WETLAND WILDLIFE POPULATIONS

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2016 WATERFOWL BREEDING POPULATION SURVEY MINNESOTA

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ABSTRACT

The number of breeding waterfowl in a portion of Minnesota has been estimated each year since 1968 as a part of the overall inventory of North American breeding waterfowl. The survey consists of aerial observations in addition to more intensive ground counts on selected routes to determine the proportion of birds counted by the aerial crew. Procedures used are similar to those used elsewhere across the waterfowl breeding grounds. The 2016 aerial survey portion was flown from May 2 to May 16. Spring ice-out dates in the southern 2/3 of the state were near record early and ~3 weeks earlier than median dates. In the northern 1/3 of the states, ice out dates were about 1 week earlier than median dates. Temperatures were well above normal in March and near normal in April and May. Precipitation was below normal in April and May except for portions of southwest Minnesota. Overall, wetland numbers (Types II-V) were unchanged from 2015 but 21% below the 10-year average and 13% below the long-term average.

The 2016 estimated mallard breeding population was 243,000, which was 18% higher than last year's estimate of 206,000 mallards, but statistically unchanged (P=0.51). Mallard numbers were unchanged from the 10-year average and 7% above the long-term average of 228,000 breeding mallards. The estimated blue-winged teal population was 317,000, which was 88% higher than last year's estimate of 169,000 blue-winged teal, but statistically unchanged (P=0.17). Blue-winged teal numbers were 50% above the long-term average of 211,000 blue-winged teal. The combined population index of other ducks, excluding scaup, was 208,000 ducks, which was 39% higher than last year's estimate and 18% above the 10-year average and 17% above the long-term average of 177,000 other ducks.

The estimate of total duck abundance (768,000), which excludes scaup, was 47% higher than last year's estimate of 524,000 ducks and was 36% above the 10-year average and 25% above the long-term average of 616,000 ducks. The estimated number of Canada geese was 108,000 and 33% lower than last year and 32% below the 10-year average.

METHODS

The aerial survey is based on a sampling design that includes three survey strata (Table 1, Figure 1). The strata cover 39% of the state area and are defined by density of lake basins (>10 acres) exclusive of the infertile northeastern lake region. The strata include the following:

Stratum I: high density, 21 or more lake basins per township.

Stratum II: moderate density, 11 to 20 lake basins per township.

Stratum III: low density, 2 to 10 lake basins per township.

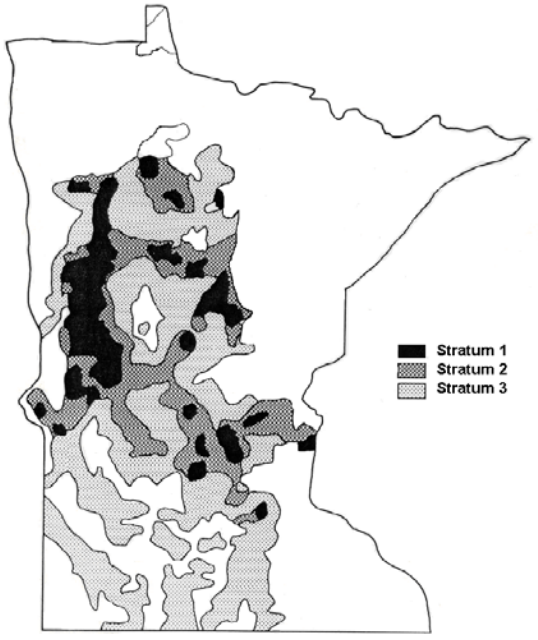

Figure 1. Location of waterfowl breeding population survey strata in Minnesota.

Areas with less than two basins per township are not surveyed. Strata boundaries were based upon "An Inventory of Minnesota Lakes" (Minnesota Conserv. Dept. 1968:12). Standard procedures for the survey follow those outlined in "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Populations and Habitat Surveys in North America" (USFWS/CWS 1987). Changes in survey methodology were described in the 1989 Minnesota Waterfowl Breeding Population Survey report. Pond and waterfowl data for 1968-74 were calculated from Jessen (1969-72) and Maxson and Pace (1989).

All aerial transects in Strata I-III (Table 1) were flown using an American Champion Scout. Wetlands were counted on only the observer's side of the plane (0.125 mile wide transect); a correction factor obtained in 1989 (123,000/203,000 = 0.606) was used to adjust previous estimates (1968-88) of wetland abundance (Type II-V; Table 2) that were obtained when the observer counted wetlands on both sides of the plane (0.25 mile wide transect). All wetland and waterfowl data were recorded on digital voice recorders and transcribed by the observer from the digital files.

Visibility correction factors (VCFs) were derived from intensive ground surveys on 14 selected routes flown by the aerial crew. Many of these routes use a county road as the mid-point of the transect boundary which aids in navigation and helps ensure the aerial and ground crews survey the same area. Ground routes each originally included about 100 wetland areas; however, drainage has reduced the number of wetlands on most of the routes. All observations from both ground crews and aerial crews were used to calculate the VCFs.

The SAS computer program was modified in 1992 to obtain standard errors for mallard and blue-winged teal breeding population estimates. These calculations were based upon SAS computer code written by Graham Smith, USFWS-Office of Migratory Bird Management. Estimates for 2015 and 2016 were compared using two-tailed Z-tests.

SURVEY CHRONOLOGY

The 2016 aerial survey began on 2 May in southern Minnesota and concluded in northern Minnesota on 16 May. Transects were flown on 10 days, May 2-9 and May 15-16 and completed in 54 flight hours. Flights began near 7 AM and were completed by 12:00 PM each day. The median date for survey completion was May 7, which was 2 weeks earlier than last year.

WEATHER AND HABITAT CONDITIONS

For the southern 2/3 of the state, ice out was extremely early with many lakes at or near their earliest dates on record and in general, about 3-4 weeks earlier than median ice out dates. In northern Minnesota, ice out dates were later but still about 1 week earlier than median dates. Temperatures in March averaged 7.6°F above normal and precipitation was 0.8 inches above normal statewide. Temperatures in April averaged 0.2°F below normal and precipitation was 0.3 inches below normal statewide. Temperatures in May averaged 1.0°F above normal statewide and precipitation was 0.5 inches below normal statewide (http://climate.umn.edu). Precipitation during the period of time just prior to and during the survey showed above average precipitation only in southwest MN and below average precipitation across the rest of the state (Appendix A).

Overall wetland conditions in spring 2016 were dry but similar to last year. In early May 2016, 91% of the state was under no drought designation and 9% of the state was classified as abnormally dry. By early June 2016, 57% of the state was under no drought designation and 43% was classified as abnormally dry. In early May 2016, statewide topsoil moisture indices

were rated as 1% very short, 6% short, 80% adequate and 13% surplus moisture. By early June 2016, statewide topsoil moisture indices were rated as 2% very short, 9% short, 77% adequate and 12% surplus moisture (http://droughtmonitor.unl.edu).

Wetland (Types II-V) numbers in 2016 were 221,000 ponds and unchanged from last year's estimate of 222,000 ponds. This was 21% below the 10-year average and 13% below the long-term average (Table 2; Figure 2). The number of temporary (Type 1) sheet water wetlands was 43% below the long-term average and very few sheet water wetlands were observed except in southwest Minnesota.

Planting dates for row crops were extremely early in 2016. By May 1, about 59% of the corn acres had been planted statewide compared to 27% for the previous 5-year average. By May 29th, about 38% of alfalfa hay had been cut, 12 days ahead of last year and average (Minnesota Agricultural Statistics Service Weekly Crop Weather Reports, (http://www.nass.usda.gov/mn/).

Due to the early spring, leaf-out dates and wetland vegetation growth was about 2-3 weeks earlier than average and visibility was poor during the entire survey.

WATERFOWL POPULATIONS:

The number of ducks, Canada geese, coots, and swans, by stratum, are shown in Tables 3-5; total numbers are presented in Table 6. These estimates are expanded for area but not corrected for visibility bias. Table 7 and Table 8 provide the unadjusted population index (Unad. PI), which is multiplied by the visibility correction factor (VCF) to obtain the population index (PI) for ducks and Canada geese. The standard error (SE) of the estimate is also provided for mallard and blue-winged teal estimates.

The 2016 breeding population estimate of mallards was 243,189 (SE = 42,502), which was 18% higher than the 2015 estimate of 206,229 mallards, but statistically unchanged (Z = 0.65, P = 0.51) (Table 7, Figure 3). Mallard numbers were similar to the 10-year average and 7% above the long-term average of 228,000 mallards. In 2016, the mallard population was comprised of 80% lone or flocked males, 15% pairs, and 5% flocked mallards. The 5-year average is 71% lone or flocked males, 21% pairs, and 8% flocked mallards.

The estimated blue-winged teal population was 317,464 (SE = 92,149), which was 88% higher than the 2015 estimate of 168,615 blue-winged teal, but statistically unchanged (Z = 1.38, P = 0.17). Blue-winged teal numbers were 118% above the 10-year average and 50% above the long-term average (Table 7, Figure 4). The blue-winged teal population was comprised of 7% lone males, 43% pairs, and 49% flocks. The long-term average is 16% lone males, 53% pairs, and 31% flocks. A number of fairly large flocks of teal were observed early in the survey in southwest Minnesota that influenced both the estimate and the standard error.

The combined population estimate of other ducks (excluding scaup) was 207,593 which was 39% above last year's estimate of 149,330 other ducks and 18% above the 10-year average and 17% above the long-term average (Table 7, Figure 5). Scaup, ring-necked ducks and wood ducks were the most abundant species of other ducks (Table 6). Scaup numbers (54,000) were 54% above last year's estimate but 11% below the long-term average.

The total duck population index, excluding scaup, was 768,000 ducks and was 47% above last year's index of 524,000 ducks and 36% above the 10-year average and 25% above the long-term average (Table 8, Figure 6).

The population index for total ducks was 822,000 ducks, which was 40% above the 10-year average and 21% above the long-term average.

Visibility Correction Factors (VCFs) were lower for mallards, blue-winged teal, other ducks, and Canada geese in 2016 compared to 2015 (Table 7, Table 8). The mallard VCF (2.07) was 22% below the 10-year average. The blue-winged teal VCF (4.48) was 14% above the 10-year average. The VCF for other ducks (2.67) was 12% below the 10-year average. The VCF for Canada geese (1.62) was 22% below the 10-year average.

The population estimate of Canada geese (adjusted for visibility) was 108,000, which was 33% below last year's estimate and 32% below the 10-year average (Table 8, Figure 7). A total of 56 Canada goose broods were observed, compared to 23 in 2015.

The estimated coot population, uncorrected for visibility, was 16,000 compared to 10,000 in 2015.

The estimated number of swans (likely trumpeters) was 13,400 swans compared to last year's estimate of 12,600 (Table 6). Lone swans are not doubled and the estimate is expanded for area but not visibility, although visibility of swans is extremely high. Trumpeter swans continue to expand their range and dramatically increase in number.

ACKNOWLEDGEMENTS

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Data supplied by: Minnesota Department of Natural Resources (MNDNR); U.S. Fish and Wildlife Service (USFWS)

Air Crew:

Pilot/Observer: Bob Geving, Conservation Officer Pilot, MNDNR, Division of Enforcement
Observer: Steve Cordts, Waterfowl Staff Specialist, MNDNR, Division of Wildlife

Ground Crew Leaders: Sean Kelly, Deputy Chief, Migratory Birds, USFWS, Region III, Twin Cities; Wayne Brininger, USFWS, Tamarac National Wildlife Refuge; Dan Hertel and Fred Oslund, USFWS, HAPET, Fergus Falls; Tom Cooper, Andy Forbes, Paul Richert, and Jim Kelley, USFWS, Twin Cities; Bruce Davis, Minnesota DNR; Tony Hewitt and Sally Zodrow, USFWS, Sherburne National Wildlife Refuge

Ground Crew Assistants: Rich Olsen, Minnesota DNR; Gina Kemper and J. Wormbold, USFWS, Tamarac National Wildlife Refuge; Tyler Zimmerman and Joe Schmit, USFWS, HAPET, Fergus Falls; Greg Dehmer and Kris Spaeth, USFWS, Sherburne National Wildlife Refuge

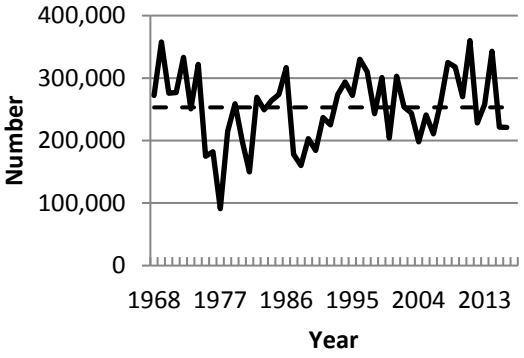

Figure 2. Number of May ponds (Types II-V) and long-term average (dashed line) in Minnesota, 1968-2016.

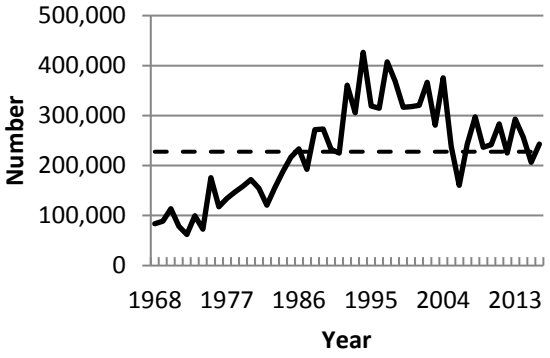

Figure 3. Mallard population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2016.

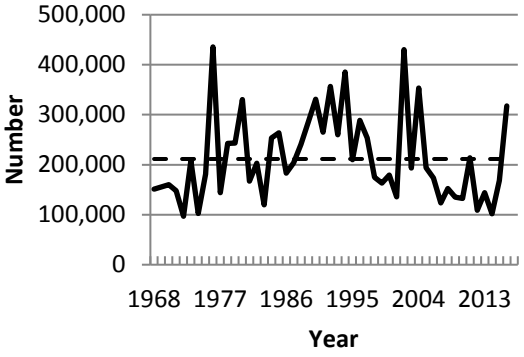

Figure 4. Blue-winged teal population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2016.

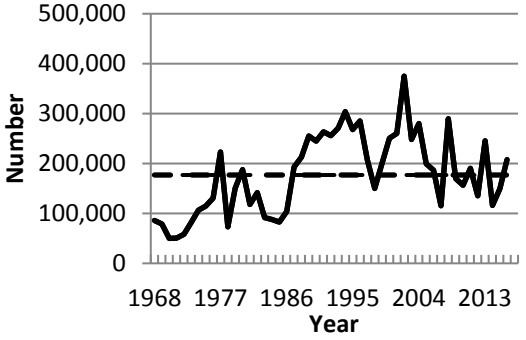

Figure 5. Other duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2016

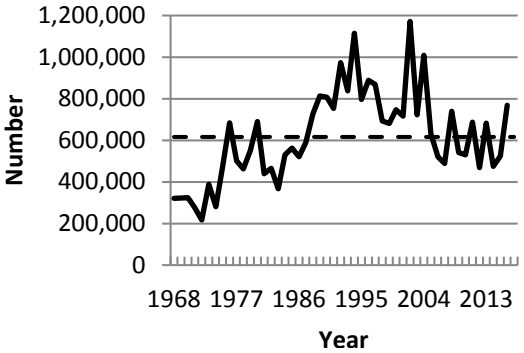

Figure 6. Total duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2016

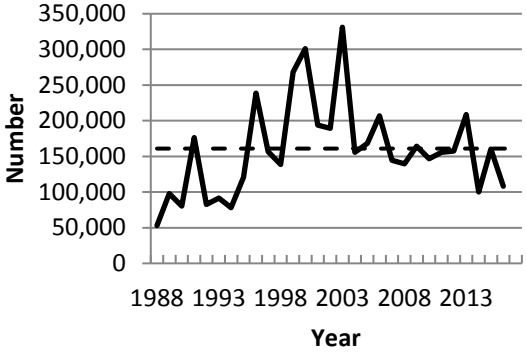

Figure 7. Canada goose population (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1988-2016.

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Table 1. Survey design for Minnesota, May 2016.[1]

	Stratum			
	1	2	3	Total
Survey design				
Square miles in stratum	5,075	7,970	17,671	30,716
Square miles in sample - waterfowl	182.75	136.375	203.125	522.25
Square miles in sample - ponds	91.375	68.1875	101.5625	261.125
Linear miles in sample	731.0	545.5	812.5	2,089.0
Number of transects in sample	39	36	40	115
Minimum transect length (miles)	5	6	7	5
Maximum transect length (miles)	36	35	39	39
Expansion Factor - waterfowl	27.770	58.442	86.996	
Expansion Factor - ponds	55.540	116.884	173.991	
Current year coverage				
Square miles in sample - waterfowl	182.75	136.375	203.125	522.25
Square miles in sample - ponds	91.375	68.1875	101.5625	261.125
Linear miles in sample	731.0	545.5	812.5	2,089.0
Number of transects in sample	39	36	40	115
Minimum transect length (miles)	5	6	7	5
Maximum transect length (miles)	36	35	39	39
Expansion Factor - waterfowl	27.770	58.442	86.996	
Expansion Factor - ponds	55.540	116.884	173.991	

[1] Also, 8 additional air-ground transects (total linear miles = 202.5, range - 10-60 miles) were flown to use in calculating the VCF.

Table 2. Estimated May ponds (Type 1 and Types II-V), 1968-2016.

Year	Number of Ponds[1]		Year	Type 1 wetlands	Number of Ponds[1]
1968	272,000		1991	82,862	237,000
1969	358,000		1992	10,019	225,000
1970	276,000		1993	199,870	274,000
1971	277,000		1994	123,958	294,000
1972	333,000		1995	140,432	272,000
1973	251,000		1996	147,859	330,000
1974	322,000		1997	30,751	310,000
1975	175,000		1998	20,560	243,000
1976	182,000		1999	152,747	301,000
1977	91,000		2000	5,090	204,000
1978	215,000		2001	66,444	303,000
1979	259,000		2002	30,602	254,000
1980	198,000		2003	34,005	244,000
1981	150,000		2004	9,494	198,000
1982	269,000		2005	30,764	241,000
1983	249,000		2006	56,798	211,000
1984	264,000		2007	32,415	262,000
1985	274,000		2008	69,734	325,000
1986	317,000		2009	39,078	318,000
1987	178,000		2010	26,880	270,000
1988	160,000		2011	89,218	360,000
1989	203,000		2012	30,910	228,000
1990	184,000		2013	9,813	258,000
			2014	54,300	343,000
			2015	22,056	222,000
			2016	34,487	221,000
		Averages:	10-year	43,120	279,700
			Long-term	60,666	253,833
		% change from:	2015	56%	0%
			10-year	-20%	-21%
			Long-term	-43%	-13%

[1] Type II-V, correction factor from 1989 (123,000/203,000=0.606) used to adjust 1968-88 pond numbers.

Table 3. Minnesota waterfowl breeding populations by species for Stratum I (high wetland density), expanded for area but not visibility, 1998-2016.

	Year																		
Species	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dabblers:																			
Mallard	33,157	26,576	26,604	28,742	29,297	25,937	29,381	19,050	16,829	16,357	25,104	19,467	18,439	19,856	18,911	21,161	19,522	19,633	26,020
Black Duck	0	0	0	0	0	0	0	56	0	0	0	0	0	0	0	333	167	222	0
Gadwall	1,111	1,777	833	1,333	944	1,250	2,111	1,166	1,444	889	1,166	1,055	1,000	167	1,389	722	555	1,083	1,000
American Wigeon	56	56	56	111	0	56	555	167	0	56	111	56	56	111	222	222	167	111	111
Green-winged Teal	333	0	278	56	278	222	444	56	56	167	278	167	56	56	56	0	0	56	111
Blue-winged Teal	8,220	6,998	11,247	7,387	14,218	9,664	23,771	9,303	5,665	5,332	9,942	5,998	7,304	4,665	5,110	4,193	3,388	4,360	6,998
Northern Shoveler	500	555	1,055	305	1,277	278	1,166	333	167	56	1,000	666	1,027	111	56	333	722	111	666
Northern Pintail	111	167	167	389	56	111	56	0	56	0	56	56	0	111	0	111	167	222	0
Wood Duck	12,302	5,582	10,219	6,720	2,888	4,499	8,081	5,498	3,555	2,666	6,665	4,277	3,999	3,416	4,138	3,249	2,527	2,222	5,610
Dabbler Subtotal	55,790	41,711	50,459	45,043	48,958	42,017	65,565	35,629	27,772	25,523	44,322	31,742	31,881	28,493	29,882	30,324	27,215	28,020	40,516
Divers:																			
Redhead	944	500	583	1,444	750	333	805	666	666	916	1,389	472	944	805	750	861	1,333	583	2,166
Canvasback	1,777	2,971	1,222	2,027	1,833	1,333	666	972	833	1,000	2,277	1,333	1,222	833	722	1,555	1,777	1,027	1,944
Scaup	9,247	1,750	7,415	5,832	2,444	2,055	5,971	4,110	111	555	6,276	8,553	2,777	2,222	1,055	1,000	1,250	5,526	10,969
Ring-necked Duck	2,749	2,360	4,776	2,444	2,777	1,361	5,165	1,722	2,055	1,555	21,494	6,859	3,138	4,804	2,666	3,582	4,554	3,110	8,220
Goldeneye	111	56	56	333	111	0	222	222	56	222	278	278	222	56	56	333	444	278	278
Bufflehead	56	111	56	111	222	111	389	167	222	56	1,611	833	389	278	56	611	56	278	500
Ruddy Duck	11,052	972	0	83	1,305	417	305	1,222	305	0	1,027	861	28	56	0	305	111	694	1,500
Hooded Merganser	389	722	500	722	555	333	278	333	555	111	666	944	555	500	555	333	666	1,000	1,222
Large Merganser	0	0	0	111	0	972	0	111	0	278	333	333	333	111	56	222	139	167	56
Diver Subtotal	26,325	9,442	14,608	13,107	9,997	6,915	13,801	9,525	4,803	4,693	35,351	20,466	9,608	9,665	5,916	8,802	10,330	12,663	26,855
Total Ducks	82,115	51,153	65,067	58,150	58,955	48,932	79,366	45,154	32,575	30,216	79,673	52,208	41,489	38,158	35,798	39,126	37,545	40,683	67,371
Other:																			
Coot	555	83	3,999	1,722	2,888	2,666	21,411	2,444	639	139	16,829	2,166	139	2,194	444	10,386	2,360	1,972	10,608
Canada Goose	16,967	19,495	22,160	24,882	24,104	22,160	23,160	22,938	21,633	29,797	18,717	16,523	16,440	13,691	26,437	23,771	18,578	23,077	17,995
Swan	56	139	0	0	111	1,000	305	417	861	389	694	500	694	1,611	1,277	2,944	1,944	2,472	3,693

Table 4. Minnesota waterfowl breeding populations by species for Stratum II (medium wetland density), expanded for area but not visibility, 1998-2016.

	Year																		
Species	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dabblers:																			
Mallard	53,942	52,247	49,559	44,650	43,773	34,715	44,474	26,883	25,130	24,779	27,935	23,494	21,507	30,974	29,689	27,409	28,987	24,078	32,085
Black Duck	0	0	0	117	0	0	0	0	0	0	0	0	0	0	0	0	0	117	0
Gadwall	584	1,519	3,039	1,636	701	584	3,565	584	1,052	234	3,039	1,169	1,286	935	1,987	701	234	818	1,286
American Wigeon	818	0	468	0	0	0	2,513	117	0	0	351	0	351	0	117	234	0	234	234
Green-winged Teal	351	117	117	117	468	234	234	0	117	0	0	234	117	0	0	117	351	584	0
Blue-winged Teal	13,208	10,578	19,637	9,701	21,390	15,955	30,624	11,513	9,000	8,416	12,740	11,104	8,474	12,390	9,000	4,383	7,364	5,026	10,753
Northern Shoveler	701	2,104	4,675	1,052	2,221	1,403	1,753	234	584	351	468	701	2,513	1,052	0	351	935	877	935
Northern Pintail	468	117	117	117	0	117	0	0	0	234	0	0	0	234	0	0	117	0	0
Wood Duck	10,520	19,753	13,792	7,831	5,143	4,558	8,766	3,273	1,753	2,221	6,546	5,260	6,312	6,955	5,143	4,792	1,636	1,753	4,149
Dabbler subtotal	80,592	86,435	91,404	65,221	73,696	57,566	91,929	42,604	37,636	36,235	51,079	41,962	40,560	52,540	45,936	37,987	39,624	33,487	49,442
Divers:																			
Redhead	935	1,636	2,805	2,455	234	584	1,110	292	175	935	935	584	760	1,578	468	468	526	468	1,110
Canvasback	117	117	935	0	468	1,052	234	0	0	1,169	468	234	117	584	117	935	1,286	1,169	1,403
Scaup	4,032	3,331	6,779	3,039	5,961	2,279	7,188	2,981	468	643	3,097	2,104	0	1,929	935	2,045	2,396	4,909	5,318
Ring-necked Duck	2,279	2,221	5,610	3,799	6,370	2,455	5,377	1,929	3,331	1,578	13,149	9,117	2,396	11,455	1,695	6,253	5,143	4,325	4,792
Goldeneye	234	935	584	468	234	234	351	117	117	0	351	584	468	468	584	935	1,519	935	1,169
Bufflehead	0	0	0	0	1,169	117	468	351	117	117	1,403	818	643	1,403	468	0	818	0	234
Ruddy Duck	0	468	0	0	1,870	2,688	0	351	58	0	0	175	409	58	234	117	0	351	643
Hooded Merganser	117	701	935	1,403	701	701	234	234	351	234	584	701	117	2,221	1,636	701	234	1,169	2,455
Large Merganser	0	0	117	117	0	0	234	351	0	0	351	0	0	234	0	234	117	234	117
Diver subtotal	7,714	9,409	17,765	11,281	17,007	10,110	15,196	6,606	4,617	4,676	20,338	14,317	4,910	19,930	6,137	11,688	12,039	13,560	17,241
Total Ducks	88,306	95,844	109,169	76,502	90,703	67,676	107,125	49,210	42,253	40,911	71,417	56,279	45,470	72,470	52,073	49,675	51,663	47,046	66,683
Other:																			
Coot	643	234	1,110	468	4,909	1,519	8,007	584	292	409	23,961	0	117	292	292	2,571	877	0	0
Canada Goose	19,812	18,585	25,831	24,604	20,688	22,091	28,461	20,688	26,825	25,890	19,753	22,675	18,935	14,201	23,260	22,442	20,572	24,312	17,533
Swan	117	117	58	117	292	994	701	1,461	994	468	1,519	2,922	2,279	7,188	3,507	6,604	3,740	5,318	4,325

Table 5. Minnesota waterfowl breeding populations by species for Stratum III (low wetland density), expanded for area but not visibility, 1998-2016.

	Year																		
Species	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dabblers:																			
Mallard	101,873	90,390	81,690	72,642	72,121	55,156	84,561	36,539	30,884	35,843	50,371	35,408	40,976	51,415	47,848	62,638	62,899	51,154	59,593
Black Duck	0	0	0	0	0	0	174	0	0	174	174	0	0	0	174	174	0	0	0
Gadwall	3,045	2,436	2,610	10,701	3,306	1,566	6,960	2,001	5,568	4,176	870	1,392	1,392	4,089	1,566	5,220	1,914	2,088	9,570
American Wigeon	696	0	522	174	1,218	174	1,566	1,044	174	348	348	174	348	1,044	174	348	174	1,566	870
Green-winged Teal	174	0	1,218	1,392	522	174	0	174	522	0	0	0	0	174	348	696	0	348	0
Blue-winged Teal	26,360	18,530	29,405	20,618	56,374	21,140	39,758	27,578	23,663	15,659	18,095	20,183	16,964	44,716	35,669	18,617	21,227	24,098	53,155
Northern Shoveler	4,176	4,002	20,444	10,701	6,264	870	3,828	348	522	870	4,002	2,088	6,873	2,088	8,265	6,786	522	1,914	4,959
Northern Pintail	870	870	696	522	0	174	348	174	174	348	174	0	174	0	174	174	0	174	522
Wood Duck	23,837	20,531	25,055	17,225	13,572	12,702	20,705	7,482	7,308	5,394	14,442	10,266	12,354	13,659	10,962	12,180	9,657	8,265	8,700
Dabbler subtotal	161,031	136,759	161,640	133,975	153,377	91,956	157,900	75,340	68,815	62,812	88,476	69,511	79,081	117,185	105,180	106,833	96,393	89,607	137,369
Divers:																			
Redhead	2,001	3,480	2,523	3,654	1,305	174	1,740	1,479	0	522	783	870	174	4,350	3,306	1,827	1,566	1,305	1,044
Canvasback	3,306	174	3,915	522	696	1,131	2,784	0	0	348	1,566	1,218	348	1,044	1,044	696	522	696	348
Scaup	15,137	8,961	18,182	6,873	4,611	783	17,747	5,307	1,392	696	5,481	1,914	522	5,133	696	8,874	2,871	435	3,915
Ring-necked Duck	2,958	1,479	8,178	8,526	7,395	1,479	5,133	10,179	6,699	1,392	8,526	6,525	3,045	6,264	9,135	6,960	5,568	3,480	4,089
Goldeneye	696	696	1,044	1,566	3,132	1,305	696	1,044	1,044	870	348	522	174	870	0	348	174	1,218	870
Bufflehead	348	0	0	0	1,218	783	2,088	0	174	696	1,218	870	174	2,871	174	3,915	4,698	522	2,523
Ruddy Duck	0	174	0	696	18,878	87	2,262	870	696	261	87	348	0	3,828	522	522	174	0	87
Hooded Merganser	696	1,218	957	174	2,175	174	1,740	1,218	870	174	696	348	1,218	1,044	1,044	348	348	522	1,392
Large Merganser	0	0	0	0	522	0	0	261	957	348	348	348	348	174	174	0	0	0	870
Diver subtotal	25,142	16,182	34,799	22,011	39,932	5,916	34,190	20,358	11,832	5,307	19,053	12,963	6,003	25,578	16,095	23,490	15,921	8,178	15,138
Total Ducks	186,173	152,941	196,439	155,986	193,309	97,872	192,090	95,698	80,647	68,119	107,529	82,474	85,084	142,763	121,275	130,323	112,314	97,785	152,507
Other:																			
Coot	5,133	14,702	67,684	3,132	14,007	7,134	77,427	8,613	14,702	5,742	15,137	7,047	435	1,479	25,664	27,578	15,746	7,917	5,829
Canada Goose	42,368	41,933	57,940	39,932	33,407	43,412	46,717	39,758	27,230	42,629	31,841	28,274	30,710	32,711	37,496	48,022	24,707	43,498	31,145
Swan	0	348	348	174	0	348	348	522	2,001	1,218	609	1,914	2,175	1,827	1,827	2,088	2,001	4,785	5,394

Table 6. Minnesota waterfowl breeding populations by species for Stratum I-III combined, expanded for area coverage but not for visibility, 1998-2016.

	Year																		
Species	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dabblers:																			
Mallard	188,972	169,213	157,853	146,034	145,191	115,974	158,416	82,472	72,843	76,979	103,411	78,368	80,922	102,245	96,448	111,208	111,408	94,866	117,698
Black Duck	0	0	0	117	0	0	174	56	0	174	174	0	0	0	174	507	167	339	0
Gadwall	4,740	5,733	6,482	13,670	4,951	3,400	12,635	3,752	8,064	5,298	5,075	3,616	3,677	5,191	4,941	6,643	2,703	3,989	11,855
American Wigeon	1,570	56	1,045	285	1,218	230	4,634	1,327	174	404	810	230	754	1,155	513	804	341	1,911	1,215
Green-winged Teal	858	117	1,613	1,564	1,267	630	678	230	694	167	278	400	172	230	404	813	351	988	111
Blue-winged Teal	47,788	36,106	60,288	37,706	91,982	46,759	94,152	48,394	38,328	29,407	40,777	37,286	32,742	61,772	49,779	27,194	31,979	33,484	70,907
Northern Shoveler	5,377	6,661	26,175	12,058	9,762	2,550	6,747	915	1,273	1,276	5,469	3,456	10,413	3,251	8,320	7,470	2,179	2,902	6,560
Northern Pintail	1,449	1,153	979	1,028	56	402	404	174	230	582	230	56	174	345	174	285	284	396	522
Wood Duck	46,659	45,866	49,067	31,777	21,603	21,759	37,553	16,253	12,616	10,281	27,652	19,802	22,664	24,029	20,242	20,221	13,820	12,240	18,459
Dabbler subtotal	297,413	264,905	303,502	244,239	276,030	191,704	315,393	153,573	134,222	124,568	183,876	143,214	151,518	198,218	180,995	175,145	163,232	151,115	227,327
Divers:																			
Redhead	3,880	5,616	5,911	7,552	2,289	1,092	3,656	2,438	842	2,373	3,107	1,926	1,878	6,733	4,523	3,155	3,425	2,356	4,320
Canvasback	5,200	3,262	6,072	2,549	2,996	3,516	3,684	972	833	2,517	4,311	2,785	1,687	2,461	1,883	3,186	3,585	2,892	3,694
Scaup	28,416	14,041	32,376	15,743	13,016	5,117	30,906	12,397	1,971	1,894	14,854	12,571	3,299	9,283	2,686	11,919	6,517	10,870	20,202
Ring-necked Duck	7,986	6,060	18,565	14,768	16,542	5,294	15,675	13,829	12,085	4,525	43,169	22,501	8,579	22,523	13,495	16,795	15,265	10,915	17,101
Goldeneye	1,041	1,687	1,684	2,367	3,477	1,539	1,269	1,383	1,216	1,092	976	1,384	864	1,393	640	1,616	2,138	2,431	2,317
Bufflehead	404	111	56	111	2,609	1,011	2,944	517	513	868	4,231	2,521	1,206	4,551	697	4,526	5,572	800	3,257
Ruddy Duck	11,052	1,613	0	779	22,054	3,192	2,567	2,443	1,060	261	1,114	1,384	437	3,942	756	944	285	1,045	2,229
Hooded Merganser	1,202	2,641	2,392	2,299	3,432	1,209	2,251	1,785	1,776	519	1,947	1,993	1,890	3,765	3,236	1,383	1,248	2,691	5,068
Large Merganser	0	0	117	228	522	972	234	723	957	626	1,032	681	681	519	230	456	256	400	1,042
Diver subtotal	59,181	35,031	67,173	46,396	66,937	22,942	63,186	36,487	21,253	14,675	74,741	47,746	20,521	55,170	28,146	43,980	38,291	34,400	59,230
Total Ducks	356,594	299,936	370,675	290,635	342,967	214,646	378,579	190,060	155,475	139,243	258,617	190,960	172,039	253,388	209,141	219,125	201,523	185,515	286,557
Other:																			
Coot	6,331	15,020	72,793	5,321	21,804	11,319	106,845	11,641	15,633	6,290	55,927	9,213	691	3,965	26,401	40,535	18,984	9,888	16,437
Canada Goose	79,147	80,012	105,932	89,418	78,200	87,663	98,339	83,384	75,688	98,316	70,311	67,473	66,085	60,603	87,193	94,235	63,857	90,887	66,672
Swan	172	604	406	291	403	2,341	1,355	2,400	3,855	2,074	2,823	5,336	5,148	10,626	6,611	11,500	7,700	12,575	13,412

Table 7. Mallard, blue-winged teal, and other duck (excluding scaup) populations in Minnesota, 1968-2016.

	Mallard				Blue-winged teal				Other ducks (exc. scaup)		
Year	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI
1968	41,030	2.04	83,701		61,493	2.44	151,141		41,419	2.08	86,152
1969	53,167	1.67	88,789		45,180	3.45	155,871		34,605	2.27	78,553
1970	67,463	1.69	113,945		31,682	5.06	160,343		30,822	1.62	49,932
1971	47,702	1.65	78,470		42,445	3.49	148,218		29,520	1.71	50,450
1972	49,137	1.27	62,158		49,386	1.96	96,895		34,405	1.69	58,127
1973	56,607	1.76	99,832		53,095	3.92	208,292		33,155	2.45	81,362
1974	44,866	1.62	72,826		39,402	2.59	102,169		38,266	2.79	106,609
1975	55,093	3.19	175,774		45,948	3.95	181,375		34,585	3.31	114,459
1976	69,844	1.69	117,806		89,370	4.87	435,607		39,022	3.35	130,669
1977	60,617	2.21	134,164		37,391	3.86	144,187		18,633	11.95	222,748
1978	56,152	2.61	146,781		28,491	8.53	242,923		22,034	3.30	72,798
1979	61,743	2.57	158,704	28,668	46,708	5.21	243,167	62,226	39,749	3.79	150,545
1980	83,775	2.05	171,957	22,312	50,966	6.49	330,616	40,571	47,322	3.97	188,020
1981	79,562	1.95	154,844	16,402	64,546	2.59	167,258	23,835	30,947	3.80	117,667
1982	51,655	2.33	120,527	17,078	42,772	4.75	203,167	34,503	32,726	4.32	141,501
1983	73,424	2.12	155,762	15,419	42,728	2.81	119,980	20,809	32,240	2.84	91,400
1984	94,514	1.99	188,149	24,065	89,896	2.82	253,821	33,286	40,326	2.18	87,709
1985	96,045	2.26	216,908	32,935	90,453	2.91	263,607	33,369	35,018	2.35	82,383
1986	108,328	2.16	233,598	30,384	68,235	2.69	183,338	28,204	38,900	2.67	103,851
1987	165,881	1.16	192,289	23,500	102,480	1.99	203,718	32,289	76,746	2.51	192,947
1988	155,543	1.75	271,718	38,675	101,183	2.38	240,532	39,512	81,514	2.61	212,988
1989	124,362	2.19	272,968	26,508	90,300	3.16	285,760	39,834	88,109	2.89	254,887
1990	140,879	1.65	232,059	26,316	107,177	3.09	330,659	44,455	124,531	1.97	245,152
1991	128,315	1.75	224,953	28,832	91,496	2.90	265,138	42,057	93,784	2.81	263,619
1992	144,126	2.50	360,870	43,621	93,107	3.83	356,679	53,619	109,779	2.33	255,774
1993	123,771	2.47	305,838	31,103	64,670	4.02	260,070	36,307	82,612	3.28	271,263
1994	138,482	3.08	426,455	66,240	70,324	5.48	385,256	82,580	85,671	3.55	303,847
1995	142,557	2.24	319,433	48,124	47,737	4.40	210,043	40,531	66,096	4.05	267,668
1996	153,473	2.05	314,816	53,461	57,196	5.05	288,913	64,064	107,950	2.64	285,328
1997	160,629	2.54	407,413	65,771	45,496	5.57	253,408	67,526	76,095	2.72	207,316
1998	188,972	1.95	368,450	61,513	47,788	3.66	174,848	33,855	91,478	1.64	149,786

	Mallard				Blue-winged teal				Other ducks (exc. scaup)		
Year	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI
1999	169,213	1.87	316,394	51,651	36,106	4.53	163,499	36,124	80,459	2.49	200,570
2000	157,853	2.02	318,134	36,857	60,288	2.97	179,055	32,189	120,158	2.09	250,590
2001	146,034	2.20	320,560	39,541	37,706	3.60	135,742	19,631	91,152	2.85	260,051
2002	145,191	2.53	366,625	46,264	91,982	4.67	429,934	87,312	92,778	4.04	374,978
2003	115,974	2.42	280,517	34,556	46,759	4.13	193,269	36,176	46,796	5.30	248,019
2004	158,416	2.37	375,313	57,591	94,152	3.75	353,209	56,539	95,105	2.94	279,802
2005	82,472	2.89	238,500	28,595	48,394	4.01	194,125	37,358	46,797	4.26	199,355
2006	72,843	2.21	160,715	24,230	38,328	4.53	173,674	60,353	42,333	4.41	186,719
2007	76,979	3.15	242,481	30,020	29,407	4.20	123,588	20,055	30,963	3.73	115,390
2008	103,411	2.88	297,565	27,787	40,777	3.74	152,359	24,157	99,575	2.91	289,629
2009	78,368	3.02	236,436	36,539	37,286	3.63	135,262	32,155	62,725	2.70	169,568
2010	80,922	2.99	241,884	33,940	32,742	4.04	132,261	27,430	55,076	2.84	156,599
2011	102,245	2.77	283,329	49,845	61,772	3.46	213,584	88,720	79,743	2.39	190,586
2012	96,448	2.33	224,965	45,057	49,779	2.18	108,607	31,971	60,228	2.24	135,017
2013	111,208	2.64	293,239	58,463	27,194	5.29	143,927	46,635	68,804	3.57	245,729
2014	111,408	2.31	256,996	55,366	31,979	3.18	101,640	24,089	51,619	2.24	115,751
2015	94,866	2.17	206,229	37,498	33,484	5.04	168,615	56,787	46,295	3.23	149,330
2016	117,698	2.07	243,189	42,502	70,907	4.48	317,464	92,149	77,750	2.67	207,593
Averages:											
10-year	92,870	2.65	244,384	39,875	38,275	3.93	145,352	41,235	59,736	3.03	175,432
Long-term	102,533	2.23	227,747	37,695	57,027	3.89	211,445	42,463	60,597	3.12	176,942
% change from											
2015	24%	-5%	18%	13%	112%	-11%	88%	62%	68%	-17%	39%
10-year average	27%	-22%	0%	7%	85%	14%	118%	123%	30%	-12%	18%
Long-term average	15%	-7%	7%	13%	24%	15%	50%	117%	28%	-14%	17%

Table 8. Scaup, total ducks (excluding scaup), total ducks, and Canada goose populations in Minnesota, 1968-2016.

	Scaup			Total Ducks (exc. scaup)		Total ducks		Canada geese		
Year	Unad. PI	VCF	PI	Unad. PI	PI	Unad. PI	PI	Unad. PI	VCF	PI
1968	22,834	2.08	47,495	144,392	320,994	167,226	368,488			
1969	9,719	2.27	22,062	132,952	323,213	142,671	345,275			
1970	12,105	1.62	19,610	129,967	324,219	142,072	343,829			
1971	5,713	1.71	9,764	119,667	277,137	125,380	286,901			
1972	12,062	1.69	20,379	132,928	217,181	144,990	237,560	366		
1973	10,633	2.45	26,093	142,857	389,486	153,490	415,580	1,965		
1974	18,378	2.79	51,201	122,534	281,605	140,912	332,806	8,835		
1975	9,563	3.31	31,649	135,626	471,608	145,189	503,257	5,997		
1976	22,494	3.35	75,323	198,236	684,082	220,730	759,405	5,409		
1977	2,971	11.95	35,517	116,641	501,099	119,612	536,616	7,279		
1978	14,774	3.35	48,812	106,677	462,502	121,451	511,314	7,865		
1979	92,134	3.79	348,948	148,200	552,416	240,334	901,364	4,843		
1980	12,602	3.97	50,070	182,063	690,593	194,665	740,663	6,307		
1981	19,844	3.88	75,451	175,055	439,769	194,899	515,220	10,156		
1982	21,556	4.32	93,204	127,153	465,195	148,709	558,399	6,600		
1983	9,551	2.84	27,077	148,392	367,142	157,943	394,219	11,081		
1984	15,683	2.18	34,111	224,736	529,679	240,419	563,790	14,051		
1985	7,409	2.35	17,430	221,516	562,898	228,925	580,328	16,658		
1986	6,247	2.67	16,678	215,463	520,787	221,710	537,465	19,599		
1987	10,306	2.51	25,910	345,107	588,954	355,413	614,864	29,960		
1988	10,545	2.61	27,553	338,240	725,238	348,785	752,791	39,057	1.36	53,004
1989	71,898	2.89	207,991	302,771	813,615	374,669	1,021,606	51,946	1.88	97,898
1990	40,075	1.97	78,892	372,587	807,870	412,662	886,761	58,425	1.37	80,147
1991	40,727	2.81	114,480	313,595	753,710	354,322	868,191	42,231	4.18	176,465
1992	66,071	2.33	153,939	347,012	973,323	413,083	1,127,262	33,965	2.43	82,486
1993	11,801	3.28	38,750	271,053	837,172	282,854	875,921	43,858	2.08	91,369
1994	57,670	3.55	204,536	294,477	1,115,558	352,147	1,320,095	48,595	1.68	77,878
1995	28,421	4.05	115,096	256,390	797,144	284,811	912,241	58,065	2.08	120,775
1996	65,585	2.64	173,351	318,619	889,057	384,204	1,062,408	60,870	3.92	238,708
1997	31,138	2.72	84,834	282,220	868,137	313,358	952,971	60,449	2.59	156,817
1998	28,416	1.64	46,528	328,238	693,084	356,654	739,612	79,147	1.75	138,507
1999	14,041	2.49	35,002	285,778	680,463	299,819	715,465	80,012	3.35	268,168

	Scaup			Total Ducks (exc. scaup)		Total ducks		Canada geese		
Year	Unad. PI	VCF	PI	Unad. PI	PI	Unad. PI	PI	Unad. PI	VCF	PI
2000	32,376	2.09	67,520	338,299	747,779	370,675	815,299	105,932	2.84	301,298
2001	15,743	2.85	44,914	274,892	716,353	290,653	761,267	89,418	2.17	193,887
2002	13,016	4.04	52,606	327,951	1,171,537	340,967	1,224,143	78,200	2.42	189,353
2003	5,117	5.30	27,120	209,529	721,805	214,646	748,925	87,663	3.78	331,094
2004	30,906	2.94	90,926	347,673	1,008,324	378,579	1,099,250	98,339	1.58	155,859
2005	12,397	4.26	52,811	177,663	631,980	190,060	684,791	83,384	2.02	168,469
2006	1,971	4.41	8,692	153,504	521,109	155,475	529,801	75,688	2.73	206,757
2007	1,894	3.73	7,058	137,349	488,517	139,243	495,575	98,316	1.47	144,289
2008	14,854	2.91	43,205	243,763	739,553	258,617	782,758	70,311	1.99	139,708
2009	12,571	2.70	33,979	178,379	541,266	190,950	575,245	67,473	2.44	164,405
2010	3,299	2.84	9,380	168,740	530,744	172,039	540,124	66,085	2.22	146,960
2011	9,283	2.39	22,186	244,105	687,499	253,043	709,685	60,603	2.57	155,750
2012	2,686	2.24	6,021	206,455	468,589	209,141	474,610	87,193	1.81	157,706
2013	11,919	3.57	42,568	207,206	682,895	219,125	725,463	94,235	2.22	208,825
2014	6,517	2.24	14,614	195,006	474,387	201,523	489,001	63,857	1.57	100,255
2015	10,870	3.23	35,062	174,645	524,174	185,515	559,236	90,887	1.77	160,427
2016	20,202	2.67	53,939	266,355	768,246	286,557	822,185	66,672	1.62	108,009
Averages:										
10-year	7,586	3.03	22,277	190,915	565,873	198,467	588,150	77,465	2.08	158,508
Long-term	20,591	3.12	60,758	220,131	616,280	240,716	677,038	48,436	2.30	160,974
% change from										
2015	86%	-17%	54%	53%	47%	54%	47%	-27%	-8%	-33%
10-year average	166%	-12%	142%	40%	36%	44%	40%	-14%	-22%	-32%
Long-term average	-2%	-14%	-11%	21%	25%	19%	21%	38%	-29%	-33%

APPENDIX A.

Precipitation in selected regions of Minnesota, 20 April - 20 May 2016 (Source: Minnesota DNR; http://www.dnr.state.mn.us/climate/historical/summary.html).

Region	Precipitation	Departure from normal
Northwest	1.47	-1.08
North Central	1.71	-0.98
Northeast	1.65	-1.14
West Central	2.44	-0.28
Central	3.00	-0.39
East Central	3.17	-0.02
Southwest	4.47	1.20
South Central	4.12	-0.14
Southeast	2.80	-0.43
Statewide	2.80	-0.43

Waterfowl information is taken from the U.S. Fish and Wildlife Service report Waterfowl Population Status, 2016 by Joshua Dooley, Pamela Garrettson, Walt Rhodes, and Nathan Zimpfer. The entire report is available on the Division of Migratory Bird Management website (**http://www.fws.gov/birds/surveys-and-data/reports-and-publications.php**).

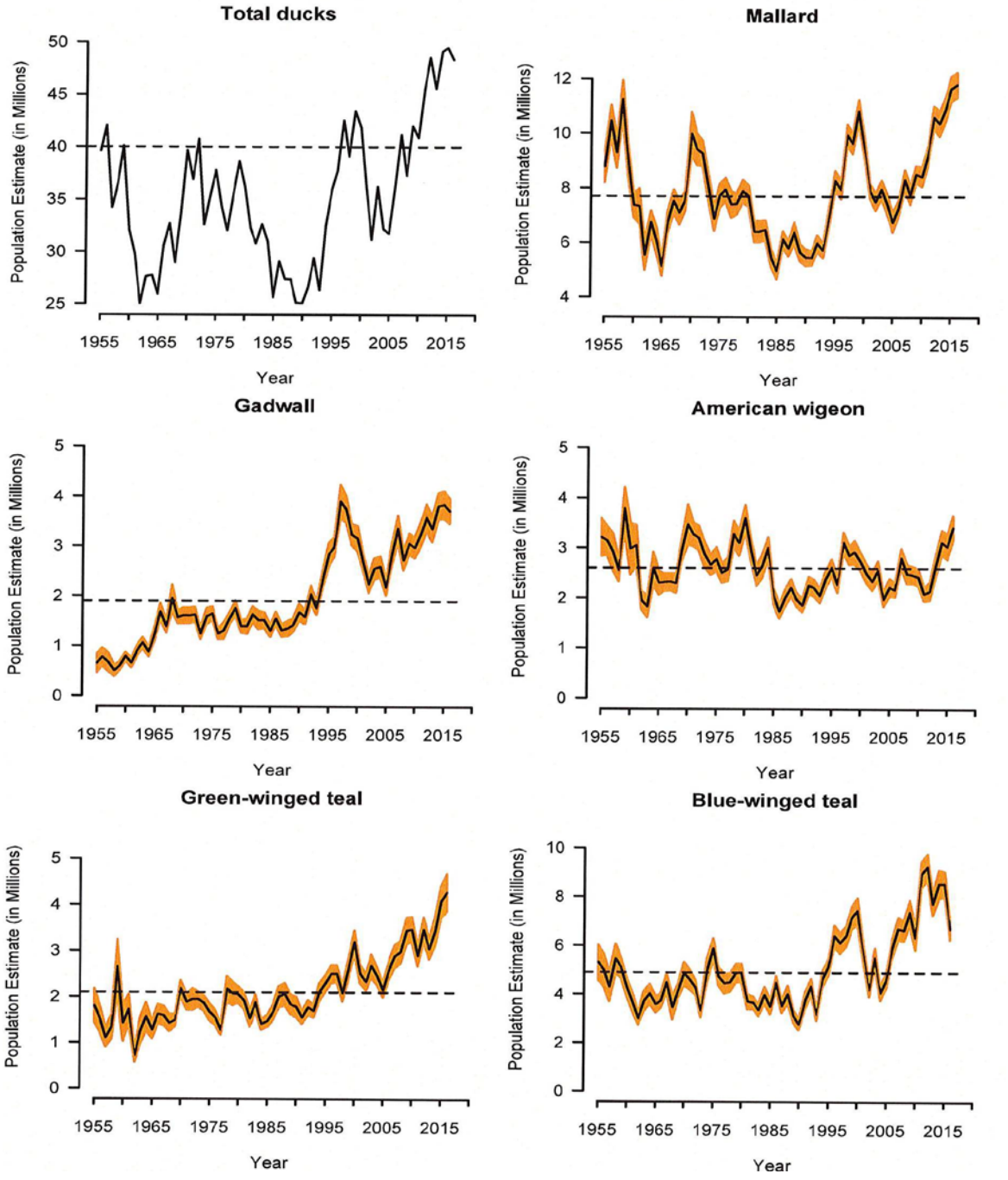

Figure 1 Estimates of North American breeding populations, 90% confidence intervals, and North American Waterfowl Management Plan population goal (dashed line) for selected species and number of water areas in May in Prairie Canada and Northcentral U.S (from: U.S. Fish and Wildlife Service 2015).

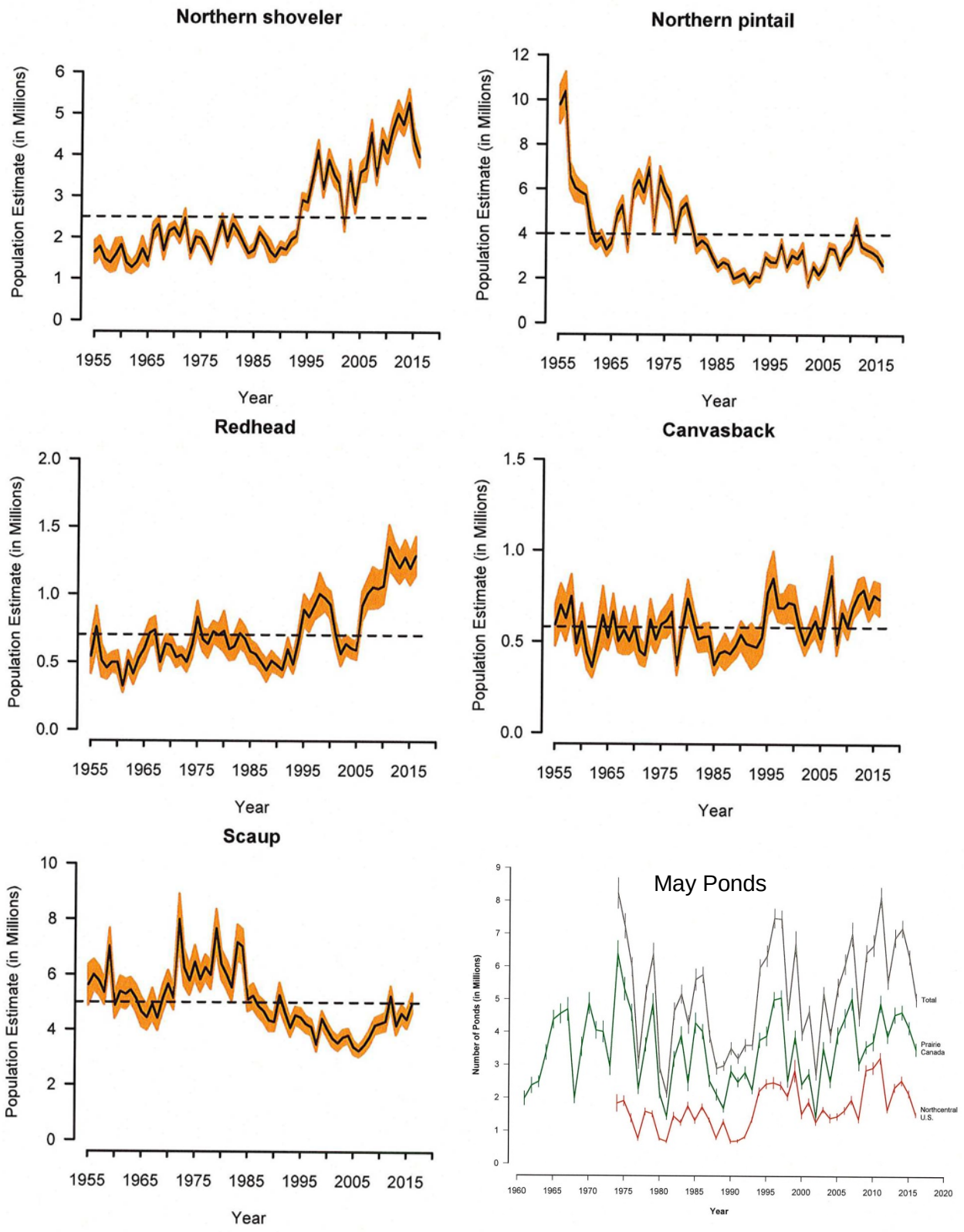

Figure 1 (continued).

2016 MINNESOTA SPRING CANADA GOOSE SURVEY

Matt Weegman, Wetland Wildlife Populations and Research Group

INTRODUCTION

This report presents results from the sixteenth year of a spring helicopter survey of locally nesting Canada geese (*Branta canadensis*) in Minnesota. Minnesota Department of Natural Resources (MNDNR) personnel developed the survey per a request from the Mississippi Flyway Council to produce a statewide population estimate having 95% confidence intervals (CI) that are within ± 25% of the estimate for this bird species.

METHODS

MNDNR Wetland Group staff initiated surveys for resident Canada geese in 2001 (Maxson 2002). Using the boundaries of the Prairie Parkland, Eastern Broadleaf Forest, Tallgrass Aspen Parklands, and Laurentian Mixed Forest provinces, they divided the state into 3 ecoregions (Aaseng et al. 2005). They combined the Eastern Broadleaf Forest and Tallgrass Aspen Parklands provinces to create the Transition ecoregion, renamed the Prairie Parkland province the Prairie ecoregion, and renamed the Laurentian Mixed Forest province the Forest ecoregion (Figure 1). Maxson (2002) excluded the 7-county Metro area from the Transition ecoregion and Lake County, Cook County, and Boundary Waters Canoe Area from the Forest ecoregion. Using Public Land Survey quarter section boundaries and ArcView, Maxson (2002) assigned quarter sections of the remaining counties to the appropriate ecoregion, which yielded 304,929 quarter section plots (hereafter plots).

From 2002–2007, they used a double sampling design. First, Maxson (2002) randomly selected 900 plots within each ecoregion (prairie, transition, and forest), which yielded a sampling frame of 2,700 total plots (Table 1). Maxson (2002) used National Wetland Inventory Circular 39 data and DNR 1:24,000 lakes GIS layers to stratify plots by habitat quality using the following classification variables: 1) total acres of type 3, 4, and 5 wetlands; 2) total acres of type 3 wetlands; 3) total acres of 1:24,000 lakes, and; 4) total acres of riverine habitat. This sampling design yielded 9 strata (Table 1) defined by the ecoregion and the expected number of pairs of resident Canada geese: 1) no nesting habitat – expect no geese, 2) limited nesting habitat – habitat capable of supporting 1 or 2 pairs of geese (e.g. F12 is Forest ecoregion habitat capable of supporting 1 or 2 pairs of geese), 3) prime nesting habitat – habitat capable of supporting 3 or more pairs (e.g., prime nesting habitat in the prairie is identified as P3). They did not survey plots in the “0 pairs” strata and the Forest ecoregion ≥3 pairs habitat-quality stratum did not contain any plots (Table 1). They implemented the second part of the double sampling design by randomly selecting 30 plots from the remaining 5 strata to survey each year, for a sample size of 150 plots.

Rave (2008) eliminated the double sampling design and randomly selected 30 plots per strata from the entire sampling frame excluding the “0” pairs strata (*n* = 128,031 plots; Table 1). He also excluded Lake of the Woods and the Northwest Angle from the Forest ecoregion. They

used the same stratification criteria and field protocols to survey resident Canada geese for all years. Thus, results should be comparable among years.

Rave (2011) further modified the sampling frame to include a binary stratification variable, which permitted a domain analysis of total geese in a proposed intensive harvest goose hunting zone (Figure 1). Using proportional allocation per strata, they randomly selected 30 plots in the proposed hunting zone and 130 plots from outside the zone for a total of 160 plots (Figure 1). The Intensive Harvest Zone that was used from 2012-2015 to delineate boundaries for an August Canada goose conservation action and an increase in daily bag limit (10 geese daily) during the September Canada goose season was larger than the proposed zone used here (see Minnesota Waterfowl Hunting Regulations Booklet, 2013, 2014, 2015). However, we continue to use the proposed zone to monitor changes in goose numbers in a portion of the intensive harvest area.

I used the methods that were established by Rave (2011) and randomly selected survey plots from each of the 9 strata using the AlaskaPak Version 3.0 toolkit in ArcGIS 10.2, using the Select Random Features tool (Sarwas 2011). I randomly selected the following plots; 5 plots in P3_Aug; 26 plots in P3; 14 plots in P12_Aug; 20 plots in P12; 9 plots in T12_Aug; 26 plots in T12; 30 plots in F12; 2 plots in T3_Aug, and 29 plots in T3 for a total of 161 plots.

Minnesota DNR Natural Resource Pilot John Heineman and I began the survey on 18 April and finished on 29 April (Figure 2), approximately 2 days earlier than the average start and end date. Surveys were flown in a military surplus OH-58 or an Enstrom 480B. While surveying a plot we flew at an altitude that allowed for best visibility of Canada geese (approximately 20 – 80 meters AGL (Figure 9). We surveyed each plot completely and typically flew 2 – 3 circles around each wetland basin in the plot to be confident that we did not miss any geese. All geese observed within a plot were recorded on a data sheet developed by Rave (2011) and subsequently entered into Microsoft Excel.

We recorded Canada geese seen within plot boundaries as singles, pairs, or groups (≥ 3 geese together; Figure 2). We doubled the number of singles and pairs prior to estimating population size. We did not survey the Twin Cities where there is a significant number of nesting Canada geese, but have used an earlier estimate (Cooper 2004) to approximate the number of geese in Minnesota.

We used statistical software Program R, version 3.2.4 and RStudio, version 0.99.896 to perform exploratory data analysis (EDA; R Core Team 2016; see Figures 2 - 5) prior to running the population estimate code to generate Figure 6.

RESULTS AND DISCUSSION

Total time spent surveying plots was approximately 399 minutes, or on average 2.47 minutes per plot. Our total flight time from 8 days of surveys was 42.3 hours. Approximately 15.7% of the time in the air was spent surveying plots while 84.2% of the time was spent enroute.

We counted a total of 100 pairs, 77 singles, and 61 birds in groups to yield a population estimate (± 95% CI) of 201,654 (± 64,297) resident Canada geese for the sampling frame (Table 2). The 2016 resident Canada goose population estimate was comparable to estimates calculated for 2014 and 2015. Relative error (95% CI half-width) was 31.9% of the estimate. The large annual confidence intervals do not indicate differences between any years, but a general pattern indicates an increase in population size from 2001 to 2006 and then again from 2007 to 2012, with population declines in 2007, 2013, and 2016 (Figure 6). The population size was lower from 2013-2015 and declined in 2016 to the lowest point estimate since surveys began in 2001. Canada goose population estimates were similar to 2015 in the Prairie

Ecoregion, but were the lowest on record in the Transition and Forest ecoregions (same as 2009 in Forest; Table 2).

We added 17,500 geese for the Twin Cities metro area (Cooper 2004), which yielded a statewide population estimate of 219,154 resident Canada geese (Table 2). The 2016 statewide population estimate represents the first year that this estimate has been below the state Canada goose population goal of 250,000 resident Canada geese.

Of the total number of Canada geese we detected, 37.1% were singles, 48.2% pairs, and 14.7% were in groups (Table 3; Figure 7). We used single birds to develop an index to nesting effort and used it to calculate a productivity estimate of 37.1% (Table 3). The proportion of productive Canada geese for 2016 was slightly less than but comparable to the estimates for 2014 and 2015 (Table 3).

All nine stratum had geese occupy a proportion of the plots. The stratification generally worked well, with >60% of the plots occupied in the ≥3 Canada goose density plots and generally <35% of the 1-2 geese/plot strata occupied (except T3 = 60% occupancy, *n*=8) having ≥ 1 Canada goose (Figure 3). The lowest proportion of plots with ≥ 1 Canada goose occurred in the forest (F12, *n*=30 plots) with only 20% of plots having at least one Canada goose.

The total number of geese was comparable across strata (Figure 4). There were two outliers in strata P3 (after doubling the singles and pairs) with approximately 49 geese in one plot and 25 in another. Aside from the outliers, the number of geese per Eco-province was fairly consistent throughout (Figure 5).

Weather conditions from March – May were likely important factors affecting Canada goose productivity. The average temperature in Minnesota from October 2015 to March 2016 was the second warmest on record and approximately 4.5°C warmer than the 20th Century average for the same time period (National Oceanic and Atmospheric Administration 2016). Median lake ice-out dates for 2016 varied across the state. Some lakes in southern Minnesota opened up after much warmer than average days during the first week of March. On Lake Minnetonka, ice-out was March 17 which was the earliest ice-out in 139 years (Minnesota Department of Natural Resources 2016). Ice-out for Mille Lacs Lake was April 5, approximately 20 days earlier than median ice-out. Lower Red lake lost its ice on and 19 April, approximately 9 days earlier than the median. Rainy Lake lost its ice on April 30, approximately 4 days earlier than the median ice out.

This is the last consecutive spring helicopter goose survey. We plan to use a redesigned May waterfowl survey (Cordts 2016) to estimate goose numbers next year. The May waterfowl survey population estimate for geese tends to be lower (see Figure 8) using current methods because the survey only covers 39% of the State. In addition, when the geese first hatch, they hide making them difficult for both aerial and ground crews used in the May survey to observe. The redesigned May survey will cover the majority of the State and will use a helicopter, which should reduce at least some of the problems. Our goal was to survey plots during mid-incubation. The above average temperature and early lake ice out suggests many pairs should have been in the incubation stage of the nesting cycle when we conducted the survey.

ACKNOWLEDGEMENTS

John Heineman piloted the helicopter and served as the second observer. Chris Scharenbroich assisted in providing GPS coordinates of plots to the pilot and making area maps. Dave Rave and Jeff Lawrence provided guidance on conducting surveys and historical context for the surveys. John Giudice provided statistical support. This project was funded in part by the Wildlife Restoration (Pittman-Robertson) Program.

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Table 1. Sampling frames used to conduct spring Canada goose surveys in Minnesota from 2001 – 2007 (*n*=2,700 plots) and 2008 – 2016 (*n* = 304,929 plots). Ecoregion is the combination of provinces across the state. Strata are determined by type and acres (ac) of wetlands and rivers per quarter section plot.

			N plots in sample frame by period	
Ecoregion	Strata	National Wetland Inventory Data	2001 – 2007[a]	2008 – 2016 [b,c]
Prairie	0 pairs[d]	Type 3, 4, and 5 wetlands <0.5 ac and rivers <10.0 ac all water	476	61,597
	1-2 pairs	Type 4 and 5 wetlands >0.5 ac but type 3 <15.0 ac or type 3, 4, and 5 <0.5 ac and rivers >10.0 ac all water	344	30,751
	≥ 3 pairs	Type 3 >15.0 ac but plot not all water	80	9,533
Transition	0 pairs[d]	Type 3, 4, and 5 wetlands <1.0 ac and rivers <8.0 ac or plot all water	377	39,484
	1-2 pairs	Type 3, 4, and 5 wetlands 1.0–25.0 ac or >25.0 ac, but type 3 <15.0 ac or type 3, 4, and 5 <1.0 ac and rivers >8.0 ac	428	29,048
	≥ 3 pairs	Type 3, 4, and 5 wetlands >25.0 ac, but type 3 >15.0 ac and plot not all water	95	8,015
Forest	0 pairs[d]	Type 3, 4, and 5 wetlands <2.0 ac and rivers <2.0 ac or plot all water	510	75,835
	1-2 pairs	Type 3, 4, and 5 wetlands >2.0 ac but plot not all water or type 3, 4, and 5 <2.0 ac and rivers >2.0 ac	390	50,666
	≥ 3 pairs	None	0	0
Total			2,700	304,929

[a] From 2001-2007, double-sampling was used to estimate stratum weights and the survey plots were randomly drawn from a sample of 900 plots in each Ecoregion.

[b] The entire sampling frame was re-stratified in 2008 and Lake of the Woods and the NW Angle were removed from the sampling frame. The sampling frame was adjusted slightly in 2009 because of some processing errors in 2008. The population estimates for 2008–2016 are based on the updated sampling frame.

[c] From 2011-15, a portion of the potential survey plots were in the original proposed intensive harvest goose hunting zone (Fig. 1). These included 9,674 of the 1-2 pair plots and 3,400 of the >3 pair plots in the Prairie Ecoregion and 5,777 of the 1-2 pair plots and 1,479 of the > 3 pair plots in the Transition Ecoregion.

[d] The 0-pair strata were excluded from the random selection process.

Table 2. Population estimates of resident Canada geese for prairie transition, and forest ecoregions, ecoregions combined ±95% confidence interval (CI), the seven-county Twin cities metro area (see Figure 1), and state of Minnesota, 2001-2015 (*n*=150 plots 2001-2007, *n*=160 plots 2008-2015, *n*=161 plots 2016).

Year	Prairie	Transition	Forest	Subtotal	95% CI	Metro	Statewide
2001	77,360	95,470	92,390	265,220	69,500	20,000	285,220
2002	135,850	144,900	33,940	314,690	134,286	20,000	334,690
2003	106,520	121,290	56,420	284,230	78,428	20,000	304,230
2004	128,501	130,609	95,636	354,747	107,303	20,000	374,747
2005	113,939	149,286	57,529	320,754	90,541	17,500	338,254
2006	126,042	164,085	67,994	358,071	108,436	17,500	375,571
2007	137,151	99,274	25,509	261,933	80,167	17,500	279,433
2008	113,483	127,490	30,400	271,373	69,055	17,500	288,872
2009	129,116	114,738	23,645	267,497	70,607	17,500	284,996
2010	83,911	151,903	57,422	293,235	70,760	17,500	310,734
2011	143,266	117,711	91,199	352,175	119,814	17,500	369,674
2012	144,762	166,727	104710	416,198	132,344	17,500	433,698
2013	104,907	91,652	54,044	250,602	73,122	17,500	268,102
2014	94,664	122,438	27,022	244,123	77,836	17,500	261,623
2015	97,847	114,986	37,156	249,988	61,291	17,500	267,488
2016	99,499	78,511	23,645	201,654	64,297	17,500	219,154

*Prior to 2008, double-sampling was used to estimate stratum weights. The entire sampling frame was re-stratified in 2008 and Lake of the Woods and the NW Angle were removed from the sampling frame. The sampling frame was adjusted slightly in 2009 because of some processing errors in 2008. The population estimates for 2008–2016 are based on the updated sampling frame.

Table 3. Percent of Canada geese seen as singles, pairs, groups, and productive geese on the Minnesota Spring Canada Goose Survey, 2001-2016.

Year	Singles[a]	Pairs[b]	Groups	Productive Geese[b]	Survey period
2001	27	63.9	9.1	36.4	4/14 to 5/02/2001
2002	30.7	52	17.2	41.5	4/26 to 5/11/2002
2003	27.9	58.2	13.9	29.3	4/22 to 5/01/2003
2004	26.5	57.5	16	35.5	4/22 to 5/04/2004
2005	33	50.2	16.8	40.7	4/20 to 5/03/2005
2006	43.5	45.9	10.6	50.3	4/24 to 5/05/2006
2007	31	51.5	17.5	36.2	4/23 to 4/28/2007
2008	38.4	55.4	6.2	42.6	4/23 to 5/05/2008
2009	41.8	50.7	7.5	45.2	4/21 to 5/01/2009
2010	42.5	48.2	9.3	46.6	4/15 to 4/20/2010
2011	50.3	47.2	2.6	55.7	4/21 to 4/29/2011
2012	30	49.6	20.4	35.1	4/16 to 4/23/2012
2013	27.1	67.8	5.1	29.8	5/06 to 5/14/2013
2014	39.3	55.1	5.6	44	4/21 to 5/04/2014
2015	38.5	56.4	5.1	41.6	4/20 to 4/28/2015
2016	37.1	48.2	14.7	37.1[c]	4/18 to 4/29/2016

[a] Singles and pairs were doubled before calculating proportions

[b] Productive Canada geese = singles + pairs with nests

[c] Productive Canada geese = singles

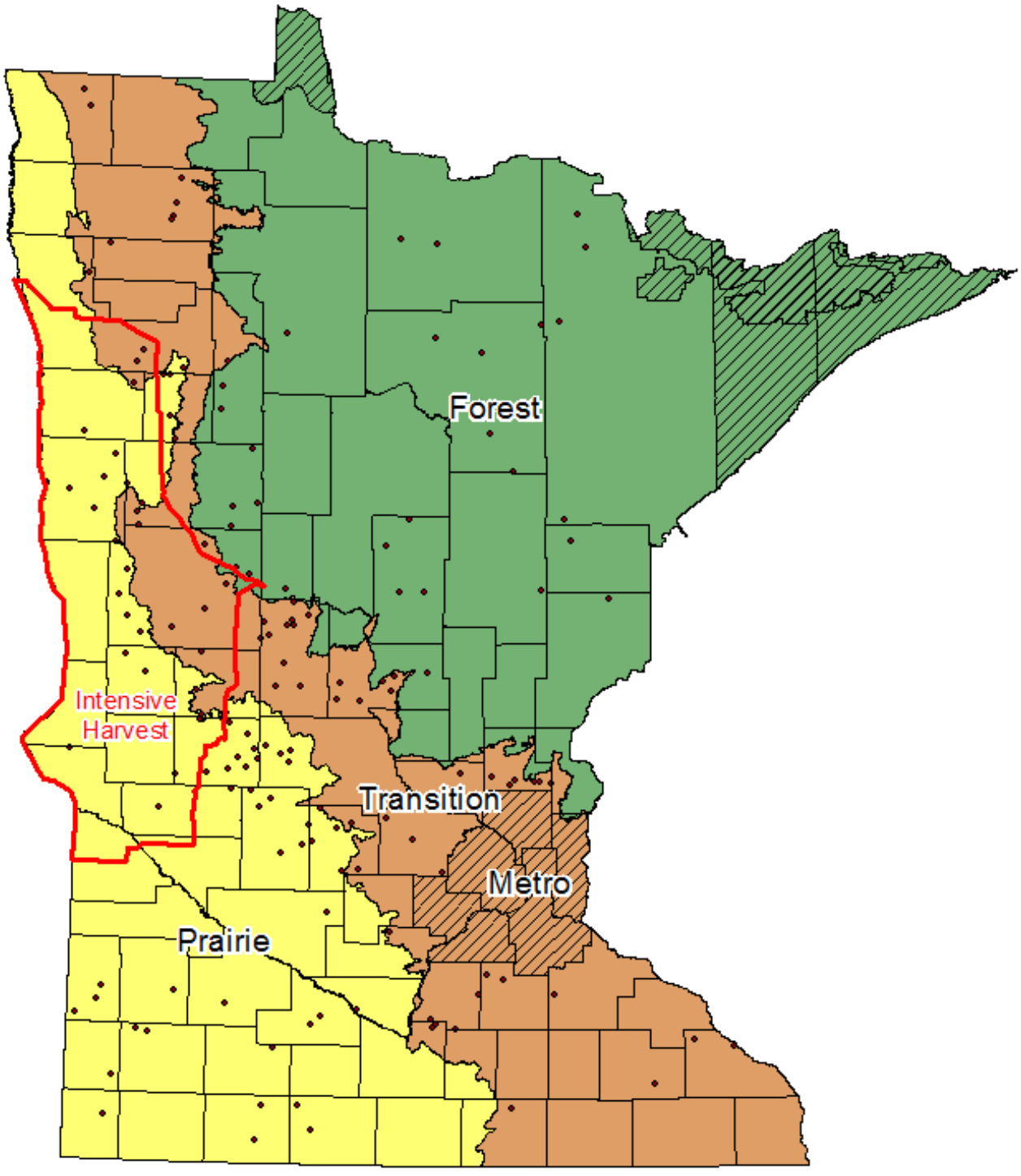

Figure 1. Location of 161 quarter section plots surveyed during the 2016 spring Canada goose survey. Plots are distributed among the Prairie, Transition, and Forest ecoregions. Cross-hatched areas were not included in the survey. The polygon delineated in red designates a portion of the Intensive goose harvest zone.

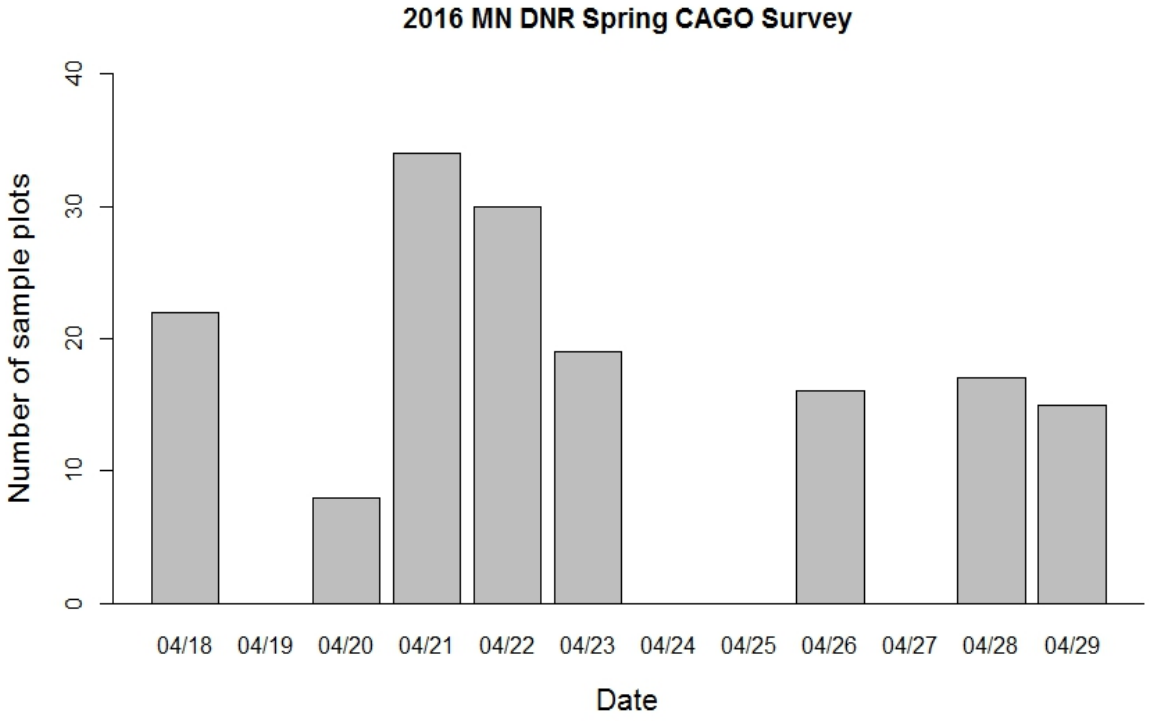

Figure 2. Number of sample plots surveyed by date. Dates without data indicate that surveys were not flown that day.

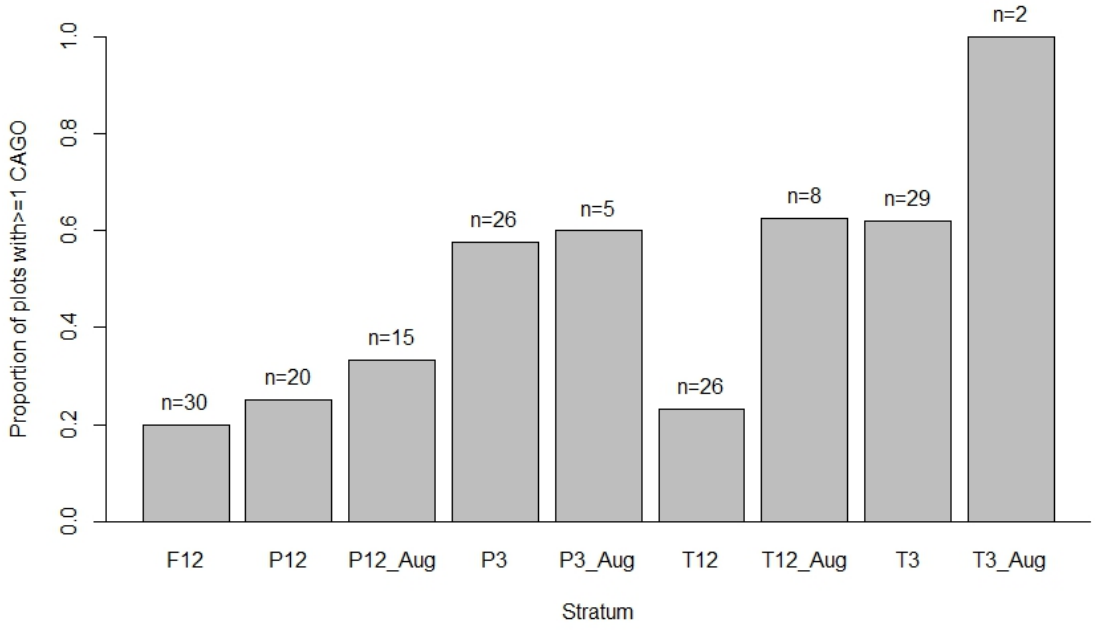

Figure 3. Percent of plots by stratum with ≥ 1 Canada goose counted (*n*=number of plots in each strata).

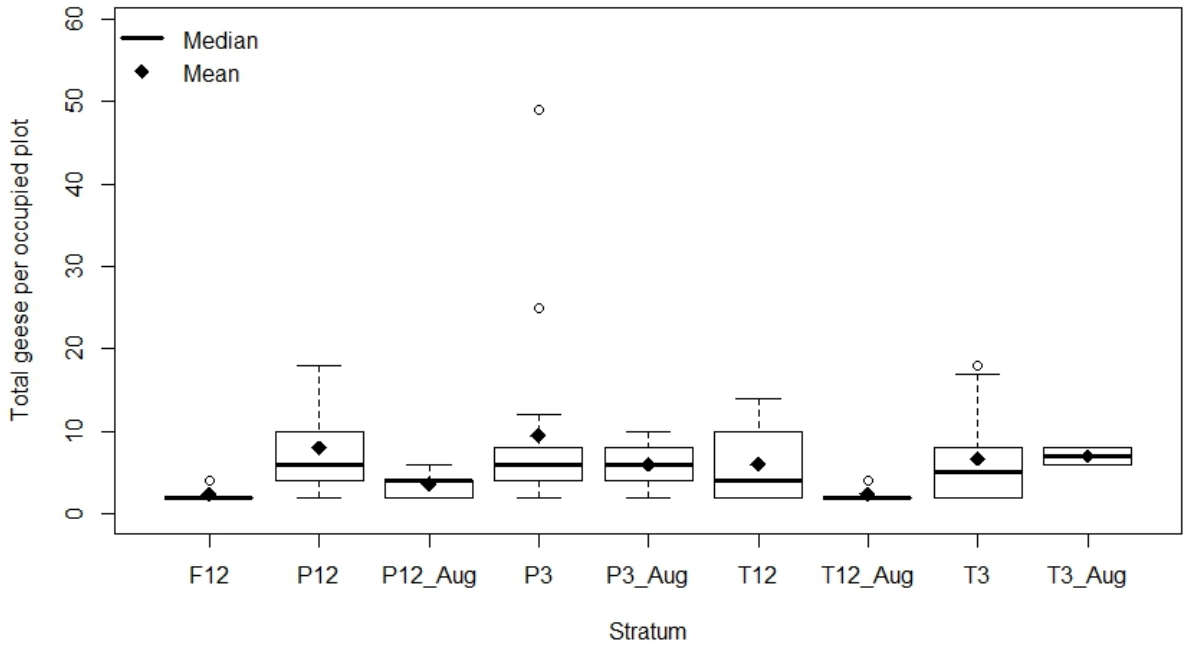

Figure 4. Mean and median number of geese per occupied plot in each strata.

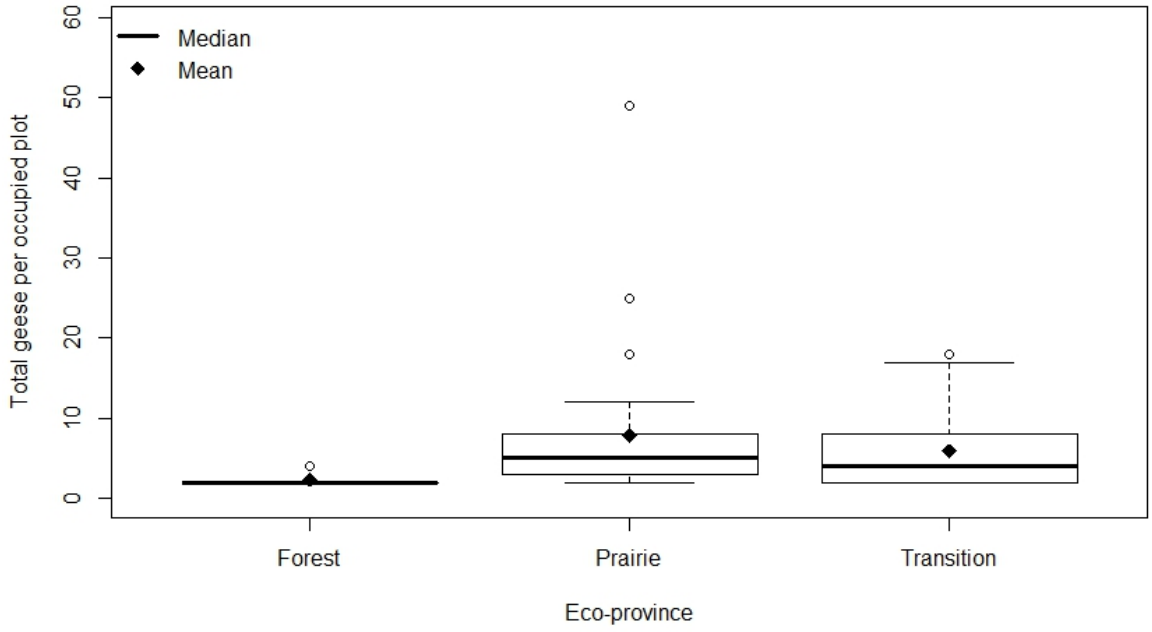

Figure 5. Mean and median number of geese per occupied plot per Eco-province.

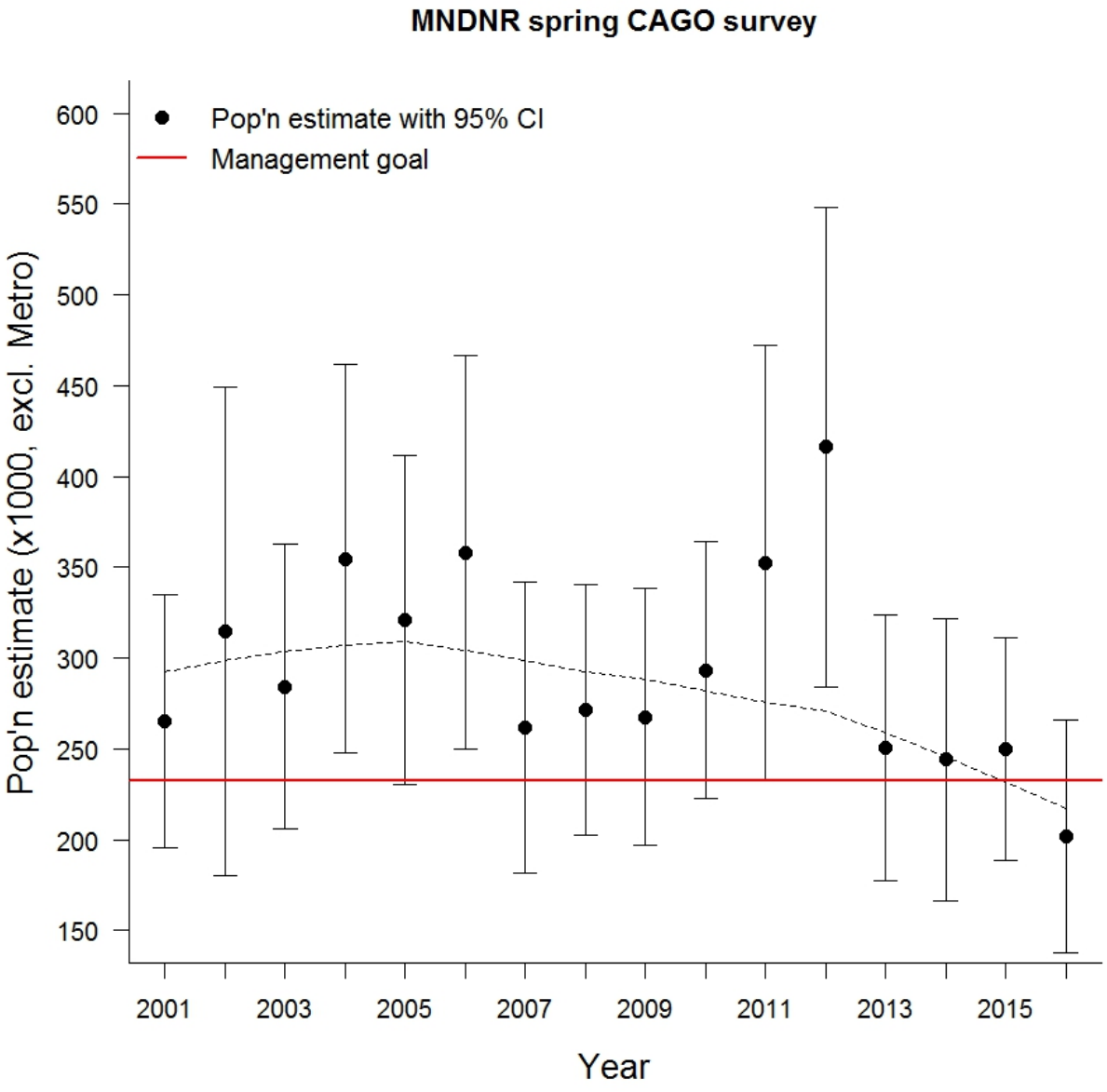

Figure 6. Resident Canada goose population estimates (± 95% CI) in Minnesota (excluding Metro), 2001–2016. The management goal is 250,000 Canada geese (250,000 – 17,500 Metro geese = 232,500).

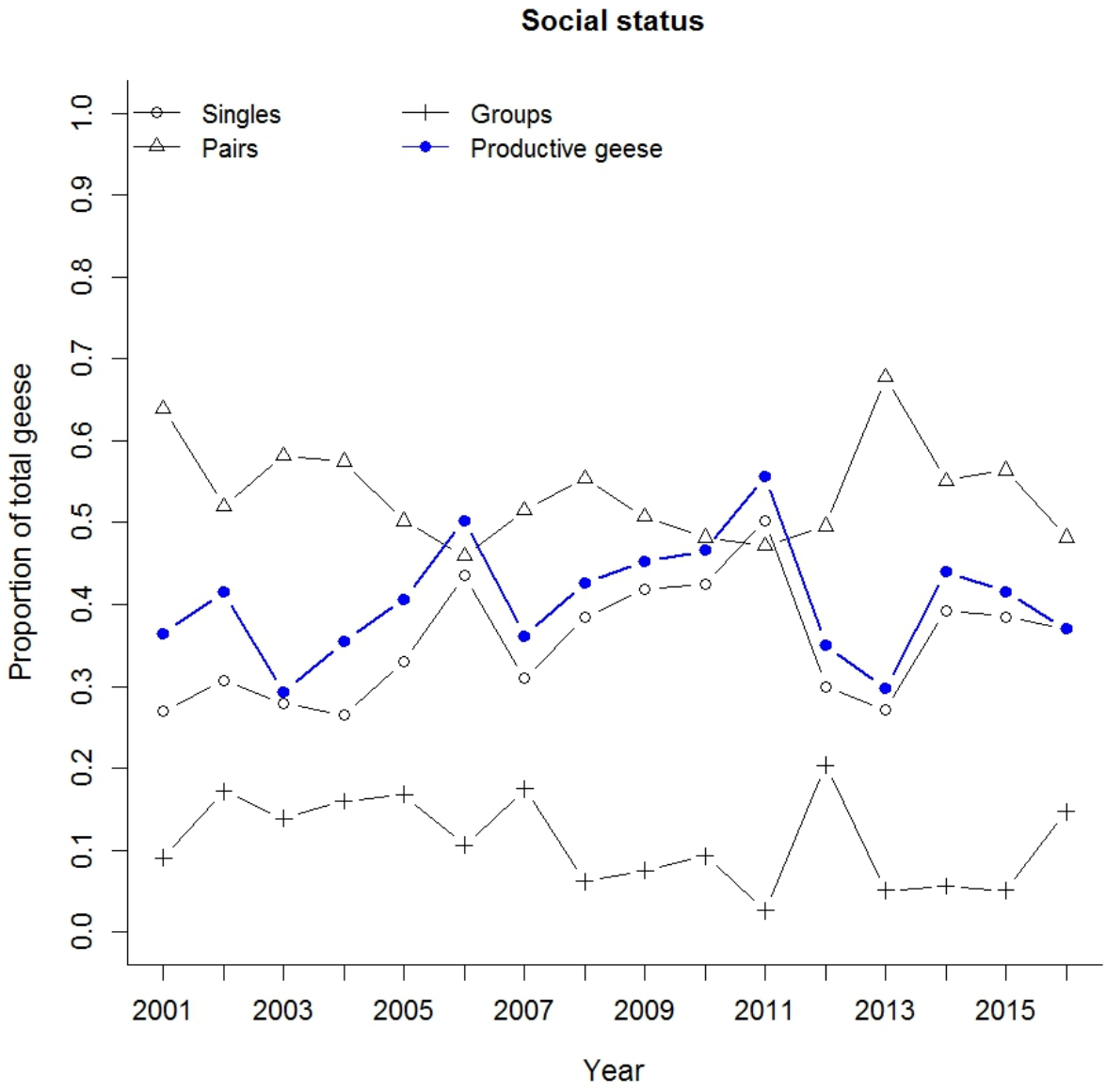

Figure 7. Social status trends from 2001 – 2016 for Canada geese in Minnnesota. The blue line represents productive Canada geese which was determined using the proportion of single birds plus pairs with nests, except in 2016 when it is just proportion of single birds.

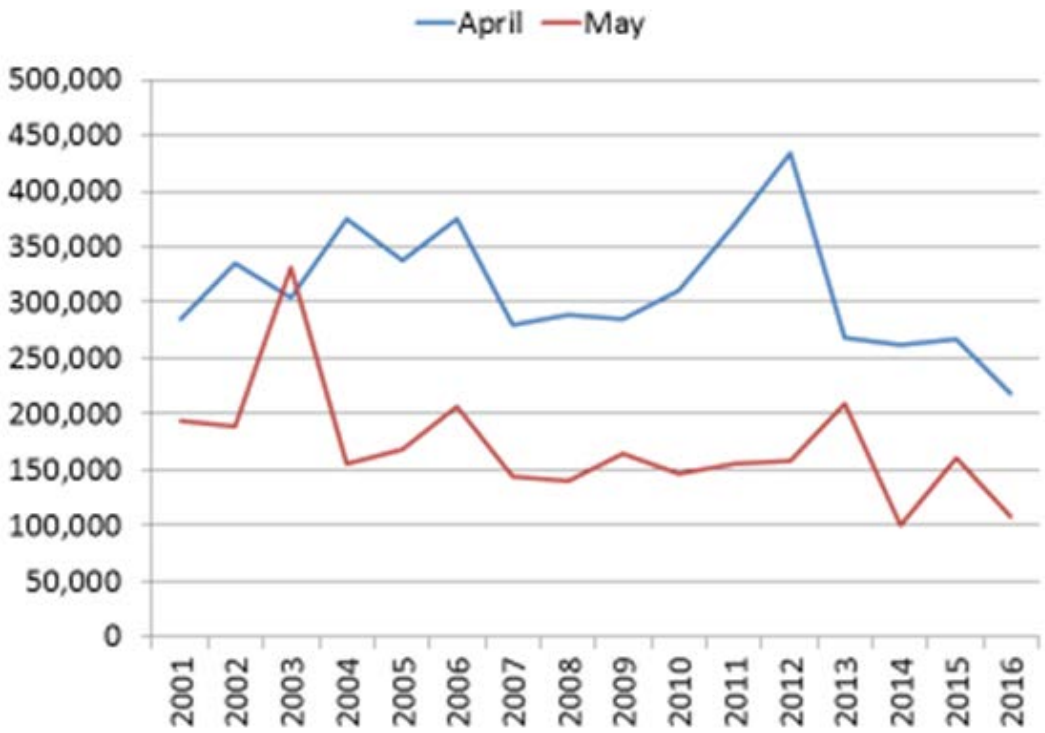

Figure 8. Comparison of Minnesota Canada goose population estimates from this survey and transect-based May fixed wing waterfowl survey (Cordts 2016).

Figure 9. Surveying a plot in the Upper Mississippi National Wildlife and Fish Refuge (Winona County).

Figure 10. Looking north towards Chen Bay Wildlife Management Area (Lincoln County). A portion of the wetland in the center (~160 acres) was randomly selected as part of the goose survey.

Mourning dove information is taken from the U.S. Fish and Wildlife Service report by Seamans, M.E. 2016. Mourning dove population status, 2016. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 20 pp. The entire report is available on the Division of Migratory Bird Management web site

(http://www.fws.gov/birds/surveys-and-data/reports-and-publications/population-status.php).

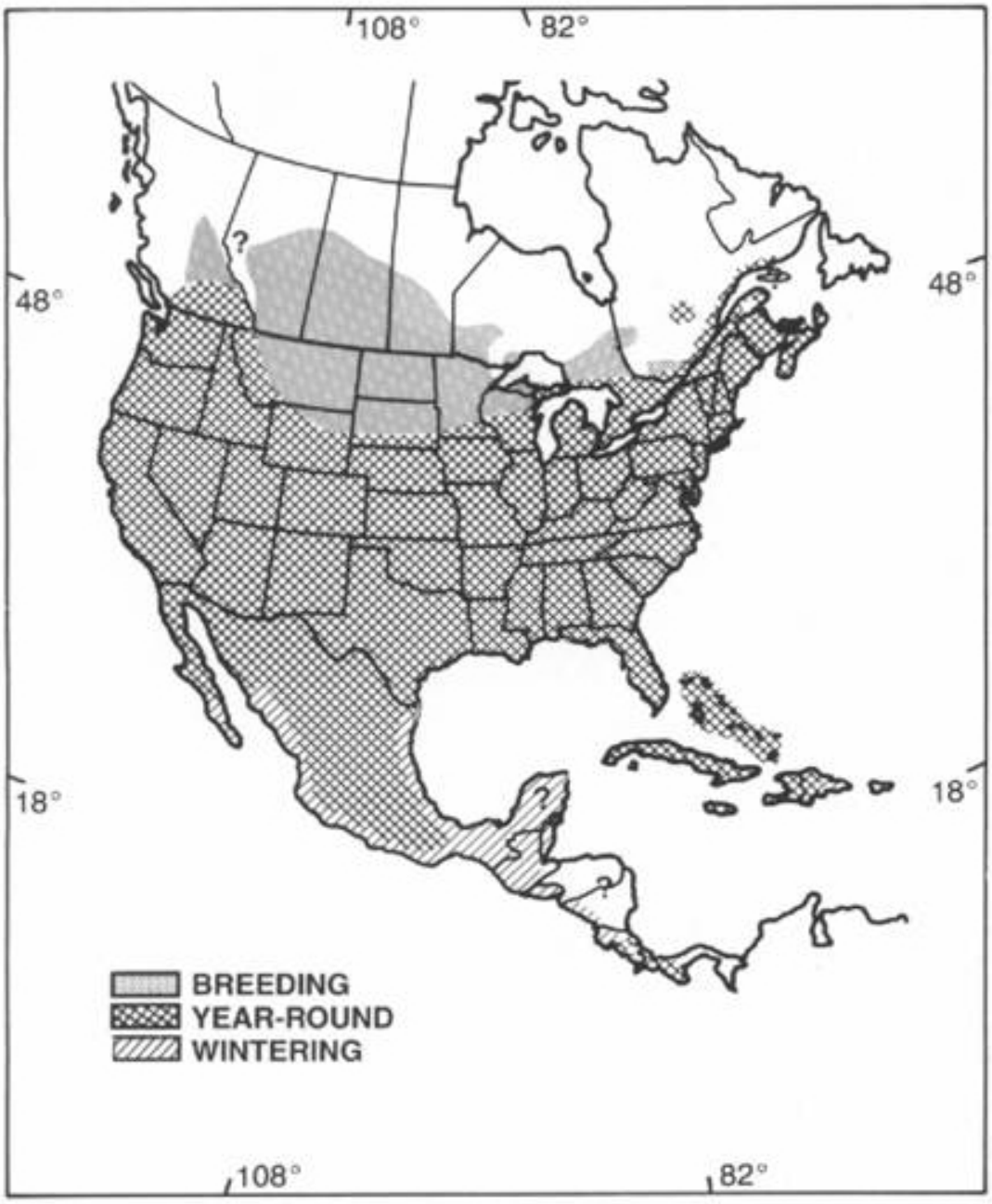

Figure 1. Breeding and wintering ranges of the mourning dove (adapted from Mirarchi and Baskett 1994). (From: Seamans, M.E. 2016. Mourning dove population status, 2016. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 20 pp.)

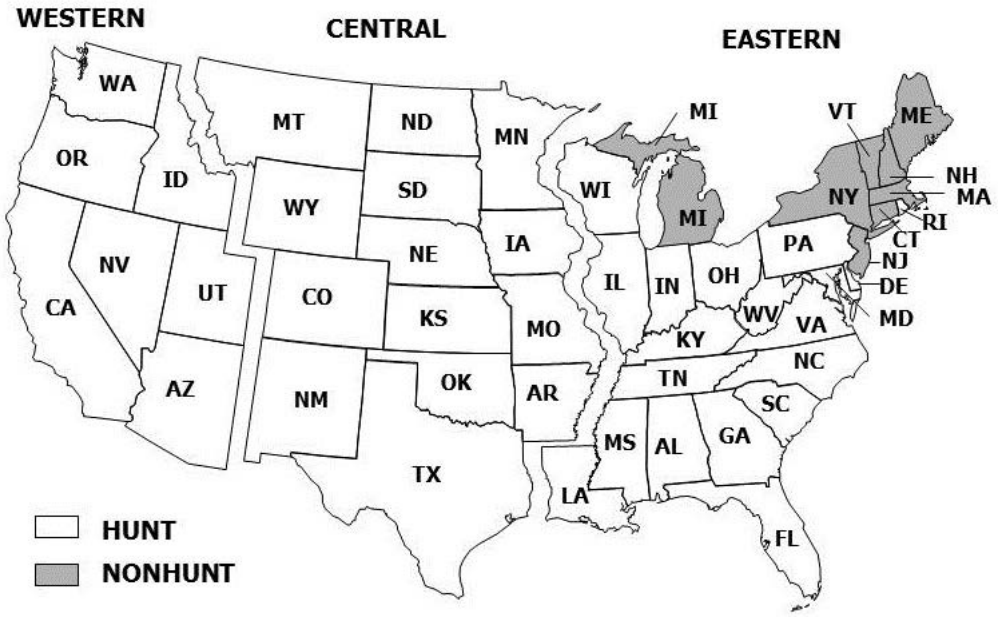

Figure 2. Mourning dove management units with 2015 hunting and non-hunting states. (From: Seamans, M.E. 2016. Mourning dove population status, 2016. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 20 pp.)

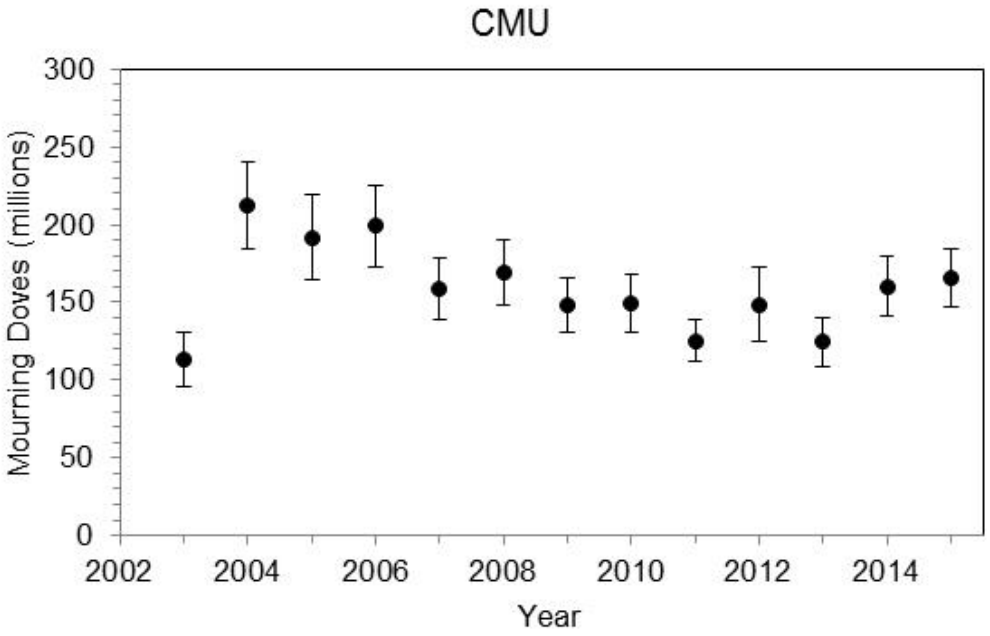

Figure 3. Estimates and 95% confidence intervals of mourning dove absolute abundance by in the Central Management Unit (CMU), 2003-15. Estimates based on band recovery and harvest data. (From: Seamans, M.E. 2016. Mourning dove population status, 2016. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 20 pp.)

Table 1. Preliminary estimates and 95% confidence intervals (CI, expressed as the interval half width in percent) of mourning dove harvest and hunter activity for the Central management unit during the 2013, 2014 and 2015 seasons [a]. (From: Seamans, M.E. 2016. Mourning dove population status, 2016. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 20 pp.)

Management unit / State	Active Hunters			Hunter Days Afield			Total Harvest		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
CENTRAL	353,000 †	427,100 †	369,800 †	1,185,300±10	1,333,600 ± 9	1,235,000 ±10	6,236,000 ±11	7,654,700 ±10	7,180,300 ±9
AR	8,900 ±42	19,900 ±21	17,88 ±24	30,100 ±57	47,900 ±28	37,600 ±22	155,900 ±46	347,900 ±29	252,400 ±22
CO	15,600 ±15	14,400 ±14	14,200 ±15	36,900 ±19	27,800 ±16	38,900 ±23	176,900 ±25	173,100 ±19	204,500 ±22
IA	12,900 ±9	9,200 ±9	9,200 ±15	49,400 ±14	27,100 ±12	24,600 ±16	214, 300 ±16	130,000 ±13	111,500 ±18
KS	31,900 ±12	26,200 ±10	28,600 ±13	93,000 ±16	70,700 ±14	86,400 ±18	504,400 ±18	485,300 ±18	558,200 ±20
MN	7,700 ±53	6,900 ±51	9,700 ±48	17,000 ±39	20,200 ±59	28,200 ±54	53,500 ±30	54,800 ±29	96,700 ±86
MO	36,400 ±11	24,100 ±12	22,500 ±14	104,500 ±18	62,200 ±15	54,300 ±17	587,600 ±28	374,000 ±17	307,400 ±24
MT	1,700 ±46	1,400 ±42	1,600 ±49	2,900 ±41	2,900 ±41	5,100 ±54	12,000 ± 41	8,500 ±37	18,000 ±54
NE	13,500 ±16	9,700 ±12	9,000 ±17	39,300 ±19	26,700 ±13	25,500 ±18	239,800 ±24	172,900 ±15	160,600 ±17
NM	6,500 ±9	7,600 ±10	7,000 ±11	23,700 ±13	24,100 ±15	23,100 ±14	123,000 ±15	115,200 ±15	111,900 ±22
ND	6,300 ±28	3,900 ±25	4,200 ±23	16,400 ±29	11,900 ±30	12,800 ±25	88,200 ±37	47,600 ±23	73,500 ±25
OK	23,300 ±13	19,100 ±13	18,200 ±15	69,400 ±24	56,900 ±24	45,300 ±17	421,200 ±25	417,900 ±21	294,000 ±18
SD	6,200 ±22	6,400 ±21	5,300 ±15	17,500 ±26	17,500 ±24	16,000 ±25	118,300 ±31	106,800 ±25	84,500 ±30
TX	178,900 ±13	276,800 ±10	220,700 ±11	677,900 ±16	934,300 ±13	834,000 ±14	3,506,700 ±18	5,199,400 ±14	4,892,100 ±13
WY	3,100 ±19	1,500 ±26	1,700 ±23	7,200 ±19	3,400 ±23	3,300 ±30	34,200 ±19	21,100 ±25	14,900 ±28

[a] Hunter number estimates at the Management Unit and national levels may be biased high, because the HIP sample frames are state specific; therefore hunters are counted more than once if they hunt in >1 state. Variance is inestimable.

[b] † No estimate available.

American Woodcock information is taken from the U.S. Fish and Wildlife Service report American Woodcock Population Status, 2016. Seamans, M.E. and R.D. Rau. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.

The entire report is available on the Division of Migratory Bird Management home page (https://www.fws.gov/migratorybirds/pdf/surveys-and-data/Population-status/Woodcock/AmericanWoodcockStatusReport16.pdf)

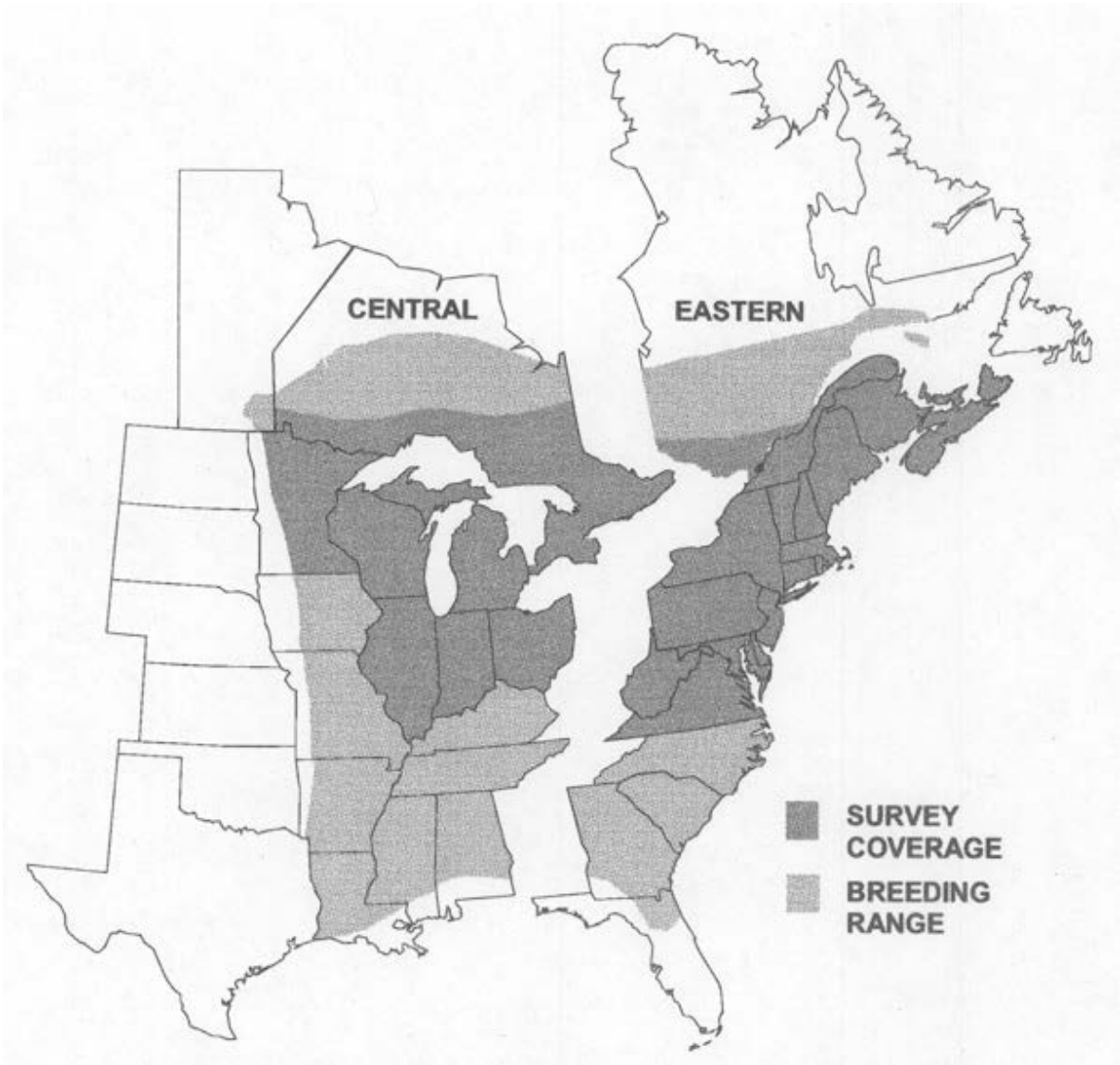

Figure 1. Woodcock management regions, breeding range, singing-ground survey coverage. (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

Table 1. Short term (2015 – 16), 10 –year (2006-2016), and long-term (1968-2016) trends (% change per year [a]) in the number of American woodcock heard during the Singing-ground Survey as determined by using the hierarchical log-linear modeling technique (Sauer et al. 2008) (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

Management Unit/State	Number of Routes[b]	n[c]	2015-16			2006-16			1968-16		
			% Change	95% CI[d]		% Change	95% CI[d]		% Change	95% CI[d]	
				lower	upper		lower	upper		lower	upper
CENTRAL	455	740	0.82	-6.18	8.24	- 0.25	-1.10	0.57	- 0.68	-0.93	-0.44
IL	29	46	-45.24	-80.98	50.60	-10.54	-20.16	-1.03	-1.17	-3.86	1.75
IN	11	62	1.27	-38.08	77.46	- 3.03	- 7.66	2.81	- 4.07	-5.28	-2.92
MB[e]	19	30	-7.89	-33.67	23.96	0.86	- 2.54	4.78	- 0.15	-1.92	1.56
MI	115	155	-3.79	-14.71	8.77	0.11	- 1.24	1.53	- 0.75	-1.11	-0.37
MN	73	122	16.42	-0.92	36.94	2.43	0.67	4.27	0.80	0.23	1.44
OH	40	73	-6.27	-27.09	17.58	- 1.56	- 4.15	1.04	- 1.50	-2.20	-0.77
ON	89	161	-0.75	-14.66	15.32	- 1.85	- 3.59	-0.10	- 0.93	-1.39	-0.47
WI	79	121	1.17	-14.01	19.09	0.43	- 1.37	2.30	- 0.35	-0.84	0.14

[a] Median of route trends estimated used hierarchical modeling. To estimate the total percent change over several years, use: 100(% change/100+1)^{y})-100 where y is the number of years. Note: extrapolating the estimated trend statistic (% change per year) over time (e.g., 30 years) may exaggerate the total change over the period.

[b] Total number of routes surveyed in 2015 for which data were received by 5 June, 2015.

[c] Number of routes with at least one year of non-zero data between 1968 and 2015.

[d] 95% credible interval, if the interval overlaps zero, the trend is considered non-significant.

[e] Manitoba began participating in the Singing-ground survey in 1992.

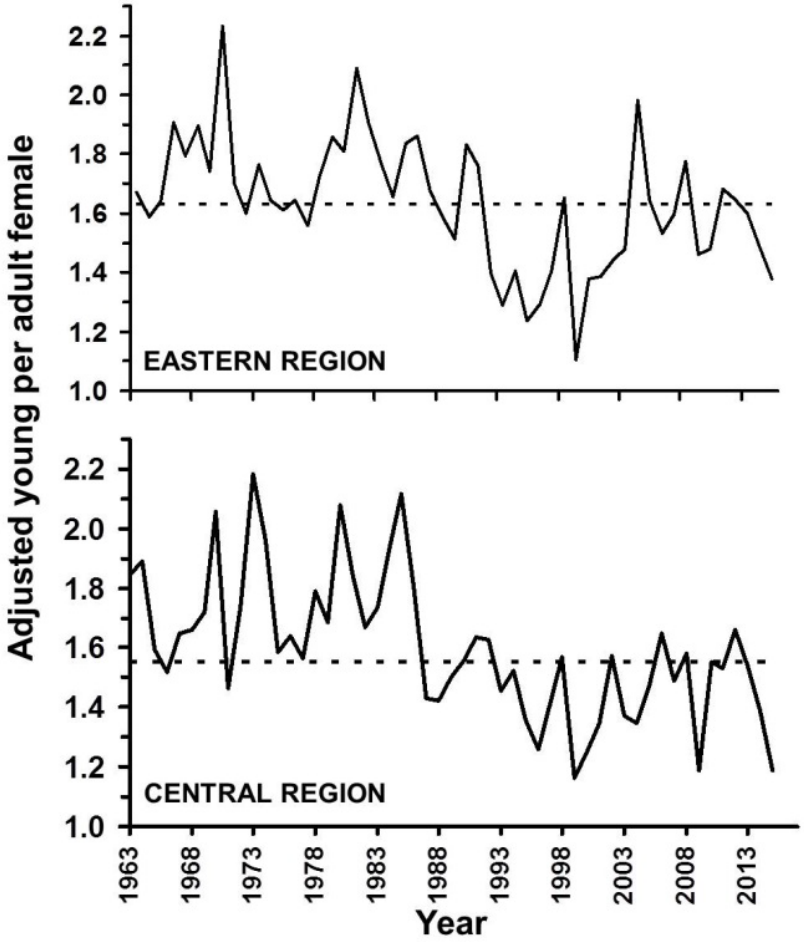

Figure 2. Weighted annual indices of American woodcock recruitment, 1963-2015. Dashed line is the 1963-2014 average. (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

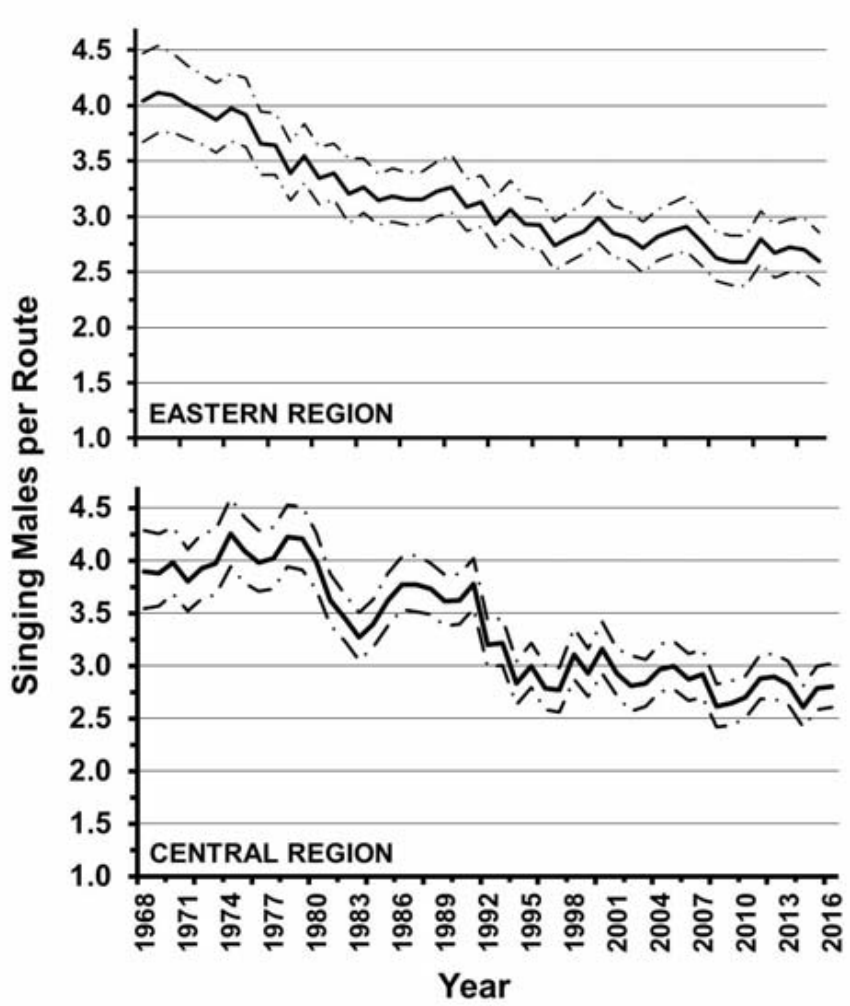

Figure 3. Annual indices of the number of woodcock heard on the Singing-ground Survey, 1968-2016. The dashed lines represent the 95th percentile credible interval. (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

Table 2. Preliminary estimates of woodcock hunter numbers, days afield, and harvest for selected states, from the 2012-13, 2013-14, 2014-15 and 2015-16 Harvest Information Program surveys. (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

Management Unit / State	Active woodcock hunters ([a])				Days afield ([a, c])				Harvest ([a, c])			
	2012-13	2013-14	2014-15	2015-16	2012-13	2013-14	2014-15	2015-16	2012-13	2013-14	2014-15	2015-16
Central Region	n.a. [b]	n.a. [b]	n.a. [b]	n.a. [b]	276,900 ± 16	306,100 ± 20	227,600 ±13.6	284,200 ±16	193,100 ± 23	180,600 ± 20	141,500 ± 23	145,700 ± 19
IL	900 ± 175	1,600 ± 128	800 ± 169	1,000 ± 170	3,500 ± 172	3,400 ± 119	2,600 ± 162	1,300 ± 133	1,900 ± 160	1,000 ± 142	300 ± 132	200 ± 114
IN	400 ± 119	700 ± 77	300 ± 99.7	400 ± 99	1,500 ± 122	1,600 ± 58	900 ± 88.1	1,100 ± 83	600 ± 84	1,400 ± 84	700 ± 43	600 ± 56
MI	25,700 ± 17	30,000 ± 19	19,400 ± 21.1	26,000 ± 18	121,400 ± 22	123,700 ± 24	87,500 ± 19.1	124,700 ± 21	74,100 ± 28	79,300 ± 28	53,500 ± 29	63,200 ± 23
MN	11,200 ± 36	10,900 ± 37	13,500 ±33.5	13,500 ±34	40,400 ± 34	74,700 ± 62	47,500 ± 31.8	47,600 ± 40	31,000 ± 59	18,600 ± 57	23,900 ± 45	25,600 ± 42
OH	600 ± 115	3,000 ± 63	1,600 ± 85.4	1,900 ± 80	2,600 ± 83	8,600 ± 64	4,500 ± 94.2	7,500 ± 95	1,500 ± 80	8,600 ± 85	300 ± 90	2,100 ± 85
WI	13,700 ± 28	14,500 ± 27	16,200 ± 25	14,700 ± 27	58,000 ± 33	60,000 ± 31	66,400 ± 26.9	66,600 ± 29	40,400 ± 37	38,400 ± 24	49,300 ± 45	31,000 ± 25

[a] All 95% Confidence Intervals are expressed as a % of the point estimate.

[b]. Regional estimates of hunter numbers cannot be obtained due to the occurrence of individual hunters being registered in the Harvest Information Program in more than one state.

[c]. Days afield and Harvest estimates are for the entire 18 state Central Region.

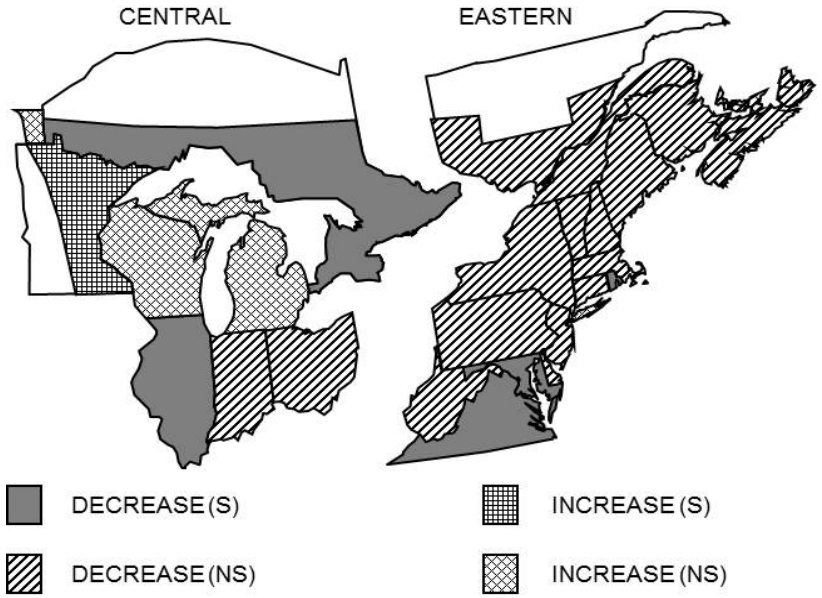

Figure 4. Ten-year trends in number of American woodcock heard on the Singing-ground Survey; 2006-16, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

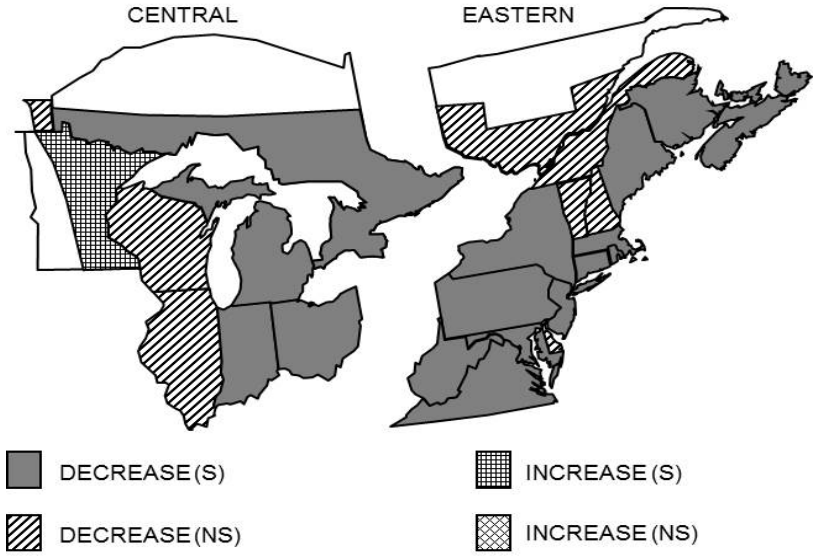

Figure 5. Long-term trends in number of American woodcock heard on the Singing-ground Survey; 1968-2016, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Seamans, M.E. and R.D. Rau. 2016. American woodcock population status, 2016. U.S. Fish and Wildlife Service, Laurel, MD. 17 pp.).

2016 NORTHWEST MINNESOTA SANDHILL CRANE BREEDING GROUND SURVEY

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SUMMARY

We conducted an annual sandhill crane (SACR, *Grus canadensis*) breeding population survey in northwest Minnesota during 2012-2016. After the first year of the survey, we excluded the portion of the Red River Prairie Ecological Classification System (ECS) Subsection from the survey area due to low crane numbers in the agricultural landscape. We used 4 km^2 plots as the primary sampling unit. In 2015 and 2016, we used a split-panel design and surveyed 129 plots: 69 plots that we surveyed in 2012 were revisited and a spatially balanced sample of 60 new plots selected using a generalized random-tessellation stratified (GRTS) design. We surveyed each sample plot once during May using a MD500E helicopter with a 2-person crew. We counted and classified all crane observations in each plot based on their social status (individuals, pairs, groups) and evidence of breeding status (e.g., nest, colts, territorial behavior).

We estimated that there were 4,469, 3,235, 1,952, 4,106, and 2,723 single and paired SACR in 2012-2016, respectively, in the area of Aspen Parklands and some adjacent areas within the Northwest Goose and Crane Zone (NWGCZ) that was consistently surveyed in all years. In 2016, conditions were dry at the beginning of the survey, but the area did receive some moisture during the survey and habitat conditions were generally good. Habitat conditions were dry in 2012 and wet by the end of the survey in 2013-2016. Habitat was very dry at the beginning of the survey in 2013 and 2015, but major precipitation events resulted in very wet conditions for the majority of the survey. We believe that wetland conditions, timing of the survey and arrival of nonbreeding cranes on the breeding grounds may influence the counts in some years.

INTRODUCTION

SACR in northwest Minnesota are part of the Mid-Continent Population (MCP), which is hunted in Canada and several Central Flyway states (Central Flyway Webless Migratory Bird Technical Committee 2006). In 2010, Minnesota began a hunting season on SACR in the NWGCZ (Figure 1). The majority of MCP SACR harvest in other states and provinces occurs on migration, staging, and wintering areas (Krapu et al. 2011); however, in northwestern Minnesota, harvest is comprised of locally-breeding cranes and likely migrant cranes from other MCP breeding areas. We previously reviewed the history and status of SACR and the hunting season (Lawrence et al. 2012). There were some indications that harvest of Minnesota-breeding SACR was greater than expected (Lawrence et al. 2011); thus, in 2012, we initiated a pilot survey of breeding SACR in northwestern Minnesota. The survey was designed to provide an estimate of the number of breeding cranes in northwest Minnesota that was within ±25% of the true population size with 90% certainty (i.e., if we could replicate the sample survey many times, 90% of the population estimates will be within ±25% of the true population size).

The breeding population size estimates obtained from this survey, combined with data on crane harvest, harvest derivation, and other parameters will allow us to better manage harvest of cranes in northwest Minnesota and may provide insights to hunting cranes in other portions of their breeding range. Here, we describe the survey sampling scheme used in 2012-2016, present population estimates for the 5 years, and discuss future survey plans.

STUDY AREA

In 2012, we selected the NWGCZ and portions of the Aspen Parklands ecological subsection that extended beyond the NWGCZ as our primary sampling frame (Figure 2). This included the Aspen Parklands ecological subsection, northwestern portions of the Red River Prairie subsection, and a small portion of the Agassiz Lowlands subsection.

Beginning in 2013, we reduced the size of the survey area to only include plots in the Aspen Parkland ECS subsection and the small area of Agassiz Lowland subsection that was within the NWGCZ. We did not survey any plots in the Red River Prairie ECS subsection because the likelihood of finding nesting cranes in this area was low (Lawrence et al. 2013).

METHODS

Sampling frame

We used ArcGIS 10.2 (Environmental Systems Research Institute, Redlands, CA) to develop an overlay grid of 4-km^2 plots for the northwestern Minnesota study area (Figure 2). The grid was rotated approximately 2.5 degrees to orient it with Public Land Survey (PLS) based features such as roads and property boundaries. We treated 4-km^2 plots as the primary sampling unit (PSU) and in 2012 excluded any PSUs not located entirely within the boundary of the SACR survey area (Figure 2). In 2012, we also non-randomly selected a 100-km^2 plot, approximately overlaying Espelie Township (EspTwp) in eastern Marshall County, based on previous crane work by DNR staff (S. Maxson, unpublished DNR files).

Beginning in 2013, we excluded the Red River Prairie survey area because first year results indicated that few breeding cranes used this area in May (Figure 3). We also included any PSUs on the border of the survey area where >50% of the plot was located within the boundary of the survey area rather than just PSUs that were located entirely within the survey area.

Sampling design

Details of sampling design for previous years are contained in previous reports (Lawrence et al. 2012, 2013, 2014, 2015). We used descriptions of crane nesting habitat in northwest Minnesota (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008) and National Land Cover Data (NLCD; Fry et al. 2011) to identify potential crane habitat. We used NLCD (30 m cell resolution) to quantify the amount (m^2) of potential SACR habitat in each 4-km^2 plot. We defined “SACR nesting habitat” as NLCD cover class 95 (emergent herbaceous wetland) and “other SACR habitat” as NLCD cover classes 11 (open water) and 90 (woody wetlands).

In 2012, we classified each 4-km2 plot into one of 4 categories:

- Stratum 1 (NLCD-1): > median amount of nesting habitat,
- Stratum 2 (NLCD-2): 0 < m2 of nesting habitat < median,
- Stratum 3 (NLCD-3): nesting habitat = 0 but other SACR habitat > 0, or
- Stratum 4 (NLCD-4): no SACR habitat.

We selected 60 plots from Stratum 1 and 2 combined and 30 plots from Stratum 3. We assumed that breeding SACR density in the NLCD4 stratum was very low (approaching zero)

and did not sample Stratum 4. We also surveyed a 100 km^2 plot (25 plots) generally overlaying Espelie Township to better understand distribution of cranes within good nesting habitat.

In 2013 and 2014, we used the GRTS design to select 115 plots from all plots with potential crane habitat with no stratification (i.e. Strata 1, 2, and 3 combined). We also recalculated the 2012 estimates based upon the 2013 sample frame.

In 2015 and 2016, we modified the sampling design to provide a more powerful measure of change. Specifically, we employed a split-panel sampling design (Warren 1994, Urquhart and Kincaid 1999) that consisted of 69 "revisit" plots and 60 "new" plots (Figure 3). Revisit plots were originally selected and surveyed in 2012, and consisted of 58 stratum 1-2 plots, 6 stratum 3 plots, and 5 randomly-selected plots of the original 25 Espelie Township plots. The "new" plots were drawn from the remaining 2,884 stratum 1, 2, and 3 plots in the reduced sampling frame using a spatially balanced simple random sampling design. We treated the 2 panels as strata, with inclusion probabilities = 1 for plots in the revisit stratum, and used the GRTS design-based estimator (Kincaid and Olsen 2013) to compute sampling statistics and estimates of population size. We also used a mixed-model framework to generate model-assisted estimates of total, singles+pairs, and breeding SACR abundance during 2012 to 2016. We used plot counts as our response variable and, at least initially, a fixed temporal slope parameter (year–2011) and random effects for year (categorical) and observation unit (plot ID). We fit the model using the lme4 package (Bates et al. 2014) in R (R Core Team 2014). We weighted the predicted mean count for each stratum and year by stratum weights and multiplied by N (sampling frame size) to obtain model-assisted population estimates. In all cases, there was little evidence to support a temporal trend (fixed slope parameter); therefore, we refit the data with an intercept-only model. We computed approximate 90% CI for the model-assisted population estimates by bootstrapping the residuals (with replacement; B=500), adding them to the fitted values, refitting the model, and predicting stratified means and expanded population estimates. Plot occupancy for revisit plots was calculated using a mixed model that accounted for repeated measurements on the same plot over years.

Target population(s)

In all years, separating breeding and non-breeding components of the population was problematic. We recorded crane observations as singles, pairs, and groups. Groups of SACR likely contain mostly non-breeders (subadults, non-territorial adult birds, and, possibly, failed breeders), whereas the breeding status of singles and pairs is more difficult to determine (Hayes and Barzen 2006). Therefore, for the purposes of this survey, we classified crane observations as follows:

1. *Indicated Breeding Birds* (IBB) = singles or pairs that were observed with a nest or young, or birds that were suspected of having a nest or young (but it was not detected) based on their behavior (e.g. reluctance to fly or leave the area, broken-wing displays).
2. *Groups* = flocks of $\geq$3 cranes.
3. *Status unknown* = singles or pairs whose breeding status could not be determined (e.g., nest or young was not detected, and did not exhibit any territorial or defense behavior).

For population estimates, we considered doubling observations of single 'breeding' birds (e.g., similar to indicated pairs in waterfowl surveys), but this could result in a positive bias for the estimate of breeding birds. For example, if single breeding birds were truly paired and their mate was missed (not detected) because it was located off the survey plot, then the missed mate is accounted for when we expand the counts for sampling (i.e., it is not necessary to double the observed count). Conversely, if the mate was on the plot but was not detected, then doubling the observed count is equivalent to applying a sightability correction factor = 2 for

single crane observations. In reality, both cases likely occurred and we could not distinguish between them. Therefore, we used a conservative approach when estimating population size by taking observations of single birds at their face value (i.e., count = 1) regardless of their breeding status.

Survey procedures

The survey was conducted during early to mid-May, which is the peak incubation period for cranes in northwest Minnesota (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008). Plots were surveyed by a pilot and one observer with a OH-58 helicopter in 2012-2015 and a MD500E helicopter in 2016. Plots were surveyed 5-45 meters above ground level at 10-100 km/hr, depending upon the land cover. In 2016, we used DNRSurvey ver. 2.11, an ArcGIS add-in developed by Minnesota DNR Wildlife and MN.IT Services GIS staff (www.dnr.state.mn.us/mis/gis/DNRSurvey/DNRSurvey.html) to record crane locations (waypoints) and aid in survey logistics.

RESULTS

Survey effort

The 2016 survey was conducted on 8 days (5, 6, 9, 11, 12, 13, 16 and 17 May) during a 13-day period. Delays in the survey were due to weather and helicopter maintenance. We averaged 16 plots/day (range: 7-25). We started the survey early in May and the survey was completed prior to the late surveys in 2013 and 2015 (Figure 4). The survey team (DNR pilot Brad Maas and observer Jeff Lawrence) spent an average of 9 min surveying each plot (range: 3–20 min), similar to 2012 and 2015 and 2.5 minutes longer that in 2013-14 (Table 1).

Sampling statistics

We detected SACR on 55 (43%) of the 129 sample plots in 2016 compared to 32-50% in 2012-15 (Table 2). Cranes were observed on 40% of the 60 randomly-selected plots in 2016 compared to 58% in 2015. The average count per 'occupied' plot (>=1 SACR observed) was 6.4, higher than any previous year (Table 2). This was mostly due to 85 flocked birds observed on 1 plot. In 2016, we counted 241 SACR on sample plots, of which 39% were pairs, 17% were singles, and 44% were in groups (Table 3). We observed 6 groups on sample plots, which ranged in size from 3 to 85 birds. We saw relatively more grouped SACR in 2012, 2013, and 2016 (37-44% of cranes observed) than in 2014-2015 (15% and 13%, respectively; Table 3, Figure 5). The proportion of singles and pairs that exhibited evidence of being breeding birds was within the range of previous years (Table 3). In 2016 we detected 22 nests, similar to the 17-20 nests annually in 2012-2015.

Population estimates and distribution

The estimated total number of cranes in the survey area in 2016 was 7,536 (90% CI: 1,355-13,717). This is a minimum estimate because we did not adjust for detection probabilities (which are likely <1, at least for singles and pairs in dense cover). The estimate of total cranes in 2016 was the least precise of any year and the coefficient of variation was 50% due to large variability in the group estimate (mostly due to 1 group of 85 SACR). If our sample of singles and pairs exhibiting breeding behavior was representative, then the estimated total number of breeding SACR in the survey area in 2016 was 747 (90% CI: 440-1,054), which was similar to other years. The estimated mean annual rate of change for model-assisted estimates was -9%/yr for IBB (P = 0.14) and <-1%/yr for singles and pairs (P=0.98). A model-assisted analysis of the survey data suggested population estimates from 2014 were likely biased low (Figure 6).

A more powerful metric of change is a comparison of the 69 plots surveyed in 2012, 2015, and 2016 (i.e., revisit plots). The number of single cranes observed on these plots was similar in 2012 (*n* = 24), 2015 (24), and 2016 (25), but the number of pairs declined from 43 in 2012 to 22 and 27 in 2015 and 2016, respectively, and the number of birds in groups declined from 73 to 8 and 7. Plot occupancy was 53% (90% CI: 37-66), 39% (25-50), and 43% (31-55) in 2012, 2015, and 2016. Twenty-four percent of the 69 plots were occupied all 3 years, 26% were not occupied any of the years, and 33% and 16% were occupied 1 or 2 of the 3 years, respectively. Numbers of SACR on individual plots often changed between years but not in any consistent pattern (Figure 7). We observed 13, 8, and 15 active nests on these plots in 2012, 2015, and 2016; but also observed 3 pairs with colts and 7 pairs or singles that were recorded as suspected breeders in 2012. More pairs and birds in groups were observed on the revisit plots in 2012 than other years, but all the birds in groups and a portion of the pairs (63, 82, and 59% of pairs in 2012, 2015, and 2016, respectively) were either nonbreeders or failed breeders.

Habitat associations

The probability of observing >=1 SACR was positively associated with the amount of nesting cover in the plot (Figure 8).

DISCUSSION

Survey effort and design considerations

In 2016, conditions were relatively dry early in the survey, but then we had several days of rain. However, we did not observe the flooded basins and standing water in fields that was common in 2013 and 2015, 2 other years that started dry followed by May rains. Spring phenology has varied each year. In 2016, very warm conditions were recorded in March, but temperatures moderated in April and phenology was close to normal by May. We had record early spring phenology in 2012, very late phenology in 2013 and 2014, and closer to average phenology in 2015. We have tried to time the survey for peak crane nest incubation, but these annual changes have made this difficult. Timing of the SACR survey may be critical to getting consistent results.

Population estimate

The number of IBB and total cranes were higher (non-significant) in 2012 than other years, but there were no significant trends over the 5-year period. Linear trends are likely not good predictors when strongly influenced by a single high or low estimate at the beginning/end of a survey period. Some of the variability in estimates may be due to factors such as survey timing and habitat conditions. The number of breeders and unknown cranes (singles and pairs) ranged from 1,952 to approximately 4,469 during the 5 years of this survey. The model-assisted estimate suggests that the 2014 count was biased low, but additional years of data would be necessary to better understand this annual variation.

The most powerful measure of change was the number of cranes observed on same plots between 2012 and 2015-2016. Cranes have strong philopatry to their nesting territories (Krapu et al. 2011, Gerber et al. 2014), and we would expect similar numbers of IBB on the same plots if populations were stable. However, other factors influencing recruitment may influence the number of cranes seen on these plots. We recorded similar numbers of singles on these plots. Singles were either observed with a nest (16-21% of singles) or are assumed to have a nesting mate nearby that was either undetected on the plot or off plot. Pairs could be either breeding or nonbreeding. The number of pairs on revisit plots in 2015 (*n*=22) and 2016 (*n*=27) was 51-62% of the number in 2012 (*n*=43). We observed few pairs with nests (4 nests) in 2015; but, the number of pairs with nests or colts was similar in 2012 (11) and 2016 (11). Many of the pairs

we observed had likely not started breeding yet, so they may be variable in return date to the breeding grounds. Cranes in groups have been included in our population estimates, yet the uneven distribution of groups makes them difficult to survey using the plot based design. We saw 73 cranes in groups on these 69 plots in 2012, yet only 7 or 8 in 2015-16. Given there were more cranes in groups on these plots in 2012, there may have been more nonbreeding pairs on the plots that year too. In addition to the inherent difficulty of counting clumped animals (groups) with a plot survey, our plot selection method was based on presence of presumed nesting habitat. Non-breeding cranes may use plots with only agricultural fields that were not included in the sample.

We report the total breeding population including groups, yet the breeding ground surveys conducted to date suggest that return dates or distribution of the nonbreeding component of the crane population may be highly variable. Similar variability in timing and distribution of sandhill cranes along the Platte River, Nebraska influenced the proportion of cranes available to be counted in the spring (Pearse et. al. 2015). Cranes in groups, some cranes in pairs, and likely a few singles would comprise the nonbreeding component of the population. We recommended that while the number of nonbreeding pairs returning in May maybe variable, the total number of cranes observed as singles and pairs should provide the most reliable measure of the crane population in Northwest Minnesota (Lawrence et al. 2015). However, the number of singles and pairs had greater variability that the model-based estimates of either IBB or total cranes and it may not be the most reliable metric.

We do not plan to conduct the crane survey in 2017. We had originally planned to conduct the survey for 3 years (2012-14), but extended the survey following the low counts in 2014. The helicopter survey was expensive to conduct and harvest of cranes in the NWGCZ has been low the past few years (range 247-407 in 2012-14). While we had a higher population estimate in 2012, the first year of the survey, generally populations have been stable the last 4 years. Ideally, a longer series of annual surveys would provide a better understanding of variability in the counts. However, we do not have comparable numbers prior to the opening of the SACR hunting season in 2010. The August roadside survey (e.g. Davros 2015) has variable counts and did not track results from the 2012-16 aerial survey (Figure 9) but may be used as a general guidance of sandhill crane status in NW Minnesota. A large decline in the August roadside index would indicate the need to repeat the helicopter survey. In addition, it may be prudent to repeat the helicopter survey in 3-5 years to ensure that the population in NW Minnesota remains at a level similar to the 2012-2016 surveys. This population size has been acceptable to hunters, wildlife watchers, and wildlife managers that value cranes in this portion of Minnesota.

ACKNOWLEDGEMENTS

This project was funded by a grant from the U.S. Fish and Wildlife Service Webless Migratory Bird Program (2012-2014) and the Minnesota Department of Natural Resources (2012-2016). Special thanks to DNR pilots Brad Maas, who flew the survey in 2015-2016 and John Heineman, who flew in 2012-2014. They both did an exceptional job flying the helicopter and helping with the survey during all 5 years.

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Table 1. Survey effort for an aerial survey of sandhill cranes in Minnesota, May 2012-2016.

			Survey Duration						
Year	Design[a]	*n* plots	Start date	End date	Calendar days	Survey days	Total flight hrs	Plots/ day	Minutes/ plot
2012	GRTS-ST3	115	7-May	15-May	9	7	30	16.3	9.8
2013	GRTS-SRS	115	17-May	23-May	7	3	23	38.0	6.7
2014	GRTS-SRS	115	9-May	16-May	8	4	26	28.8	6.7
2015	SP12-GRTS	129	5-May	21-May	17	5	34	25.8	8.7
2016	SP12-GRTS	129	5-May	17-May	13	8	37	16.1	9.2

[a]-GRTS-ST3: generalized random-tessellation stratified with 3 strata; GRST-SRS: generalized random-tessellation stratified, simple random sample, SP12-GRTS: repeat 2012 Aspen Parkland plots, generalized random-tessellation stratified, simple random sample for remainder of plots

Table 2. Sampling statistics[a] for an aerial survey of sandhill cranes in northwestern Minnesota, May 2012-2016.

								Counts/occupied plot				
Year	Strata	Sampling allocation[b]	n	N	srate	n.occ	p.occ	min	max	med	mean	SE
2012	3	OPT	115	3,160	0.036	51	0.47	1	43	2	4.9	1.27
2013	1	SRS	115	2,953	0.039	49	0.43	1	46	3	4.4	1.06
2014	1	SRS	115	2,953	0.039	37	0.32	1	10	2	2.4	0.31
2015	2	SP-SRS	129	2,953	0.044	64	0.50	1	14	2	2.8	0.45
2016	2	SP-SRS	129	2,953	0.044	55	0.43	1	94	2	6.4	3.74

[a]n = sample size (4-km^2 plots), N = stratum size, srate = sampling rate, n.occ = number of "occupied" plots (>1 sandhill crane detected), p.occ = proportion of plots with >1 crane detected, and count statistics for "occupied" plots.

[b]OPT = Optimal, SRS = simple random sample, SP-SRS=Split plot-simple random sample.

Table 3. Social and breeding classification of sandhill crane observations, 2012-2016.

	n by year					Proportion by year					Proportion of singles of pairs				
Social Class[a]	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Pairs (x2)	114	92	38	104	94	0.48	0.43	0.43	0.59	0.39					
Breeding birds	50	28	12	24	32	0.21	0.13	0.14	0.14	0.13	0.44	0.30	0.32	0.23	0.34
Status unknown	64	64	26	80	62	0.27	0.3	0.29	0.46	0.26	0.56	0.70	0.68	0.77	0.66
Singles	37	34	38	48	40	0.15	0.16	0.43	0.27	0.17					
Breeding birds	8	9	11	10	9	0.03	0.04	0.12	0.06	0.04	0.22	0.26	0.29	0.21	0.23
Status unknown	29	25	27	38	31	0.12	0.12	0.3	0.22	0.13	0.78	0.74	0.71	0.79	0.78
Groups	89	90	13	23	107	0.37	0.42	0.15	0.13	0.44					
Total	240	216	89	175	241										

[a]- Breeding birds = singles or pairs that were observed with a nest or young, or birds that were suspected of having a nest or young (but it was not detected) based on their behavior (e.g. reluctance to fly or leave the area, broken-wing displays); Groups = flocks of >3 cranes; or status unknown = singles or pairs whose breeding status could not be determined (e.g., nest or young was not detected, and did not exhibit any territorial or defense behavior).

Table 4. Population estimates (N) by indicated breeding status for sandhill cranes in northwestern Minnesota, May 2012-2016.

Year		Status[b]	Plots surveyed	Total plots	n plots with cranes	Minimum cranes/plot	Maximum cranes/plot	Avg. birds/plot	SE birds/plot	^ N	SE	LCB (90%)	UCB (90%)	CV %
2012	With Red River Valley	Breeding birds	115	3,160	28	1	4	0.5	0.08	1,447	264	1,014	1,881	18
		Status unknown	115	3,160	40	1	6	0.9	0.13	2,751	415	2,069	3,433	15
		Singles + Pairs	115	3,160	50	1	8	1.3	0.18	4,198	556	3,283	5,113	13
		Groups	115	3,160	9	3	37	1	0.49	3,013	1,545	472	5,554	51
		Total	115	3,160	51	1	43	2.3	0.58	7,211	1,818	4,220	10,202	25
2012[a]	Without Red River Valley	Breeding birds		2,953						1,416	268	975	1,857	19
		Status unknown		2,953						2,749	424	2,052	3,446	15
		Singles + Pairs		2,953						4,469	590	3,499	5,439	13
		Groups		2,953						3,100	1,606	458	5,742	52
		Total		2,953						7,264	1,885	4,163	10,365	26
2013	Without Red River Valley	Breeding birds	115	2,953	22	1	2	0.3	0.05	950	158	691	1,210	17
		Status unknown	115	2,953	36	1	6	0.8	0.11	2,285	318	1,763	2,808	14
		Singles + Pairs	115	2,953	48	1	7	1.1	0.12	3,235	363	2,639	3,832	11
		Groups	115	2,953	6	3	43	0.8	0.38	2,311	1,122	466	4,157	49
		Total	115	2,953	49	1	46	1.9	0.4	5,547	1,194	3,582	7,511	22
2014	Without Red River Valley	Breeding birds	115	2,953	15	1	4	0.2	0.05	591	135	368	813	23
		Status unknown	115	2,953	26	1	9	0.5	0.09	1,361	276	907	1,815	20
		Singles + Pairs	115	2,953	36	1	10	0.7	0.11	1,952	314	1,435	2,469	16
		Groups	115	2,953	3	3	6	0.1	0.05	334	162	68	600	49
		Total	115	2,953	37	1	10	0.8	0.12	2,285	346	1,716	2,855	15
2015	Without Red River Valley	Breeding birds	129	2,953	21	1	3	0.4	0.08	1,069	240	674	1,465	22
		Status unknown	129	2,953	52	1	9	1	0.16	3,036	481	2,245	3,827	16
		Singles + Pairs	129	2,953	63	1	11	1.4	0.2	4,106	597	3,124	5,087	15
		Groups	129	2,953	5	3	8	0.2	0.13	729	398	75	1,383	55
		Total	129	2,953	64	1	14	1.6	0.27	4,835	801	3,516	6,153	17
2016	Without Red River Valley	Breeding birds	129	2,953	22	1	5	0.3	0.06	747	186	440	1,054	25
		Status unknown	129	2,953	41	1	9	0.7	0.15	1,976	430	1,269	2,682	22
		Singles + Pairs	129	2,953	54	1	9	0.9	0.92	2,723	496	1,907	3,538	18
		Groups	129	2,953	6	3	85	1.6	1.16	4,814	3,436	107	10,466	71
		Total	129	2,953	55	1	94	2.6	1.27	7,536	3,758	1,355	13,717	50

[a] 2012 data adjusted to reflect 2013-14 sampling frame.

[b] Breeding birds = singles and pairs (x2) with a nest or young, or exhibiting some type of breeding or territorial behavior; Status unknown=Singles and pairs (x2) without a nest or young, and no behavioral evidence that they were breeding birds; Singles+Pairs=breeding birds+Status unknown.

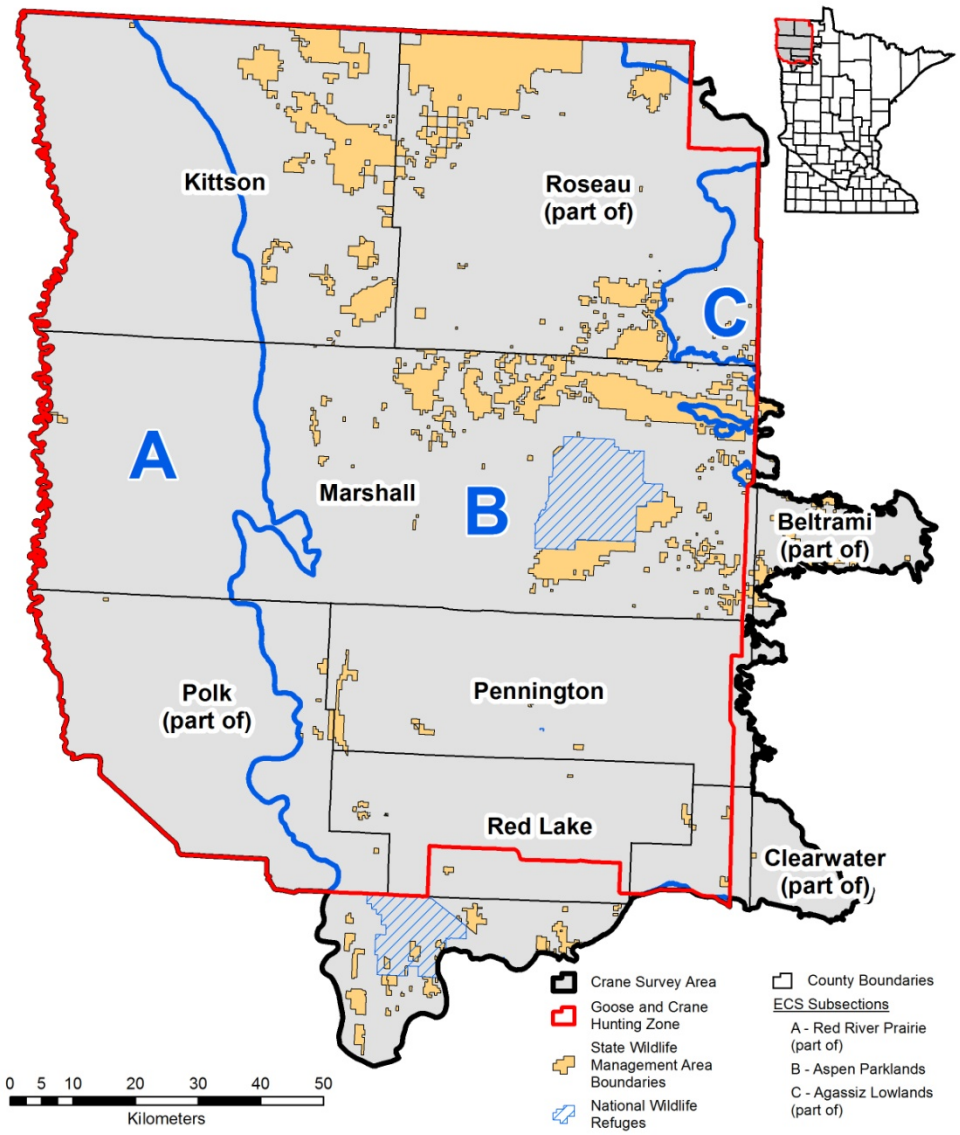

Figure 1 Location of the Northwest Goose and Sandhill Crane Hunting Zone in Minnesota and the sandhill crane survey area. ECS subsection A (portion of Red River Prairie) was surveyed in 2012 but not in 2013-2015.

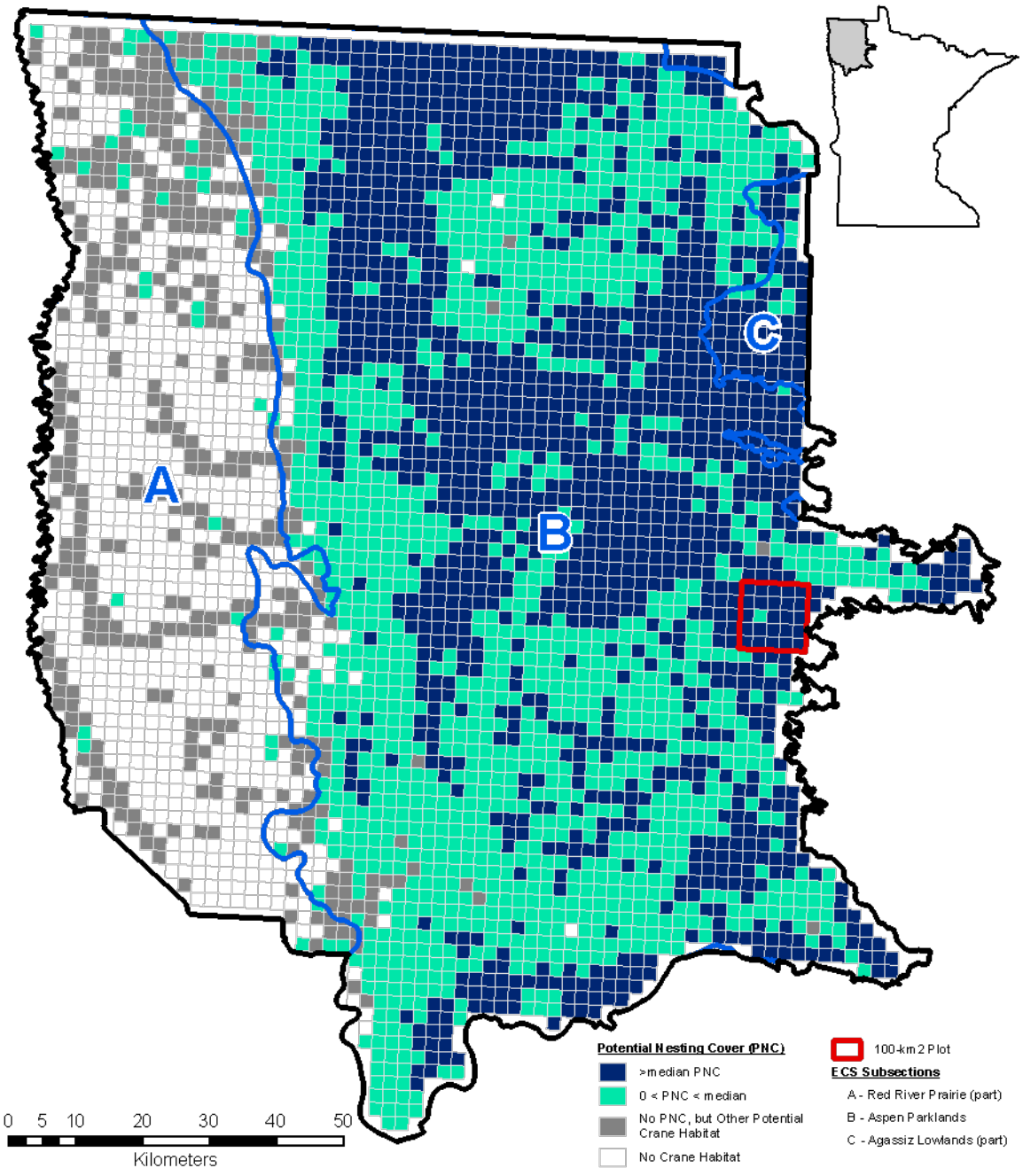

Figure 2. Sampling frame for the spring aerial survey of sandhill cranes, northwestern Minnesota. The primary sampling unit was 4-km^2 plots. Colored squares denote plots by strata as defined by National Land Cover Data: dark blue = NLCD-1 (>median amount of potential crane nesting cover [PNC]), turquoise = NLCD-2 (0 < potential nesting cover < median), gray = NLCD-3 (no nesting cover but other potential crane cover), white = NLCD-4 (no crane habitat). Black lines denote the boundaries of the survey area and blue lines note boundaries of ecological subsections. In 2012, we selected plots from strata 1-3 in the 3 subsections above (see text). After 2012, we excluded plots in the Red River Prairie ECS subsection (A above) and did not survey the 100-km^2 plot. Also, note there were additional plots on the edge of the survey area after 2012.

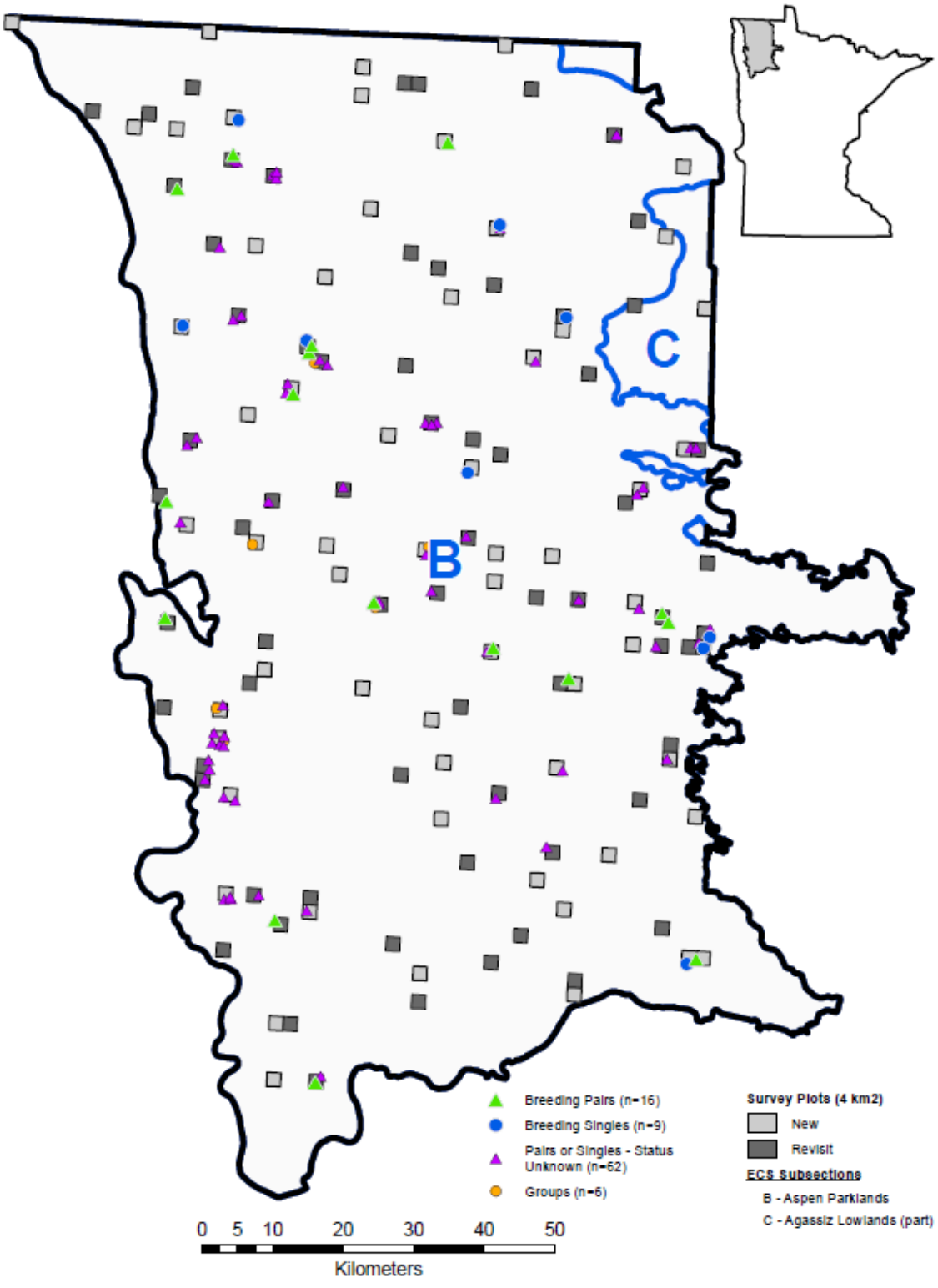

Figure 3. Distribution of sample plots (n = 129) and sandhill crane observations by type in the 2016 MNDNR spring aerial survey, northwestern Minnesota. Each sample plot was 4 km2 and the SACR survey area was 11,812 km2.

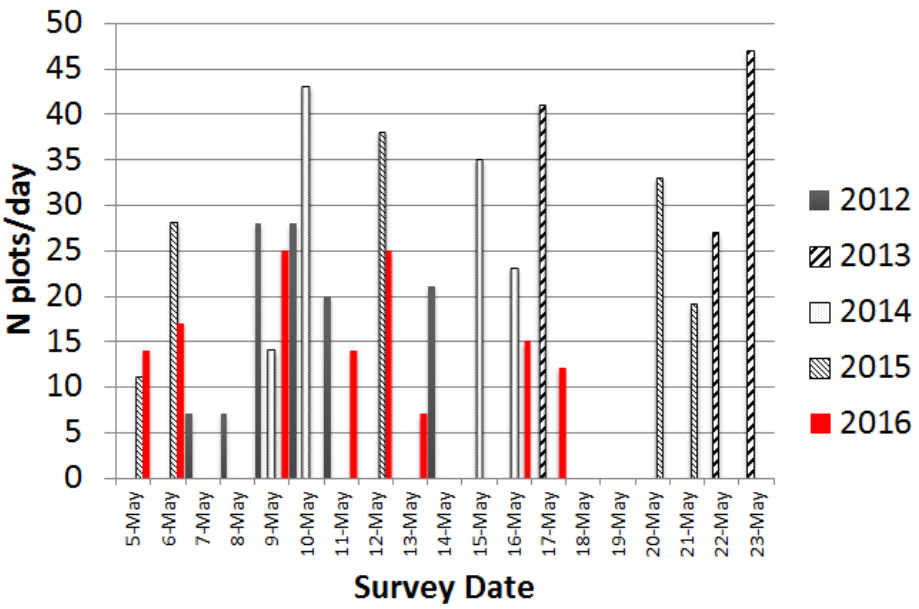

Figure 4. Number of plots surveyed by calendar date during the Northwestern Minnesota Sandhill Crane breeding population survey, 2012-2016. 115 plots were flown each year from 2012 to 2014 and 129 were flown in 2015 and 2016.

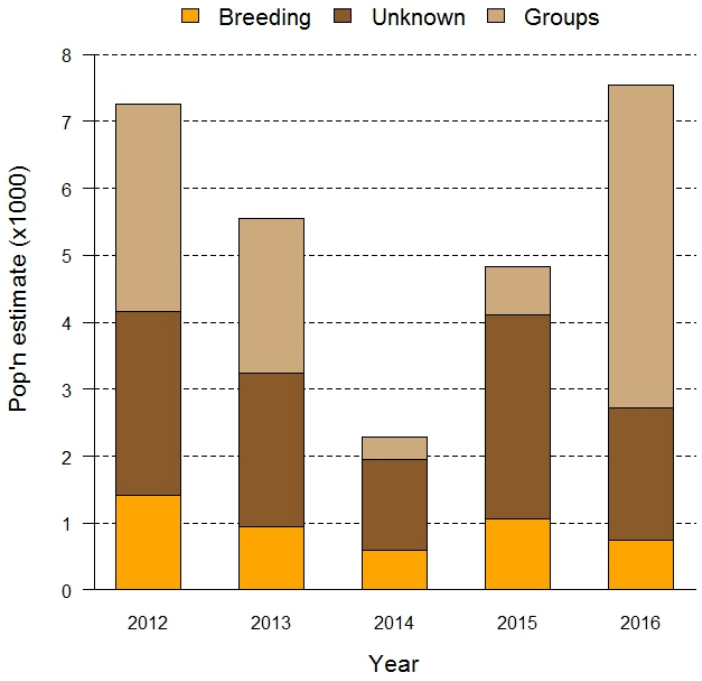

Figure 5. Number of cranes by social grouping in the Aspen Parklands survey area of northwestern Minnesota, 2012-2016.

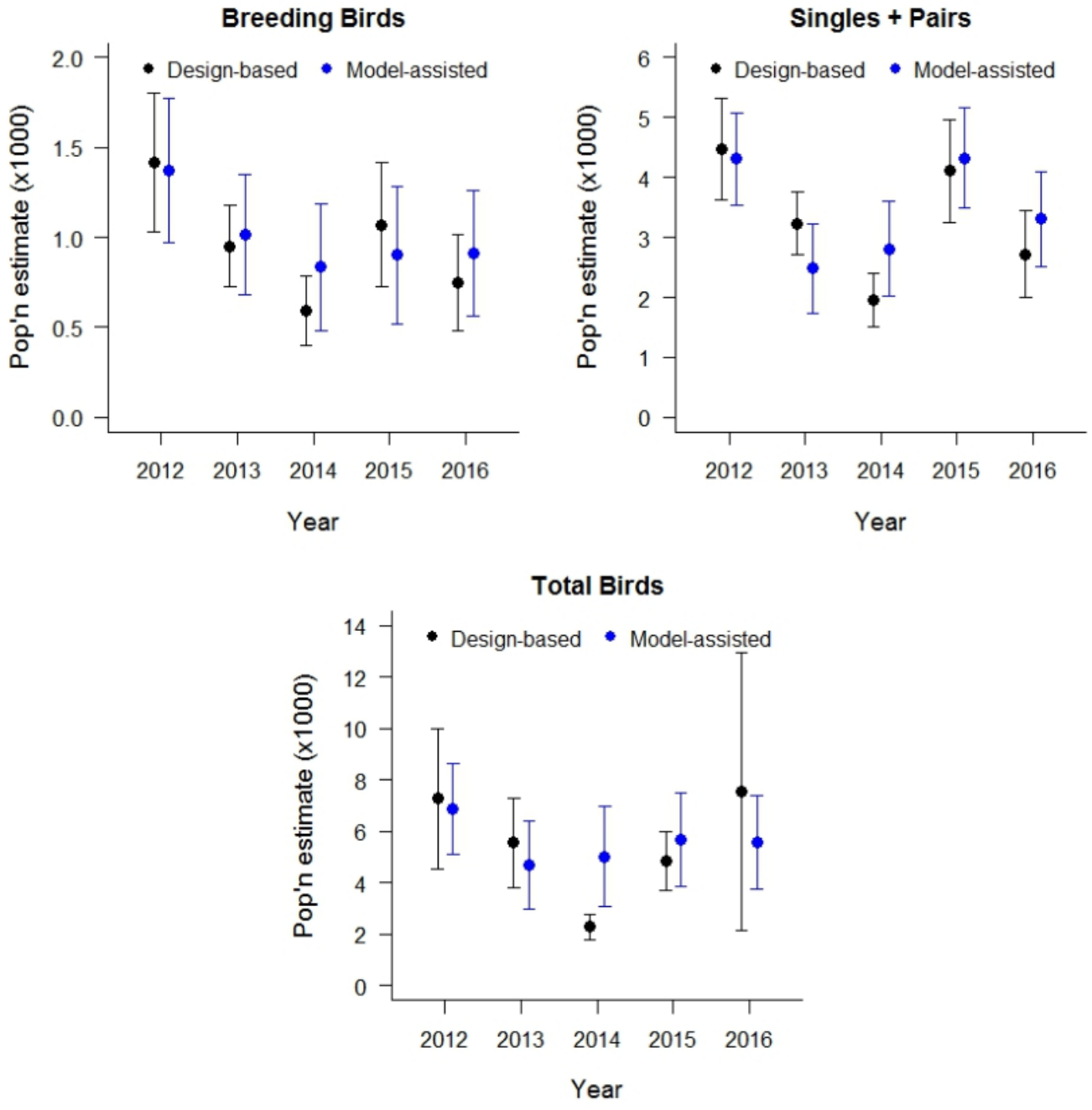

Figure 6. Design-based and model-assisted estimates of breeding sandhill cranes (SACR) and total breeding ground population in the Aspen Parklands survey area of northwestern Minnesota, 2012-2016. See text for explanation of the methods.

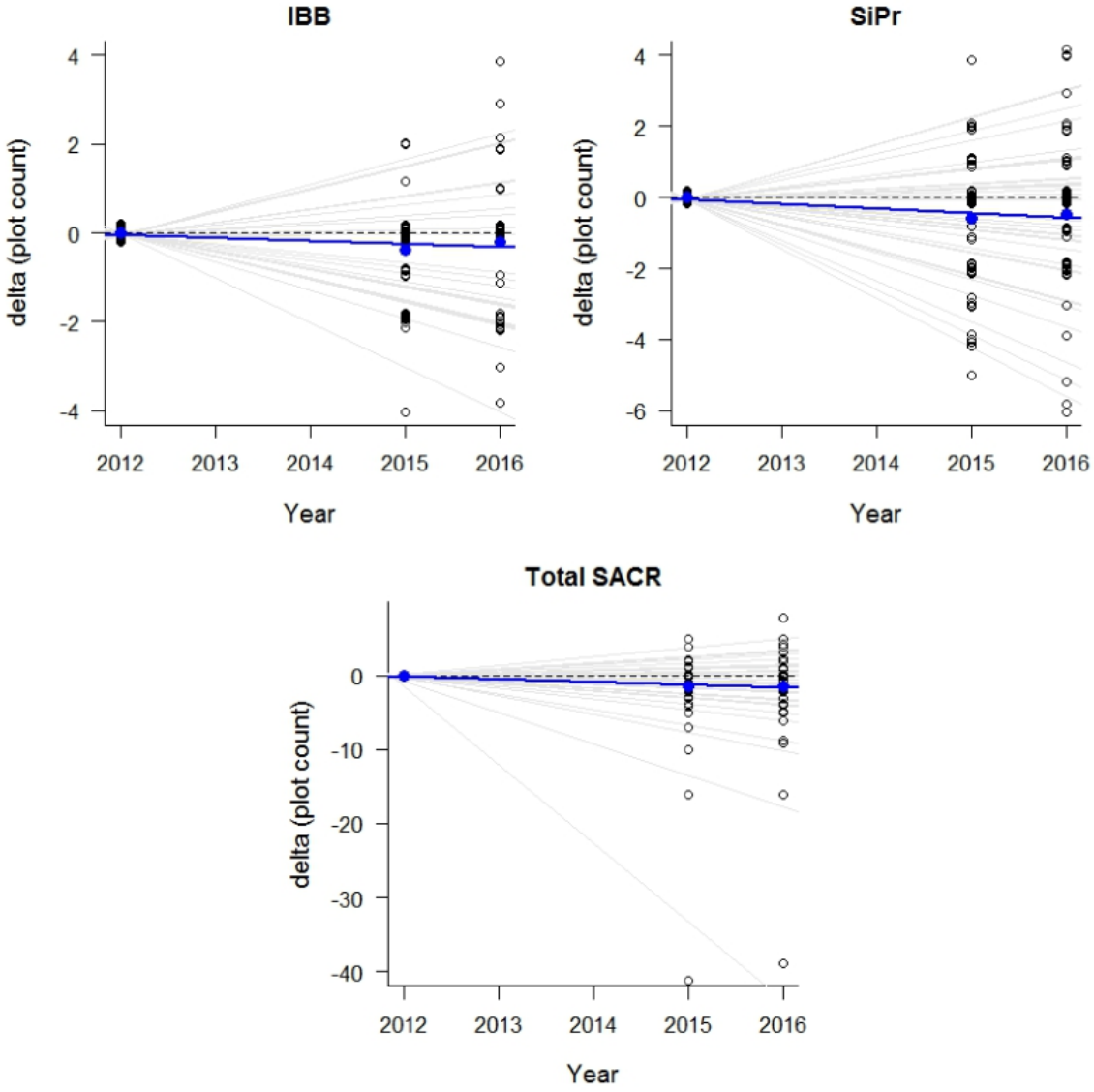

Figure 7. Change in plot counts on individual plots for Indicated Breeding Birds (IBB), singles and pairs (SiPr), and Total SACR in the Aspen Parklands survey area of northwestern Minnesota, 2012, 2015, and 2016. The blue lines denote mean relative population-level changes in plot counts (from 2012), whereas gray lines denote plot-level changes.

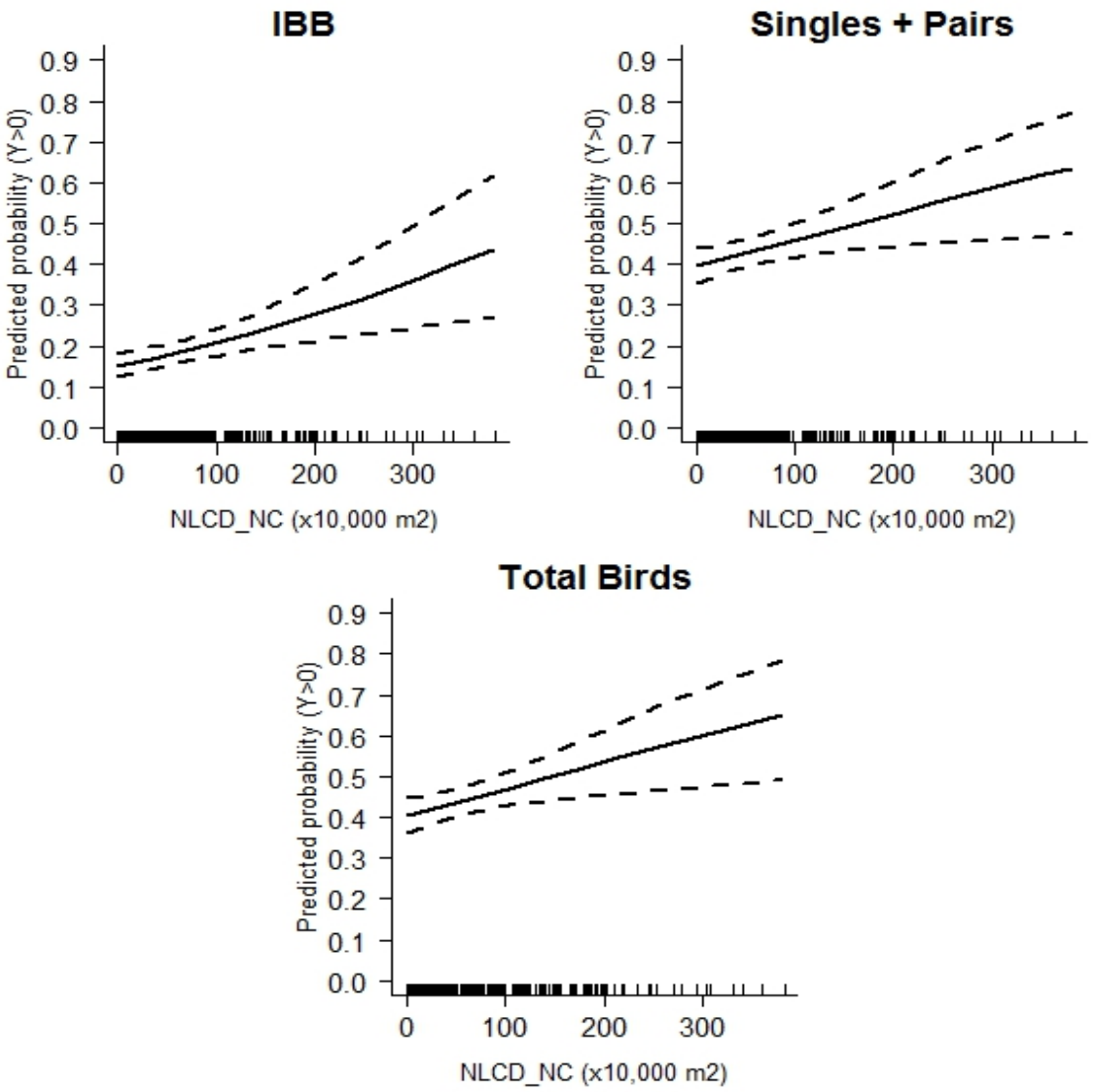

Figure 8. Relationship between sandhill crane occurrence (Indicated Breeding Birds [IBB], total singles and pairs, and total SACR) and habitat abundance (as defined by NLCD classification schemes [see text]) based on 578 4-km2 plots surveyed in northwest Minnesota, 2102-2016.

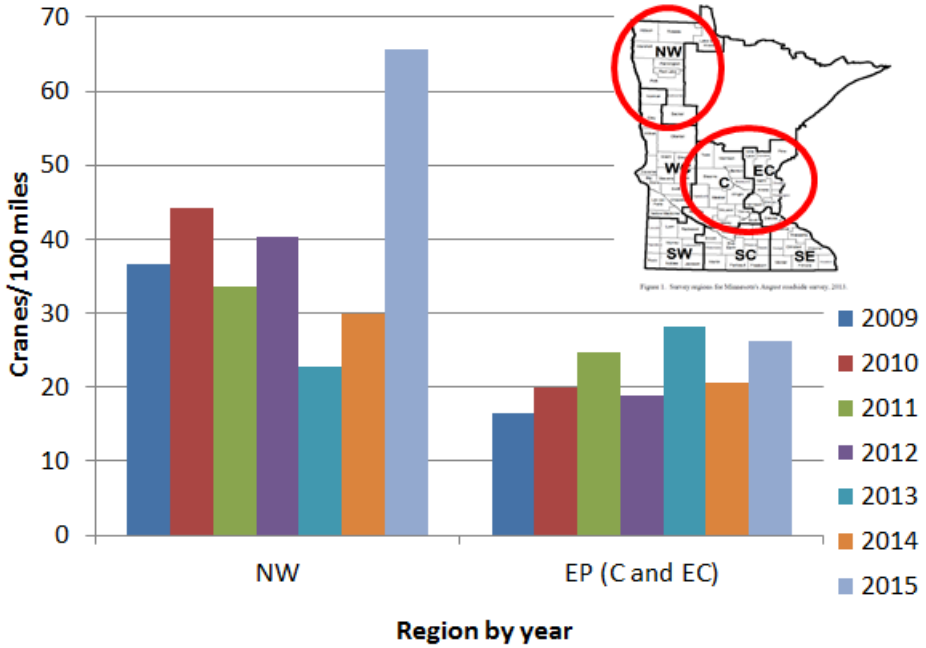

Figure 9. Number of sandhill cranes observed per 100 miles driven in northwest and Eastern Population (central and east-central regions combined), August roadside survey, 2009-2015 (data from 2009-2015 Minnesota August Roadside survey reports, in Status of wildlife population reports, Fall 2009-2015, Division of Fish and Wildlife, Minnesota Department of Natural Resources).