GROUSE SURVEYS IN MINNESOTA DURING SPRING 2006

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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 2006. Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.0 (95% confidence interval = 0.9–1.1) drums/stop (dps). That was significantly greater than the 0.8 (0.7–0.9) dps observed during 2005 and similar to counts from 2001.

During the spring 2006 survey 1,463 sharp-tailed grouse were observed at 159 dancing grounds. The mean number of sharp-tailed grouse per dancing ground was 8.2 (6.9–9.7) in the East Central survey region, 9.9 (8.7–11.1) in the Northwest region, and 9.2 (8.3–10.1) statewide. Index values in the Northwest and statewide were significantly less during 2006 than during 2005, but the statewide index value was near the most recent 20-year mean.

We counted 1,766 male prairie-chickens and located 152 booming grounds. Within survey blocks we observed 0.29 leks/mi^2 (0.11 leks/km^2) and 13.9 males/lek. Approximately 21% fewer males and 18% fewer leks were counted in survey blocks during spring 2006 than during spring 2005. Densities observed during 2006, however, were greater than the means observed for 1993–2002.

INTRODUCTION

Index Surveys

The purpose of surveys of grouse populations in Minnesota is to monitor changes in the densities of grouse over time. Estimates of density, however, are difficult and expensive to

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

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 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 1998–2005. 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. To determine regional boundaries, I evaluated Spearman's rank correlations among annual mean drum counts in the 7 forested sections of the Ecological Classification System (ECS) in Minnesota. Drum counts during the last 2 full cycles of the ruffed grouse population (i.e., 1984–2004) were highly correlated among the 4 sections comprising the Laurentian Mixed Forest province (i.e., Northeast region), which covers the core and bulk of the

range of ruffed grouse in Minnesota (Figure 2). Apparent long-term population dynamics were noticeably different and correlations were lower for the other 3 ECS sections (i.e., Northwest, Southwest, and Southeast regions), which are along the periphery of ruffed grouse range. The new survey regions are similar to the traditional ruffed grouse zones. The Southeast region and zone are identical, the Southwest region is analogous to the Central Hardwoods zone, the Northwest region consists of the western half of the Northwest zone, and the Northeast region includes the Northeast and North Central zones (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; see Figure 2 caption for full section names). 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 1982–2006. 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 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.

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 2006. The number of grouse included those recorded as males and those recorded as being of unknown sex. 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 2005 and 2006.

I ran a similar analysis for survey data from 2004 and 2005, including calculating mean index values and differences between years, because there was an error in the results I presented in the 2005 Grouse Survey Report. I had not removed dancing grounds with <2 male grouse before calculating the means, so the reported index values were less than they should have been. For example, although observers counted 1,824 grouse while visiting 193 lek sites, only 1,818 grouse were observed at the 161 leks with ≥2 males (i.e., a conservative definition of a dancing ground).

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 and Northern Minnesota & Ontario Peatlands 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 16 cooperating organizations surveyed 128 routes between 9 April and 19 May 2006. Most routes (87%) were run between 20 April and 8 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, 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 52%, 35%, and 13% of 122 routes, respectively. Survey conditions during 2005 were Excellent, Good, and Fair on 48%, 39%, and 12% of routes, respectively.

Mean counts of ruffed grouse drums throughout the forested regions of Minnesota were 1.0 (95% confidence interval = 0.9–1.1) drums/stop (dps) during 2006. That was similar to counts during 2001 and significantly greater than the 0.8 (0.7–0.9) dps observed last year (Figure 4). Increases of 0.2–0.3 dps from 2005 means were observed in the Northeast, Northwest, and Southwest regions but not in the Southeast region (Figure 5). Drum counts by survey region were 1.1 (0.9–1.2) dps in the Northeast, 1.0 (0.8–1.4) dps in the Northwest, 0.8 (0.4–1.2) dps in the Southwest, and 0.6 (0.2–1.1) dps in the Southeast. 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 throughout most of Minnesota during spring 2006 were likely greater than spring densities during 2004 and 2005. This year, therefore, could mark the beginning of the next cyclical increase in the population. Given the

variability in the cycle and uncertainties about the survey results, however, such a conclusion cannot be made until at least next year.

Sharp-tailed Grouse

A total of 1,463 sharp-tailed grouse was observed at 159 dancing grounds with ≥2 male grouse (or grouse of unknown sex) during spring 2006. The resulting index value was similar to the mean from the last 26 years (Figure 6). Leks with ≥2 grouse were visited a mean of 1.9 times, and 125 historic lek sites with ≤1 male were also surveyed at least once.

The index value in the EC region has remained the same at 8–9 grouse/lek since at least 2004 (Table 1). The index values among comparable leks in the NW region and statewide declined by 3.6 (95% CI = 1.9–5.3) and 2.5 (95% CI = 1.3–3.7) grouse/lek, respectively, between 2005 and 2006. Somewhat smaller declines also occurred in the NW and statewide between 2004 and 2005, despite annual means that increased slightly that year. The apparent paradox was caused by differences in the leks included in each annual data set compared to the set of "comparable" leks. The discrepancies highlight the problems with making inferences from samples that cannot be assumed to be representative of the population of interest.

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	159	9.9	8.7–11.1	95	8.2	6.9– 9.7	64
$\text{Difference}_{04\text{-}05}$	-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

[a] Survey regions; see Figure 1.
[b] Year or the mean difference between comparable leks during consecutive years.
[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 4 cooperating organizations counted prairie-chickens during spring 2006. Cooperators included the DNR Division of Fish and Wildlife, Fergus Falls and

Detroit Lakes Wetland Management Districts (U.S. Fish & Wildlife Service), University of Minnesota–Crookston, and The Nature Conservancy. Observers located 152 booming grounds and counted 1,766 male prairie-chickens (Table 2). Within hunting permit areas we observed 0.09 leks/mi^2 (0.04 leks/km^2) and 12.2 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 2006. 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	4	0	66
407A	295.1	7	58	22
407B	171.9	28	282	0
407C	161.1	25	467	0
420A	168.1	24	347	0
420B	101.3	17	182	0
421A	236.6	11	77	42
PA subtotal[b]	1,236.0	116	1,413	130
Outside PAs[c]	NA[d]	36	353	38
Grand total	NA	152	1,766	168

[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.

Each booming ground was observed on a median of 2 (mean = 1.9) different days, but 39% 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 1,110 males (includes birds of unknown sex) on 80 leks (Table 3). That was 21% fewer males and 18% fewer leks than were counted in survey blocks during spring 2005. Leks were defined as having ≥2 males, so observations of single males were excluded from summaries by survey block. During spring 2006 we observed 0.35 leks/mi^2 (0.13 leks/km^2) and 15.1 males/lek in survey blocks in the core of the range, whereas

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

		Area	2006		Change from 2005[a]	
Range[b]	Survey Block	(miles^2)	Leks	Males[c]	Leks	Males[c]
Core	Polk 2	16.2	4	65	-5	-54
	Norman 1	16.1	3	42	-2	13
	Norman 3	16.0	6	90	1	22
	Clay 1	17.6	9	155	1	10
	Clay 2	16.0	2	101	-1	-7
	Clay 3	16.1	9	143	0	-25
	Clay 4	14.9	5	57	-1	-11
	Wilkin 1	15.4	9	93	-1	-87
	Wilkin 3	16.1	6	71	0	-30
	Otter Tail 1	15.9	3	30	1	-1
	Core subtotal	160.2	56	847	-7	-170
Periphery	Polk 1	15.9	4	48	-6	-41
	Norman 2	16.3	5	62	-3	-37
	Mahnomen	16.1	3	48	-2	-19
	Becker 1	16.0	3	24	-1	-17
	Becker 2	16.1	4	42	0	-1
	Wilkin 2	16.1	2	16	0	-7
	Otter Tail 2	15.7	3	23	1	-5
	Periphery subtotal	112.2	24	263	-11	-127
Grand total		272.4	80	1,110	-18	-297

[a] The 2005 count was subtracted from the 2006 count, so a negative value indicates a decline.
[b] Survey blocks were classified as either mostly within the hunting permit areas (core) or mostly outside the permit areas (periphery).
[c] Includes birds recorded as being of unknown sex but excludes lone males not observed at a booming ground.

we observed 0.21 leks/mi^2 (0.08 leks/km^2) and 11.0 males/lek in peripheral blocks (Table 3). The densities of prairie-chickens observed during 2006 were greater than the means of 0.2 leks/mi^2 and 11.5 males/lek observed in survey blocks from 1993 until 2002.

ACKNOWLEDGEMENTS

I sincerely appreciate the efforts of all the DNR staff and volunteer cooperators who conducted and helped coordinate the grouse surveys. I also thank Laura Gilbert for helping with data entry and archiving and Mark Lenarz for reviewing an earlier draft of this report.

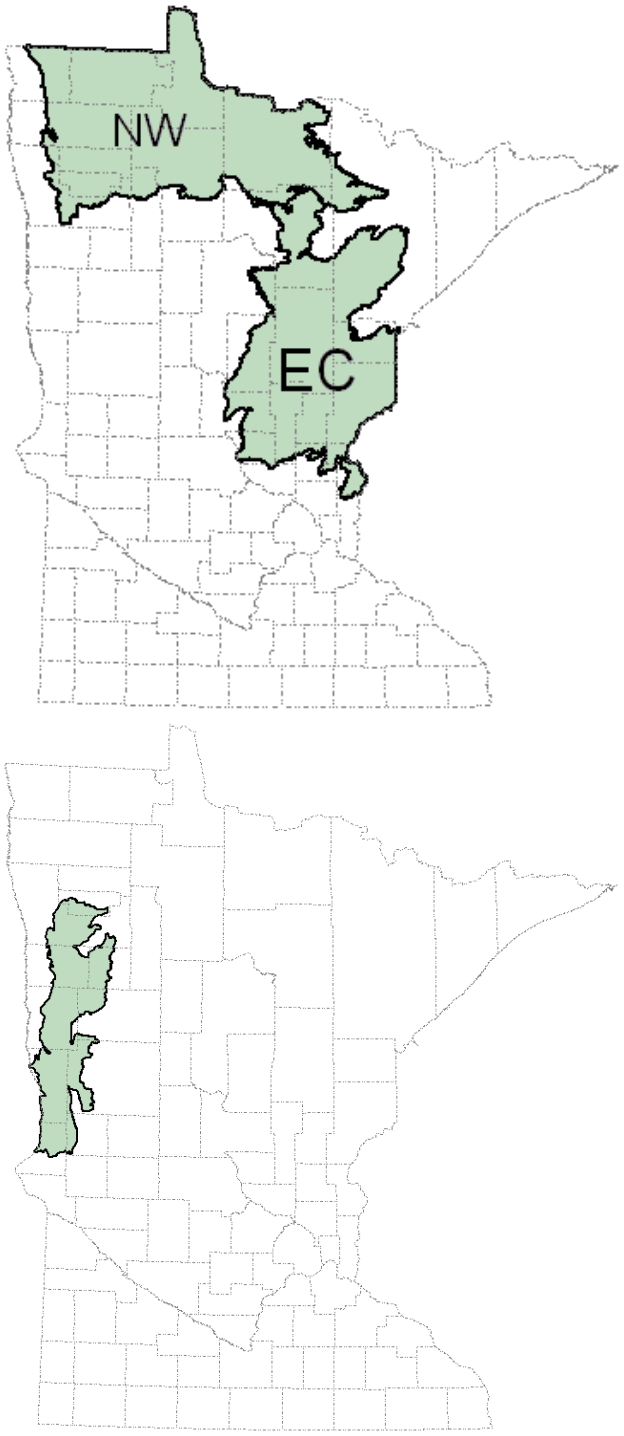

Figure 1. Northwest (NW) and East Central (EC) survey regions for **sharp-tailed grouse** (top panel) and primary range of **greater prairie-chickens** (bottom panel) relative to county boundaries in Minnesota. The sharp-tailed grouse regions were based largely on boundaries of ECS Subsections, whereas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

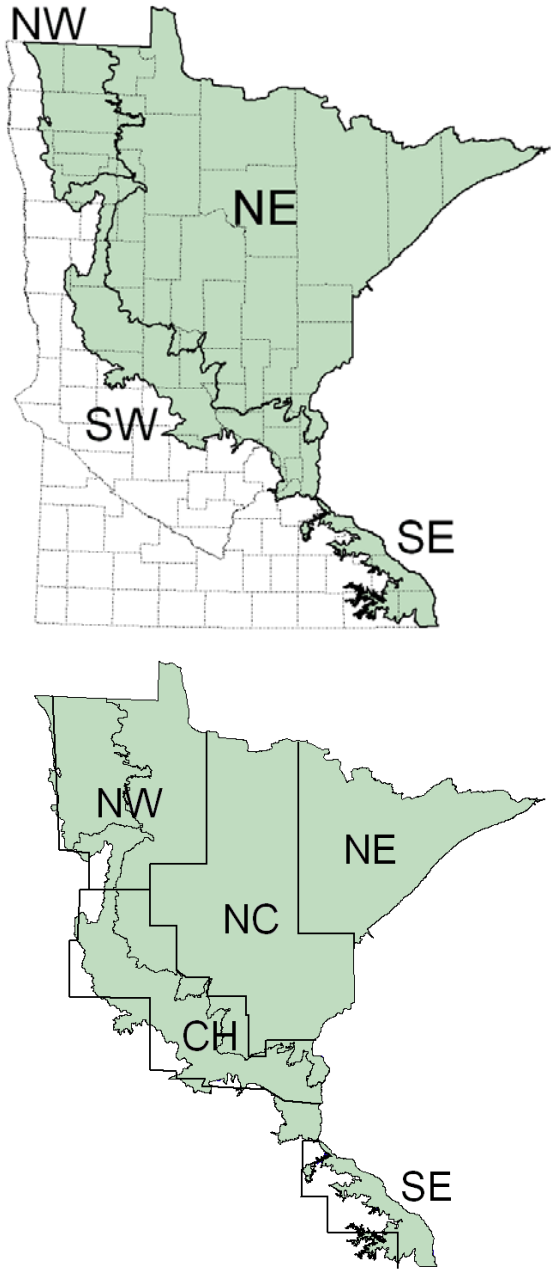

Figure 2. **Ruffed grouse** survey regions (shaded, curved boundaries). Top panel: regions are labeled and overlaid on counties (dashed lines). Bottom panel: former survey zones (straight boundaries) are labeled and overlaid on regions. The northeast (NE) region corresponds to the northeast (NE) and northcentral (NC) zones. It includes the Northern Minnesota & Ontario Peatlands, Northern Superior Uplands, Northern Minnesota Drift & Lake Plains, and Western Superior Uplands sections, including a small portion of the Southern Superior Uplands in eastern Carlton County. The northwest (NW) region corresponds to the northwest (NW) zone and consists of the Lake Agassiz & Aspen Parklands section. The southwest (SW) region is similar to the central hardwoods (CH) zone and consists of the northern half of the Minnesota and Northeast Iowa Morainal section. The southeast (SE) region is identical to the southeast (SE) zone and consists of the eastern half of the Paleozoic Plateau section.

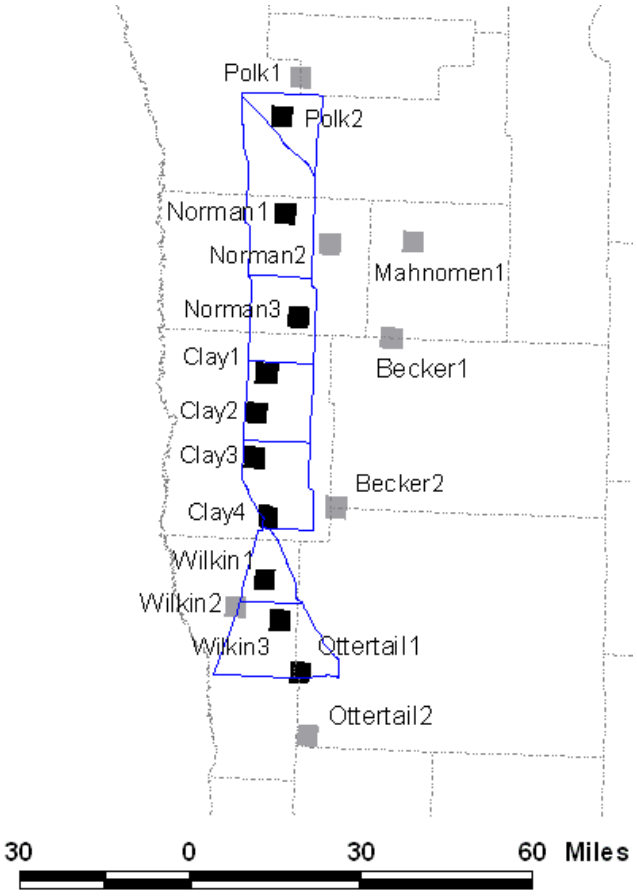

Figure 3. Survey blocks (labeled squares) and hunting permit area boundaries (solid lines) for **prairie-chickens** in western Minnesota. Survey blocks were designated as being in either the core (black) or periphery (gray) of the range. Blocks were named after the counties (dashed lines) in which they were primarily located. Permit areas are ordered from north to south: 405A, 407A, 407B, 407C, 420A, 420B, and 421A.

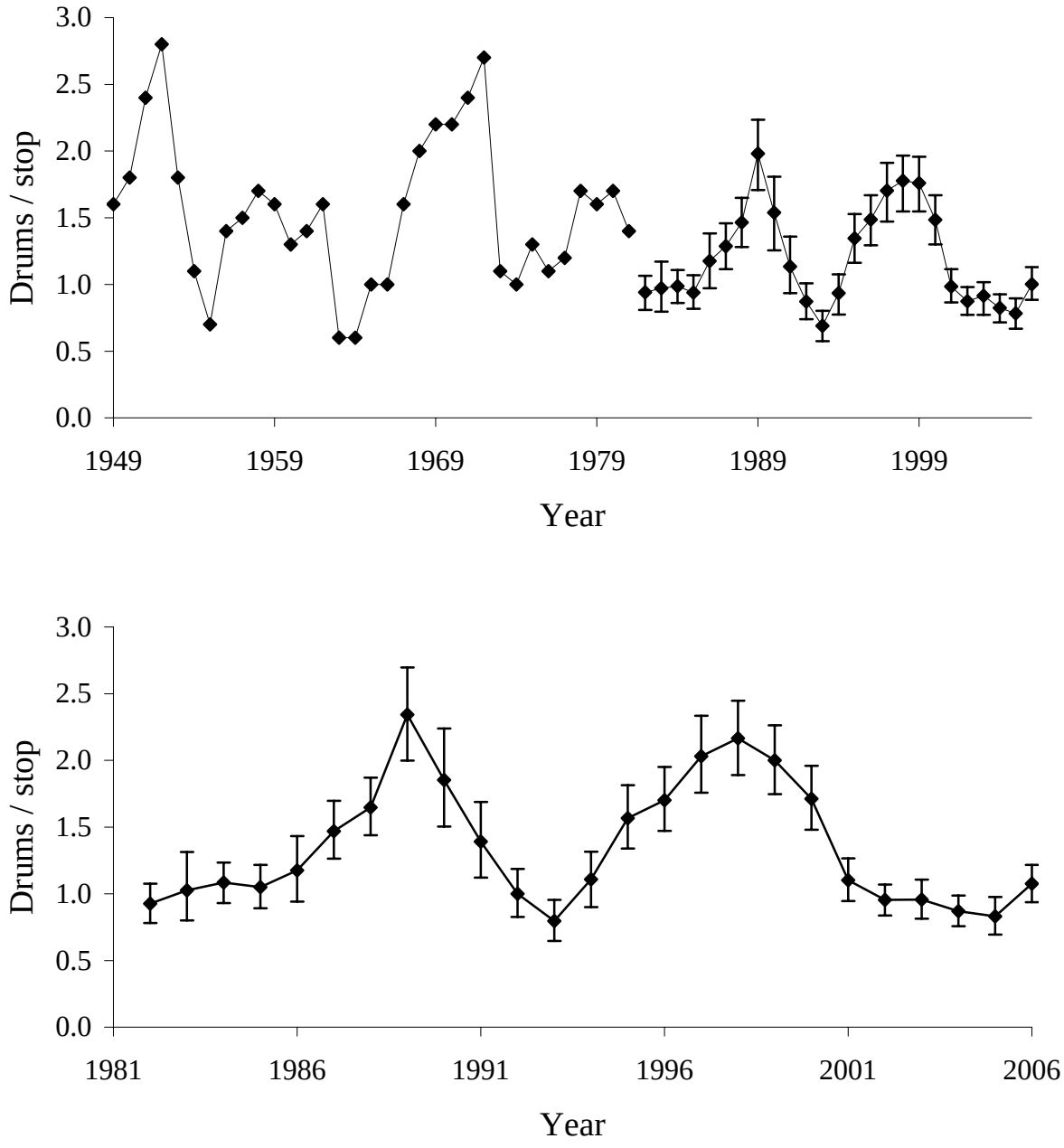

Figure 4. Ruffed grouse drum count index values in **Minnesota** (top) and just the **Northeast** region (bottom). Vertical error bars represent 95% confidence intervals based on bootstrap samples. Statewide means before 1982 were not re-analyzed with the current methods, so confidence intervals were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

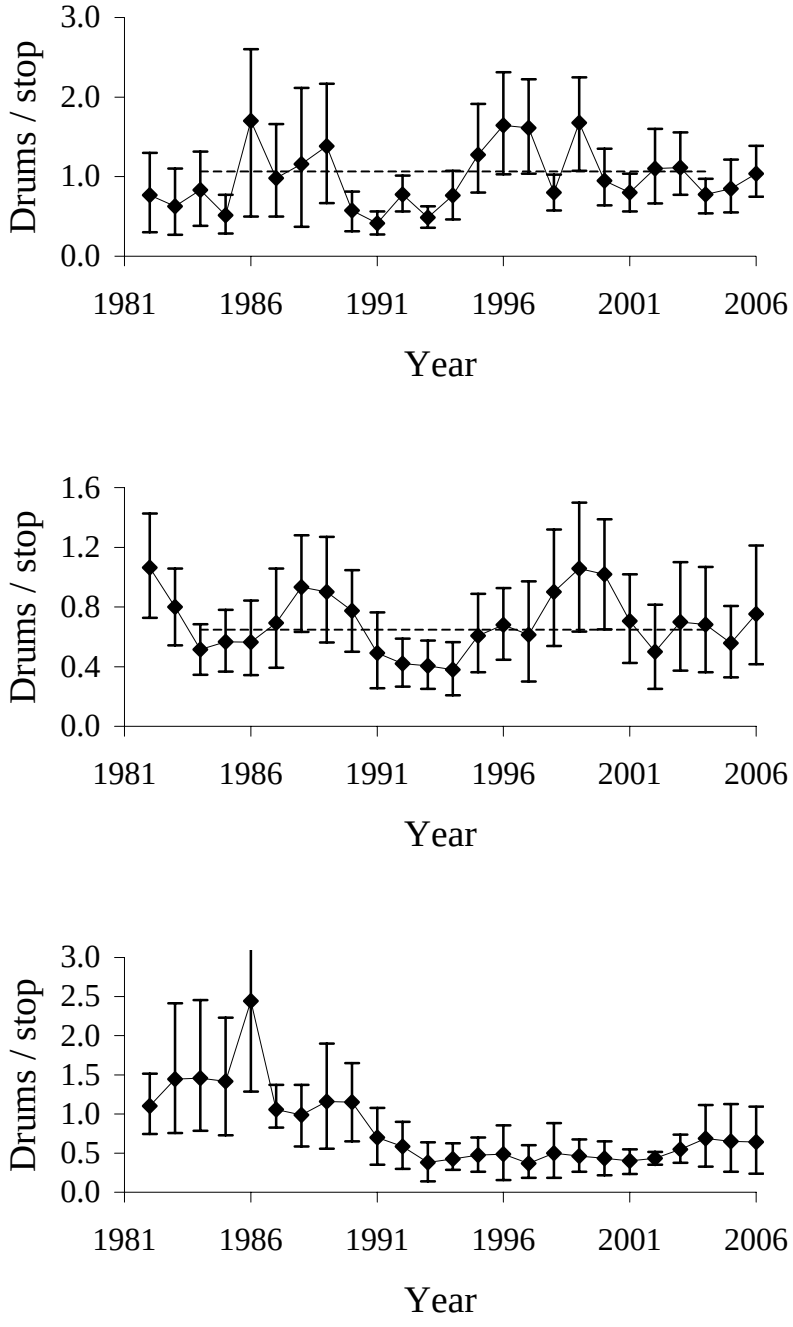

Figure 5. Ruffed grouse drum count index values in the **Northwest** (top), **Southwest** (middle), and **Southeast** (bottom) survey regions of Minnesota. Dashed horizontal lines indicate the mean from 1984 to 2004. Vertical error bars represent 95% confidence intervals based on bootstrap samples. One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

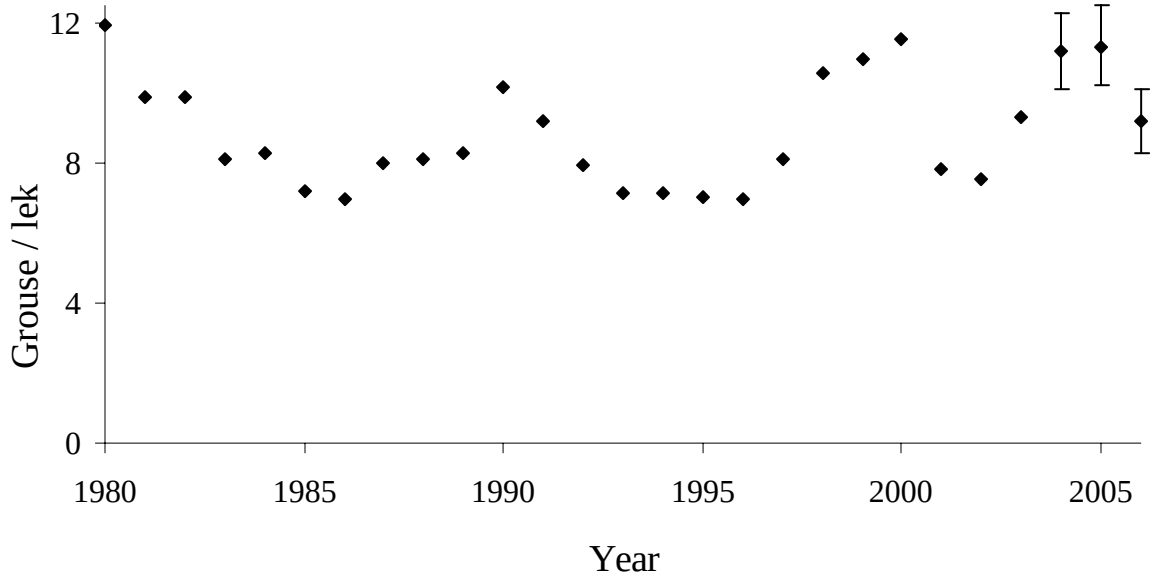

Figure 6. Mean number of **sharp-tailed grouse** observed in Minnesota during spring surveys of dancing grounds. Vertical error bars, which were not calculated for 1980–2003, represent 95% confidence intervals based on bootstrap samples. No line connects the annual means because they are not based on comparable samples of leks.