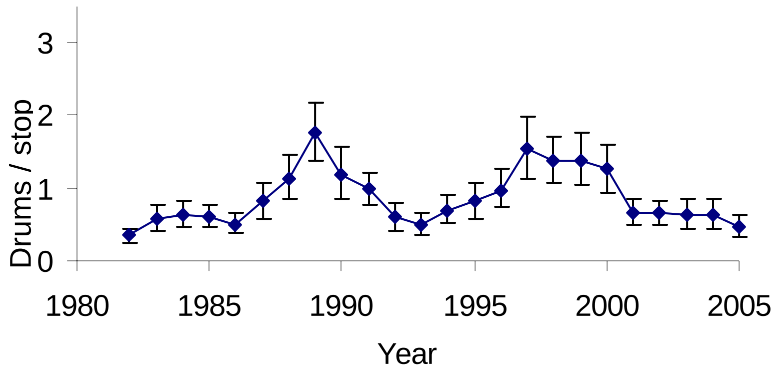


Figure 6. Ruffed grouse drum count index values in the **Northeast** survey zone of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

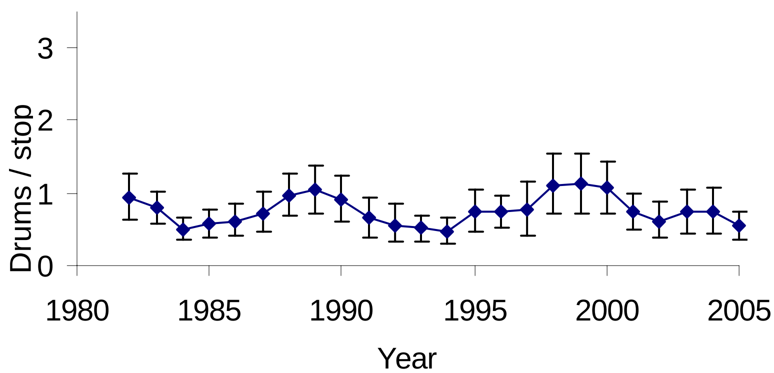


Figure 7. Ruffed grouse drum count index values in the **Central Hardwoods** survey zone of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

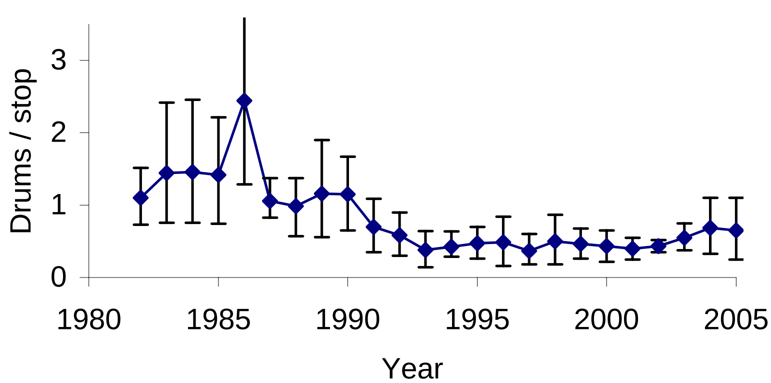


Figure 8. Ruffed grouse drum count index values in the **Southeast** survey zone of Minnesota. This represents the same area as the **Paleozoic Plateau** ECS section. Vertical error bars represent 95% confidence intervals based on bootstrap samples. The y-axis truncated 1 error bar so the scale would be identical for Figures 3–14.

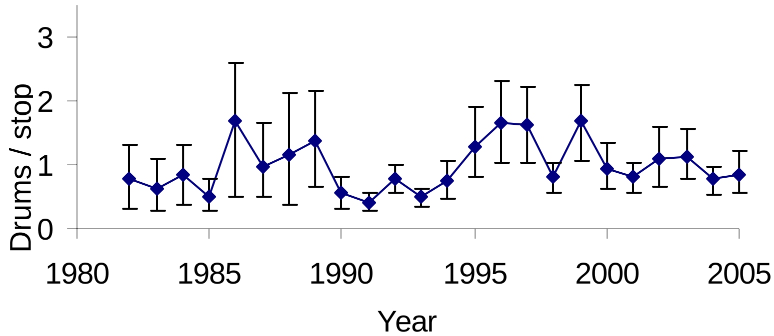


Figure 9. Ruffed grouse drum count index values in the **Lake Agassiz and Aspen Parklands** ECS section of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

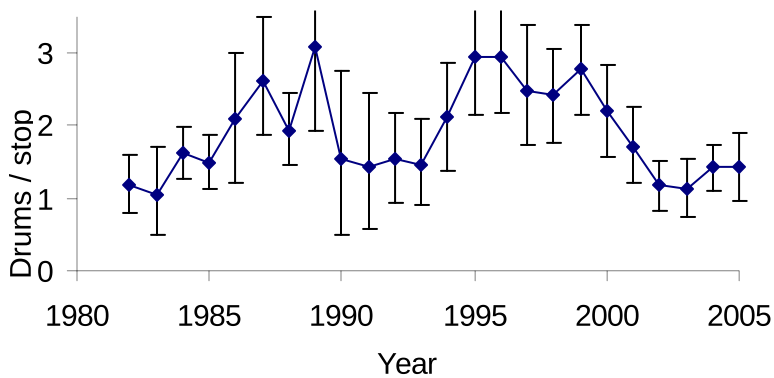


Figure 10. Ruffed grouse drum count index values in the **Northern Minnesota & Ontario Peatlands** ECS section of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples. The y-axis truncated 3 error bars so the scale would be identical for Figures 3–14.

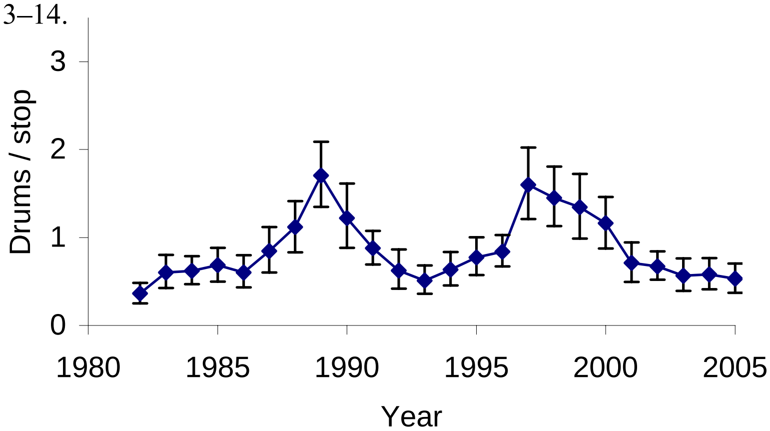


Figure 11. Ruffed grouse drum count index values in the **Northern Superior Uplands** ECS section of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

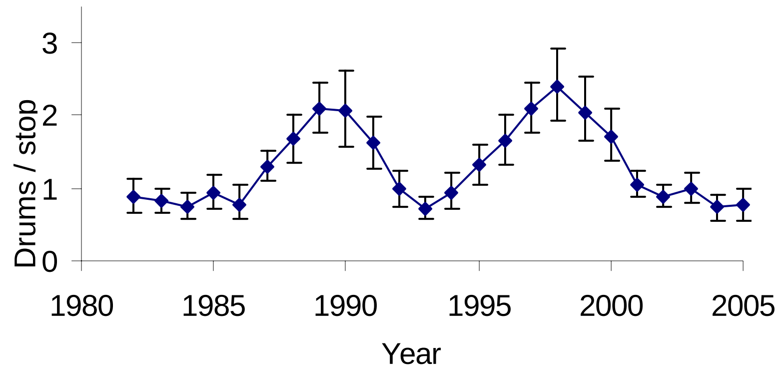


Figure 12. Ruffed grouse drum count index values in the **Northern Minnesota Drift & Lake Plains** ECS section of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

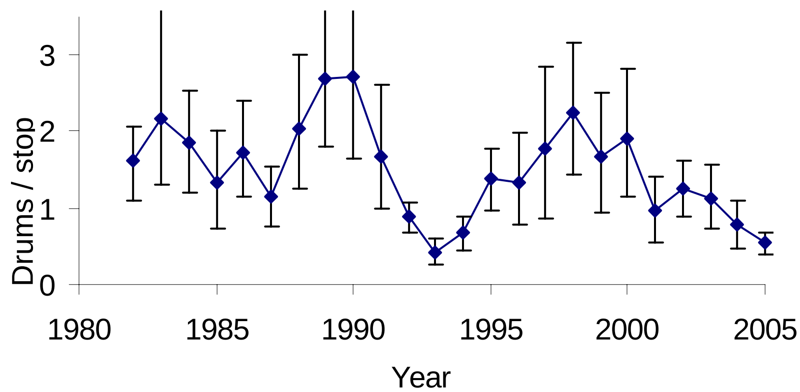


Figure 13. Ruffed grouse drum count index values in the **Western Superior Uplands** ECS section of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples. The y-axis truncated 3 error bars so the scale would be identical for Figures 3–14.

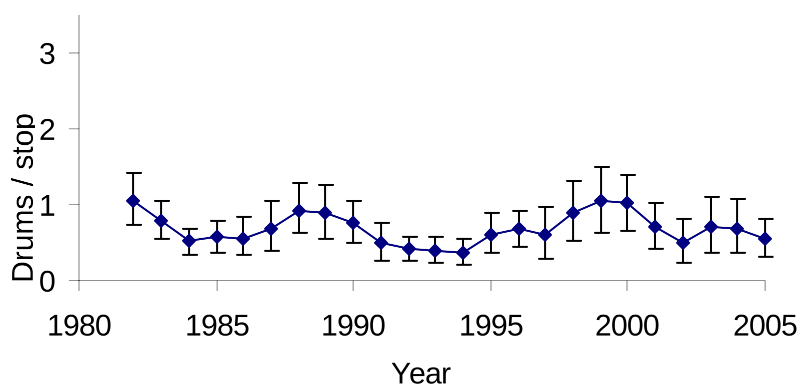


Figure 14. Ruffed grouse drum count index values in the **Minnesota and Northeast Iowa Morainal** ECS section of Minnesota. Vertical error bars represent 95% confidence intervals based on bootstrap samples.

Sharp-tailed Grouse

A total of 1,824 sharp-tailed grouse was observed at 193 dancing grounds during spring 2005 (Table 3). The number of sharp-tailed grouse counted per dancing ground in the EC range was lower than in the NW range, and the statewide mean was 9.5 (95% CI = 8.3–10.6) grouse counted per dancing ground (Table 4). The mean number of birds counted per dancing ground during 2005 was not different than during 2004 for the 182 dancing grounds where birds were counted during both years (i.e., all CIs contained 0; Tables 3 and 5).

Table 3. Number of sharp-tailed grouse dancing grounds observed during 2005 surveys and during both 2004 and 2005 surveys.

		Former[a]		New	
	Statewide	EC[b]	NW	EC	NW
2005 only	193	100	93	78	115
2004 & 2005	182	94	88	76	106

[a] See Methods for definitions of “former” and “new”range boundaries.
[b] EC = East Central, NW = Northwest.

DISCUSSION

Ruffed Grouse

Based upon the drum count index ruffed grouse densities during spring 2005 were likely very similar to spring densities during 2002–2004. Index values during low periods of the population cycle are often <0.9 drums/stop (dps), so drum counts during recent years are not unusual. Although 2005 was the 4th or 5th year of an apparent low period in the population cycle, similar 4- to 5-year periods of relatively low drum counts have occurred as recently as the early-1980s. The number of ruffed grouse encountered by hunters and other outdoors people this fall likely will depend nearly as much upon recruitment of juveniles as on densities of males during spring.

Sharp-tailed Grouse

Counts of sharp-tailed grouse at dancing grounds in Minnesota during 2005 were very similar to counts during 2004. The slight decline in counts between years in the NW range, given the moderate degree of uncertainty in the estimates, was not sufficient evidence to infer a meaningful change in the abundance of sharp-tailed grouse in northwestern Minnesota. Furthermore, sources of temporal variation that are not related to the abundance of sharp-tailed grouse, such as the timing and duration of surveys, could cause minor changes in bird counts and index values.

Although index values from different years are not necessarily comparable, the mean number of sharp-tailed grouse counted per dancing ground has fluctuated in a pattern consistent with an apparent long-term population cycle similar to that of ruffed grouse. During the last 20 years values of the sharp-tailed grouse index have been between approximately 7 and 11 birds counted per dancing ground. This year’s statewide mean of 9.5 (8.3–10.6) birds counted per dancing ground was in the middle of that range.

Table 4. Number of sharp-tailed grouse counted per dancing ground in Minnesota during spring.

	Statewide		Former[a] EC[b]		Former[a] NW		New EC		New NW	
Year	Mean	95% CI[c]	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
2004	10.0	9.0–11.1	7.6	6.5–8.8	12.3	10.8–13.9	7.2	5.9–8.5	11.7	10.4–13.1
2005	9.5	8.3–10.6	7.6	6.3–8.9	11.4	9.6–13.2	7.2	5.8–8.7	11.0	9.4–12.6

[a] See Methods for definitions of "former" and "new" range boundaries.
[b] EC = East Central, NW = Northwest.
[c] 95% CI = 95% confidence interval for the mean. It is an estimate of the uncertainty in the value of the mean.

Table 5. Differences in counts of sharp-tailed grouse at comparable dancing grounds during 2004 and 2005 in Minnesota.

	Statewide		Former[a] EC[b]		Former[a] NW		New EC		New NW	
	Value	95% CI[c]	Value	95% CI	Value	95% CI	Value	95% CI	Value	95% CI
Birds/ground	-0.6	-1.4–0.3	0.1	-0.9–1.1	-1.2	-2.6–0.1	0.0	-1.0–1.0	-0.9	-2.2–0.3
% difference in total birds	-6	-13–3	1	-11–15	-10	-20–1	0	-13–14	-8	-17–3

[a] See Methods for definitions of "former" and "new" range boundaries.
[b] EC = East Central, NW = Northwest.
[c] 95% CI = 95% confidence interval for the value. It is an estimate of the uncertainty in the magnitude of the value.

ACKNOWLEDGEMENTS

I sincerely appreciate the help of all the DNR staff and volunteer cooperators who conducted the grouse surveys. I also appreciate the efforts of Bill Berg, who coordinated the collection of grouse survey data for many years, and John Erb and others who translated most of the grouse survey data into a digital format.

Spring 2005 Prairie-Chicken Survey in Minnesota

Mike Larson, Ph.D., Forest Wildlife Populations & Research Group

INTRODUCTION

Greater prairie-chickens (*Tympanuchus cupido pinnatus*) are a medium-sized grouse species (800–1000 g; 1.8–2.2 lbs). During spring they gather on communal breeding areas, or leks, where males display and compete for opportunities to mate. Prairie-chicken leks are also called booming grounds because males make a low-frequency, booming vocalization during their displays. Orange air sacs on the sides of a male's neck inflate and amplify the booming sound. Pinnae, the long feathers on the sides of the neck, stand erect above the male prairie-chicken's head during display (Schroeder and Robb 1993). Prairie-chickens are also called pinnated grouse.

During the early 1800s prairie-chickens were present along the southern edge of Minnesota. Following the planting of crops and clearing of forests by immigrants of European descent, the range of prairie-chickens expanded to cover most of the state by approximately 1900. As agriculture intensified, more prairies were tilled, and grassland openings in northeastern Minnesota succeeded back to forest, the range of prairie-chickens receded (Svedarsky *et al*. 1997). Currently, most prairie-chickens in Minnesota occur along the beach ridges of glacial Lake Agassiz in the west. The population of prairie-chickens there was expanded southward to the upper Minnesota River valley by a series of relocations during 1998–2005. A remnant population of prairie-chickens still exists in central Minnesota also (primarily Wadena and Cass counties).

From 1974 to 2003 the Minnesota Prairie Chicken Society (MPCS) coordinated annual counts of prairie-chickens at booming grounds. The MPCS surveys provided evidence to support the initiation in 2003 of a prairie-chicken hunting season, which had not occurred in Minnesota since 1942. The hunt has been limited to 100 participants, and fewer than 130 birds/year have been harvested. During 2003 and 2004 the Minnesota Department of Natural Resources (DNR) began coordinating the annual prairie-chicken surveys, and a standardized survey design was adopted (Giudice 2004). The objectives of the current survey are to monitor trends in the abundance of prairie-chickens in selected but widely distributed areas and to provide conservative information for making decisions about regulations for the fall hunting season.

METHODS

During the few hours near sunrise from late-March until mid-May cooperating biologists from the DNR, U.S. Fish & Wildlife Service (FWS), and The Nature Conservancy (TNC) 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 1). 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 1).

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 (Svedarsky 1983). Females are also more difficult to detect because they do not vocalize or display like males. Counts of males rather than females, therefore, were used to make comparisons between core and peripheral ranges and between years.

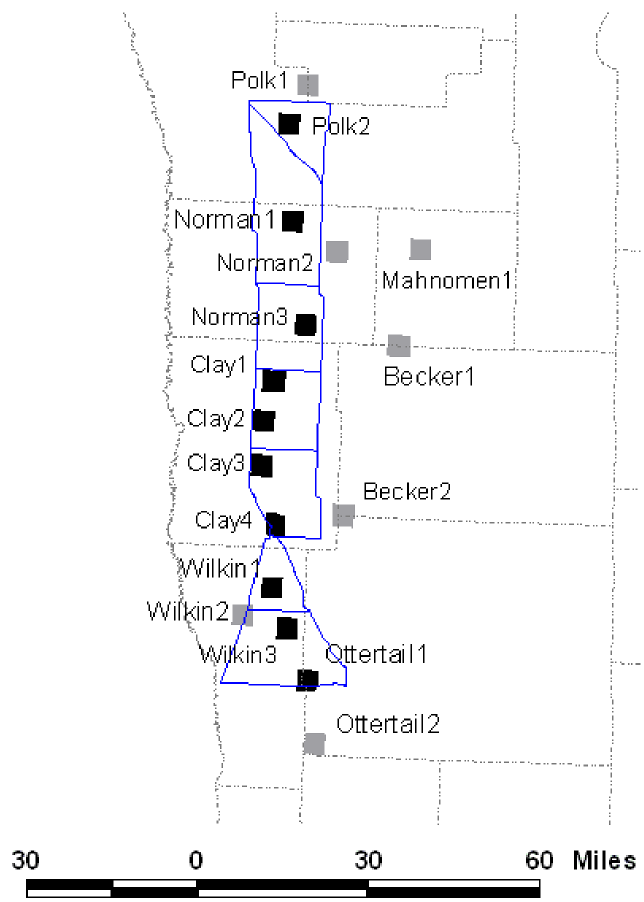


Figure 1. Survey blocks (labeled squares) and hunting permit area boundaries (solid lines) for prairie-chickens in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which they were primarily located. Permit areas are ordered from north to south: 405A, 407A, 407B, 407C, 420A, 420B,and 421A.

RESULTS AND DISCUSSION

During spring 2005 there were a minimum of 2,958 male prairie-chickens in western Minnesota (Table 1). Within hunting permit areas there were a minimum of 0.13 leks/mi^2 (0.05 leks/km^2) and 1.7 males/mi^2 (0.7 males/km^2). Minimum counts in Table 1 and the densities calculated from them are not comparable among permit areas or years because they included surveys conducted outside of the survey blocks. It was likely that probabilities of detecting leks and individual males were substantially different among permit areas during 2005 and among years within most permit areas. Minimum counts of males summarized by permit area provide conservative information for setting quotas for the fall hunting season.

Table 1. Minimum abundance of prairie-chickens within and outside of hunting permit areas in western Minnesota during spring 2005. Counts of leks and birds are not comparable among permit areas or years.

Permit Area	Area (sq. mi.)	Leks	Males	Unk.[a]
405A	101.9	25	327	4
407A	295.1	16	128	13
407B	171.9	27	257	4
407C	161.1	27	531	0
420A	168.1	27	375	0
420B	101.3	24	304	35
421A	236.6	11	182	16
PA subtotal[b]	1,236.0	157	2,104	72
Outside PAs[c]	NA[d]	86	854	47
Grand total	NA	243	2,958	119

[a] Unk. = prairie-chickens of unknown sex. It is likely that most were males.
[b] Sum among the 7 permit areas.
[c] Counts from outside the permit areas.
[d] NA = not applicable. The size of the area outside permit areas was not defined.

Within survey blocks observers counted 1,319 male prairie-chickens on 98 booming grounds (Table 2). Each booming ground was observed on a median of 2 (mean = 1.9) different days, but 45% of leks were observed only once. Attendance of males at prairie-chicken leks varies among days and by time of day (Svedarsky 1983). 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 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 (Yoccoz *et al*. 2001).

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

Range[a]	Survey Block	Area (sq. mi.)	2005 Leks	2005 Males	2005 Unk.[b]	Change from 2004[c] Leks	Change from 2004[c] Males
Core	Polk 2	16.2	9	119	0	2	14
	Norman 1	16.1	5	22	7	4	14
	Norman 3	16.0	5	66	2	-1	-2
	Clay 1	17.6	8	145	0	0	-14
	Clay 2	16.0	3	108	0	1	-16
	Clay 3	16.1	9	168	0	1	-59
	Clay 4	14.9	6	68	0	0	-26
	Wilkin 1	15.4	10	145	35	0	-70
	Wilkin 3	16.1	6	85	16	1	-29
	Otter Tail 1	15.9	2	31	0	-1	-16
	Core subtotal	160.2	63	957	60	7	-204
Periphery	Polk 1	15.9	10	89	0	3	-8
	Norman 2	16.3	8	88	11	-6	-20
	Mahnomen	16.1	5	67	0	2	44
	Becker 1	16.0	4	41	0	0	20
	Becker 2	16.1	4	43	0	-2	-20
	Wilkin 2	16.1	2	23	0	0	-5
	Otter Tail 2	15.7	2	11	17	-1	-54
	Periphery subtotal	112.2	35	362	28	-4	-43
Grand total		272.4	98	1,319	88	3	-247

[a] Survey blocks were classified as either mostly within the hunting permit areas (core) or mostly outside the permit areas (periphery).
[b] Unk. = prairie-chickens of unknown sex. It is likely that most were males.
[c] The 2004 count was subtracted from the 2005 count, so a negative value indicates a decline.

In survey blocks in the core of the range we observed 0.39 leks/mi^2 (0.15 leks/km^2) and 15.2 males/lek, whereas in peripheral blocks we observed 0.31 leks/mi^2 (0.12 leks/km^2) and 10.3 males/lek (Table 2). Counts of males in survey blocks during 2005 were 16% less than during 2004, with declines of 18% and 11% in the core and periphery, respectively. Eight of 10 core blocks and 5 of 7 peripheral blocks experienced declines in counts. The number of leks observed in survey blocks during 2005 was 3% greater than during 2004, with an increase of 13% and a decrease of 10% in the core and periphery, respectively.

It is premature to infer a population trend from 2 annual surveys. The apparent decline in the abundance of male prairie-chickens in survey blocks between the springs of 2004 and 2005, however, has 2 possible explanations. First, if the decline in abundance was real, it was likely part of normal fluctuations experienced by wildlife populations. Such fluctuations may be caused by weather patterns, random variations in the rates of survival and reproductive success, or fluctuations in habitat quality or predator populations. The hunting season alone could not have caused a decline in the prairie-chicken population. Only approximately 55 birds were killed during the fall 2004 hunting season (Larson 2005), and the harvest allowed under the prairie-chicken hunting regulations (i.e., a maximum of 200 birds) is conservative and unlikely to affect the abundance of prairie-chickens the following spring. The second possible explanation for the decline in counts is that the probability of detecting leks or individual males during the 2005 survey may have been less than the probabilities of detection during 2004. The ratio of detection probabilities during the 2 surveys is unknown, so inferences about changes in true abundance should be made cautiously. Overall, the abundance of prairie-chickens in western Minnesota appears to have been increasing steadily from 1997 to 2004 (Giudice 2004).

ACKNOWLEDGEMENTS

Mark Chase (FWS), Doug Hedtke, Ross Hier, Earl Johnson, Tom Kucera, Doug Wells (FWS), Brian Winter (TNC), and Terry Wolfe coordinated and supervised individual surveys. John Giudice prepared last year's survey report, upon which I depended heavily. He, Mark Lenarz, and Jack Wingate reviewed and helped me improve an earlier draft of this report. I sincerely appreciate all their contributions and the efforts of the volunteer cooperators and DNR staff who conducted the prairie-chicken surveys.

BIBLIOGRAPHY

Giudice, J. H. 2004. Minnesota prairie chicken survey: 2004 annual report. Minnesota Department of Natural Resources, St. Paul, MN.

Larson, M. A. 2005. 2004 Minnesota prairie-chicken hunting season and hunter survey. Minnesota Department of Natural Resources, St. Paul, MN.

Schroeder, M. A., and L. A. Robb. 1993. Greater prairie-chicken. The birds of North America, number 36. The American Ornithologists' Union, Washington, DC, and The Academy of Natural Sciences, Philadelphia, PA.

Svedarsky, W. D. 1983. Reproductive chronology of greater prairie-chickens in Minnesota and recommendations for censusing and nest searching. Prairie Naturalist 15:120–124.

Svedarsky, W. D., T. J. Wolfe, and J. E. Toepfer. 1997. The greater prairie-chicken in Minnesota. Minnesota Wildlife Report 11. Minnesota Department of Natural Resources, St. Paul, MN.

Yoccoz, N. G., J. D. Nichols, and T. Boulinier. 2001. Monitoring of biological diversity in space and time. Trends in Ecology and Evolution 16:446–453.

REGISTERED FURBEARER POPULATION MODELING
2005 Report

John Erb, Forest Wildlife Populations & Research Group

INTRODUCTION

For populations of secretive carnivores, obtaining field-based estimates of population size remains a challenging task (Hochachka et al. 2000; Wilson and Delehay 2001; Conn et al. 2004). This is particularly true when one is interested in annual estimates, multiple species, and/or large areas. Nevertheless, population estimates are desirable to assist in making management/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. 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 1980's, 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. Obtaining updated Minnesota-specific survival estimates remains a goal for future research.

Harvest data is obtained through mandatory furbearer registration. A detailed summary of 2004 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 2004 registered DNR trapping and hunting harvest set a new record (631; Table 1). Modeled harvest, which includes tribal take, was 709. Based on population modeling estimates, 28% of the fall population was harvested. The percentage of yearlings in the harvest was slightly higher and the percentage of adults slightly lower than normal, a reversal of the deviation noted last year. Nevertheless, overall age/sex statistics and average take per trapper/hunter were within the bounds previously observed (Table 1).

Based on examination of reproductive tracts, pregnancy rate of yearlings was estimated at 48%, compared to only 16% last year. Average litter size for pregnant yearlings was 2.3 (2.0 last year). Pregnancy rate for 2+ year olds averaged 82%, with a mean litter size of 2.75. While sample sizes are small for the oldest age-classes, data from the past 2 years suggests pregnancy rates and litter sizes are highest for 4-6 year old females.

After another record harvest, modeling predicts a decline in this spring's bobcat population (Figure 1) to pre-2001 levels. Winter track counts, however, remain well above pre-2001 levels. The estimated 2005 spring population is ~ 1,700.

Fisher: Harvest under the DNR framework was 2,552 (Table 2). Modeled take was 2,753, a 1% increase from 2003. An estimated 17% of the fisher population was harvested, within the bounds of previous seasons. Carcass collections ended in 1994, so no current age or reproductive data are available. Population modeling suggests a steadily increasing fisher population for the past 6 years. However, harvests have remained relatively stable during this time, and winter track counts have declined the last 2 years (Figure 3). Modeling estimates a current spring population of ~12,600.

Marten: For the third year in a row, marten harvest set a record (DNR framework – 3,241; modeled take – 3,592) (Table 3). Although juveniles clearly predominate in the marten harvest, 'older' marten are evident in the harvest as well (Figure 5). The maximum age observed this year was 12, similar to last year's result (13) as well as information from Ontario (13; Fryxell et al. 2001). Based on modeling, a record 23% of the fall population was harvested. The percent juveniles (26%) and the juvenile:adult female ratio (1.3) in the harvest dropped to their lowest levels since data collection began.

Following 3 years of increased harvest, modeling suggests the population is declining, with an estimated spring population of ~11,800 (Figure 4). Since 1997, averaged winter track indices have been stable to slightly declining.

Otter: The DNR framework harvest increased 25% to a record 3,450, and the modeled harvest total was 3,700 (Table 4). An estimated 27% of the fall population was harvested, the highest such estimate since modeling began. Carcass collections ended in 1986, so no age or reproductive data are available. Modeling indicates the population has slightly declined in each of the past 4 years (Figure 6). No independent otter survey data are currently available for comparison. The current estimated spring population is ~ 10,600.

LITERATURE CITED

Conn, P. B., L. L. Bailey, and J. R. Sauer. 2004. Indexes as surrogates to abundance for low-abundance species. Pages 59-76 *in* W. L. Thompson, editor. Sampling rare or elusive species: Concepts, designs, and techniques for estimating population parameters. Island Press, Washington, D.C., USA.

Fryxell, J., J. B. Falls, E. A. Falls, R. J. Brooks, L. Dix, and M. Strickland. 2001. Harvest dynamics of mustelid carnivores in Ontario, Canada. Wildlife Biology 7:151-159.

Hochachka, W. M., K. Martin, F. Doyle, and C. J. Krebs. 2000. Monitoring vertebrate populations using observational data. Canadian Journal of Zoology 78:521-529.

Olson, C. 2005. 2004 small mammal survey report. Technical Report 05-01. 1854 Authority, Duluth, MN.

Wilson, G. J., and R. J. Delahay. 2001. A review of methods to estimate the abundance of terrestrial carnivores using field signs and observation. Wildlife Research 28:151-164.

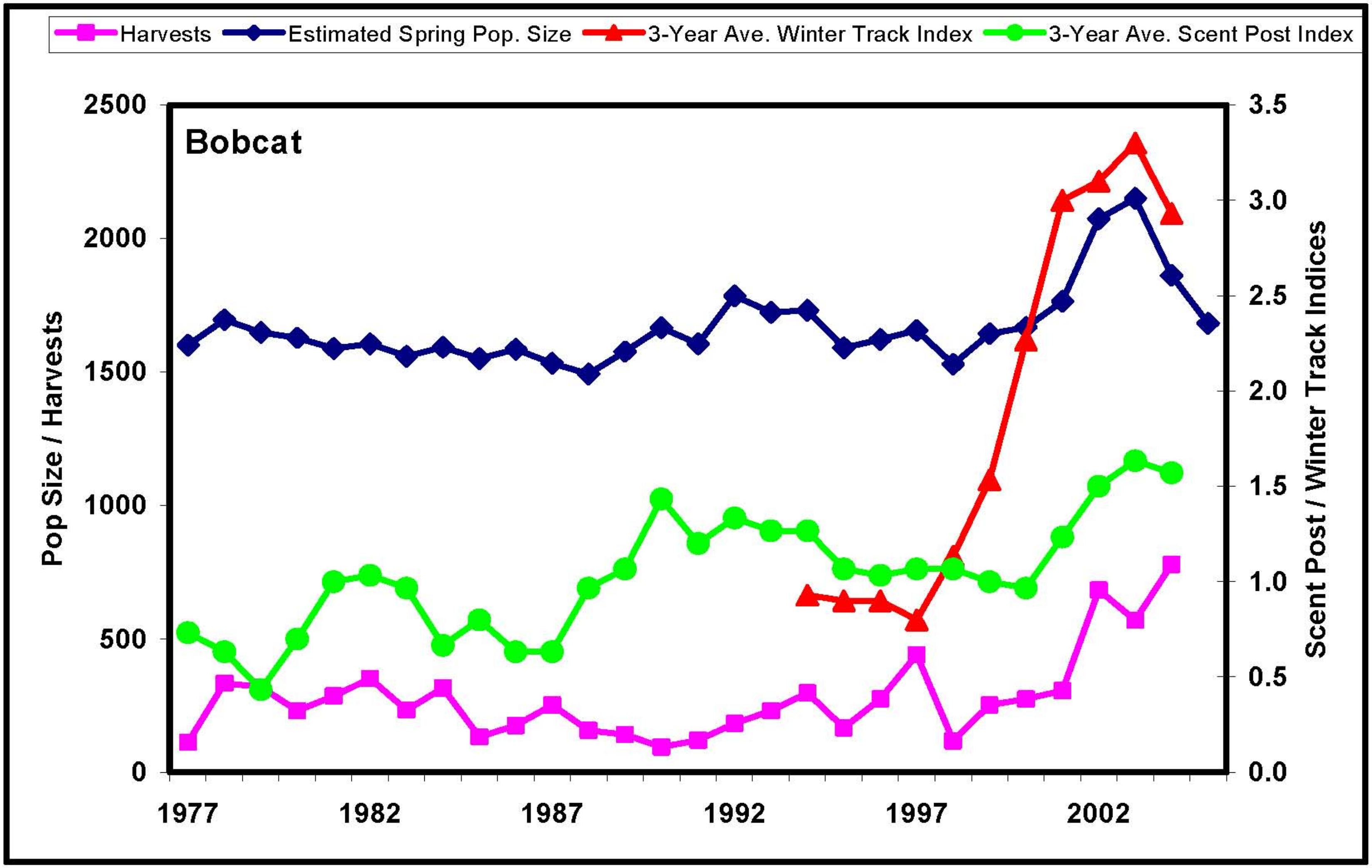


Figure 1. Bobcat populations, harvests, and survey indices, 1977-2005. Harvests include estimated accidental take.

Table 1. Bobcat harvest data, 1977 to 2004.

Year	Season	Limit	Registered 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[5]
1977	12/1-1/31	5	103	103	5%	34	35	18	47	1.2	50	33	41	41	$74
1978	12/1-1/31	5	304	304	14%	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	12%	230	37	23	40	2.1	59	63	55	58	$73
1982	12/1-1/23	5	274	320	14%	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	13%	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	11%	163	33	16	51	1.4	44	52	48	48	$101
1988	11/26-1/1	5	140	143	8%	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	5%	62	20	34	46	0.8	58	80	44	59	$43
1991	11/30-1/5	5	106	110	6%	93	35	33	32	3.6	59	55	70	61	$37
1992	11/28-1/3	5	167	167	9%	151	28	22	50	1.2	55	45	53	53	$28
1993	12/4-1/9	5	201	210	11%	161	32	20	48	1.4	51	45	52	50	$43
1994	12/3-1/8	5	238	270	14%	187	26	16	58	0.8	64	43	45	50	$36
1995	12/2-1/7	5	134	152	9%	96	31	15	54	2.7	57	71	79	71	$34
1996	11/30 -1/5	5	223	250	13%	164	35	20	45	1.5	51	30	49	46	$33
1997	11/29-1/4	5	364	401	20%	270	35	16	49	1.2	60	37	43	48	$30
1998	11/28-12/13	5	103	107	6%	77	29	26	45	1.6	59	60	60	60	$28
1999	12/4-1/9	5	206	228	12%	163	18	24	58	0.8	55	59	62	60	$24
2000	12/2-1/7	5	231	250	13%	183	31	26	43	1.5	54	59	50	53	$33
2001	11/24-1/6	5	259	278	13%	213	30	21	49	1.3	52	51	53	52	$35
2002	11/30-1/5	5	544	621	31%	475	27	25	48	1.0	66	49	46	52	$46
2003	11/29-1/4	5	483	518	18%	425	25	13	62	0.9	61	46	53	54	$96
2004	11/27 – 1/9	5	631	709	28%	524	28	34	38	1.6	51	40	54	49	$99

[1]includes DNR and Tribal harvests
[2]estimated from population model; includes estimated accidental harvests of 10%.
[3]population index for autumn prior to harvest season
[4]different population index for winter during/after harvest season
[5] Average pelt price based on a survey of in-state fur buyers only.

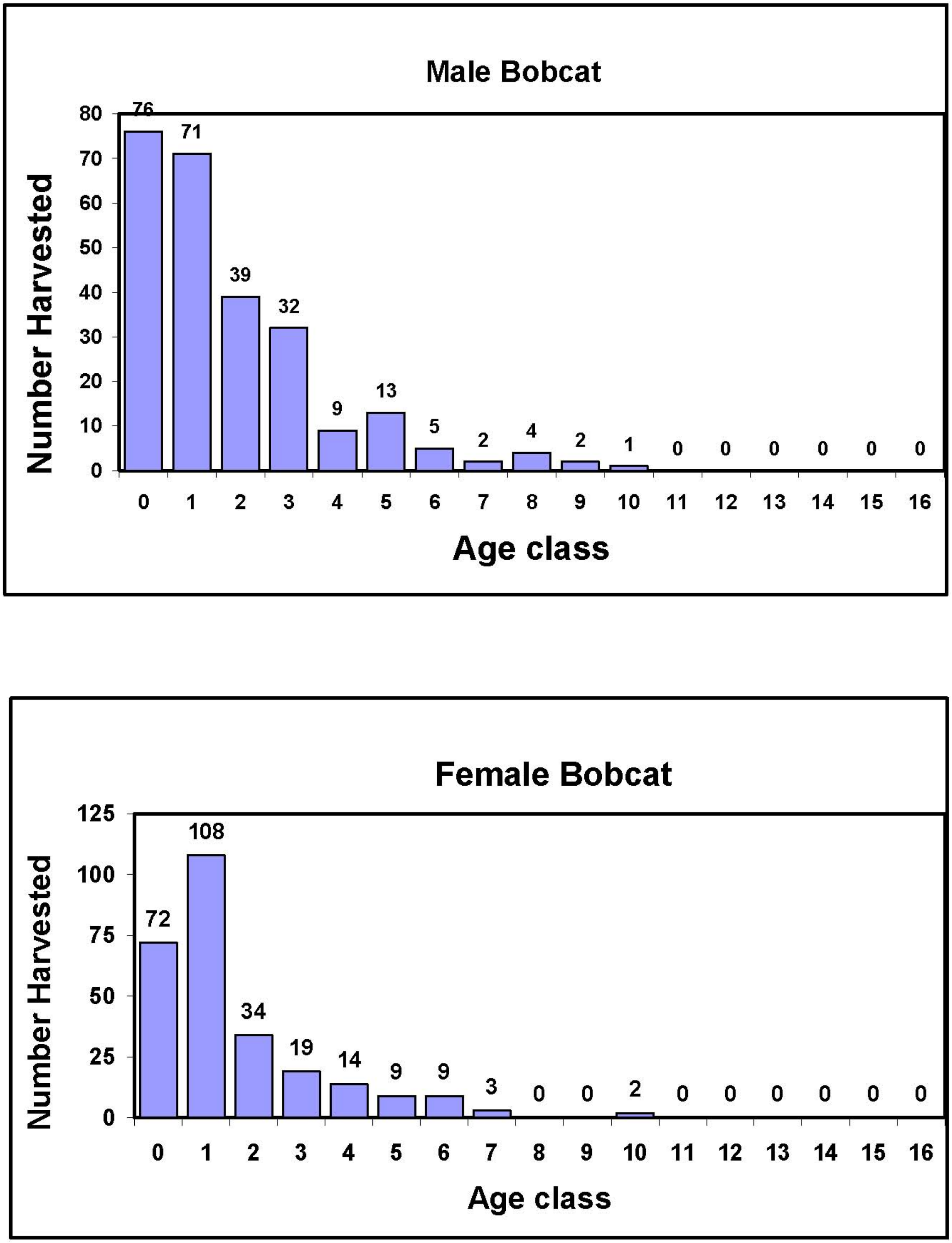


Figure 2. Age structure of male and female bobcat in the 2004-05 harvest.

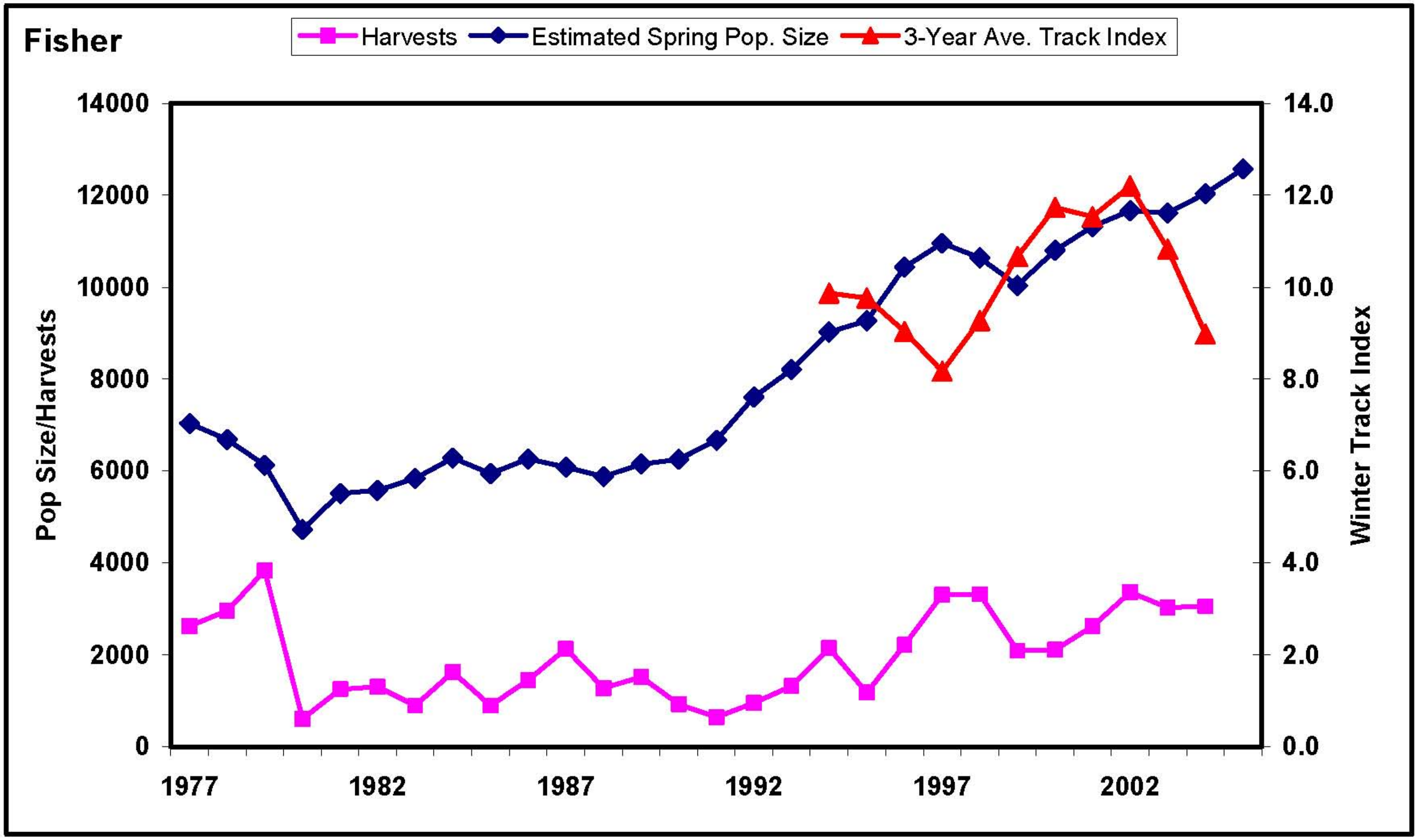


Figure 3. Fisher populations, harvests, and survey indices, 1977-2005. Harvests include estimated accidental take.

Table 2. Fisher harvest data, 1977 to 2004.

Year	Season	Limit	Registered 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 Males[5]	Pelt price females[5]
1977	12/1-1/31	3	2150	2150	25%	562	69%	16%	14%	8.4:1	54%	28%	43%	48%	$71	$71
1978	12/1-1/31	3	2426	2426	29%	577	70%	16%	14%	7.1:1	44%	35%	28%	40%	$132	$147
1979	12/1-1/31	3	3032	3032	41%	467	65%	15%	21%	5.6:1	54%	46%	44%	50%	$108	$128
1981	12/1-12/10	1	862	1022	16%	843	66%	24%	10%	10.5:1	48%	43%	37%	47%	$94	$110
1982	12/1-12/10	1	912	1073	14%	1073	66%	19%	15%	9.4:1	46%	41%	52%	46%	$70	$99
1983	12/1-12/11	1	631	735	11%	662	69%	18%	13%	8.8:1	45%	40%	40%	44%	$71	$121
1984	12/1-12/16	1	1285	1332	19%	1270	63%	20%	17%	7.2:1	52%	45%	45%	49%	$70	$122
1985	11/30-12/15	1	678	735	11%	712	63%	20%	18%	5.4:1	46%	40%	34%	43%	$74	$130
1986	11/29-12/4	1	1068	1186	17%	1186	59%	24%	18%	5.3:1	48%	50%	37%	46%	$84	$162
1987	11/28-12/13	1	1642	1749	24%	1534	63%	15%	22%	4.7:1	46%	40%	37%	43%	$84	$170
1988	11/26-12/11	1	1025	1050	16%	805	70%	15%	15%	6.8:1	48%	45%	33%	45%	$54	$100
1989	12/2-12/17	1	1243	1243	15%	1024	64%	19%	17%	5.8:1	47%	47%	36%	45%	$26	$53
1990	12/1-12/16	1	746	756	11%	592	65%	14%	21%	4.5:1	44%	55%	30%	43%	$35	$46
1991	11/30-12/15	1	528	528	7%	410	66%	21%	13%	7.8:1	50%	52%	35%	48%	$21	$48
1992	11/28-12/13	1	778	782	10%	629	58%	21%	21%	4.9:1	42%	55%	45%	46%	$16	$29
1993	12/4-12/19	2	1159	1192	12%	937	59%	22%	19%	5.3:1	47%	37%	42%	44%	$14	$28
1994	12/3-12/18	2	1771	1932	18%	1360	56%	18%	26%	4.0:1	47%	54%	44%	48%	$19	$30
1995	12/2-12/17	2	942	1060	10%	-	-	-	-	-	-	-	-	-	$16	$25
1996	11/30-12/15	2	1773	2000	18%	-	-	-	-	-	-	-	-	-	$25	$34
1997	11/29-12/14	2	2761	2974	26%	-	-	-	-	-	-	-	-	-	$31	$34
1998	11/28-12/13	2	2695	2987	25%	-	-	-	-	-	-	-	-	-	$19	$22
1999	12/4-12/19	2	1725	1880	13%	-	-	-	-	-	-	-	-	-	$19	$20
2000	12/2-12/17	4	1674	1900	13%	-	-	-	-	-	-	-	-	-	$20	$19
2001	11/24-12/9	4	2145	2362	16%	-	-	-	-	-	-	-	-	-	$20	$19
2002	11/30-12/15	5	2660	3028	20%	-	-	-	-	-	-	-	-	-	$23	$23
2003	11/29-12/14	5	2521	2728	18%	-	-	-	-	-	-	-	-	-	$27	$26
2004	11/27-12/12	5	2552	2753	17%	-	-	-	-	-	-	-	-	-	$30	$27

[1]includes DNR and Tribal harvests

[2]estimated from population model, includes estimated accidental harvests of 22% 1977-1992, and 11% in 1993-1999

[3] Population index for winter during/after harvest season

[4]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.

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

Note: Season closed in 1980. Carcass collections ended in 1994.

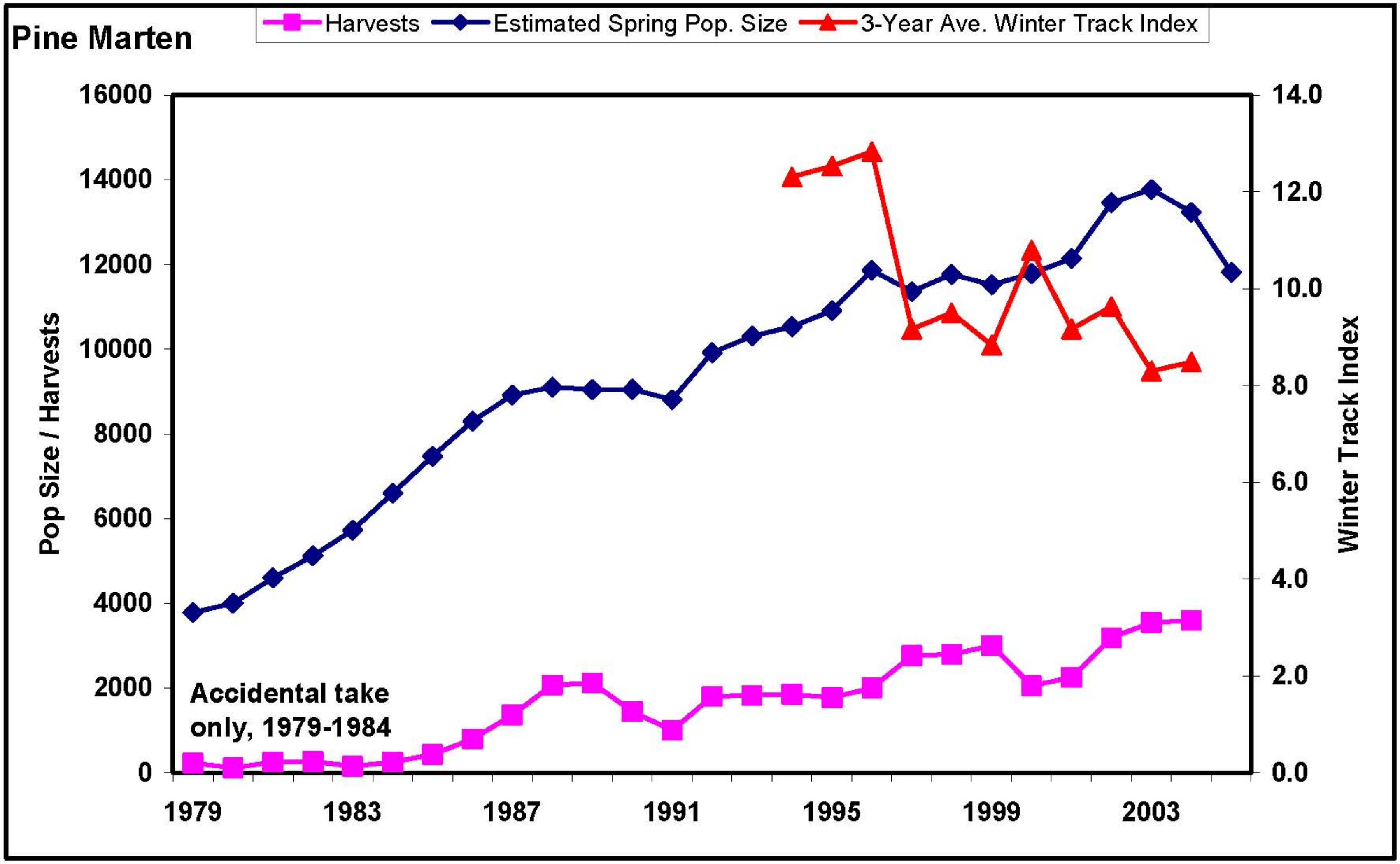


Figure 4. Pine marten populations, harvests, and survey indices, 1979-2005. Harvests include estimated accidental take.

Table 3. Pine marten harvest data, 1985 to 2004.

Year	Season	Limit	Registered DNR harvest	Modeled harvest[1]	% Autumn Pop. Taken[2]	Carcasses examined	% 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	6%	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	21%	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%	11.0	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	20%	2391	48%	17%	35%	4.0	57%	65%	66%	62%	$30	$27
2004	11/27-12/12	5	3241	3592	23%	2776	26%	28%	46%	1.3	52%	64%	57%	58%	$31	$27

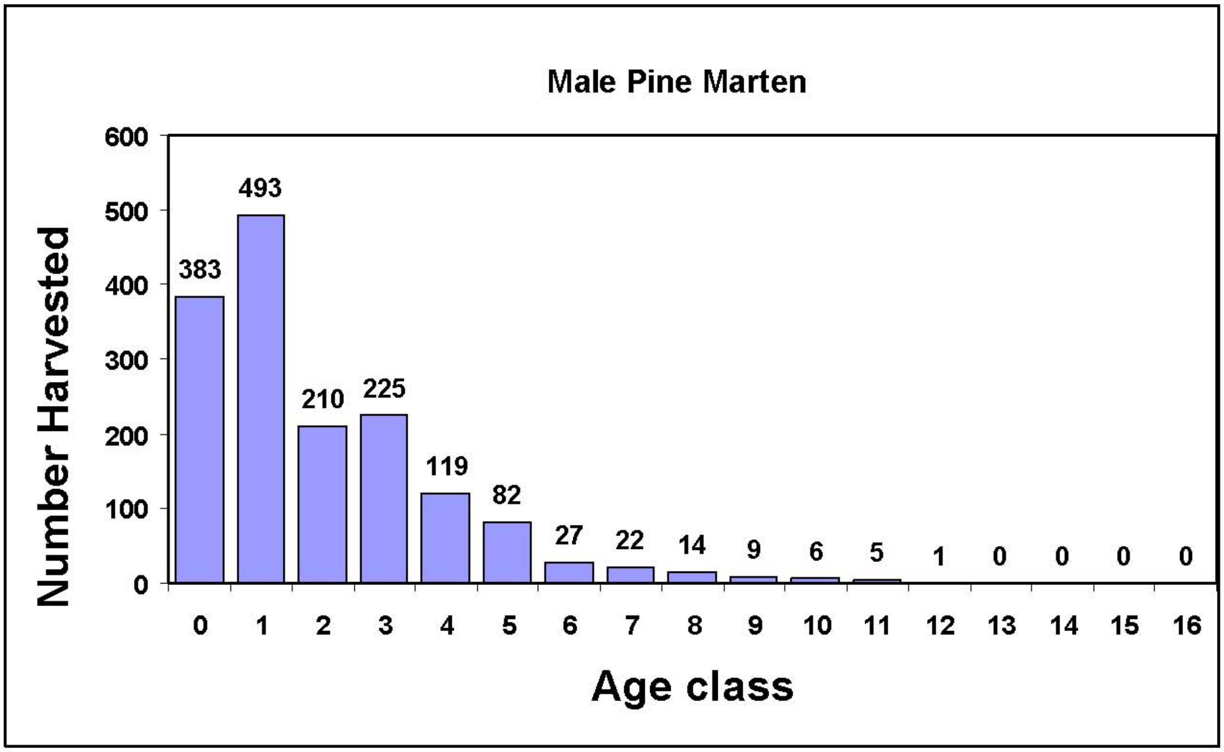
[1] includes DNR and Tribal harvests

[2] estimated from population model; includes estimated accidental harvests of 40% in 1985-1987 and 1991, 20% in 1988-1990 and 1992-1998, and 15% from 1999-present.

[3] population index for winter during/after harvest season

[4] 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.

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



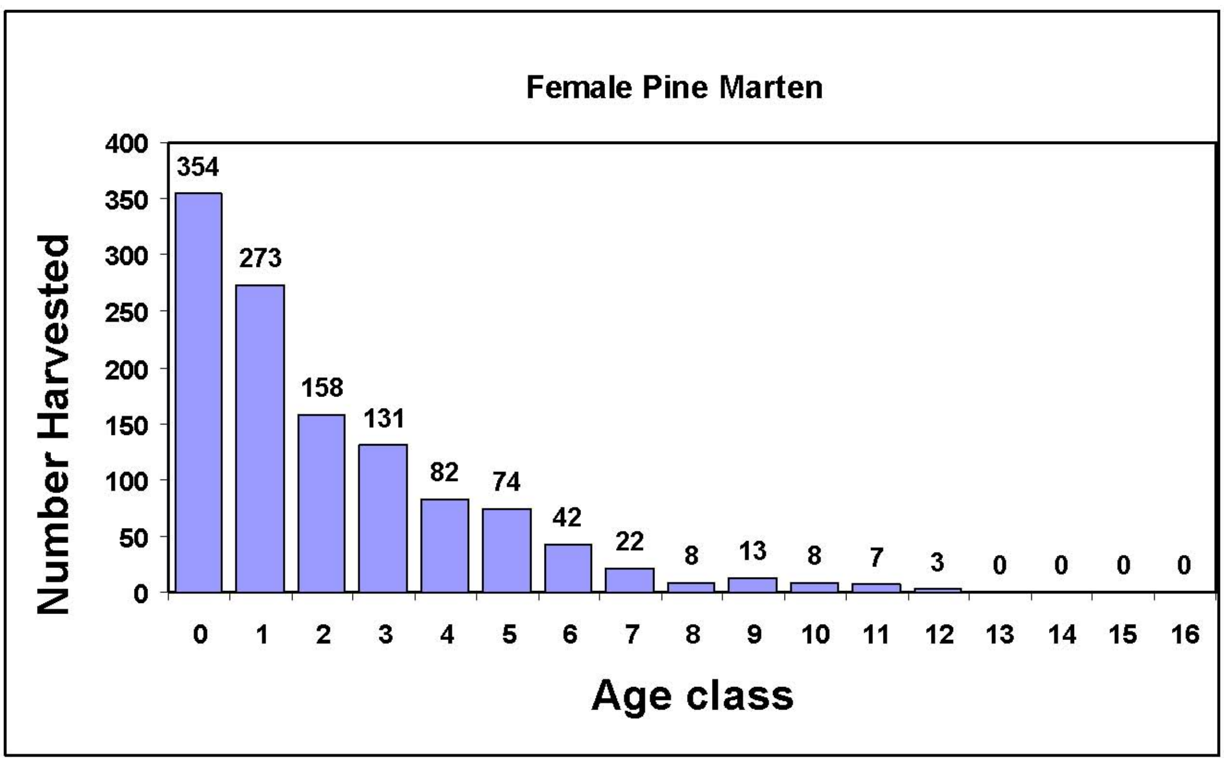


Figure 5. Age structure of male and female pine marten in the 2004-05 harvest.

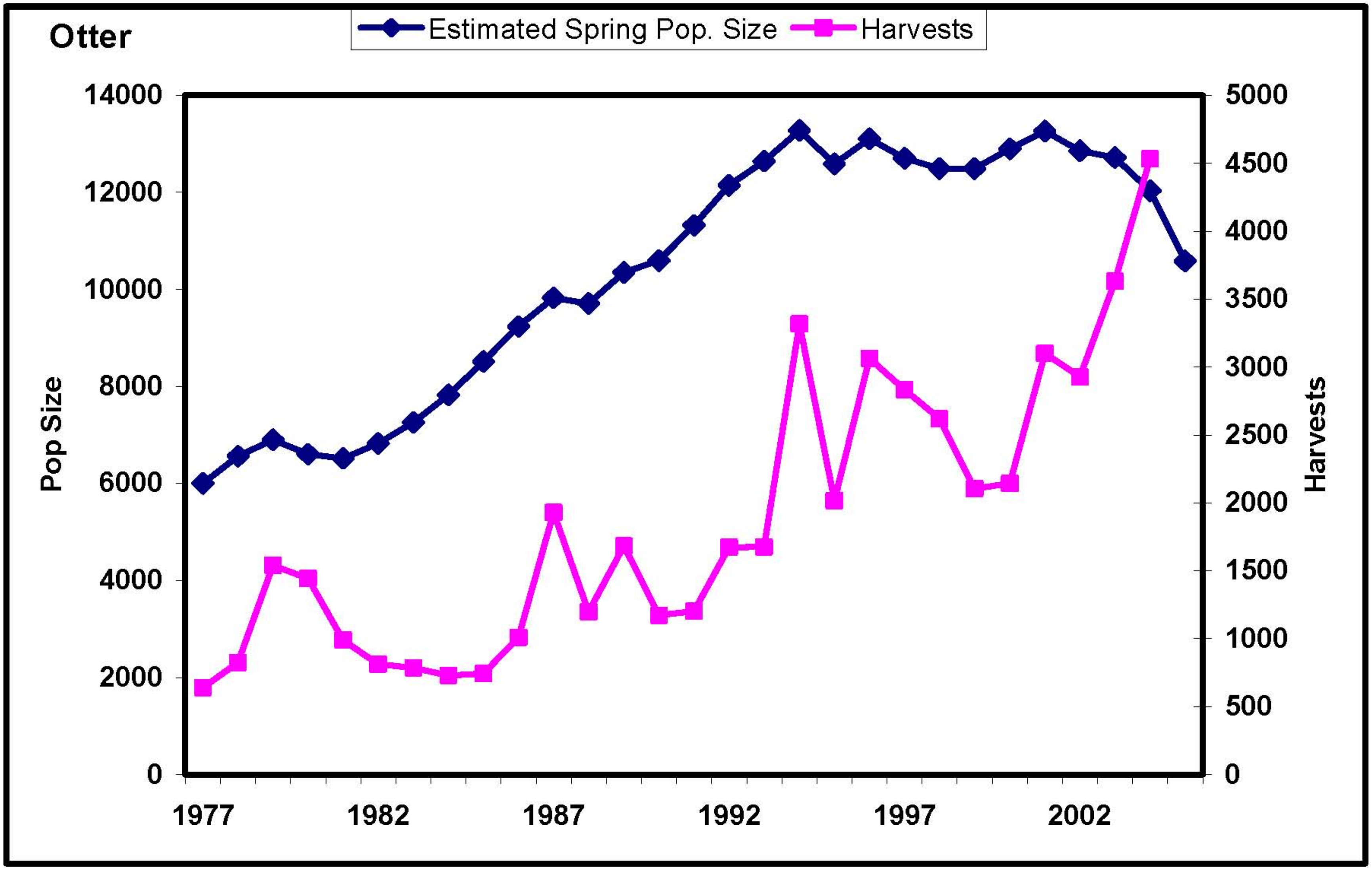


Figure 6. Otter populations and harvests, 1977-2005. Harvests include estimated accidental take.

Table 4. Otter harvest data, 1980-2004. Carcasses were not collected after 1986.

Year	Season dates	Limit	Registered DNR harvest	Modeled harvest[1]	% Autumn Pop. taken[2]	Carcasses examined	% juveniles	% yearlings	% male juveniles	% males yearlings	Mean pelt prices: otter[3]	Mean pelt prices: beaver (autumn)[3]
1980	11/15-11/29	2	1111	1111	16%	88	54.5	14.7	39.6	57.5	$33	$18
1981	11/14-11/28	2	485	762	11%	471	55	19.7	55.6	53.3	$30	$14
1982	11/13-11/27	2	385	625	9%	389	50.6	25.6	56.7	65.1	$26	$11
1983	11/12-11/26	2	408	614	8%	433	42.3	30.9	55.7	56.8	$25	$12
1984	11/17-12/01	2	513	561	7%	549	47.9	23.3	47.1	50	$22	$12
1985	11/16-12/15	3	559	572	7%	572	43.4	22.9	53.3	50	$21	$15
1986	10/24-11/29	3	777	777	8%	745	45.2	23.3	45.1	48.1	$24	$20
1987	10/27-11/29	3	1386	1484	15%	-	-	-	-	-	$23	$17
1988	10/29-11/27	3	922	922	8%	-	-	-	-	-	$22	$14
1989	10/28-12/17	3	1294	1294	12%	-	-	-	-	-	$22	$12
1990	10/27-1/6	3	888	903	8%	-	-	-	-	-	$24	$9
1991	10/26-1/5	3	855	925	8%	-	-	-	-	-	$25	$9
1992	10/24-1/3	4	1368	1368	10%	-	-	-	-	-	$30	$7
1993	10/23-1/9	4	1459	1646	10%	-	-	-	-	-	$43	$11
1994	10/29-1/8	4	2445	2708	19%	-	-	-	-	-	$48	$14
1995	10/28-1/7	4	1435	1466	12%	-	-	-	-	-	$38	$13
1996	10/26-1/5	4	2219	2500	17%	-	-	-	-	-	$39	$19
1997	10/25-1/4	4	2145	2313	16%	-	-	-	-	-	$39	$19
1998	10/24-1/3	4	1946	2139	16%	-	-	-	-	-	$34	$11
1999	10/23-1/9	4	1635	1717	13%	-	-	-	-	-	$41	$12
2000	10/28-1/7	4	1578	1750	12%	-	-	-	-	-	$51	$15
2001	10/27-1/6	4	2323	2531	17%	-	-	-	-	-	$51	$15
2002	10/26-1/5	4	2145	2390	17%	-	-	-	-	-	$46	$13
2003	10/25-1/4	4	2766	2966	21%	-	-	-	-	-	$85	$13
2004	10/23-1/9	4	3450	3700	27%	-	-	-	-	-	$87	$14

[1] Includes DNR and Tribal harvests
[2] Estimated from population modeling; includes estimated accidental harvests of 30% to 1991, and 22% after 1991.
[3] Average pelt price based on a survey of in-state fur buyers only.

Population Trends of White-tailed Deer in the Forest Zone – 2005

Mark S. Lenarz, Forest Wildlife Populations & 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 2004 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.

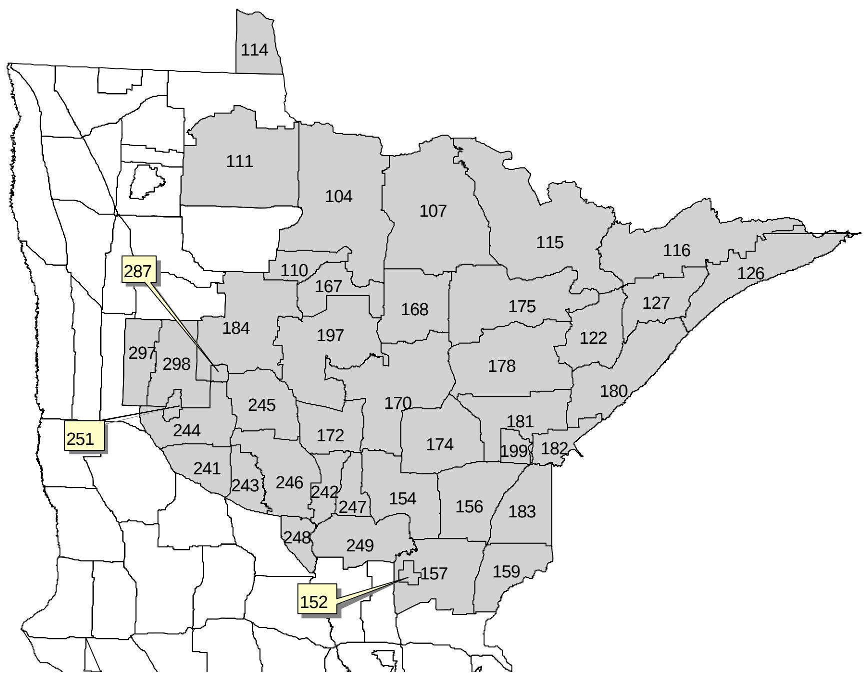


Figure 1. Either-sex permit areas in the forested zone, 2005. Permit areas 283 and 110 were combined into single permit area (110). Permit area numbers 211, 214 and 284 changed to 111, 114, and 184, respectively. Permit areas 114, 152, and 287, were not modeled.

HARVEST

In 2004, hunters registered 260,604 deer, the second highest harvest ever recorded in Minnesota. Of that number, 51% or 132,442 deer were harvested in the forested zone (Figure 1, Table 1). The 2004 forest zone harvest declined 11% from the 2003 harvest. The following discussion applies to the subset of deer harvested in the forest zone.

The buck harvest increased or remained stable in 20 of the 37 permit areas (Table 2). The total forest zone buck harvest declined 3%, however. The change in buck harvest by permit area was correlated with the change in simulated density *($r = 0.52$, $p<0.01$)*. This implies that the buck harvest did not decline in response to the high number of either-sex opportunities and still represents a good trend indicator for deer populations in the forest. Buck hunter success (buck harvest/licenses) in 2004 remained at historically high levels in both Zones 1 and 2 (Figure 2).

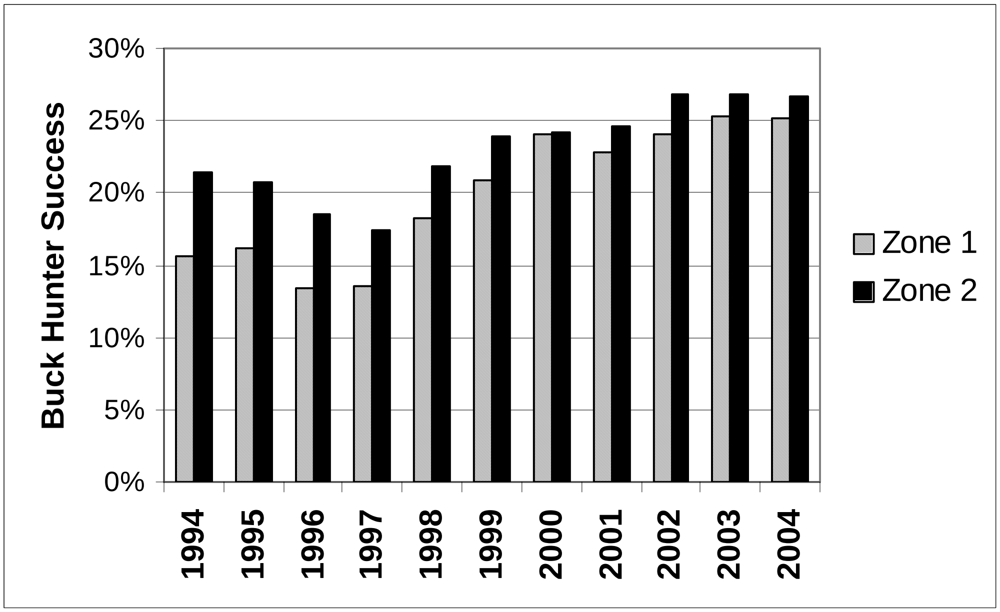


Figure 2. Success of licensed hunters at killing a buck, 1994-2004.

The antlerless harvest declined in 31 of the 37 permit areas (Table 3) and the total antlerless harvest declined 17%. The greatest decline occurred in Permit Area 180 (60%), which shifted from “managed” status in 2003 to “lottery” in 2004. Similarly, the greatest increases in antlerless harvest took place in permit areas (PA126, 131%; PA168, 37%; and PA297, 232%), which shifted from “lottery” in 2003 to “managed” in 2004.

The decline in the antlerless harvest was likely caused by a combination of several factors. Model simulations indicated that there were 8% fewer deer in the forest zone in 2004 (Table 4). In addition, anecdotal reports suggested that many hunters still had venison left over from the 2003 season and were less interested in killing more than one deer. This conjecture is corroborated by the fact that statewide sales of bonus permits decreased 6% from 2003.

The harvest by archers and muzzleloader hunters accounted for almost 7% of the total harvest. The archery harvest increased 6% over the previous year while the muzzleloader harvest increased by 7%. Increased sales of All Season Licenses and the availability of bonus permits likely account for these increases.

Population Trends and Model Projections

Based on the winter severity index (WSI), the winter of 2004-05 was relatively mild in the southwestern portion of the forest zone (Figure 3). Stations in the remainder of the forest zone had WSI values more representative of a moderate to moderately severe winter. Warm temperatures in late March and early April rapidly melted off the snow and likely reduced levels of winter mortality, especially along the Canadian border and in the “Arrowhead”.

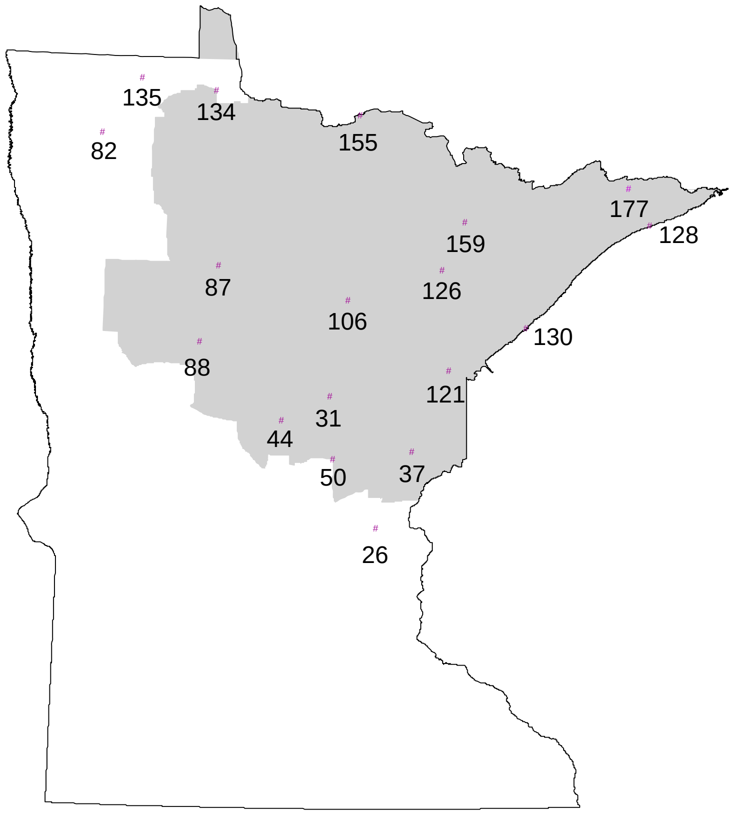


Figure 3. Winter Severity Index (WSI) readings from winter 2004-2005. WSI readings between 100 and 180 are considered moderate.

Simulation modeling was used in 36 permit areas (Figure 1, Table 4) to approximate deer density, identify trends, and project the effect of the 2005-hunting season. To better summarize the results for this report, permit areas were lumped in to one of 5 areas (Figs. 4 and 5). Deer density varied according to area 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 in response to low (or no) antlerless permits and mild winters. In the South (S), deer density peaked in 2000, stabilized, and then declined in response to an increased opportunity to kill multiple antlerless deer. The remaining areas peaked in 2003. Since 2003, the declines in the NW, WC and Central (C) were a response to the high antlerless harvest. There was less opportunity to kill antlerless deer in the NE and the decline there, was likely associated with winters that were more severe than elsewhere in the forest.

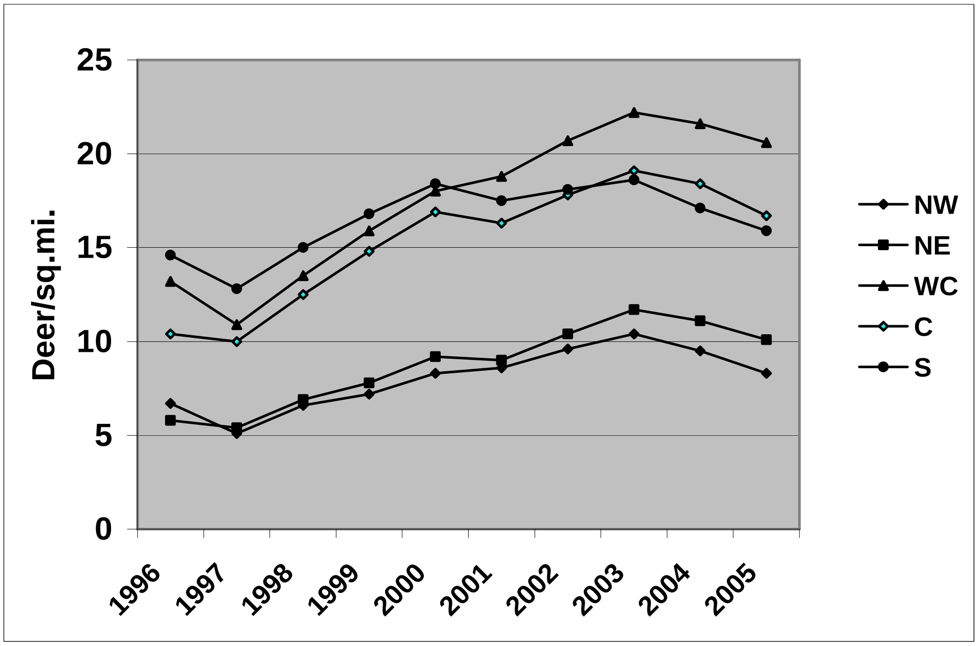


Figure 4. Population trends of deer in forest zone. Trend lines represent the groups of permit areas as illustrated in Figure 5. Density represents pre-fawn density.

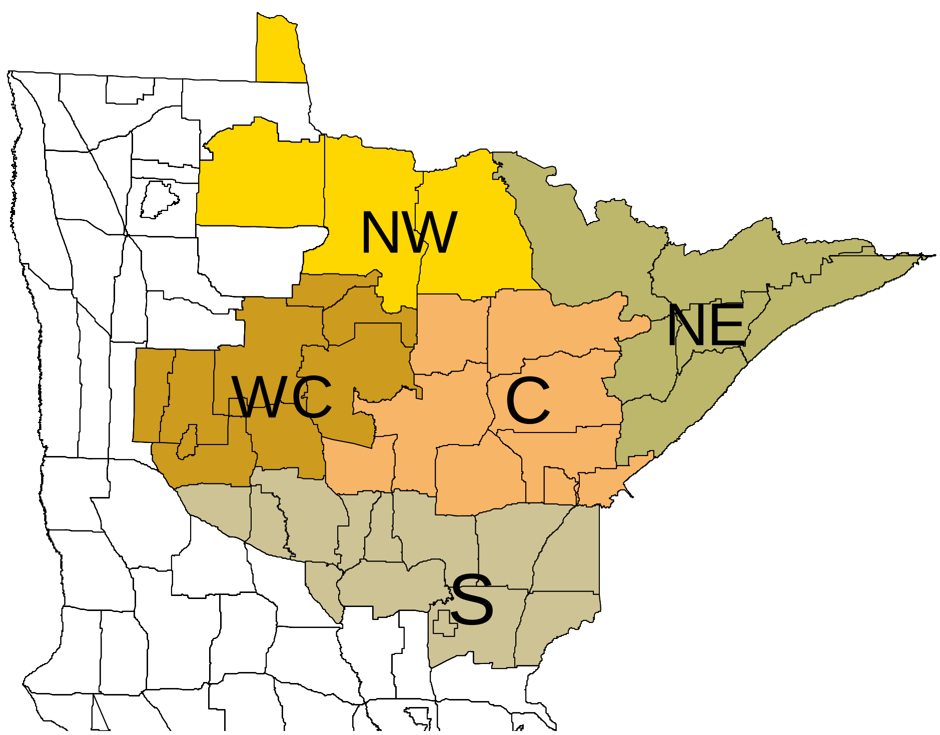


Figure 5. Groups of permit areas discussed in text and in figure 4.

After simulation modeling, wildlife managers in the forest zone came to consensus on the status of permit areas for the 2005 deer-hunting season. Managers recommended that 9 permit areas be designated as “Lottery” areas with a total of 19,700 permits. Most of these areas extend from the Leech Lake Indian reservation, east to the BWCAW (Figure 6). Thirteen permit areas in the west central or southern part of the forest were designated as “Intensive”. The remaining 20 areas were designated as “Managed”.

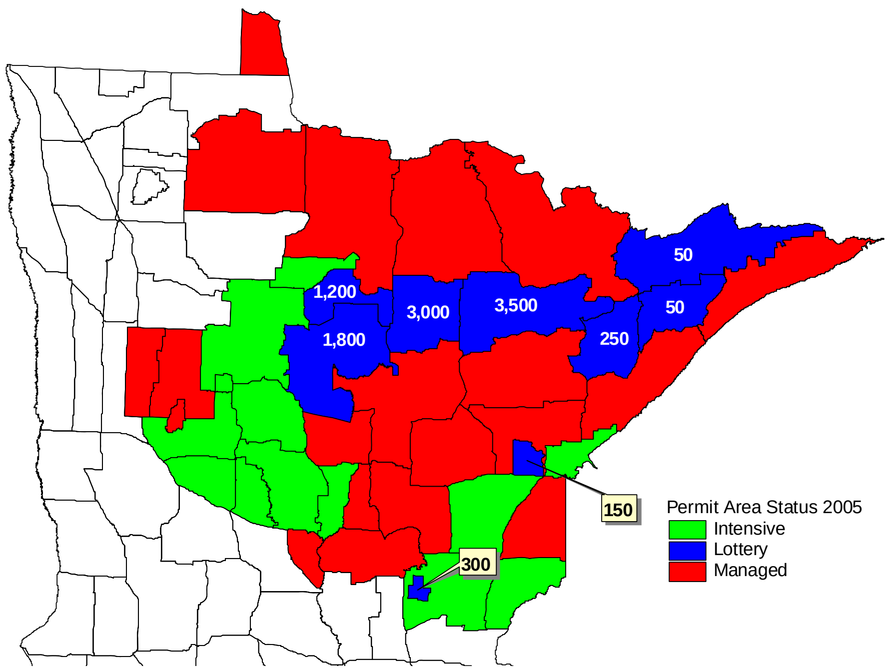


Figure 6. Final designation of permit areas in Minnesota’s Forested Zone. Number of permits listed within Lottery permit areas.

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

Permit Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change
104	3,381	756	567	897	1,372	1,837	1,940	2,253	3,421	2,902	-15%
107	3,892	1,090	948	1,176	1,994	2,846	3,550	3,499	5,206	4,027	-23%
110	710	193	153	228	933	944	949	1,080	1,372	1,509	10%
115	3,653	1,216	1,029	1,347	2,334	3,170	3,589	3,815	5,373	4,417	-18%
116	210	113	100	146	138	150	162	157	264	295	12%
122	769	273	251	457	296	551	622	564	685	716	5%
126	507	210	197	268	306	445	470	595	690	837	21%
127	105	54	63	83	176	81	99	108	146	165	13%
152	260	129	143	213	225	283	264	217	235	246	5%
154	2,254	1,334	1,370	1,952	2,977	4,415	4,168	5,032	5,717	5,176	-9%
156	2,286	1,500	1,546	2,109	2,646	3,753	3,036	3,246	4,935	4,583	-7%
157	4,323	2,892	3,293	4,709	5,385	6,985	7,196	7,727	9,001	7,606	-15%
159	2,933	1,881	2,312	3,493	3,971	5,070	4,167	3,934	5,028	3,871	-23%
167	1,955	476	338	599	1,452	1,601	1,971	2,488	1,572	1,463	-7%
168	3,247	785	552	988	2,410	2,686	2,379	3024	3,218	3,978	24%
170	4,404	1,152	1,143	2,220	2,857	4,938	4,833	4,716	8,460	7,154	-15%
172	2,999	859	979	1,443	2,960	4,253	4,624	4,910	7,004	5,490	-22%
174	2,241	755	754	1,371	1,927	2,436	2,141	2,678	3,811	3,346	-12%
175	2,683	2,684	2,685	2,686	2,320	3,029	3,339	3184	5,034	4,254	-15%
178	2,833	914	1,532	2,190	2,344	3,064	3,343	3,650	5,486	5,267	-4%
180	1,587	612	595	1,009	1,003	1,592	1,790	1,960	3,279	2,465	-25%
181	2,385	909	914	1,532	2,298	3,046	3,159	3110	4,524	4,489	-1%
183	1,671	637	640	1,073	2,296	2,939	2,934	2,964	4,235	3,779	-11%
197	1,324	442	407	597	933	1,372	1,167	1,413	1,652	1,723	4%
211	2,971	1,598	580	733	1,198	1,861	2,353	2,264	3,064	2,621	-14%
243	2,068	1,435	1,268	1,602	1,908	2,634	2,864	3,238	4,131	3,684	-11%
244	3,837	2,449	2,034	2,396	2,952	3,862	4,841	5,805	7,452	6,702	-10%
245	2,929	1,607	1,021	1,657	3,524	4,838	5,056	5,626	8,231	6,377	-23%
246	3,677	2,550	2,254	2,847	3,358	4,760	5,150	5,149	7,530	6,782	-10%
247/242	2,858	2,020	2,250	2,664	3,183	3,743	4,188	4527	5,512	4,826	-12%
248	1,230	756	564	943	850	1,039	881	1,352	1,897	1,864	-2%
249	2,125	1,474	1,110	1,514	2,217	2,826	3,149	3,238	4,223	3,800	-10%
251	409	234	231	255	246	326	254	298	470	387	-18%
283/284/285	7,640	4,028	2,221	3,120	6,548	7,715	8,185	9284	13,860	12,920	-7%
287	311	312	313	314	368	376	460	470	529	425	-20%
297	395	153	138	220	201	244	296	313	343	563	64%
298	819	465	326	516	704	803	826	932	1988	1733	-13%
Forested Zone	83,881	40,947	36,821	51,567	72,810	96,513	100,395	108,820	149,578	132,442	-11%

Note: Permit area totals prior to 1999 are estimates that assume an evenly distributed harvest in the old permit areas and may be biased.

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

Permit Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change
104	1,523	747	565	887	1,137	1,240	1,266	1,332	1,589	1,586	0%
107	1,758	1,085	942	1,160	1,706	1,948	2,174	2,119	2,523	2,277	-10%
110	312	179	140	212	421	487	484	500	561	593	6%
115	1,855	1,207	1,009	1,316	1,898	2,036	2,145	2,371	2,894	2,663	-8%
116	159	112	100	144	138	150	156	157	238	249	5%
122	494	267	242	447	293	415	452	441	490	567	16%
126	383	210	183	250	306	390	417	493	582	587	1%
127	97	54	62	81	176	80	82	93	126	145	15%
152	137	76	89	127	173	191	182	130	106	152	43%
154	1,119	935	984	1,437	2,017	2,304	2,142	2,169	2,071	2,049	-1%
156	1,157	1,037	1,081	1,531	1,836	2,066	1,680	1,645	1,989	1,996	0%
157	2,302	1,748	1,988	2,675	3,099	3,327	3,143	3,047	3,207	3,030	-6%
159	1,712	1,194	1,428	1,867	1,980	2,412	1,773	1,605	1,916	1,514	-21%
167	843	466	327	585	906	1,036	968	1,211	821	819	0%
168	1,402	774	543	973	1,579	1,653	1,454	1,675	1,698	1,889	11%
170	2,110	1,121	1,135	2,109	1,609	3,106	2,787	2,611	3,435	3,233	-6%
172	1,278	791	896	1,175	1,820	2,292	2,260	2,200	2,359	2,147	-9%
174	1,188	741	702	1,224	1,234	1,446	1,255	1,361	1,541	1,596	4%
175	1,526	831	810	1,273	1,917	2,107	2,072	2,113	2,463	2,319	-6%
178	1,661	905	895	1,363	1,945	2,052	2,012	2,212	2,638	2,756	4%
180	956	603	538	924	998	1,265	1,434	1,469	1,921	1,927	0%
181	1,326	896	819	1,378	1,737	2,081	2,026	2,069	2,471	2,493	1%
183	929	628	574	965	1,747	2,052	1,765	1,684	1,776	1,769	0%
197	744	442	403	585	923	1,142	953	998	1,040	1,143	10%
211	1,522	1,109	552	719	1,113	1,350	1,474	1,463	1,467	1,408	-4%
243	856	734	752	957	1,082	1,192	1,169	1,247	1,343	1,217	-9%
244	1,500	1,295	1,159	1,452	1,848	2,105	2,040	2,300	2,540	2,390	-6%
245	1,354	1,122	973	1,480	2,216	2,492	2,180	2,430	2,743	2,449	-11%
246	1,522	1,306	1,338	1,701	1,954	2,300	2,041	2,384	2,599	2,527	-3%
242/247	1,164	1,081	1,181	1,426	1,782	2,169	1,941	1,772	1,959	1,695	-13%
248	370	284	176	365	541	550	430	720	694	739	6%
249	860	756	668	1,045	1,310	1,590	1,479	1,429	1,479	1,327	-10%
251	109	105	94	110	129	134	152	132	176	183	4%
283/284/285	3,303	2,564	2,105	2,720	4,077	4,369	4,115	4,509	4,815	5,068	5%
287	128	118	70	127	167	189	201	184	207	182	-12%
297	205	118	106	161	154	169	213	225	266	307	15%
298	532	465	326	492	601	648	685	654	952	894	-6%
Forested Zone	40,396	28,106	25,955	37,443	48,569	56,535	53,202	55,154	61,695	59,885	-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.

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

Permit Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change
104	1,858	9	2	10	235	597	674	921	1,832	1,316	-28%
107	2,134	5	6	16	288	898	1,376	1,380	2,683	1,750	-35%
110	398	14	13	16	512	457	465	580	811	916	13%
111	1,449	489	28	14	85	511	879	801	1,597	1,213	-24%
115	1,798	9	20	31	436	1,134	1,444	1,444	2,479	1,754	-29%
116	51	1	0	2	0	0	6	0	26	46	77%
122	275	6	9	10	3	136	170	123	195	149	-24%
126	124	0	14	18	0	55	53	102	108	250	131%
127	8	0	1	2	0	1	17	15	20	20	0%
152	123	53	54	86	52	92	82	87	129	94	-27%
154	1,135	399	386	515	960	2,111	2,026	2,863	3,646	3,127	-14%
156	1,129	463	465	578	810	1,687	1,356	1,601	2,946	2,587	-12%
157	2,021	1,144	1,305	2,034	2,286	3,658	4,053	4,680	5,794	4,576	-21%
159	1,221	687	884	1,626	1,991	2,658	2,394	2,329	3,112	2,357	-24%
167	1,112	10	11	14	546	565	1,003	1,277	751	644	-14%
168	1,845	11	9	15	831	1,033	925	1,349	1,520	2,089	37%
170	2,294	31	8	111	1,248	1,832	2,046	2,105	5,025	3,921	-22%
172	1,721	68	83	268	1,140	1,961	2,364	2,710	4,645	3,343	-28%
174	1,053	14	52	147	693	990	886	1,317	2,270	1,750	-23%
175	1,157	1,853	1,875	1,413	403	922	1,267	1,071	2,571	1,935	-25%
178	1,172	9	637	827	399	1,012	1,331	1,438	2,848	2,511	-12%
180	631	9	57	85	5	327	356	491	1,358	538	-60%
181	1,059	13	95	154	561	965	1,133	1,041	2,053	1,996	-3%
183	742	9	66	108	549	887	1,169	1,280	2,459	2,010	-18%
184	4,337	1,464	116	400	2,471	3,346	4,070	4,775	9,045	7,852	-13%
197	580	0	4	12	10	230	214	415	612	580	-5%
243	1,212	701	516	645	826	1,442	1,695	1,991	2,788	2,467	-12%
244	2,337	1,154	875	944	1,104	1,757	2,801	3,505	4,912	4,312	-12%
245	1,575	485	48	177	1,308	2,346	2,876	3,196	5,488	3,928	-28%
246	2,155	1,244	916	1,146	1,404	2,460	3,109	2,765	4,931	4,255	-14%
247/242	1,694	939	1,069	1,238	1,401	1,574	2,247	2,755	3,553	3,131	-12%
248	860	472	388	578	309	489	451	632	1,203	1,125	-6%
249	1,265	718	442	469	907	1,236	1,670	1,809	2,744	2,473	-10%
251	300	129	137	145	117	192	102	166	294	204	-31%
287	183	194	243	187	201	187	259	286	322	243	-25%
297	190	35	32	59	47	75	83	88	77	256	232%
298	287	0	0	24	103	155	141	278	1,036	839	-19%
Forested Zone	43,485	12,841	10,866	14,124	24,241	39,978	47,193	53,666	87,883	72,557	-17%

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.)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Change
104	2,078	7	5	6	6	7	8	9	10	9	8	-9%
107	1,895	8	7	9	11	12	12	13	15	13	11	-15%
110[a]	300	16	14	18	21	23	23	25	26	25	24	-7%
111[b]	1,831	5	3	4	5	6	6	7	7	6	6	-13%
115	1,872	10	9	12	14	17	17	20	22	20	18	-10%
116	1,158	2	2	2	2	3	3	3	3	3	3	-15%
122	620	3	2	3	3	4	3	4	4	4	3	-16%
126	940	4	4	5	5	5	5	5	6	6	4	-20%
127	562	3	2	3	3	4	3	4	4	4	3	-16%
154	761	10	10	12	14	16	16	16	16	14	13	-10%
156	826	11	11	12	14	15	14	15	16	15	14	-6%
157	890	15	14	17	19	21	20	21	21	19	18	-6%
159	568	17	17	20	21	22	19	19	20	18	18	-1%
167	440	-	13	18	18	19	19	20	18	17	15	-9%
168	724	11	10	13	15	16	15	16	16	16	14	-13%
170	1,315	13	12	15	18	21	20	22	24	24	22	-6%
172	451	17	17	22	28	33	31	33	35	31	27	-12%
174	835	9	8	10	12	13	13	14	15	15	14	-7%
175	1,266	8	8	9	11	12	11	12	13	12	11	-13%
178	1,264	9	9	11	13	15	15	17	19	19	17	-10%
180	1,059	8	7	9	10	12	12	14	16	17	16	-2%
181	1,009	11	11	13	15	16	16	17	18	18	16	-13%
183	707	12	12	14	16	17	16	16	17	15	12	-19%
184[c]	1,260	13	11	15	18	21	22	25	27	26	24	-5%
197	960	10	9	11	12	13	13	15	16	17	17	2%
242	209	-	18	21	23	25	23	23	23	20	17	-14%
243	314	24	22	27	31	35	35	37	38	37	35	-4%
244	586	20	19	23	26	31	33	37	39	38	37	-4%
245	583	16	16	21	25	29	30	32	33	30	27	-9%
246	758	19	17	20	23	25	24	24	25	24	23	-6%
247	229	-	18	21	23	25	23	23	23	20	17	-14%
248	213	16	15	18	19	21	19	20	21	20	18	-10%
249	502	13	11	13	15	17	16	17	17	16	15	-8%
251	56	17	15	17	19	21	21	23	26	25	26	1%
297	439	6	5	6	7	7	8	8	9	10	10	-1%
298	620	13	11	13	14	16	16	18	20	19	18	-5%
Forest Zone	30,100	10	9	11	13	15	15	16	17	16	15	-8%

[a] Now includes old permit area 283; [b] formerly permit area 211; [c] formerly permit area 284

Aerial Moose Survey, 2005

Mark S. Lenarz, Forest Wildlife Populations & Research Group

INTRODUCTION

Each year, we conduct an aerial survey 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 a simulation model to identify population trends and the harvestable surplus.

METHODS

We used a stratified random block survey protocol originally developed in Alaska to estimate moose population parameters (Gasaway et al. 1986). Briefly, moose numbers and age/sex ratios were estimated by flying transects within a stratified random sample of survey plots (Figure 1). In contrast to previous years, all survey plots in 2005 were rectangular (5 x 2.67 mi.) and all transects were oriented east west. The survey was conducted using helicopters (Bell Jet Ranger) flown by DNR Enforcement pilots. 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. 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.

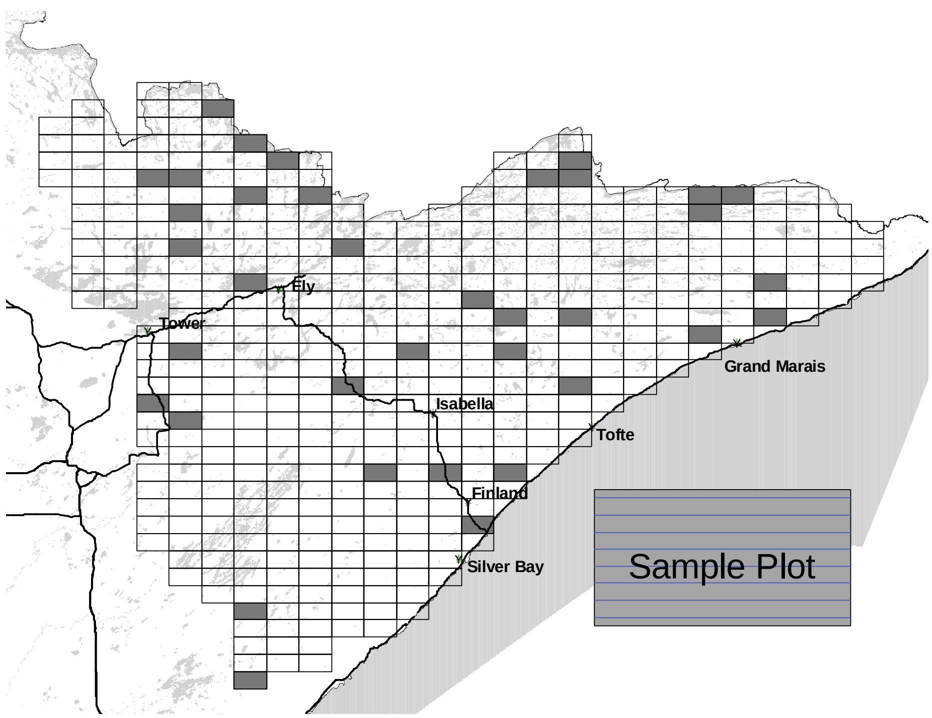


Figure 1. Northeast moose survey area and sample plots (dark gray) flown in the 2005 aerial moose survey. The sample plot illustrates the transect lines flown in the helicopter to locate moose.

Test plots (one-half of a rectangular plot) containing 1 or more radio-collared moose also were flown during the survey with the same protocol used 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 suite of covariates mentioned above was collected. These data were used to develop a logistic regression model or "sightability model" (Ackerman 1988, Anderson and Lindzey 1996, Otten et al. 1993, Quayle et al. 2001, Samuel et al. 1987) to correct for animals not seen during the aerial survey. This sightability model was also used to recalculate the population estimate, bull:cow and calf:cow ratios from the 2004 survey.

RESULTS

The survey was initiated on 3 January and completed on 26 January. Snow depth ranged from 8" to 16" on 10 plots and greater than 16" on 26 plots. Survey conditions were rated as "Good" (highest rank) on all 36 plots. During the survey flights, a total of 372 moose were located on the 36 plots (478 mi^2) and included 152 bulls, 138 cows, 70 calves, and 12 unidentified moose.

Forty-one radio-collared moose were located in 31 test plots; 21 were observed from transects and 17 were located using telemetry. A sightability model was developed from these observations. The model with the highest predictive reliability incorporated a single covariate (visual obstruction [VOC]) grouped into 6 equal intervals (Giudice and Fieberg, unpubl.). The inverse of the probability of detection calculated with this model was used to "correct" the number of moose in each moose observation. Data on VOC from the test plots collected in 2004 were not consistent among observers and were not included in this year's sightability model.

Based on the moose observed on the survey plots and "corrected" by the sightability model, the estimated moose population in northeastern Minnesota numbered 6,481±1,697 (Table 1). Estimates of the calf:cow and bull:cow ratio were 0.49 and 0.84, respectively (Table 1).

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

Survey	Estimate	**Calves/ Cows**	**Bulls/ Cows**	**% 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	10,826 ±27%	0.47	1.19	4
2005	6,481±26%	0.49	0.84	9

DISCUSSION

The 2005 population estimate is considerably lower than the 2004 estimate and reflects a change in how some observers determined the level of VOC. Mean VOC in 2005 ($\bar{x}$ = 44) was significantly lower than determined in 2004 ($\bar{x}$ = 58, t = 5.14, $P < 0.001$). In 2004, one or more observers equated VOC to crown closure and this tended to over-estimate VOC. A mature aspen stand, for example, may have 100% crown closure, but the trees don't totally obscure moose. In contrast, it would be virtually impossible to observe moose in a conifer stand with 100% crown closure. The increased VOC in 2004 resulted in a population estimate that was biased high. The 2005 estimate is likely a more accurate estimate of moose numbers in northeastern Minnesota.

The relationship between VOC and detection probability varied between 2004 and 2005, likely a result of differences in how VOC was determined. Utilization of a sightability model in the moose survey assumes that this relationship does not vary annually. We intend to collect additional information for the sightability model for at least three more years to test for annual variability and allow for testing of other possible models.

Given that the 2004 estimate was biased high, it should not be inferred that the 2005 population estimate represents an increase from 2003. We are using a new procedure to estimate moose numbers and the estimates are not directly comparable.

Prior to 1998 we initiated the survey each year as soon as there was 8 to 12 inches of snow on the ground in the survey area. Analyses (Lenarz 1998) indicated, however, that estimated population size declined as a function of the starting date. In 1993, for example, we began the survey on 4 January and the estimate was 4,421; in the following year, we began the survey on 9 December and the estimate increased to 6,005. A mid-winter shift to coniferous cover, where moose are more difficult to see, is common to moose populations throughout the boreal forest (Lynch 1975, Peek et al. 1976, Crête et al 1986, Peterson and Page 1993) and likely contributes to this bias. To deal with this relationship we changed the survey protocol in 1998 so that the survey was initiated on a consistent starting date in early January. With this change, we acknowledged that population estimates were biased low, but believed that results were more comparable among years. This year's estimate better accounts for differences in visibility during the survey and suggests that moose numbers are higher than we previously believed.

In September 2004, survey plot boundaries were re-drawn and all plots were stratified. As a group, wildlife managers, researchers, and tribal biologists from northeastern Minnesota reviewed GIS data, past survey data, and used personal knowledge to assign each of the new rectangular plots to 1 of 3 strata (low, medium, or high moose density). This re-stratification appears to have improved the precision of this year's estimate. In contrast to 2004, differences in mean moose/plot (corrected for sightability) agreed with strata designations of relative abundance. Differences in sampling variance indicate that the allocation of sample units was nearly optimal (Giudice and Fieberg, unpubl.).

The estimated bull:cow ratio (Table 1) was significantly lower than the average estimated for the previous 20 years (=120, *t*=15.03, *P<0.001*), in part because of the new methodology. Each observation is corrected based on the level of VOC to account for animals not observed. Because VOC values for cows tended to higher ($_{bulls}$ =40, $_{cows}$ = 46), the number of cows was increased generating a lower bull:cow ratio. The "uncorrected" estimate for this ratio was 1.10, a value more in line with previous estimates.

The estimated calf:cow ratio (Table 1) was significantly lower than the average estimated in the previous 20 years (=59, *t*=2.7, *P*=0.0071). The proportion of twins observed was not significantly different (=6.8%, *t* =-1.85, *P*=0.079). The low calf:cow ratios in both 2004 and 2005 were not caused by the new methodology. Calves continue to accompany cows during the winter and hence, their numbers would be corrected equally based on measurements of VOC.

In the January survey, only 3% of the moose exhibited hair loss, which is indicative of infestation with the winter tick (*Dermacentor albipictus*). Moose will often rub off patches of hair when high numbers of the tick begin to engorge. During the capture operation in early February, 73% of the moose (n=30) had bare patches and ticks were observed on 100% of the moose handled. None of the moose had lost more than 25% of their hair.

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 Authority. In particular, I would like to thank Mike Trenhom for coordinating all of the helicopters and pilots; Dan Litchfield for coordinating flights and survey crews; and Mike Schrage (Fond du Lac) and Andy Edwards (1854 Authority) for securing supplemental survey funding from their respective groups. I also want to thank Dan Litchfield, Tom Rusch, Andy Edwards, Mike Schrage, and Kevin Carlisle 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 countless hours he has spent creating and improving the GIS survey maps

LITERATURE CITED

Ackerman, B. R. 1988. Visibility bias of mule deer aerial census procedures in southeast Idaho. Ph D. Dissertation. University of Idaho., Moscow.

Anderson, C. R. and F. G. Lindzey. 1996. Moose sightability model developed for helicopter surveys. Wildlife Society Bulletin. 24:247-259.

Crête, M., R.P. Rivest, H. Jolicoeur, J.M. Brassard, and F. Messier. 1986. Predicting and correcting helicopter counts of moose with observations made from fixed-wing aircraft in southern Quebec. Journal Applied Ecology. 23:751-761.

Gasaway, W.C., S.D. DuBois, S. Harbo, and D. J. Reed. 1986. Estimating moose demography from aerial surveys. Biological Papers, University of Alaska, Fairbanks. No.22.

Lenarz, M.S. 1998. Precision and bias of aerial surveys in northeastern Minnesota. Alces. 34(1):117-124.

Lynch, G.M. 1975. Best timing of moose surveys in Alberta. Proceedings North American Moose Conference and Workshop. 1:141-153.

Mitchell, H.B. 1970. Rapid aerial sexing of antlerless moose in British Columbia. Journal Wildlife Management. 34: 645-646.

Otten, R.M., J.B. Haufler, S.R. Winterstien, and L.C. Bender. 1993. An aerial census procedure for elk in Michigan. Wildlife Society Bulletin. 21:73-80.

Peek, J.M., D.L. Urich, and R.J. Mackie. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildlife Monographs 48:1-65.

Peterson, R.O. and R.E. Page. 1993. Detection of moose in midwinter from fixed-wing aircraft over dense forest cover. Wildlife Society Bulletin. 21:80-86.

Quayle, J.F., A.G. MacHutchon, and D. N. Jury. 2001. Modeling moose sightability in south-central British Columbia. Alces 37:43-54.

Samuel, M.D., E.O. Garton, M.W. Schlegel, and R.G. Carson. 1987. Visibility bias during aerial surveys of elk in northcentral Idaho. Journal Wildlife Management. 51:622-630.