FOREST WILDLIFE POPULATIONS

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2016 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

Ages 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. This was scaled upwards (to include bears that died of other causes), using 4 statewide tetracycline mark–recapture estimates as a guide. Whereas both the tetracycline-based and reconstructed populations showed a “humped” trajectory, with an increase during the 1990s, followed by a decline during the 2000s, 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 tet-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, so it is possible that the curve for the most recent years should be higher (Fig. 1).

Harvests were intentionally reduced in the quota zone when it was surmised (in the mid-2000s) that the population was declining. Since 2013, quotas were maintained at a low level, although harvests varied with food. Population reconstruction does not provide reliable estimates for the 2 most recent years, and since the model provides “pre-hunt” estimates, the most recent estimate shows only the effects of the 2013 harvest (and not the low harvest of 2014, or unexpectedly high harvest of 2016).

The no-quota zone has also shown a population decline during the 2000s, but at a slower rate than in the quota zone. Again, though, model results following the record no-quota harvest in 2016 are not yet available.

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 (67–75%). 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. Segregating the data into time blocks showed harvest rates increasing from 1980–1999, then declining with reductions in hunter numbers (Fig. 1). Harvest rates since 2010 have been, on average, less than what they were in the early 1980s, when the population was increasing (Figs. 2, 3).

Figure. 1. Statewide bear population trend (pre-hunt) derived from Downing reconstruction using the harvest age structures. 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 2014 are unreliable.

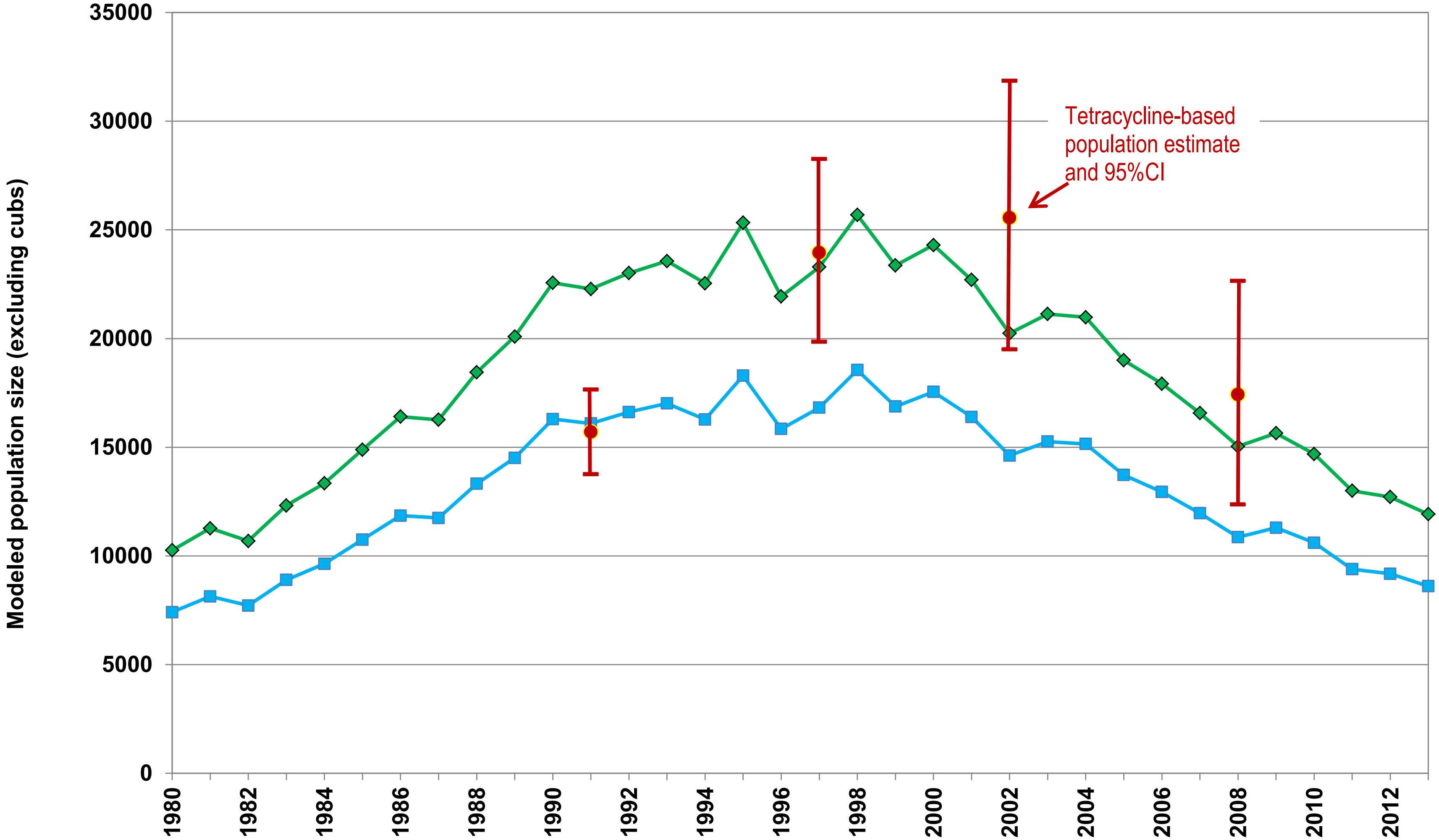


Figure 2. Population trends during 2000s derived from Downing reconstruction for quota and no-quota zones compared to respective harvests. Population curves were scaled (elevated to account for non-harvest mortality) using a multiplier midway between the two curves in Fig. 1 (i.e., the actual scale of the population estimates is not empirically-based).

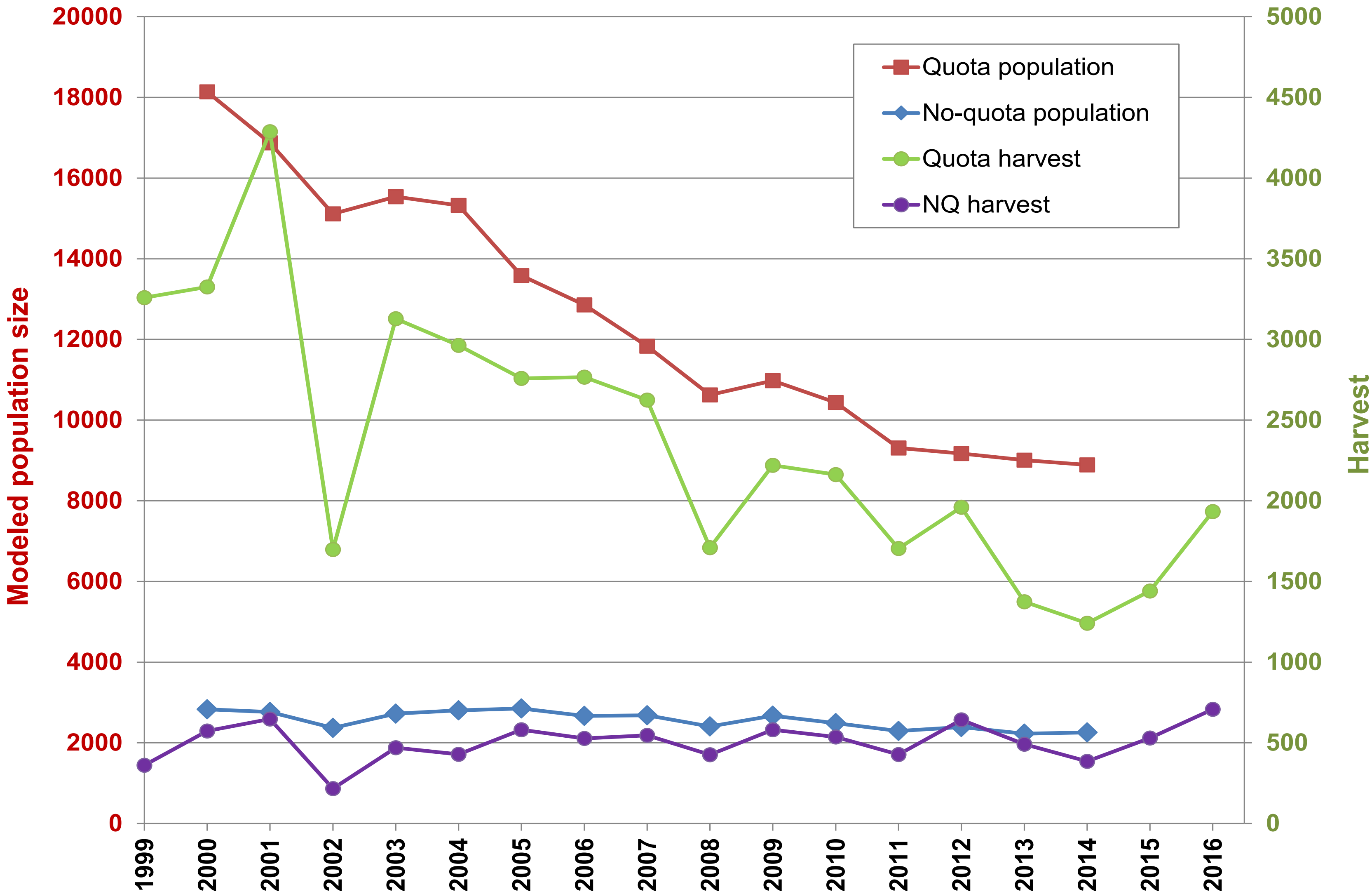
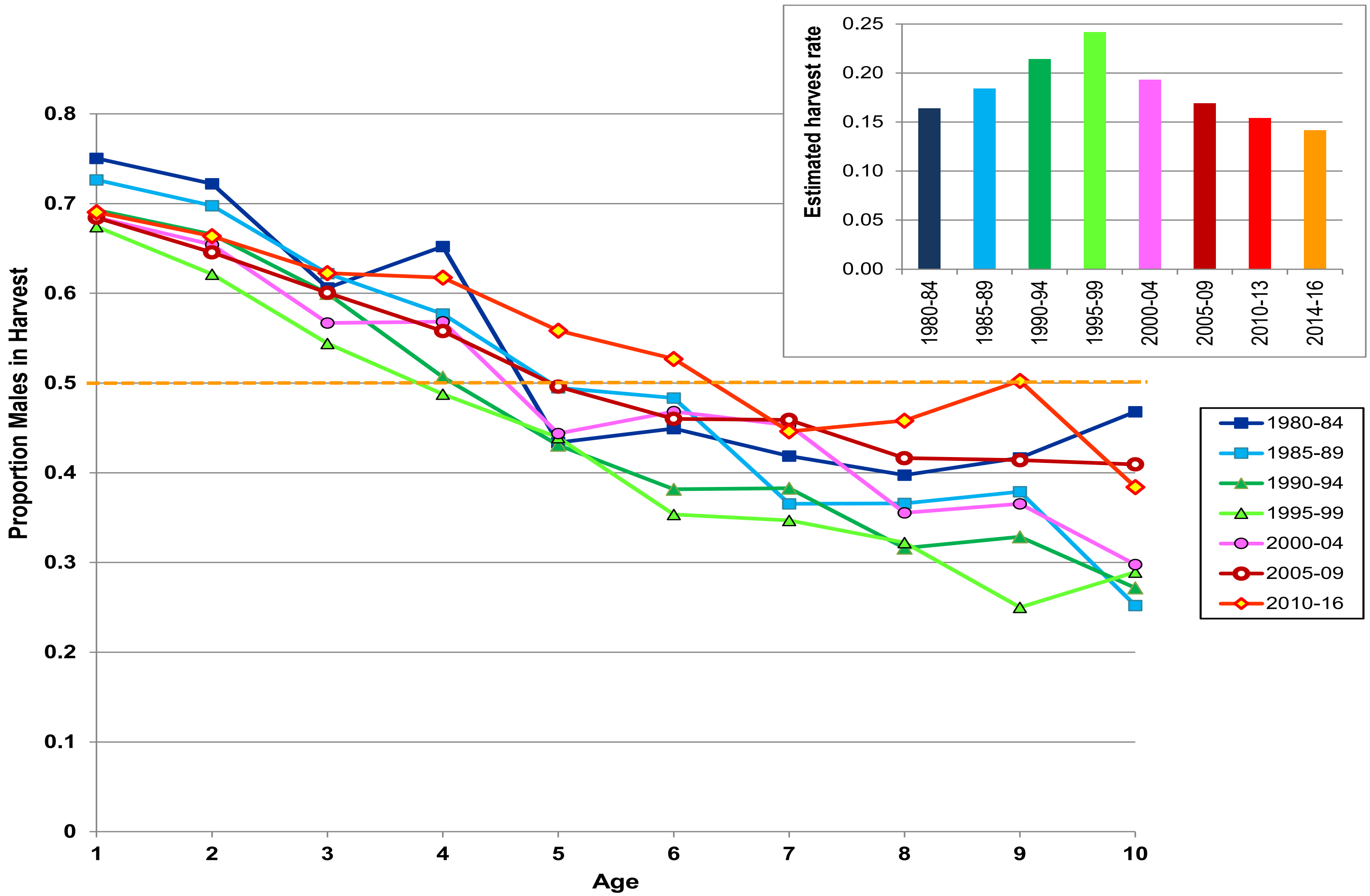


Figure 3. Trends in proportion of male bears in statewide harvest at each age, 1–10 years, grouped in 5-year time blocks, 1980–2016 (last interval is 7 years). Higher harvest rates result in steeper curves because males are reduced faster than females. Fitting a line to the data for each time block and predicting the age at which 50% of the harvest is male (dashed yellow line) yields approximately the inverse of the harvest rate (derived rates are shown in inset).



2017 MINNESOTA SPRING GROUSE SURVEYS

Charlotte Roy, Forest Wildlife Populations and Research Group

SUMMARY OF FINDINGS

The Minnesota DNR coordinates ruffed grouse (*Bonasa umbellus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) surveys statewide each spring with the help of wildlife managers, cooperating agencies, and organizations (e.g., tribal agencies, U.S. Forest Service, counties). In 2017, ruffed grouse surveys were conducted between 7 April and 15 May. Mean ruffed grouse drums per stop (dps) were 2.1 statewide (95% confidence interval = 1.7–2.4) and increased (57%) from the previous year, as expected during the increasing phase of the 10-year population cycle. Statewide, the mean ruffed grouse drums per stop were as high as during the last peak in drumming in 2009, but in western portions of the survey area, means have not yet reached previous peak levels, which are expected to occur in the next few years.

Sharp-tailed grouse surveys were conducted between 26 March and 13 May 2017, with 1,756 birds (males and birds of unknown sex) observed at 181 leks. The mean numbers of sharp-tailed grouse/lek were 7.2 (5.8–8.6) in the East Central (EC) survey region, 10.4 (9.2–11.8) in the Northwest (NW) region, and 9.7 (8.7–10.8) statewide. Comparisons between leks observed in consecutive years (2016 and 2017) indicated a similar number of birds/lek statewide ($t = 0.5$, $P > 0.5$), in the NW region ($t = 0.4$, $P > 0.5$), and in the EC region ($t = 0.4$, $P > 0.05$).

INTRODUCTION

The ruffed grouse (*Bonasa umbellus*) is the most popular game bird in Minnesota, with an annual harvest averaging >500,000 birds (~150,000 to 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 2.5th and 97.5th percentiles of bootstrap frequency distributions.

Nine surveys from 2016 were received after the report was written last year, so the 2016 analysis was updated to include these late submissions.

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 ≥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 & DISCUSSION

Ruffed Grouse

Observers from 15 cooperating organizations surveyed 122 routes between 7 April and 15 May 2017. Most routes (95%) were surveyed between 12 April and 10 May, with a median survey date of May 3, which is a few days later than last year (April 29) and the median survey date for the most recent 10 years. Excellent (68%), Good (27%), and Fair (5%) survey conditions were reported for 115 routes reporting conditions.

Statewide counts of ruffed grouse drums averaged 2.1 dps (95% confidence interval = 1.7–2.4 dps) during 2017 (Figure 3). Drum counts were 2.5 (2.0–2.9) dps in the Northeast (n = 98 routes), 1.6 (0.8–2.4) dps in the Northwest (n = 8), 0.9 (0.4–1.4) dps in the Central Hardwoods (n = 13), and 0.8 (0.4–1.4) dps in the Southeast (n = 8) regions (Figure 4a-d). Statewide drum counts increased (57%) from last year. An increase was expected given that the ruffed grouse population is in the increasing phase of the 10-year cycle and expected to peak soon. In the Northeast, the index has reached its former peak in the last cycle, but in the Northwest and Central Hardwoods the index is still rising, whereas in the Southeast, cycling is very weak.

Sharp-tailed Grouse

A total of 1,756 male sharp-tailed grouse and grouse of unknown sex were counted at 181 leks (Table 1) during 16 March to 13 May 2017. The statewide index value of 9.7 (8.7–10.8) grouse/lek was centrally located among values observed since 1980 (Figure 5). In the EC survey region, 286 grouse were counted on 40 leks, and 1,470 grouse were counted on 141 leks in the NW survey region. The grouse/lek index was similar statewide and in both survey regions compared to 2016 (Table 1). Leks with $\geq$2 grouse were observed an average of 2.0 times. Counts at leks observed during both 2016 and 2017 were similar ($t = 0.4$, $P > 0.05$) statewide, in the NW region ($t = 0.4$, $P > 0.05$), and in the EC region ($t = 0.4$, $P > 0.05$; Table 2).

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. Ruffed grouse populations increased dramatically this year, but increases were not observed in the sharp-tailed grouse population index, nor in comparisons of leks surveyed both years in either region or statewide. The number of birds counted in the EC region was 59% higher this year than during 2016 and higher than the preceding 5 years when ~200 birds were counted. However, survey effort can strongly influence the number of leks surveyed and can explain this result. The additional leks and birds counted in the EC region this year were predominantly (9 leks, 94 birds) in the portion of the Aitkin work area where leks have been more stable in recent years. Survey effort in the Aitkin work area last year was focused on areas of perceived declines and included many traditional lek sites that no longer support leks. [Workloads do not permit exhaustive surveys in the Aitkin or Tower work areas.] This year, efforts in the Aitkin work area focused more broadly on surveying as many existing leks as time permitted. Thus, the number of birds and leks counted in the EC region was higher in 2017, but the grouse/lek index and comparisons of leks surveyed in 2016 and 2017 did not change. Comprehensive consideration of these data leads to the conclusion that the EC sharp-tailed grouse population remains unchanged from last year. Importantly, the multi-year declining population pattern observed in southern portions of the EC region (e.g., Pine and Kanabec counties) appear not to be an artifact of survey effort after considering similar evidence (see the 2016 Survey Report). 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 stable or increasing over the same period. In 2016 and 2017, 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. 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.

ACKNOWLEDGMENTS

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. N. Benson and R. Haindfield surveyed leks as part of a research project this year. 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 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
2017	9.7	8.7 – 10.8	181	10.4	9.2 – 11.8	141	7.2	5.8 – 8.6	40

[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
2016 – 2017	-0.3	-1.5 – 0.9	166	-0.3	-1.8 – 1.2	128	-0.2	-1.2 – 0.8	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.

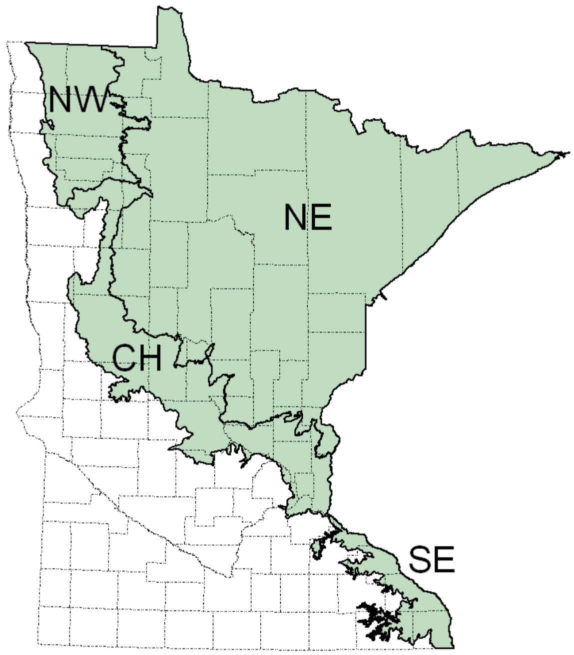


Figure 1. Survey regions for **ruffed grouse** in Minnesota. Northwest (NW), Northeast (NE), Central Hardwoods (CH), and Southeast (SE) survey regions are depicted relative to county boundaries (dashed lines) and influenced by the Ecological Classification System.

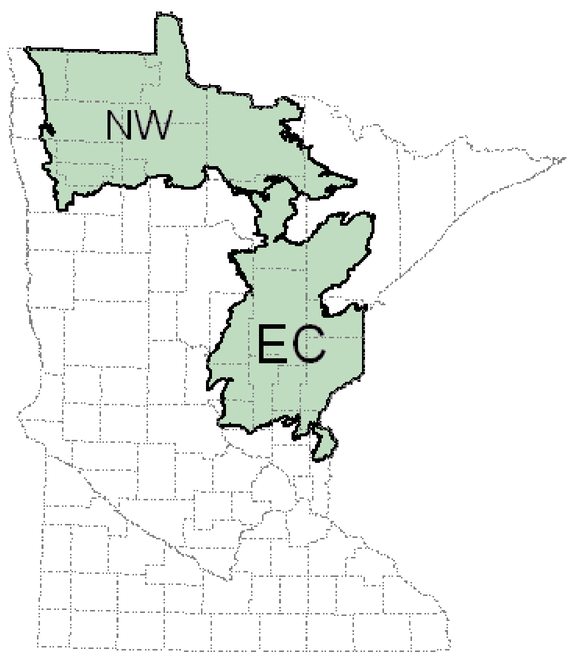


Figure 2. Survey regions for **sharp-tailed grouse** in Minnesota. Northwest (NW) and East Central (EC) survey regions are depicted relative to county boundaries (dashed lines) and influenced by Ecological Classification System Subsections boundaries.

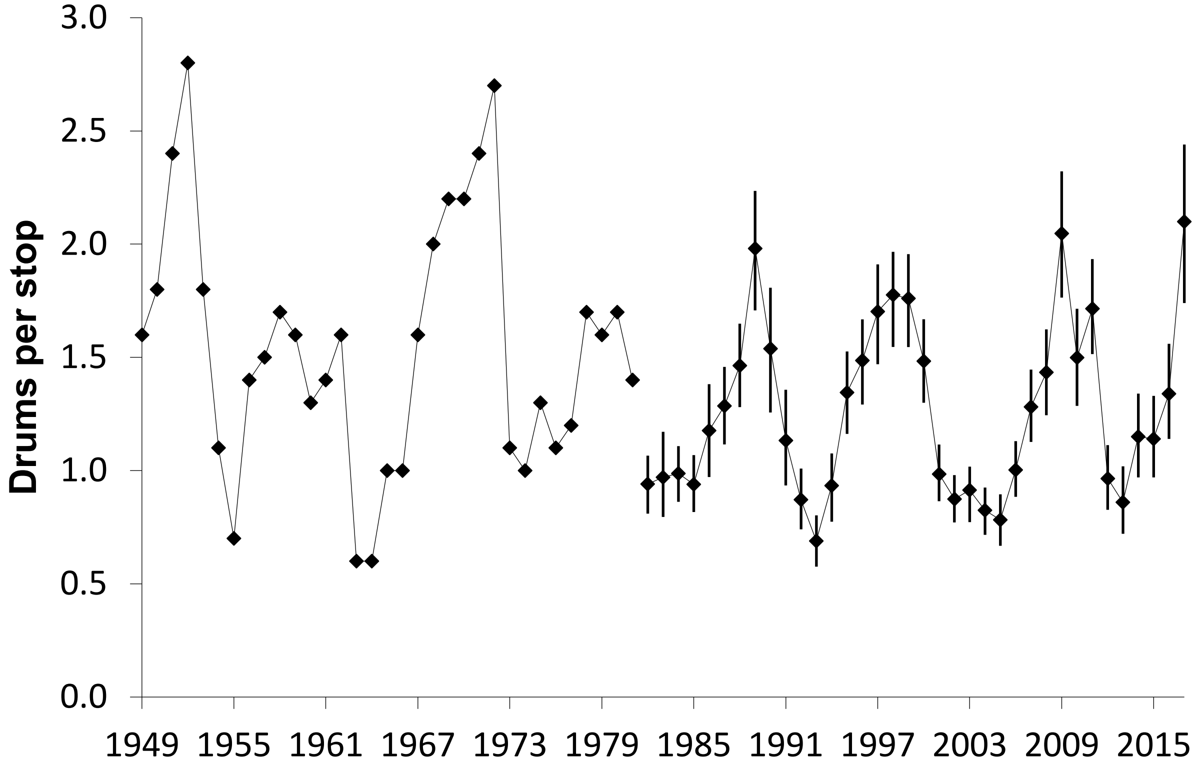
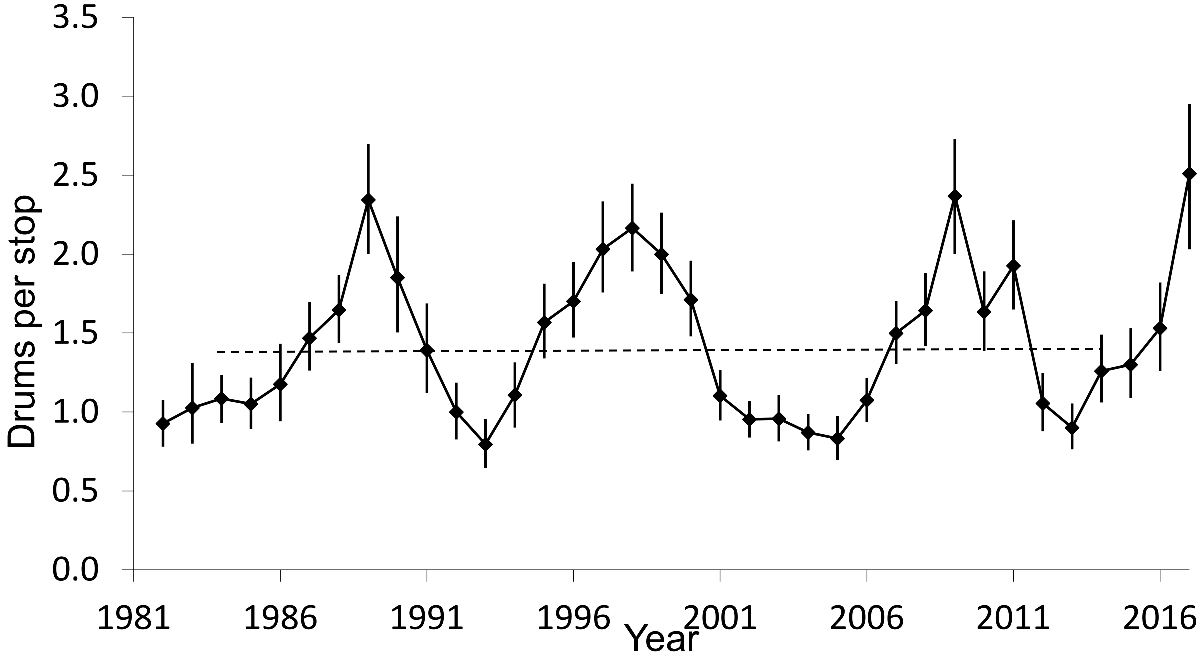
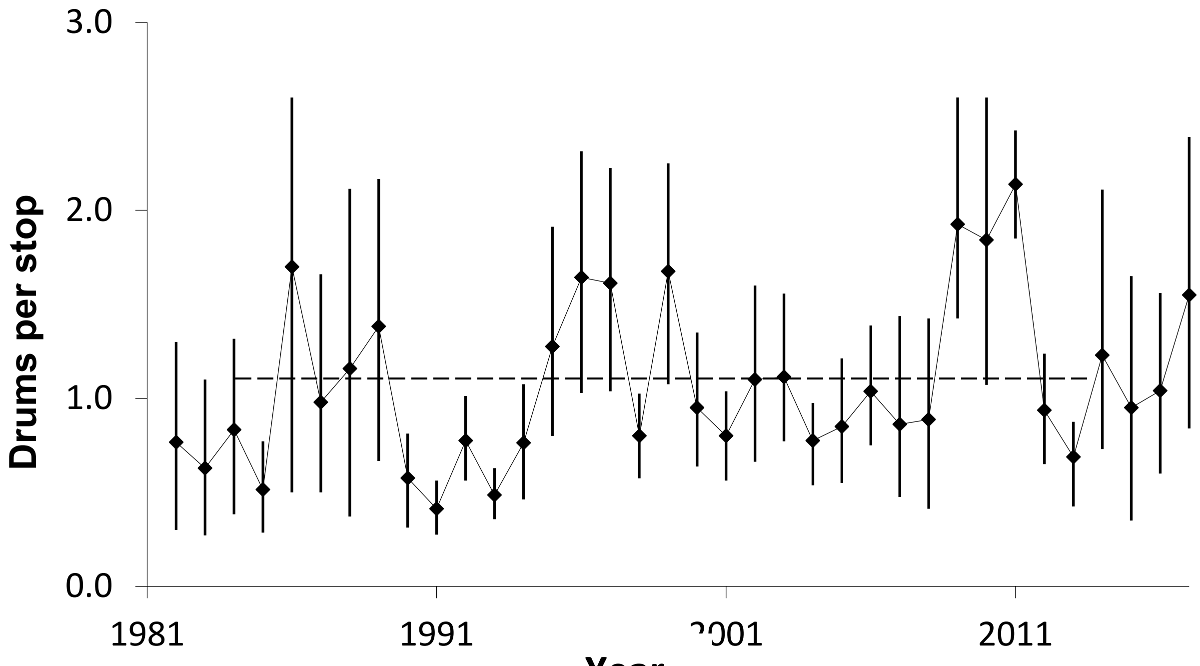


Figure 3. Statewide ruffed grouse population index values in Minnesota. Bootstrap (95%) confidence intervals (CI) are provided after 1981, but different analytical methods were used prior to this and thus CI are not available for earlier years. The difference between 1981 and 1982 is biological and not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

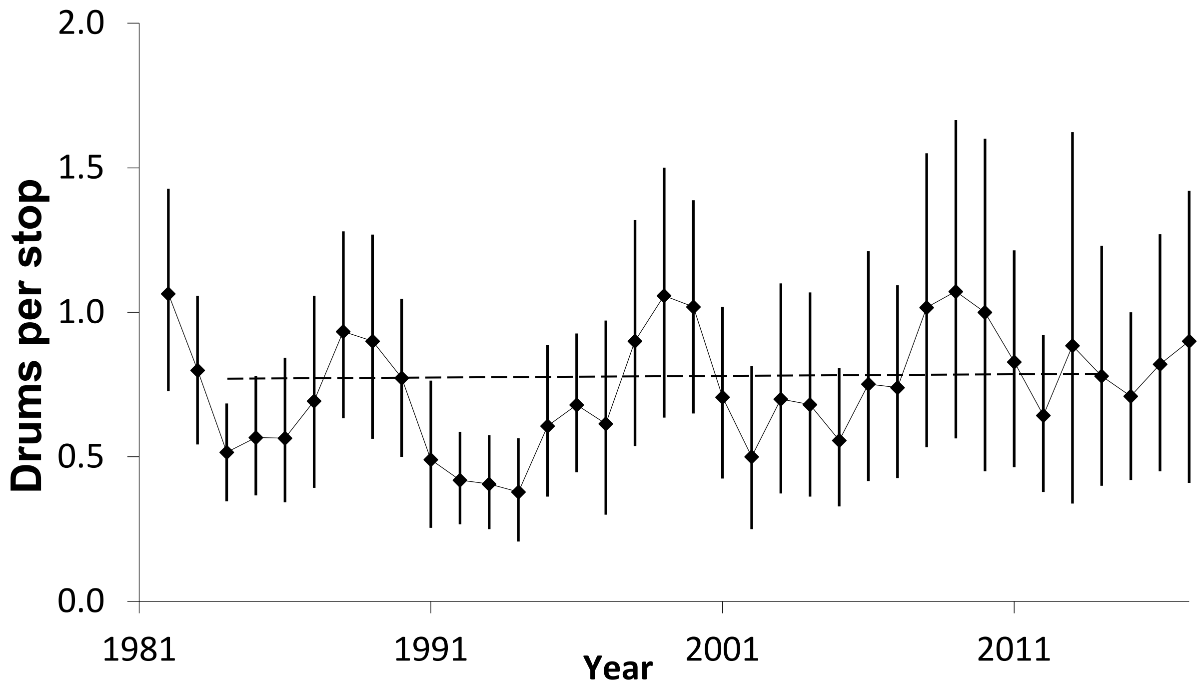
a.


3.5
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
1.0
0.0
Drums per stop
1981
1991
2001
2011
Year

c.



d.

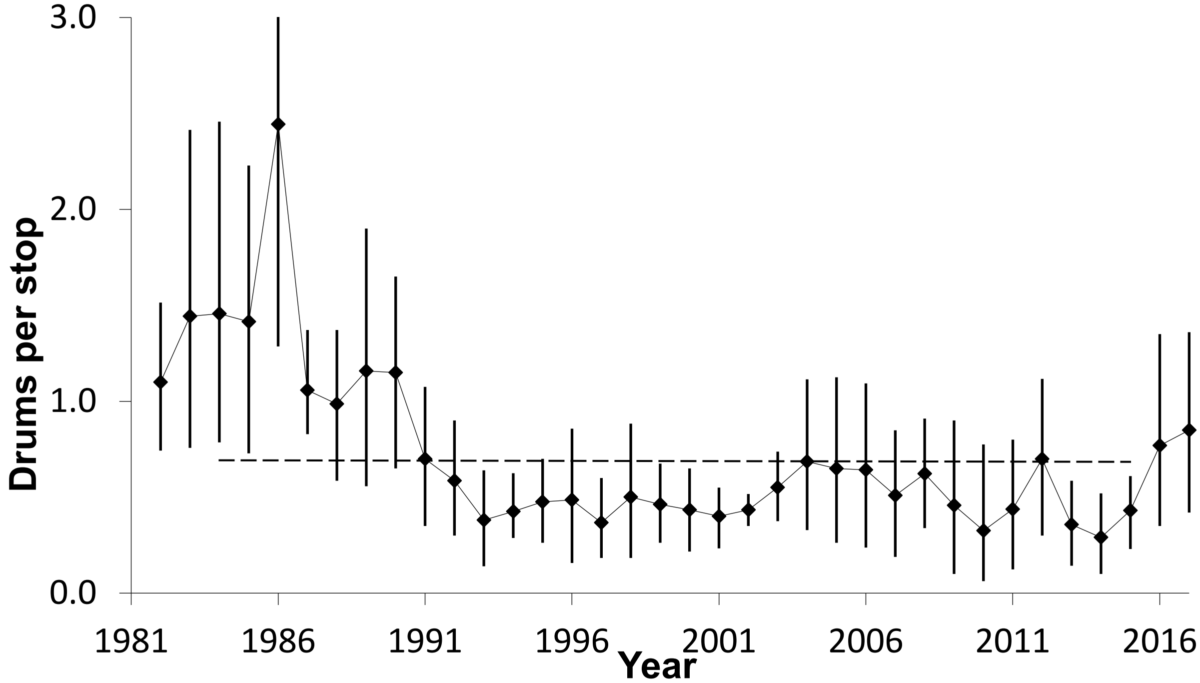


Figure 4a,b,c,d. Ruffed grouse population index values in the **Northeast** (a), **Northwest** (b), **Central Hardwoods** (c), and **Southeast** (d) survey regions of Minnesota. The mean for 1984-2014 is indicated by the dashed line. Bootstrap (95%) confidence intervals are provided for each mean. In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

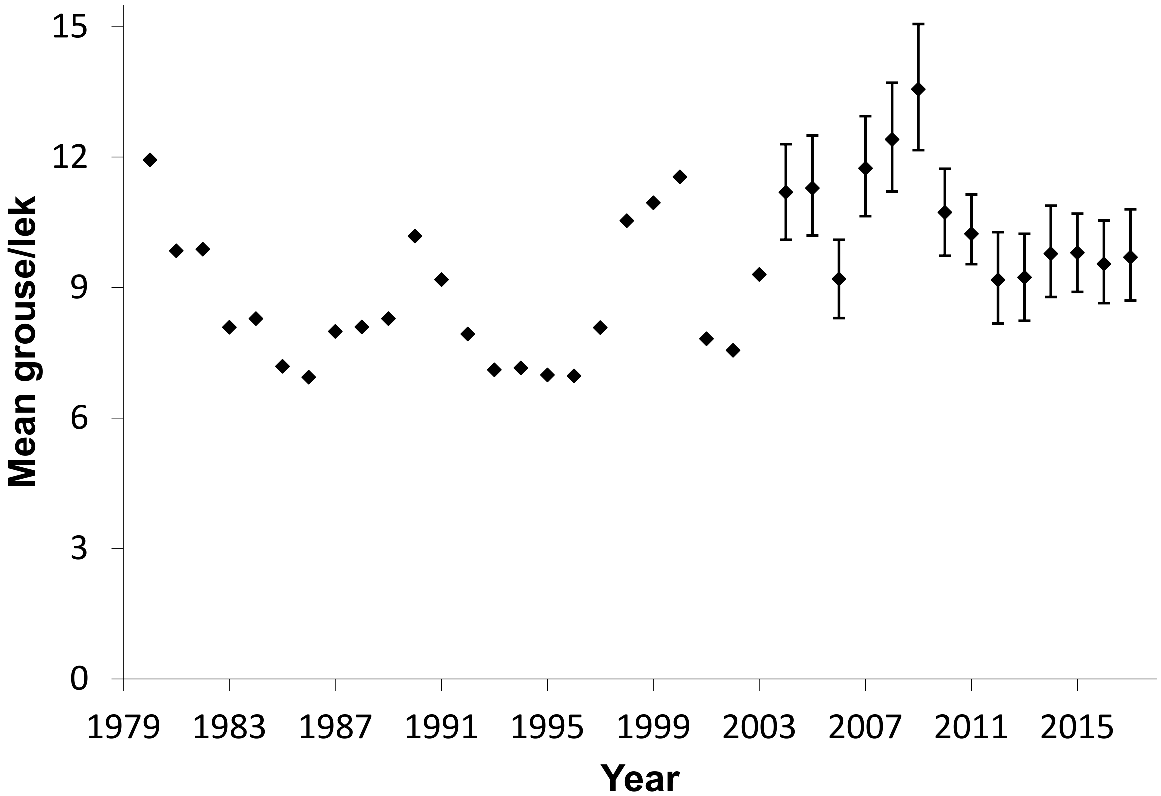


Figure 5. **Sharp-tailed grouse** counted in spring lek surveys statewide during 1980–2017. Bootstrap (95%) confidence intervals are provided for recent years. Annual means are not connected by lines because the same leks were not surveyed every year.

2017 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 2017. Observers located 64 booming grounds and counted 663 males and birds of unknown sex in the survey blocks. They located 146 booming grounds,1,412 male prairie-chickens, and 159 birds of unknown sex throughout the prairie-chicken range. Estimated densities of 0.09 (0.07–0.11) booming grounds/km^2 and 10.4 (8.4–12.3) 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 observer attempted to find and survey each booming ground repeatedly in his/her assigned block, which comprised 4 sections of the Public Land Survey (approximately 4,144 ha). Observers 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 observers to submit surveys 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 28 March and 20 May 2017. Observers located 146 booming grounds and observed 1,412 male prairie-chickens and 159 birds of unknown sex within and outside survey blocks (Table 1). These counts represent a minimum number of prairie-chickens in Minnesota during 2017, but because survey effort outside of survey blocks is not standardized among years, these counts should not be compared among years or permit areas.

Table 1. Minimum abundance of prairie-chickens within and outside hunting permit areas in Minnesota during spring 2017. Lek and bird counts are not comparable among permit areas or years.

Permit Area	Area (km^2)	Leks	Males	Unk[a]
803A	1,411	12	103	0
804A	435	2	15	0
805A	267	17	163	0
806A	747	10	65	18
807A	440	23	273	5
808A	417	21	349	0
809A	744	12	164	0
810A	505	8	68	17
811A	706	9	51	18
812A	914	8	42	21
813A	925	7	58	0
PA subtotal	7,511	129	1,351	79
Outside PAs[b]	NA[c]	17	61	80
Grand total	NA[c]	146	1,412	159

[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.

Within the standardized survey blocks, 663 males and birds of unknown sex were counted on 64 booming grounds during 2017 (Table 2). These counts are the second lowest—only lower in 2016—since the standardized survey began in 2004 and 1,566 males and 95 booming grounds were counted. This 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 31% 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.

Densities of prairie-chickens in the 10 core survey blocks were 0.10 (0.07–0.12) booming grounds/km^2 and 11.8 (9.1–14.5) males/booming ground (Table 2, Figure 2). In the 7 peripheral survey blocks, densities were 0.08 (0.04–0.11) booming grounds/km^2 and 7.6 (5.8–9.5) males/booming ground. The density of 0.09 (0.07–0.11) booming grounds/km^2 in all survey blocks during 2017 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 10.4 (8.4–12.3) males/booming ground in all survey blocks during 2017 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.

			2017		Change from 2016[a]	
Range[b]	Survey Block	Area (km^2)	Booming grounds	Males[c]	Booming grounds	Males[c]
Core	Polk 1	41.2	6	57	0	-4
	Polk 2	42.0	4	45	-1	-13
	Norman 1	42.0	2	15	1	10
	Norman 2	42.2	6	43	3	9
	Norman 3	41.0	4	36	-1	-34
	Clay 1	46.0	7	100	0	16
	Clay 2	41.0	2	76	0	12
	Clay 3	42.0	4	61	-3	-10
	Clay 4	39.0	3	19	0	4
	Wilkin 1	40.0	4	43	1	4
	Core subtotal	415.0	42	495	0	-6
Periphery	Mahnomen	41.7	3	39	1	21
	Becker 1	41.4	6	51	2	23
	Becker 2	41.7	5	23	2	6
	Wilkin 2	41.7	1	5	-1	-9
	Wilkin 3	42.0	4	33	-1	-10
	Otter Tail 1	41.0	2	9	1	2
	Otter Tail 2	40.7	1	8	0	2
	Periphery subtotal	290.6	22	168	4	35
Grand total		705.5	64	663	4	29

[a] The 2016 count was subtracted from the 2017 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.

ACKNOWLEDGMENTS

I would like to thank cooperators who conducted and helped coordinate the prairie-chicken survey. Cooperators within the DNR included Emily Hutchins, Brian Torgusson, Rob Baden, Michael Oehler, Becky Ekstein, Matt Morin, 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, Tony Nelson, Dennis Thielen, and Lindsey Reinarz; cooperators with the US Fish and Wildlife Service included Shawn Papon, Chad Raitz, Cody Townsend, Ben Walker; and numerous additional volunteers participated, including Dan Svedarsky, Doug Wells, Tom Kucera, Jon Voz, Ross Hier, Tori Drake, and Kaly Adkins. Bemidji

State University faculty and students, Brian Hiller and Adam Maleski, also assisted with surveys this year. This survey was funded in part by the Wildlife Restoration (Pittman-Robertson) Program W-69-S-15 Project #14. Mike Larson provided assistance and comments which improved this report.

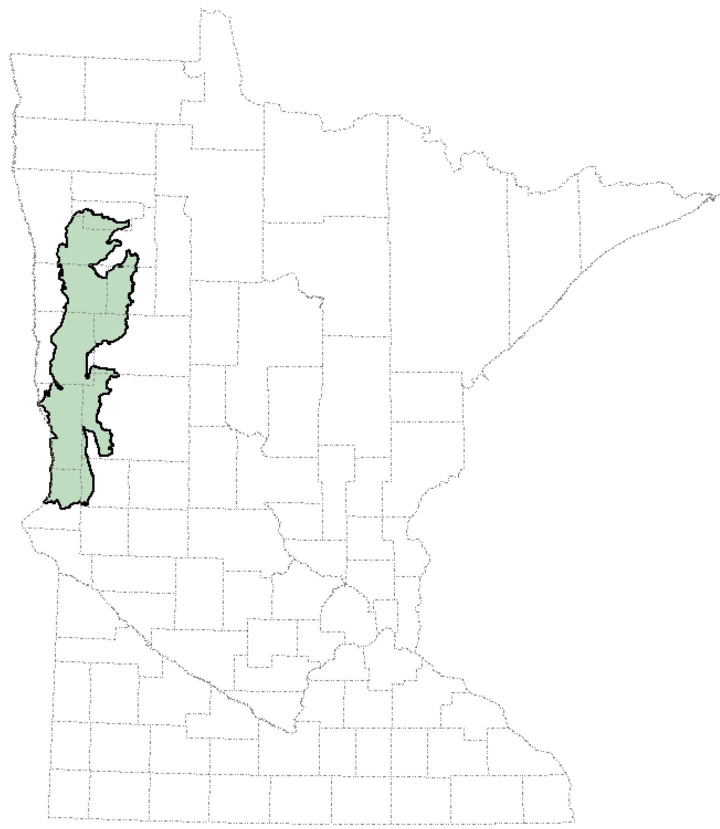


Figure 1. Primary greater prairie-chicken range in Minnesota (shaded area) relative to county boundaries. The range boundary was based on Ecological Classification System Land Type Associations and excludes some areas known to be occupied by prairie-chickens.

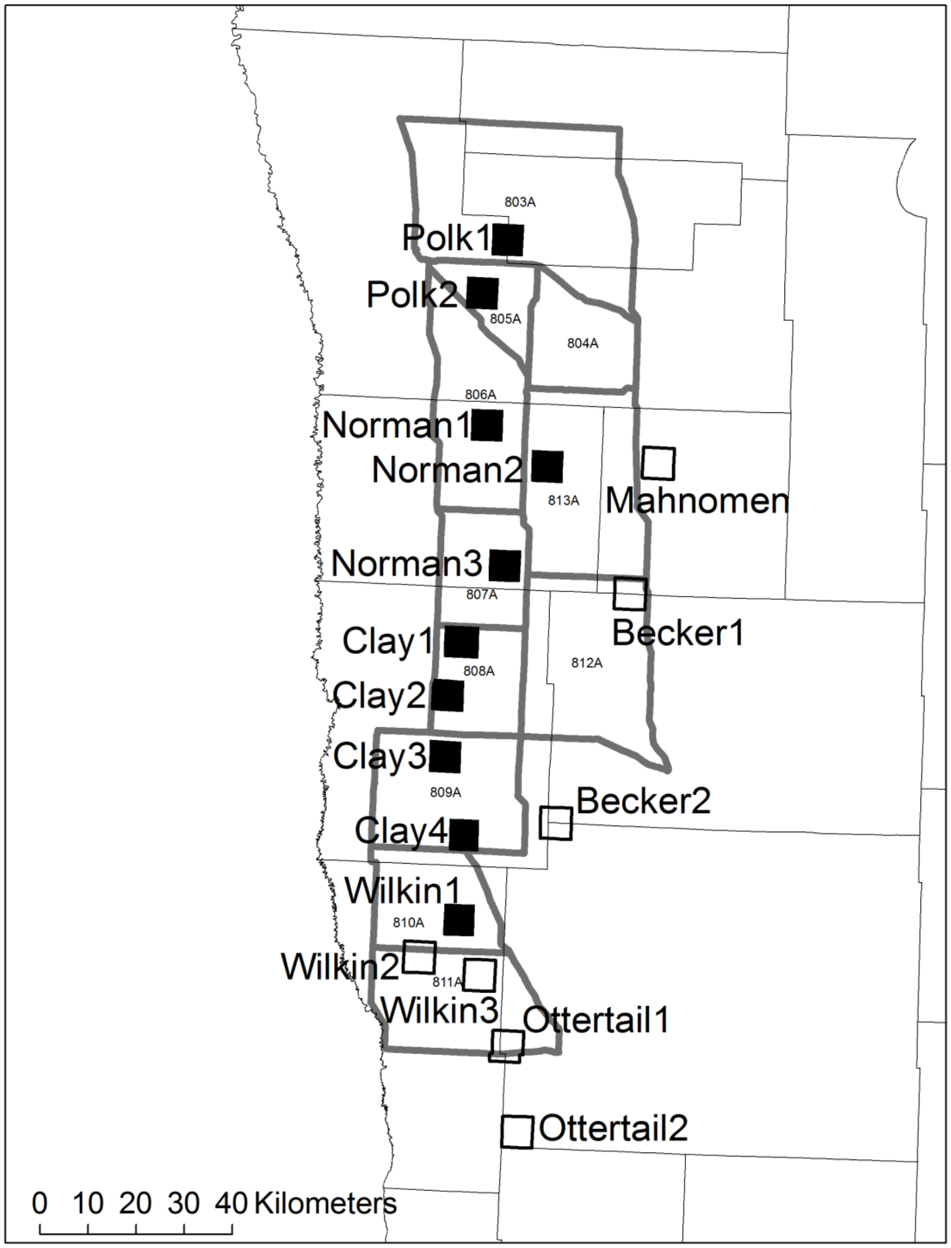


Figure 2. Prairie-chicken lek survey blocks (41 km^2, labeled squares) and hunting permit areas (thick grey lines) in western Minnesota. Survey blocks were either in the core (black) or periphery (white) of the range with a threshold of 1.0 male/km^2 in 2010, and were named after their respective counties (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.

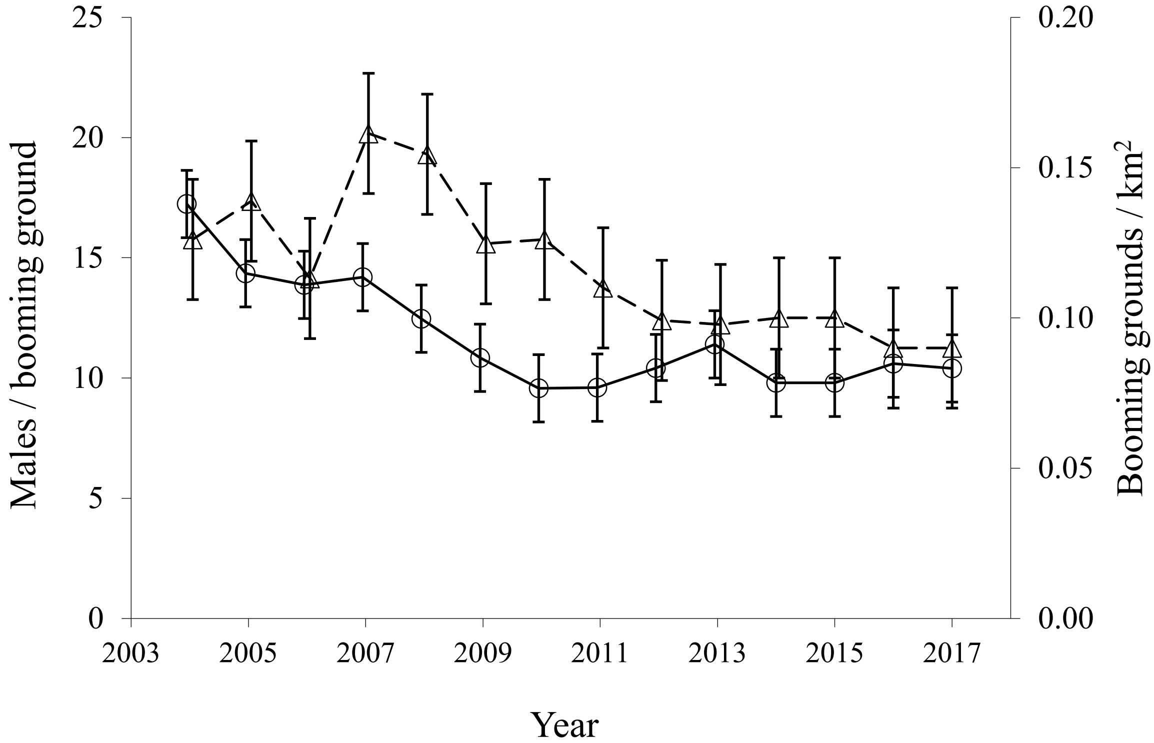


Figure 3. Mean prairie-chicken males/booming ground (circles connected by solid line) and booming grounds/km^2 (triangles connected by dashed line) in survey blocks in Minnesota with 95% confidence intervals.

2017 NW MN ELK SURVEYS

Doug Franke, Area Wildlife Manager, Thief River Falls

INTRODUCTION

This year we used only fixed-wing aircraft (Cessna 185) to conduct aerial elk surveys for the Lancaster, Caribou-Vita, and Grygla elk herds. The fixed-wing aircraft followed predetermined transects spaced 1/5 mile apart at an altitude of 300 to 400 feet and speeds of 80-85 mph. The pilot and two observers recorded elk location(s) and documented the sex and size class of bulls.

METHODS

The surveys started on February 1st and ended on February 21st, 2017. Snow depths and conditions were much better than the past two years for the Lancaster and Grygla survey blocks. Snow depths ranged from 10 to 15 inches throughout the elk range. Weather conditions were average for this time of the year with temperatures ranging from a low of -16°F to a high of 32°F and mostly sunny days. There were no major delays due to precipitation, wind, or temperatures.

We waited to complete the Caribou-Vita block this year since Manitoba Wildlife staff planned to survey elk on the Canadian side in late February. The surveys for both the Canadian and US border area were completed on February 21st, 2017 within a two hour period of each other. The entire region lost a lot of snow cover prior to the surveys, resulting in fair survey conditions.

RESULTS

Lancaster—Water Tower and Percy WMA herds

This survey started on February 1st and was completed on February 3rd, 2017. The area surveyed was the same 167 mi^2 area as last year and took 16.1 hours for the fixed-wing to complete (wheels up to wheels down). The fixed-wing recorded elk at 6 separate locations within the survey boundary. Total elk recorded was 61 and included: 45 Antlerless (cows/calves) and 16 bulls (5 mature, 9 raghorn, and 2 spike bulls. The Water Tower group had 30 antlerless elk with a majority of the Lancaster bulls located less than five miles to the east. We located the Percy WMA antlerless herd (15 animals) on the western edge of Beaches Lake WMA, just east of the Percy WMA this year. Four raghorn bulls were located within a mile of the antlerless herd.

Grygla herd

This survey started on February 8th and was completed on February 9th, 2017. The area surveyed was the same 133 mi^2 area as last year and took 10.6 hours for the fixed-wing to complete. The entire survey area received a fresh snowfall the day before and made for excellent survey conditions. The fixed-wing recorded elk at 3 separate locations within the survey boundary. Total elk observed was 17 and included: 7 antlerless (cows/calves) and 10 bulls (4 mature, 2 raghorn, and 4 spike bulls).

Caribou-Vita (a.k.a. border herd)

This survey started and was completed on February 21st, 2017. The area surveyed was the same 35.5 mi^2 area as last year and took 3.4 hours for the fixed-wing to complete. The fixed-wing only recorded a single elk (1 raghorn bull) within survey boundary. 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. This was later confirmed when we received results from the Manitoba aerial elk survey.

The MN DNR and Manitoba Wildlife staff successfully coordinated a joint aerial elk survey that was completed February 21st, 2017 for the survey areas close to the US/Canadian border. Manitoba completed the survey for the Vita area the next day on February 22nd, 2017. Manitoba Wildlife staff used a Jet Ranger helicopter to fly north/south transects within predetermined survey blocks that covered a broad area along the border. They recorded 108 elk near the US/Canadian border and another 55 elk slightly north of Vita. Table 2 details the age/sex breakdown for these two populations.

Table 1 on page three summarizes MN DNR elk observations during the past four years of NW MN aerial elk surveys. The last two pages are maps showing 2017 locations of elk within each survey block.

ACKNOWLEDGMENTS

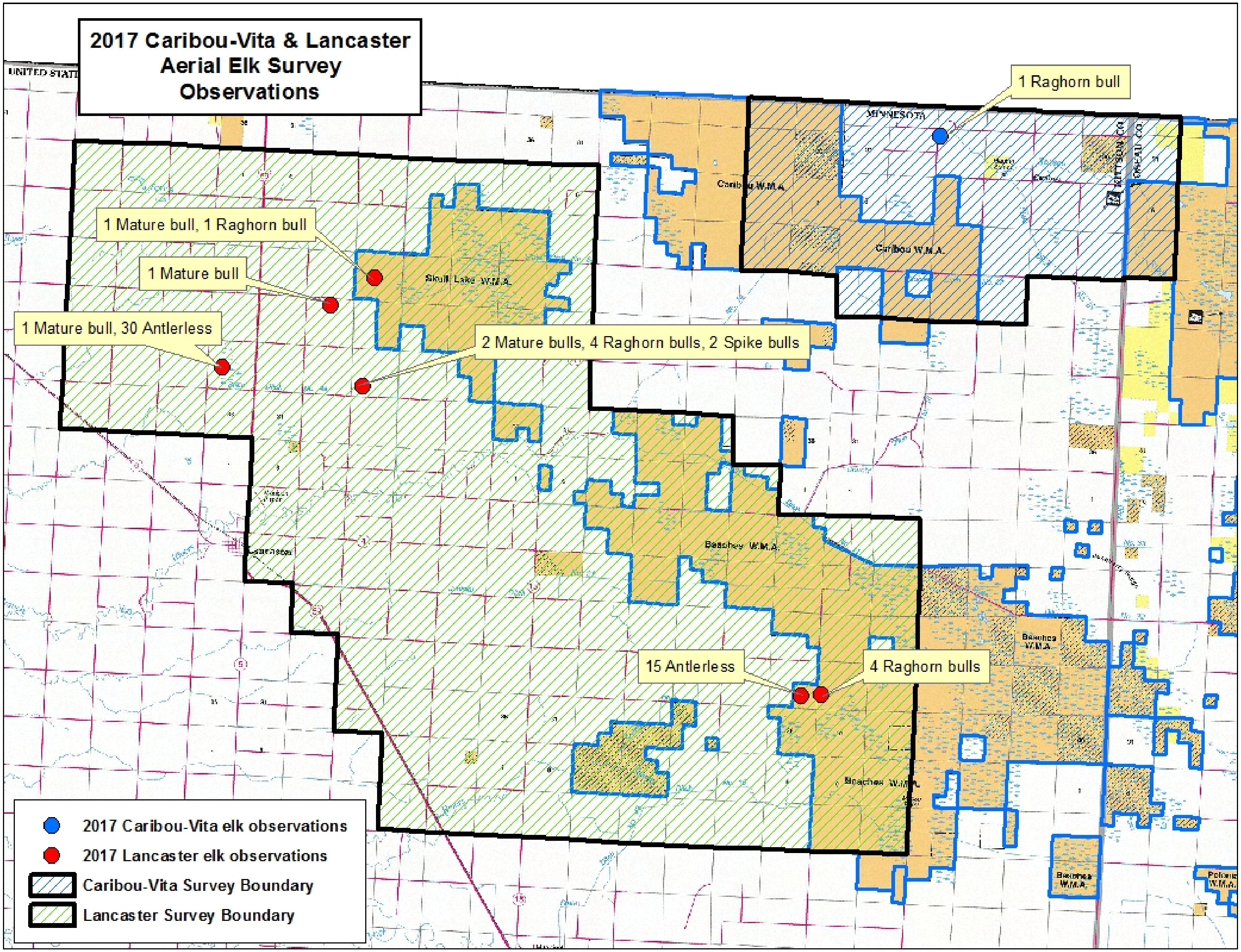
I would like to thank all those that helped with the survey this year, especially the fixed-wing pilots Chris Lofstuen, Bob Geving, and John Heineman who provided safe flying for all of us. This was Bob's first time flying the elk surveys and he did a great job! Observers this year included: Kyle Arola (Thief Lake Assistant Manager), Jason Wollin (Karlstad Assistant Area Wildlife Manager), Matt Morin (Thief River Falls Assistant Manager), and myself. Special thanks again to Brian Haroldson who put together all of the survey materials and computer used during the survey.

Table 1. Comparison of elk observations between 2014 and 2017 for the Lancaster, Caribou-Vita, and Grygla herds.

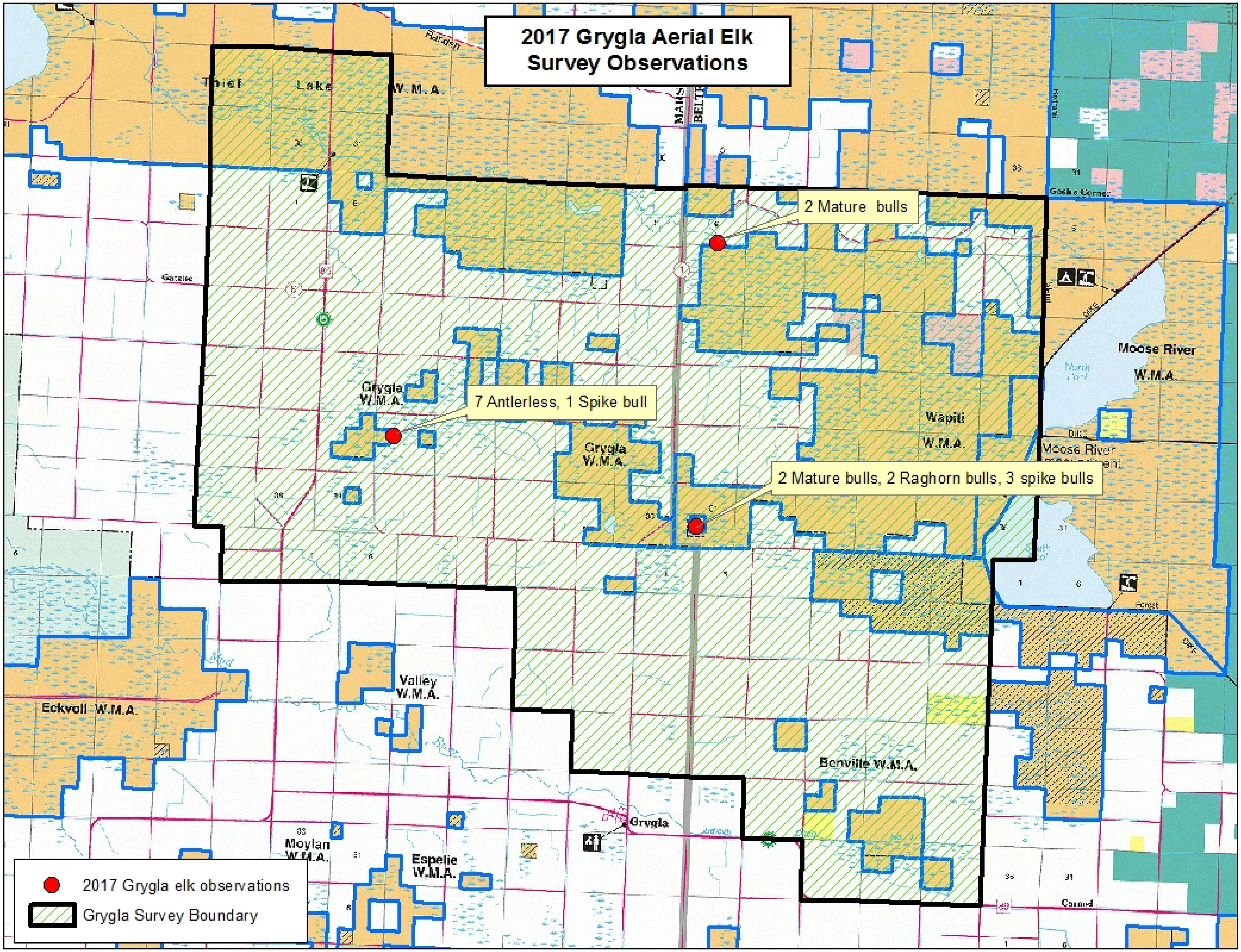
	Lancaster				**Caribou-Vita**				**Grygla**			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Spike bull	3	2	6	2	10	5	0	0	2	3	2	4
Raghorn bull	7	8	2	9	5	9	4	1	1	5	5	2
Mature Bull	7	8	10	5	2	8	2	0	3	1	4	4
Total Bulls	**17**	**18**	**18**	**16**	**17**	**22**	**6**	**1**	**6**	**9**	**11**	**10**
Antlerless	**20**	**16**	**34**	**45**	**34**	**57**	**4**	**0**	**14**	**9**	**10**	**7**
Total Elk	**37**	**34**	**52**	**61**	**51**	**79**	**10**	**1**	**20**	**18**	**21**	**17**

Table 2. Elk observations recorded by Manitoba Wildlife staff during their aerial survey conducted February 21st and 22nd, 2017

	Border (Caribou)	**Vita**
Spike bull	2	4
Branch bull	17	7
Total Bulls	**19**	**11**
Cow	68	32
Calf	21	12
Total Antlerless	**89**	**44**
Total Elk	**108**	**55**



2017 Caribou-Vita & Lancaster Aerial Elk Survey Observations
1 Raghorn bull
1 Mature bull, 1 Raghorn bull
1 Mature bull
1 Mature bull, 30 Antlerless
2 Mature bulls, 4 Raghorn bulls, 2 Spike bulls
15 Antlerless
4 Raghorn bulls
Caribou W.M.A.
Skull Lake W.M.A.
Beaches W.M.A.
2017 Caribou-Vita elk observations
2017 Lancaster elk observations
Caribou-Vita Survey Boundary
Lancaster Survey Boundary


2017 Grygla Aerial Elk Survey Observations
2 Mature bulls
7 Antlerless, 1 Spike bull
2 Mature bulls, 2 Raghorn bulls, 3 spike bulls
Thief Lake W.M.A.
Grygla W.M.A.
Grygla W.M.A.
Wapiti W.M.A.
Moose River W.M.A.
Moose River
Valley W.M.A.
Eckvoll W.M.A.
Benville W.M.A.
Moylan W.M.A.
Espelie W.M.A.
Grygla
2017 Grygla elk observations
Grygla Survey Boundary

2017 AERIAL MOOSE SURVEY

Glenn D. DelGiudice, Forest Wildlife Populations and Research Group

INTRODUCTION

Each year we conduct an aerial survey in northeastern Minnesota to estimate the moose (*Alces americanus*) population and to monitor and assess changes in the overall status of the state's largest deer species. Specifically, the primary objectives of this annual survey are to estimate moose abundance, 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), composition, and distribution; 2) set the harvest quota for the subsequent State hunting season (when applicable); 3) with research findings, 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 (Figure 1). To keep the stratification current, 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. In addition, individual plots are re-stratified after each annual survey if observations warrant. Survey plots are 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. These same 9 plots are surveyed each year in an effort to better understand moose use of disturbed areas and evaluate the effect of forest disturbance on moose density over time. In total, we surveyed 52 (43 randomly sampled and the 9 habitat plots) of the 436 plots this year.

All 436 survey plots in the grid (designed in 2005) are 13.9-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 pilots flew the 2 helicopters used to conduct the survey—1 Bell Jet Ranger (OH-58) and 1 MD500E. We determined the sex of moose using the presence of antlers or the presence of a vulva patch (Mitchell 1970), nose coloration, and bell size and shape. We identified calves by 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 the selected background in *real time*, and to efficiently record data using a tablet pen with a menu-driven data-entry form. Two 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 "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. Estimated VO was the proportion of a circle where vegetation 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 [sightability] correction) of bulls, cows, and calves, adjusted for sampling, to calculate the bull:cow and calf:cow ratios at the population level (i.e., using the combined ratio estimator; Cochran 1977:165).

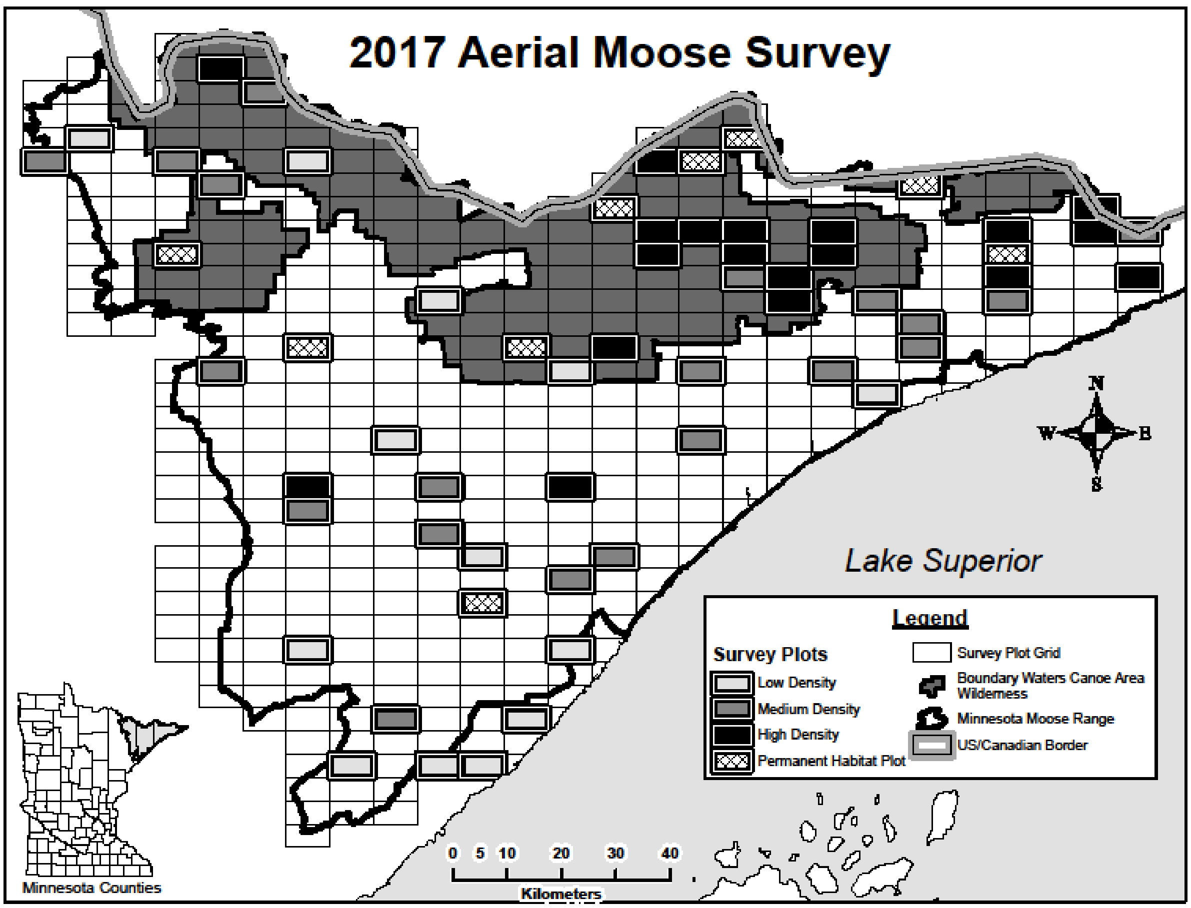


Figure 1. Moose survey area and 52 sample plots flown in the 2017 aerial moose survey.

RESULTS AND DISCUSSION

The survey was conducted from 5 to 14 January 2017. It consisted of 8 actual survey days, and as in 2014, 2015, and 2016, 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 2017). Generally, 8" of snow cover is our minimum threshold depth for conducting the survey. Snow depths were 8–16" and >16" on 27% and 73% of the sample plots, respectively. Overall, survey conditions were rated as good for 90% and fair for 10% of the plots when surveyed. Average survey intensity was 50 minutes/plot (13.9 mi^2) and ranged from 41 to 65 minutes/plot (Giudice 2017).

This year a total of 508 moose were observed on 47 (90%) of the 52 plots surveyed (a total 723 mi^2), almost identical to the 506 moose observed on 47 of 52 plots during the 2016 survey. Similarly, an average of 10.8 moose (range = 1–39) were observed per "occupied" plot. Plot occupancy during the past 13 years averaged 81% (range = 65–95%) with a mean 11.8 moose observed per occupied plot. This year's 508 observed moose included 206 bulls, 217 cows, 74 calves, and 11 unclassified adults. Overall, estimated VO averaged 34% (range = 0−90%) and average estimated detection probability was 0.63 (range = 0.20−0.85); both were comparable to those of previous years.

After adjusting for sampling and sightability, we estimated the population in northeastern Minnesota at 3,710 (3,010–4,710, 90% confidence interval [CI]) moose (Table 1, Figure 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. These data are best suited to establishing long-term trends; even short-term trends must be viewed cautiously.

Past aerial survey and research results have indicated that the long-term trend of the population in northeastern Minnesota has been declining since 2006 (Lenarz et al. 2010, DelGiudice 2016). The current population estimate is 58% less than the estimate in 2006 and the declining linear trend during the past decade remains statistically significant (r^2 = 0.80, P< 0.001, Figure 2). However, the leveling since 2012 persists, and a piecewise polynomial curve indicates that the trend from 2012 to 2017 is not declining (Figure 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 2017).

Table 1. Estimated moose abundance, 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, 2005–2017.

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
2017	3,710	3,010 – 4,710	0.36	15	4	0.91

The January 2017 calf:cow ratio of 0.36 is low but similar to the 12-year average since 2005 (0.35, Table 1, Figure 4). Calves were 14.5% of the total 508 moose actually observed and represented 15% of the estimated population (Table 1, Figure 4). Twin calves were observed with 9 of the 217 (4%) cow moose (Table 1). Overall, survey results indicate calf survival to January 2017 is low, but it is typical compared to most years since the population decline began following the 2006 survey. Findings of an ongoing moose calf study also indicate similar survival rates (0.442−0.485) in early winter in 2015−16 and 2016−17 (Severud et al., unpublished data; Obermoller et al., unpublished data). Annual recruitment of calves can have a significant influence on population performance of moose, but it is not actually determined until the next spring's calving season when calves observed during winter become yearlings. One study documented average survival of calves from January to April (2005−2011) in northeastern Minnesota at 59% (39.6−78.4, 90% CL; Schrage et al., unpublished data). This spring a helicopter calf survey targeting adult GPS-collared females that were known to be pregnant during the spring 2016 calving season will shed additional light on annual calf survival (recruitment). 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). Consistent with the recent relative stability of the population trend, the annual survival rate of adult GPS-collared moose has changed little (85–88%) during the past 3 years (Carstensen et al. 2017, unpublished data), but it is slightly higher than the previous long-term (2002−2008) average of 81% (Lenarz et al. 2009).

The estimated bull:cow ratio (0.91, Table 1; Figure 5) is similar to the long-term mean of 0.98 during 2005–2016. 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.

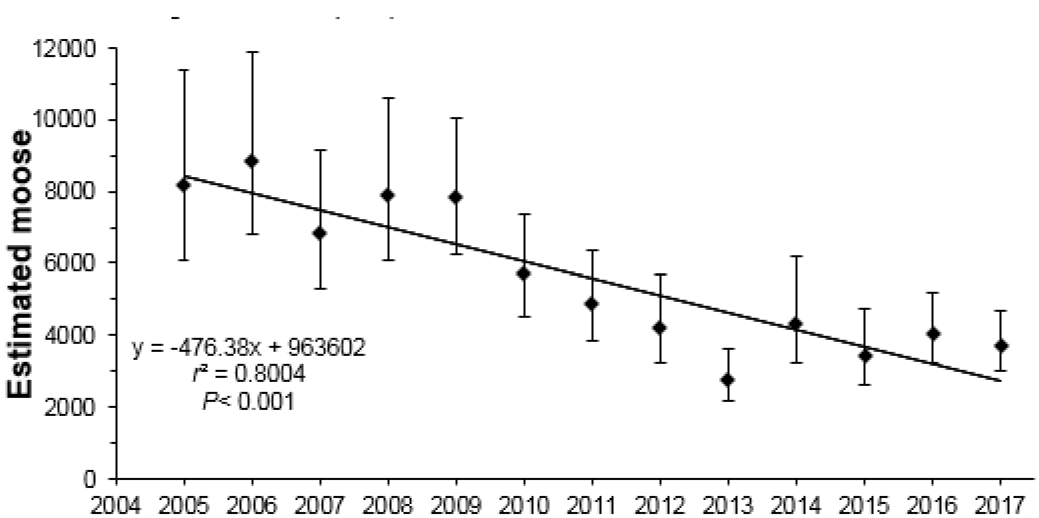


Figure 2. Point estimates, 90% confidence intervals, and a linear trend line of estimated moose abundance in northeastern Minnesota, 2005–2017. (Note: The 2005 survey was the first to be flown with helicopters and to include a sightability model and a uniform grid of east-west oriented rectangular 13.4-mi^2 plots).

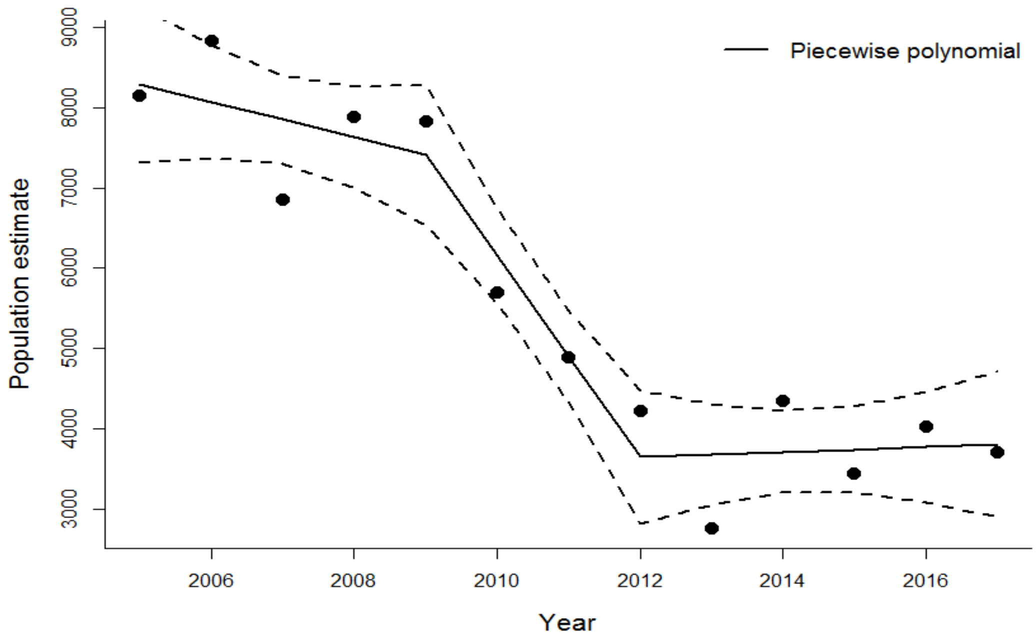


Figure 3. Point estimates, 90% confidence intervals, and a piecewise polynomial curve of moose abundance in northeastern Minnesota, 2005–2017. This curve shows a change in the short-term slope of the trend from 2012 to 2017 compared to 2009 to 2012.

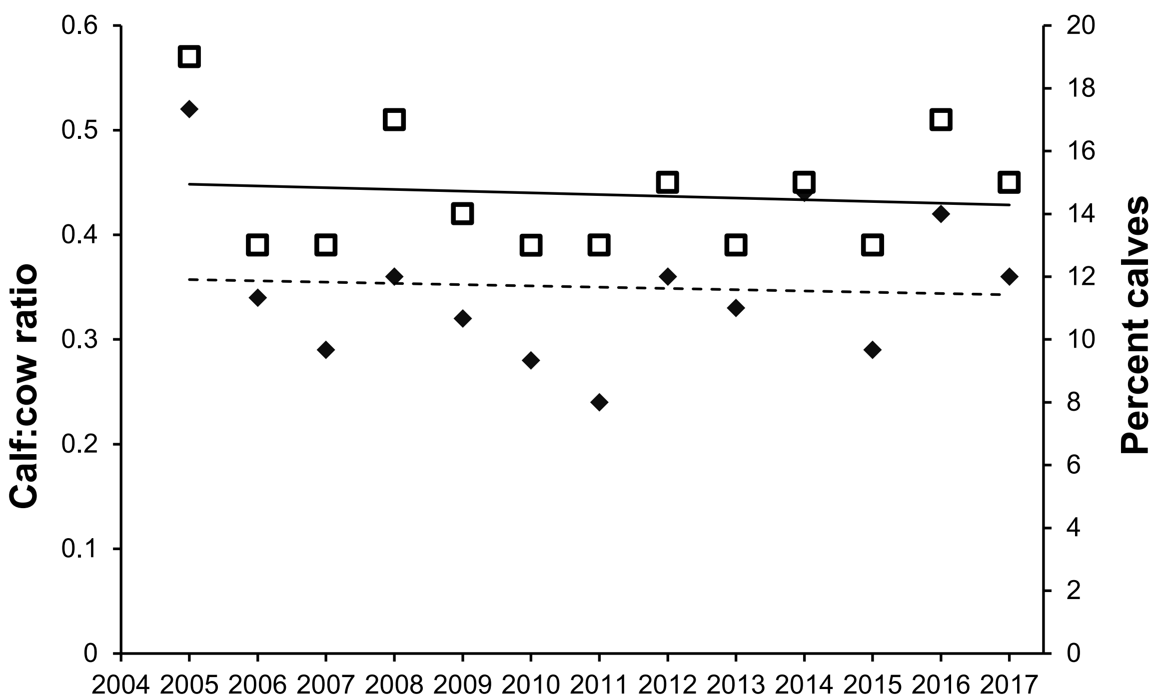


Figure 4. Estimated calf:cow ratios (solid diamonds, dashed trend line) and percent calves (open squares, solid trend line) of the population from aerial moose surveys in northeastern Minnesota, 2005–2017.

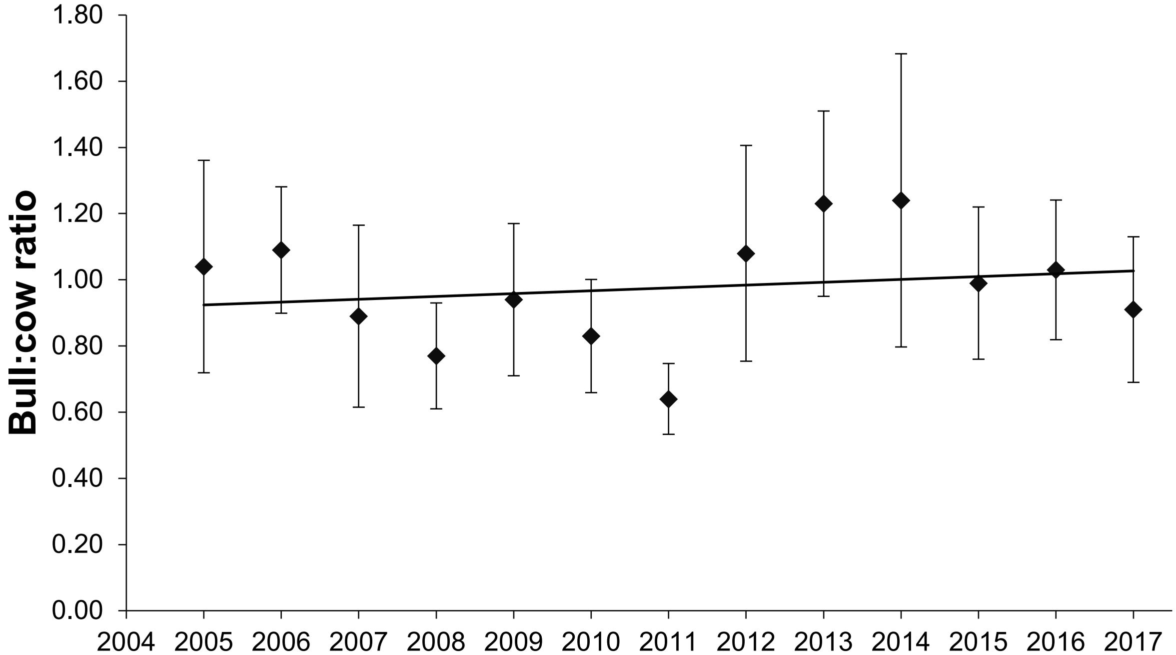


Figure 5. Estimated bull:cow ratios, 90% confidence intervals, and trend line from aerial moose surveys in northeastern Minnesota, 2005–2017.

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This survey is an excellent partnership between the Divisions of Enforcement and of Fish and Wildlife, the Fond du Lac Band of Lake Superior Chippewa, and the 1854 Treaty Authority. Specifically, thank you to Thomas Buker, Chief Pilot, for coordinating all of the aircraft and pilots; Tom Rusch for coordinating flights and survey crews; and Mike Schrage (Fond du Lac Band of Lake Superior Chippewa) and Andy Edwards (1854 Treaty Authority) for securing supplemental survey funding from their respective groups. Enforcement pilots Brad Maas and John Heineman skillfully piloted the aircraft during the surveys, and Tom Rusch, Andy Edwards, Mike Schrage, Nancy Hansen, and Jeremy Maslowski flew as observers. The consistent annual efforts of these teams contribute to the rigor of this survey and the comparability of long-term results, and are greatly appreciated. Thank you to John Giudice who continues to provide critical statistical consultation and analyses, and to Barry Sampson for creating the process to generate the GIS survey maps and GPS coordinates for the transect lines and for his work on re-stratification of the survey plots. We gratefully acknowledge Bob Wright, Brian Haroldson, and Chris Pouliot for creating the program, DNRSurvey. Bob also modifies the software as needed and each year provides refresher training for survey observers using DNRSurvey. The efforts of all of these people contribute to survey improvements. This report has been reviewed by Paul Telander, Lou Cornicelli, Mike Larson, Mike Schrage, and Andy Edwards. This project was funded in part by the Wildlife Restoration (Pittman-Robertson) Program.

LITERATURE CITED

Cochran, W. G. 1977. Sampling techniques. Third edition. Wiley and Sons, New York, USA.

DelGiudice, G. D. 2016. 2016 Aerial moose survey. Minnesota Department of Natural Resources, Section of Wildlife, unpublished report. St. Paul, Minnesota. 6pp.

Fieberg, J. 2012. Estimating population abundance using sightability models: R sightability model package. Journal of Statistical Software 51:1–20.

Gasaway, W. C., and S. D. DuBois. 1987. Estimating moose population parameters. Swedish Wildlife Research (Supplement) 1:603–617.

Giudice, J. H., J. R. Fieberg, M. S. Lenarz. 2012. Spending degrees of freedom in a poor economy: a case study of building a sightability model for moose in northeastern Minnesota. Journal of Wildlife Management 76:75–87.

Giudice, J. H. 2017. Analysis report: 2017 MNDNR aerial moose survey. Biometrics Unit, Section of Wildlife, Minnesota Department of Natural Resources, St. Paul.

Lenarz, M. S. 1998. Precision and bias of aerial moose surveys in northeastern Minnesota. Alces 34:117−124.

Lenarz, M. S., M. E. Nelson, M. W. Schrage, and A. J. Edwards. 2009. Temperature mediated moose survival in northeastern Minnesota. Journal of Wildlife Management 73:503–510.

Lenarz, M. S., J. Fieberg, M. W. Schrage, and A. J. Edwards. 2010. Living on the edge: viability of moose in northeastern Minnesota. Journal of Wildlife Management 74:1013–1023.

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

R Development Core Team. 2011, R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Version 2.13.1, ISBN 3-900051-07-0 http://www.r-project.org/.

Wright, R. G., B. S. Haroldson, and C. Pouliot. 2015. DNRSurvey – Moving map software for aerial surveys. http://www.dnr.state.mn.us/mis/gis/DNRSurvey/DNRSurvey.html

MINNESOTA WOLF POPULATION UPDATE 2017

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. Herein we provide an update of population status from the 2016-17 winter survey.

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 can also be an artifact of territory underestimation when there are comparatively sparse radiolocations. Hence, for packs with < 100 radiolocations (n=7; mean number of radiolocations = 32), we multiplied each estimated territory size by 1.37 as in the past. For packs with > 100 radiolocations (n = 30; mean number of radiolocations = 2,013), 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,

$$N = ((\text{km}^2 \text{ of occupied range/mean scaled territory size})\text{*mean pack size})/0.85.$$

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

A total of 39 packs were monitored during all or part of the survey period (April 2016 to April 2017). We obtained territory and winter pack size data from 30 radio-marked wolf packs (Figure 1). Seven additional wolf packs had adequate radiolocation data to delineate territories, but we were unable to obtain mid-winter pack counts, and we obtained pack counts on 2 packs for which there was insufficient data to delineate a territory.

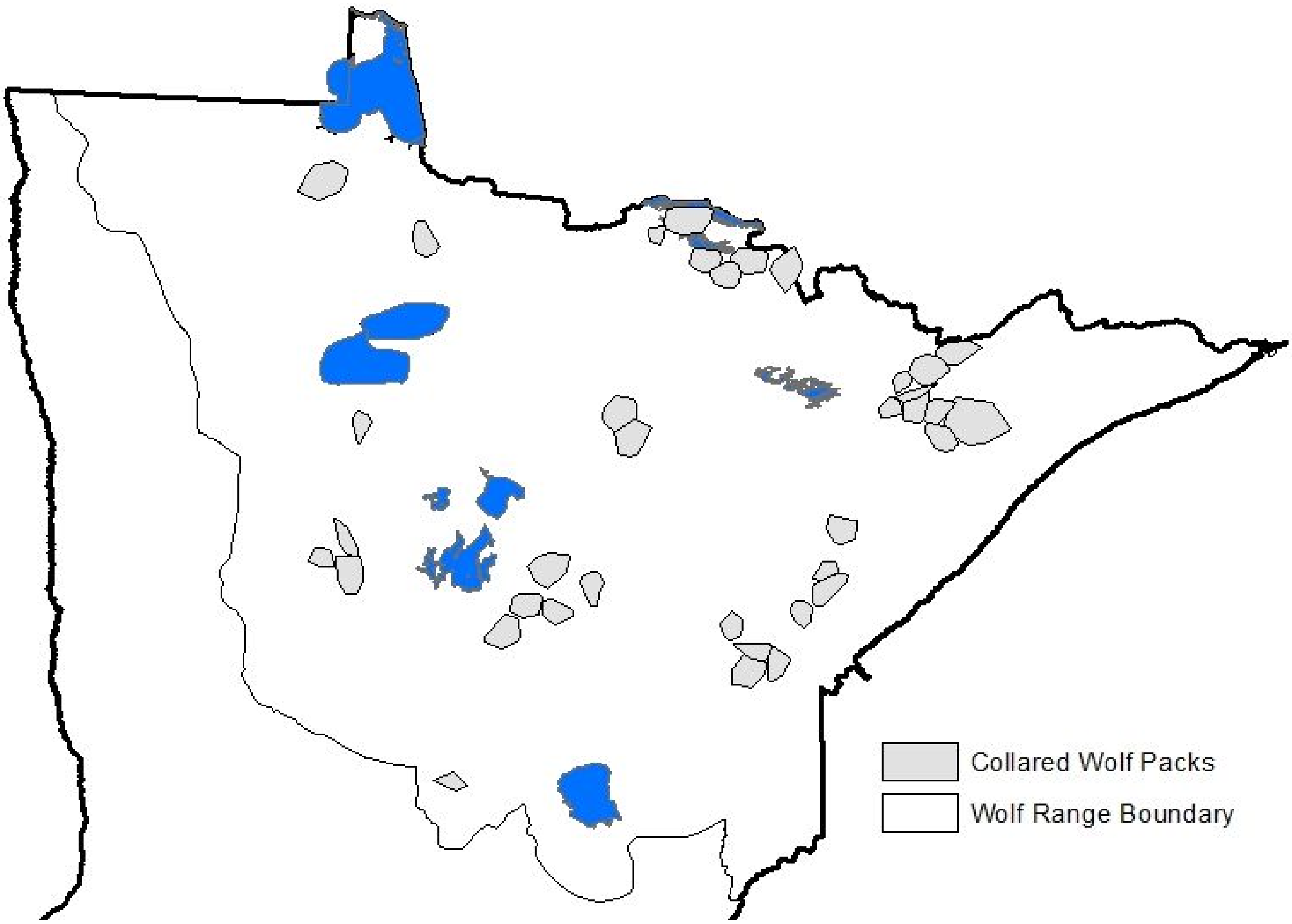

Figure 1. Location of radio-marked wolf packs during the 2016-17 survey.

Comparison of land cover type proportions within territories of collared packs with proportions throughout wolf range suggests that habitat within collared pack territories was representative of cover types throughout wolf range (Table 1; Chi-square $p = 0.7$; 8 df). Using spring 2016 deer density data (MNDNR, unpublished data) for deer hunting permit areas, weighted by number of radio-collared wolf packs in a permit area, we estimate an average of approximately 11 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, 2016 spring deer density for the entirety of occupied wolf range (weighted by permit area) in Minnesota was approximately 12 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	32.6	29.0
Deciduous Forest	23.6	25.3
Emergent Herbaceous Wetlands	9.9	7.0
Mixed Forest	7.2	8.8
Evergreen Forest	7.0	11.5
Open Water	5.4	8.1
Shrub/Scrub	4.5	6.1
Pasture/Hay/Grassland/Crops	7.7	2.5
Developed, All	2.2	1.7

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

The point estimate for average territory size this winter declined 14% from last winter and was the lowest since surveys began. However, with the exception of comparison to the 2014-15 estimate, average territory size this winter was not significantly different from estimates obtained after 1998 (Figure 2). After applying the territory scaling factors, average estimated territory size for radio-marked packs during the 2016-17 survey was 139 km^2 (range = 53 – 437 km^2).

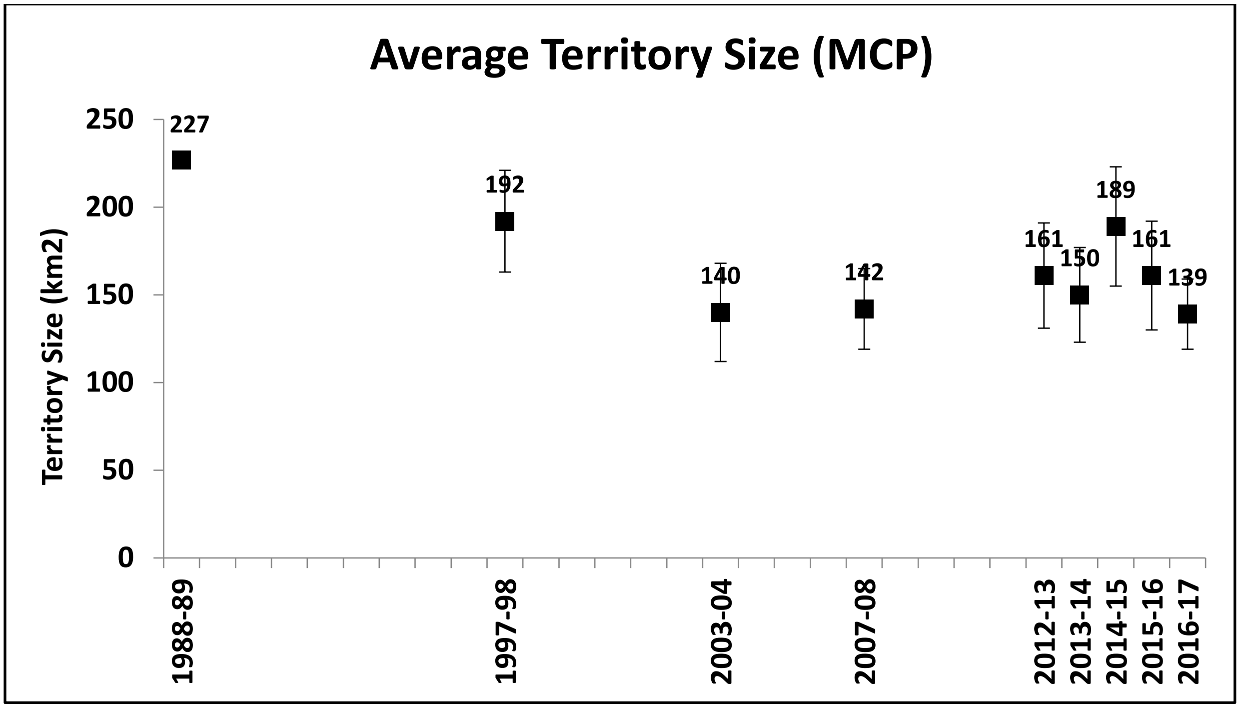

Figure 2. Average scaled territory size for radio-marked wolf packs in Minnesota from 1989 to 2017.

The point estimate for average winter pack size increased 9% from last winter, but the confidence interval widely overlaps those from the previous 5 surveys. Average winter pack size in 2016-17 was estimated to be 4.8 (range = 2 – 8, Figure 3).

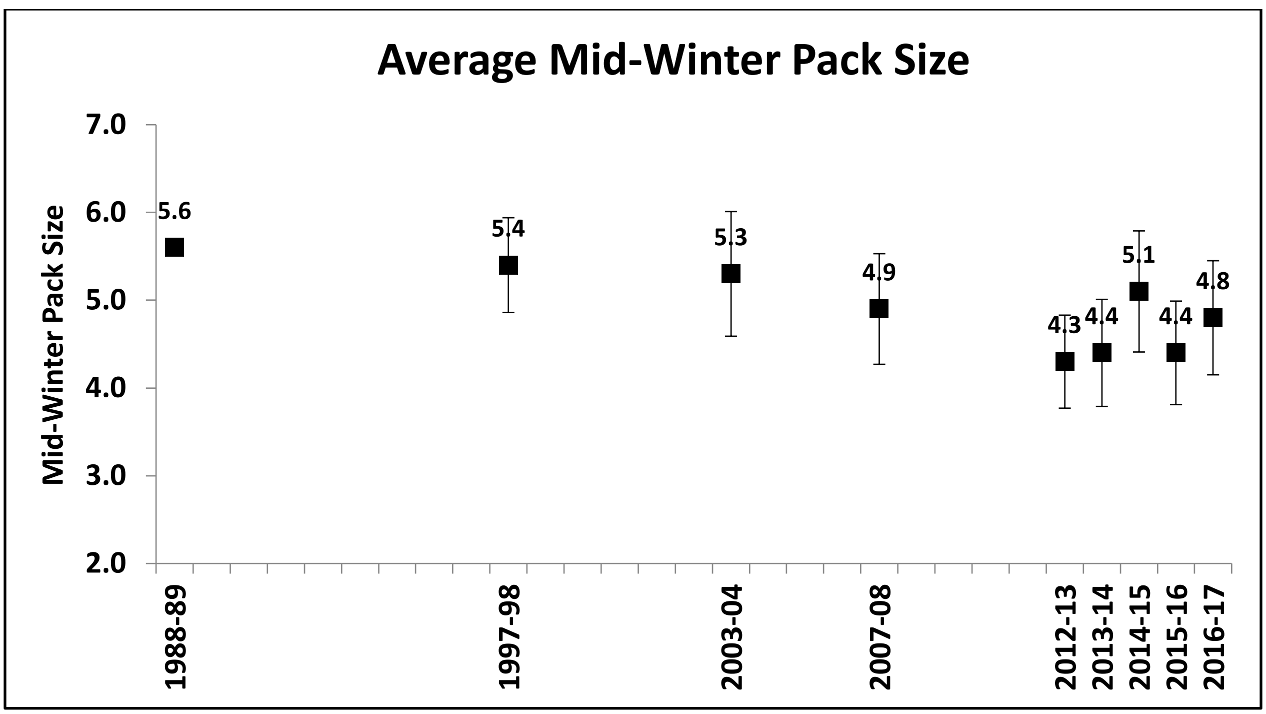

Figure 3. Average mid-winter pack size for radio-marked wolf packs in Minnesota from 1989 to 2017.

Wolf Numbers

Given an average territory size of approximately 139 km^2 and assuming occupied range has not changed since the 2012-13 survey (70,579 km^2; Erb and Sampson 2013), we estimated a total of 508 wolf packs in Minnesota during winter 2016-17. 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).

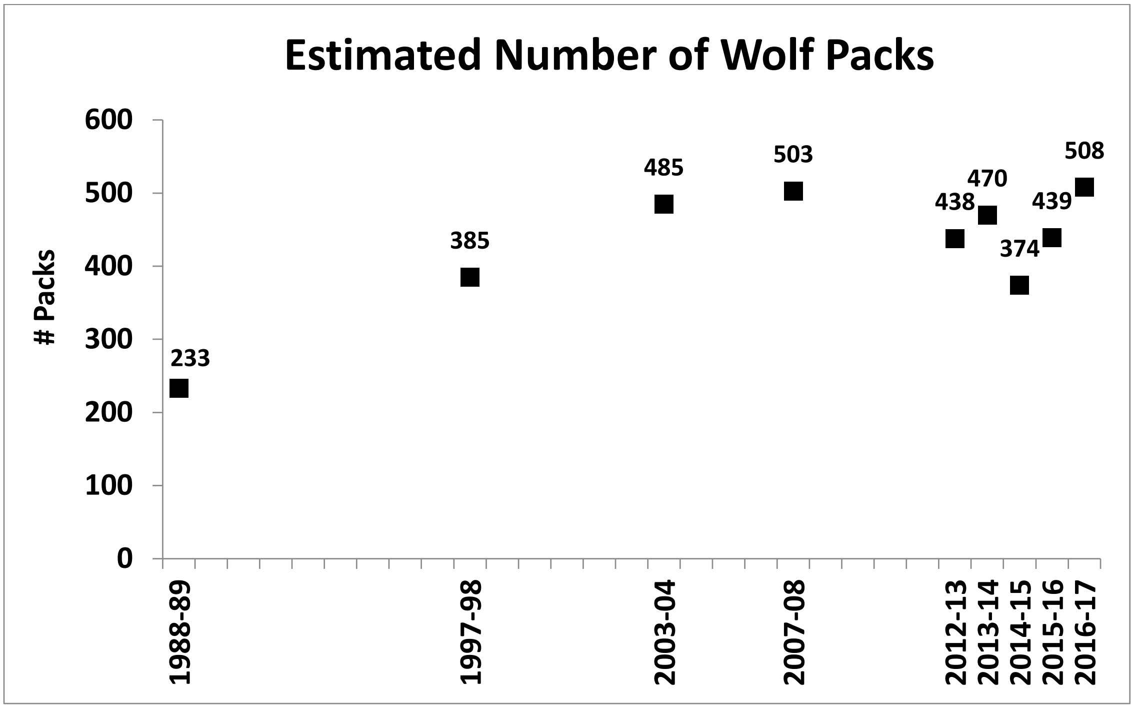

Figure 4. Estimated number of wolf packs in Minnesota at periodic intervals from 1989 to 2017

.After accounting for the assumed 15% lone wolves in the population, we estimated the 2016-17 mid-winter wolf population at 2,856 wolves, or 4.0 wolves per 100 km^2 of occupied range. The 90% confidence interval was approximately +/- 500 wolves, specifically 2,371 to 3,382. Comparison of point estimates from 2015-16 and 2016-17 suggests a 25% increase in the wolf population to levels similar to that estimated during the 2003 and 2007 surveys. Although there is some overlap with the 2015-16 confidence interval, a comparison of differences among the 2015-16 and 2016-17 bootstrap replicates results in 2016-17 population estimates being greater for 92% of the samples. We conclude that the 2016-17 statewide wolf population increased from the previous winter, consistent with expectations arising from a growing prey base over the past 2 years.

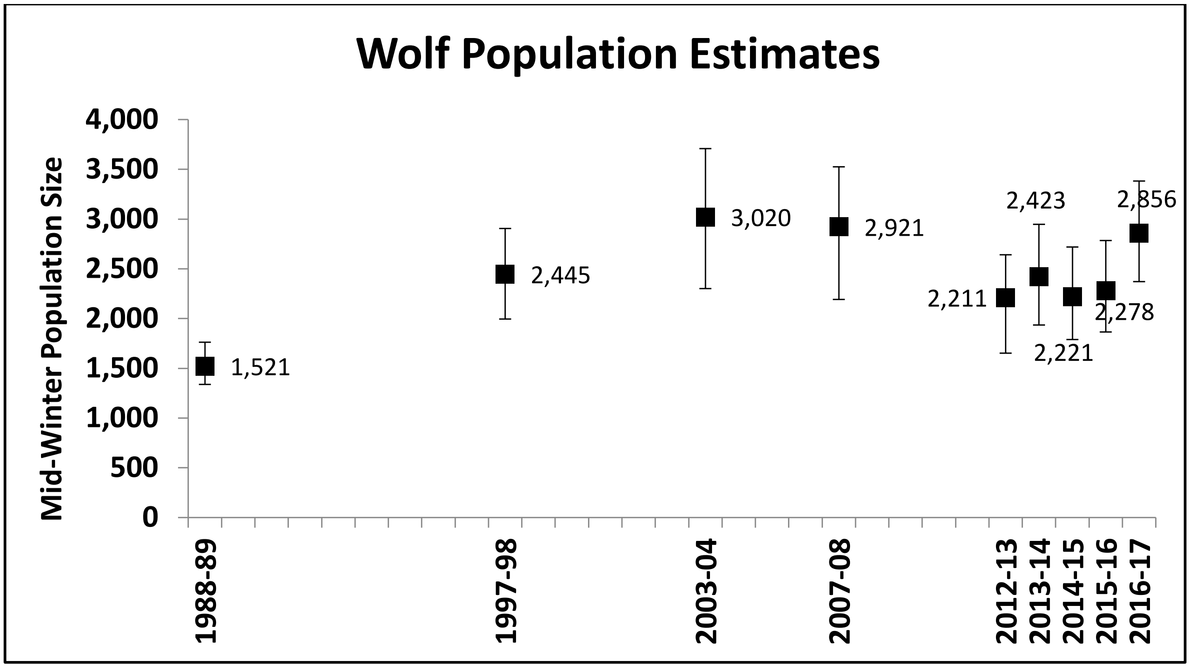

Figure 5. Wolf population estimates from periodic standardized surveys in Minnesota from 1989 to 2017.

From spring 2015 to spring 2016, deer density within wolf range is estimated to have increased approximately 22%, and the point estimate for mid-winter wolf density increased by approximately 25%. Over the past 5 years, wolf population estimates have been positively correlated with average deer density within wolf range (Figure 6).

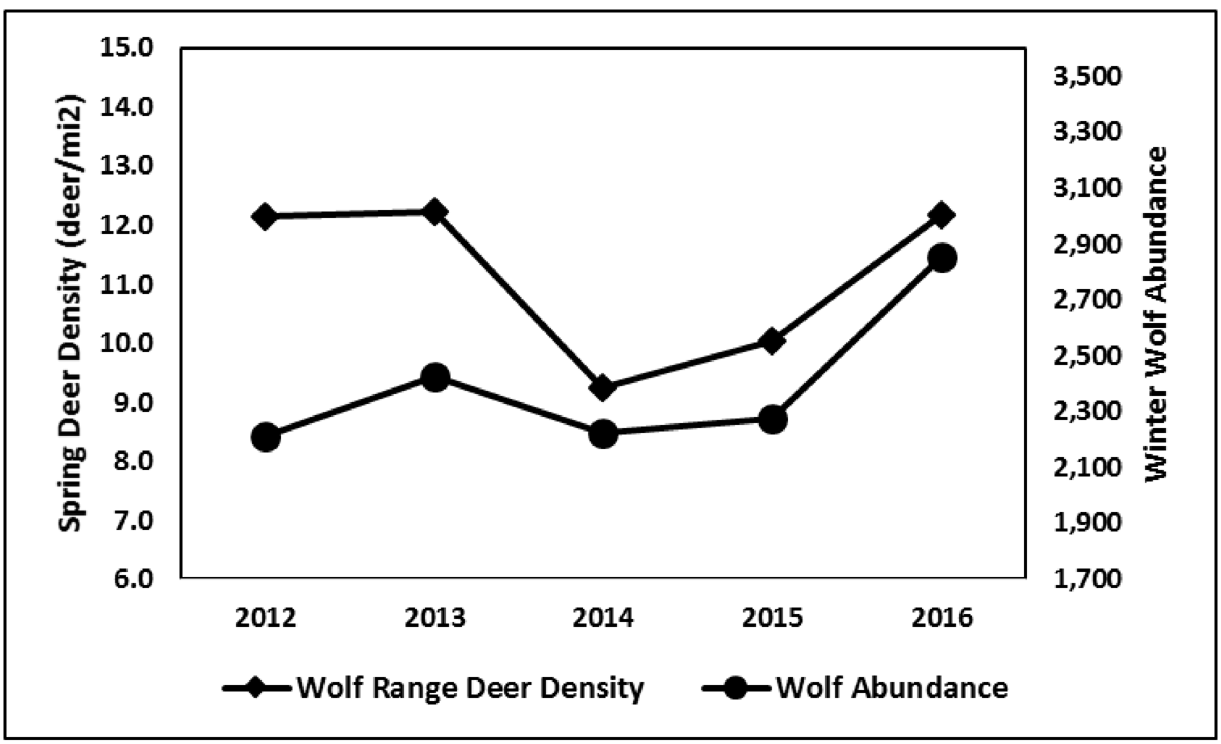

Figure 6. Comparison of estimated pre-fawn deer density and winter wolf abundance in Minnesota, 2012-2016.

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LITERATURE CITED

Erb, J., and M. DonCarlos. 2009. An overview of the legal history and population status of wolves in Minnesota. Pages 49-64 in A. P. Wydeven, T. R. Van Deelen , and E. J. Heske, editors. Recovery of gray wolves in the Great Lakes Region of the United States: an endangered species success story. Springer. New York, New York.

Erb, J., and B. Sampson. 2013. Distribution and abundance of wolves in Minnesota, 2012-13. Minnesota Department of Natural Resources, St. Paul.

Erb, J., C. Humpal, and B. Sampson. 2014. Minnesota wolf population update 2014. Minnesota Department of Natural Resources, St. Paul.

Fuller, T. K. 1989. Population dynamics of wolves in north-central Minnesota. Wildlife Monographs 105.

Fuller, T. K., W. E. Berg, G. L. Radde, M. S. Lenarz, and G. B. Joselyn. 1992. A history and current estimate of wolf distribution and numbers in Minnesota. Wildlife Society Bulletin 20:42-55.

Fuller, T. K., L. D. Mech, and J. F. Cochrane. 2003. Wolf population dynamics. Pages 161-191 *in* L. D. Mech and L. Boitani, editors. Wolves: behavior, ecology, and conservation. University of Chicago Press, Chicago, Illinois.

Manly, B. F. J. 1997. Randomization, bootstrap and Monte Carlo methods in biology. Chapman and Hall, London.

Minnesota Department of Natural Resources. 2001. Minnesota wolf management plan. Minnesota Department of Natural Resources, St. Paul.