FOREST WILDLIFE POPULATIONS

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2015 MINNESOTA SPRING GROUSE SURVEYS

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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 2015, ruffed grouse surveys were conducted between 14 April and 16 May, with one route run later. Mean ruffed grouse drums per stop (dps) were 1.1 statewide (95% confidence interval = 1.0–1.3) and did not change (-1%) from the previous year.

Sharp-tailed grouse surveys were conducted between 13 March and 8 May 2015, with 2,019 birds observed at 206 leks. The mean numbers of sharp-tailed grouse/lek were 5.3 (4.3-6.4) in the East Central (EC) survey region, 10.8 (9.9–11.9) in the Northwest (NW) region, and 9.8 (8.9–10.7) statewide. Comparisons between leks observed in consecutive years (2014 and 2015) were unchanged statewide ($t = 0.7$, $P = 0.4$) and in regional comparisons ($P > 0.05$).

INTRODUCTION

The ruffed grouse (*Bonasa umbellus*) is the most popular game bird in Minnesota, with an annual harvest averaging >500,000 birds (~150,000 -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 126 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 & DISCUSSION

Ruffed Grouse

Observers from 12 cooperating organizations surveyed routes between 14 April and 28 May 2015. Most routes (96%) were surveyed between 14 April and 9 May, with the median date (April 29) earlier than last year (May 10) and more similar to recent years (April 23 and 25 in 2010 and 2012, and May 1 and 3 in 2009 and 2011, respectively). Excellent (63%), Good (31%), and Fair (6%) survey conditions were reported for 117 routes reporting conditions.

Statewide counts of ruffed grouse drums averaged 1.1 dps (95% confidence interval = 1.0–1.3 dps) during 2015 (Figure 3). Drum counts were 1.3 (1.1–1.5) dps in the Northeast (n = 103 routes), 1.0 (0.4–1.7) dps in the Northwest (n = 8), 0.7 (0.4–1.0) dps in the Central Hardwoods (n = 15), and 0.4 (0.2–0.6) dps in the Southeast (n = 8) regions (Figure 4a-d).

Statewide drum counts were similar to last year (-1% change). Although counts increased statewide last year, the spring of 2014 was very cold and wet and likely had a negative impact on production last spring. We also had comparatively little snow last year for snow roosting, which may have influenced overwinter survival.

Sharp-tailed Grouse

A total of 2,019 male sharp-tailed grouse and grouse of unknown sex was counted at 206 leks (Table 1) during 13 March - 8 May 2015. More leks (14%) were observed in 2015 than during 2014, in part due to the filling of several DNR Wildlife staff vacancies and increased survey effort in the EC region this year. Leks with $\geq$2 grouse were observed an average of 1.9 times.

The statewide index value of 9.8 (8.9–10.7) was centrally located among values observed since 1980 (Figure 5). In the EC survey region, 208 grouse were counted on 39 leks, and 1,811 grouse were counted on 167 leks in the NW region. The index value (i.e., grouse/lek) was similar statewide and in both regions compared to 2014, and confidence intervals overlapped those from the last few years (Table 1). Counts at leks observed during both 2014 and 2015 were also similar ($t = 0.7$, $P = 0.4$) statewide and by region ($P > 0.05$; 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, although sharp-tailed grouse peaks can follow those of ruffed grouse by as much as 2 years. However, both grouse population indices did not change this year.

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, Leech Lake, Red Lake, and White Earth Reservations; 1854 Treaty Authority; Agassiz and Tamarac National Wildlife Refuges (U.S. Fish & Wildlife Service); Vermilion Community College; Cass County Land Department; 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. Clarinda Wilson and Sophia Crosby also assisted with sharp-tailed grouse surveys 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 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

[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	-1.0– 0.9	141	-0.3	-1.9– 1.3	102	-0.1	-1.1– 1.1	39

[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.

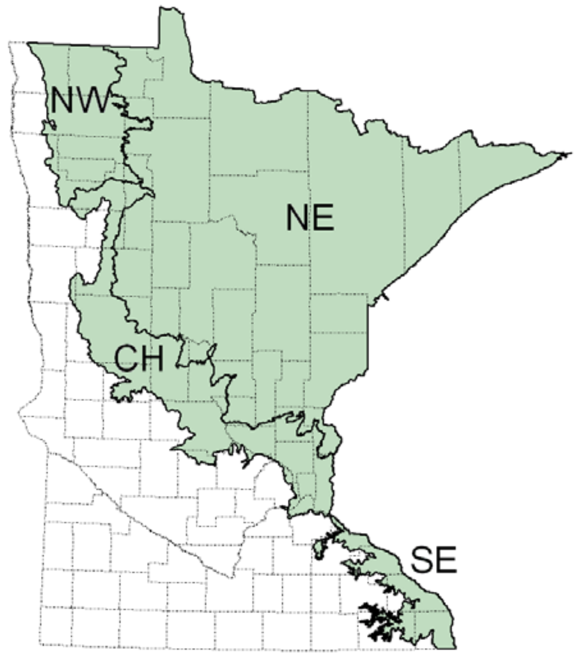


Figure 1. Survey regions for **ruffed grouse** in Minnesota. Northwest (NW), Northeast (NE), Central Hardwoods (CH), and Southeast (SE) survey regions are depicted relative to county boundaries (dashed lines) and influenced by the Ecological Classification System.

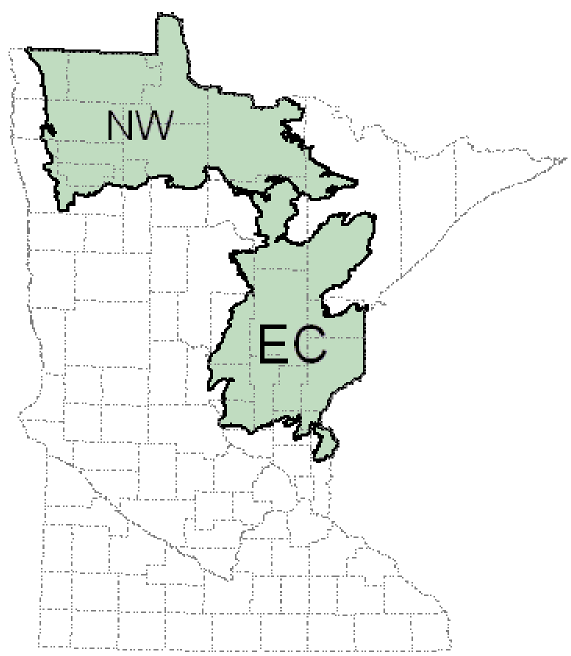


Figure 2. Survey regions for **sharp-tailed grouse** in Minnesota. Northwest (NW) and East Central (EC) survey regions are depicted relative to county boundaries (dashed lines) and influenced by Ecological Classification System Subsections boundaries.

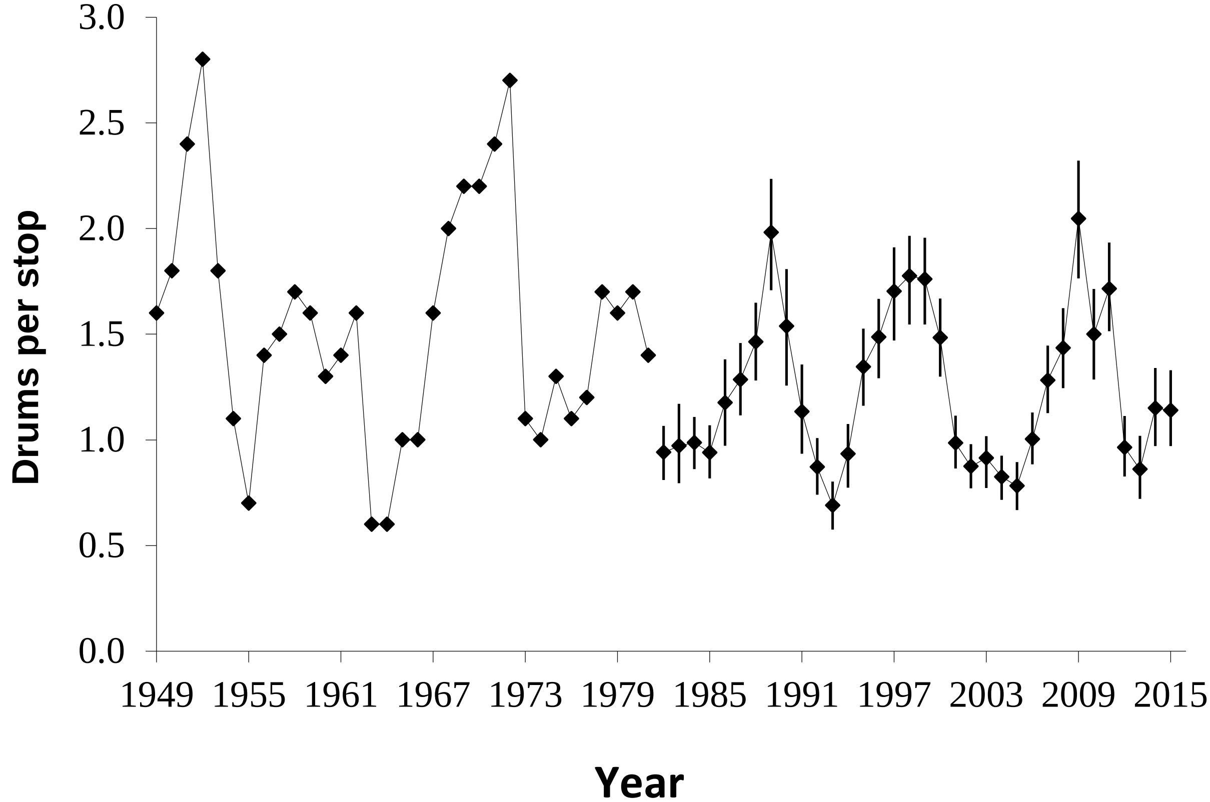
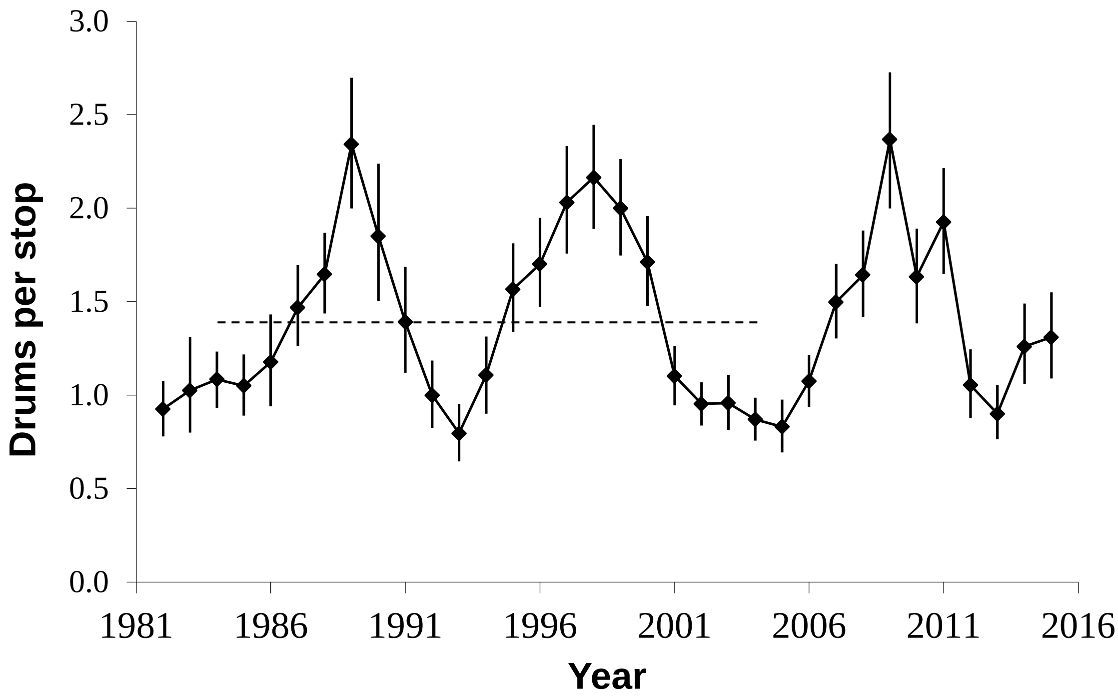
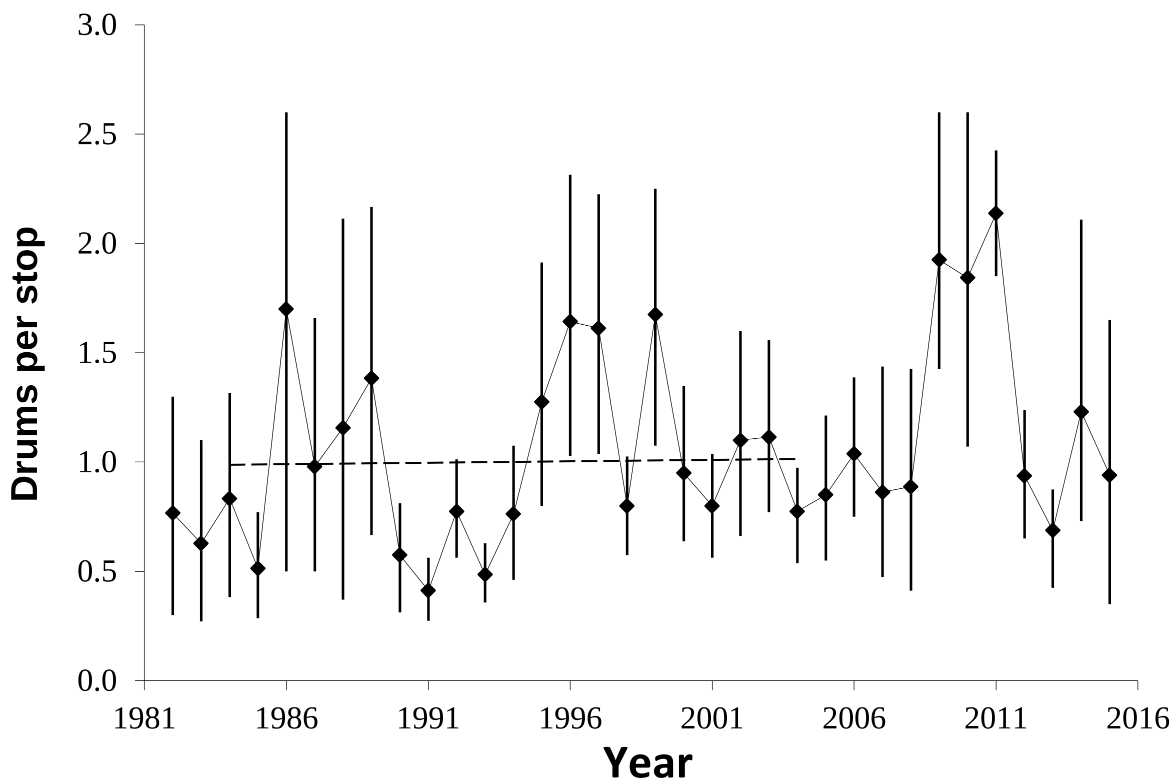


Figure 3. Statewide ruffed grouse population index values in Minnesota. Bootstrap (95%) confidence intervals (CI) are provided after 1981, but different analytical methods were used prior to this and thus CI are not available for earlier years. The difference between 1981 and 1982 is biological and not 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
2.5
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Drums per stop
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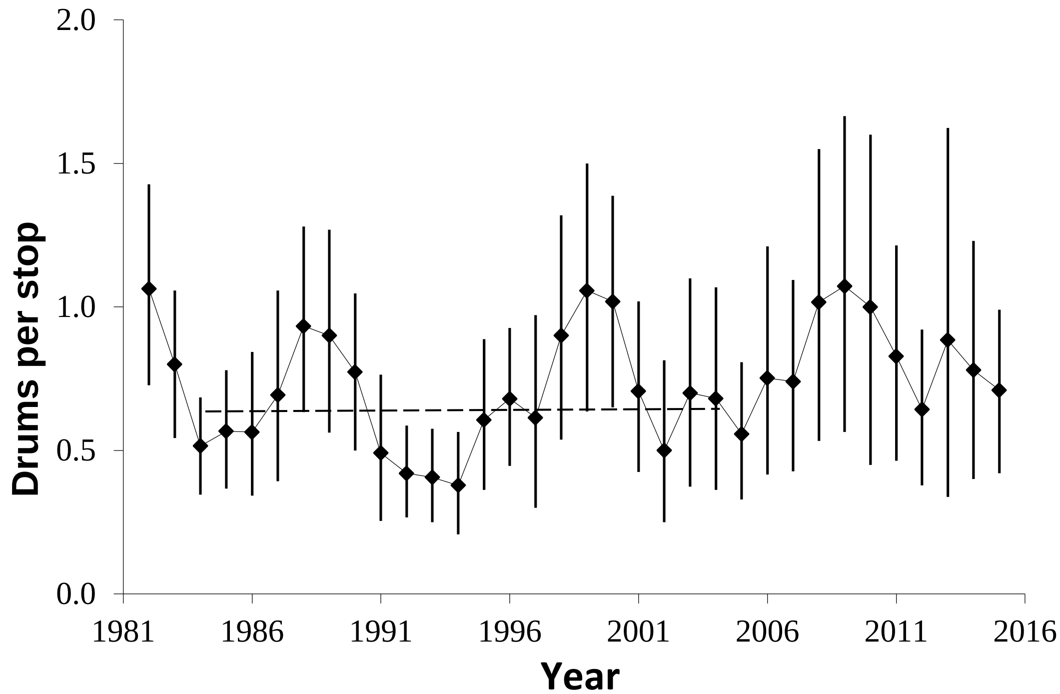
c



d.

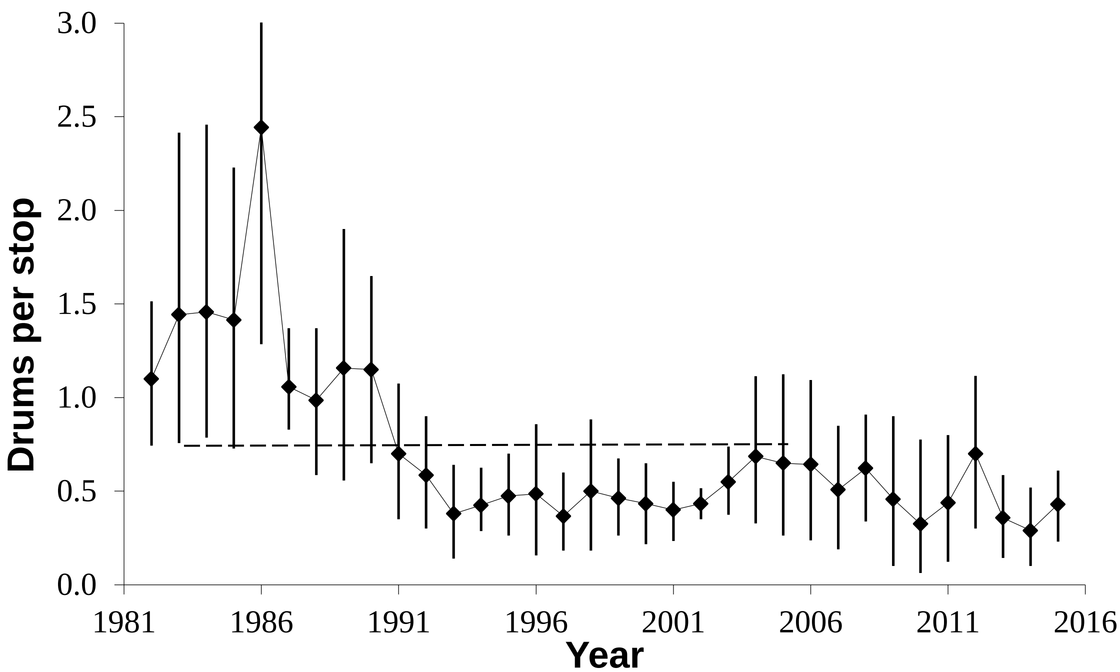


Figure 4a,b,c,d. Ruffed grouse population index values in the **Northeast** (a), **Northwest** (b), **Central Hardwoods** (c), and **Southeast** (d) survey regions of Minnesota. The mean for 1984-2004 is indicated by the dashed line. Bootstrap (95%) confidence intervals are provided for each mean. In the bottom panel, the CI for 1986 extends beyond area depicted in the figure.

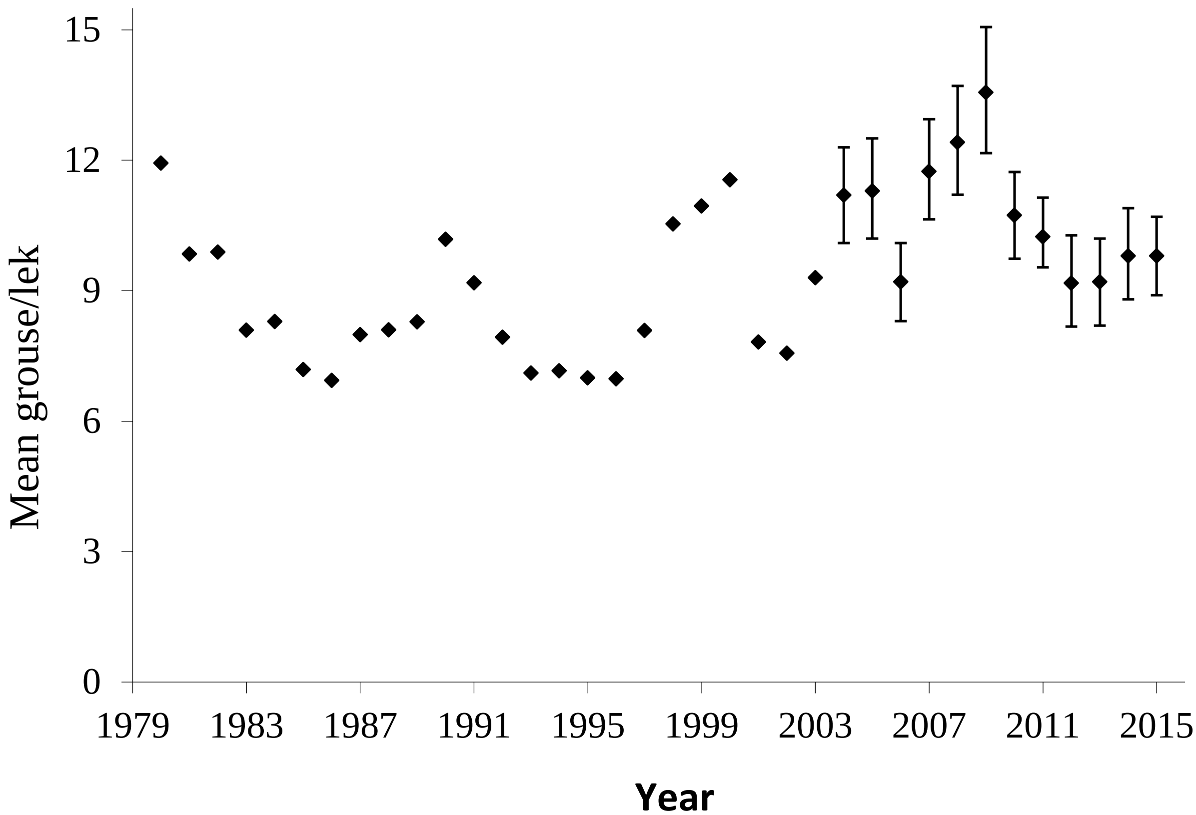


Figure 5. **Sharp-tailed grouse** counted in spring lek surveys statewide during 1980–2015. Bootstrap (95%) confidence intervals are provided for recent years. Annual means are not connected by lines because the same leks were not surveyed every year.

2015 MINNESOTA PRAIRIE-CHICKEN SURVEY

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SUMMARY OF FINDINGS

Greater prairie-chickens (*Tympanuchus cupido pinnatus*) were surveyed in all 17 survey blocks during the spring of 2015. Observers located 137 booming grounds and counted 1,383 male prairie-chickens and 51 birds of unknown sex. Estimated densities of 0.10 (0.07–0.12) booming grounds/km^2 and 9.8 (8.4–11.2) 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).

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 continued to be lost from the landscape, prairie-chicken populations began to decline, their range contracted, and hunting 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 mid-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 block data 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 18 March and 21 May 2015. Observers located 137 booming grounds and observed 1,383 male prairie-chickens and 51 birds of unknown sex within and outside survey blocks (Table 1). These counts represent a minimum number of prairie-chickens in Minnesota during 2015, 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 2015. Lek and bird counts are not comparable among permit areas or years.

Permit Area	Area (km^2)	Leks	Males	Unk[a]
803A	1,411	16	147	0
804A	435	0	0	0
805A	267	20	214	0
806A	747	9	70	0
807A	440	16	142	0
808A	417	21	277	0
809A	744	13	159	0
810A	505	8	110	0
811A	706	11	86	19
812A	914	5	33	6
813A	925	5	58	17
PA subtotal	7,511	124	1,296	42
Outside PAs[b]	NA[c]	13	87	9
Grand total	NA[c]	137	1,383	51

[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, 724 males and birds of unknown sex were counted on 68 booming grounds during 2015 (Table 2). Each lek was observed an average of 2.1 times (median = 2), with 41% of booming grounds observed just once. Densities of prairie-chickens in the 10 core survey blocks were 0.12 (0.08–0.15) booming grounds/km^2 and 10.9 (9.1–12.7) males/booming ground (Table 2, Figure 2). In the 7 peripheral survey blocks, densities were 0.07 (0.06–0.08) booming grounds/km^2 and 7.8 (5.9–9.6) males/booming ground.

The density of 0.10 (0.07–0.12) booming grounds/km^2 in all survey blocks during 2015 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 9.8 (8.4–11.2) males/booming ground in all survey blocks during 2015 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). 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 are similar among years, then this index can be used to monitor changes in abundance among years.

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

			2015		Change from 2014[a]	
Range[b]	Survey Block	Area (km^2)	Booming grounds	Males[c]	Booming grounds	Males[c]
Core	Polk 1	41.2	9	87	3	38
	Polk 2	42.0	5	84	-1	-13
	Norman 1	42.0	1	12	0	-1
	Norman 2	42.2	4	53	2	20
	Norman 3	41.0	6	58	-3	9
	Clay 1	46.0	8	77	2	4
	Clay 2	41.0	2	52	0	9
	Clay 3	42.0	5	57	0	6
	Clay 4	39.0	3	22	0	-5
	Wilkin 1	40.0	5	67	1	20
	Core subtotal	415.0	48	569	4	87
Periphery	Mahnomen	41.7	4	29	1	-8
	Becker 1	41.4	2	22	-8	-36
	Becker 2	41.7	3	26	-1	-7
	Wilkin 2	41.7	3	18	1	-2
	Wilkin 3	42.0	3	27	0	2
	Otter Tail 1	41.0	2	14	0	0
	Otter Tail 2	40.7	3	19	NA[d]	NA[d]
	Periphery subtotal	290.6	20[e]	155[e]	-7[e]	-51[e]
Grand total		705.5	68[e]	724[e]	-3[e]	36[e]

[a] The 2014 count was subtracted from the 2015 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.
[d] Surveys were not conducted in this block during 2014.
[e] These totals only reflect blocks for which count data were available.

ACKNOWLEDGMENTS

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, and Michael Oehler; cooperators with The Nature Conservancy included Brian Winter, Travis Issendorf, and volunteers Pat Beauzay, Rick Julian, Dennis Thielen, Matt Mecklenburg, Tyler Larson, Bob O'Connor, and Tony Nelson; cooperators with the US Fish and Wildlife Service included Maria Fosado, Shawn Papon, Chad Raitz, Larry Hanson; and numerous additional volunteers participated including Steve Bommersbach, Dan Svedarsky, Doug Wells, Terry Wolfe, Jill Fejszes, Kris Spaeth, Tom Kucera, and Doug Hedtke. This year, Clarinda Wilson and Sophia Crosby also assisted with surveys. 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.

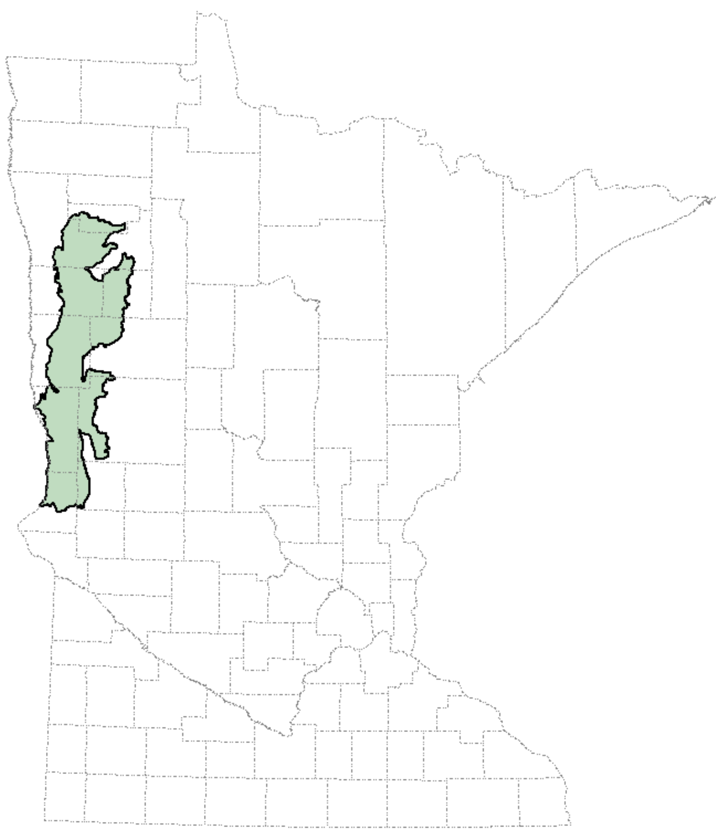

Figure 1. Primary greater prairie-chicken range in Minnesota (shaded area) relative to county boundaries. The range boundary was based on Ecological Classification System Land Type Associations and excludes some areas known to be occupied by prairie-chickens.

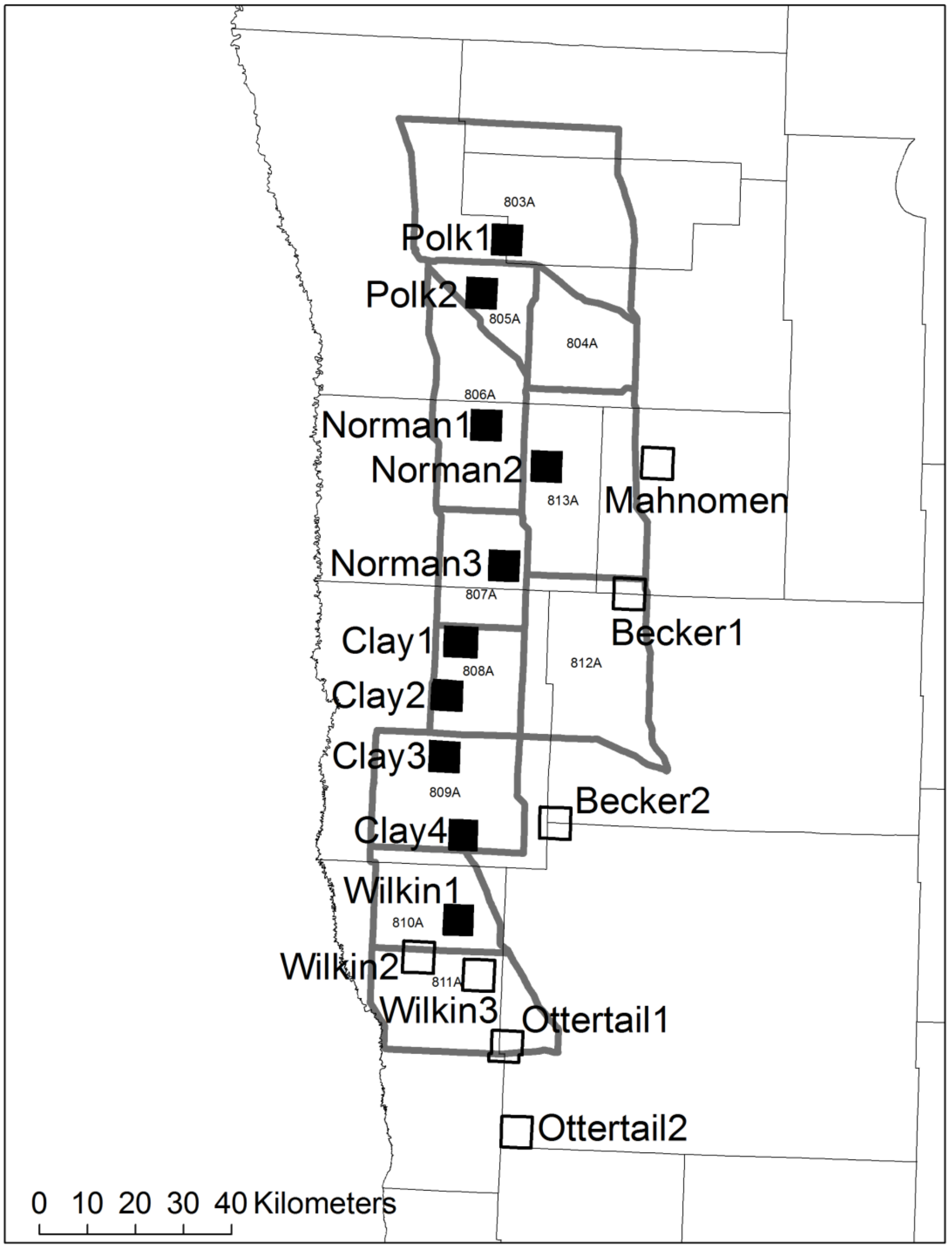

Figure 2. Prairie-chicken lek survey blocks (41 km^2, labeled squares) and hunting permit areas (thick grey lines) in western Minnesota. Survey blocks were either in the core (black) or periphery (white) of the range with a threshold of 1.0 male/km^2 in 2010, and were named after their respective counties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

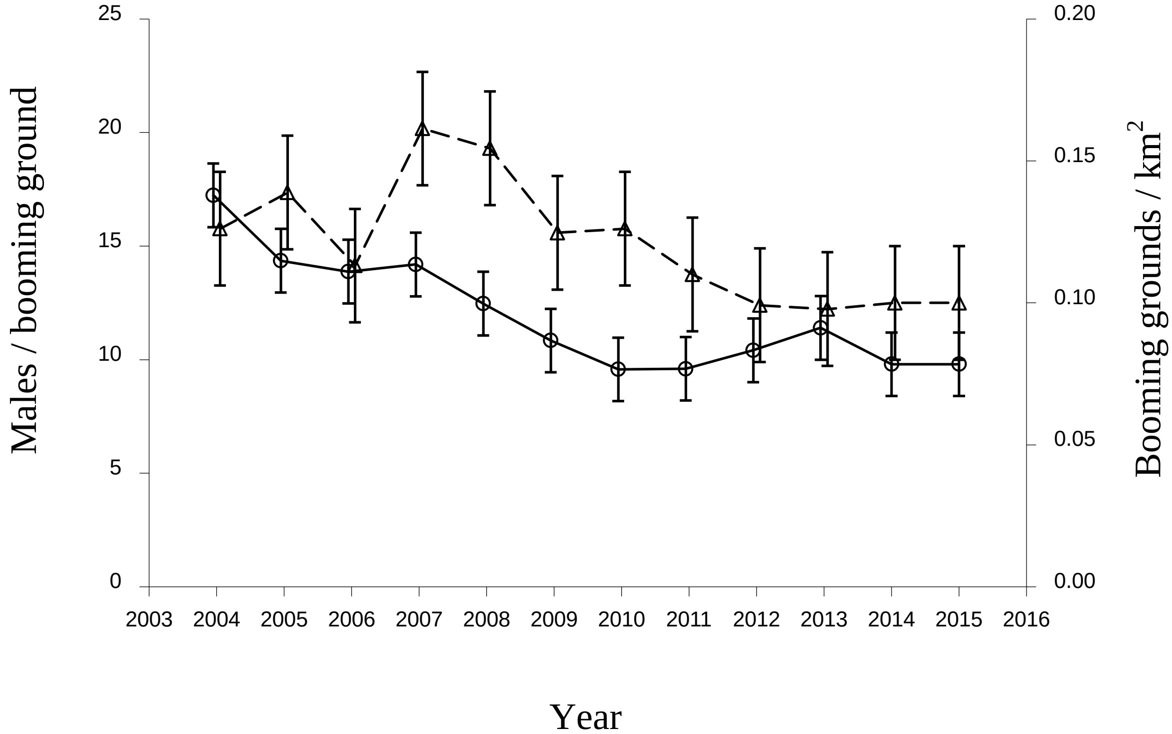

Figure 3. Mean prairie-chicken males/booming ground (circles connected by solid line) and booming grounds/km^2 (triangles connected by dashed line) in survey blocks in Minnesota with 95% confidence intervals.

2015 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, calf:cow and bull:cow ratios. We use these data to determine and assess the population's long-term trend and composition, set the harvest quota for the subsequent hunting season when applicable, improve our understanding of moose ecology, and otherwise contribute to sound future management strategies.

METHODS

The survey area is approximately 5,985 mi^2 (Lenarz 1998, Giudice et al. 2012). We estimated moose numbers, age and sex ratios by flying transects within a stratified random sample of the 436 total survey plots (Figure 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 harvested moose in past years, and extensive field experience of moose managers and researchers. The most recent re-stratification was conducted in November 2013; survey plots were classified as low, medium, or high based on whether < 2, 3-7, or $\geq$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 4^{th} stratum represented by a series of 9 plots which have undergone disturbance by wildfire, prescribed burning, and 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.

All survey plots of the 436-plot grid (designed in 2005) are rectangular (5 x 2.67 mi.) and oriented east to west with 8 transects spaced about 0.3 miles apart. Minnesota Department of Natural Resources (MNDNR) Enforcement pilots flew the 2 Bell Jet Ranger (OH-58) helicopters used to conduct the survey. We sexed moose using the presence of antlers or the presence of a vulval patch (Mitchell 1970), nose coloration, bell size and shape, and identified calves on the basis of size and behavior. We used the program DNRSurvey on Toughbook® tablet style computers to record survey data. DNRSurvey allowed us to display transect lines superimposed on a background of aerial photography, observe each aircraft's flight path over this background in *real time*, and record data using a tablet pen with a menu-driven data entry form. Two of the primary strengths of this survey are the consistency and standardization of the methods since 2005 and the long-term consistency of the survey team personnel.

We accounted for visibility bias by using a sightability model (Giudice et al. 2012). This model was developed between 2004 and 2007 using 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 defined VO as the proportion of vegetation within a circle (30'-radius or roughly 4 moose lengths) that would prevent you from seeing a moose when circling that spot from an oblique angle. If we observed more than 1 moose 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).

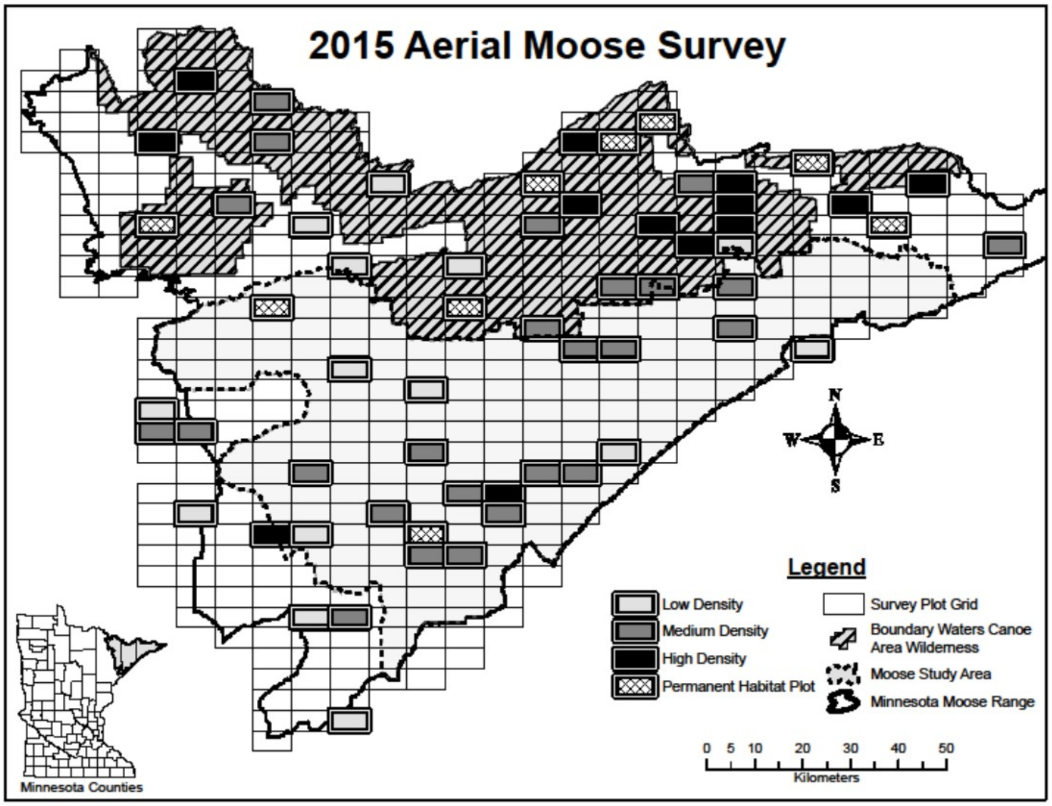

Figure 1. Moose survey area and 52 sample plots flown in the 2015 aerial moose survey. The study area for ongoing MNDNR moose research also is shown.

RESULTS AND DISCUSSION

The survey was conducted from 13 to 29 January 2015. It consisted of 8 actual survey days, and as in 2014, included 52 survey plots. This year, based on optimal allocation analyses, we surveyed 11 low, 22 medium, and 10 high density plots, and the 9 permanent plots (Giudice 2015). Generally, 8" of snow cover is our minimum threshold depth for conducting the survey. Snow depths were marginal on 6% of the survey plots, but 8-16" and greater than 16" on 92% and 2% of the plots, respectively. Overall, survey conditions were good for 86% and fair for 14% of the plots when surveyed. Average survey intensity was 47 minutes/plot (13.4 mi^2) and ranged from 30 to 65 minutes/plot (Giudice 2015).

This year a total of 392 moose were observed on 34 (65%) of the 52 plots surveyed (694 mi^2), not markedly dissimilar from last year (419 moose on 41 plots), and included 162 bulls, 169 cows, 56 calves, and 5 unclassified moose. This apparent occupancy of plots is lower than the 10-year average of 82%. An average of 11.5 moose were observed per "occupied" plot (range = 1-46 moose) compared to a 10-year average of 12.2 moose. Estimates of the calf:cow and bull:cow ratios were 0.29 and 0.99, respectively. This calf:cow ratio is one of the lowest since 2005 (Table 1).

After adjusting for sampling and sightability, we estimated the population in northeastern Minnesota at 3,450 (2,610–4,770, 90% confidence interval) moose (Table 1, Fig. 2). As can be noted from the 90% confidence limits associated with the population point estimates (Table 1,Figure 2), 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) on their movements, and (5) interaction of these factors. Short-term, year-to-year statistical comparisons of population estimates are not supported by these surveys, rather they 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 2013). This downward trend persists (r^2= 0.821, P = 0.001, Figure 2), and the 2015 population estimate of 3,450 indicates a 61% decline since 2006; however, the population estimate is not statistically different from last year.

Table 1. Estimated moose numbers, 90% confidence intervals, and calf:cow ratios, percent calves in the population, percent cows with twins, and bull:cow ratios estimated from aerial surveys in northeastern Minnesota, 2005-2015.

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

Based on the survey's recorded calf:cow ratio (0.29), estimated calf recruitment in spring of 2015 could be one of the lowest in several years (Table 1, Fig. 3). The calf:cow ratio in mid- January 2015 was 0.29, down markedly compared to last year's survey (0.44) and 17% below the 10- year average of 0.35. Calves were 14% of the total 392 moose actually observed and represented 13% of the estimated population (Table 1, Fig. 3). The sighting of twins with cows, 3% of the 169 cow moose observed, has not been uncommon since 2005 (Table 1). Survey results indicate calf survival to late January 2015 was low. Findings from an ongoing study of GPS-collared moose calves indicate that calf survival was low in 2013-14 and likely in 2014-15 (Severud et al. 2014). 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 winter survey-observed calves become yearlings. At this point, 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). For the past year annual mortality of adult moose has been lower (11% vs. 20%; Carstensen et al., unpublished data).

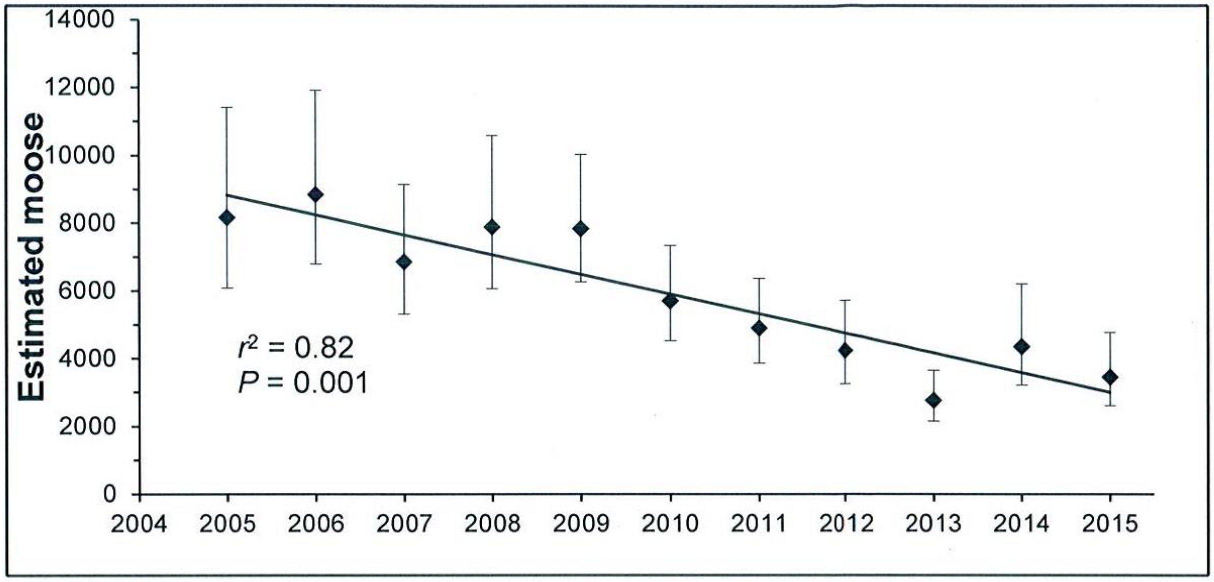

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2015. (Note: The 2005 survey was the first to be flown with helicopters and to include a sightability model and a uniform grid of east-west oriented rectangular 13.4-mi^2 plots).

The estimated bull:cow ratio (Table 1; Figure 4) exhibits an apparent decrease compared to 2013 and 2014, but is similar to the mean of 2005-2015 (0.98). There is a great deal of annual variability associated with the bull:cow ratios, consequently, they exhibited no clear upward or downward long-term trend (2005-2015).

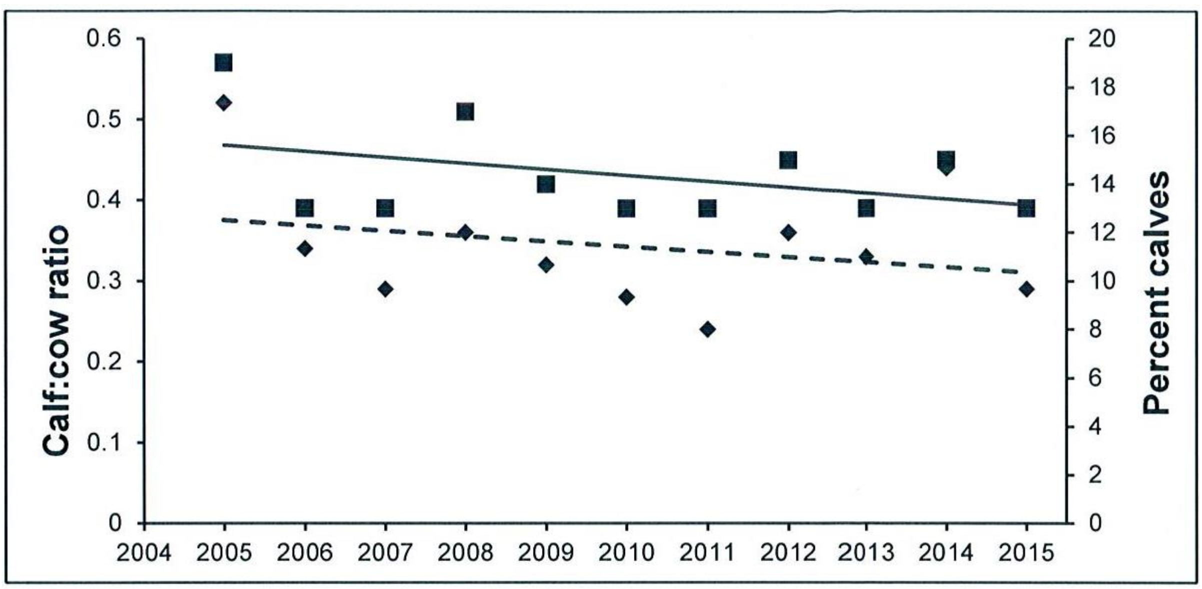

Figure 3. Estimated calf:cow ratios (solid diamonds, dashed trend line) and percent calves (solid squares, solid trend line) of the population from aerial moose surveys in northeastern Minnesota, 2005-2015.

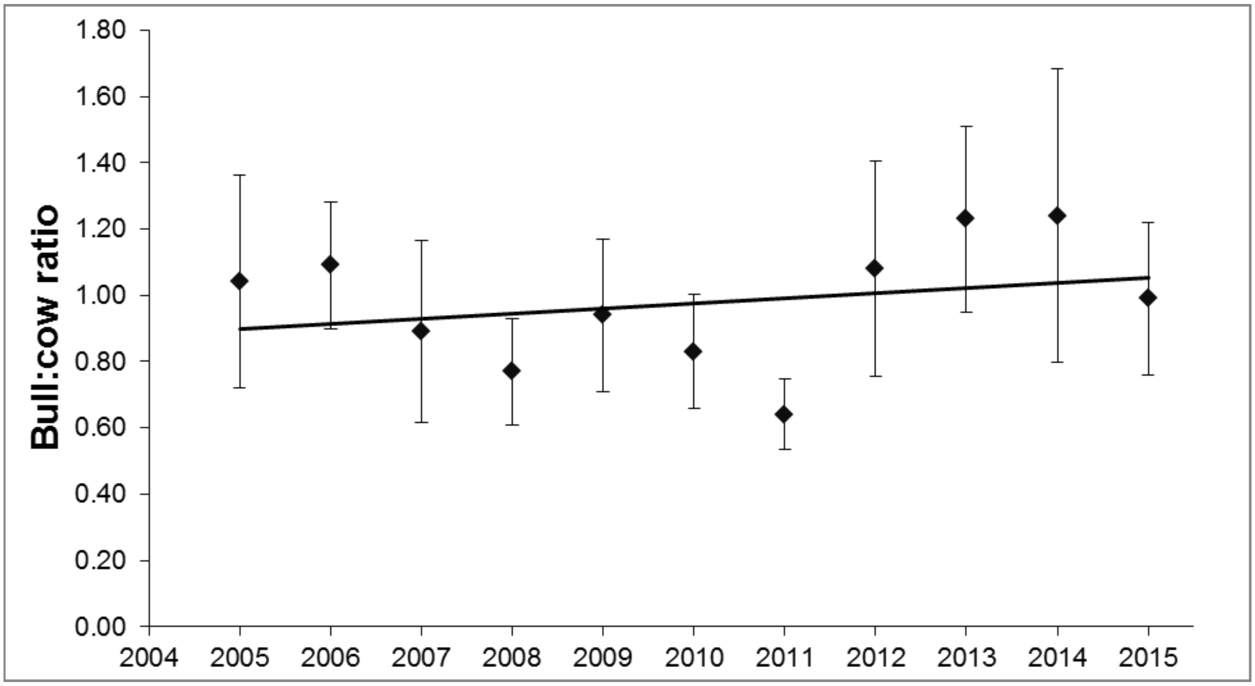

Figure 4. Estimated bull:cow ratios, 90% confidence intervals, and trend line from aerial moose surveys in northeastern Minnesota, 2005-2015.

ACKNOWLEDGMENTS

This survey is an excellent partnership between the Division of Enforcement, the Division of Fish and Wildlife, the Fond du Lac Band of Lake Superior Chippewa and the 1854 Treaty Authority. In particular, I would like to thank 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, Jessica VanDuyn, Bailey Petersen, and Chris Balzer 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 gratefully 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 project was funded in part by the Wildlife Restoration (Pittman-Robertson) Program.

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REGISTERED FURBEARER POPULATION MODELING 2015 REPORT

Drawing by Gilbert Proulx

John Erb, Forest Wildlife Populations and Research Group

INTRODUCTION

For populations of secretive carnivores, obtaining field-based estimates of population size remains a challenging task (Hochachka et al. 2000; Wilson and Delehay 2001; Conn et al. 2004). This is particularly true when one is interested in annual estimates, multiple species, or large areas. Nevertheless, population estimates are desirable to assist in making management or harvest decisions. Population modeling is a valuable tool for synthesizing our knowledge of population demography, predicting outcomes of management decisions, and approximating population size.

In the late 1970s, Minnesota developed population models for 4 species of carnivores (fisher, marten, bobcat, and otter) to help 'estimate' population size and track population changes. All are deterministic accounting models that do not currently incorporate density-dependence. However, annual adjustments to demographic inputs are often made for bobcats, fishers, and martens in response to the known or assumed influence of factors such as prey fluctuations, winter conditions, or competitor/predator density. Modeling projections are interpreted in conjunction with harvest data and results from any annual field-based track surveys.

METHODS

Primary model inputs include the estimated 1977 'starting' population size, estimates of age-specific survival and reproduction, and sex- and age-specific harvest data. Reproductive inputs were originally based largely on carcass data collected in the early 1980s. However, reproductive data for fishers and martens has been collected over the past 8 years from a telemetry study, and for bobcats, additional carcass data was collected in 1992 and from 2003-present. Initial and subsequent survival inputs were based on a review of published estimates in the literature, updated for fishers and martens based on recent Minnesota research, and are periodically adjusted based on presumed relationships as noted above. In some cases, parameter adjustments for previous years are delayed until additional data on prey abundance trends is available. Hence, population estimates reported in previous reports may not always match those reported in current reports.

Harvest data is obtained through mandatory furbearer registration. A detailed summary of 2014 harvest information is available in a separate report. Bobcat, marten, and fisher age data is obtained via x-ray examination of pulp cavity width or microscopic counts of cementum annuli from teeth of harvested animals. Although the population models only utilize data for the 3 age-classes (juvenile, yearling, adult), cementum annuli counts have periodically been collected for all non-juveniles either to examine age-specific reproductive output (bobcats) or to obtain periodic information on year-class distribution for selected species. The data will also be used for deriving independent estimates of abundance using statistical population reconstruction (e.g., Skalski et al. 2012). In years where age data is not obtained for a given species, harvest age proportions are approximated using averages computed from the most recent period when data was collected.

For comparison to model projections, field-based track survey indices are presented in this report as running 3-year (t-1, t, t+1) averages of the observed track index, with the most recent year's average computed as (2/3*current index + 1/3*previous index). More detailed descriptions of scent post and winter track survey methods and results are available in separate reports.

RESULTS AND DISCUSSION

Bobcat. The 2014 registered DNR trapping and hunting harvest increased 33% to 1,384 (Table 1). Total modeled harvest, which includes reported tribal take, was 1,453. Age and reproductive data from bobcats harvested in 2014 is not complete at this time. Past data is presented in Figures 1 – 5 and Table 1.

Based on projections from the population model, 25% of the fall 2014 population was harvested. As a result of the high harvests in 2011 and 2012, plus an assumed reduction in survival from two severe winters and reduced ungulate prey, population modeling projects a 6% decline in the bobcat population (Figure 3), with an estimated 2015 spring population size of ~ 4,000 (Figure 6). Both track indices remain near the upper end of their previously recorded range (Figure 6).

Fisher. Over the past 7 years, the fisher harvest season has become progressively more conservative, with the past 3 seasons each lasting only 6 days and a per trapper combined limit of 2 fisher/marten. Fisher harvest this year under the DNR framework decreased ~ 18% to 943 (Table 2). Modeled harvest, which includes reported tribal take, was 1,045.

After a 15-year lapse, fisher carcass collections were resumed in 2010 to collect current information on harvest age distribution. A total of 881 carcasses were collected in 2014 (Table 2). Juveniles accounted for 56% of the total harvest, the highest since aging resumed in 2010, but below the average (64%) from 1977-1994. The juvenile:adult female ratio was 3.7, identical to the previous 4-year average, but well below the 1977-1994 average of 6.6 (Table 2). Average age of harvested males and females was 1.4 and 1.9, respectively, with the harvest being comprised of few fishers over the age of 1.5 (Figures 7 and 8).

Based on model projections, 14% of the fall fisher population was harvested during the 2014 season. After years of estimated decline based on track surveys and modeling, fisher trends have stabilized or slightly increased the past 2 years (Figure 9). Along the southern and western periphery of fisher range, an area not represented in track surveys, harvest data and other anecdotal information clearly indicate a population increase over the past 5-10 years, though these areas represent a comparatively small portion of overall fisher range. Acknowledging this caveat, modeling projects a 1.6% increase in the fisher population with an estimated 2015 spring population size of ~ 6,100 fishers (Figure 9).

Marten. As with fishers, the marten harvest season has become progressively more conservative in recent years, with the past 2 seasons lasting 6 days and a per trapper combined limit of 2 fisher/marten. Harvest this year under the DNR framework was 1,059, slightly above last year and the second lowest since 1991 (Table 3). Modeled harvest, which includes reported tribal take, was 1,124.

Juveniles accounted for 58% of the total harvest with a juvenile:adult female ratio of 5.8 (Table 3, Figure 10). Both numbers are above their 2002-13 averages (3.8; 43%) when modeling projects the population to have been in decline, though the juvenile:adult female ratio remains below that estimated from the 1987 – 2001 period (9.1) when the population is projected to have increased. Average age of harvested males and females was 1.9 and 1.8, respectively (Figures 11 and 12).

Based on projections from the marten population model, 12% of the fall 2014 population was harvested. This represents the lowest estimated harvest rate since 1991 (Table 3). Although the estimated population remains well below the peaks in the mid to late 1990's, modeling indicates that the population has stabilized in recent years (Figure 13), with an estimated 3% increase in the population from last year. The 2015 spring population is projected at ~ 7,750 martens (Figure 13).

Otter. From 1977 - 2007, otter harvest was only allowed in the northern part of the state. From 2007-2009, otter harvest was allowed in 2 separate zones with differing limits (4 otter in the north zone, 2 in the southeast zone). Beginning in 2010, otter harvest was allowed statewide with a consistent limit of 4 otter per trapper. Statewide otter harvest in 2014 under the DNR framework decreased 24% to 2,154 (Table 4). Modeled statewide otter harvest, which includes tribal take, was 2,235 (Table 4).

An estimated 16% of the fall 2014 otter population was harvested. Carcass collections ended in 1986 so no age or reproductive data are available, and no harvest-independent otter survey is currently established. Because demographic parameters in the otter model are typically held constant, annual differences in population trajectory are largely a function of varying harvest levels. Harvest levels exceeding ~3,000 for consecutive years typically predict population declines. Since 2002, otter population estimates have fluctuated as a result of cycles in fur prices that have altered harvest above and below this threshold. The population remains near the high end of levels estimated over the past 35 years (Figure 14) with the 2015 spring population estimated to be ~ 12,100, a 2.4% increase from last year.

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This project was funded in part by the Wildlife Restoration Program.

Table 1. Bobcat harvest data, 1985 to 2014.

Year	DNR Harvest	Modeled Harvest[1]	% Autumn Pop. Taken[2]	Carcasses Examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	Overall % males	Mean Pelt Price[3]
1985	119	121	6	99	33	19	48	1.2	41	41	43	42	$70
1986	160	160	8	132	26	17	57	0.9	53	32	51	51	$120
1987	214	229	12	163	33	16	51	1.3	44	52	48	48	$101
1988	140	143	7	114	40	18	42	1.7	58	62	46	54	$68
1989	129	129	6	119	39	17	44	2.0	49	53	56	53	$48
1990	84	87	4	62	20	34	46	0.8	58	80	44	59	$43
1991	106	110	5	93	35	33	32	3.5	59	55	70	61	$37
1992	167	167	7	151	28	22	50	1.2	55	45	53	53	$28
1993	201	210	8	161	32	20	48	1.4	51	45	52	50	$43
1994	238	270	11	187	26	16	58	0.8	64	43	45	50	$36
1995	134	152	6	96	31	15	54	2.7	57	71	79	71	$32
1996	223	250	10	164	35	20	45	1.8	51	30	49	46	$33
1997	364	401	16	270	35	16	49	1.4	60	37	43	48	$30
1998	103	107	4	77	29	26	45	1.6	59	60	60	60	$28
1999	206	228	8	163	18	24	58	0.8	55	59	62	60	$24
2000	231	250	8	183	31	26	43	1.4	54	59	50	53	$33
2001	259	278	8	213	30	21	49	1.3	46	45	47	46	$46
2002	544	621	15	475	27	25	48	1.1	68	51	48	54	$72
2003	483	518	13	425	25	13	62	0.9	62	48	54	55	$96
2004	631	709	14	524	28	34	38	1.7	52	40	55	49	$99
2005	590	638	13	485	25	13	62	0.8	51	48	47	48	$96
2006	890	983	18	813	26	17	57	1.1	60	51	58	57	$101
2007	702	758	14	633	34	14	52	1.2	55	60	47	52	$93
2008	853	928	15	714	26	25	49	1.1	55	52	50	52	$75
2009	884	942	15	844	24	22	54	0.9	57	46	51	51	$43
2010	1012	1042	15	955	38	16	46	1.4	62	55	42	52	$71
2011	1711	1898	26	1626	23	21	55	0.8	61	73	47	56	$98
2012	1875	2026	29	1744	25	19	56	1.0	63	53	54	56	$144
2013	1038	1128	20	634	35	18	47	1.4	59	50	48	52	$89
2014	1384	1453	25	1296				Not yet available				58	

[1] Includes DNR and Tribal harvests
[2] Estimated from population model; includes estimated non-reported harvest of 10%.
[3] Average pelt price based on a survey of in-state fur buyers only.

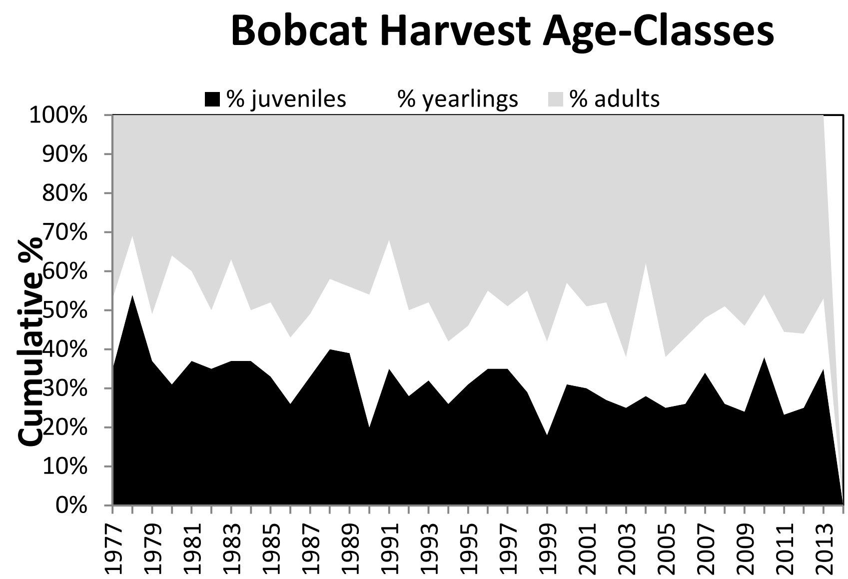

Figure 1. Age-class distribution of bobcats harvested in Minnesota 1977 - 2013.

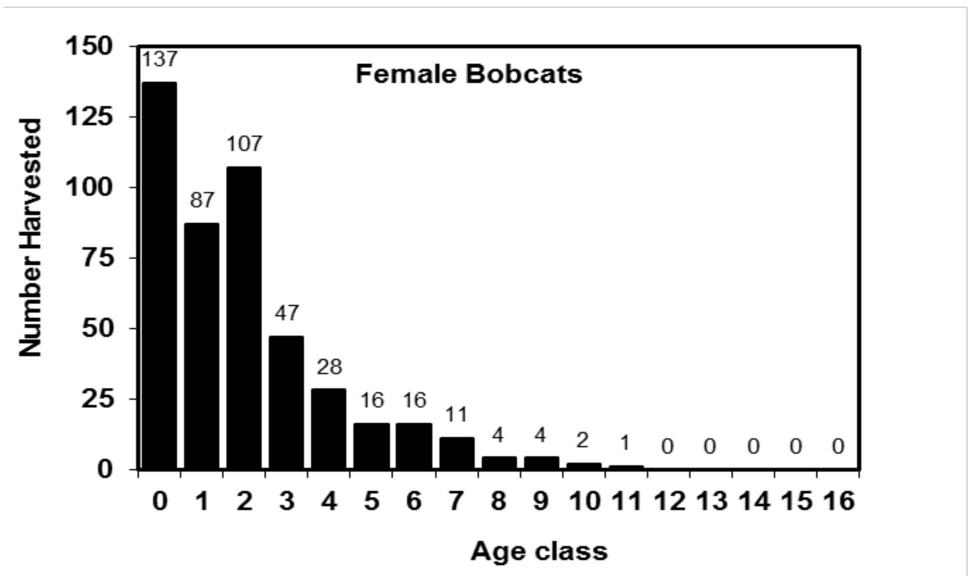

Figure 2. Age structure of female bobcats in the 2013 harvest.

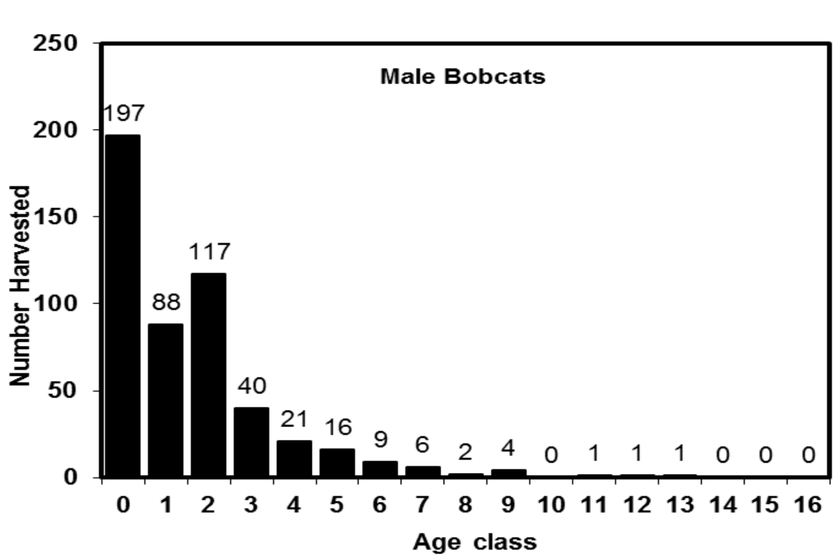

Figure 3. Age structure of male bobcats in the 2013 harvest.

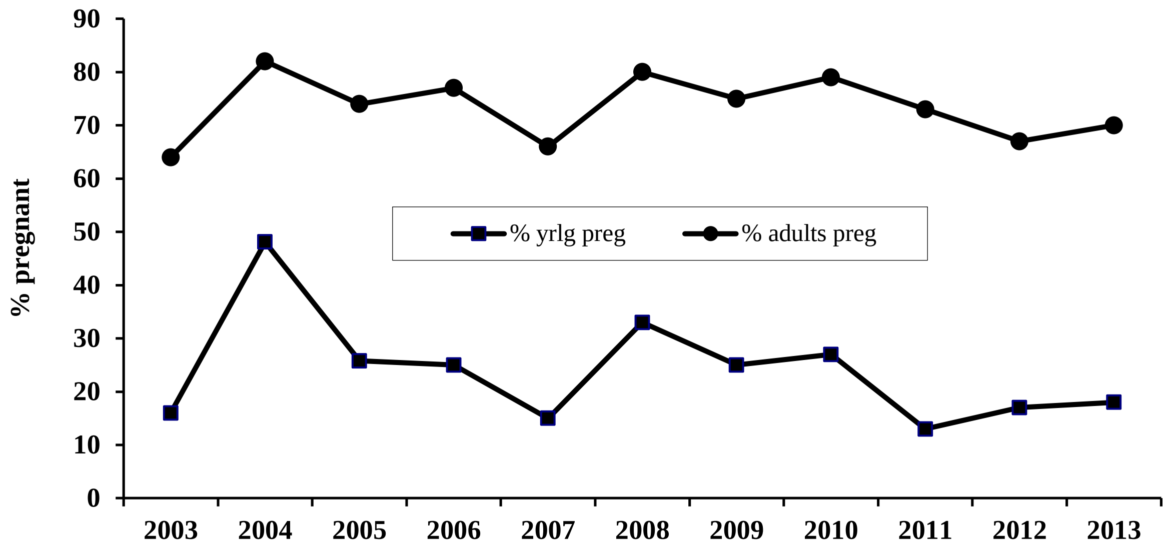

Figure 4. Pregnancy rates for yearling and adult bobcats in Minnesota, 2003-2013.

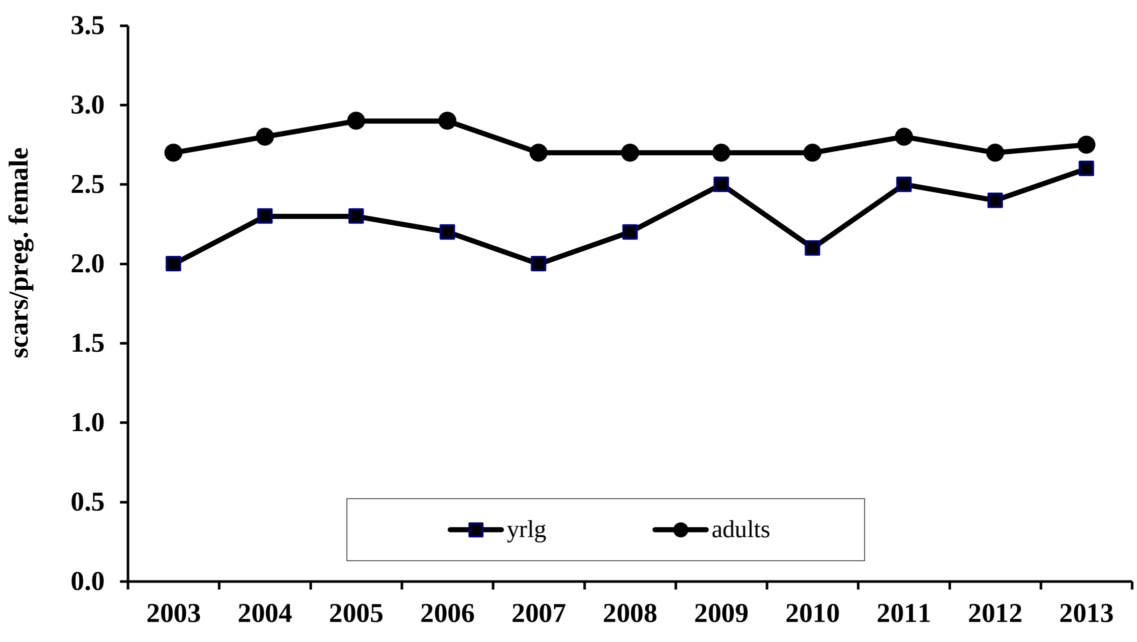

Figure 5. Litter size for parous yearling and adult bobcats in Minnesota, 2003-2013.

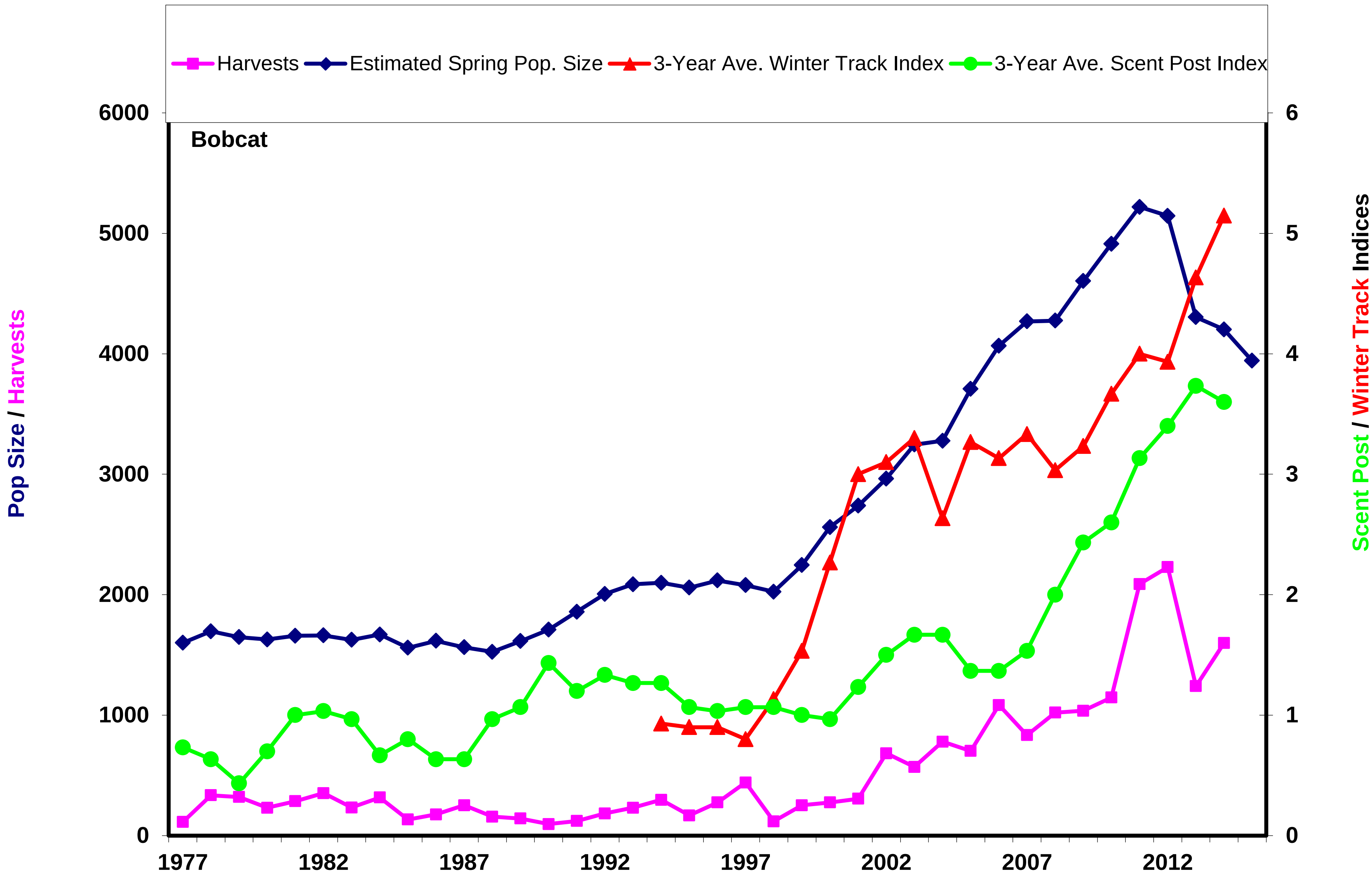

Figure 6. Bobcat populations, harvests, and survey indices, 1977-2015. Harvests include an estimate of non-reported take.

Table 2. Fisher harvest data, 1985 to 2014.

Year	DNR harvest	Modeled Harvest[1]	% Autumn Pop. Harvested[2]	Carcasses examined	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[3]	Pelt price Females[3]
1985	678	735	10	712	63	20	18	5.5	46	40	34	43	$74	$130
1986	1068	1186	15	1186	59	24	18	5.2	48	50	37	46	$84	$162
1987	1642	1749	22	1534	63	15	22	4.7	46	40	37	43	$84	$170
1988	1025	1050	14	805	70	15	15	6.7	48	45	33	45	$54	$100
1989	1243	1243	16	1024	64	19	17	5.8	47	47	36	45	$26	$53
1990	746	756	9	592	65	14	21	4.4	44	55	30	43	$35	$46
1991	528	528	6	410	66	21	13	7.5	50	52	35	48	$21	$48
1992	778	782	8	629	58	21	21	4.8	42	55	45	46	$16	$29
1993	1159	1192	10	937	59	22	19	6.0	47	37	42	44	$14	$28
1994	1771	1932	15	1360	56	18	26	4.0	47	54	44	48	$19	$30
1995	942	1060	8	-	-	-	-	-	-	-	-	45	$16	$25
1996	1773	2000	14	-	-	-	-	-	-	-	-	45	$25	$34
1997	2761	2974	20	-	-	-	-	-	-	-	-	45	$31	$34
1998	2695	2987	20	-	-	-	-	-	-	-	-	45	$19	$22
1999	1725	1880	13	-	-	-	-	-	-	-	-	45	$19	$20
2000	1674	1900	13	-	-	-	-	-	-	-	-	45	$20	$19
2001	2145	2362	15	-	-	-	-	-	-	-	-	54	$23	$23
2002	2660	3028	20	-	-	-	-	-	-	-	-	54	$27	$25
2003	2521	2728	19	-	-	-	-	-	-	-	-	55	$27	$26
2004	2552	2753	20	-	-	-	-	-	-	-	-	52	$30	$27
2005	2388	2454	19	-	-	-	-	-	-	-	-	52	$36	$31
2006	3250	3500	29	-	-	-	-	-	-	-	-	51	$76	$68
2007	1682	1811	18	-	-	-	-	-	-	-	-	52	$63	$48
2008	1712	1828	19	-	-	-	-	-	-	-	-	52	$22	$37
2009	1259	1323	15	-	-	-	-	-	-	-	-	53	$35	$34
2010	903	951	11	759	52	25	23	4.5	55	54	50	54	$38	$37
2011	1473	1651	19	1314	47	28	25	3.2	59	53	42	53	$48	$40
2012	1293	1450	18	1108	51	24	25	3.7	59	53	45	54	$62	$63
2013	1146	1295	17	1040	51	24	25	3.4	55	56	42	52	$74	$68
2014	943	1045	14	881	56	21	23	3.7	57	57	36	52		

[1] Includes DNR and Tribal harvests

[2] Estimated from population model, includes estimated non-reported harvest of 20% 1977-1992, and 10% from 1993-present.

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

Figure 7. Age structure of female fishers in the 2014 harvest.

Figure 8. Age structure of male fishers in the 2014 harvest.

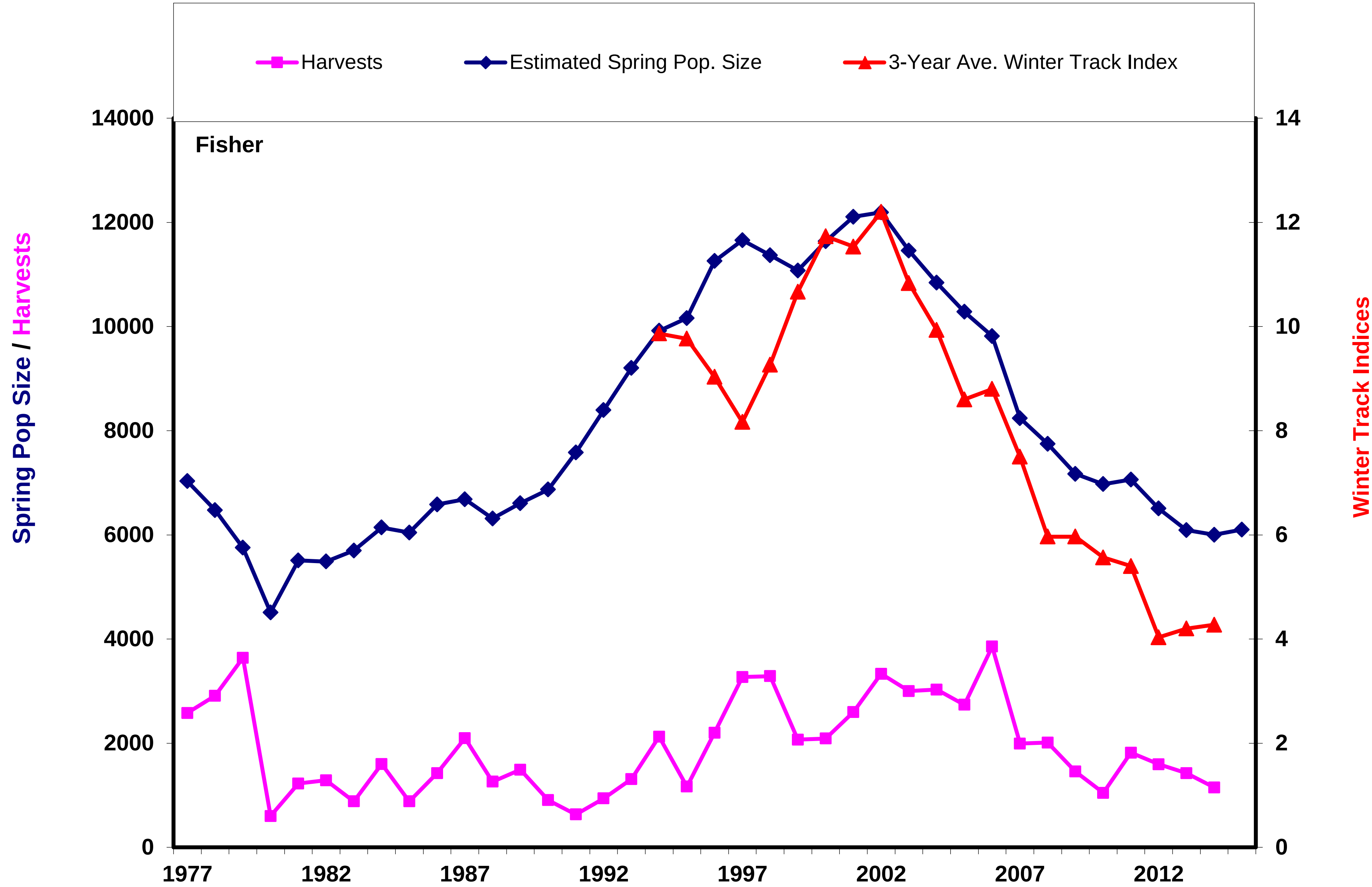

Figure 9. Fisher populations, harvests, and survey indices, 1977-2015. Harvests include an estimate of non-reported take.

Table 3. Marten harvest data, 1985 to 2014.

Year	DNR harvest	Modeled Harvest[1]	% Autumn Pop. Harvested[2]	Carcasses Examined[3]	% juveniles	% yearlings	% adults	Juv: Ad. Female ratio	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Males[4]	Pelt price Females[4]
1985	430	430	6	507	73	18	9	49.2	69	68	82	70	$30	$28
1986	798	798	9	884	64	21	15	23.1	65	71	81	69	$36	$27
1987	1363	1363	15	1754	66	18	16	16.7	65	67	75	67	$43	$39
1988	2072	2072	18	1977	66	11	23	8.8	58	50	66	59	$50	$43
1989	2119	2119	19	1014	68	12	20	9.9	57	63	65	59	$48	$47
1990	1349	1447	13	1375	48	18	34	3.6	59	54	61	59	$44	$41
1991	686	1000	8	716	74	9	17	13.5	69	71	72	70	$40	$27
1992	1602	1802	14	1661	65	18	17	14.8	63	70	75	66	$28	$25
1993	1438	1828	14	1396	57	20	23	7.6	61	71	67	64	$36	$30
1994	1527	1846	13	1452	58	15	27	6.5	62	76	67	66	$34	$28
1995	1500	1774	13	1393	60	18	22	8.2	63	68	66	65	$28	$21
1996	1625	2000	14	1372	48	22	30	4.9	62	69	67	65	$34	$29
1997	2261	2762	20	2238	61	13	26	6.2	60	60	63	61	$28	$22
1998	2299	2795	21	1577	57	18	25	6.5	62	66	65	63	$20	$16
1999	2423	3000	21	2013	67	12	21	9.9	65	66	67	66	$25	$21
2000	1629	2050	15	1598	56	25	19	8.8	62	69	66	64	$28	$21
2001	1940	2250	15	1895	62	15	23	10.7	65	73	74	69	$24	$23
2002	2839	3192	20	2451	38	30	32	3.3	59	65	62	62	$28	$27
2003	3214	3548	23	2391	49	16	35	4.2	59	66	68	64	$30	$27
2004	3241	3592	24	2776	26	28	46	1.4	54	67	59	60	$31	$27
2005	2653	2873	22	1992	53	16	31	5.1	64	63	65	65	$37	$32
2006	3788	4120	32	1914	64	17	20	9.5	67	68	67	67	$74	$66
2007	2221	2481	21	1355	30	29	41	1.6	60	68	54	60	$59	$50
2008	1823	1953	18	1095	40	21	39	2.4	62	64	57	60	$31	$28
2009	2073	2250	20	1252	56	15	29	5.1	67	49	63	63	$27	$30
2010	1842	1977	18	1202	47	25	28	4.4	71	56	62	65	$40	$37
2011	2525	2744	25	1615	39	25	36	2.7	64	64	60	62	$42	$39
2012	1472	1610	17	1260	34	30	36	2.6	67	57	64	63	$57	$54
2013	1014	1323	15	942	43	20	37	3.5	59	62	68	63	$74	$71
2014	1059	1124	12	991	58	14	28	5.8	65	67	64	65		

[1] Includes DNR and Tribal harvests

[2] Estimated from population model; includes estimated non-reported harvest of 40% in 1985-1987 and 1991, 20% in 1988-1990 and 1992-1998, and 10% from 1999-present.

[3] Starting in 2005, the number of carcasses examined represents a random sample of ~ 70% of the carcasses collected in each year.

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

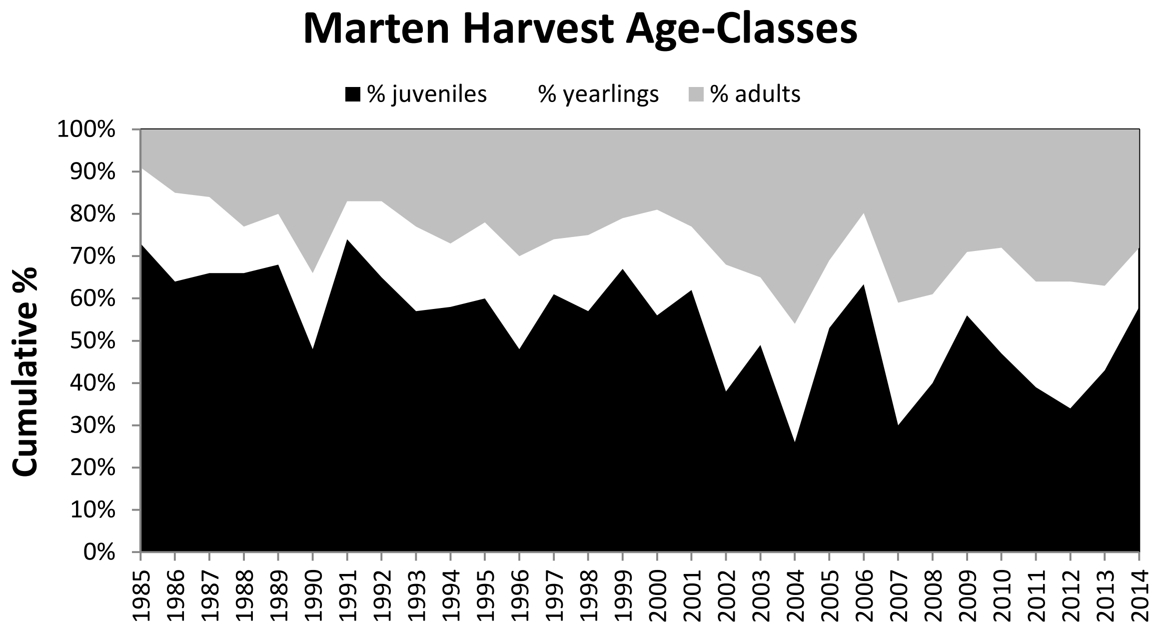

Figure 10. Age-class distribution of martens harvested in Minnesota, 1985 - 2014.

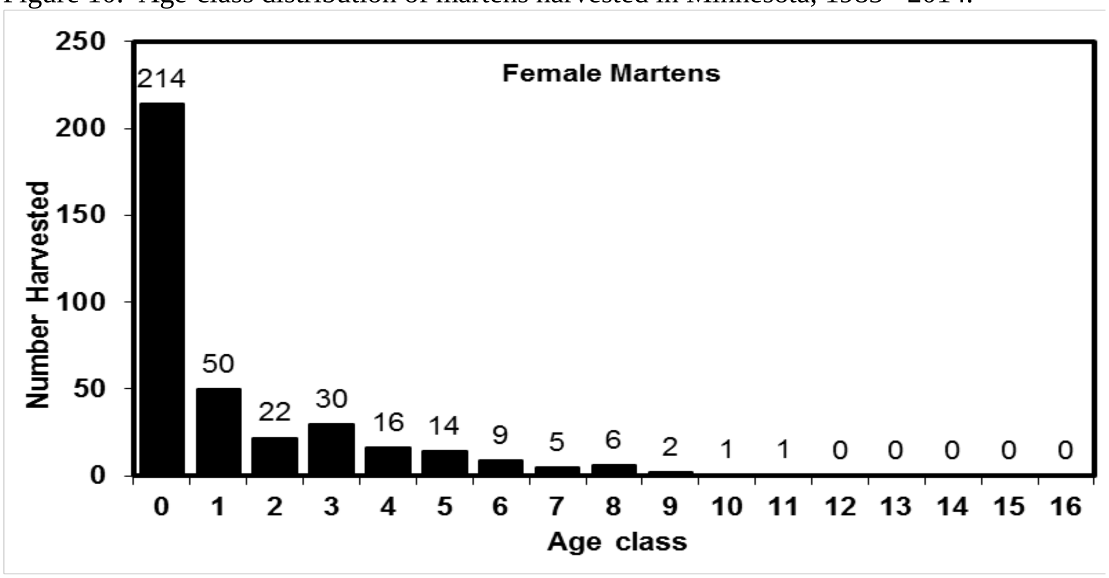

Figure 11. Age structure of female martens in the 2014 harvest.

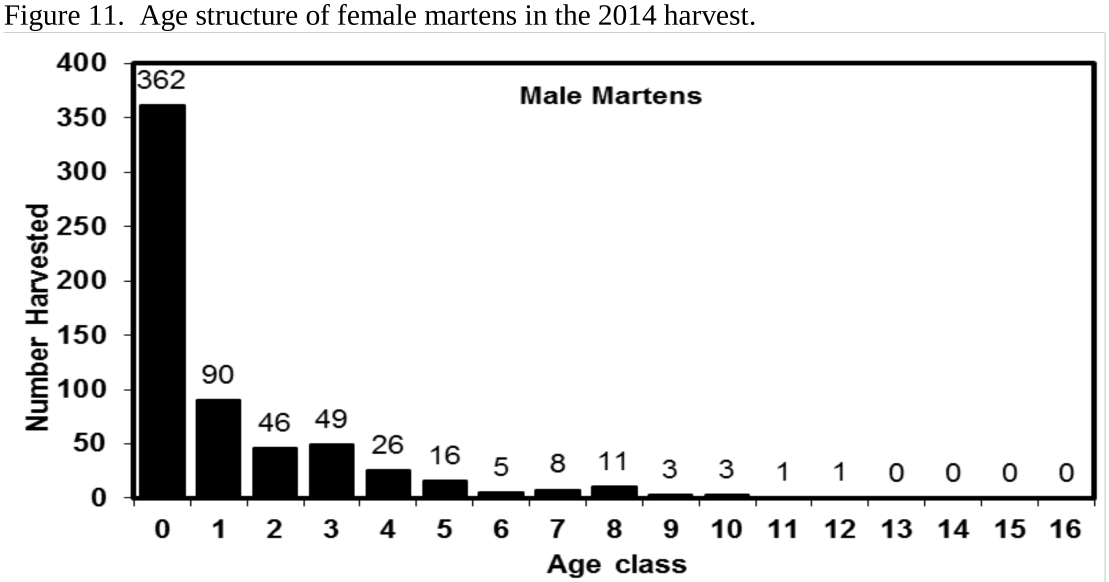

Figure 12. Age structure of male martens in the 2014 harvest.

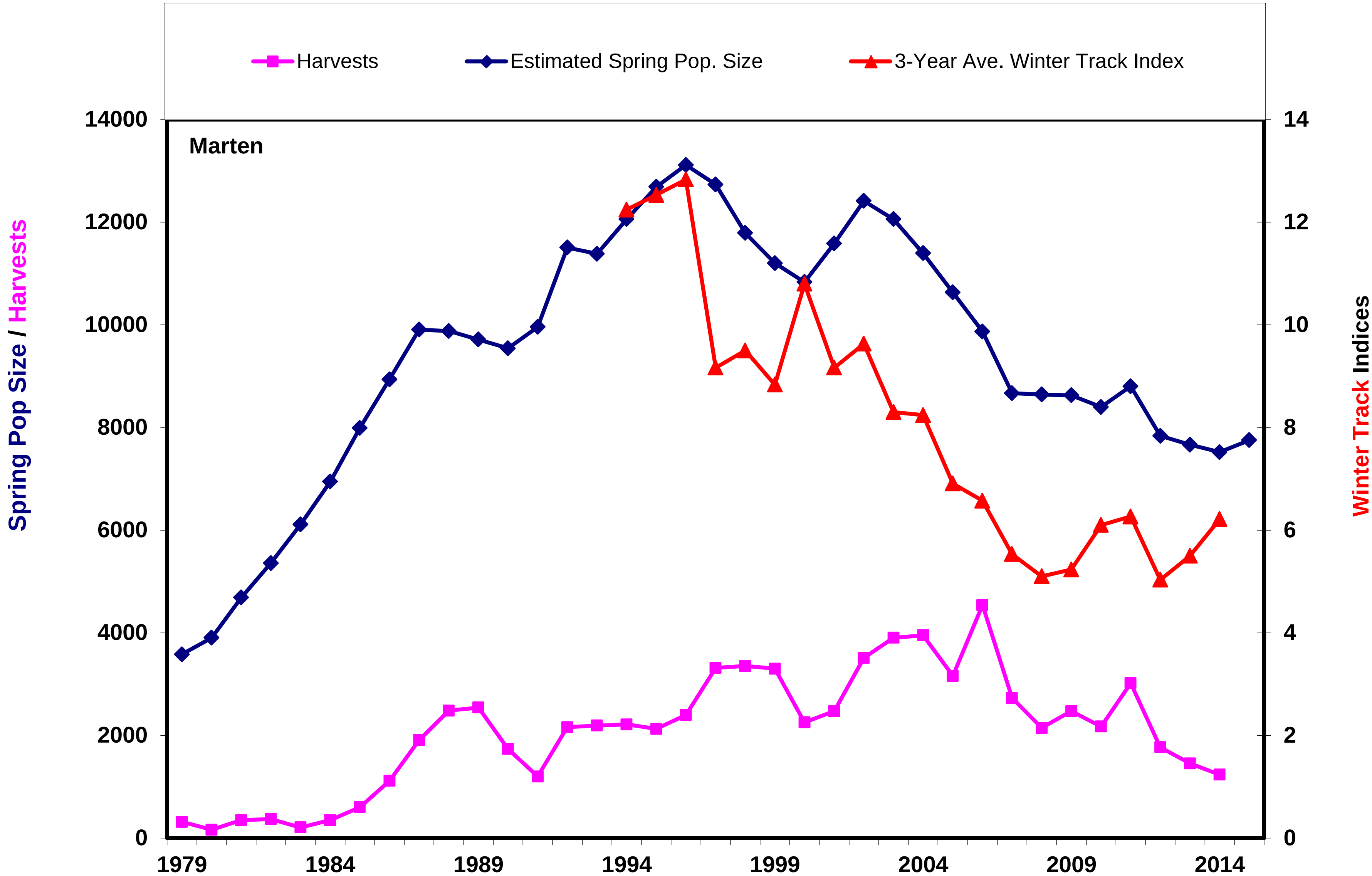

Figure 13. American marten populations, harvests, and survey indices, 1979-2015. Harvests include an estimate of non-reported take.

Table 4. Otter harvest data[1], 1985 to 2014. Carcasses were only collected from 1980-86.

Year	DNR harvest	Modeled Harvest[1]	% Autumn Pop. Harvested[2]	Carcasses examined	% juveniles	% yearlings	% adults	Juv:ad. females	% male juveniles	% male yearlings	% male adults	% males overall	Pelt price Otter[3]	Pelt price Beaver[3]
1985	559	572	6	572	43	23	34	2.2	53	50	43	51	$21	$15
1986	777	777	8	745	45	23	32	2.7	45	48	46	47	$24	$20
1987	1386	1484	15	-	-	-	-	-	-	-	-	52	$23	$17
1988	922	922	9	-	-	-	-	-	-	-	-	52	$22	$14
1989	1294	1294	12	-	-	-	-	-	-	-	-	52	$22	$12
1990	888	903	8	-	-	-	-	-	-	-	-	52	$24	$9
1991	855	925	8	-	-	-	-	-	-	-	-	51	$25	$9
1992	1368	1365	10	-	-	-	-	-	-	-	-	52	$30	$7
1993	1459	1368	10	-	-	-	-	-	-	-	-	52	$43	$10
1994	2445	2708	18	-	-	-	-	-	-	-	-	52	$48	$14
1995	1435	1646	12	-	-	-	-	-	-	-	-	52	$39	$12
1996	2219	2500	17	-	-	-	-	-	-	-	-	52	$39	$19
1997	2145	2313	16	-	-	-	-	-	-	-	-	52	$40	$17
1998	1946	2139	15	-	-	-	-	-	-	-	-	52	$34	$13
1999	1635	1717	12	-	-	-	-	-	-	-	-	52	$41	$11
2000	1578	1750	12	-	-	-	-	-	-	-	-	52	$51	$14
2001	2301	2531	17	-	-	-	-	-	-	-	-	57	$46	$13
2002	2145	2390	15	-	-	-	-	-	-	-	-	59	$61	$10
2003	2766	2966	19	-	-	-	-	-	-	-	-	57	$85	$12
2004	3450	3700	24	-	-	-	-	-	-	-	-	56	$87	$14
2005	2846	3018	22	-	-	-	-	-	-	-	-	58	$89	$15
2006	2720	2873	21	-	-	-	-	-	-	-	-	56	$43	$17
2007	1861	1911	15	-	-	-	-	-	-	-	-	55	$29	$16
2008	1938	1983	15	-	-	-	-	-	-	-	-	59	$24	$12
2009	1544	1578	12	-	-	-	-	-	-	-	-	59	$36	$13
2010	1814	1830	13	-	-	-	-	-	-	-	-	57	$35	$13
2011	2294	2490	17	-	-	-	-	-	-	-	-	58	$51	$17
2012	3171	3377	22	-	-	-	-	-	-	-	-	60	$72	$16
2013	2824	2993	21	-	-	-	-	-	-	-	-	48	$61	$17
2014	2154	2235	16	-	-	-	-	-	-	-	-	59		

[1] Includes DNR and Tribal harvests

[2] Estimated from population model. Incl. estimated non-reported harvest of 30% to 1991, 22% from 1992-2001, and 15% from 2002-present.

[3] Weighted average of spring (beaver only) and fall prices based on a survey of in-state fur buyers.

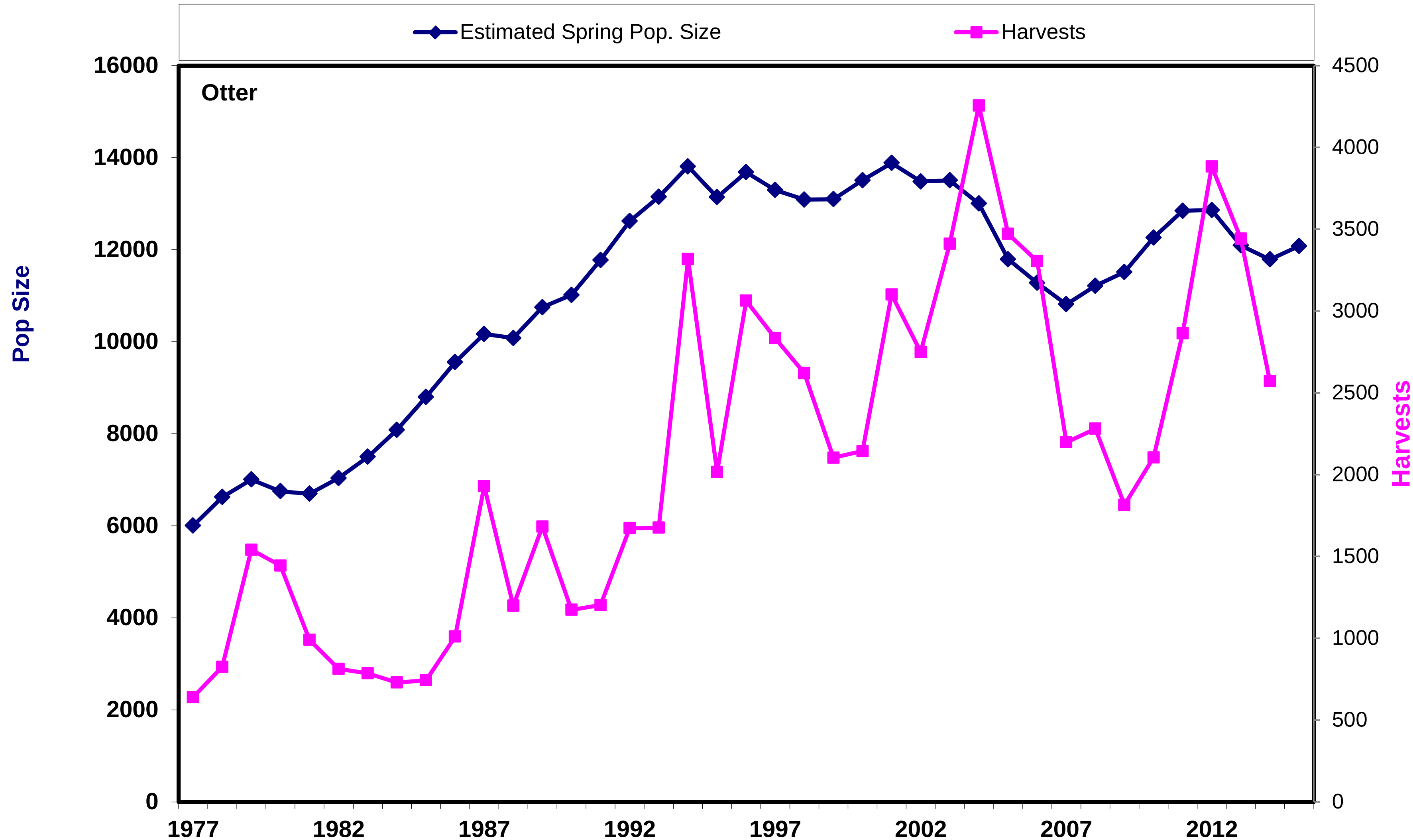

Figure 14. Otter populations and harvests, 1977-2015. Harvests include an estimate of non-reported take.

MINNESOTA WOLF POPULATION UPDATE 2015

John Erb, Carolin Humpal, and Barry Sampson, Minnesota Department of Natural Resources

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), then at approximately 5-year intervals thereafter (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 two winters post-harvest, wolf population point estimates have varied from approximately 2,200 to 2,400 (Erb and Sampson 2013, 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. This update summarizes the results of the 2014-15 winter survey.

METHODS

The methodology used to estimate wolf population size in Minnesota utilizes three primary pieces of information: 1) an estimate of the number of square kilometers 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. Ten 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, an antibiotic and the antagonist Yohimbine 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 from 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.

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=12; mean number of radiolocations = 29), we multiplied each estimated territory size by 1.37 as in the past. For packs with > 100 radiolocations (n = 36; mean number of radiolocations = 1,017), territories were assumed fully delineated and 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 some cases where visual observations were insufficient (n = 5 packs), we relied on estimates of pack size based on tracks observed in the snow within the pack territory. If snow-track counts 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 40 radio-marked wolf packs (Figure 1). Eight 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 13% of occupied wolf range.

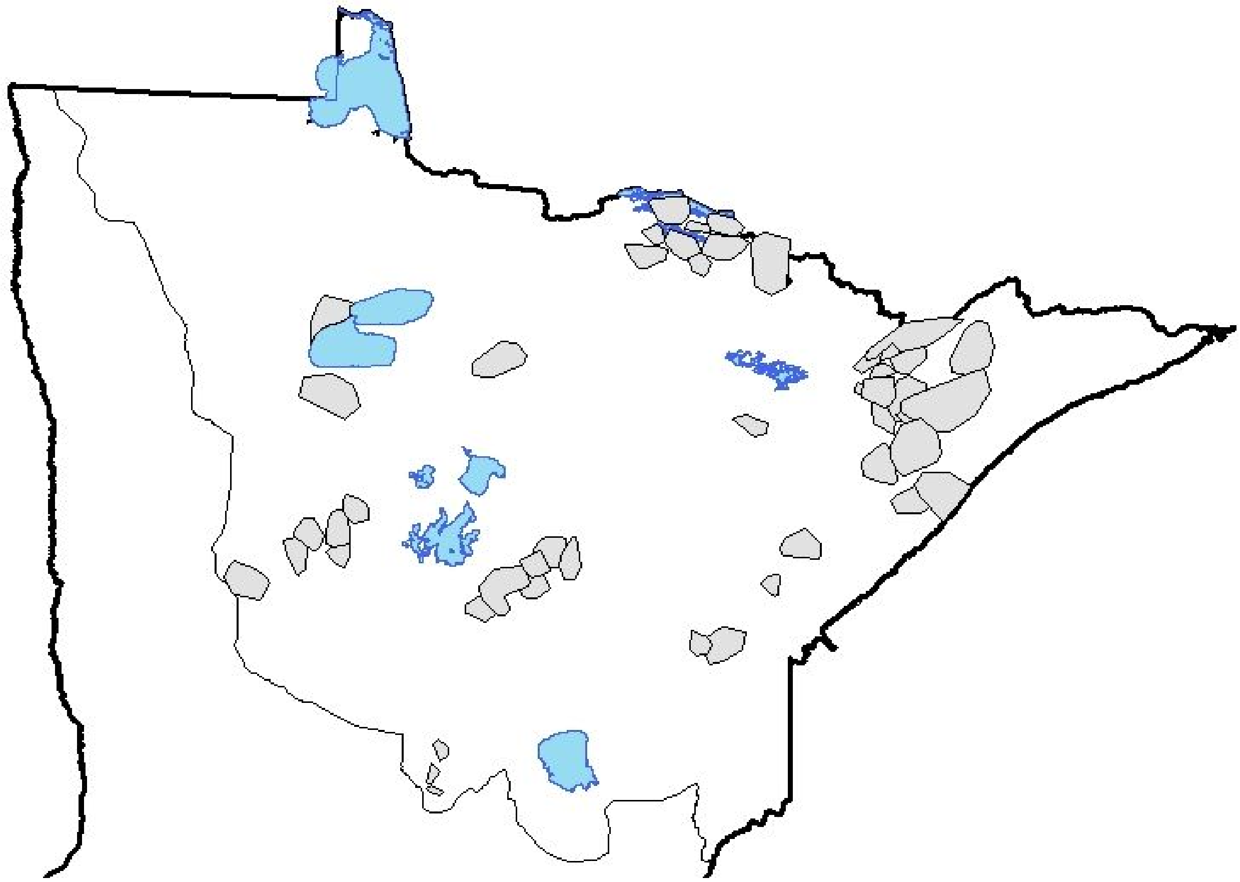

Figure 1. Location of radio-marked wolf packs during the 2014/15 survey.

A land cover comparison using the 2011 National Land Cover Database suggests that land cover within territories of radio-marked packs used in the survey was representative of land cover throughout the entirety of occupied wolf range in Minnesota (Table 1; Chi-square $p = 0.34$). Using spring 2014 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 7.9 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, 2014 spring deer density for the entirety of occupied wolf range (weighted by permit area) in Minnesota was approximately 7.3 deer/mi^2 in spring 2014. Collectively, we believe that 'conditions' within marked pack territories closely 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	27.8
Deciduous Forest	23.6	26.9
Emergent Herbaceous Wetlands	9.9	4.1
Mixed Forest	7.2	9.9
Evergreen Forest	6.9	12.6
Open Water	5.4	8.5
Shrub/Scrub	4.5	5.2
Pasture/Hay	3.4	1.5
Cultivated Crops	2.9	0.3
Developed, Open Space	1.8	1.5
Grassland/Herbaceous	1.4	1.2
Developed, Low Intensity	0.2	0.1
Barren Land (Rock/Sand/Clay)	0.1	0.1
Developed, Medium Intensity	<0.1	<0.1
Developed, High Intensity	<0.1	<0.1

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

After applying the territory scaling factors, the average estimated territory size for radio-marked packs during the 2014-15 survey was 188.77 km^2 (range = 27 – 717 km^2). Average territory size was similar to that observed in the 1997-98 survey (Figure 2), which, like this survey, followed 2 sequential severe winters and a notable decline in the deer population. Prey density is often a key determinant of longer-term variation in pack territory sizes (Fuller et al. 2003).

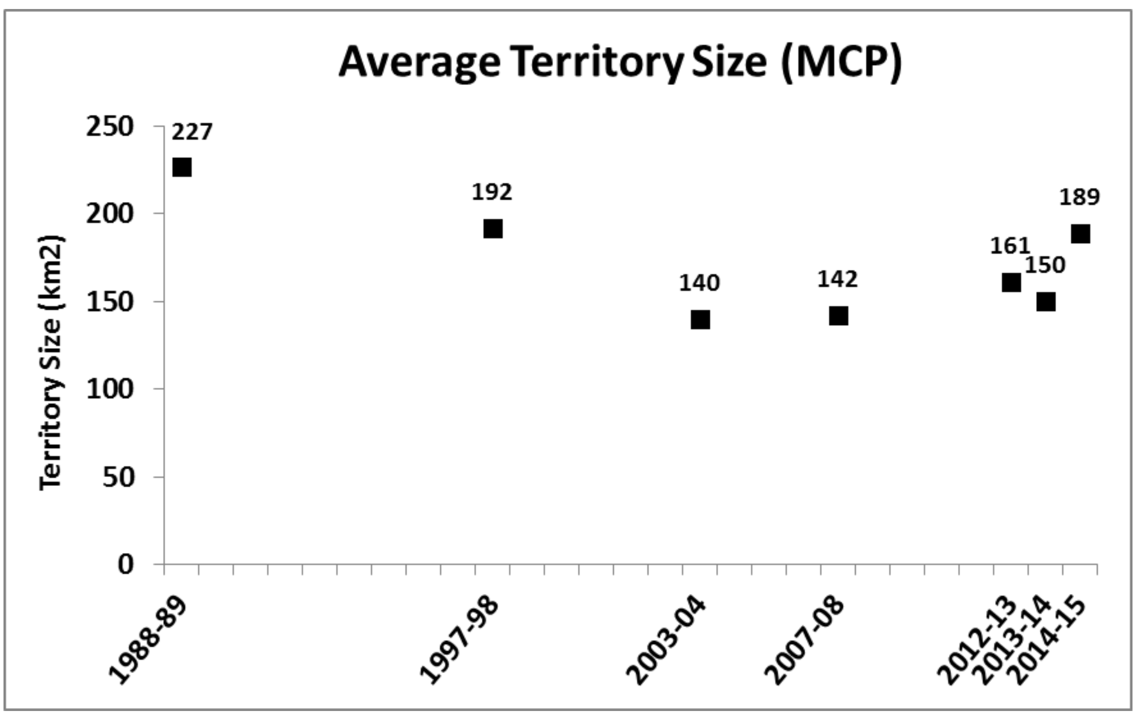

Figure 2. Average scaled territory size for radio-marked wolf packs in Minnesota from 1989 to 2015.

Average pack size had slowly declined from 1988 to 2012, then stabilized the last 2 years. However, average pack size in winter 2014-15 increased 16% to approximately 5.1 (range = 2 – 13, Figure 3).

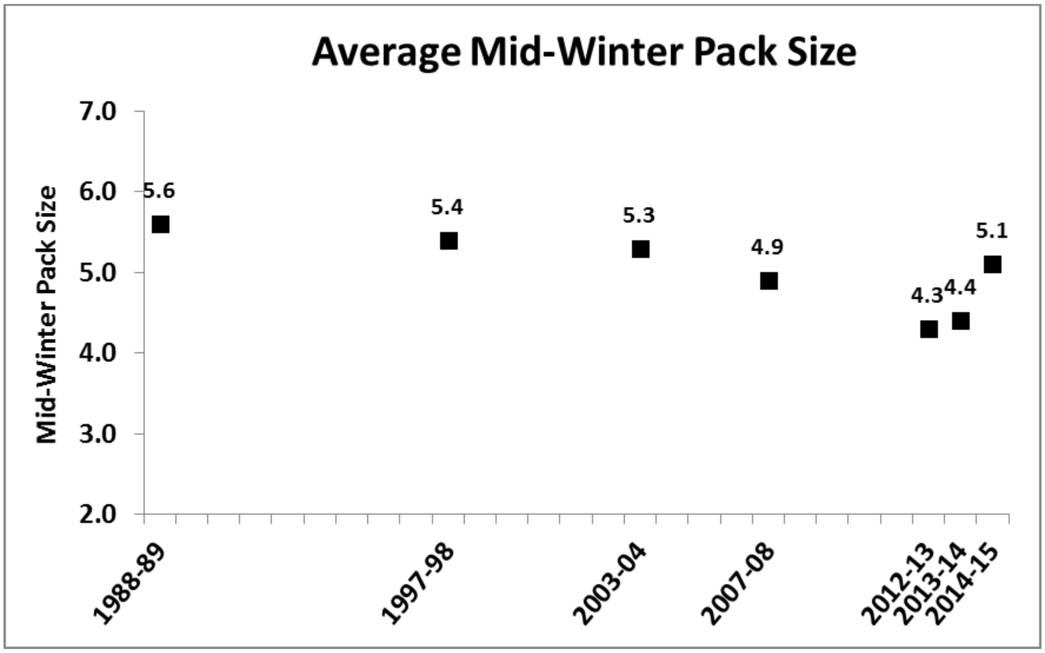

Figure 3. Average mid-winter pack size for radio-marked wolf packs in Minnesota from 1989 to 2015.

Wolf Numbers

Given an average territory size of approximately 189 km^2 and assuming occupied range unchanged since 2013 (70,579 km^2; Erb and Sampson 2013), we estimate a total of 374 wolf packs in Minnesota. 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).

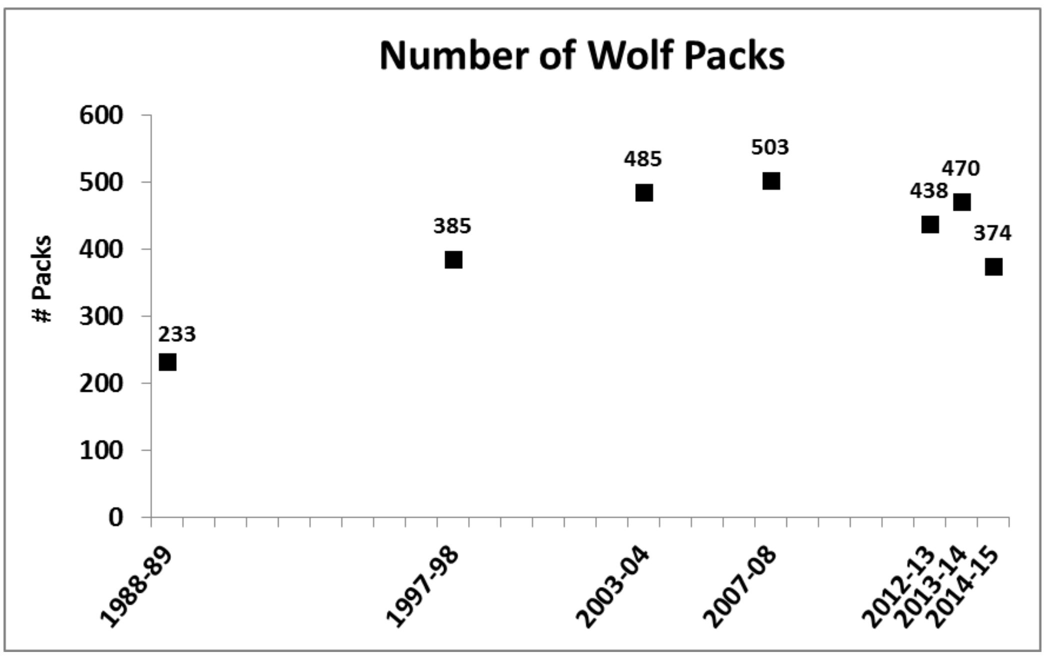

Figure 4. Estimated number of wolf packs in Minnesota at periodic intervals from 1989 to 2015.

After accounting for the assumed 15% lone wolves in the population, we estimate the 2014-15 mid-winter wolf population at 2,221 wolves, or 3.2 wolves per 100 km^2 of occupied range. The 90% confidence interval was approximately +/- 500 wolves, specifically 1,789 to 2,719. Given the substantial overlap with the 2012 and 2013 confidence intervals, we conclude there has been no statistically significant change in the size of the statewide mid-winter wolf population over the past 3 years.

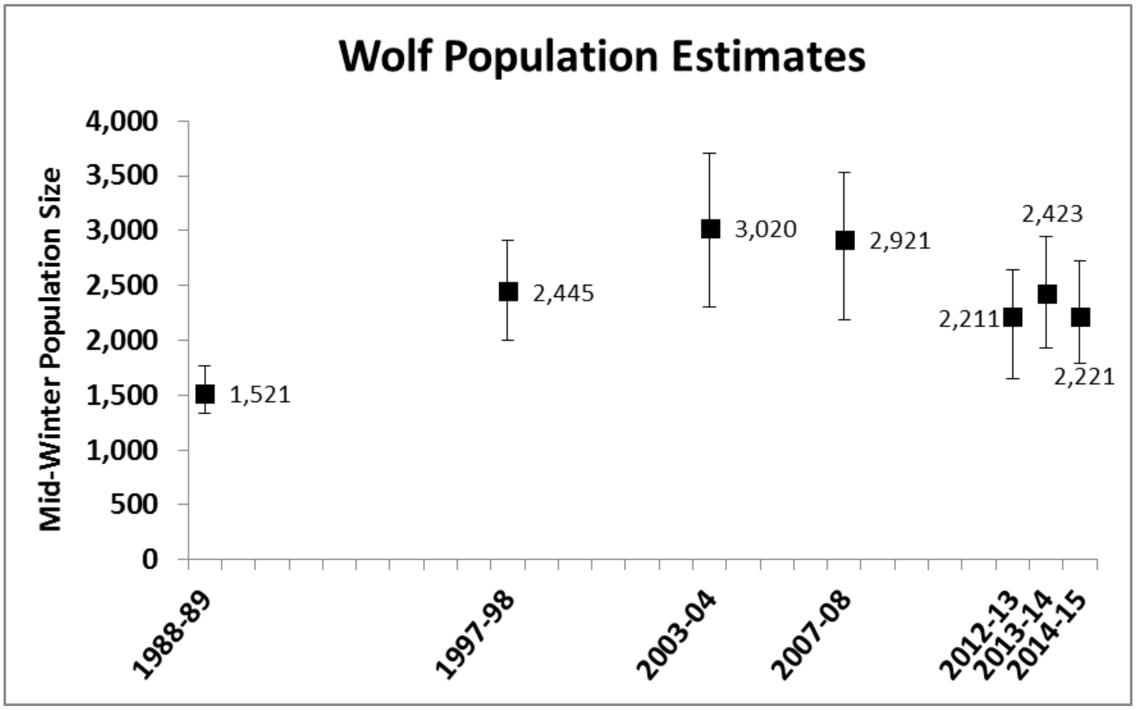

Figure 5. Wolf population estimates from periodic standardized surveys in Minnesota from 1989 to 2015.

ACKNOWLEDGEMENTS

We thank Dan Stark and staff with the USDA Wildlife Services program (John Hart, Kevin Fuller, Jeff Grabarkewitz, Pete Sahr, and Dave Kuehn) for assistance with capturing and radio-collaring wolves, and staff at Itasca State Park for logistical assistance in wolf trapping activities therein. We are grateful for the critical contributions of DNR pilots Jason Jensen, John Heineman, Chris Lofstuen, Tom Buker, Bob Geving, and Tom Pfingsten during wolf telemetry and pack counts. Special thanks to numerous collaborators for their assistance or sharing of radio-telemetry data utilized in this survey, including Dave Mech and Shannon Barber-Meyer (USGS), Steve Windels and Bryce Olson (Voyageurs National Park), Jay Huseby and Dave Price (Red Lake Band of Chippewa), Mike Schrage, Tom Howes, and others (Fond-du-Lac Band of Chippewa), Ron Moen and Brian Kot (Univ. of Minnesota-Duluth), and Brian Dirks and Nancy Dietz (Camp Ripley Military Reservation). This project was funded in part by the Wildlife Restoration Program (Pittman-Robertson).

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