FOREST WILDLIFE POPULATIONS

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2015 STATUS OF MINNESOTA BEAR POPULATION

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INTRODUCTION

The size of the Minnesota bear population has been estimated in the past using a biomarker (tetracycline) and mark–recapture based on hunter-submitted samples (Garshelis and Visser 1997, Garshelis and Noyce (2006). The last estimate was produced in 2008, and the use of that biomarker may no longer be permitted. Since then, trends in the population have been assessed using various modelling approaches, based on composition (sex-age) of harvest data.

METHODS

Successful hunters must register their bears and submit a tooth sample, which is used to estimate age, and thus harvest age structure. Hunters also report the sex of their harvested bear; we adjust this for a known bias in hunter-reported sex (11% of female bears reported as males). Ages and sexes of harvested bears accumulated since 1980 were used to reconstruct minimum statewide population sizes through time (i.e., the size of the population that eventually died due to hunting) using a technique formulated by Downing (1980): each sex was estimated separately, and then summed. Age groups were collapsed to 1, 2, and 3+ years in order to estimate population size 3 years in the past (no more recent estimates can be obtained using this technique). This technique only estimates the size of the population that eventually dies due to hunting; to account for bears that die of other causes, the trend lines are scaled upward to attempt to match tetracycline-based estimates.

A second, independent assessment of population trend is obtained by investigating harvest rates (% of living bears harvested each year). A relatively low harvest rate would signify a population with more potential growth. Harvest rate is estimated from the inverse of the age at which the number of males and females in the harvest is equal, based on methodology of Fraser (1984).

RESULTS

Population trend

Both the tetracycline-based and Downing reconstructed populations showed an increase during the 1990s, followed by a decline during the 2000s (Fig. 1); however, the shapes of the 2 trajectories differed somewhat (the reconstructed population curves were less steep). Therefore, it was not possible to exactly match the curve from the reconstruction to all 4 tetracycline-based estimates.

Downing population reconstruction assumes equal harvest pressure through time: as harvest pressure is diminished, and fewer bears are killed (as has been the trend since 2003), ensuing population estimates will be biased low, and population estimates will tend to follow changes in harvests (instead of population size). Hence, population trends showed a decline in the 2000s in the quota zone (Fig. 2), with reduced harvests there (which were designed to increase population size). Conversely, population trends appear stable in the no-quota zone, where harvests have been stable.

Trends in harvest rates

The sex ratio of harvested bears varies by age in accordance with the relative vulnerability of the sexes. With male bears being more vulnerable to harvest than females, males always predominate among harvested 1-year-olds. They also predominate, but less strongly among 2 and 3-year-old harvested bears. However, older aged bears (≥7 years) are nearly always dominated by females, because, although old females continue to be less vulnerable, there are far more of them than old males. The age at which the line fitted to these proportions crosses the 50:50 sex ratio is approximately the inverse of the harvest rate (Fig. 3). Segregating the harvest age data into 5-year intervals showed harvest rates increasing from 1980–1999, then declining with reductions in hunter numbers. Harvest rates during 2010–2015 were, on average, less than what they were in 1980–84, when the population was increasing (Fig. 1, 3).

Fig. 1. Statewide bear population trend (pre-hunt) derived from Downing reconstruction using the harvest age structures from 1980−2013. Curves were scaled (elevated to account for non-harvest mortality) to various degrees to attempt to match the tetracycline-based mark–recapture estimates. Estimates beyond 2013 (when harvests were reduced) are unreliable.

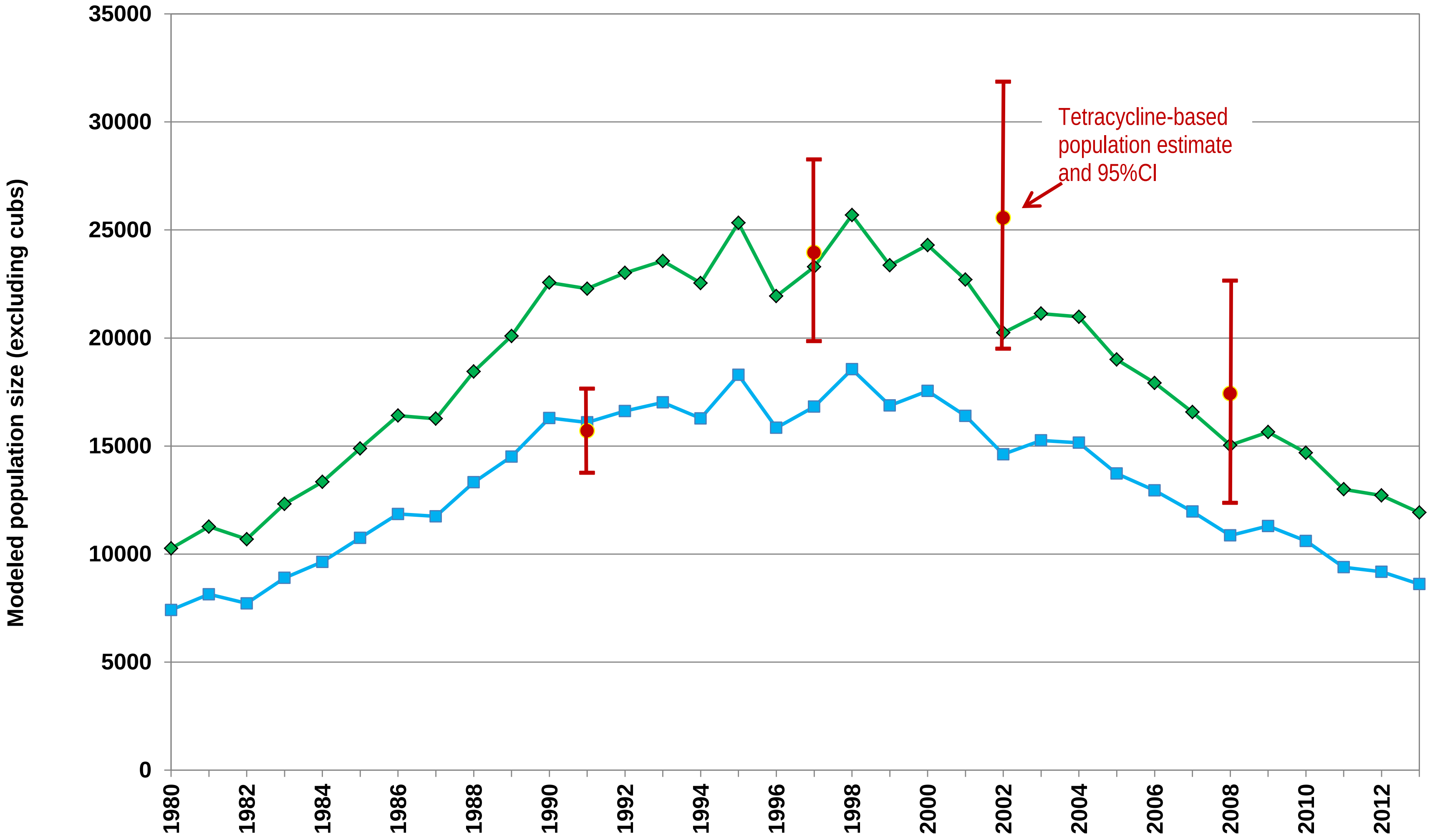


Fig. 2. Population trends during 2000s derived from Downing reconstruction for quota and no-quota zones compared to respective harvests. Population curves were scaled (elevated to account for non-harvest mortality) using a multiplier midway between the two curves in Fig. 12 (i.e., the actual scale of the population estimates is not empirically-based).

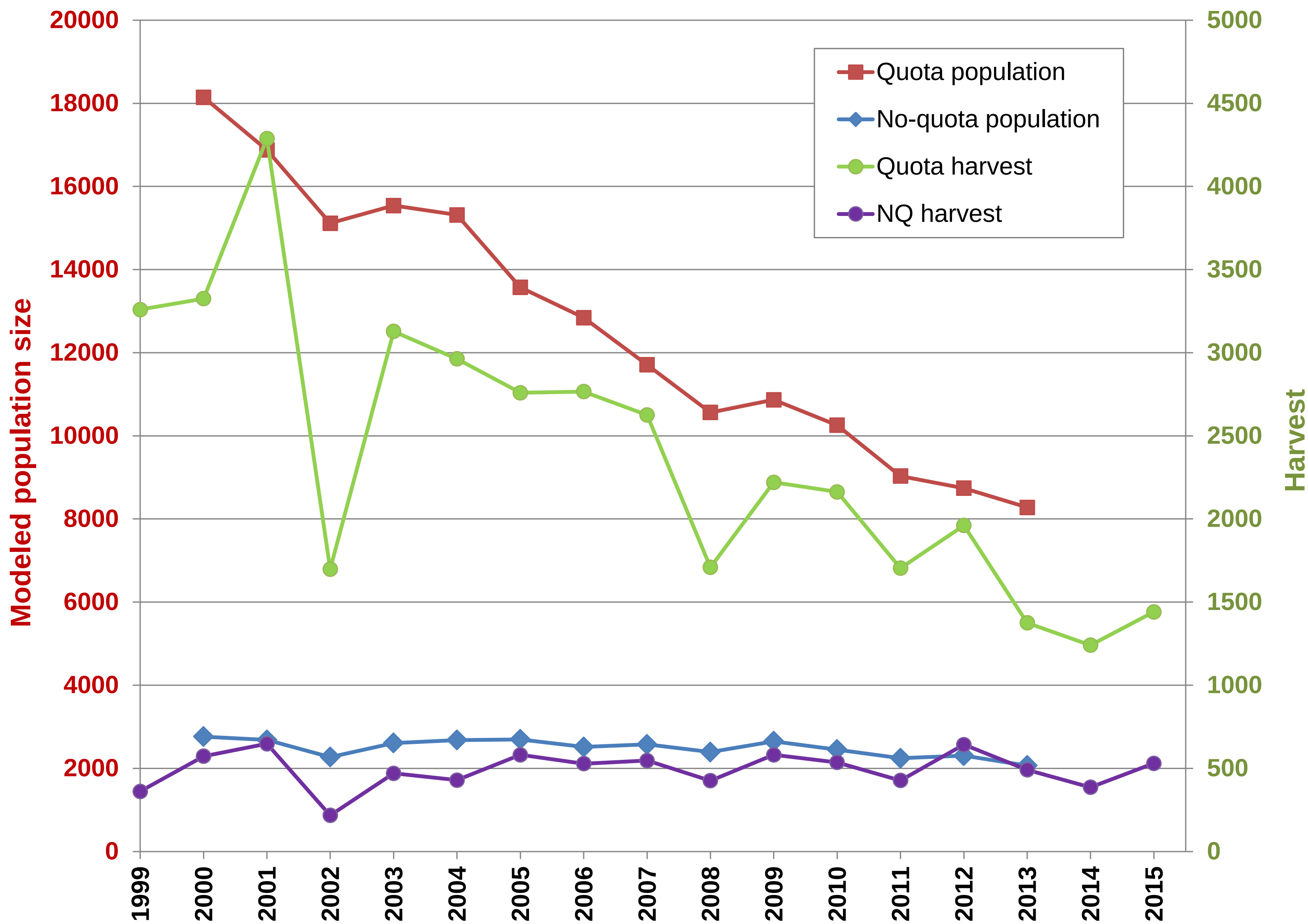
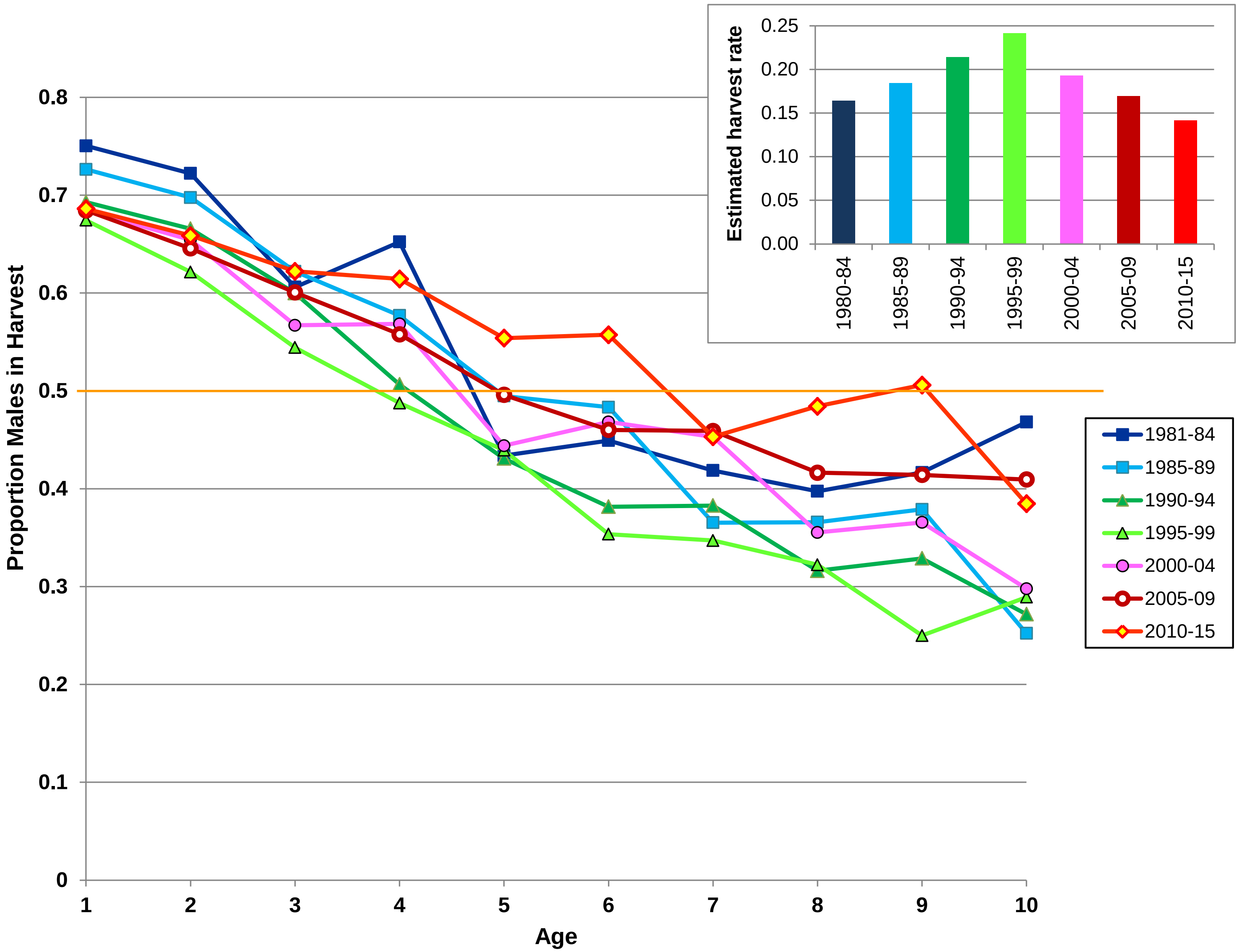


Fig. 3. Trends in proportion of male bears in statewide harvest at each age, 1–10 years, grouped in 5-year time blocks, 1981–2015. Higher harvest rates result in steeper curves. Fitting a line to the data for each time block and predicting the age at which 50% of the harvest is male yields approximately the inverse of the harvest rate (derived rates shown in inset).



2016 MINNESOTA SPRING GROUSE SURVEYS

Charlotte Roy, Forest Wildlife Populations and Research Group

SUMMARY OF FINDINGS

Each spring, the Minnesota DNR coordinates statewide ruffed grouse (*Bonasa umbellus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) surveys with the help of wildlife managers, cooperating agencies, and organizations (e.g., tribal agencies, U.S. Forest Service, college wildlife clubs). In 2016, ruffed grouse surveys were conducted between 4 April and 13 May. Mean ruffed grouse drums per stop (dps) were 1.3 statewide (95% confidence interval = 1.1–1.6) and increased (18%) from the previous year, as expected during the increasing phase of the 10-year population cycle.

Sharp-tailed grouse surveys were conducted between 14 March and 3 May 2016, with 1,737 birds (males and birds of unknown sex) observed at 182 leks. The mean numbers of sharp-tailed grouse/lek were 6.0 (4.9-7.3) in the East Central (EC) survey region, 10.2 (9.2–11.4) in the Northwest (NW) region, and 9.5 (8.6–10.5) statewide. Comparisons between leks observed in consecutive years (2015 and 2016) indicated fewer birds/lek statewide ($t = 2.2$, $P = 0.02$), and in the NW region ($t = 2.2$, $P = 0.03$), but the EC region remained statistically unchanged ($t = 0.4$, $P > 0.05$). Nevertheless, fewer leks have been reported in the EC region in recent years despite similar average lek size, likely indicating that birds are combining into fewer leks.

INTRODUCTION

The ruffed grouse (*Bonasa umbellus*) is the most popular game bird in Minnesota, with an annual harvest averaging >500,000 birds (~150,000 -1.4 million birds). Ruffed grouse hunter numbers have been as high as 92,000 during the last decade, although hunter numbers did not peak with the recent peak in grouse numbers, as they have traditionally. Sharp-tailed grouse (*Tympanuchus phasianellus*) are also popular among hunters, with an annual harvest of 6,000-22,000 birds since the early-1990s and 5,000-10,000 hunters in Minnesota.

The Minnesota DNR coordinates grouse surveys each year to monitor changes in grouse populations through time. These surveys provide a reasonable index to population trends, when the primary source of variation in counts among years is change in densities. However, weather, habitat conditions, observer ability, and grouse behavior, also vary over time and can influence survey counts. Thus, making inferences from survey data over short time periods (e.g., a few years) can be tenuous. Nevertheless, over longer time periods and when large changes in index values occur, these surveys can provide a reasonable index to long-term grouse population trends. Spring surveys, in combination with hunter harvest statistics, provide evidence that the ruffed grouse population cycles at approximately 10-year intervals.

The first surveys of ruffed grouse in Minnesota occurred in the mid-1930s, and the first spring survey routes were established along roadsides in 1949. By the mid-1950s, ~50 routes were established with ~70 more routes added during the late-1970s and early-1980s. Since that time, spring drumming counts have been conducted annually to survey ruffed grouse in the forested regions of the state where ruffed grouse habitat occurs. Drumming is a low sound produced by males as they beat their wings rapidly and in increasing frequency to signal the location of their territory. These drumming displays also attract females that are ready to begin nesting, so the frequency of drumming increases in the spring during the breeding season. The sound produced when male grouse drum is easy to hear and thus drumming counts are a convenient way to survey ruffed grouse populations in the spring.

Sharp-tailed grouse were first surveyed in Minnesota between the early-1940s and 1960. The current survey is based on counts at dancing grounds during the spring and was first conducted in 1976. Male sharp-tailed grouse display, or dance, together in open areas to attract females in the spring. This display consists of the males stomping their feet with out-stretched wings. Females visit the dancing grounds to select males for breeding. These dancing grounds, or leks, are reasonably stable in location from year to year, allowing surveyors to visit and count individuals each spring. Surveys are conducted in openland portions of the state where sharp-tailed grouse persist, although they were formerly much more widely distributed in Minnesota at the early part of the 20th century.

METHODS

Ruffed Grouse

Surveys for ruffed grouse were conducted along established routes throughout the state. Each route consisted of 10 listening stops at approximately 1.6-km (1-mile) intervals. The placement of routes on the landscape was determined from historical survey routes, which were originally placed near ruffed grouse habitat in low traffic areas. Annual sampling of these historical routes provides information about temporal changes along the routes, but may not be representative of the counties or regions where the routes occurred.

Survey observers were solicited from among state, federal, tribal, private, and student biologists. Each observer was provided a set of instructions and route location information. No formal survey training was conducted but all observers had a professional background in wildlife science, and most had previously participated in the survey. Participants were asked to conduct surveys at sunrise during peak drumming activity (in April or May) on days that had little wind and no precipitation. Each observer drove the survey route once and listened for drumming at each stop for 4 minutes. Observers recorded the number of drums heard at each stop (not necessarily the number of individual grouse), along with information about phenology and weather at the time of the survey.

The number of drums heard per stop (dps) was used as the survey index value. I determined the mean dps for each route, for each of 4 survey regions (Figure 1), and for the entire state. For each survey region, I calculated the mean of route-level means for all routes partially or entirely within the region. Routes that traversed regional boundaries were included in the means for both regions. Because the number of routes within regions was not related to any proportional characteristic, I used the weighted mean of index values for the 4 Ecological Classification Sections (ECS) in the Northeast region and the 7 ECS sections in the state. The geographic area of the section was used as the weight for each section mean (i.e., Lake Agassiz, Aspen Parklands = 11,761 km^2, Northern Minnesota and Ontario Peatlands = 21,468 km^2, Northern Superior Uplands = 24,160 km^2, Northern Minnesota Drift and Lake Plains = 33,955 km^2, Western Superior Uplands = 14,158 km^2, Minnesota and Northeast Iowa Morainal (MIM) = 20,886 km^2, and Paleozoic Plateau (PP) = 5,212 km^2). The area used to weight drum index means for the MIM and PP sections was reduced to reflect the portion of these areas within ruffed grouse range (~50%) using subsection boundaries. A 95% confidence interval (CI) was calculated to convey the uncertainty of each mean index value using 10,000 bootstrap samples of route-level means for survey regions and the whole state. Confidence interval boundaries were defined as the 2.5^{th} and 97.5^{th} percentiles of bootstrap frequency distributions.

Sharp-tailed Grouse

Wildlife Managers and volunteers surveyed known sharp-tailed grouse lek locations in their work areas in the Northwest (NW) and East Central (EC) portions of the state (Figure 2). The NW region consisted of Lake Agassiz & Aspen Parklands, Northern Minnesota & Ontario Peatlands, and Red River Valley ECS sections. The EC region consisted of selected subsections of the Northern Minnesota Drift & Lake Plains, Western Superior Uplands, and Southern Superior Uplands sections. Some leks may have been missed, but most managers believed that they included most of the leks in their work area. Given the uncertainty in the proportion of leks missed, especially those occurring outside traditional areas, the survey may not necessarily reflect sharp-tailed grouse numbers in larger areas such as counties or regions.

Each cooperator was provided with instructions and asked to conduct surveys on $\geq$1 day in an attempt to obtain a maximum count of male sharp-tailed grouse attendance at each lek. Observers were asked to conduct surveys within 2.5 hours of sunrise under clear skies and during low winds (<16 km/hr, or 10 mph) when lek attendance and ability to detect leks were expected to be greatest. Data recorded during each lek visit included the number of males, females, and birds of unknown sex.

The number of sharp-tailed grouse per dancing ground was used as the index value and was averaged for the NW region, the EC region, and statewide, using known males and birds of unknown sex. Observations of just 1 grouse were not included in the index. Data from former survey years were available for comparison, however, survey effort and success varied among years rendering comparisons of the full survey among years invalid. Therefore, to make valid comparisons between 2 consecutive years, only counts of birds from dancing grounds that were surveyed during both years were considered. Paired t-tests were used to test the significance of comparisons among years. Confidence intervals (95%) were calculated using 10,000 bootstrap samples of lek counts for each region and statewide.

RESULTS AND DISCUSSION

Ruffed Grouse

Observers from 14 cooperating organizations surveyed routes between 4 April and 13 May 2016. Most routes (96%) were surveyed between 12 April and 10 May, with a median survey date of April 29, which is the same median date as last year and the median survey date for the most recent 10 years. Excellent (58%), Good (34%), and Fair (8%) survey conditions were reported for 106 routes reporting conditions.

Statewide counts of ruffed grouse drums averaged 1.3 dps (95% confidence interval = 1.1 – 1.6 dps) during 2016 (Figure 3). Drum counts were 1.5 (1.2 – 1.8) dps in the Northeast (n = 93 routes), 1.1 (0.6 – 1.6) dps in the Northwest (n = 8), 0.8 (0.5 – 1.3) dps in the Central Hardwoods (n = 16), and 0.8 (0.4 – 1.4) dps in the Southeast (n = 6) regions (Figure 4a-d). Statewide drum counts increased (18%) from last year. An increase was expected given that the ruffed grouse population is in the increasing phase of the 10-year cycle.

Sharp-tailed Grouse

A total of 1,737 male sharp-tailed grouse and grouse of unknown sex were counted at 182 leks (Table 1) during 14 March - 3 May 2016. The statewide index value of 9.5 (8.6–10.5) grouse/lek was centrally located among values observed since 1980 (Figure 5). In the EC survey region, 180 grouse were counted on 30 leks, and 1,557 grouse were counted on 152 leks in the NW survey region. The index value was similar statewide and in both survey regions compared to 2015 (Table 1). Counts at leks observed during both 2015 and 2016 were lower (t = 2.2, P = 0.03) statewide and in the NW region (t = 2.2, P = 0.02), but counts were statistically unchanged in the EC region (t = 0.4, P > 0.05; Table 2). Leks with ≥2 grouse were observed an average of 2.2 times, but fewer leks (13%) were observed in 2016 than during 2015.

Ruffed grouse populations increased this year, but similar increases were not observed in the sharp-tailed grouse population. Sharp-tailed grouse population index values peaked with those for ruffed grouse in 2009, and appear to have troughed with them in 2013, but sharp-tailed grouse peaks can follow those of ruffed grouse by as much as 2 years. Although the index grouse/lek remained unchanged in both regions, fewer leks were observed in the EC region than have been observed in >30 years. Likewise, the number of birds counted in the EC region has been ~200 birds for the last 4 years, and counts have not been this low for >30 years. Although survey effort is a large factor in the number of leks surveyed, the declining patterns observed in the EC region appear not to be an artifact of survey effort. Survey effort (as indicated by number of lek sites visited, including historic leks where grouse have not been observed in recent years) was below the 10-year average of 102 leks in 2013 (84 leks); 2014 (82 leks); and 2015 (93 leks), but survey effort in 2016 (109 leks) exceeded the 10 year average and was the highest since the last peak in 2009. Likewise, the average number of surveys per lek in the EC region was up this year to 2.2 surveys/lek, the highest observed in the last 10 years (Roy and Larson, unpubl. data). Thus, declines in the EC region are indicated by the counts, after considering survey effort. Observed lek size can vary as a function of population changes, lek numbers, and the timing, effort, and conditions of surveys, so it is important to consider all these factors when interpreting the data.

In the NW region, the number of leks counted has been increasing over the same period. In 2016, the DNR allowed the capture and translocation of sharp-tailed grouse from the NW region to supplement a population of sharp-tailed grouse at Moquah Barrens in Wisconsin. Trapping occurred at 7 leks in Kittson, Marshall, and Roseau counties with 104 birds captured and 29 birds moved (13 females and 16 males) to Wisconsin. Continued monitoring will document whether the NW population will continue to be a stronghold for sharp-tailed grouse in the state and the impact of potential management actions in response to declines in the EC region.

ACKNOWLEDGEMENTS

The ruffed grouse survey was accomplished this year through the combined efforts of staff and volunteers at Chippewa and Superior National Forests (USDA Forest Service); Fond du Lac, Grand Portage, Leech Lake, Red Lake, and White Earth Reservations; 1854 Treaty Authority; Blandin Paper, Agassiz and Tamarac National Wildlife Refuges (U.S. Fish & Wildlife Service); Vermilion Community College; Beltrami County and Cass County Land Departments; and DNR staff at Aitkin, Baudette, Bemidji, Brainerd, Cambridge, Carlos Avery Wildlife Management Area (WMA), Cloquet, Crookston, Detroit Lakes, Fergus Falls, Grand Rapids, International Falls, Karlstad, Little Falls, Mille Lacs WMA, Park Rapids, Red Lake WMA, Rochester, Roseau River WMA, Sauk Rapids, Thief Lake WMA, Thief River Falls, Tower, Two Harbors, Whitewater WMA, and Winona work areas. I would like to thank DNR staff and volunteers at Aitkin, Baudette, Bemidji, Cambridge, Cloquet, Crookston, Karlstad, International Falls, Tower, Thief River Falls, and Thief Lake work areas, staff and volunteers at Red Lake and Roseau River WMAs, and partners at Agassiz National Wildlife Refuge for participating in sharp-tailed grouse surveys. Laura Gilbert helped enter ruffed grouse data. Gary Drotts, John Erb, and Rick Horton organized an effort to enter the ruffed grouse survey data for 1982–2004, and Doug Mailhot and another volunteer helped enter the data. I would also like to thank Mike Larson for his assistance in the transition coordinating the surveys and for making helpful comments on this report. This work was funded in part through the Federal Aid in Wildlife Restoration Act.

Table 1. Sharp-tailed grouse / lek (≥2 males) at all leks observed during spring surveys each year in Minnesota.

	Statewide			Northwest[a]			East Central[a]		
Year	Mean	95% CI[b]	*n*[c]	Mean	95% CI[b]	*n*[c]	Mean	95%CI[b]	*n*[c]
2004	11.2	10.1 – 12.3	183	12.7	11.3 – 14.2	116	8.5	7.2 – 9.9	67
2005	11.3	10.2 – 12.5	161	13.1	11.5 – 14.7	95	8.8	7.3 – 10.2	66
2006	9.2	8.3 – 10.1	161	9.8	8.7 – 11.1	97	8.2	6.9 – 9.7	64
2007	11.6	10.5 – 12.8	188	12.7	11.3 – 14.1	128	9.4	8.0 – 11.0	60
2008	12.4	11.2 – 13.7	192	13.6	12.0 – 15.3	122	10.4	8.7 – 12.3	70
2009	13.6	12.2 – 15.1	199	15.2	13.4 – 17.0	137	10.0	8.5 – 11.7	62
2010	10.7	9.8 – 11.7	202	11.7	10.5 – 12.9	132	8.9	7.5 –10.5	70
2011	10.2	9.5 – 11.1	216	11.2	10.2 – 12.2	156	7.8	6.7 – 8.9	60
2012	9.2	8.2 – 10.3	153	10.7	9.3 – 12.3	100	6.3	5.4 – 7.3	53
2013	9.2	8.2 – 10.2	139	10.5	9.3 – 11.7	107	4.8	3.8 – 5.9	32
2014	9.8	8.8 – 10.9	181	10.9	9.8 – 12.1	144	5.4	4.5 – 6.4	37
2015	9.8	8.9 – 10.7	206	10.8	9.9 – 11.9	167	5.3	4.4 – 6.4	39
2016	9.5	8.6 – 10.5	182	10.2	9.2 – 11.4	152	6.0	4.9 – 7.3	30

[a] Survey regions; see Figure 1.

[b] 95% CI = 95% confidence interval

[c] *n* = number of leks in the sample.

Table 2. Difference in the number of sharp-tailed grouse / lek observed during spring surveys of the same lek in consecutive years in Minnesota.

	Statewide			Northwest[a]			East Central[a]		
Comparison[b]	Mean	95% CI[c]	*n*[d]	Mean	95% CI[c]	*n*[d]	Mean	95%CI[c]	*n*[d]
2004 – 2005	-1.3	-2.2 – -0.3	186	-2.1	-3.5 – -0.8	112	0.0	-1.0 – 1.1	74
2005 – 2006	-2.5	-3.7 – -1.3	126	-3.6	-5.3 – -1.9	70	-1.1	-2.6 – 0.6	56
2006 – 2007	2.6	1.5 – 3.8	152	3.3	1.7 – 5.1	99	1.2	0.1 – 2.3	53
2007 – 2008	0.4	-0.8 – 1.5	166	0.0	-1.6 – 1.6	115	1.2	0.1 – 2.5	51
2008 – 2009	0.9	-0.4 – 2.3	181	1.8	-0.1 – 3.8	120	-0.8	-2.1 – 0.6	61
2009 – 2010	-0.6	-1.8 – 0.6	179	-0.8	-2.6 – 1.0	118	-0.1	-1.2 – 1.0	61
2010 – 2011	-1.7	-2.7 – -0.8	183	-1.8	-3.1 – -0.5	124	-1.5	-2.8 – -0.3	59
2011 – 2012	-2.0	-2.9 – -1.1	170	-1.7	-2.9 – -0.4	112	-2.4	-3.3 – -1.6	58
2012 – 2013	-0.8	-2.0 – 0.4	140	0.4	-1.3 – 2.3	88	-2.9	-4.2 – -1.8	52
2013 – 2014	1.4	0.1 – 2.7	121	1.6	-0.3 – 3.5	79	1.1	-0.1 – 2.3	42
2014 – 2015	-0.2	-1.4 – 0.9	141	-0.3	-1.9 – 1.3	102	-0.1	-1.1 – 1.1	39
2015 – 2016	-1.3	-2.3 – -0.2	167	-1.6	-2.9 – -0.2	129	-0.2	-1.3 – 0.9	38

[a] Survey regions; see Figure 1.

[b] Consecutive years for which comparable leks were compared.

[c] 95% CI = 95% confidence interval

[d] *n* = number of leks in the sample. Here, a lek can have a 0 count in 1 of the 2 years and still be considered.

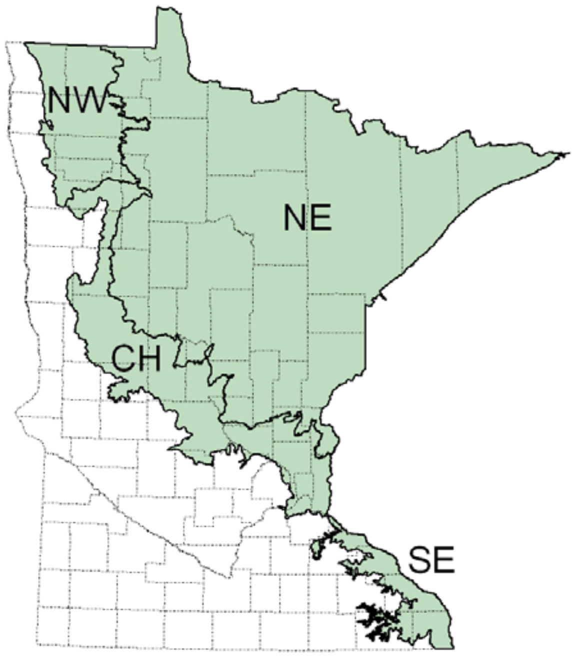


Figure 1. Survey regions for **ruffed grouse** in Minnesota. Northwest (NW), Northeast (NE), Central Hardwoods (CH), and Southeast (SE) survey regions are depicted relative to county boundaries (dashed lines) and influenced by the Ecological Classification System.

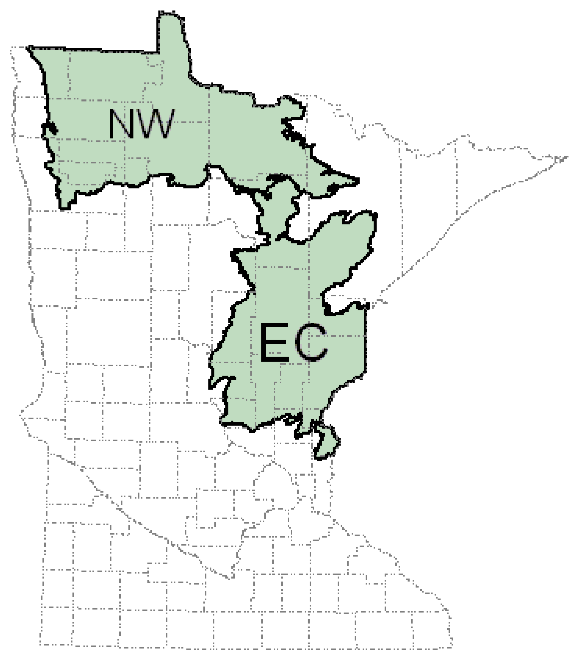


Figure 2. Survey regions for **sharp-tailed grouse** in Minnesota. Northwest (NW) and East Central (EC) survey regions are depicted relative to county boundaries (dashed lines) and influenced by Ecological Classification System Subsections boundaries.

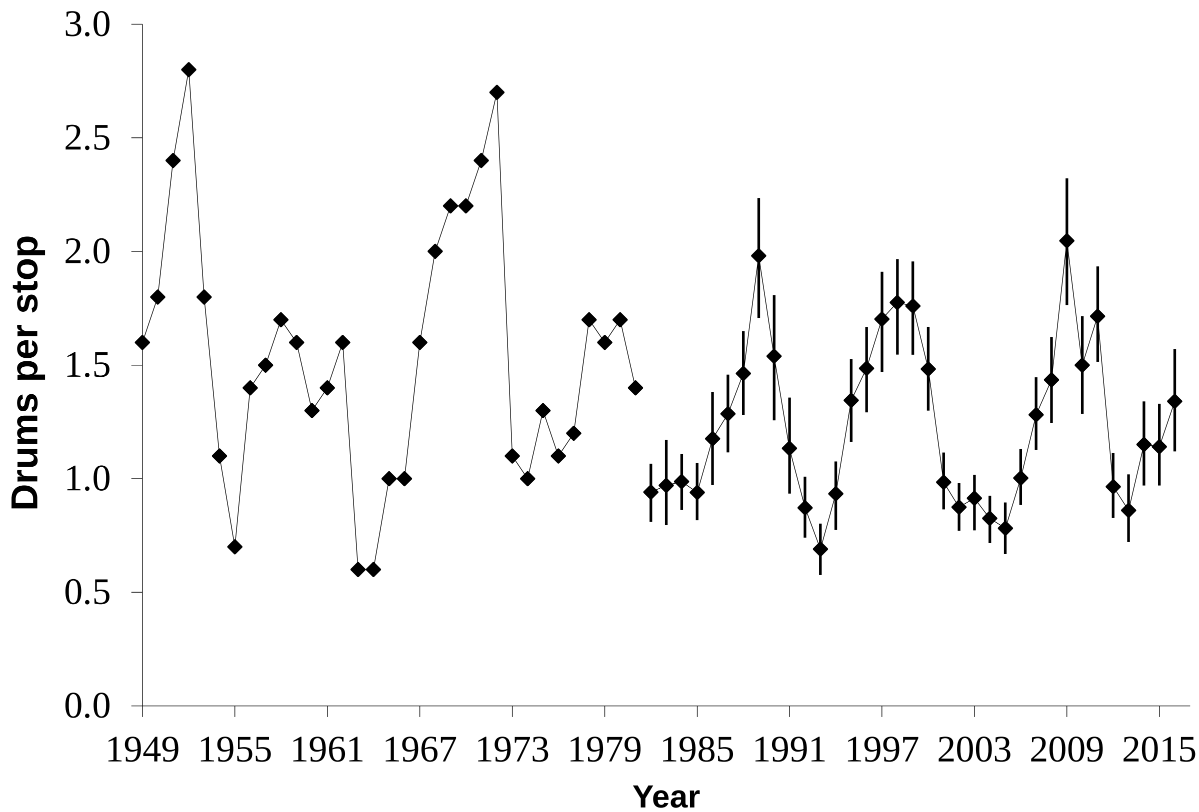
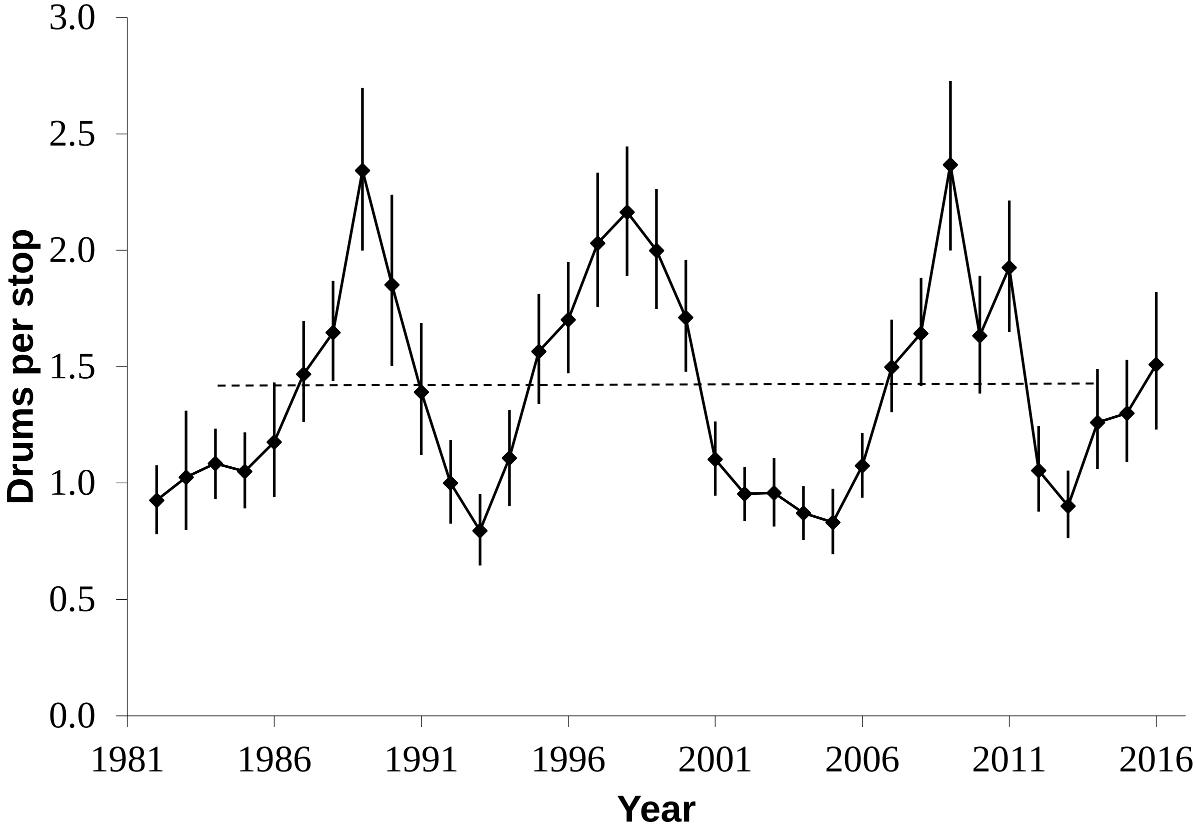
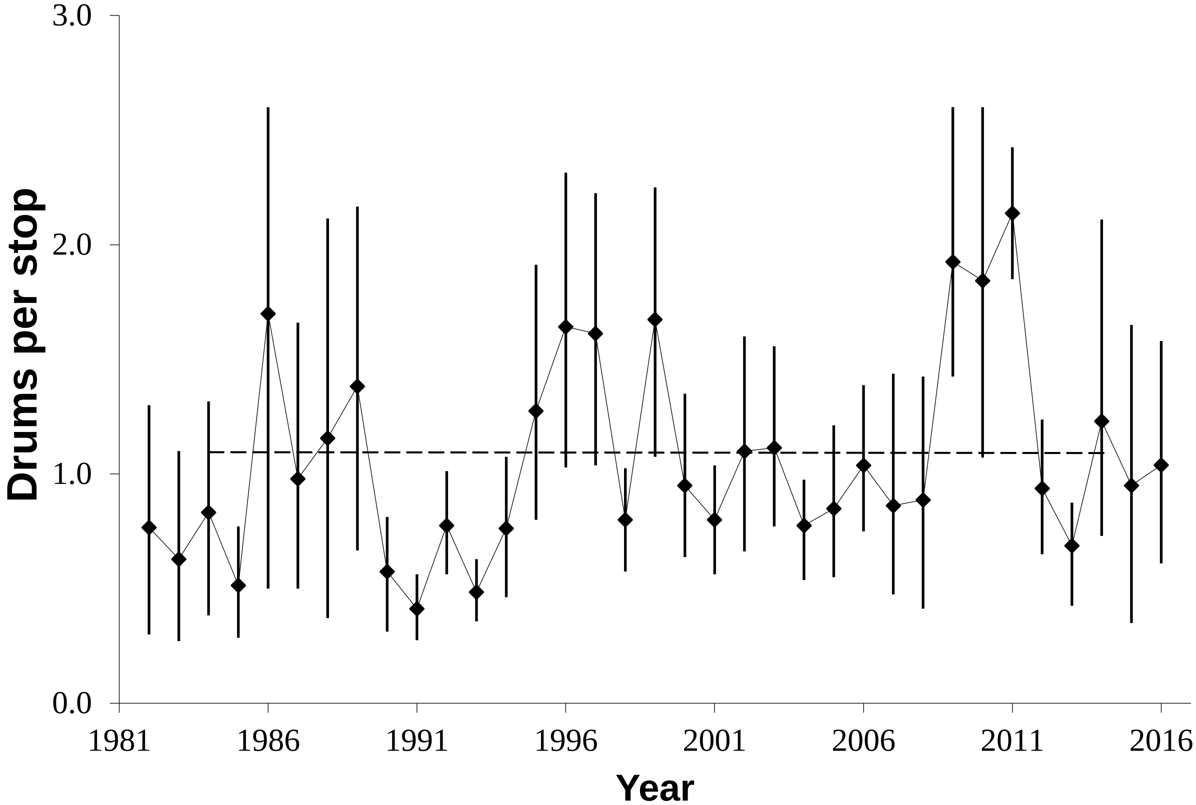


Figure 3. Statewide ruffed grouse population index values in Minnesota. Bootstrap (95%) confidence intervals (CI) are provided after 1981, but different analytical methods were used prior to this and thus CI are not available for earlier years. The difference between 1981 and 1982 is biological and not an artifact of the change in analysis methods.

a.


3.0
2.5
2.0
1.5
1.0
0.5
0.0
Drums per stop
1981
1986
1991
1996
2001
2006
2011
2016
Year

b.


3.0
2.0
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Drums per stop
1981
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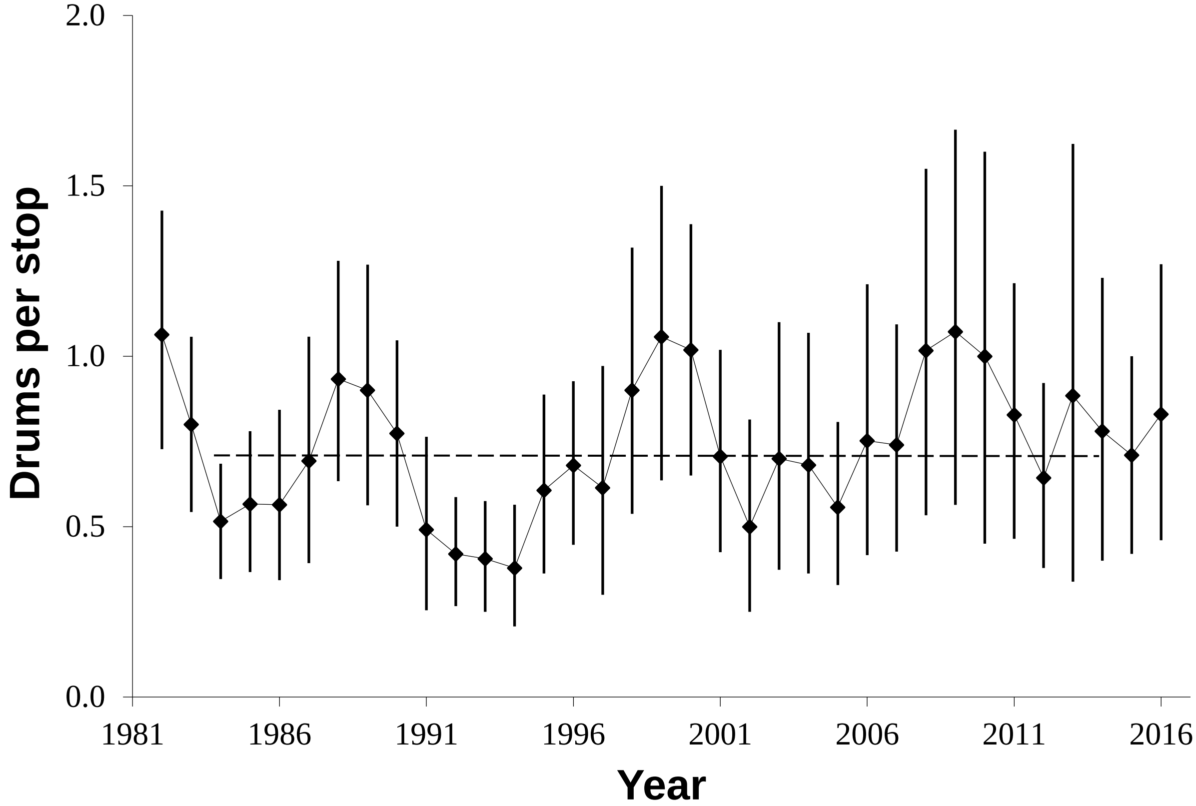
Year

c.



2.0
1.5
1.0
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Drums per stop
1981
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2016
Year

d.

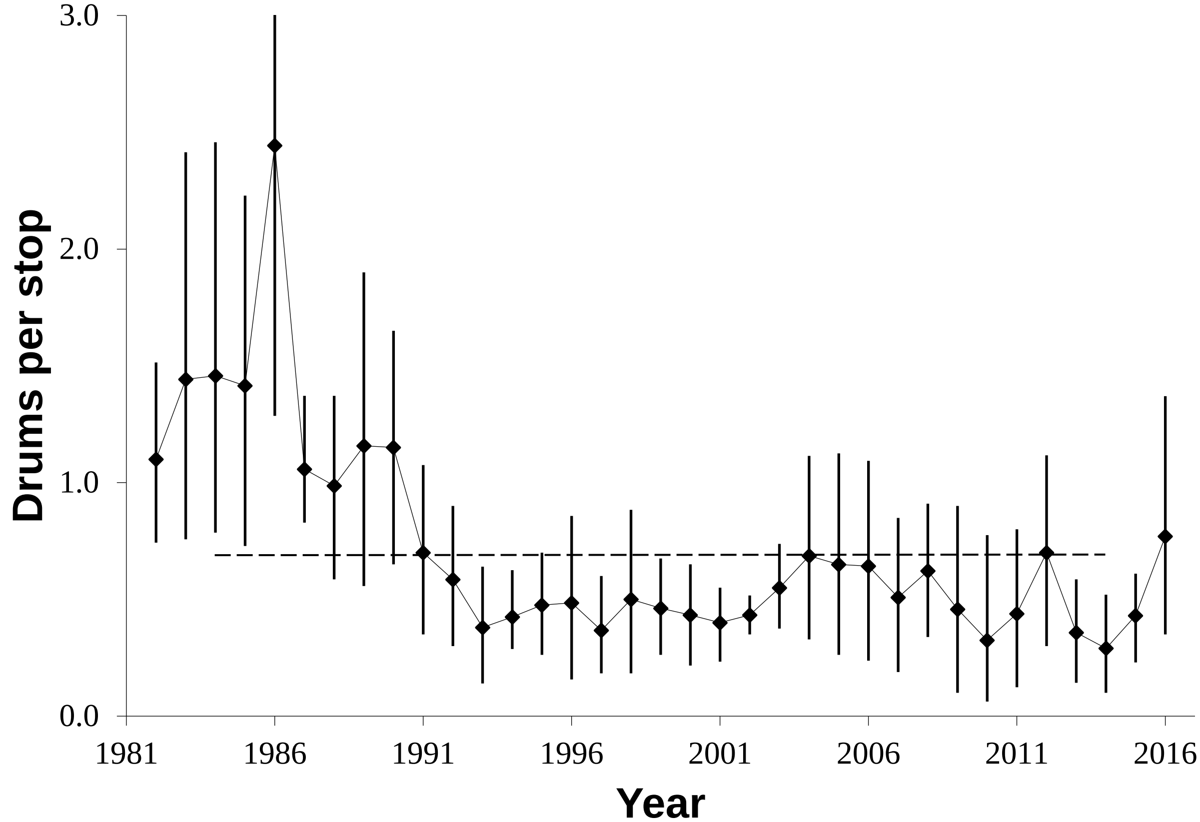

Figure 4a,b,c,d. Ruffed grouse population index values in the **Northeast** (a), **Northwest** (b), **Central Hardwoods** (c), and **Southeast** (d) survey regions of Minnesota. The mean for 1984-2014 is indicated by the dashed line. Bootstrap (95%) confidence intervals are provided for each mean. In the bottom panel, the CI for 1986 extends beyond area depicted in the figure.

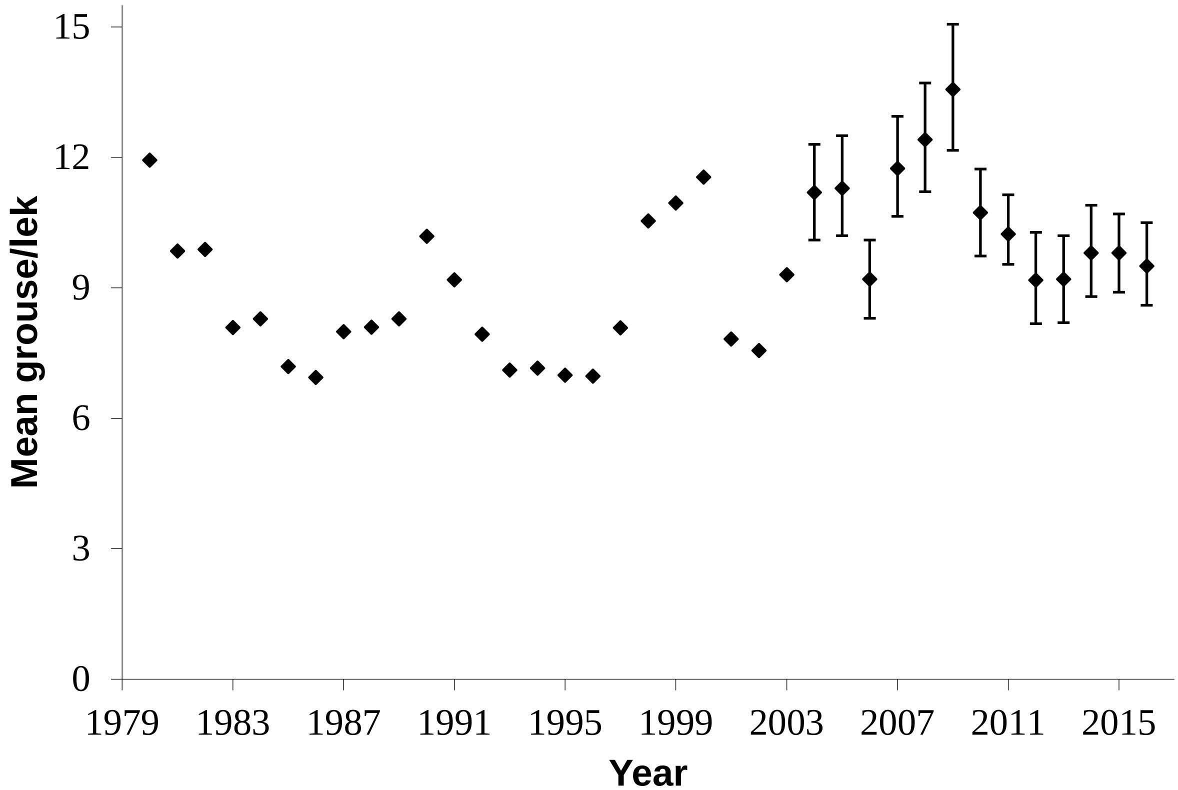

Figure 5. **Sharp-tailed grouse** counted in spring lek surveys statewide during 1980–2016. Bootstrap (95%) confidence intervals are provided for recent years. Annual means are not connected by lines because the same leks were not surveyed every year.

2016 MINNESOTA PRAIRIE-CHICKEN POPULATION SURVEY

Charlotte Roy, Forest Wildlife Populations and Research Group

SUMMARY OF FINDINGS

Greater prairie-chickens (*Tympanuchus cupido pinnatus*) were surveyed in all 17 survey blocks during the spring of 2016. Observers located 60 booming grounds and counted 634 males and birds of unknown sex in the survey blocks. They located 130 booming grounds,1,280 male prairie-chickens, and 142 birds of unknown sex throughout the prairie-chicken range. Estimated densities of 0.09 (0.06–0.11) booming grounds/km^2 and 10.6 (8.7–12.5) males/booming ground within the survey blocks were similar to densities during recent years and during the 10 years preceding modern hunting seasons (i.e., 1993–2002), but have declined since the standardized survey began in 2004. All population indices began to decline in 2008, but seem to have stabilized in recent years at a lower level.

INTRODUCTION

Historically, greater prairie-chicken (*Tympanuchus cupido pinnatus*) range in Minnesota was restricted to the southeastern portion of the state. However, dramatic changes in their range occurred in the 19th century as settlers expanded and modified the landscape with farming and forest removal, providing abundant food sources and access to new areas. However, as grass was lost from the landscape, prairie-chicken populations began to decline, their range contracted, and hunting seasons closed after 1942. In an attempt to bolster populations and expand prairie-chicken range, the Minnesota Department of Natural Resources (DNR) conducted a series of translocations in the Upper Minnesota River Valley during 1998-2006. Today, the beach ridges of glacial Lake Agassiz hold most of Minnesota's prairie-chickens, but their populations do extend southward (Figure 1). Hunting was re-opened using a limited-entry season in 2003, and approximately 120 prairie-chickens are now harvested annually.

With the opening of the new hunting season, the DNR had a greater interest in the monitoring of prairie-chicken populations, which the Minnesota Prairie-Chicken Society (MPCS) had been coordinating since 1974. The DNR, in collaboration with MPCS members, began coordinating prairie-chicken surveys and adopted a standardized survey design in 2004. These surveys are conducted at small open areas called leks, or booming grounds, where male prairie-chickens display for females in the spring and make a low-frequency booming vocalization that can be heard for miles.

Prairie-chickens continue to be surveyed to monitor changes in population densities over time. However, density estimates can be costly and difficult to obtain, so instead we count individuals and make the assumption that changes in density are the primary source of variation in counts among years. If true, counts should provide a reasonable index to long-term trends in prairie-chicken populations. However, counts are also influenced by weather, habitat conditions, observer ability, and bird behavior among other factors, which make it difficult to make inferences over short periods of time (e.g., a few annual surveys) or from small changes in index values. Nevertheless, over long time periods and when changes in index values are large, inferences from prairie-chicken surveys are more likely to be valid.

METHODS

Cooperating biologists and volunteers surveyed booming grounds in all 17 designated survey blocks in western Minnesota (Figure 2) during late-March through May. Each survey block was nonrandomly selected so that surveys would be conducted in areas where habitat was expected to be good (i.e., grassland was relatively abundant) and leks were known to occur. Each surveyor attempted to find and observe each booming ground repeatedly in his/her assigned block, which comprised 4 sections of the Public Land Survey (approximately 4,144 ha). We obtained multiple counts at each booming ground in the morning because male attendance at leks varies throughout the season and throughout the day.

During each survey, observers obtained visual counts of males, females, and birds of unknown sex from a distance with binoculars. Sex was determined through behavior; males display conspicuously, and females do not. If no birds were displaying during the survey period, then sex was recorded as unknown. When a reliable count could not be obtained visually because vegetation or topography prevented it, birds were flushed for counts and sex was recorded as unknown. Most birds for which sex was unknown were likely male because female attendance at leks is sporadic, and they are less conspicuous during lek attendance than displaying males.

In the analysis, I used counts of males and unknowns at each booming ground but not females. Leks were defined as having ≥2 males, so observations of single males were not counted as leks. Data were summarized by hunting permit area and spring survey block. The survey blocks were separated into a core group and a periphery group for analysis. The core group had a threshold density of approximately 1.0 male/km^2 during 2010, and was located proximally to other such blocks (Figure 2). I compared densities of leks and prairie-chickens to estimated densities from previous years.

I also encouraged surveyors to submit observations of booming grounds outside the survey blocks because these observations may provide additional information that is helpful to prairie-chicken management. These data were included in estimates of minimum abundance of prairie-chickens. However, these data were not used in the analysis of lek and prairie-chicken densities because effort and methods may have differed from those used in the survey blocks.

RESULTS & DISCUSSION

Observers from DNR Division of Fish and Wildlife, the U.S. Fish & Wildlife Service, and The Nature Conservancy, as well as many unaffiliated volunteers counted prairie-chickens between 24 March and 24 May 2016. Observers located 130 booming grounds and observed 1,280 male prairie-chickens and 142 birds of unknown sex within and outside survey blocks (Table 1). These counts represent a minimum number of prairie-chickens in Minnesota during 2016, but because survey effort outside of survey blocks is not standardized among years, these counts should not be compared among years or permit areas.

Within the standardized survey blocks, 634 males and birds of unknown sex were counted on 60 booming grounds during 2016 (Table 2). These are the lowest counts since the standardized survey began in 2004, when 1,566 males and 95 booming grounds were counted, and contrasts with the high count of 1,618 males and 114 booming grounds in 2007. Each lek was observed an average of 2.5 times (median = 2), with 36% of booming grounds observed just once. These counts should not be regarded as estimates of abundance because detection probabilities of leks and birds have not been estimated. However, if we assume that detection probabilities and effort are similar among years in the survey blocks, then population indices based on survey block data can be used to monitor changes in abundance among years.

Table 1. Minimum abundance of prairie-chickens within and outside hunting permit areas in Minnesota during spring 2016. Lek and bird counts are not comparable among permit areas or years.

Permit Area	Area (km^2)	Leks	Males	Unk[a]
803A	1,411	18	148	0
804A	435	2	15	17
805A	267	19	195	20
806A	747	8	65	5
807A	440	17	182	30
808A	417	18	286	0
809A	744	15	143	0
810A	505	4	68	0
811A	706	11	65	45
812A	914	4	8	20
813A	925	4	46	0
PA subtotal	7,511	120	1,221	137
Outside PAs[b]	NA[c]	10	59	5
Grand total	NA[c]	130	1,280	142

[a] Unk = prairie-chickens for which sex was unknown, but which were probably males.
[b] Counts done outside permit areas (PA).
[c] NA = not applicable because the area outside permit areas was not defined.

Densities of prairie-chickens in the 10 core survey blocks were 0.10 (0.07–0.13) booming grounds/km^2 and 11.9 (9.4–14.4) males/booming ground (Table 2, Figure 2). In the 7 peripheral survey blocks, densities were 0.06 (0.04–0.09) booming grounds/km^2 and 7.4 (5.5–9.3) males/booming ground. The density of 0.09 (0.06–0.11) booming grounds/km^2 in all survey blocks during 2016 was similar to densities during recent years (Table 2, Figure 3) and the average of 0.08 (0.06–0.09) booming grounds/km^2 during the 10 years preceding recent hunting seasons (i.e., 1993–2002). Similarly, the density of 10.6 (8.7–12.5) males/booming ground in all survey blocks during 2016 was comparable to densities during recent years and similar to the average of 11.5 (10.1–12.9) males/booming ground observed during 1993–2002 (Table 2, Figure 3). However, these densities are lower than the years preceding 2008 when CRP enrollments in the counties containing the survey blocks were highest. Densities appear to have stabilized over the last several years at a new lower level. These changes in the population indices coincide with gains and losses in enrollments in the Conservation Reserve Program. More explicit examination of these patterns is underway in collaboration with researchers at the Cooperative Wildlife Research Unit at the University of Minnesota.

Table 2. Prairie-chicken counts within survey blocks in Minnesota.

			2016		Change from 2015[a]	
Range[b]	Survey Block	Area (km^2)	Booming grounds	Males[c]	Booming grounds	Males[c]
Core	Polk 1	41.2	6	61	-3	-25
	Polk 2	42.0	5	58	0	-25
	Norman 1	42.0	1	5	0	-7
	Norman 2	42.2	3	34	-1	-19
	Norman 3	41.0	5	70	-1	12
	Clay 1	46.0	7	84	-1	7
	Clay 2	41.0	2	64	0	12
	Clay 3	42.0	7	71	2	14
	Clay 4	39.0	3	15	0	-7
	Wilkin 1	40.0	3	39	-2	-28
	Core subtotal	415.0	42	501	-6	-66
Periphery	Mahnomen	41.7	2	18	-2	-11
	Becker 1	41.4	4	28	2	6
	Becker 2	41.7	3	17	0	-8
	Wilkin 2	41.7	2	14	-1	-4
	Wilkin 3	42.0	5	43	2	17
	Otter Tail 1	41.0	1	7	-1	-7
	Otter Tail 2	40.7	1	6	-2	-13
	Periphery subtotal	290.6	18	133	-2	-20
Grand total		705.5	60	634	-8	-86

[a] The 2015 count was subtracted from the 2016 count, so positive values indicate increases.
[b] Survey blocks were categorized as within the core or periphery of the Minnesota prairie-chicken range based upon bird densities and geographic location.
[c] Includes birds recorded as being of unknown sex but excludes lone males.

ACKNOWLEDGEMENTS

I would like to thank cooperators who conducted and helped coordinate the prairie-chicken survey. Cooperators within the DNR included Ross Hier, Emily Hutchins, Brian Torgusson, Rob Baden, Michael Oehler, and Phil Doll; cooperators with The Nature Conservancy included Brian Winter, Travis Issendorf, and volunteers Pat Beauzay, Rick Julian, Matt Mecklenburg, Tyler Larson, Derek Savage, and Tony Nelson; cooperators with the US Fish and Wildlife Service included Maria Fosado, Shawn Papon, Chad Raitz, Ben Walker, Gregg Knutsen; and numerous additional volunteers participated, including Dan Svedarsky, Doug Wells, Terry Wolfe, Alexandra Wardwell, and Tom Kucera. Bemidji State University faculty and students, Brian Hiller, Adam Maleski, and Irain Adams also assisted with surveys this year. This survey was funded in part by the Wildlife Restoration (Pittman-Robertson) Program W-69-S-13 Project #16. Mike Larson provided assistance and comments which improved this report.

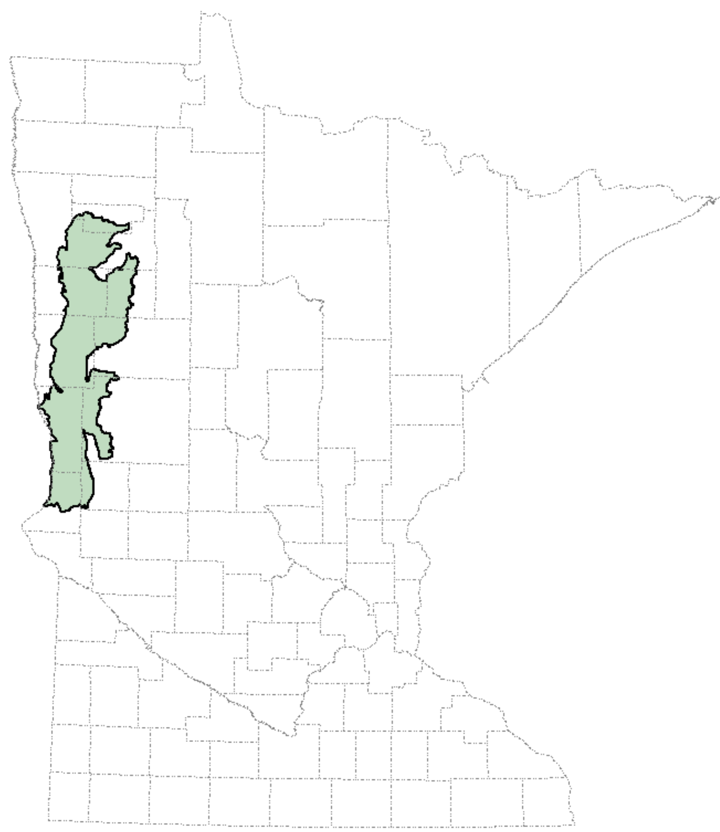

Figure 1. Primary greater prairie-chicken range in Minnesota (shaded area) relative to county boundaries. The range boundary was based on Ecological Classification System Land Type Associations and excludes some areas known to be occupied by prairie-chickens.

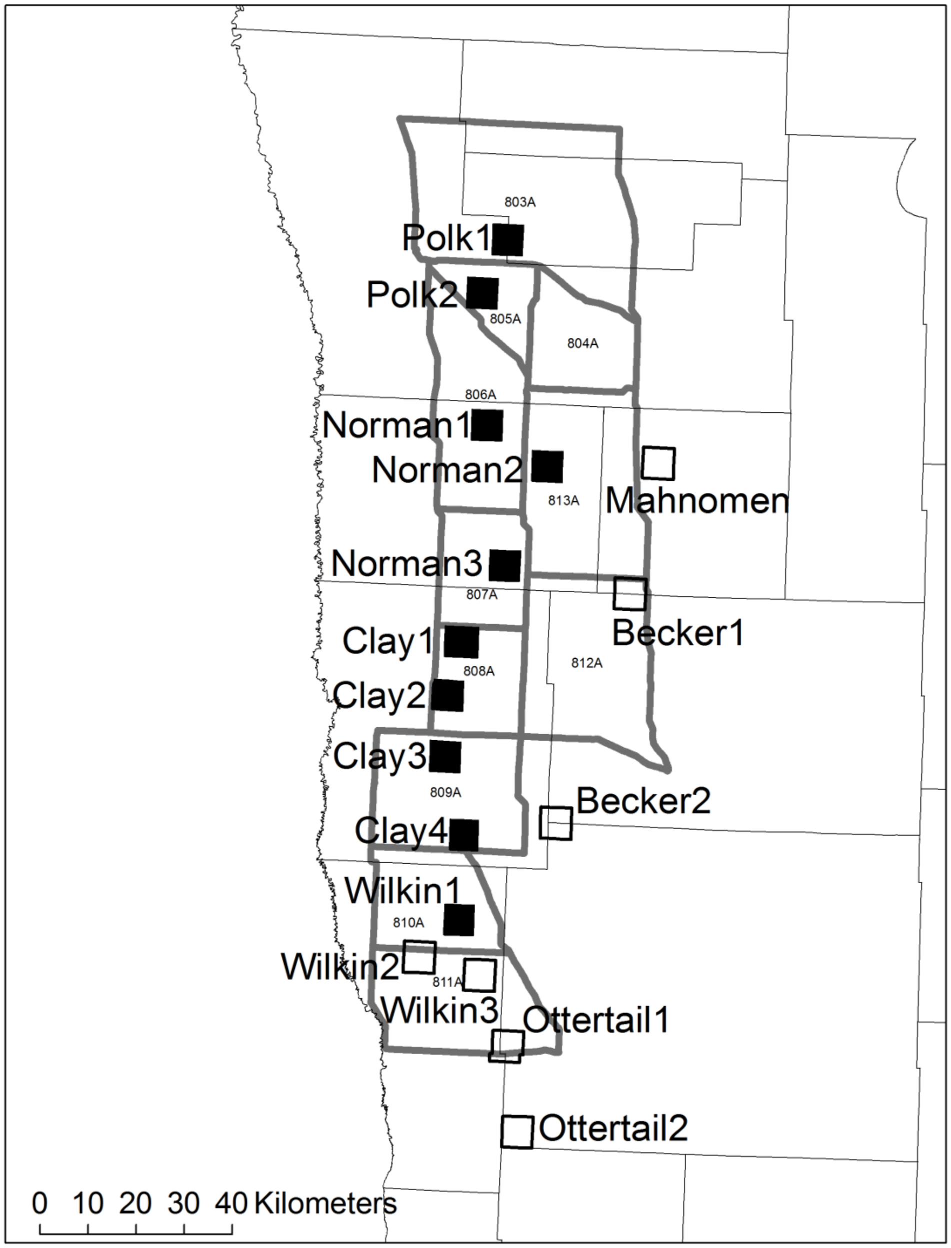

Figure 2. Prairie-chicken lek survey blocks (41 km^2, labeled squares) and hunting permit areas (thick grey lines) in western Minnesota. Survey blocks were either in the core (black) or periphery (white) of the range with a threshold of 1.0 male/km^2 in 2010, and were named after their respective counties (thin black lines). Permit areas were revised in 2013 to eliminate 801A and 802A, modify 803A, and add 812A and 813A. See previous reports for former permit area boundaries.

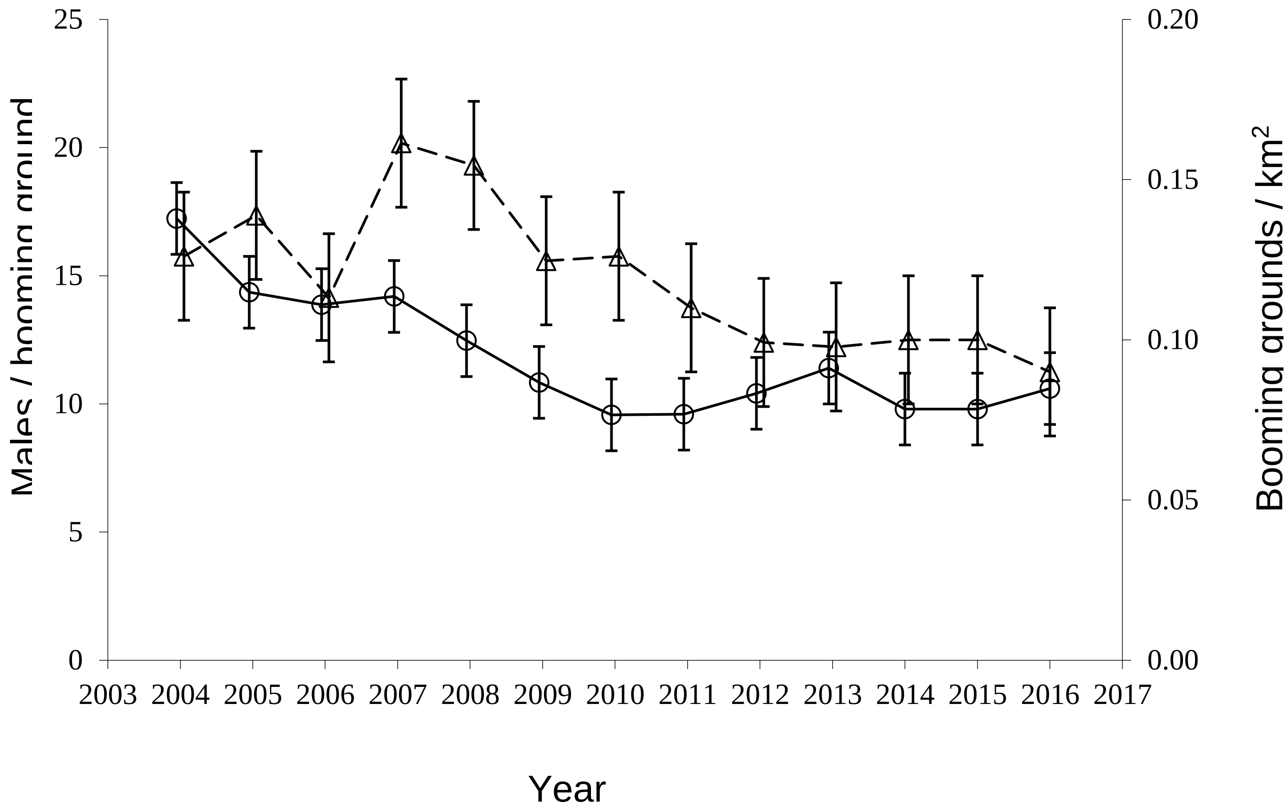

Figure 3. Mean prairie-chicken males/booming ground (circles connected by solid line) and booming grounds/km^2 (triangles connected by dashed line) in survey blocks in Minnesota with 95% confidence intervals.

MNDNR

2016 NW MN ELK SURVEYS

Doug Franke, Area Wildlife Manager, Thief River Falls

This was the fourth year using a combination of a fixed wing (Cessna 185) and helicopter (Enstrom) to conduct aerial elk surveys for the Lancaster, Caribou, and Grygla elk herds. The fixed-wing aircraft follows predetermined transects spaced 1/5 mile apart at an altitude of 300 to 500 feet and speeds of 70 mph. The pilot and two observers record elk location(s) and document the sex and size class of bulls as best they can. Once the fixed-wing crew records elk locations, the helicopter crew (pilot and two observers) verifies their data by resurveying the square mile with elk and all the square miles that border it (yielding 9 mi^2 for each elk observation). The helicopter flies lower and slower (200 feet and 50 mph) to maximize observations. This protocol has been used to determine if using a fixed-wing aircraft is efficient enough for counting and determining sex and bull size class for the annual elk survey.

The surveys started on January 28th and ended on February 5th, 2016. Similar to last year, snow depths ranged from 5 to 7 inches throughout the elk range. Grass cover was standing vertical due to the lack of snow cover and fresh snow had not fallen for a couple weeks, making for fair observation conditions. Weather conditions were fairly mild with temperatures ranging from a low of 7°F to a high of 34°F with most days overcast—which made for good visibility.

GRYGLA HERD

This survey started on January 28th and was completed on February 1st, 2016. The area surveyed was the same 133 mi^2 area as last year and took 11.7 hours for the fixed-wing to complete. The fixed-wing recorded elk at six (6) separate locations within the survey boundary. The helicopter crew resurveyed the area immediately after and verified all the fixed-wing observations, but also found a seventh location of two spike bulls about 1.0 mile SE of the cow herd. Total elk observed was 21 and included: 10 antlerless (cows/calves) and 11 bulls (4 mature, 5 raghorn, and 2 spike bulls).

CARIBOU (A.K.A. VITA OR BORDER HERD)

This survey started and was completed on February 2nd, 2016. The area surveyed was the same 35.5 mi^2 area as last year and took 3.5 hours for the fixed-wing to complete. The fixed-wing recorded elk at four (4) separate locations within the survey boundary. The helicopter crew resurveyed the area immediately after and verified the four locations of elk located by the fixed-wing and located single animals at two (2) additional locations. Total elk observed was 10 and included: 4 antlerless (cows/calves) and 6 bulls (2 mature and 4 raghorn). We did fly a single transect at a higher altitude down the center of the next two miles south and one mile west of the survey block, but did not see any sign of a larger group of antlerless elk. There were a lot of elk tracks near the Canadian border and we assumed a majority of this herd was north of the Minnesota border.

LANCASTER—WATER TOWER AND PERCY WMA HERDS

This survey started on February 3rd and was completed on February 5th, 2016. The area surveyed was the same 167 mi^2 area as last year and took 15.7 hours for the fixed-wing to complete. The fixed-wing recorded elk at four (4) separate locations within the survey boundary. The helicopter crew resurveyed the area immediately after and verified all the fixed- wing observations, but counted two fewer animals. Total elk observed was 52 and included: 34 Antlerless (cows/calves) and 18 bulls (10 mature, 2 raghorn, and 6 spike bulls. We did locate the antlerless herd west of the Percy WMA area this year, but most of the bulls were located about seven miles north and closer to the Water Tower antlerless herd.

I have provided a table on the following page that lists a breakdown of elk observations by survey block for the past three years. Also, attached are maps showing locations of elk within each survey block in 2016.

I would like to thank all those that helped with the survey this year, especially the pilots Chris Lofstuen and Luke Ettl (fixed-wing) and Brad Maas (helicopter) that provided safe flying for all of us. This was both Chris's and Luke's first time flying the elk surveys and they did a great job! Observers this year included: Becky Ekstein and Matt Morin (Thief River Falls Assistant Managers), Kyle Arola (Thief Lake Assistant Manager), Jason Wollin (Karlstad Assistant Area Wildlife Manager), and Doug Franke. Special thanks again to Brian Haroldson who put together all of the survey materials and computers used during the survey.

Figure 1. Elk survey crew, 2016. Left to right: Jason Wollin, Becky Ekstein, Brad Maas, Kyle Arola, Doug Franke, Chris Lofstuen

Table 1. Comparison of elk observations between 2014 and 2016 for the Caribou, Lancaster, and Grygla herds.

	Lancaster			**Caribou-Vita**			**Grygla**		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Spike bull	3	2	6	10	5	0	2	3	2
Raghorn bull	7	8	2	5	9	4	1	5	5
Mature Bull	7	8	10	2	8	2	3	1	4
Total Bulls	**17**	**18**	**18**	**17**	**22**	**6**	**6**	**9**	**11**
Antlerless	20	16	34	34	57	4	14	9	10
Total Elk	**37**	**34**	**52**	**51**	**79**	**10**	**20**	**18**	**21**

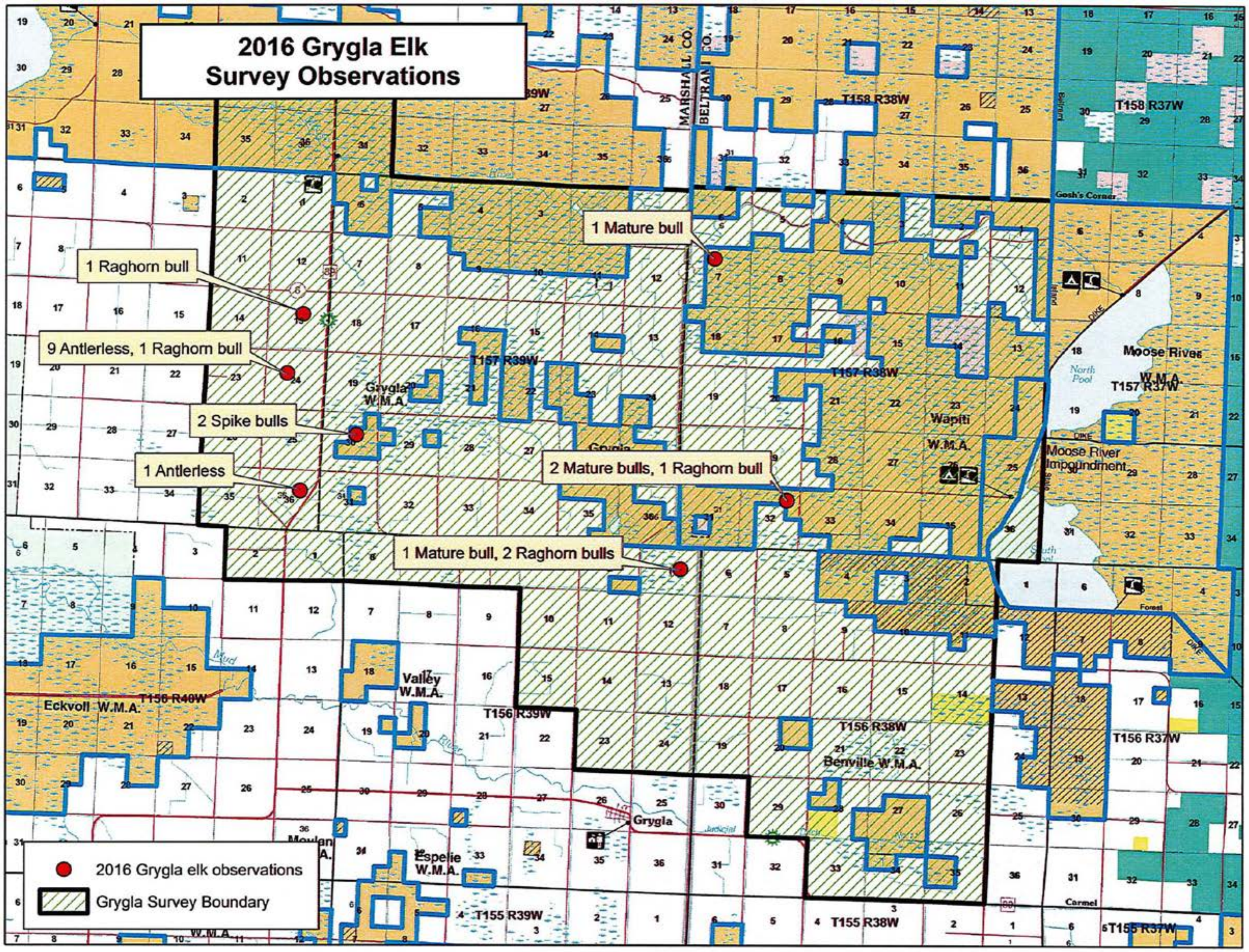

Figure 2. Survey observations of Elk near Grygla, MN, 2016.

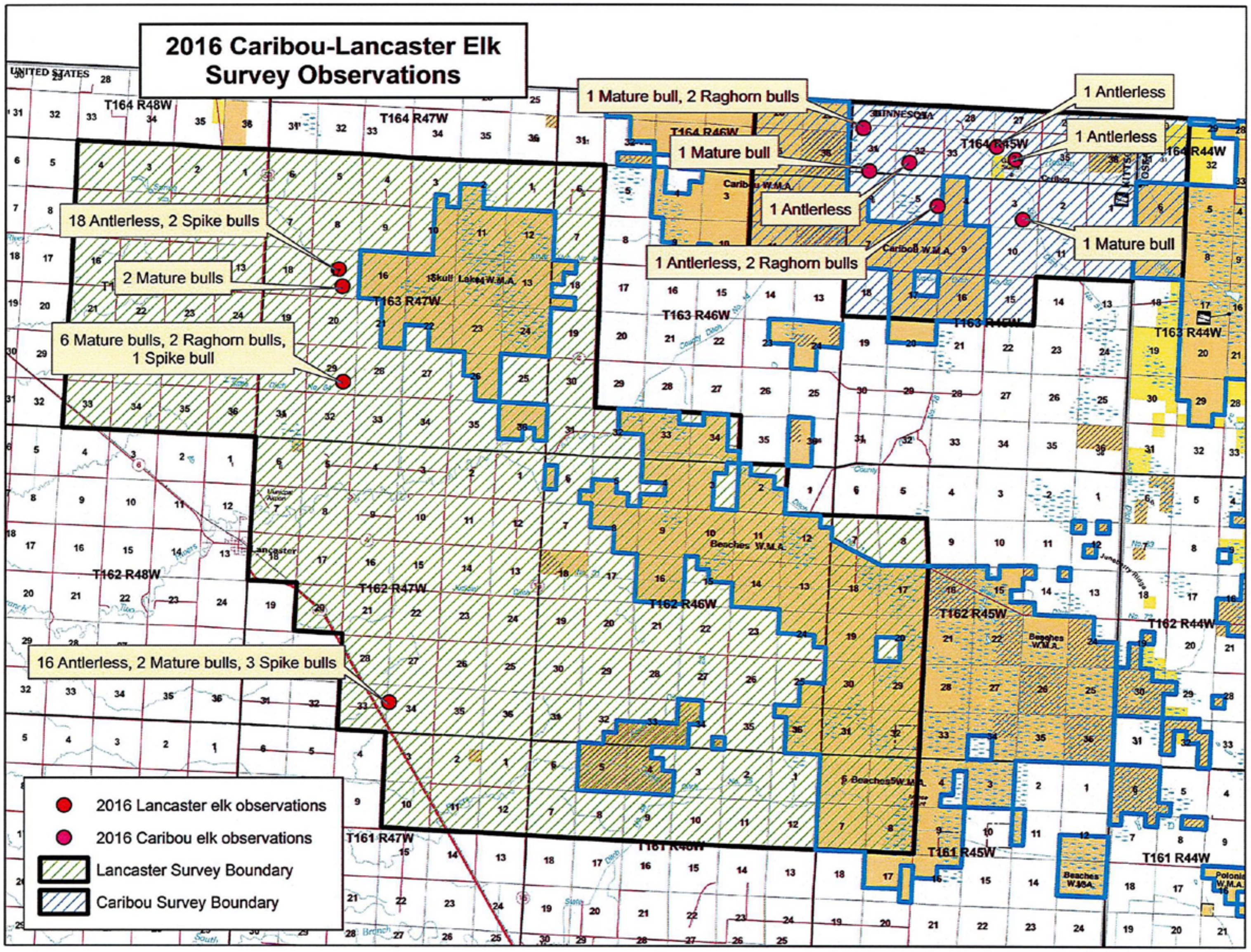

Figure 3. Survey observations of Caribou- Lancaster Elk herds, 2016.

2016 AERIAL MOOSE SURVEY

Glenn D. DelGiudice, Forest Wildlife Populations and Research Group

INTRODUCTION

Each year, we conduct an aerial survey in northeastern Minnesota to monitor moose (*Alces americanus*) numbers and fluctuations in the overall status of the state's largest deer species. The primary objectives of this annual survey are to estimate moose numbers, percent calves, and calf:cow and bull:cow ratios. These demographic data help us to 1) best determine and understand the population's long-term trend (decreasing, stable, or increasing) and composition, 2) set the harvest quota for the subsequent hunting season (when applicable), 3) improve our understanding of moose ecology, and 4) otherwise contribute to sound future management strategies.

METHODS

The survey area is approximately 5,985 mi^2 (almost 4 million acres, Lenarz 1998, Giudice et al. 2012). We estimate moose numbers, and age and sex ratios by flying transects within a stratified random sample of the 436 total survey plots that cover the full extent of moose range in northeastern Minnesota (Fig. 1). All survey plots are reviewed and re-stratified as low, medium, or high moose density about every 5 years based on past survey observations of moose, locations of recently harvested moose, and extensive field experience of moose managers and researchers. The most recent re-stratification was conducted in November 2013 for the 2014 survey. Survey plots were classified as low, medium, or high based on whether ≤ 2, 3–7, or ≥8 moose, respectively, would be expected to occur in a specific plot. Stratification is most important to optimizing precision of our survey estimates. In 2012, we added a 4th stratum represented by a series of 9 plots (referred to as "habitat plots") which have already undergone, or will undergo, significant disturbance by wildfire, prescribed burning, or timber harvest. Each year since, these same 9 plots are surveyed in an effort to evaluate the effect of disturbance on moose density over time. In total, we surveyed 52 of the 436 plots this year.

All 436 survey plots in the grid (designed in 2005) are 13.4-mi^2 rectangles (5 x 2.77 mi), oriented east to west, with 8 flight-transects evenly spaced 0.3 mi apart. Minnesota Department of Natural Resources (MNDNR) Enforcement and Forestry pilots flew the 2 Bell Jet Ranger (OH-58) helicopters used to conduct the survey. We determined the sex of moose using the presence of antlers or the presence of a vulval patch (Mitchell 1970), nose coloration, and bell size and shape. We identified calves on the basis of size and behavior. We used the program DNRSurvey on tablet-style computers (Toughbook®) to record survey data (Wright et al. 2015). DNRSurvey allowed us to display transect lines superimposed on aerial photography, topographical maps, or other optional backgrounds to observe each aircraft's flight path over this background in *real time*, and to efficiently record data using a tablet pen with a menu-driven data entry form. Two of the primary strengths of this aerial moose survey are the consistency and standardization of the methods since 2005 and the long-term consistency of the survey team's personnel, survey biometrician, and GIS specialists.

We accounted for visibility bias using a sightability model (Giudice et al. 2012). This model was developed between 2004 and 2007 using adult moose that were radiocollared as part of a study of survival and its impact on dynamics of the population (Lenarz et al. 2009, 2010). Logistic regression indicated that the covariate "visual obstruction" (VO) was the most important covariate in determining whether radiocollared moose were observed. We estimated VO within a 30-ft radius (roughly 4 moose lengths) of the observed moose. VO was the proportion of vegetation that would prevent you from seeing a moose from an oblique angle when circling that spot in a helicopter. If we observed more than 1 moose (a group) at a location, VO was based on the first moose sighted. We used uncorrected estimates (no visibility bias correction) of bulls, cows, and calves, adjusted for sampling, to calculate the bull:cow and calf:cow ratios (i.e., using the combined ratio estimator; Cochran 1977:165).

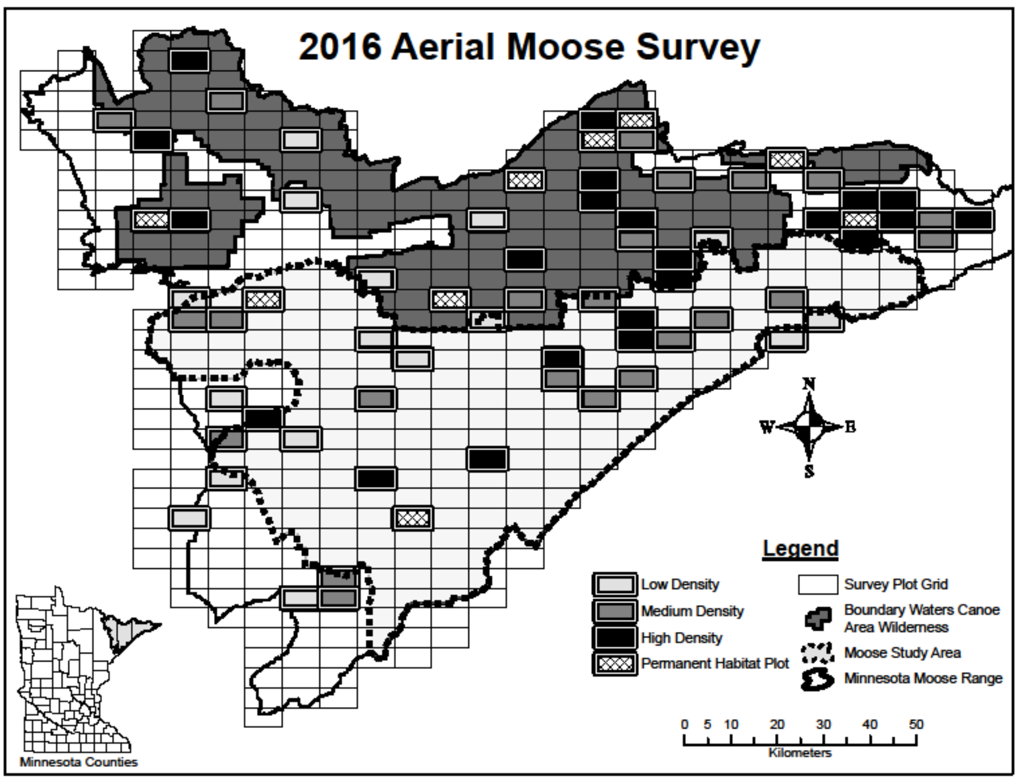

Figure 1. Moose survey area and 52 sample plots flown in the 2016 aerial moose survey. The study area for ongoing MNDNR moose research also is shown.

RESULTS AND DISCUSSION

The survey was conducted from 4 to 15 January 2016. It consisted of 9 actual survey days, and as in 2014 and 2015, it included a sample of 52 survey plots. This year, based on optimal allocation analyses, we surveyed 10 low-, 17 medium-, and 16 high-density plots, and the 9 permanent or habitat plots (Giudice 2016). Generally, 8" of snow cover is our minimum threshold depth for conducting the survey. Snow depths were marginal (less than 8") on 10% of the survey plots, but 8–16" and >16" on 62% and 29% of the sample plots, respectively. Overall, survey conditions were good for 79% and fair for 21% of the plots when surveyed.

Average survey intensity was 49 minutes/plot (13.4 mi^2) and ranged from 40 to 65 minutes/plot (Giudice 2016).

This year a total of 506 moose were observed on 47 (90%) of the 52 plots surveyed (a total 697 mi^2). An average of 10.8 moose (range = 1–38) were observed per occupied plot. This is a notable difference from the 392 moose observed on 34 of 52 plots (65%) in the 2015 survey. Plot occupancy during the past 12 years averaged 81% (range = 65–95%) with a mean 11.9 moose per occupied plot. This year's 506 observed moose included 208 bulls, 206 cows, 87 calves, and 5 unclassified.

After adjusting for sampling and sightability, we estimated the population in northeastern Minnesota at 4,020 (3,230–5,180, 90% confidence interval) moose (Table 1, Fig. 2). As can be noted from the 90% confidence intervals associated with the population point estimates, statistical uncertainty inherent in aerial wildlife surveys can be quite large, even when surveying large, dark, relatively conspicuous animals such as moose against a white background during winter. This is attributable to the varied (1) occurrence of dense vegetation, (2) habitat use by moose, (3) behavioral responses to aircraft, (4) effects of annual environmental conditions (e.g., snow depth, ambient temperature) on their movements, and (5) interaction of these and other factors. Consequently, year-to-year statistical comparisons of population estimates are not supported by these surveys. Rather, these data are best suited to establishing long-term trends.

Past aerial survey and research results have indicated that the trend of the population in northeastern Minnesota has been declining since 2006 (Lenarz et al. 2010, DelGiudice 2015). The current population estimate is 55% less than the estimate in 2006 and the declining linear trend during the past decade is still significant ($r^2 = 0.79$, $P < 0.001$, Fig. 2). However, there appears to be a leveling since 2012, and a piecewise polynomial curve indicates that the trend from 2012 to 2016 is not declining (Fig. 3). While this recent short-term trend is noteworthy, it applies only to the existing survey estimates, not the future trajectory of the population (Giudice 2016).

Table 1. Estimated moose numbers, 90% confidence intervals, calf:cow ratios, percent calves in the population, percent cows with twins, and bull:cow ratios estimated from aerial surveys in northeastern Minnesota, 2005–2016.

Survey	Estimate	90% Confidence Interval	Calf:Cow	% Calves	% Cows w/ twins	Bull:Cow
2005	8,160	6,090-11,410	0.52	19	9	1.04
2006	8,840	6,790-11,910	0.34	13	5	1.09
2007	6,860	5,320-9,100	0.29	13	3	0.89
2008	7,890	6,080-10,600	0.36	17	2	0.77
2009	7,840	6,270-10,040	0.32	14	2	0.94
2010	5,700	4,540-7,350	0.28	13	3	0.83
2011	4,900	3,870-6,380	0.24	13	1	0.64
2012	4,230	3,250-5,710	0.36	15	6	1.08
2013	2,760	2,160-3,650	0.33	13	3	1.23
2014	4,350	3,220-6,210	0.44	15	3	1.24
2015	3,450	2,610-4,770	0.29	13	3	0.99
2016	4,020	3,230-5,180	0.42	17	5	1.03

The January 2016 calf:cow ratio of 0.42 is 24% higher than the 11-year average since 2005 (0.34, Table 1, Fig. 4), and is the third highest since 2005. Calves were 17% of the total 506 moose actually observed and represented 17% of the estimated population (Table 1, Fig. 4). Twin calves were observed with 5% of the 206 cow moose, which is elevated slightly relative to most years since 2005 (Table 1). Overall, survey results indicate calf survival to January 2016 is higher than in most years since the population decline began following the 2006 survey. This is consistent with results of a separate helicopter survey which documented the number of adult GPS-collared cows that had calved in spring 2015 that were still accompanied by calves in early November–early December 2015 (Severud and DelGiudice, unpublished data). Annual recruitment of calves can have a significant influence on the population performance of moose, but it is not actually determined until the next spring's calving season when calves observed during winter become yearlings. Little is known about survival of moose calves during the period between the annual winter survey and subsequent spring calving. It also is important to note that adult moose survival has the greatest long-term impact on annual changes in the moose population (Lenarz et al. 2010). Somewhat consistent with the recent (2012–2016) apparent relative stability of the population trend, the annual survival rate of adult GPS-collared moose has been 85–88% during the past 2 years, slightly higher than in 2013 (81%, Carstensen et al., unpublished data) and the previous long-term average of 81% (Lenarz et al. 2009).

The estimated bull:cow ratio (1.03, Table 1; Fig. 5) is similar to the long-term mean of 0.98 during 2005–2015. However, there has been a great deal of annual variability associated with the bull:cow ratios, consequently, they exhibit no clear upward or downward long-term trend.

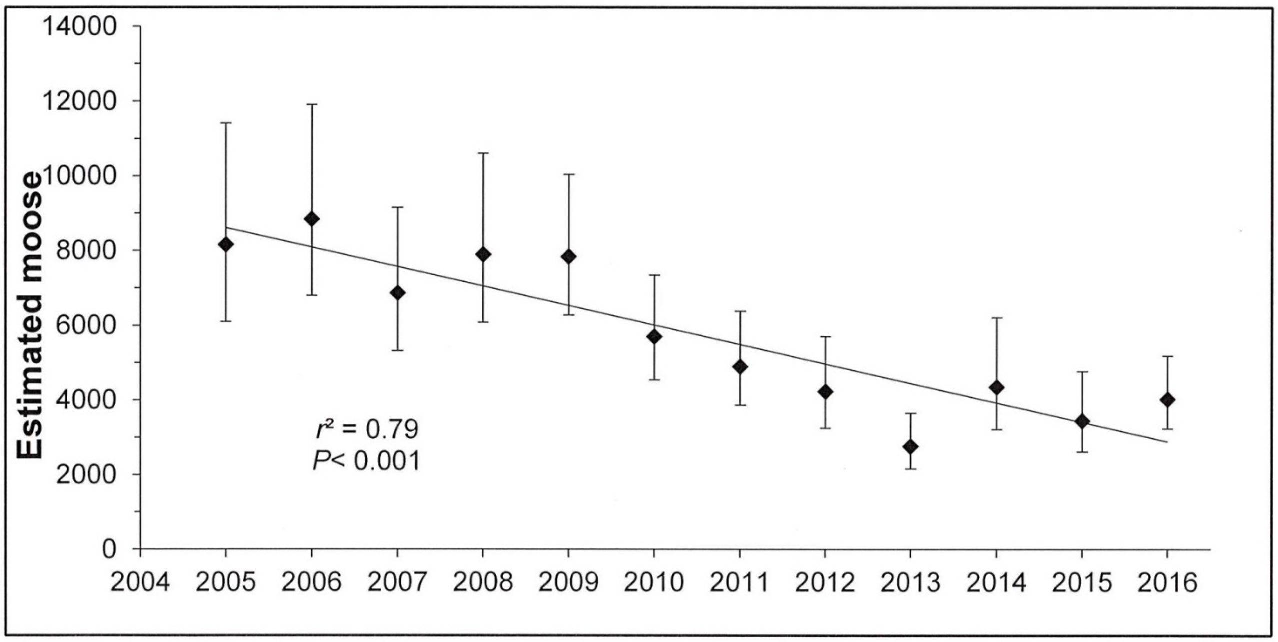

Figure 2. Point estimates, 90% confidence intervals, and a linear trend line of estimated moose numbers in northeastern Minnesota, 2005–2016. (Note: The 2005 survey was the first to be flown with helicopters and to include a sightability model and a uniform grid of east-west oriented rectangular 13.4-mi^2 plots).

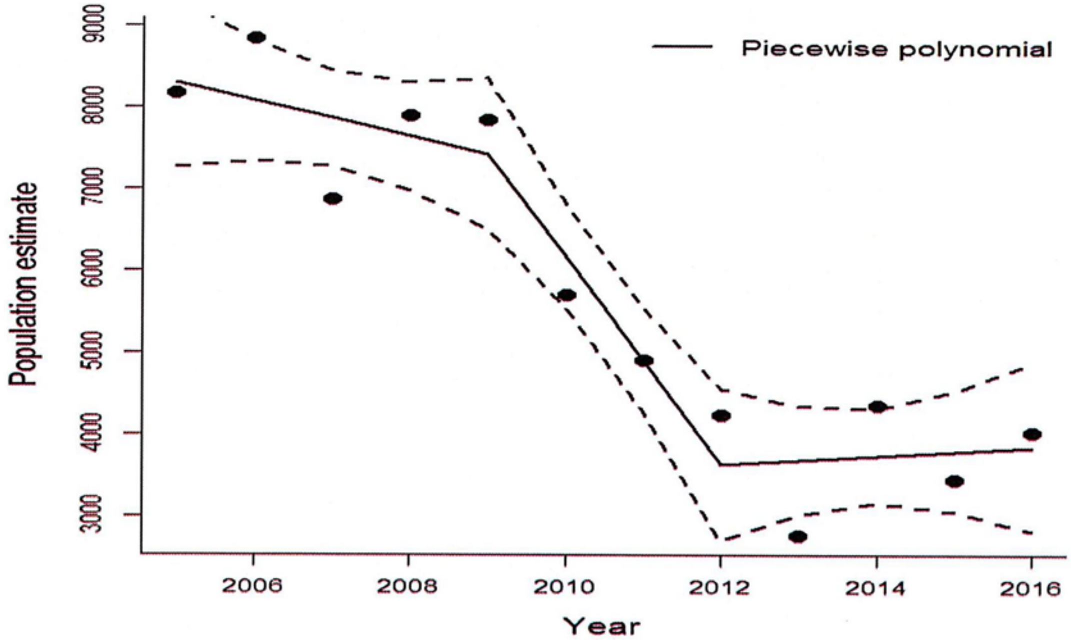

Figure 3. Point estimates of moose, 90% confidence intervals, and a piecewise polynomial curve of moose numbers in northeastern Minnesota, 2005–2016. This curve shows a change in the short-term slope of the trend from 2012 to 2016 compared to 2009 to 2012.

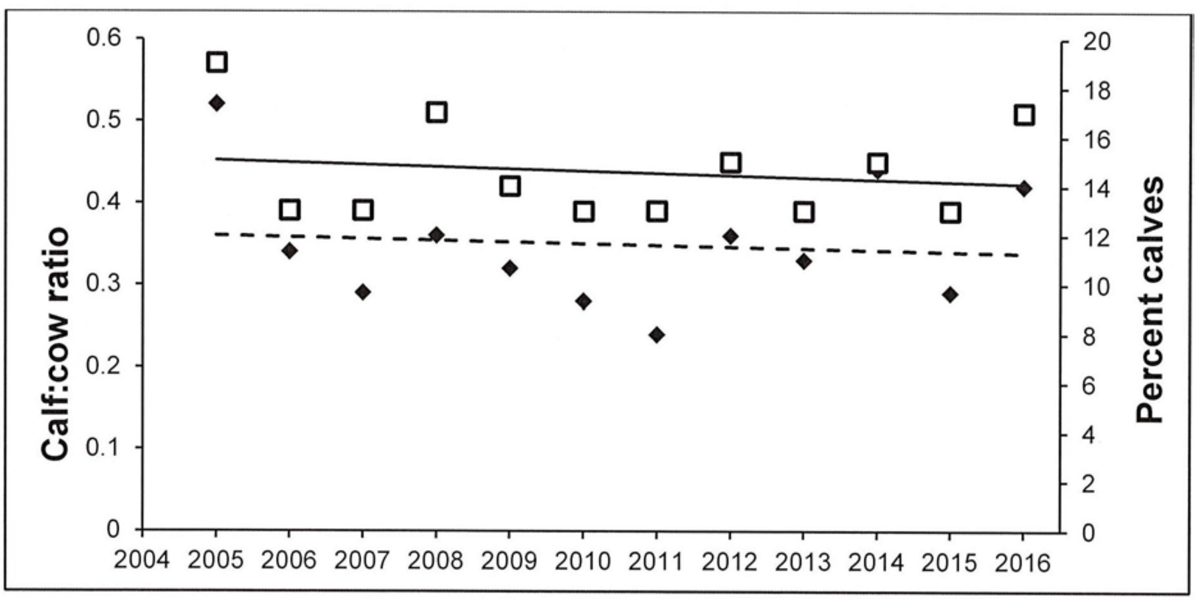

Figure 4. Estimated calf:cow ratios (solid diamonds, dashed trend line) and percent calves (open squares, solid trend line) of the population from aerial moose surveys in northeastern Minnesota, 2005–2016.

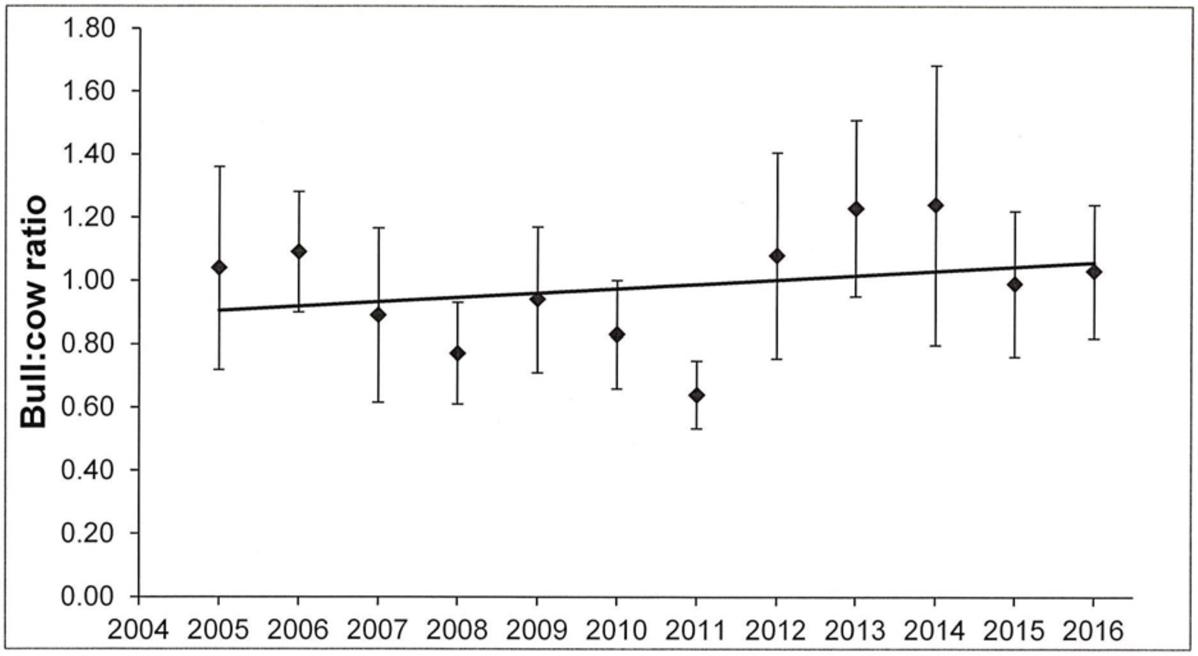

Figure 5. Estimated bull:cow ratios, 90% confidence intervals, and trend line from aerial moose surveys in northeastern Minnesota, 2005–2016.

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MINNESOTA WOLF POPULATION UPDATE 2016

John Erb, Carolin Humpal, and Barry Sampson, Forest Wildlife Populations and Research Group

INTRODUCTION

Since the late 1970's, Minnesota has monitored its statewide wolf population using an approach that combines attributes of territory mapping with an *ad hoc* approach to determine the total area of the state occupied by wolf packs. The methods employed have changed only slightly during this time. Initially, surveys were conducted at approximately 10-year intervals (1978, 1988, 1997), thereafter at approximately 5-year intervals (2003, 2007, 2012). Results indicated a geographically and numerically expanding population through the 1997-98 survey, with little geographic expansion from 1998 to 2007 (Erb and DonCarlos 2009). These results were generally consistent with separate wolf population trend indicators (annual scent station survey, winter track survey, and number of verified depredations) in Minnesota.

In 2012, wolves in the Western Great Lakes Distinct Population Segment were removed as a listed species under the federal Endangered Species Act. The de-listing coincided with the normally scheduled (every 5th year) wolf survey as well as survey timeline specifications in the Minnesota Wolf Management Plan (i.e., first and fifth year after delisting; Minnesota Department of Natural Resources 2001). The 2012-13 survey (Erb and Sampson 2013) concluded that overall wolf range had expanded along its south and west edge, but with minimal change in the total amount of land occupied by wolf packs.

After federal de-listing in 2012, wolf harvest seasons were established and population surveys have been conducted annually to better inform annual management decisions. In the first three winters after de-listing, wolf population point estimates varied from approximately 2,200 to 2,400 (Erb et al. 2014). In December 2014, following the third consecutive wolf harvest season, wolves in Minnesota were returned to the list of federally threatened species as a result of a court ruling. Hence, no public harvest season took place during winter 2015-16 and this report provides an update of population status approximately one year since the last public harvest.

METHODS

The methodology used to estimate wolf population size in Minnesota utilizes three primary pieces of information: 1) an estimate of the total area of land occupied by wolf packs; 2) an estimate of average wolf pack territory size; and 3) an estimate of average mid-winter pack size. It is likely that occupied range changes on a comparatively slow timescale compared to fluctuations in average territory and pack size. As such, since the 2012-13 survey we have assumed that occupied range has remained unchanged (i.e., 70,579 km^2; Erb and Sampson 2013) and tentatively plan to re-evaluate occupied range at 5-year intervals.

To radio-collar wolves, we and various collaborators captured wolves using foothold traps (LPC # 4, LPC #4 EZ Grip, or LPC #7 EZ Grip) approved as part of research conducted under the Association of Fish and Wildlife Agencies Best Management Practices for trapping program. Twenty-five wolves have also been captured with the use of live-restraining neck snares, and a few by helicopter dart-gun. Wolves were typically immobilized using a mixture of either Ketamine:Xylazine or Telazol:Xylazine. After various project-specific wolf samples and measurements were obtained, the antagonist Yohimbine and an antibiotic were typically administered to all animals prior to release. Various models of radio-collars were deployed depending on study area and collar availability. Most GPS radio-collars were programmed to take 3-6 locations per day, while wolves fitted with VHF-only radio-collars were relocated at approximately 7 to 10 day intervals throughout the year, or in some cases primarily from early winter through spring.

To estimate average territory size, we delineated territories of radio-collared packs using minimum convex polygons (MCP) for consistency with previous surveys. Prior to delineating wolf pack territories, we removed 'outlier' radiolocations using the following guidelines, though subjective deviations were made in some cases as deemed biologically appropriate: 1) for wolves with approximately weekly VHF radiolocations only, locations > 5 km from other locations were excluded as extraterritorial forays (Fuller 1989); 2) for GPS collared wolves with temporally fine-scale movement information, we removed obvious movement paths if the animal did not travel to that area on multiple occasions and if use of the path would have resulted in inclusion of obviously unused areas in the MCP; and 3) for consistency with the way in which the data is used (i.e., to estimate number of packs), points that result in notable overlap with adjacent territories are removed.

In past surveys where all or the majority of territories were delineated using VHF radiolocations, raw territory sizes were increased 37% to account for the average amount of interstitial space between delineated wolf pack territories, as estimated from several Minnesota studies (Fuller et al. 1992:50) where the number of radiolocations per pack typically averaged 30-60. Interstitial spaces are a combination of small voids created by landscape geometry and wolf behavior, but are much more likely to be an artifact of territory underestimation when there are comparatively sparse radiolocations. Hence, for packs with < 100 radiolocations (n=8; mean number of radiolocations = 35), we multiplied each estimated territory size by 1.37 as in the past. For packs with > 100 radiolocations (n = 34; mean number of radiolocations = 2,107), territories were assumed to be fully delineated and were not re-scaled.

To estimate average mid-winter pack size, radio-marked wolves were repeatedly located via aircraft during winter to obtain visual counts of pack size. In cases where visual observations were insufficient, we also rely on any estimates of pack size based on tracks observed in the snow and trail camera images from within the pack's territory. If any reported count produced uncertain estimates (e.g., 4 to 5 wolves), we used the lower estimate. Overall, counts are assumed to represent minimum known mid-winter pack size.

The estimated number of packs within occupied wolf range is computed by dividing the area of occupied range by average scaled territory size. The estimated number of packs is then multiplied by average mid-winter pack size to produce an estimate of pack-associated wolves, which is then divided by 0.85 to account for an estimated 15% lone wolves in the population (Fuller et al. 1992:46, Fuller et al. 2003:170). Specifically,

N = ((km^2 of occupied range/mean scaled territory size)*mean pack size)/0.85.

Using the accelerated bias-corrected method (Manly 1997), the population size confidence interval (90%) was generated from 9,999 bootstrapped re-samples of the pack and territory size data and does not incorporate uncertainty in estimates of occupied range or percent lone wolves.

RESULTS AND DISCUSSION

Pack and Territory Size

We obtained territory and winter pack size data from 37 radio-marked wolf packs (Figure 1). Five additional wolf packs had adequate radiolocation data to delineate territories, but we were unable to obtain mid-winter pack counts. Using scaled territory sizes for all packs combined, radio-collared pack territories represented approximately 10% of occupied wolf range.

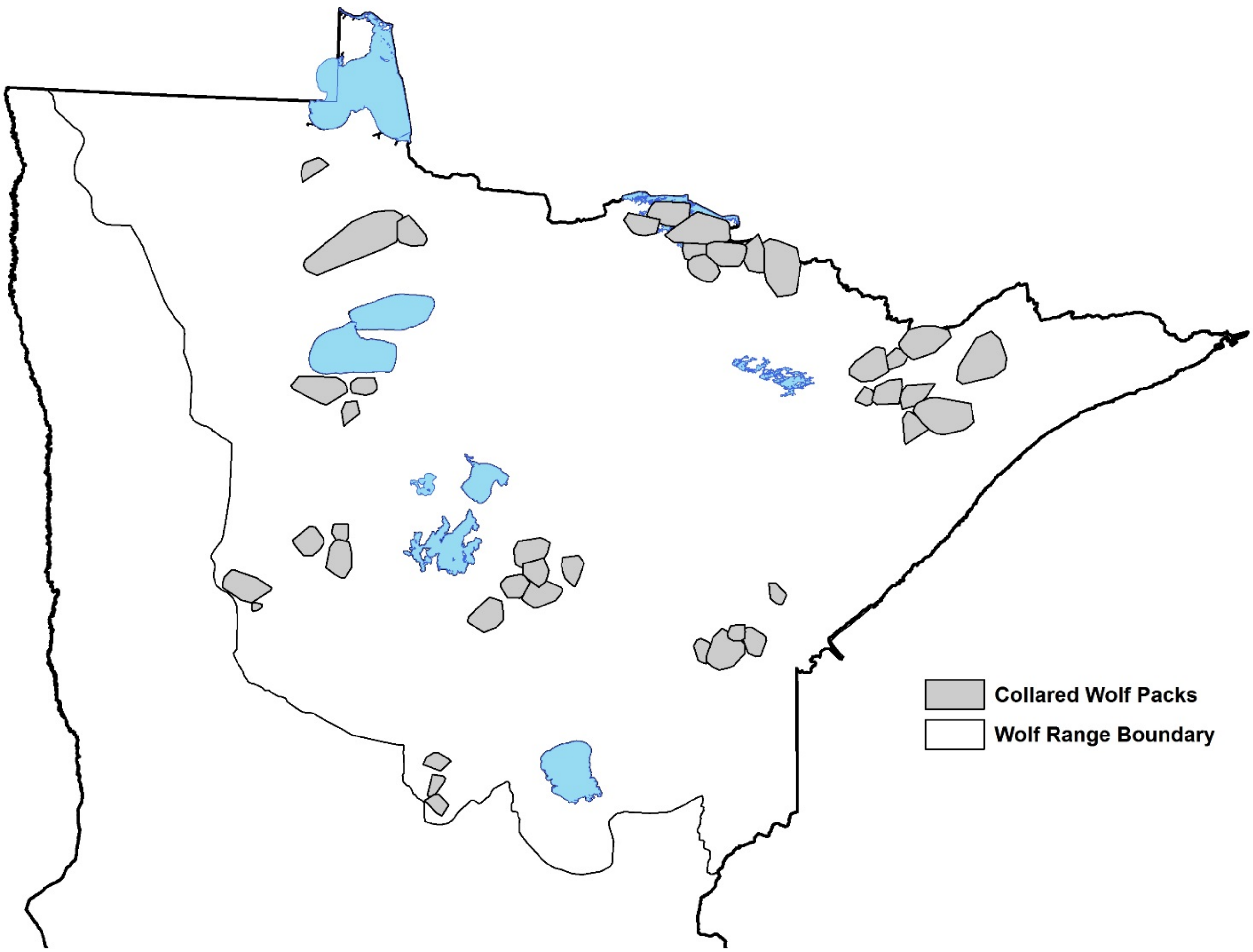

Figure 1. Location of radio-marked wolf packs during the 2015-16 survey.

Comparison of land cover type proportions within territories of collared packs with proportions throughout wolf range suggests differences (Table 1; Chi-square $p = 0.03$; 8 df) consistent with collaring activities often occurring on forested public land with abundant lakes and less agriculture or human developments. Nevertheless, the 3 cover types contributing most to the significant difference account for less than 20% of overall wolf range. Using spring 2015 deer density data (MNDNR, unpublished data) for deer hunting permit areas, weighted by number of wolf packs in a permit area, we estimate an average of approximately 9.4 deer/mi^2 (pre-fawn) in territories of radio-marked packs at the beginning of the biological year in which the survey was conducted. In comparison, 2015 spring deer density for the entirety of occupied wolf range (weighted by permit area) in Minnesota was approximately 10.3 deer/mi^2. Considering both cover type and deer density, we believe that key 'conditions' within marked pack territories last winter sufficiently approximated conditions within overall wolf range.

Table 1. Comparison of land cover[a] in territories of radio-collared wolf packs with land cover in all of occupied wolf range in Minnesota.

	Overall Occupied Wolf range	Radio-collared Wolf Territories
Land Cover Category	% Area	% Area
Woody Wetlands	33	36
Deciduous Forest	24	33
Emergent Herbaceous Wetlands	10	5
Mixed Forest	7	3
Evergreen Forest	7	6
Open Water	5	14
Shrub/Scrub	4	1
Pasture/Hay/Grassland/Crops	8	1
Developed, All	2	1

[a] Land cover data derived from the 2011 National Land Cover Database

After a marginally significant increase in territory size last year, territory size this winter was similar to the 2012-13 and 2013-14 averages (Figure 2). After applying the territory scaling factors, average estimated territory size for radio-marked packs during the 2015-16 survey was 161 km^2 (range = 15 – 666 km^2).

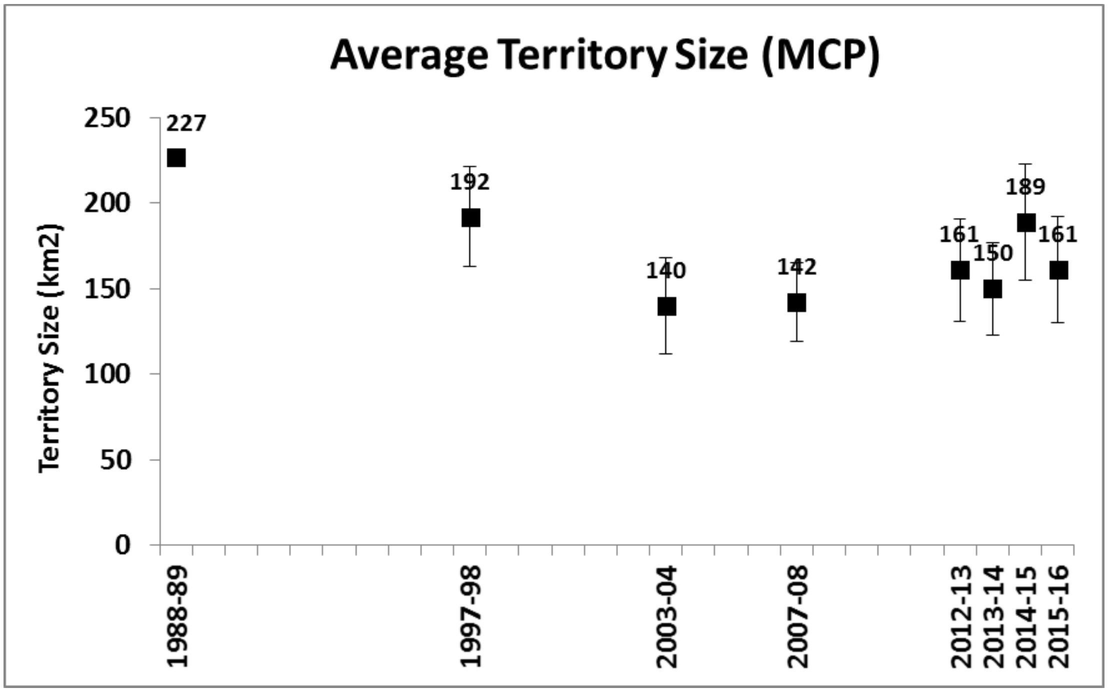

Figure 2. Average scaled territory size for radio-marked wolf packs in Minnesota from 1989 to 2016.

Similar to territory size, after a marginally significant increase in average pack size during winter 2014-15, average pack size in 2015-16 (4.4; range = 2 – 10, Figure 3) was similar to that observed during the 2012-13 and 2013-14 surveys.

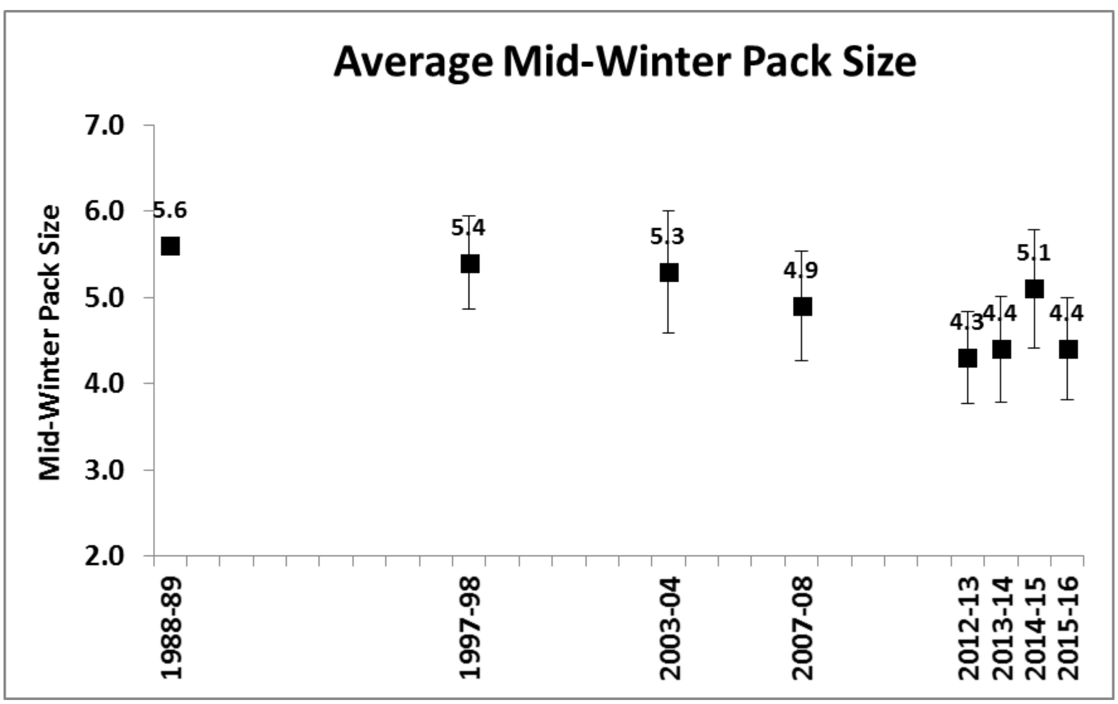

Figure 3. Average mid-winter pack size for radio-marked wolf packs in Minnesota from 1989 to 2016.

Wolf Numbers

Given an average territory size of approximately 161 km^2 and assuming occupied range has not changed since 2013 (70,579 km^2; Erb and Sampson 2013), we estimated a total of 439 wolf packs in Minnesota during winter 2015-16. Although also influenced by the estimated amount of occupied range, trends in the estimated number of packs (Figure 4) are generally the inverse of trends in estimated territory size (Figure 2).

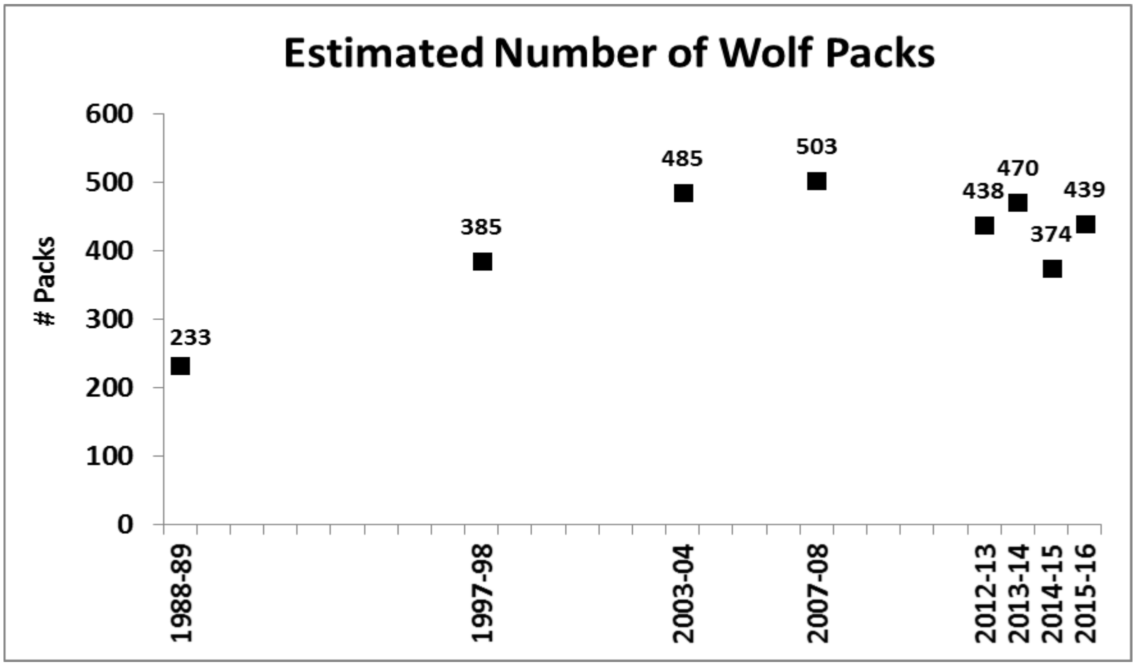

Figure 4. Estimated number of wolf packs in Minnesota at periodic intervals from 1989 to 2016.

After accounting for the assumed 15% lone wolves in the population, we estimated the 2015-16 mid-winter wolf population at 2,278 wolves, or 3.2 wolves per 100 km^2 of occupied range. The 90% confidence interval was approximately +/- 450 wolves, specifically 1,865 to 2,784. Given the very small changes in recent population estimates and substantial overlap in their confidence intervals, we conclude there has been no biologically or statistically significant change in the size of the statewide mid-winter wolf population over the past 4 years.

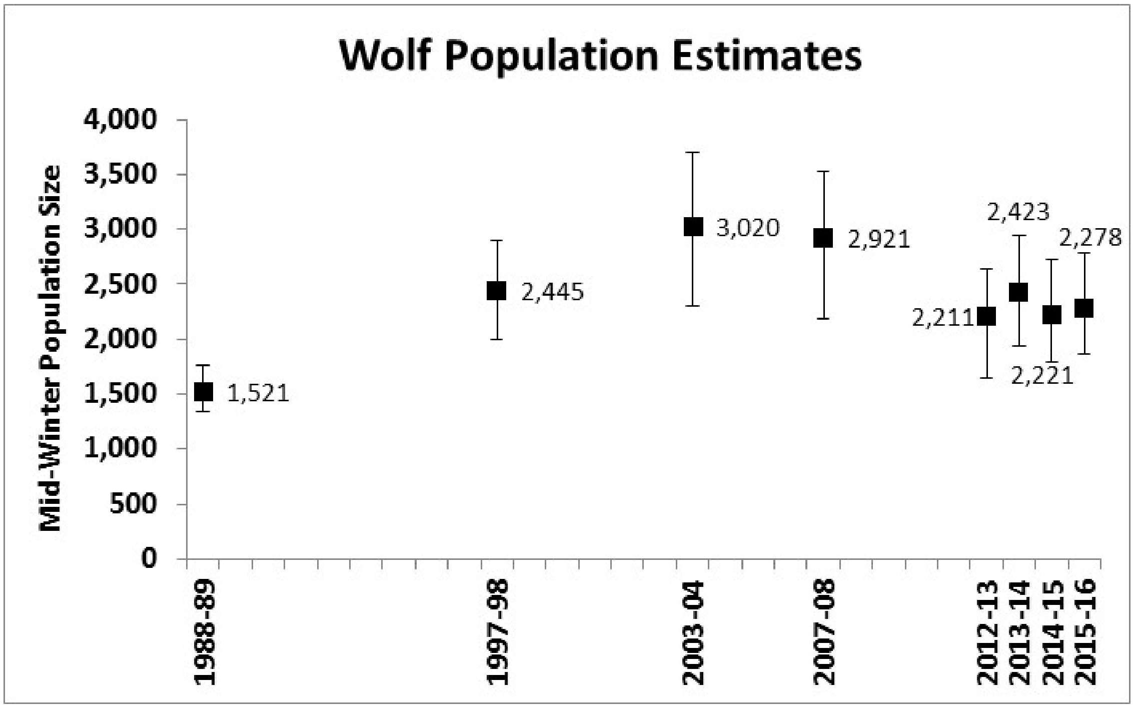

Figure 5. Wolf population estimates from periodic standardized surveys in Minnesota from 1989 to 2016.

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