WETLAND WILDLIFE POPULATIONS

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2014 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 2014 aerial survey portion was flown from May 10 to May 24. Both the start and end dates were about a week later than normal due to the late spring and weather delays during the survey. Spring ice-out dates were ~2 weeks later than average across the state. Temperatures were well below normal and precipitation was well above normal in March, April, and May. Spring wetland conditions were very good overall with drier conditions in southwest Minnesota and extremely wet conditions in east central Minnesota. Overall, wetland numbers (Types II-V) increased 33% compared to 2013 and were above both the 10-year (+28%) and long-term (+28%) averages. The number of temporary wetlands (Type 1) remained 13% below the long-term average.

The 2014 estimated mallard breeding population was 257,000, which was 12% lower than last year's estimate of 293,000 mallards, but statistically unchanged (P=0.65). Mallard numbers were 1% below the 10-year average and 13% above the long-term average of 228,000 breeding mallards. The estimated blue-winged teal population was 102,000, which was 29% lower than last year's estimate of 144,000 blue-winged teal, but statistically unchanged (P=0.42). Blue-winged teal numbers remained 41% below the 10-year average and 53% below the long-term average of 215,000 blue-winged teal. The combined population index of other ducks, excluding scaup, was 116,000 ducks, which was 53% lower than last year's estimate and 41% below the 10-year average and 35% below the long-term average of 179,000 other ducks.

The estimate of total duck abundance (474,000), which excludes scaup, was 31% lower than last year's estimate of 683,000 ducks and was 25% below the 10-year average and 24% below the long-term average of 621,000 ducks. The estimated number of Canada geese was 100,000 and 52% lower than last year and 39% below the 10-year average.

Visibility Correction Factors declined for mallards, blue-winged teal, other ducks, and Canada geese and were 15-30% below their respective 10-year averages.

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.

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 a Cessna 185. 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 by the pilot and observer and transcribed by the observer from the digital files. On transects with low waterfowl abundance, the observer recorded all observations to make transcription easier.

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 2013 and 2014 were compared using two-tailed Z-tests.

SURVEY CHRONOLOGY:

The 2014 aerial survey began on 10 May in southern Minnesota and concluded in northern Minnesota on 24 May. The start date was similar to last year but about 1 week later than average due to the late spring. Transects were flown on 9 days, May 10-11, May 14-16, and May 21-24. Flights began no earlier than 7 AM and were completed by 12:30 PM each day. The median date for survey completion was May 21, which was similar to last year but one of the latest surveys on record.

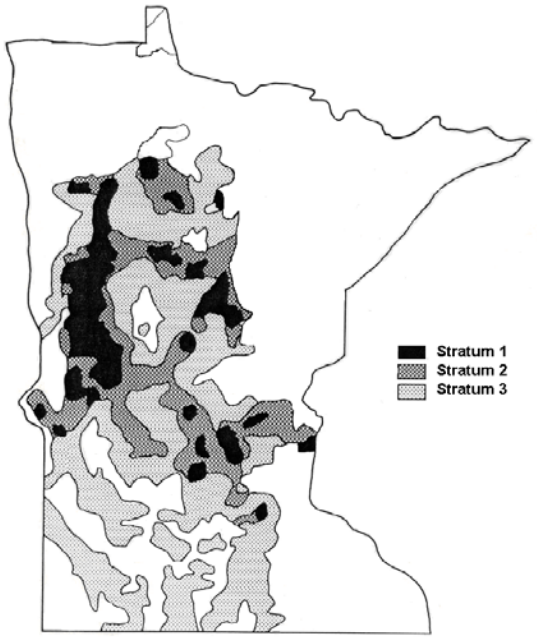

Figure. 1. Location of waterfowl breeding population survey strata in Minnesota.

WEATHER AND HABITAT CONDITIONS:

For the majority of Minnesota lakes, ice out was about 2 weeks later than average but a few days earlier than 2013. Temperatures in March averaged 8°F below normal and precipitation was 1.0 inches above normal statewide. Temperatures in April averaged 4°F below normal. April precipitation was 1.5 inches above normal statewide and ranged from 0.5 inches below normal in southwest Minnesota to 3.0 inches above normal in east central Minnesota. May

temperatures averaged 0.8°F below normal statewide. May precipitation was 0.4 inches above normal statewide and ranged from 2.0 inches above normal in northeast and central Minnesota to 1.0 inches below normal in southwest Minnesota (http://climate.umn.edu). Additional temperature and precipitation data are provided in Appendix A.

Wetland conditions in April were variable and ranged from dry in southwest Minnesota to very wet in the east central region. In early May 2014, 8% of the state was under moderate drought, 10% was abnormally dry, and 82% of the state was under no drought designation. In early May 2013, 15% of the state was under severe drought, 15% was moderate drought, 40% was abnormally dry, and 15% of the state was under no drought designation. In early May 2014, statewide topsoil moisture indices were rated as 1% very short or short, 62% adequate and 37% surplus moisture *(http://droughtmonitor.unl.edu).*

Planting dates for row crops were late in 2014. By May 11, only 31% of the corn acres had been planted statewide compared to 16% in 2013 and 62% for the previous 5-year average. By June 1, only 6% of alfalfa hay had been cut compared to 2% in 2013 and a 5-year average of 29% (Minnesota Agricultural Statistics Service Weekly Crop Weather Reports, (http://www.nass.usda.gov/mn/).

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

Wetland numbers (Type II-V) increased 33% from 2013 and were 28% above both the 10-year average and the long-term average (Table 2; Figure 2). The number of temporary (Type 1) sheet water wetlands was 13% below the long-term average. In general, wetland conditions improved in mid to late May, particularly in the eastern portions of the survey region.

WATERFOWL POPULATIONS:

The number of ducks, Canada geese, and coots, 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 2014 breeding population estimate of mallards was 256,996 (SE = 55,366), which was 12% lower than the 2013 estimate of 293,239 mallards, but statistically unchanged (Z = 0.45, P = 0.65) (Table 7, Figure 3). Mallard numbers were 1% below the 10-year average and 13% above the long-term average of 228,000 mallards. In 2013, the mallard population was comprised of 75% lone or flocked males, 21% pairs, and 4% flocked mallards. The 5-year average is 74% lone or flocked males, 20% pairs, and 6% flocked mallards.

The estimated blue-winged teal population was 101,640 (SE = 24,089), which was 29% below the 2013 estimate of 143,927 blue-winged teal, but statistically unchanged (Z = 0.81, P = 0.42). Blue-winged teal numbers were 41% below the 10-year average and 53% below the long-term average (Table 7, Figure 4). The blue-winged teal population was comprised of 7% lone males, 53% pairs, and 40% flocks. The long-term average is 20% lone males, 54% pairs, and 26% flocks. The lower percentage of lone males and higher percentage of flocks may reflect a later nesting effort due to the extremely late spring.

The combined population estimate of other ducks (excluding scaup) was 115,751 which was 53% below last year's estimate of 246,000 other ducks and 41% below the 10-year average and 35% below the long-term average (Table 7, Figure 5). Ring-necked ducks and wood ducks were the most abundant species of other ducks (Table 6). Scaup numbers (15,000) were 54% below the 10-year average and 77% below the long-term average.

The total duck population index, excluding scaup, was 474,000 ducks and was 31% below last year's index of 683,000 ducks and 25% below the 10-year average and 24% below the long-term average (Table 8, Figure 6).

The population index for total ducks was 489,000 ducks, which was 26% below the 10-year average and 28% below the long-term average.

Visibility Correction Factors (VCFs) for mallards, blue-winged teal, other ducks, and Canada geese were all lower in 2014 than 2013 and below their long-term averages (Table 7, Table 8). The mallard VCF (2.31) was 13% below last year's estimate and 4% above the long-term average. The blue-winged teal VCF (3.18) was 40% below last year's estimate and 18% below the long-term average. The VCF for other ducks (2.24) was 37% below last year's estimate and 28% below the long-term average. The VCF for Canada geese (1.57) was 29% below last year's estimate and 33% below the long-term average.

The population estimate of Canada geese (adjusted for visibility) was 100,255, which was 39% below the 10-year average (Table 8, Figure 7). A total of 13 Canada goose broods were observed, compared to 5 in 2013 and 70 in 2012, which indicates a late nesting effort again this year.

The estimated coot population, uncorrected for visibility, was 19,000 compared to 40,500 in 2013.

The estimated number of swans (likely trumpeters) was 7,700 swans compared to last year's estimate of 11,500. This estimate is expanded for area but not visibility and lone swans are not doubled. Trumpeter swans continue to expand their range and dramatically increase in number.

SUMMARY:

Ice out was about 2 weeks later than average across the state in 2014. Temperatures in March, April, and May were below normal statewide. Precipitation in March, April, and May was above average throughout most of the survey area. Wetland conditions were very good across the region in spring 2014. Overall, wetland numbers were 33% higher than last year and 28% above the long-term average. Mallard abundance in 2014 was 257,000 mallards, which was 12% lower than last year, similar to the 10-year average, and 13% above the long-term average of 228,000 breeding mallards. Blue-winged teal abundance (102,000) was 29% lower than 2013 and 53% below the long-term average of 215,000 blue-winged teal. The combined population index of other ducks (116,000) was 53% lower than 2013 and 35% below the long-term average of 179,000 other ducks. Total duck abundance (474,000), excluding scaup, was 31% lower than 2013 and was 24% below the long-term average. Canada goose numbers, adjusted for visibility bias, decreased 52% from 2013. Visibility Correction Factors were lower for all species of ducks and Canada geese in 2014 and were all below their long-term averages.

ACKNOWLEDGMENTS:

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Oslund, USFWS, HAPET, Fergus Falls; Tom Cooper and Jim Kelley; USFWS, Region III, Twin Cities; Bruce Davis; Minnesota DNR; Greg Dehmer and Sally Zodrow; USFWS, Sherburne National Wildlife Refuge;

Ground Crew Assistants: Brad Nylin, Minnesota Waterfowl Association; Rich Olsen, Minnesota DNR; Lowell Deede and Gina Kemper, USFWS, Tamarac National Wildlife Refuge; Tony Hewitt and Paul Soler, USFWS, Sherburne National Wildlife Refuge; Nathan Williams and Jenny Dubay; USFWS, HAPET, Fergus Falls; Paul Richert and Dave Fronczak; USFWS, Region III, Twin Cities

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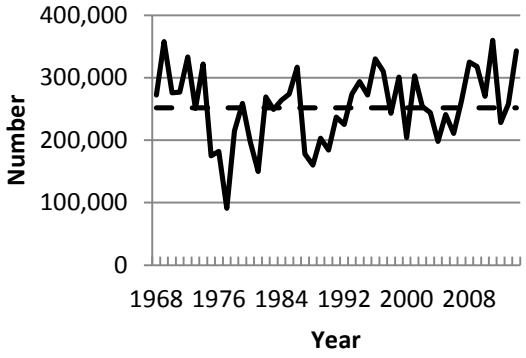

Figure 2. Number of May ponds (Types II-V) and long-term average (dashed line) in Minnesota, 1968-2014.

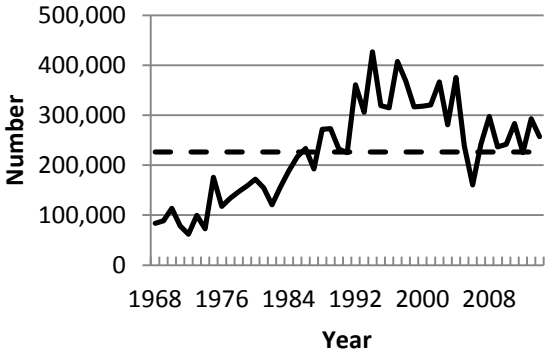

Figure 3. Mallard population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2014.

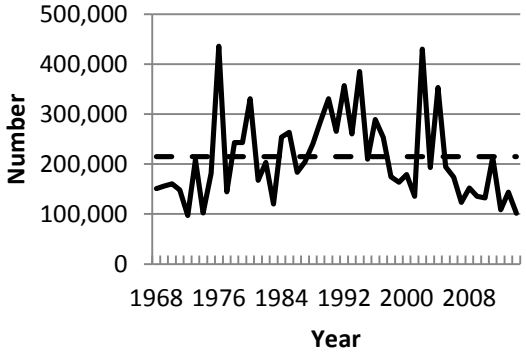

Figure 4. Blue-winged teal population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2014.

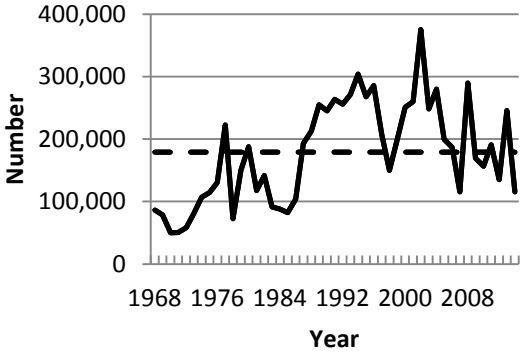

Figure 5. Other duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2014

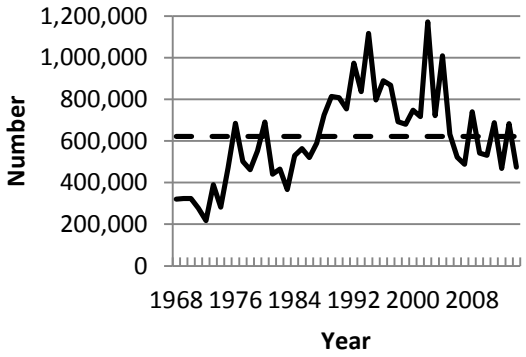

Figure 6. Total duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2014

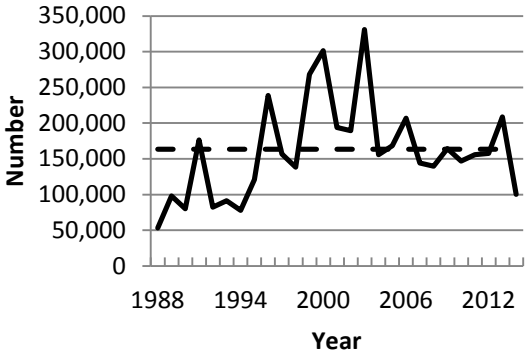

Figure 7. Canada goose population (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1988-2014.

Table 1. Survey design for Minnesota, May 2014.[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), 1968-2014.

	Year	Type I	Number of ponds[1]
	1968		272,000
	1969		358,000
	1970		276,000
	1971		277,000
	1972		333,000
	1973		251,000
	1974		322,000
	1975		175,000
	1976		182,000
	1977		91,000
	1978		215,000
	1979		259,000
	1980		198,000
	1981		150,000
	1982		269,000
	1983		249,000
	1984		264,000
	1985		274,000
	1986		317,000
	1987		178,000
	1988		160,000
	1989		203,000
	1990		184,000
	1991	82,862	237,000
	1992	10,019	225,000
	1993	199,870	274,000
	1994	123,958	294,000
	1995	140,432	272,000
	1996	147,859	330,000
	1997	30,751	310,000
	1998	20,560	243,000
	1999	152,747	301,000
	2000	5,090	204,000
	2001	66,444	303,000
	2002	30,602	254,000
	2003	34,005	244,000
	2004	9,494	198,000
	2005	30,764	241,000
	2006	56,798	211,000
	2007	32,415	262,000
	2008	69,734	325,000
	2009	39,078	318,000
	2010	26,880	270,000
	2011	89,218	360,000
	2012	30,910	228,000
	2013	9,813	258,000
	2014	54,300	343,000
Averages:	10-year	39,510	267,000
	Long-term	62,622	268,000
% change from:	2013	453%	33%
	10-year	37%	28%
	Long-term	-13%	28%

Table 3. Minnesota waterfowl breeding populations by species for Stratum I (high wetland density), expanded for area but not visibility, 1996-2014.

	Year																		
Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dabblers:																			
Mallard	25,104	26,992	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
Black Duck	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0	0	333	167
Gadwall	1,083	611	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
American Wigeon	0	0	56	56	56	111	0	56	555	167	0	56	111	56	56	111	222	222	167
Green-winged Teal	278	56	333	0	278	56	278	222	444	56	56	167	278	167	56	56	56	0	0
Blue-winged Teal	6,720	6,387	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
Northern Shoveler	1,277	1,500	500	555	1,055	305	1,277	278	1,166	333	167	56	1,000	666	1,027	111	56	333	722
Northern Pintail	167	111	111	167	167	389	56	111	56	0	56	0	56	56	0	111	0	111	167
Wood Duck	6,498	9,497	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
Dabbler Subtotal	41,127	45,154	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
Divers:																			
Redhead	722	778	944	500	583	1,444	750	333	805	666	666	916	1,389	472	944	805	750	861	1,333
Canvasback	1,166	1,333	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
Scaup	13,829	3,416	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
Ring-necked Duck	3,166	2,694	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
Goldeneye	167	0	111	56	56	333	111	0	222	222	56	222	278	278	222	56	56	333	444
Bufflehead	278	0	56	111	56	111	222	111	389	167	222	56	1,611	833	389	278	56	611	56
Ruddy Duck	139	528	11,052	972	0	83	1,305	417	305	1,222	305	0	1,027	861	28	56	0	305	111
Hooded Merganser	611	555	389	722	500	722	555	333	278	333	555	111	666	944	555	500	555	333	666
Large Merganser	0	56	0	0	0	111	0	972	0	111	0	278	333	333	333	111	56	222	139
Diver Subtotal	20,078	9,360	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
Total Ducks	61,205	54,514	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
Other:																			
Coot	3,055	5,054	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
Canada Goose	12,774	10,330	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

Table 4. Minnesota waterfowl breeding populations by species for Stratum II (medium wetland density), expanded for area but not visibility, 1996-2014.

	Year																		
Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dabblers:																			
Mallard	48,507	54,643	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
Black Duck	0	0	0	0	0	117	0	0	0	0	0	0	0	0	0	0	0	0	0
Gadwall	935	468	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
American Wigeon	468	351	818	0	468	0	0	0	2,513	117	0	0	351	0	351	0	117	234	0
Green-winged Teal	935	234	351	117	117	117	468	234	234	0	117	0	0	234	117	0	0	117	351
Blue-winged Teal	13,851	13,792	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
Northern Shoveler	1,636	2,571	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
Northern Pintail	117	234	468	117	117	117	0	117	0	0	0	234	0	0	0	234	0	0	117
Wood Duck	8,708	11,338	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
Dabbler subtotal	75,157	83,631	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
Divers:																			
Redhead	1,110	1,987	935	1,636	2,805	2,455	234	584	1,110	292	175	935	935	584	760	1,578	468	468	526
Canvasback	234	701	117	117	935	0	468	1,052	234	0	0	1,169	468	234	117	584	117	935	1,286
Scaup	21,916	18,935	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
Ring-necked Duck	7,714	3,565	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
Goldeneye	1,753	818	234	935	584	468	234	234	351	117	117	0	351	584	468	468	584	935	1,519
Bufflehead	117	117	0	0	0	0	1,169	117	468	351	117	117	1,403	818	643	1,403	468	0	818
Ruddy Duck	58	117	0	468	0	0	1,870	2,688	0	351	58	0	0	175	409	58	234	117	0
Hooded Merganser	234	468	117	701	935	1,403	701	701	234	234	351	234	584	701	117	2,221	1,636	701	234
Large Merganser	0	0	0	0	117	117	0	0	234	351	0	0	351	0	0	234	0	234	117
Diver subtotal	33,136	26,708	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
Total Ducks	108,293	110,339	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
Other:																			
Coot	7,013	5,026	643	234	1,110	468	4,909	1,519	8,007	584	292	409	23,961	0	117	292	292	2,571	877
Canada Goose	13,559	16,364	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

Table 5. Minnesota waterfowl breeding populations by species for Stratum III (low wetland density), expanded for area but not visibility, 1996-2014.

	Year																		
Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dabblers:																			
Mallard	79,862	78,993	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
Black Duck	0	0	0	0	0	0	0	0	174	0	0	174	174	0	0	0	174	174	0
Gadwall	3,306	2,436	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
American Wigeon	1,044	348	696	0	522	174	1,218	174	1,566	1,044	174	348	348	174	348	1,044	174	348	174
Green-winged Teal	957	348	174	0	1,218	1,392	522	174	0	174	522	0	0	0	0	174	348	696	0
Blue-winged Teal	36,625	25,316	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
Northern Shoveler	12,701	11,049	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
Northern Pintail	870	522	870	870	696	522	0	174	348	174	174	348	174	0	174	0	174	174	0
Wood Duck	27,926	14,268	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
Dabbler subtotal	163,291	133,280	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
Divers:																			
Redhead	1,044	1,044	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
Canvasback	1,392	0	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
Scaup	29,840	8,787	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
Ring-necked Duck	12,875	3,654	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
Goldeneye	1,914	522	696	696	1,044	1,566	3,132	1,305	696	1,044	1,044	870	348	522	174	870	0	348	174
Bufflehead	1,044	174	348	0	0	0	1,218	783	2,088	0	174	696	1,218	870	174	2,871	174	3,915	4,698
Ruddy Duck	1,740	348	0	174	0	696	18,878	87	2,262	870	696	261	87	348	0	3,828	522	522	174
Hooded Merganser	1,566	696	696	1,218	957	174	2,175	174	1,740	1,218	870	174	696	348	1,218	1,044	1,044	348	348
Large Merganser	0	0	0	0	0	0	522	0	0	261	957	348	348	348	348	174	174	0	0
Diver subtotal	51,415	15,225	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
Total Ducks	214,706	148,505	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
Other:																			
Coot	182,953	24,620	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
Canada Goose	34,537	33,755	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

Table 6. Minnesota waterfowl breeding populations by species for Stratum I-III combined, expanded for area coverage but not for visibility, 1996-2014.

	Year																		
Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dabblers:																			
Mallard	153,473	160,628	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
Black Duck	0	0	0	0	0	117	0	0	174	56	0	174	174	0	0	0	174	507	167
Gadwall	5,324	3,515	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
American Wigeon	1,512	699	1,570	56	1,045	285	1,218	230	4,634	1,327	174	404	810	230	754	1,155	513	804	341
Green-winged Teal	2,170	638	858	117	1,613	1,564	1,267	630	678	230	694	167	278	400	172	230	404	813	351
Blue-winged Teal	57,196	45,495	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
Northern Shoveler	15,614	15,120	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
Northern Pintail	1,154	867	1,449	1,153	979	1,028	56	402	404	174	230	582	230	56	174	345	174	285	284
Wood Duck	43,132	35,103	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
Dabbler subtotal	279,575	262,065	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
Divers:																			
Redhead	2,876	3,809	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
Canvasback	2,792	2,034	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
Scaup	65,585	31,138	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
Ring-necked Duck	23,755	9,913	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
Goldeneye	3,834	1,340	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
Bufflehead	1,439	291	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
Ruddy Duck	1,937	993	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
Hooded Merganser	2,411	1,719	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
Large Merganser	0	56	0	0	117	228	522	972	234	723	957	626	1,032	681	681	519	230	456	256
Diver subtotal	104,629	51,293	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
Total Ducks	384,204	313,358	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
Other:																			
Coot	193,021	34,700	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
Canada Goose	60,870	60,449	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

Table 7. Mallard, blue-winged teal, and other duck (excluding scaup) populations in Minnesota, 1968-2014.

	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

	Mallard				Blue-winged teal				Other ducks (exc. scaup)		
Year	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI
1998	188,972	1.95	368,450	61,513	47,788	3.66	174,848	33,855	91,478	1.64	149,786
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
Averages:											
10-year	96,331	2.73	259,443	39,207	45,983	3.88	173,060	42,537	64,135	3.20	196,839
Long-term	102,506	2.23	227,579	37,196	58,093	3.88	214,763	42,578	61,103	3.13	178,872
% change from											
2013	0%	-13%	-12%	-5%	18%	-40%	-29%	-48%	-25%	-37%	-53%
10-year average	16%	-15%	-1%	41%	-30%	-18%	-41%	-43%	-20%	-30%	-41%
Long-term average	9%	4%	13%	49%	-45%	-18%	-53%	-43%	-16%	-28%	-35%

Table 8. Scaup, total ducks (excluding scaup), total ducks, and Canada goose populations in Minnesota, 1968-2014.

	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

Table 8. Scaup, total ducks (excluding scaup), total ducks, and Canada goose populations in Minnesota, 1968-2014.

	Scaup			Total Ducks (exc. scaup)		Total ducks		Canada geese		
Year	Unad. PI	VCF	PI	Unad. PI	PI	Unad. PI	PI	Unad. PI	VCF	PI
1999	14,041	2.49	35,002	285,778	680,463	299,819	715,465	80,012	3.35	268,168
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
Averages:										
10-year	10,178	3.20	31,683	206,484	630,048	216,627	661,730	80,163	2.11	164,873
Long-term	21,109	3.14	62,320	221,666	621,367	242,768	683,687	47,058	2.34	163,330
% change from										
2013	-45%	-37%	-66%	-6%	-31%	-8%	-33%	-32%	-29%	-52%
10-year average	-36%	-30%	-54%	-6%	-25%	-7%	-26%	-20%	-25%	-39%
Long-term average	-69%	-29%	-77%	-12%	-24%	-17%	-28%	36%	-33%	-39%

Appendix A. Temperature and precipitation at selected cities in, or adjacent to, Minnesota May Waterfowl Survey Strata, 27 April - 26 May 2014 (Source: Minnesota Climatological Working Group, http://climate.umn.edu/cawap/nwssum/nwssum.asp).

		Temperature (F) for week ending:										Total weekly precipitation (inches)					Precipitation departure from normal
		27-April		4-May		11-May		18-May		25-May							
Region	City	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	27-April	4-May	11-May	18-May	25-May	1 Apri1-May 25
NW	Crookston	45.5	-1.0	42.9	-6.6	48.8	-3.5	45.8	-9.1	61.4	3.9	0.73	1.26	0.41	0.28	0.18	-0.42
NC	Grand Rapids	38.4	-7.4	40.0	-8.7	48.4	-3.0	44.7	-9.3	60.2	3.8	0.64	0.74	1.43	1.09	0.33	1.23
	Itasca	39.8	-3.5	39.7	-6.7	47.0	-2.3	44.7	-7.4	M	M	1.59	0.33	0.76	0.87	M	1.60
WC	Alexandria	43.2	-4.5	42.6	-8.1	52.0	-1.4	46.8	-9.2	61.9	3.5	1.83	0.81	1.13	0.41	0.82	1.71
	Montevideo	47.5	-1.3	42.8	-9.0	53.1	-1.5	46.0	-11.3	62.4	2.5	1.22	1.43	0.86	0.12	0.20	-0.78
	Morris	45.5	-2.6	42.0	-9.1	49.7	-4.3	44.8	-11.9	61.3	2.1	1.61	0.97	1.26	0.54	0.30	1.27
C	Becker	47.4	-2.7	42.2	-10.8	54.0	-1.7	49.7	-8.5	61.4	1.0	2.96	2.05	2.91	0.37	1.36	6.14
	Hutchinson	49.0	-0.7	42.2	-10.3	54.0	-1.1	49.0	-8.7	62.4	2.2	1.37	2.12	1.44	1.66	1.39	4.27
	St. Cloud	44.8	-3.6	45.4	-5.8	55.0	1.2	50.0	-6.2	62.8	4.2	2.63	1.84	2.83	0.24	0.95	5.22
	Willmar	46.2	-3.2	41.6	-10.8	51.0	-4.6	45.6	-12.2	60.2	-0.2	1.40	2.24	0.93	0.72	0.63	1.69
EC	Aitkin	43.1	-2.5	41.2	-7.0	47.8	-3.2	46.6	-6.5	58.7	3.2	0.62	1.10	1.85	0.74	0.44	1.62
	Msp Airport	46.7	-4.5	44.6	-9.3	56.8	0.5	51.2	-7.6	62.3	1.1	3.10	1.37	1.32	0.27	2.25	4.87
SW	Pipestone	50.6	1.7	42.4	-9.3	53.4	-1.0	45.0	-12.0	64.1	4.6	0.60	1.25	0.16	1.19	0	-1.83
	Redwood Falls	48.6	-1.9	44.8	-8.6	56.5	0.4	49.4	-9.3	63.6	2.4	1.01	1.42	1.28	0.12	0.01	0.00
	Worthington	51.6	2.9	43.4	-8.2	54.8	0.5	46.8	-10.3	62.4	2.7	0.42	0.89	0.45	0.38	0	-2.83
SC	Faribault																
	Waseca	49.4	-0.6	42.4	-10.5	54.5	-1.2	48.8	-9.6	60.7	-0.3	1.13	2.95	0.58	1.54	0.38	1.82
	Winnebago	51.2	1.0	43.4	-9.6	56.2	0.4	48.8	-9.6	62.6	1.7	0.67	2.08	0.82	2.00	0.03	0.73
Statewide		45.1	-2.4	42.2	-8.2	51.3	-1.6	47.2	-8.3	60.7	2.7	1.20	1.55	1.07	0.88	0.60	

[1] Average temperature (°F) for the week ending on the date shown.
[2] Departure from normal temperature.
M=missing data.

Waterfowl information is taken from the U.S. Fish and Wildlife Service report Waterfowl Population Status, 2014 by Kathy Fleming, Pamela Garrettson, Walt Rhodes, and Nathan Zimpfer. The entire report is available on the Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/reports/reports.html).

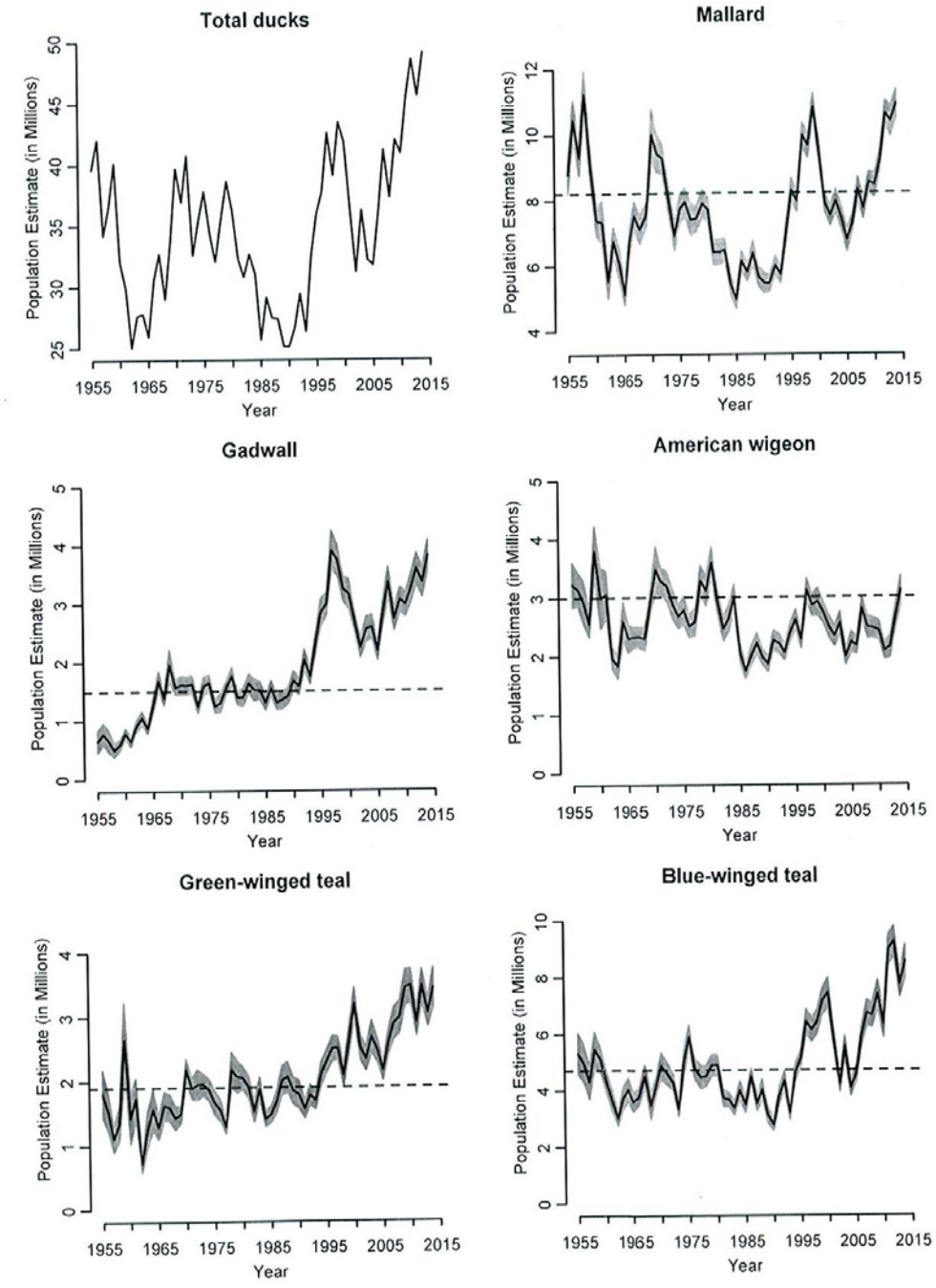

Figure 1 Estimates of North American breeding populations, 95% confidence intervals, and North American Waterfowl Management Plan population goal (dashed line) for selected species and number of water areas in May in Prairie Canada and Northcentral U.S (from: U.S. Fish and Wildlife Service 2014).

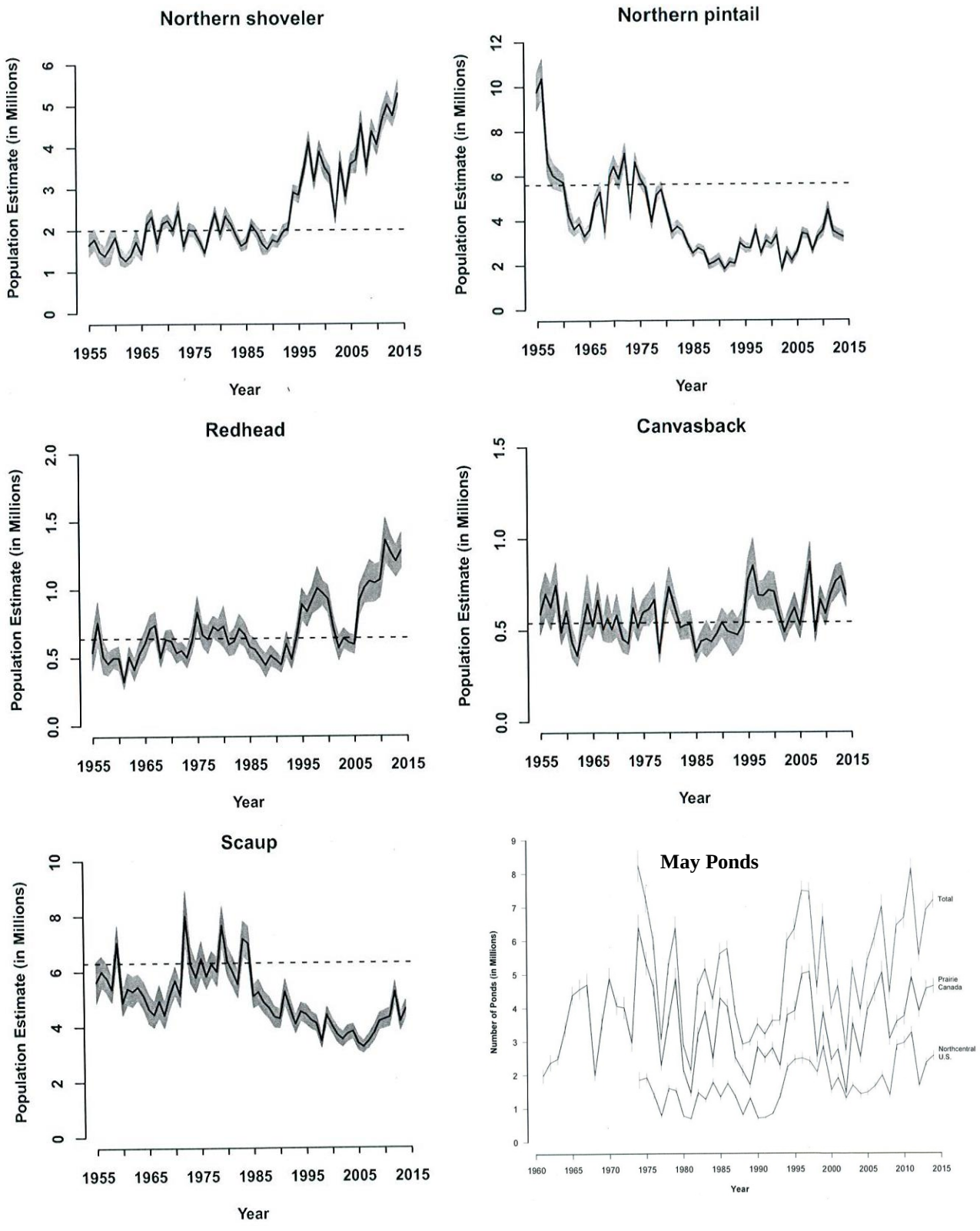

Figure 1 (continued).

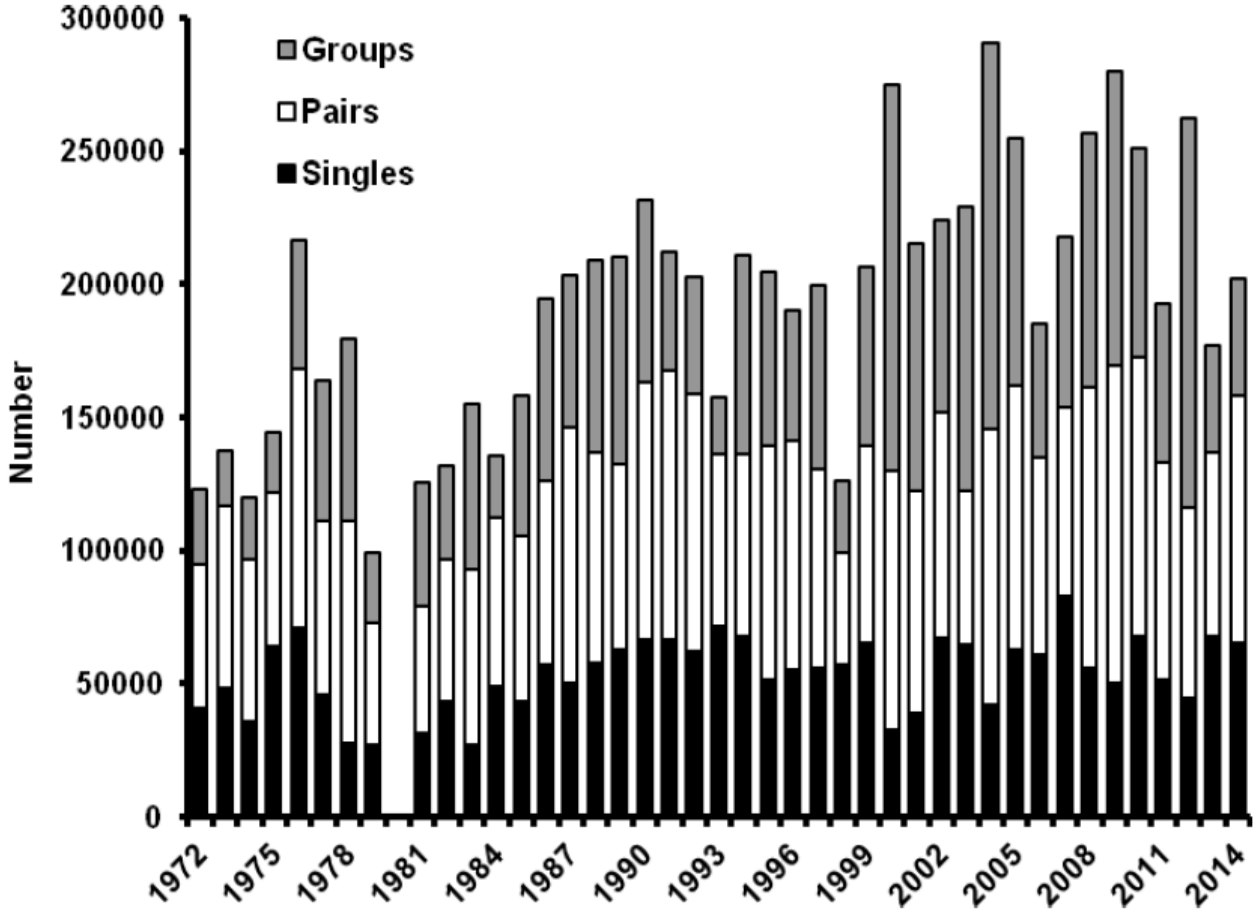

Figure 2 Breeding ground survey estimates of the Eastern Prairie Population of Canada geese, 1972-2014. (from: Baldwin, F., J. Wollenberg, and B. Lubinski. 2014. 2014 EPP Breeding Population Survey. Unpublished report prepared for the Mississippi Flyway Council Technical Section). Data not available for 1980.

2014 MINNESOTA SPRING CANADA GOOSE SURVEY

David Rave, Wetland Habitat Team

INTRODUCTION

This report presents results from the fourteenth year of a spring helicopter survey of resident Canada geese in Minnesota. The survey was developed to comply with a Mississippi Flyway Council request to produce a statewide population estimate of resident giant Canada geese having 95% confidence intervals (C.I.'s) that are within $\pm$ 25% of the estimate.

METHODS

The original survey was initiated in 2001 using a double sampling design where an annual stratified sample was randomly selected from 900 plots in each ecoregion (Maxson 2002). I eliminated the double sampling design in 2008 by stratifying all potential plots in each ecoregion, and randomly sampling from the entire sampling frame (i.e., it is now a simple stratified sampling design with new sample plots drawn each year).

The state was divided into three ecoregions (Prairie Parkland, Eastern Broadleaf Forest/Tallgrass Aspen Parklands, Laurentian Mixed Forest) hereafter referred to as Prairie, Transition, and Forest. The 7- county Metro area was excluded from the Transition ecoregion. Similarly, Lake and Cook Counties plus the Boundary Waters Canoe Area and the Northwest Angle were excluded from the Forest ecoregion. Four Statewide ArcView shapefiles were then unioned together: National Wetlands Inventory circular 39, DNR 1:24k lakes, Public Land Survey Quarter section Boundaries, and ECS provinces, to assign each quarter section plot to the appropriate strata.

Four new fields were then computed: total acres of Type 3, 4, and 5 wetlands per quarter section (Circ39_acr), total acres of 1:24k lakes per quarter section (Lakes_acr), total acres of type 3 wetlands per quarter section (Sum_type3_acr) and total acres of river per quarter section (Sum_Riv_acr). A summary table was created with text fields for each of the 8 strata (habitat-quality class x ecoregion). Using the query builder in ArcMap, quarter sections in each ecoregion were assigned to habitat-quality classes for resident geese: 1) not nesting habitat – expect no geese, 2) limited nesting habitat – habitat capable of supporting 1 or 2 pairs of geese, 3) prime nesting habitat – habitat capable of supporting 3 or more pairs.

Habitat-classification criteria for each ecoregion:

Prairie

No geese =	Type 3-4-5 <0.5 acres and rivers <10 acres or plot is all water. (n = 61,597 plots).
1-2 pairs =	Type 3-4-5 $\geq$ 0.5 acres but Type 3 <15 acres or Type 3-4-5 <0.5 acres and rivers >10 acres. (n = 30,874 plots).
3+ pairs =	Type 3 >15 acres, but plot is not all water. (n = 9,537 plots).

Transition

No geese =	Type 3-4-5 <1 acre and rivers <8 acres or plot is all water. (n = 39,484 plots).

1-2 pairs = Type 3-4-5 = 1-25 acres or Type 3-4-5 >25 acres, but Type 3 <15 acres or Type 3-4-5 <1 acre and rivers >8 acres. (n = 31,091 plots).

3+ pairs = Type 3-4-5 >25 acres, but Type 3 >15 acres and plot is not all water. (n = 7,988 plots).

Forest

No geese = Type 3-4-5 <2 acres and rivers <2 acres or plot all water. (n = 75,835 plots).

1-2 pairs = Type 3-4-5 ≥2 acres, but not all water or Type 3-4-5 <2 acres and rivers >2 acres. (n = 51,155 plots).

3+ pairs = None.

Plots in the "no geese class" are not flown and there are no plots in the "3+ pairs" class in the Forest ecoregion. Prior to 2011, 30 plots were randomly selected in each of the 5 remaining strata using ArcView's AlaskaPak extension, and these 150 plots were surveyed at low level using a helicopter. The stratification was modified slightly in 2011 to include a binary stratification variable (zone), which permitted a domain analysis of total geese in a proposed new hunting zone (Figure 1). Thus, the 9 strata for 2014 were Forest–12, Transition–12new, Transition–12other, Transition–3new, Transition– 3other, Prairie–12new, Prairie–12other, Prairie–3new, and Prairie–3other. Thirty plots (quarter sections) were randomly selected from strata in the new zone (using proportional allocation) and 130 plots were selected from strata not in the new zone for a total of 160 sample plots (Figure 1). Ideally, the survey should be conducted during mid-incubation.

Pilot John Heineman and I flew the survey on 8 days between 21 April and 4 May, 2014, which are about average start and end dates over the past 12 years. Canada geese seen within plot boundaries were recorded as singles, pairs, and groups. We also recorded whether singles and pairs were observed with a nest. The number of singles and pairs was doubled when the total number of geese per plot was calculated.

RESULTS AND DISCUSSION

The total Canada goose population estimate in the surveyed area for 2014 was 244,100 (±77,800). Adding 17,500 for the Twin Cities metro area (Cooper 2004) yields a statewide estimate of 261,600 Canada geese (Table 1). Relative error (95% CI half-width) was 31.9% of the estimate. The survey tallied 39.0% singles, 55.0% pairs, and 5.5% groups (Table 2). Typically, some of the pairs seen on this survey are not associated with nests and are likely non-breeders. An index to nesting effort (i.e., Productive Geese) was obtained by combining singles and pairs associated with nests. In 2014, 44.0% of the geese seen were classified as Productive Geese (Table 2).

The 2014 Canada goose breeding population estimate for the surveyed area was very similar to the estimate in 2013 (2.5% decline). Goose number estimates were lower than 2013 in Prairie and Forest Ecoregions, and higher than 2013in the Transition Ecoregion (Table 1). A time-series plot suggests the goose population in the survey area has been reasonably stable over the last 14 years (Figure 2). The 2014 estimated breeding population in a portion of the new August hunting zone that has been surveyed since 2011 was 93,600 (±54,300), which was similar to the 2013 estimate for this zone, 79,700 (±48,000).

Ambient temperatures in Minnesota during April and May of 2014 were below average prior to and during the Canada goose survey, and lake ice-out dates statewide were ≥ 10 days later than normal statewide. The below average cold and late ice-out conditions likely affected Canada goose population estimates again in 2014. For a second consecutive year, when the survey started, resident Canada geese were in various stages of pairing, laying and incubation. This is different than the norm, when there is a slight difference in stages between geese in the southern portions of the state, and the north. April and May temperatures well below normal caused birds in the southern third of the state to be anywhere from seeking nest sites to late incubation when the survey started. Ice, which still covered lakes in the northernmost portions of the state on the final day of the survey, may actually have prevented breeding birds from even arriving before the survey was concluded in northern portions of the state.

Wetland and habitat quality were variable in the state this year. Wetland conditions during the Canada goose survey were drier than average in prairie portions of the state, and about average in transition and forested portions of the state. After the survey was completed, heavy rains fell statewide, which may have improved conditions in parts of the state, but likely also flooded some goose nests. One interesting note, very few muskrat houses were seen during the 2014 Canada goose survey. When available, many geese nest on muskrat houses, and the lack of these houses will mean geese must find alternative nesting sites. The late spring likely influenced the number of total geese observed this year. However, although the late spring likely reduced the total number of Canada geese counted on the survey again this year, the numbers of productive geese was higher than in 2013, and close to the average percentage of productive geese counted on this survey. Weather conditions throughout June and July will also influence goose productivity in 2014. Regardless, the total 2014 Canada goose population estimate was above the state Canada goose population goal of 250,000 geese.

With the same number of geese in the population as in 2013, but an overall higher percentage of productive geese, I expect better goose production in Minnesota in 2014 than in 2013, and an overall average production of goslings.

ACKNOWLEDGMENTS

Frank Martin (Univ. of MN) and Steve Maxson were instrumental in the original design of this survey. Steve also was the principal observer during the first 6 years of the survey. Tim Loesch, Christopher Pouliot, and Shelly Sentyrz set up the original 2,700 ¼-section plots using ArcView and were very helpful in getting the survey up and running in 2001. Shelly Sentyrz was also instrumental in helping to restratify plots statewide for the 2008 survey. Chris Scharenbroich and Jacqueline Amor provided GPS coordinates of plots to the pilot, and printed out maps of the 160 plots flown this year. John Heineman piloted the helicopter and served as the second observer. Margaret Dexter was instrumental in coordinating the sampling scheme for the survey, and entered the data. John Giudice provided statistical assistance, and analyzed the data.

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Table 1. Spring Canada goose population estimates in Minnesota, 2001-2014.

Year	Prairie	Transition	Forest	Subtotal	95% CI	Metro	**TOTAL**
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	271,372	±69,055	17,500	**288,872**
2009	129,115	114,737	23,644	267,496	±70,607	17,500	**284,996**
2010	83,911	151,902	57,421	293,234	±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	104,710	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**

*Prior to 2008, double-sampling for stratification was used to estimate stratum weights. The entire frame was re-stratified in 2008 (double-sampling was eliminated) and Lake of the Woods and the NW Angle were removed from the frame. The sampling frame was adjusted slightly in 2009 because of some processing errors in 2008. The population estimates for 2008-2014 are based on the updated sampling frame.

Table 2. Percent of Canada Geese seen as singles, pairs, groups, and productive geese on the Minnesota Spring Canada Goose Survey, 2001-2014.

Year	Singles[1]	Pairs[1]	Groups	Productive Geese[2]	Dates of Survey	Number of productive geese
2001	27.0	63.9	9.1	36.4	4/14 to 5/02/2001	103,820
2002	30.7	52.0	17.2	41.5	4/26 to 5/11/2002	138,896
2003	27.9	58.2	13.9	29.3	4/22 to 5/01/2003	89,139
2004	26.5	57.5	16.0	35.5	4/22 to 5/04/2004	133,035
2005	33.0	50.2	16.8	40.7	4/20 to 5/03/2005	137,679
2006	43.5	45.9	10.6	50.3	4/24 to 5/05/2006	188,912
2007	31.0	51.5	17.5	36.2	4/23 to 4/28/2007	101,154
2008	38.4	55.4	6.2	42.6	4/23 to 5/05/2008	123,059
2009	41.8	50.7	7.5	45.2	4/21 to 5/01/2009	128,818
2010	42.5	48.2	9.3	46.6	4/15 to 4/20/2010	144,802
2011	50.3	47.2	2.6	55.7	4/21 to 4/29/2011	205,908
2012	30.0	49.6	20.4	35.1	4/16 to 4/23/2012	152,228
2013	27.0	68.0	5.0	30.0	5/06 to 5/14/2013	80,431
2014	39.3	55.1	5.6	44.0	4/21 to 5/4/2014	115,114

[1]Singles and pairs were doubled before calculating proportions.
[2]Productive geese equals Singles + Pairs with nests.

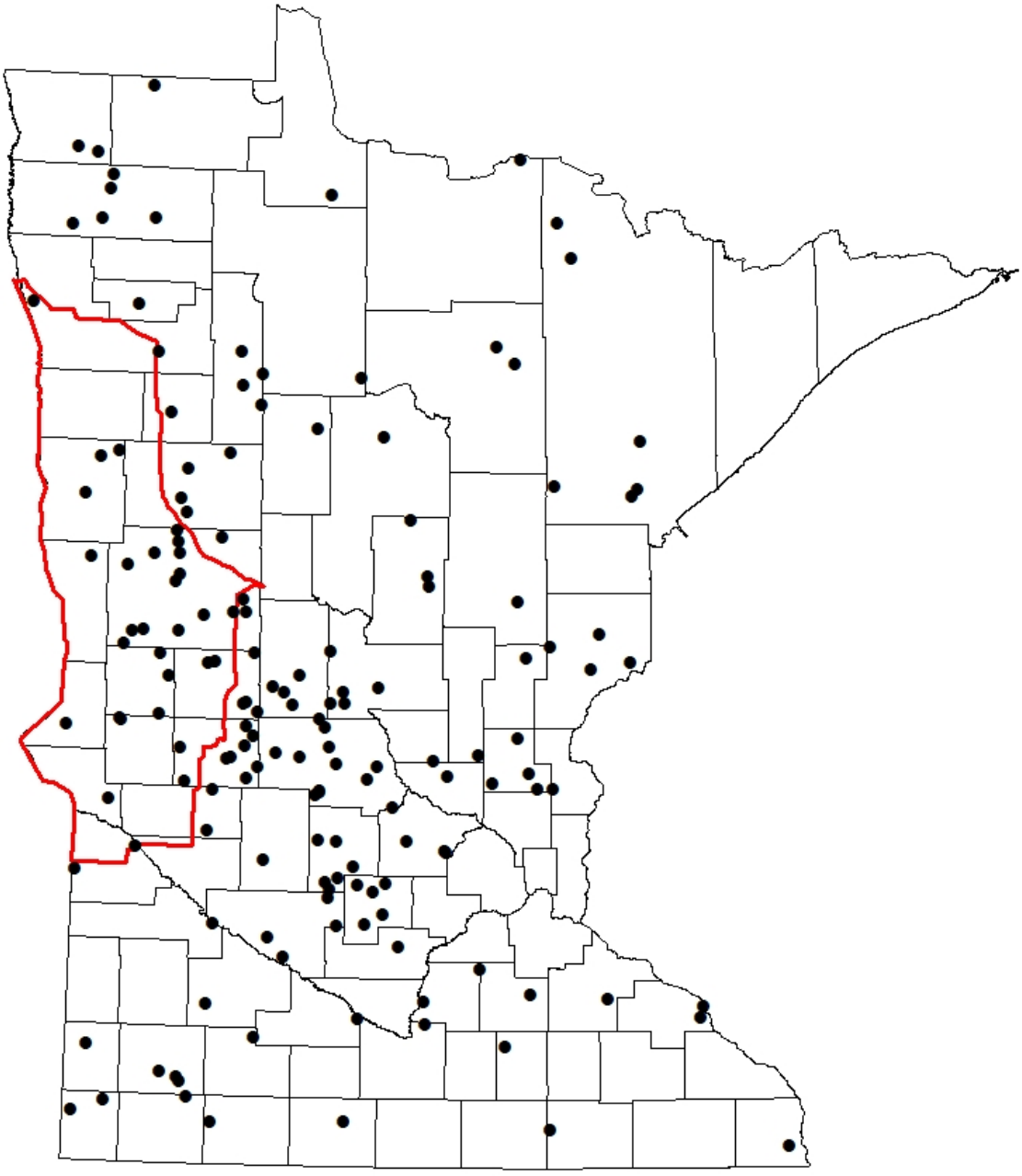

Figure 1. Location of 160 ¼ mi^2 plots surveyed for the 2014 Canada goose breeding pair survey within 3 ecoregions of Minnesota; forest, transition, and prairie. Red outlined polygon was the original location of a possible "new" Early Season Canada goose hunting zone.

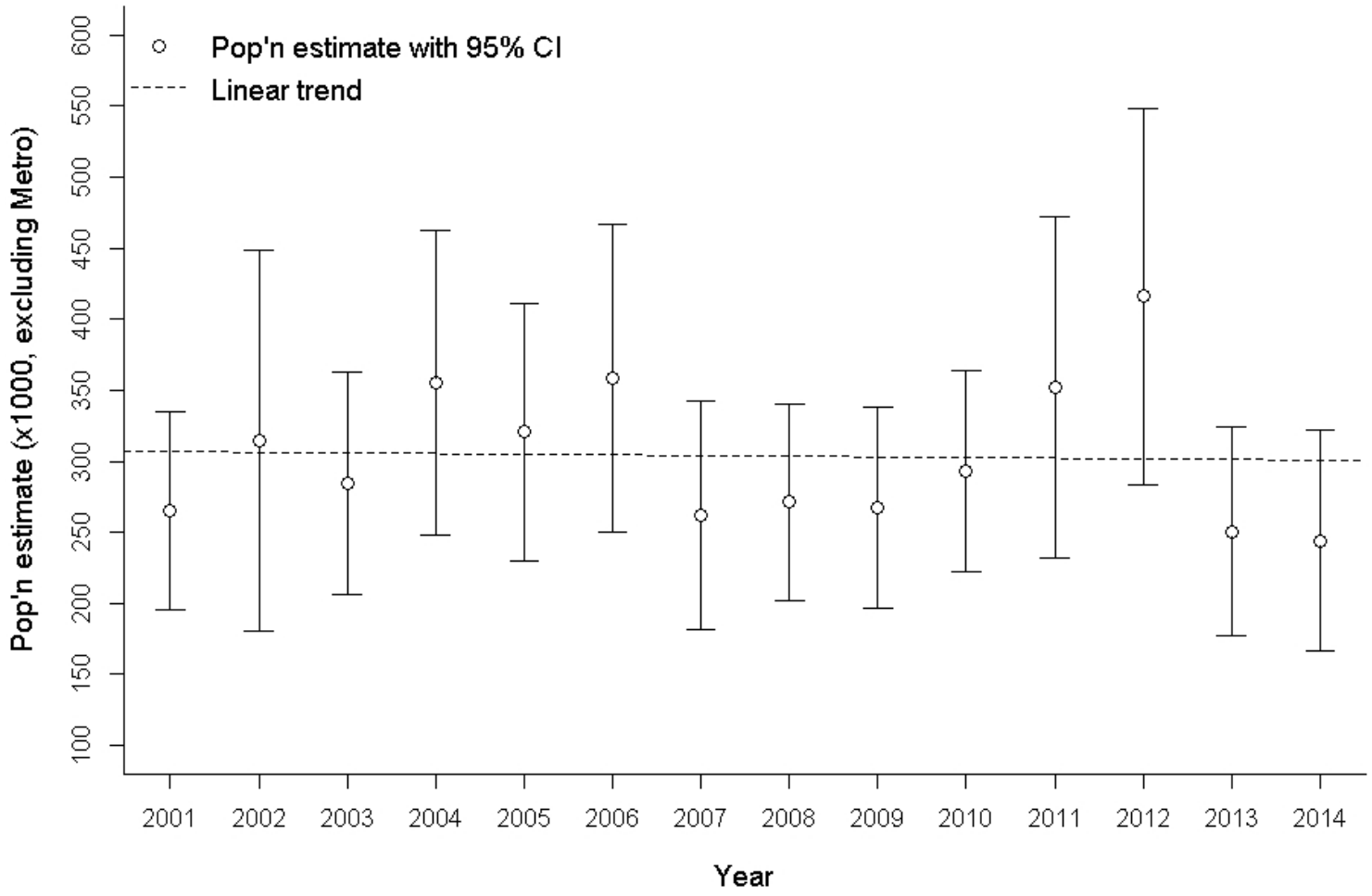

Figure 2. Spring Canada goose population estimates (±95% CI) in Minnesota, 2001-2014. (Does not include Metro area.)

Mourning dove information is taken from the U.S. Fish and Wildlife Service report by Seamans, M.E., and T.A. Sanders. 2014. Mourning dove population status, 2014. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 17 pp. The entire report is available on the Division of Migratory Bird Management web site (http://www.fws.gov/migratorybirds/NewReportsPublications/PopulationStatus.html).

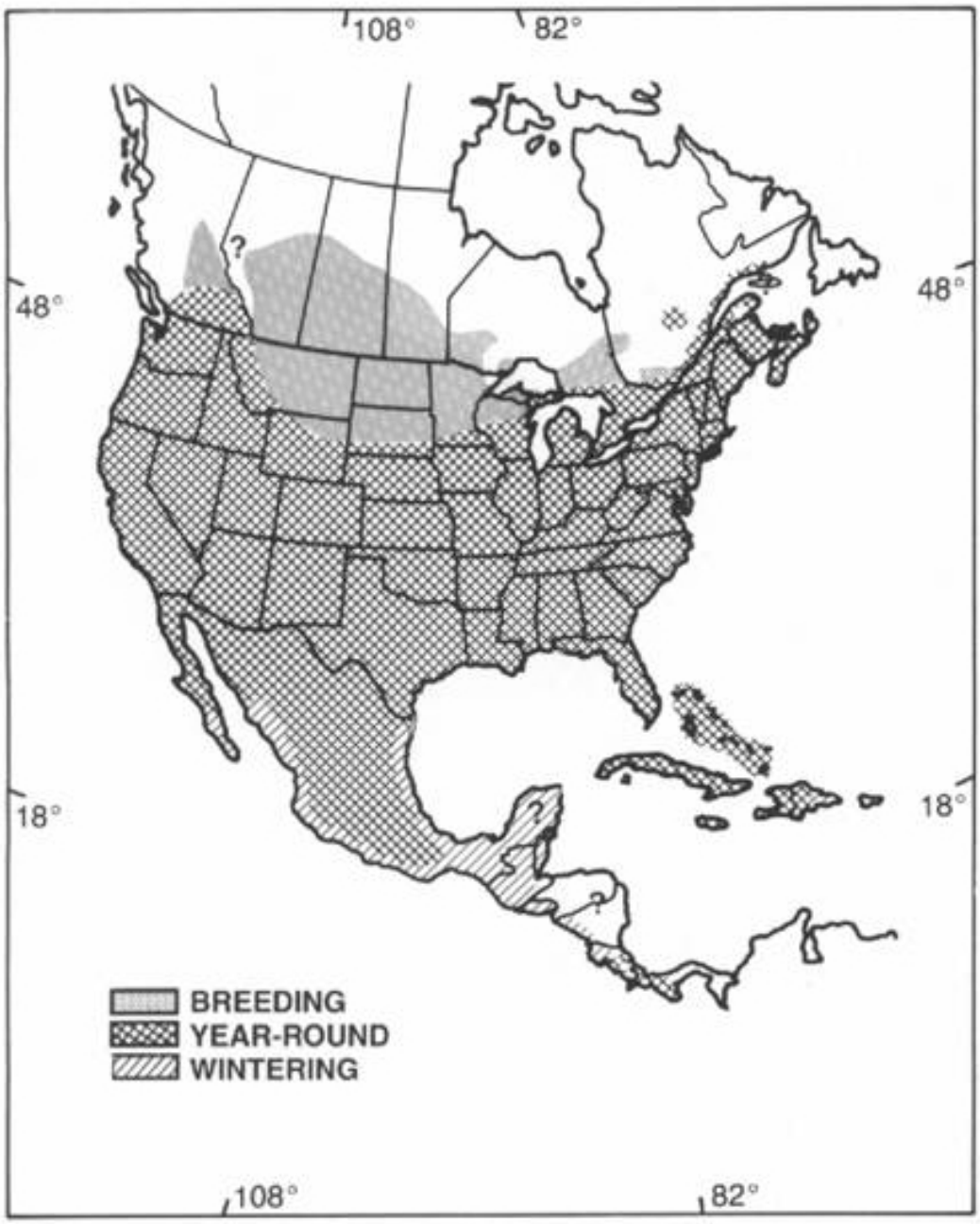

Figure 1. Breeding and wintering ranges of the mourning dove (adapted from Mirarchi and Baskett 1994). (From: Seamans, M.E., R.D. and T.A. Sanders. 2014. Mourning dove population status, 2014. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 17 pp.)

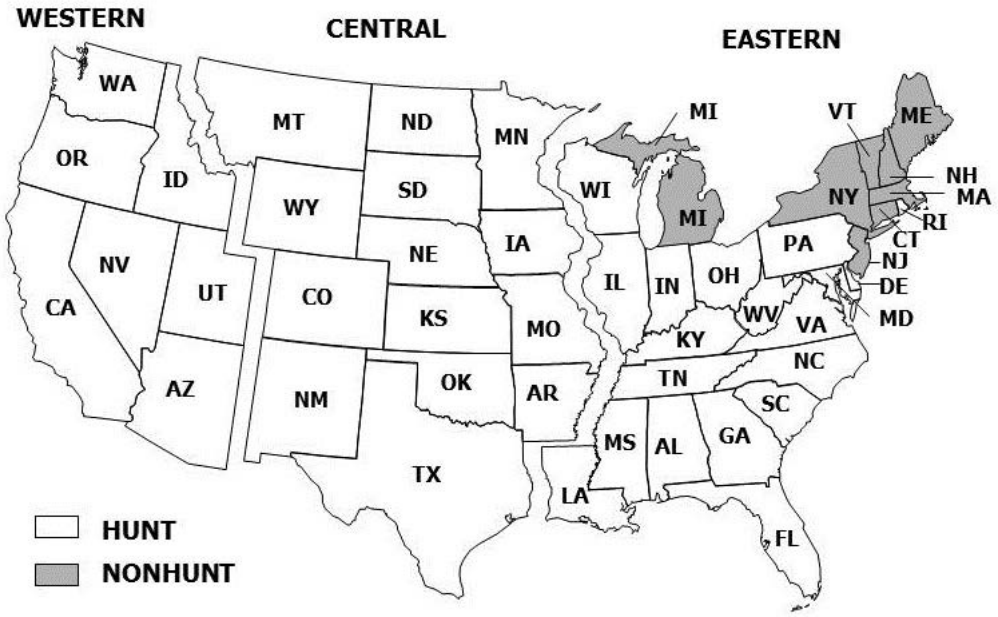

Figure 2. Mourning dove management units with 2014 hunting and non-hunting states. (From: Seamans, M.E., and T.A. Sanders. 2014. Mourning dove population status, 2014. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 17 pp.)

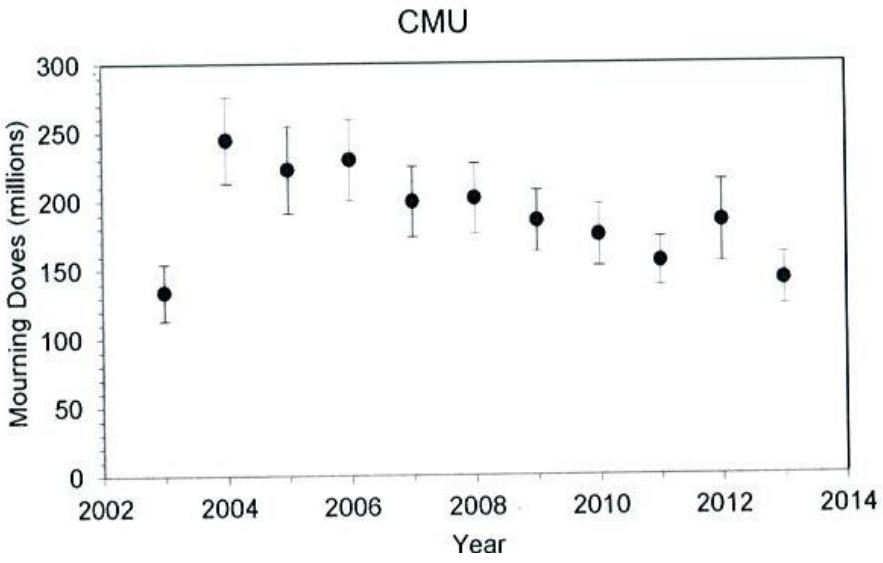

Figure 3. Estimates and 95% confidence intervals of mourning dove absolute abundance in the Central Management Unit (CMU), 2003-13. Estimates based on band recovery and harvest data. (From: Seamans, M.E. and T.A. Sanders. 2014. Mourning dove population status, 2014. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 17 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 2011, 2012 and 2013 seasons [a]. (From: Seamans, M.E. and T.A. Sanders. 2014. Mourning dove population status, 2014. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 17 pp.)

Management unit / State	Active Hunters			Hunter Days Afield			Total Harvest		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
CENTRAL	427,700 †	338,700 †	353,000 †	1,444,800±11	1,108,700 ±11	1,185,300±10	7,657,700 ±9	6,361,600 ±14	6,236,000 ±11
AR	25,300 ±20	21,400 ±22	8,900 ±42	63,800 ±34	57,600 ±26	30,100 ±57	519,300 ±43	494,200 ±30	155,900 ±46
CO	15,300 ±14	17,000 ±18	15,600 ±15	44,500 ±24	43,800 ±26	36,900 ±19	178,700 ±14	204,300 ±26	176,900 ±25
IA	5,800 ±11	†[b]	12,900 ±9	19,000 ±17	†[b]	49,400 ±14	56,800 ±21	†[b]	214, 300 ±16
KS	32,800 ±10	12,200 ±39	31,900 ±12	95,800 ±15	49,100 ±52	93,000 ±16	534,800 ±18	244,800 ±62	504,400 ±18
MN	9,400 ±49	6,800 ±52	7,700 ±53	25,100 ±51	21,600 ±48	17,000 ±39	57,300 ±40	65,400 ±75	53,500 ±30
MO	31,600 ±11	23,800 ±29	36,400 ±11	74,600 ±14	51,400 ±50	104,500 ±18	359,600 ±16	296,600 ±81	587,600 ±28
MT	2,200 ±37	200 ±87	1,700 ±46	5,900 ±47	500 ±120	2,900 ±41	14,400 ±61	2,600 ±161	12,000 ± 41
NE	15,500 ±16	13,200 ±17	13,500 ±16	46,900 ±28	39,000 ±17	39,300 ±19	265,500 ±23	223,400 ±20	239,800 ±24
NM	6,700 ±39	9,000 ±11	6,500 ±9	24,600 ±49	38,000 ±17	23,700 ±13	76,900 ±42	160,100 ±17	123,000 ±15
ND	3,700 ±25	4,900 ±30	6,300 ±28	10,400 ±29	17,400 ±36	16,400 ±29	41,800 ±31	78,900 ±37	88,200 ±37
OK	17,100 ±15	15,700 ±14	23,300 ±13	54,200 ±25	49,200 ±19	69,400 ±24	379,400 ±33	349,700 ±26	421,200 ±25
SD	6,200 ±21	4,500 ±22	6,200 ±22	16,300 ±26	14,700 ±28	17,500 ±26	87,200 ±26	65,500 ±28	118,300 ±31
TX	253,200 ±11	207,200 ±13	178,900 ±13	958,600 ±16	720,200 ±16	677,900 ±16	5,061,100 ±13	4,150,800 ±20	3,506,700 ±18
WY	2,700 ±30	2,700 ±32	3,100 ±19	5,100 ±38	6,300 ±38	7,200 ±19	25,000 ±52	25,300 ±40	34,200 ±19

[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, 2014. Cooper, T.R. and R.D. Rau. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.
The entire report is available on the Division of Migratory Bird Management home page (http://www.fws.gov/migratorybirds/NewReportsPublications/PopulationStatus.html).

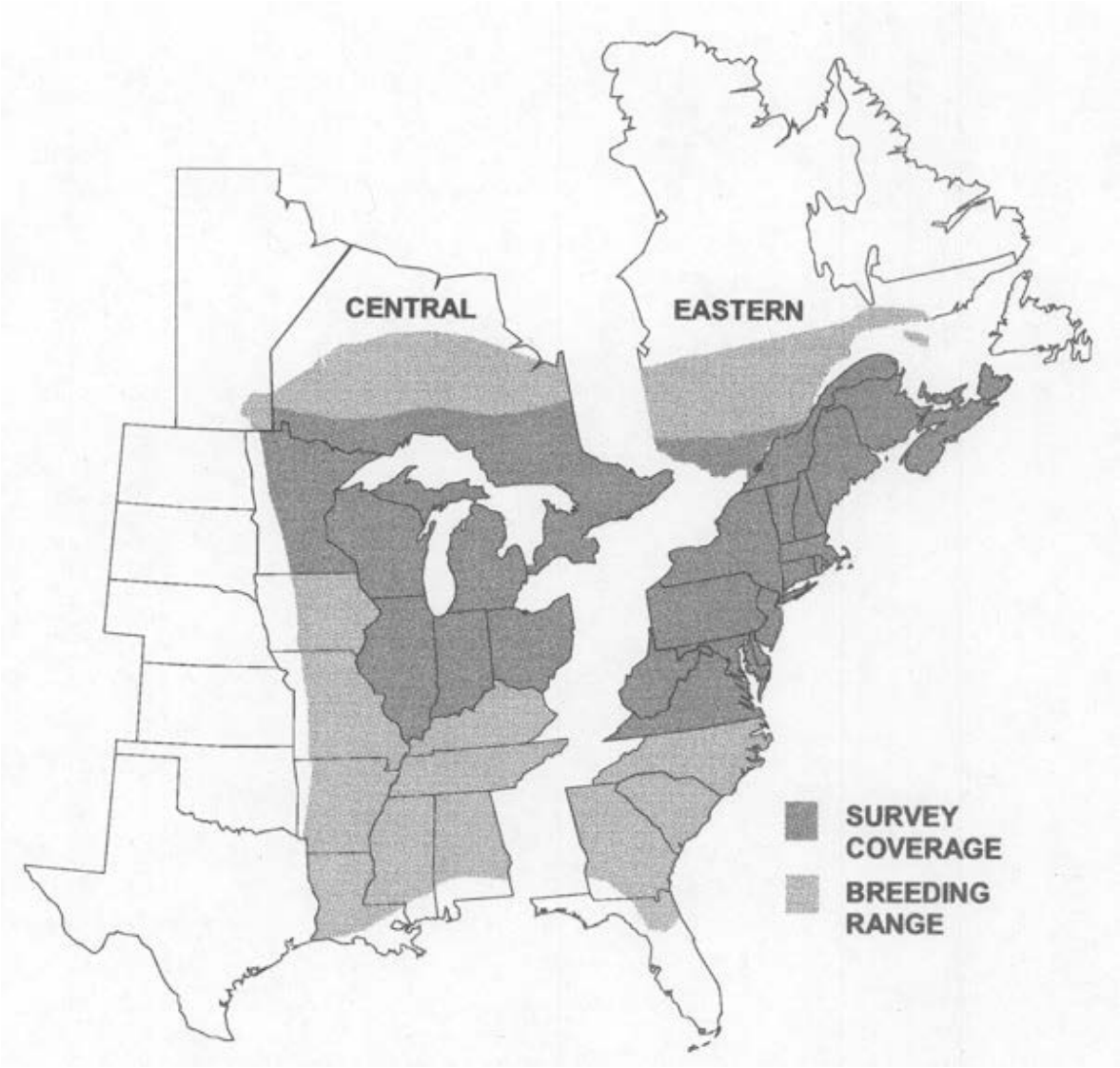

Figure 1. Woodcock management regions, breeding range, singing-ground survey coverage, (from: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Table 1. Short term (2013 – 14), 10 –year (2004-2014), and long-term (1968-2014) 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: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Management Unit/State	Number of Routes[b]	n[c]	2013-14			2004-14			1968-14		
			% Change	95% CI[d] lower	upper	% Change	95% CI[d] lower	upper	% Change	95% CI[d] lower	upper
CENTRAL	408	729	-7.26	-14.02	-0.02	- 1.22	-2.08	- 0.36	- 0.90	-1.16	-0.65
IL	12	46	19.68	-66.36	328.50	- 14.12	-24.85	- 4.19	- 1.04	-4.28	2.32
IN	15	60	2.89	-38.43	85.69	- 3.99	- 9.53	1.26	- 4.13	-5.49	-2.88
MB[e]	18	30	4.44	-22.17	43.40	- 1.09	- 2.18	5.36	- 0.31	-2.23	1.75
MI	95	153	-4.36	-15.81	8.59	- 0.53	- 1.93	0.95	- 0.77	-1.17	-0.38
MN	76	120	-7.86	-22.19	8.57	- 0.43	- 2.19	1.38	- 0.09	-0.68	0.53
OH	30	73	-3.61	-27.17	26.80	- 2.61	- 5.80	0.08	- 1.58	-2.38	-0.78
ON	82	157	-2.55	-16.80	14.45	- 1.43	- 3.22	0.42	- 0.90	-1.38	-0.39
WI	80	120	-22.21	-34.41	-7.81	- 0.64	- 2.50	1.29	- 0.76	-1.27	-0.24

[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 2014 for which data were received by 3 June, 2014.

[c] Number of routes with at least one year of non-zero data between 1968 and 2014.

[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.

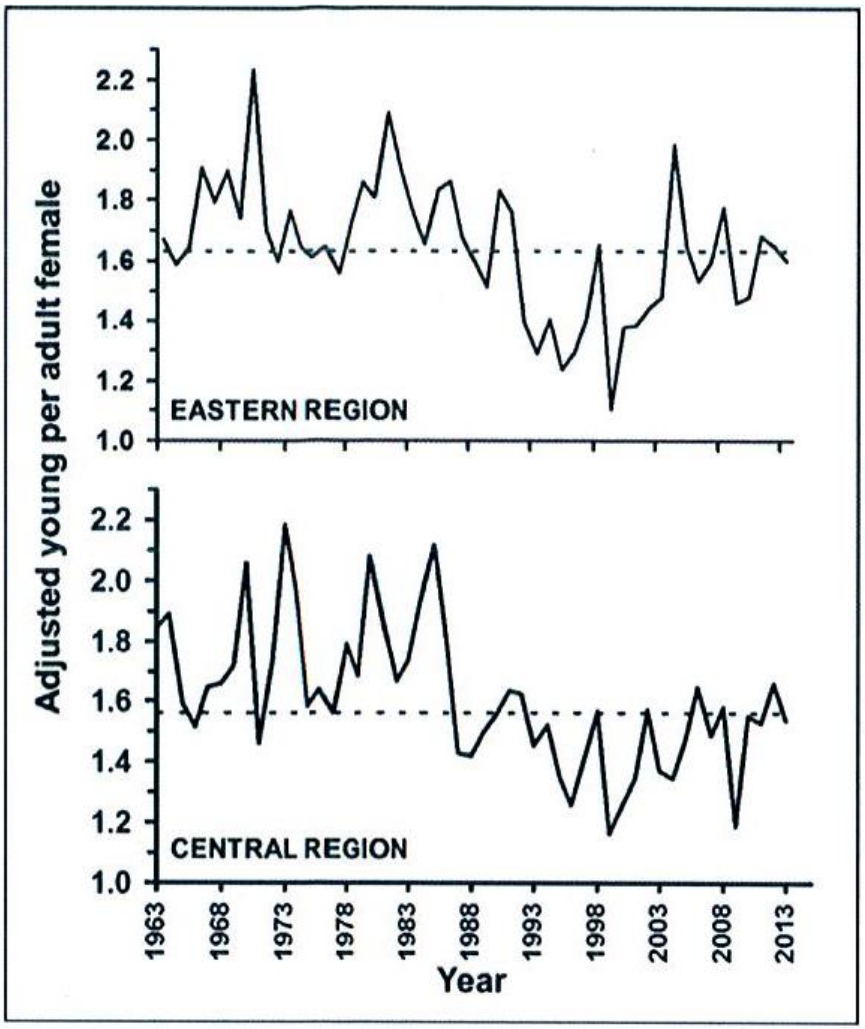

Figure 2. Weighted annual indices of American woodcock recruitment, 1963-2013. Dashed line is the 1963-2012 average. (from: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

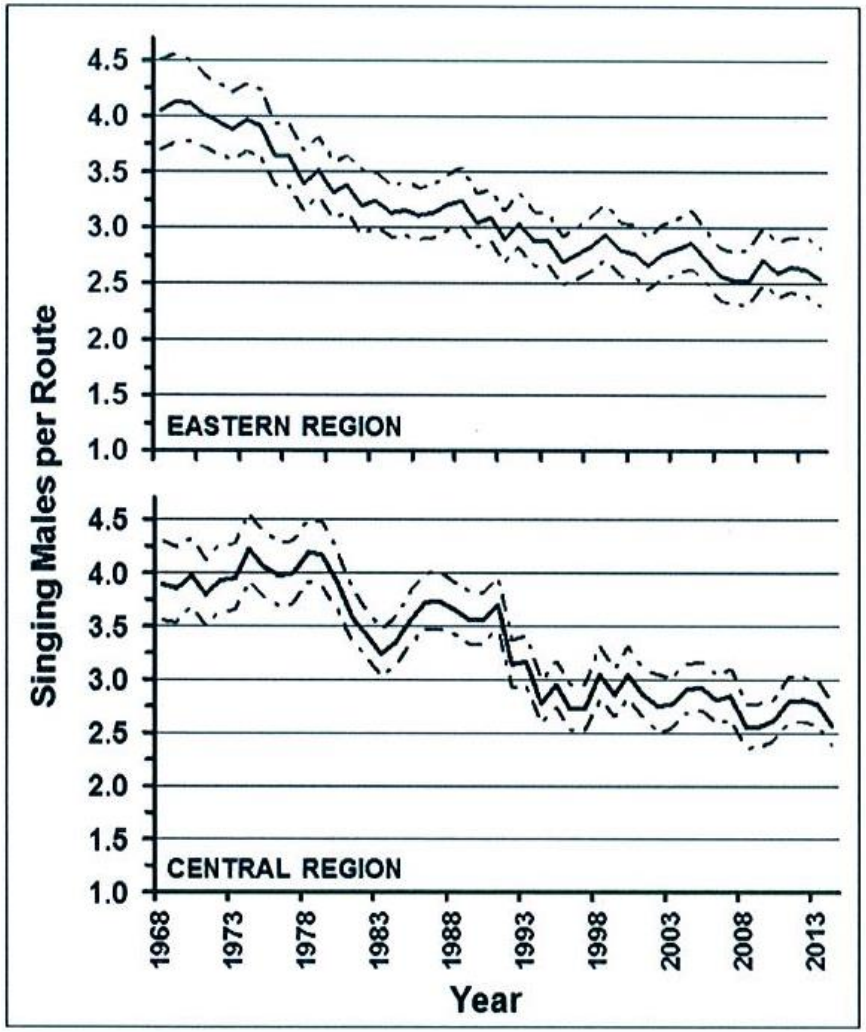

Figure 3. Annual indices of the number of woodcock heard on the Singing-ground Survey, 1968-2014. The dashed lines represent the 95th percentile credible interval. (from: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Table 2. Preliminary estimates of woodcock hunter numbers, days afield, and harvest for selected states, from the 2010-11, 2011-12, 2012-13 and 2013-14 Harvest Information Program surveys. Note: beginning 2008-09 all estimates rounded to the nearest 100 for harvest, hunters, and days afield. (from: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Management Unit / State	Active woodcock hunters ([a])				Days afield ([a, c])				Harvest ([a, c])			
	2010-11	2011-12	2012-13	2013-14	2010-11	2011-12	2012-13	2013-14	2010-11	2011-12	2012-13	2013-14
Central Region	n.a. [b]	n.a. [b]	n.a. [b]	n.a. [b]	392,400 ± 20	350,500 ± 16	276,900 ± 16	306,100 ± 20	233,100 ± 20	231,700 ± 20	193,100 ± 23	180,600 ± 20
IL	800 ± 171	2,900 ± 108	900 ± 175	1,600 ± 128	1,200 ± 123	8,800 ± 131	3,500 ± 172	3,400 ± 119	900 ± 106	3,700 ± 195	1,900 ± 160	1,000 ± 142
IN	1,000 ± 66	1,100 ± 79	400 ± 119	700 ± 77	3,900 ± 89	4,100 ± 86	1,500 ± 122	1,600 ± 58	3,000 ± 134	1,800 ± 102	600 ± 84	1,400 ± 84
MI	31,100 ± 14	28,400 ± 15	25,700 ± 17	30,000 ± 19	159,200 ± 19	144,000 ± 18	121,400 ± 22	123,700 ± 24	93,200 ± 21	106,900 ± 28	74,100 ± 28	79,300 ± 28
MN	13,900 ± 32	17,000 ± 29	11,200 ± 36	10,900 ± 37	55,400 ± 33	76,900 ± 46	40,400 ± 34	74,700 ± 62	34,800 ± 39	44,200 ± 42	31,000 ± 59	18,600 ± 57
OH	1,800 ± 98	3,100 ± 98	600 ± 115	3,000 ± 63	4,300 ± 70	10,200 ± 96	2,600 ± 83	8,600 ± 64	1,700 ± 93	2,300 ± 74	1,500 ± 80	8,600 ± 85
WI	14,600 ± 25	15,200 ±25	13,700 ± 28	14,500 ± 27	65,700 ± 40	69,000 ± 30	58,000 ± 33	60,000 ± 31	42,300 ± 22	42,600 ± 31	40,400 ± 37	38,400 ± 24

[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.

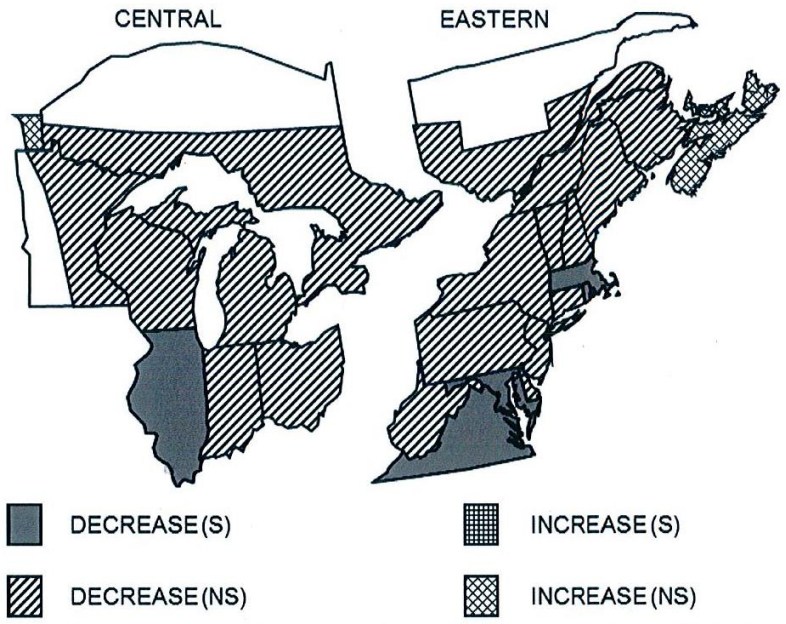

Figure 4. Ten-year trends in number of American woodcock heard on the Singing-ground Survey; 2004-14, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

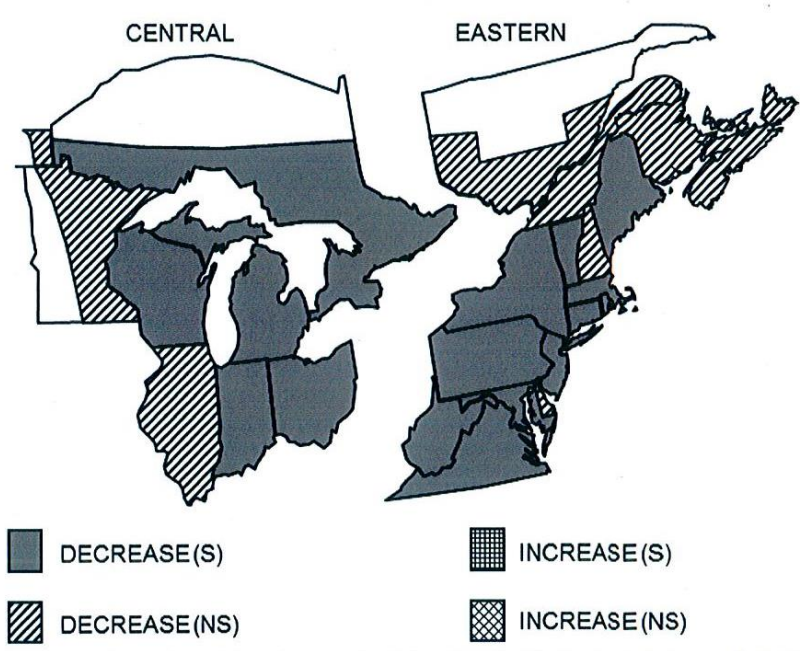

Figure 5. Long-term trends in number of American woodcock heard on the Singing-ground Survey; 1968-2014, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Cooper, T.R. and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

ESTIMATING NUMBERS OF BREEDING SANDHILL CRANES IN NORTHWEST MINNESOTA, 2012-2014

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SUMMARY

We conducted an annual sandhill crane (SACR, *Grus canadensis*) breeding population survey in northwest Minnesota during 2012-2014. In 2013 and 2014, we excluded the portion of the Red River Prairie Ecological Classification System (ECS) Subsection that we surveyed in 2012 due to low crane numbers in the agricultural landscape. We used 4 km^2 plots as the primary sampling unit and used a generalized random-tessellation stratified (GRTS) design to select a spatially balanced sample of 115 plots in each year. We surveyed each sample plot once during May using a Bell OH-58 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 7,265, 5,550, and 2,285 SACR in the area of Aspen Parklands and some adjacent areas within the Northwest Goose and Crane Zone (NWGCZ) that was consistently surveyed in all 3 years. Habitat conditions were very different with dry conditions in 2012 and wet conditions in 2013 and 2014. We believe that survey timing and arrival of nonbreeding cranes on the breeding grounds may have influenced the count in 2014. This final report documents results of the 3-year pilot survey.

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.

When we began the survey, there was no template for a large-scale, aerial survey specifically designed for breeding SACR. Thus, we proposed conducting a pilot survey for three years to provide sufficient information for making intelligent survey-design choices, including developing and evaluating a stratification scheme (e.g., Zicus et al. 2008), answering questions about bias-precision-cost tradeoffs (e.g., Giudice et al. 2010), and identifying important sources of variation in estimates of abundance and population trends (Thompson et al. 1998:149). 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).

In 2012, we stratified 4 km^2 plots in the NWGCZ and adjoining Aspen Parkland Habitat based upon amount of expected crane nesting habitat in each plot (Lawrence et al. 2012), and surveyed 60 plots in more likely crane nesting habitat, mostly associated with the Aspen Parkland, (Figure 2) and 30 plots in less likely habitat, which was mostly associated with the Red River Valley. We also surveyed one 100-km^2 plot in an area with previous records of nesting cranes. We did not survey plots that were not

expected to have any cranes. For the second and third years of this pilot survey, we used results from 2012 to modify the survey area and focus on parkland habitat where most of the breeding cranes were detected.

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. The survey design will also provide the potential to monitor breeding crane populations in other areas, e.g. east-central Minnesota.

Here, we describe the survey sampling scheme used in 2012-2014, present population estimates for the 3 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.

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. Although there were a few Stratum 2 plots (some nesting cover) and several Stratum 3 plots (no nesting cover, but other possible habitat) in the Red River Prairie subsection, there were only 2 SACR observations in plots we flew in this area in 2012. We used the same survey area in 2014 as in 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 east 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).

In 2013 and 2014, we excluded the Red River Prairie survey area because 2012 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

We used descriptions of crane nesting habitat in northwest Minnesota (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008) to evaluate GIS layers to stratify potential survey plots. Prior to the 2012 survey, we examined land cover data layers contained in Minnesota Gap Analysis Project (GAP; Drotts and Heinzen 2007) and National Land Cover Data (NLCD; Fry et al. 2011) to identify potential nesting cover. Both the GAP and NLCD land cover layers have a cell resolution of 30 meters. We considered 3 preliminary classification scenarios: GAP1 – nesting cover defined as GAP level-4 habitat types 14 (sedge meadow) and 15 (broadleaf sedge/cattail); GAP2 – similar to GAP1 but nesting cover also included habitat type 10 (lowland deciduous shrub); and NLCD - nesting cover defined as cover type 95 (emergent herbaceous wetland). We visually compared data layers associated with crane nest locations from the DNR Rare Natural Features database to decide which GIS data layers to use for stratification (Lawrence et al. 2012). We decided to use the 2006 NLCD to stratify the survey plots for the pilot year and then examine relationships of crane sightings and GIS layers to consider better stratifications in future years.

We used NLCD to quantify the amount (m^2) of potential SACR habitat in each 4-km^2 plot. NLCD is a Landsat-based land cover database created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey (USGS National Land Cover Database). We used the same definition of SACR habitat in all years. 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). We then classified each 4-km^2 plot into 4 categories:

NLCD-1: $\geq$ median amount of nesting habitat,
NLCD-2: 0 < m^2 of nesting habitat < median,
NLCD-3: nesting habitat = 0 but other SACR habitat > 0,
NLCD-4: no SACR habitat.

In 2012, the NLCD plot classifications were strongly correlated with ecological subsections (Figure 2). Therefore, we stratified the sampling frame (4-km^2 plots) into 3 strata:

1. NLCD12 plots – Stratum 1 and 2 plots; 71% of sampling frame; mostly associated with Aspen Parklands and Agassiz Lowlands.
2. NLCD3 plots – 11% of sampling frame; mostly associated with Red River Prairie.
3. NLCD4 plots – 18% of sampling frame; mostly associated with Red River Prairie.

We assumed that SACR density in the NLCD4 stratum was very low (approaching zero) and did not sample stratum NLCD4. Likewise, we expected SACR density to be low (but > 0) in the NLCD3 stratum. For NLCD12 and NLCD3 strata in 2012, we drew a spatially-balanced, Generalized Random-Tessellation Stratified (GRTS) sample (Stevens and Olsen 2004) with n = 60 (sampling rate = 2.2%) and 30 (sampling rate = 7.3%), respectively. We sampled the NLCD3 stratum at a higher rate to ensure we had a sufficient sample size to evaluate the feasibility of estimating SACR numbers in this low-density stratum. We also surveyed a 100-km^2 block (n = 25 4-km^2 plots) to better examine distribution of cranes within a specific area. Thus, the total sample size in 2012 was 115 4-km^2 plots (Figure 3).

In 2013 and 2014, we only sampled plots within the reduced survey area that included all the Aspen Parkland ECS subsection and parts of the Agassiz Lowlands subsection within the NWGCZ (Figures 4 and 5). We included the 95 Stratum 3 plots in the reduced survey area in the sample of plots, but did not survey the 74 Stratum 4 plots in this area. We used the GRTS design to select 115 plots within Stratum 1, 2, and 3 combined, without further stratification. We also recalculated the 2012 estimates based upon the 2013 sample frame. Results from 2012-13 indicated small differences in crane numbers related to the amount of nesting habitat in each stratum (Lawrence et al. 2012, 2013), thus we did not use further stratification in 2014.

Target population(s)

In 2013 and 2014, we chose to not survey the Red River Prairie, thus we did not have an estimate of cranes for the entire NWGCZ and adjacent parkland habitats. However, 2012 results suggest that the area we surveyed in 2013 and 2014 provides a good approximation of the total number of cranes in the zone. 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. *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).
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.

We determined SACR distribution by calculating the number of single and paired (x2) birds/km^2 in the survey plots. Then density maps were generated from plot density data using the Inverse Distance Weighted and Reclassify tools in ArcGIS ver. 10.2.2.

Survey Procedures

The survey was conducted during mid-May, which is the peak incubation period for cranes in northwest Minnesota (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008). All plots were surveyed using Bell OH-58 [Jet Ranger] containing a pilot and one observer. Plots were surveyed 5-45 meters above ground level at 10-100 km/hr, depending upon the land cover. During the first 2 years of the survey, observations were recorded in digital voice files, each associated with a UTM location, on a tablet computer using the DNRSurvey software program developed by Minnesota DNR Wildlife and GIS staff (Wright et al. 2011). In 2014, we used DNRSurvey ver. 2.11, an ArcGIS addin developed by Minnesota DNR Wildlife and MN.IT Services GIS staff.

RESULTS

Survey effort

The 2014 survey was conducted over 4 days (9, 10, 14, and 15 May) and averaged 29 plots/day (range: 14-43). The survey timing (Figure 6) was slightly later than in 2012 (7-11 May, 14-15 May), but earlier than in 2013 (17, 22, 23 May). The survey team (DNR pilot John Heineman and observer Jeff Lawrence) spent an average of 7 min surveying each plot (range: 2.3 – 19.4 min), similar to 2013 but less than the 9 minutes/plot in 2012 (Table 1). Fifty percent of the total aerial survey time in 2014 was associated with surveying plots.

Sampling statistics

We detected SACR on 37 (32%) of the 115 sample plots in 2014 compared to on 53% and 43% of the plots in 2012 and 2013 (Table 2), respectively. The average count per occupied plot was 2.4 birds, also less than the 4.4-4.9 in 2012 or 2013. In 2014, we counted 89 SACR on sample plots, of which 43% were pairs, 43% were singles, and 15% were groups (Table 3). We observed 5 groups, which ranged in size from 3 to 6 birds. We did not see as many groups (11 in 2012, 8 in 2013) or the larger groups that were recorded in the 2 previous surveys. In 2014, about 15% of the birds observed were in groups compared to approximately 40% in 2012 and 2013 (Table 3). Thirty percent of observed pairs and singles exhibited some evidence of being breeding birds (32% of pairs and 29% of singles), similar to the previous years (Table 3). In 2014, we detected 17 nests; 15 nests had 2 eggs and 2 nests had 1 egg. We detected 20 nests each in 2012 and 2013.

Population estimates and Distribution

The estimated total number of cranes declined (Z-test, P=0.004) to 2,285 (90% CI: 1,720-2,850) in 2014 compared to 5,550 (90% CI: 3,580–7,510) in 2013 (Table 4). The population in the reduced survey area was an estimated 7,260 (90% CI: 4,160–10,370) in 2012. The 2014 estimate was less than in 2012 or 2013 (see confidence intervals, Figure 7). These are minimum estimates because we did not adjust for detection probabilities (which are likely <1, at least for singles and pairs in dense cover). If our sample of singles and pairs exhibiting breeding behavior was representative of the relative abundance of breeding birds in the target population, then we estimated there were a minimum of 1,450, 950, and 590

breeding birds in the survey area in 2012-2014, respectively (Table 4). The estimate of breeding birds in 2014 was similar to 2013, but less than 2012.

In 2014, the bound on the estimated total (all strata) met the usual target level for a Minnesota Department of Natural Resources (MNDNR) wildlife survey (i.e., CV = 15% and relative bound = 25%). This was not true in 2012 and 2013, when one plot in each year had a high count of birds (46-49 birds) which increased the estimated population variance. The estimated CV for breeding birds and status-unknown birds was greater than the target (20-23%; Table 4).

Cranes were distributed throughout much of the study area, but indicated lower densities in the northeast and portions of the southern Aspen Parkland survey area (Figure 8). These areas had less nesting cover (Figure 2), but there were other areas on the western side of the Aspen Parklands that had limited nesting cover yet had nesting cranes.

Habitat associations

We did not stratify the plots by amount of potential crane habitat in 2013 or 2014 because we saw little benefit to this during the 2012 survey (Lawrence et al. 2012). In 2012-14, there were only weak relationships between plot counts (total birds or breeding birds) and amount of potential nesting cover as defined by NLCD and GAP cover data (Figure 9). However, there was a positive relationship between the probability that a plot would contain cranes and the amount of NLCD nesting cover (Figure 10).

DISCUSSION

Survey Effort and Design Considerations

The surveys in 2013 and 2014 were completed in 3-4 days compared to 7 days in 2012. The shorter surveys in 2013 and 2014 were in part due to the reduced survey area compared to 2012, but we also flew longer each day. We flew all 115 plots in 26-28 hours of helicopter time in 2013-14 compared to 37 hours in 2012. The additional helicopter time in 2012 was due to the larger survey area and the resurvey plots (Lawrence et al. 2012).

In 2014, we began the survey on 9 May which was 8 days earlier than 2013 and 2 days later than 2012. Spring and ice out in 2014 were late relative to historical averages, but ice out was about 9 days earlier than 2013. (http://www.dnr.state.mn.us/climate/journal/2014_ice_out_recap.html). 2013 was characterized by a late spring and near record late ice out on Minnesota lakes (http://climate.umn.edu/doc/journal/ice_out_recap_2013.htm). This was in contrast to the near record early spring in 2012 (http://climate.umn.edu/doc/journal/warm_spring2012.htm). In 2012, we observed some SACR colts during the survey even though we began 1 week earlier than originally scheduled. We did not observe any colts in 2013 and believe our survey timing was good and likely near mid-incubation. However, in 2014, the number and size of groups was smaller than in previous years and the number of pairs declined, too. This suggested that the survey may have been flown too early in 2014.

Timing of the SACR survey may be critical to getting consistent results. Survey timing may need to vary dependent upon spring phenology and crane activity. Prior to the 2012 survey, we planned to begin the survey on 14 May; however, we began on 7 May due to the early spring phenology. The delayed start in 2013 was appropriate, and although there was a decline in proportion of detected breeding pairs, many birds were associated with nests and no young were observed. In 2014, we began early and fewer pairs and groups were observed.

Similar to the last 2 days of the survey in 2013, conditions were very wet when we flew the 2014 survey. There was standing water in some fields and rivers were high. Conversely, onditions were extremely dry in 2012. They were also extremely dry on the first day of the 2013 survey, but then rainfall (~7.4 cm in Thief River Falls) forced us to delay the survey until 22 May. The landscape had changed dramatically when we resumed the survey, with standing water in many fields, flooded rivers, and likely increased water levels in many wetlands. We suspect some crane nests were flooded in 2013.

Population Estimate

The number of cranes was lower in 2014 than 2012, but was not different between 2012 and 2013 although the point estimate declined by 28% (95% CI =-62% to +38%). Generally, precision of our aerial breeding population surveys (e.g., May waterfowl, Canada goose) is not adequate to determine annual

changes to populations, but the surveys provide guidance on long-term population trends. For the SACR survey, we would need approximately a 50% change in the breeding population or a 40% change in the breeding pair estimate to detect a difference between years. This was only the third year of the crane survey, thus we do not know how much annual variability in population estimates we will observe. It is possible the decline in the point estimates observed in crane population size was also partially due to spring phenology. Future surveys will provide insights on changes in estimates of population size and whether there is a trend.

In 2013, we reduced the size of the survey area to what we believe, and 2012 survey results supported, was the core SACR breeding habitat in the NWGCZ. There were a few nesting birds in the Red River Prairie subsection in 2012, but they accounted for 290 of the 7,200 estimated birds (Lawrence et al. 2012). We do not know how strong the affinity is for nonbreeding birds to be associated with SACR nesting habitat that we used to select the survey plots. We did not record any flocks in the Red River Prairie in 2012, but it is possible that nonbreeders may use these agricultural habitats. We suspect there may have been a reduced nesting effort in 2013 and in 2014 due to the delayed spring, and a larger proportion of the population may have been nonbreeders. This was evident in Minnesota's Canada goose breeding population (Rave 2013); however, the timing of goose nesting is earlier than SACR nesting. We note that in 2012, we questioned if some cranes had foregone nesting due to the extremely dry conditions.

Our estimates of breeding and status unknown birds was reasonably precise (CV% $\leq$ 23%). Much of the variability in the population estimates is due to the groups that tend to use agricultural fields, thus their distribution on the landscape is difficult to predict relative to nesting cranes. In 2012 and 2013, one plot contained 42-48% of the cranes in groups. In 2014, the sample did not include a plot with a large group(s) and the number of birds in groups indicated a substantial decline. We may consider using breeding and status unknown birds (singles and pairs) to provide a better index of the status of population trends in the future.

We suspect most of the unknown-status pairs were likely nonbreeders, although some may have been failed nesters. Some nests were likely flooded with the increase in water levels following the rainfall during the 2013 survey. A portion of the unknown-status singles likely had a mate on an undetected nest. All singles recorded as breeders were observed on a nest and it is likely that these birds had an undetected mate in the vicinity, although some may have been off plot. Usually, there were no other singles on any of these plots that could have been mates, although we are uncertain how far the mate may be from the bird on the nest.

Survey Evaluation

Post-hoc stratification analyses of 3 years of survey results indicate that NLCD was not a very effective stratification variable at the plot level, although there was a weak positive correlation (Figure 9). Additional cover attributes may be needed to increase stratification effectiveness. For example, many crane observations were in or adjacent to agricultural fields (e.g., feeding sites). Thus, developing an effective stratification scheme for the SACR survey may require a more sophisticated suite of habitat metrics. However, we did see a relationship between the presence of cranes and the amount of NLCD habitat, suggesting that more nesting habitat increased the probability of $\geq$1 crane being present on a plot.

After 3 years, we have UTM coordinates of crane nests and approximate locations of crane observations, which will allow us to examine habitat associations at finer scales (e.g., 1-km^2 subplot) and explore the utility of using other land-cover data sources to stratify the sampling frame. Our efforts to stratify were based upon potential nesting cover, which may not reflect the distribution of nonbreeding cranes. Many of the non-breeders were observed in agricultural habitats.

We have learned a great deal during the 3 year pilot survey, but our results also raised several questions. It is unlikely the population decline was as substantial as indicated during these 3 surveys. Other information may suggest a decline, but of a smaller magnitude.

In 2009, MNDNR wildlife managers began formally counting cranes as part of the statewide August Roadside (Pheasant) Survey. The numbers of cranes counted during this survey showed relatively high numbers of both adults and juveniles in northwest and east-central Minnesota (Figure 11, N. Davros and R. Curtis, MN DNR, 2014 unpublished report,

http://files.dnr.state.mn.us/recreation/hunting/pheasant/roadside_survey.pdf). The population index for cranes in northwest Minnesota suggests a decline since 2012, in contrast to an increase in central and east-central Minnesota (Figure 11). Thus, the August Roadside Survey provides some information on relative abundance, but probably has low power for detecting anything but a large-magnitude population change. The August Roadside Survey does not provide an estimate of the actual size of the breeding population.

Agassiz National Wildlife Refuge (NWR) began counting pairs of cranes on and near the Refuge in 2011 (G. Knutsen, 2014, Agassiz NWR Breeding Sandhill Crane Survey Results, unpublished report). Counts of crane pairs at Agassiz NWR were lower in 2013 and 2014 than in 2011 (*n* pairs = 28, 20, and 19 in 2011, 2013, and 2014, respectively). Crane surveys were not conducted at Agassiz in 2012.

While there is evidence that the population of cranes is lower in northwest Minnesota than when we began the survey in 2012 (this survey, August Roadside s\Survey, Agassiz NWR Breeding Sandhill Crane Survey), we believe the magnitude of this decline was overestimated due to incorrect timing of the helicopter survey, especially in 2014. The lack of non-breeding cranes, both pairs and groups, suggest that this portion of the overall population may have not been present on the survey area in 2014. Alternatively, they may have not been present on the plots; however, we did not observe as many cranes during transit between plots in 2014 as in 2012 and 2013, suggesting that nonbreeders had not yet reached the breeding grounds.

We had hoped to establish a baseline population level with the 3-year pilot survey and then use other information (e.g. August roadside counts) to provide an index to population change over time. However, the low count in 2014 led us to plan for an additional helicopter crane survey in northwest Minnesota in 2015. The random plot selection used in 2012-2014 provides the most appropriate estimate of breeding population size. However, we will consider the utility of using the same sample of plots (e.g. similar to the same transects in the May breeding waterfowl survey) or perhaps use a mixture of random plots and resample plots as was used in the ring-necked duck helicopter survey (Herwig 2010) to better determine population trend.

We will further evaluate the habitat associated with crane observations and consider other options for improving the survey prior to next year. We plan to conduct the survey again in May 2015.

ACKNOWLEDGEMENTS

This project was funded by a grant from the U.S. Fish and Wildlife Service Webless Migratory Bird Program and the Minnesota Department of Natural Resources. Special thanks to pilot John Heineman, who did an exceptional job flying the helicopter and helping with the survey during all 3 years. The Thief River Falls DNR Wildlife office provided support with the helicopter fuel truck in 2012. Steve Cordts suggested the initiation formal counts of cranes during the August Roadside Survey.

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Table 1. Survey effort (minutes) by activity for an aerial survey of sandhill cranes in Minnesota, May 2012-2014.

		Survey time			Transit time			Total time[a]	
Year	Stratum	Total minutes	Plots	Min/ plot	Total minutes	Number transits	Min/ transit	Total minutes	Min/plot
2012	NLCD-123	822	90	9.1	663	104	6.4	1,485	16.5
	EspTwp	310	25	12.4	16	6	2.7	326	13.0
	All	1,132	115	9.8	679	110	6.2	1,811	15.7
2013	All	766	115	6.7	620	125	5.0	1,386	12.1
2014	All	758	115	6.7	776	131	5.0	1,534	13.3

[a] excludes visibility surveys conducted in 2012.

Table 2. Sampling statistics [a] for an aerial survey of sandhill cranes in northwestern Minnesota, May 2012-2014.

								Counts/occupied plot				
Year	*n* strata	Sampling allocation	nh	Nh	srate	n.occ	p.occ	min	max	med	mean	SE
2012	3	~Optimal	115	3,160	0.036	51	0.47	1	43	2	4.9	1.27
2013	1	SRS[b]	115	2,953	0.039	49	0.43	1	46	2	4.4	1.06
2014	1	SRS	115	2,953	0.039	37	0.32	1	10	1	2.4	0.31

[a] nh = sample size (4-km^2 plots), Nh = 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] simple random sample.

Table 3. Social and breeding classification of sandhill crane observations, 2012-2014.

	2012			2013			2014		
Social class[a]	Count	Proportion of total	Proportion of pairs and singles	Count	Proportion of total	Proportion of pairs and singles	Count	Proportion of total	Proportion of pairs and singles
Pairs (x2)	114	0.48		92	0.43		38	0.43	
Breeding birds	50	0.21	0.44	28	0.13	0.30	12	0.14	0.32
Status unknown	64	0.27	0.56	64	0.30	0.70	26	0.29	0.68
Singles	37	0.15		34	0.16		38	0.43	
Breeding birds	8	0.03	0.22	9	0.04	0.27	11	0.12	0.29
Status unknown	29	0.12	0.78	25	0.12	0.73	27	0.30	0.71
Groups	89	0.37		90	0.42		13	0.15	
Total	240	1.00		216	1.00		89	1.00	

[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 2012-2014.

Year	Survey Area	Status	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[b]	115	3,160	28	1	4	0.5	0.08	1,447	264	1,014	1,881	18
		Groups	115	3,160	9	3	37	1	0.49	3,013	1,545	472	5,554	51
		Status unknown[c]	115	3,160	40	1	6	0.9	0.13	2,751	415	2,069	3,433	15
		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[b]		2,953						1,416	268	975	1,857	
		Groups		2,953						3,100	1,606	458	5,742	
		Status unknown[c]		2,953						2,749	424	2,052	3,446	
		Total		2,953						7,264	1,885	4,163	10,365	
2013	Without Red River Valley	Breeding birds[b]	115	2,953	22	1	2	0.3	0.05	950	158	691	1,210	17
		Groups	115	2,953	6	3	43	0.8	0.38	2,311	1,122	466	4,157	49
		Status unknown[c]	115	2,953	36	1	6	0.8	0.11	2,285	318	1,763	2,808	14
		Total	115	2,953	49	1	46	1.9	0.40	5,547	1,194	3,582	7,511	22
2014	Without Red River Valley	Breeding birds[b]	115	2,953	15	1	4	0.2	0.05	591	135	368	813	23
		Groups	115	2,953	3	3	6	0.1	0.05	334	162	68	600	49
		Status unknown[c]	115	2,953	26	1	9	0.5	0.09	1,361	276	907	1,815	20
		Total	115	2,953	37	1	10	0.8	0.12	2,285	346	1,716	2,855	15

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

[b] Singles and pairs (x2) with a nest or young, or exhibiting some type of breeding or territorial behavior.

[c] Singles and pairs (x2) without a nest or young, and no behavioral evidence that they were breeding birds.

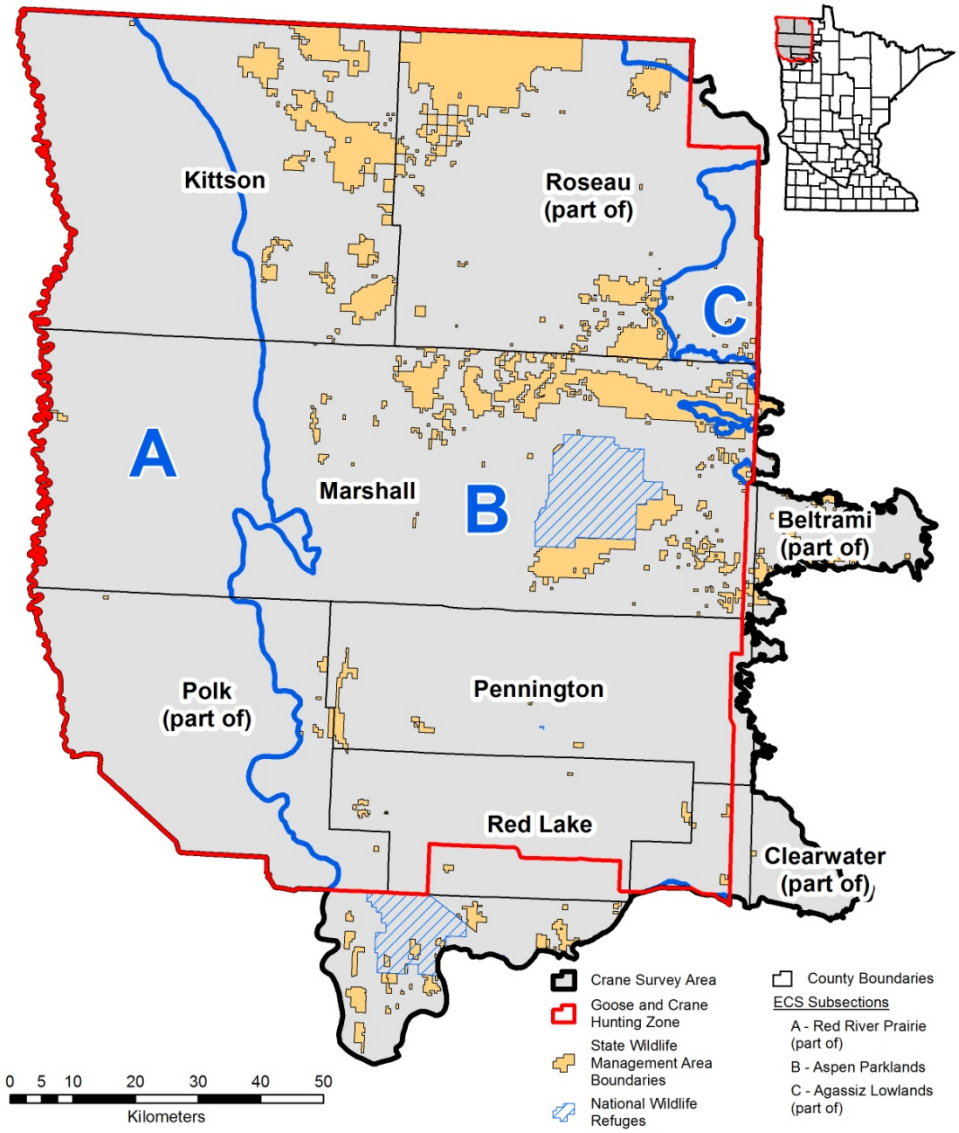

Figure 1. Location of the Northwest Goose and Sandhill Crane Hunting Zone in Minnesota and the sandhill crane survey area. ECS subsection A (portion of Red River Prairie) was surveyed in 2012 but not in 2013 or 2014.

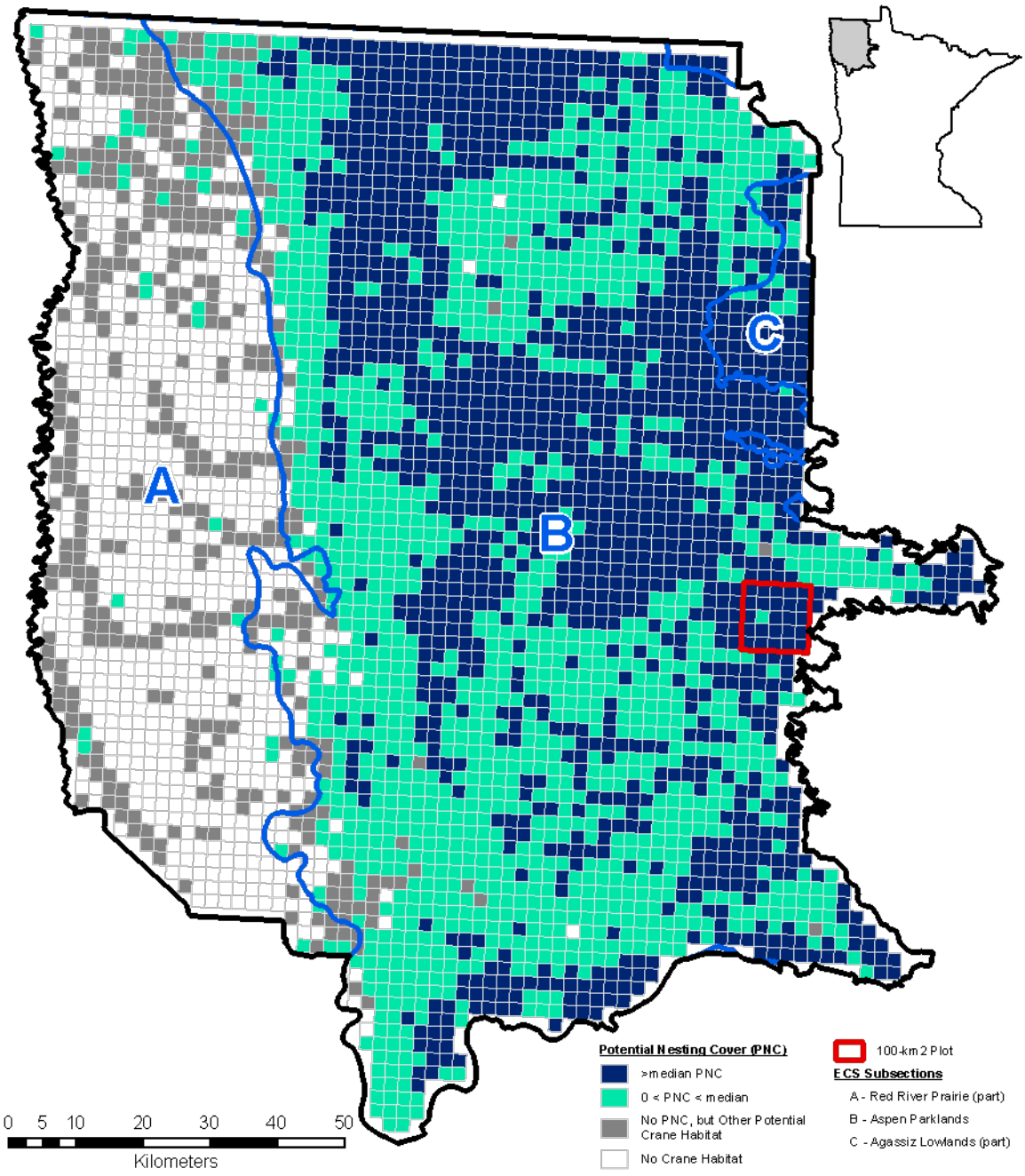

Figure 2. Sampling frame for the spring aerial survey of sandhill cranes, northwestern Minnesota. The primary sampling unit was 4-km^2 plots. Colored squares denote plots by strata as defined by National Land Cover Data: dark blue = NLCD-1 (>median amount of potential crane nesting cover [PNC]), turquoise = 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). In 2013 and 2014, 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 in 2013 and 2014.

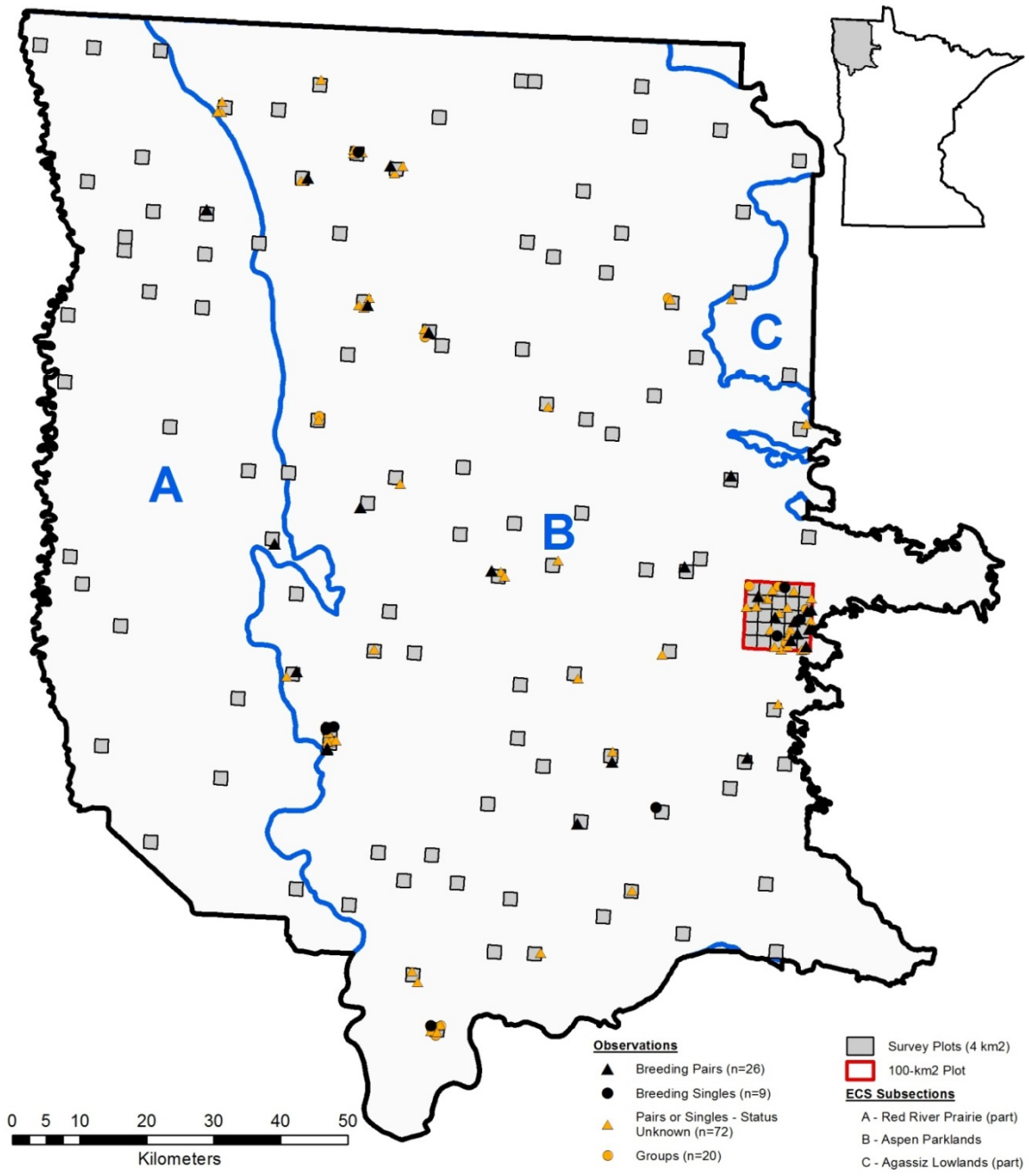

Figure 3. Distribution of sample plots (n = 115) and sandhill crane observations by type in the 2012 MNDNR spring aerial survey, northwestern Minnesota. Each sample plot was 4 km^2 and the SACR survey area was 16,350 km^2.

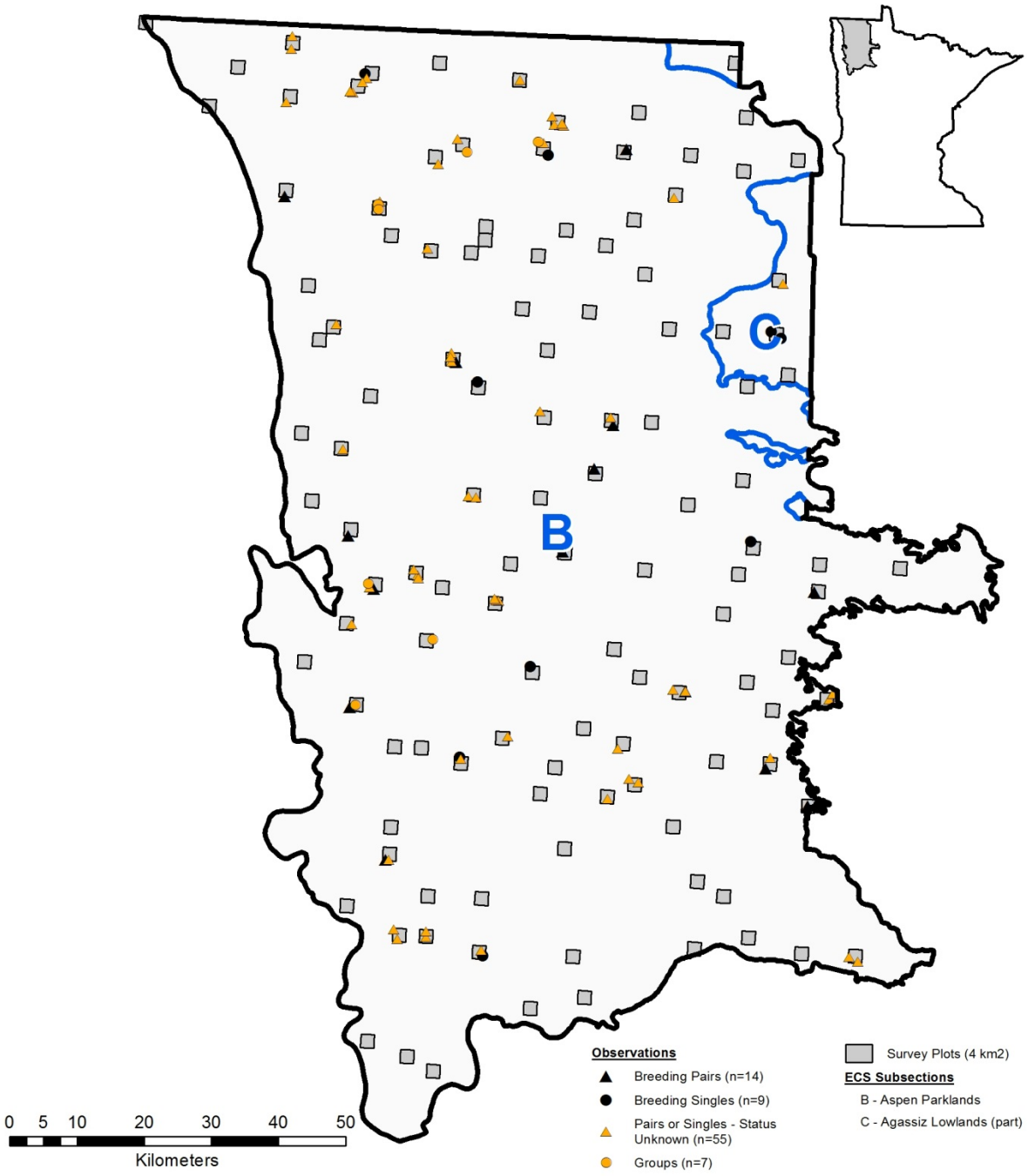

Figure 4. Distribution of sample plots (n = 115) and sandhill crane observations by type in the 2013 MNDNR spring aerial survey, northwestern Minnesota. Each sample plot was 4 km^2 and the SACR survey area was 11,812 km^2.

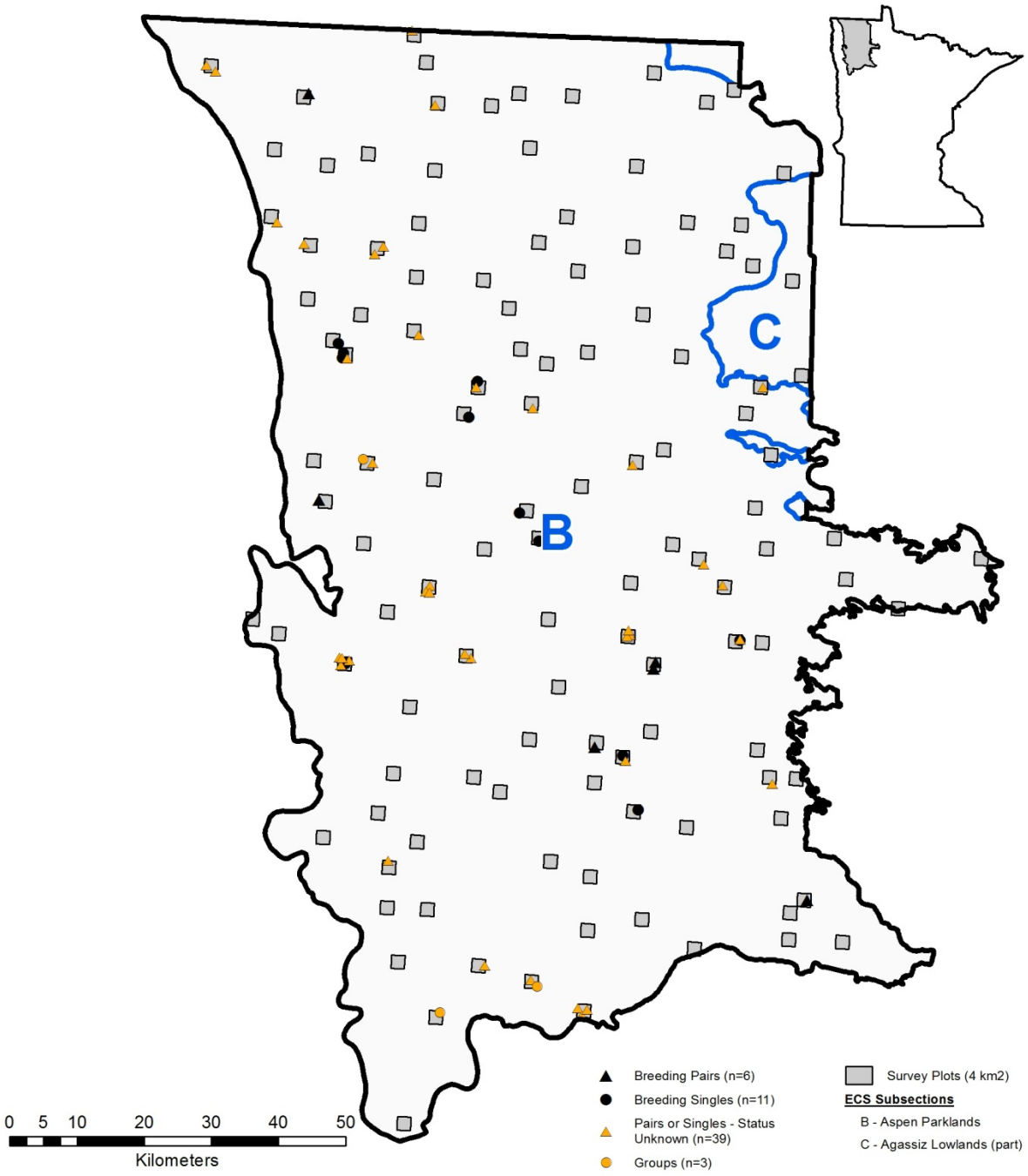

Figure 5. Distribution of sample plots (n = 115) and sandhill crane observations by type in the 2014 MNDNR spring aerial survey, northwestern Minnesota. Each sample plot was 4 km^2 and the SACR survey area was 11,812 km^2.

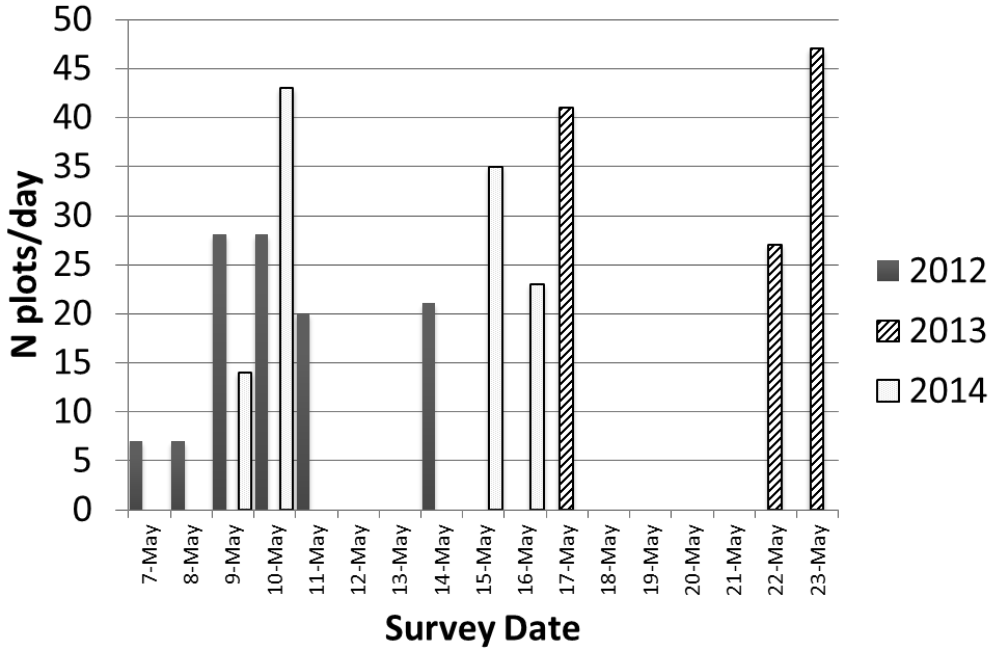

Figure 6. Number of plots surveyed by calendar date during the Northwestern Minnesota Sandhill Crane breeding population survey, 2012-2014. A total of 115 plots were flown in each year.

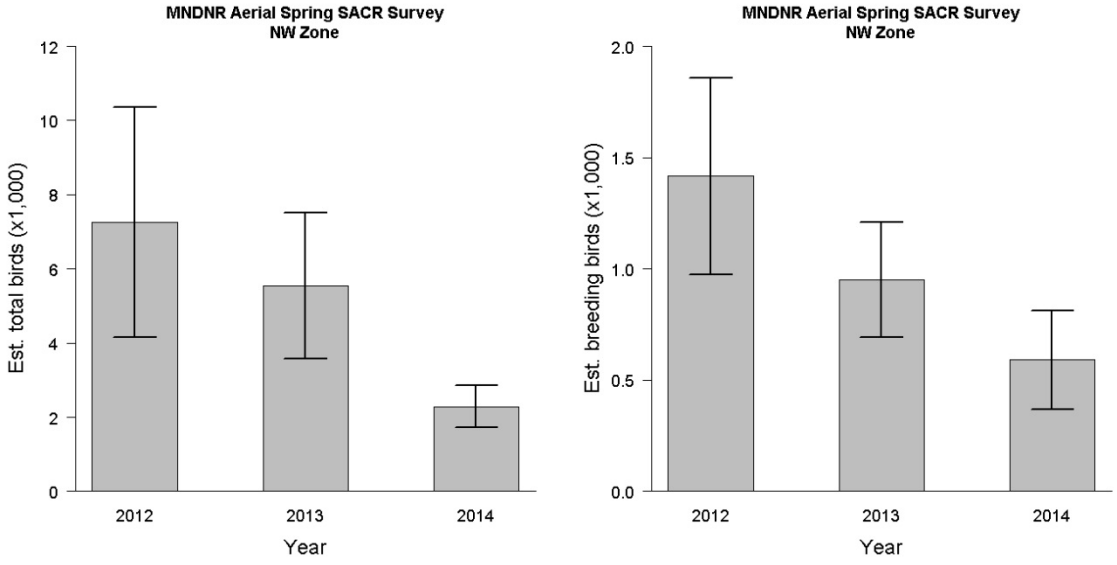

Figure 7. Estimates of total breeding ground population and breeding sandhill cranes in the Aspen Parklands survey area of northwestern Minnesota, 2012-2014.

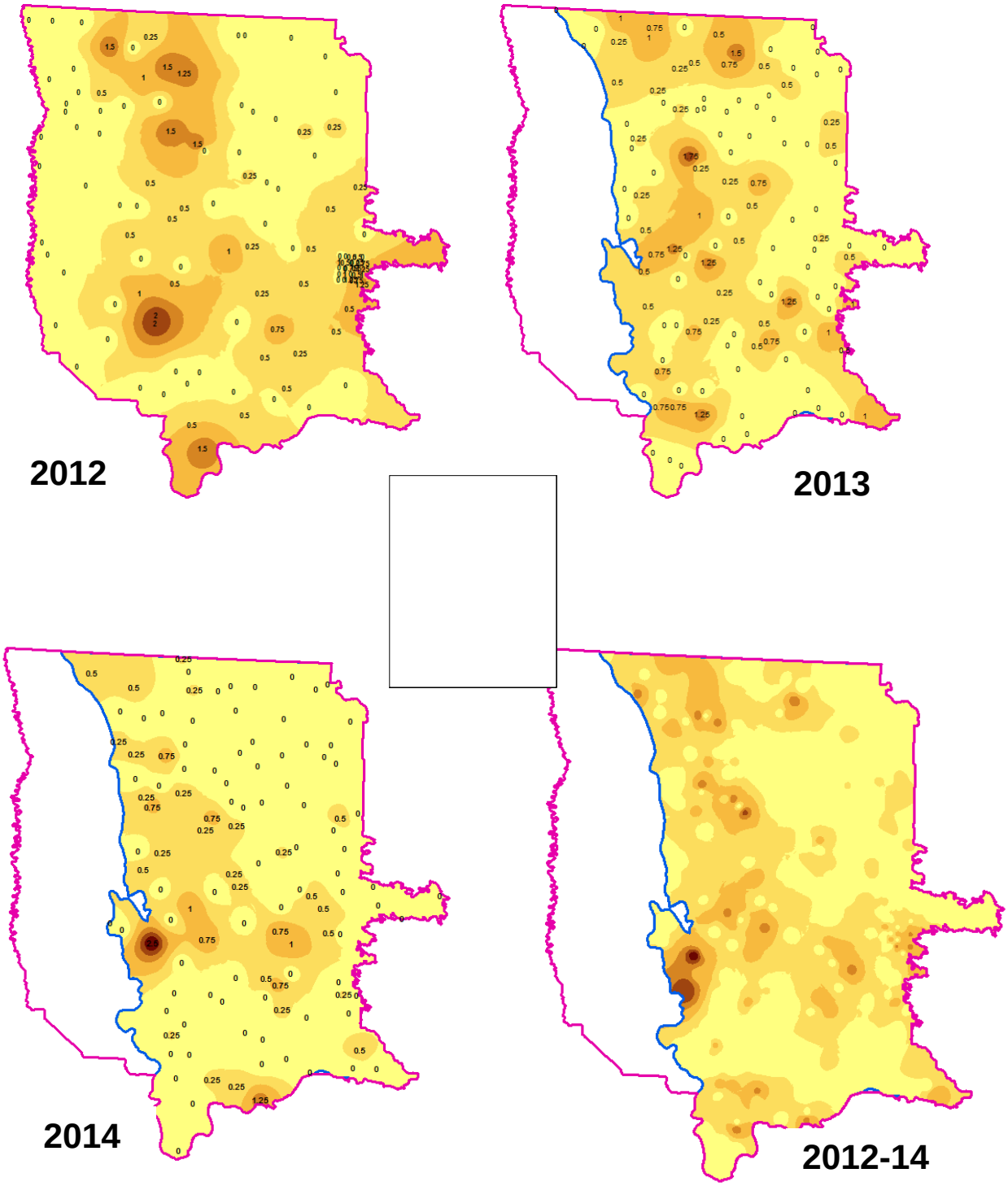

Figure 8. Densities of breeding sandhill cranes (singles + pairs) in the northwest Minnesota crane survey areas, 2012-2014.

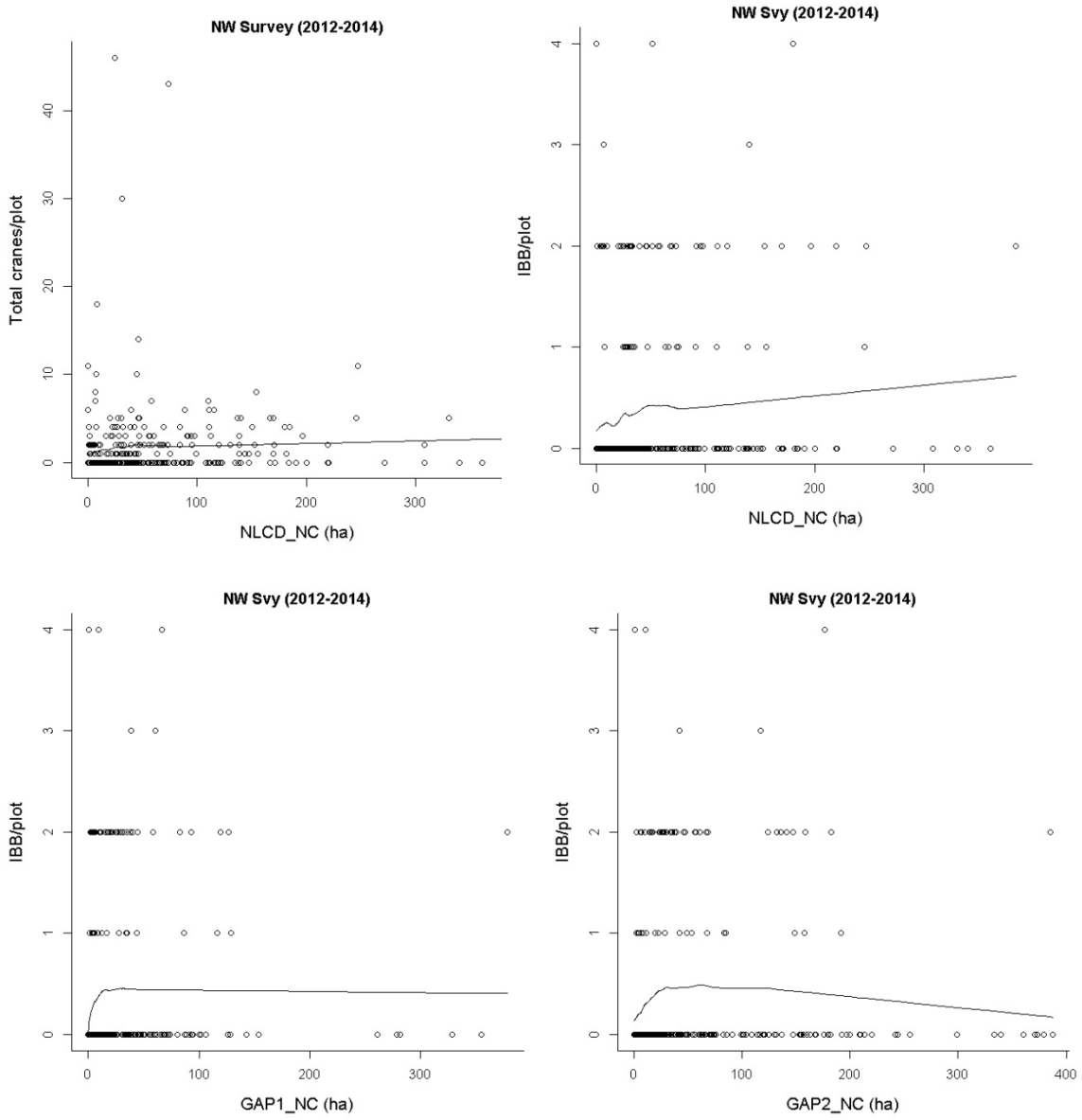

Figure 9. Relationship between sandhill crane observations (total SACR and Indicated Breeding Birds [IBB]) and habitat abundance (as defined by NLCD or GAP classification schemes [see text]) based on 345 4-km^2 plots surveyed in northwest Minnesota, 2102-2014.

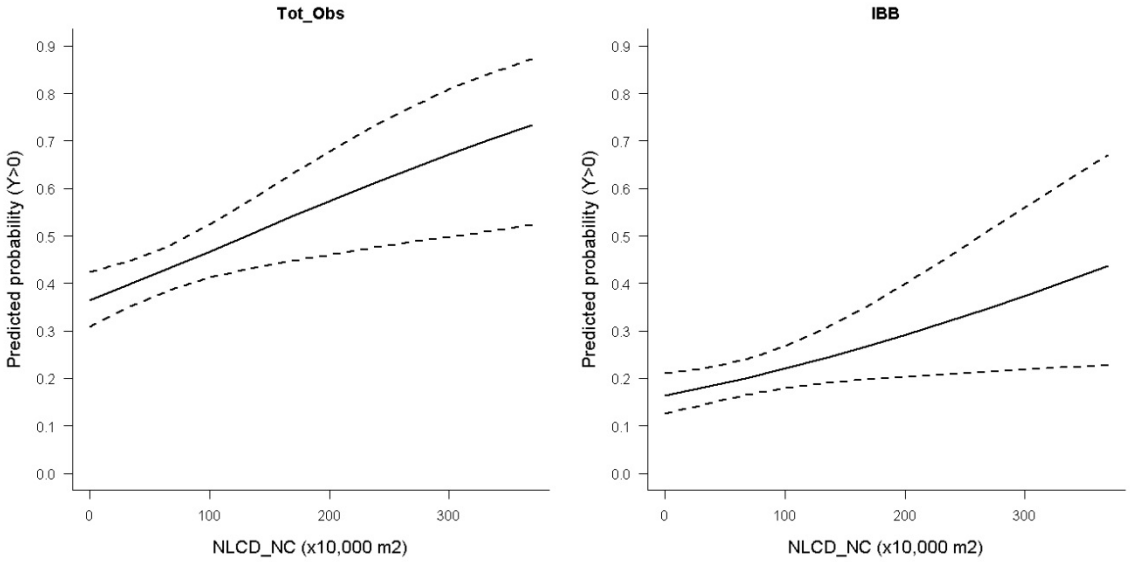

Figure 10. Relationship between sandhill crane occurrence (total SACR and Indicated Breeding Pairs [IBB]) and habitat abundance (as defined by NLCD classification schemes [see text]) based on 345 4-km2 plots surveyed in northwest Minnesota, 2102-2014.

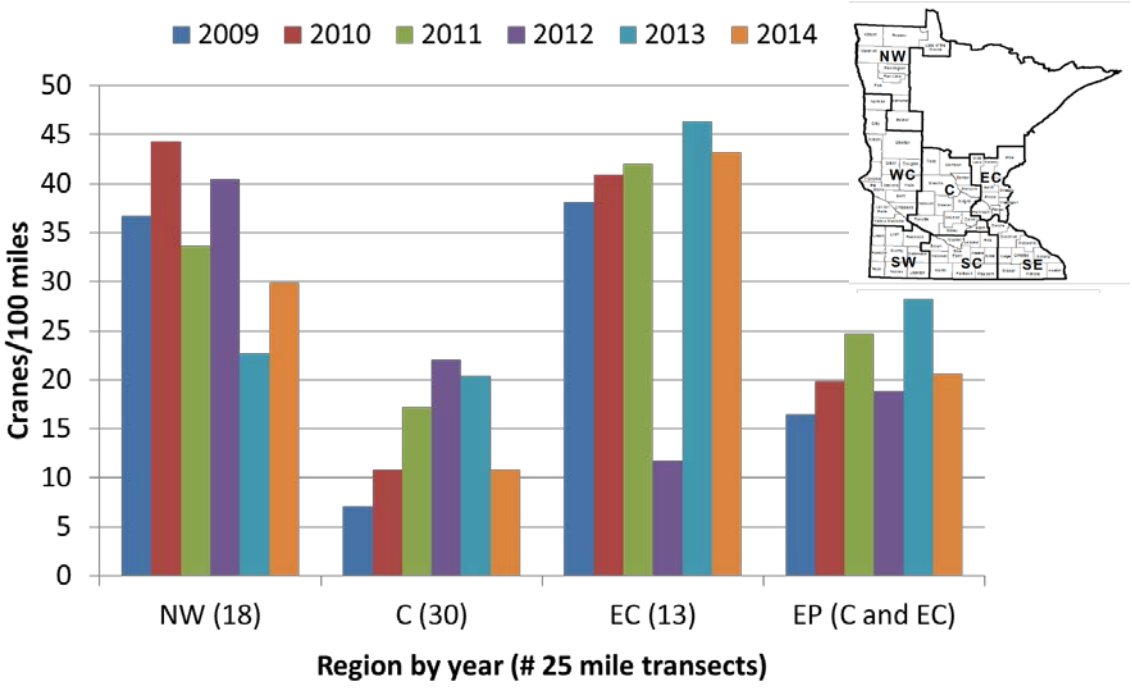

Figure 11. Cranes/100 miles counted during the Minnesota August Roadside Survey, 2009-2014. Counts are shown for the Northwest, Central, and East Central regions, and for the Eastern Population (Central and East Central combined).

ESTIMATING NUMBERS OF BREEDING SANDHILL CRANES IN EAST-CENTRAL MINNESOTA, 2014

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SUMMARY

We conducted a pilot sandhill crane (SACR, *Grus canadensis*) breeding population survey in east-central Minnesota (EC MN) in May 2014. The survey area we selected included the majority of 2 Ecological Classification System subsections. We used the crane survey design developed in northwest Minnesota (NW MN) with 4 km^2 plots as the primary sampling unit. We selected a spatially balanced sample of 115 plots using a generalized random-tessellation stratified (GRTS) design. We surveyed each sample plot once during May using a Bell OH-58 helicopter with a 2-person crew. All crane observations were counted and classified 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 1,924 SACR in EC MN survey area and approximately 1,000 of these were breeding. One group of SACR was observed. Habitat conditions were very wet in 2014. All cranes were located in the western ½ of the survey area, and a different area may be selected if we were to repeat this survey in the future.

INTRODUCTION

SACR in EC MN are part of the Eastern Population (EP), which has been increasing in recent years (Ad hoc Eastern Population Sandhill Crane Committee 2010). Surveys of EP SACR at Sherburne National Wildlife Refuge indicate that breeding cranes have increased from a few in the 1970s to 40-50 pairs in the past few years (Anthony Hewitt, U.S. Fish and Wildlife Service, personal communication). In addition, fall staging cranes have increased from <100 in the early 1990s to 6,500-7,200 at the refuge since 2012. Breeding SACR have also expanded their range in Minnesota so that the delineation between EP and Midcontinent population cranes (MCP) that nest in NW MN is no longer clear. The Minnesota Cooperative Fish and Wildlife Research Unit, in cooperation with Minnesota Department of Natural Resources (MNDNR) and the U.S. Fish and Wildlife Service began a Legislative-Citizen Commission on Minnesota Resources funded project in 2014 to delineate the boundary between these 2 populations.

We began a breeding population survey of MCP SACR in northwestern Minnesota in 2012 (Lawrence et al. 2014) and believed we could apply the same techniques to surveying breeding cranes in EC MN. The 2014 EC survey was designed similar to the NW survey. Our objective was to provide an estimate of the number of breeding cranes in a portion of EC MN that was within ±25% of the true population size with 90% certainty.

STUDY AREA

We examined data from the Minnesota Breeding Bird Atlas (http://www.mnbba.org/) and information from Wildlife Managers to select Ecological Classification System subsections

(http://www.dnr.state.mn.us/ecs/index.html) to survey. We chose to survey portions of the Mille Lacs Upland and Anoka Sand Plain subsections (Figure 1). The Mille Lacs Upland Subsection is the only subsection in the Western Superior Uplands Section and is in the Laurentian Mixed Forest Province. The Anoka Sand Plain is one of 5 subsections in the Minnesota and Northeast Iowa Morainal Section and is part of the Eastern Broadleaf Forest Province. We excluded the portion of the Anoka Sand Plain in Anoka County and south due to high human populations in the Twin Cities Metropolitan area.

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 EC MN study area (Figure 2). The grid was rotated approximately 2.5 degrees east 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 excluded any PSUs where the centroid was not located within the boundary of the SACR survey area. We excluded plots that were mostly in Mille Lacs Lake, plots that overlapped any of Camp Ripley, and plots in the St. Cloud metro area. We also deleted 2 plots on the Wisconsin border where the centroid was in Minnesota, but much of the plot was in Wisconsin. There were 4,098 PSU in the study area.

Sampling design

We used National Land Cover Data (NLCD; Fry et al. 2011) to identify potential nesting habitat using the same criteria we used in NW MN (Lawrence et al. 2014) to delineate potential SACR breeding habitat in each 4-km^2 plot. NLCD is a Landsat-based land cover database created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey (USGS National Land Cover Database). 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). All but 12 of the 4,098 PSU contained at least some NLCD emergent herbaceous wetland nesting cover (Figure 2) and 10 of these 12 contained some NLCD other SACR habitat. The median amount of nesting cover per PSU was 8.5% and the maximum amount was 69% (Figure 3). Thus, because essentially all the plots had as least some potential crane nesting cover and we did not know the relationship between the amount of nesting cover and crane density, we did not stratify the sample plots. We used a spatially-balanced, simple random sampling design (Generalized Random-Tessellation [GRTS], Stevens and Olsen 2004) to select 115 primary survey plots (sampling rate = 2.8%) and 20 alternate plots.

Target population(s)

As in the NW MN survey, 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. *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).
2. *Groups* = flocks of ≥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 did not double observations of single 'breeding' birds to estimate indicated pairs (Lawrence et al. 2014). 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.

We determined SACR distribution by calculating the number of single and paired (x2) birds/km^2 in the survey plots. Then a density map was generated from plot density data using the Inverse Distance Weighted and Reclassify tools in ArcGIS ver. 10.2.2.

Survey procedures

The survey was conducted during late-May, slightly later than the peak incubation period for cranes in NW MN (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008). All plots were surveyed using Bell OH-58 [Jet Ranger] containing a pilot and one observer. Plots were surveyed 5-45 meters above ground level at 10-100 km/hr, depending upon the land cover. We used DNRSurvey ver. 2.11, an ArcGIS addin developed by Minnesota DNR Wildlife and MN.IT Services GIS staff, to record digital voice files, each associated with a UTM location, on a tablet computer.

RESULTS

Survey effort

The 2014 survey was conducted over 4 consecutive days (20-23 May) and we flew an average 29 plots/day (28, 38, 39, 10). The survey team (DNR pilot John Heineman and observer Beau Liddell) spent an average of 5.7 min surveying each plot (range: 2.6 – 13.4 min). Thirty-nine percent of the total aerial survey time was associated with surveying plots.

We surveyed 115 (2.8%) of the 4,098 4 km^2 plots in the survey area. Prior to the survey, the observer examined all the plots and replaced 10 of the 115 original plots with alternate plots. The 10 plots were replaced due to heavy residential development, poultry farms or feedlots.

Sampling statistics

We detected SACR on 24 (21%) of the 115 sample plots (Figure 4). The average count was 2.2 cranes per occupied plot and 0.5 cranes for all plots. We counted 54 SACR on sample plots, of which 48% were pairs, 46% were singles, and 6% were groups (Table 1). We observed 1 group of 3 birds. Fifty-seven percent of observed pairs and singles (54% of pairs and 60% of singles) exhibited some evidence of breeding (Table 1). We detected 17 nests and 2 pairs with colts.

Population estimates and distribution

We estimated 1,924 sandhill cranes (90% CI: 1,375-2,473) in the survey area in 2014. These are minimum estimates because we did not adjust for detection probabilities (which are likely <1, at least for singles and pairs in dense cover). If our sample of singles and pairs exhibiting breeding behavior was representative of the relative abundance of breeding birds in

the target population, then we estimated there were a minimum of 1,033 breeding birds in the survey area (Table 2).

The bound on the estimated total (all strata) was slightly greater than the usual target level for a MNDNR wildlife survey (i.e., CV = 15% and relative bound = 25%). The estimated CV for breeding birds and status-unknown birds was greater than the target (20-27%; Table 2). Cranes were located in the western portion of the survey area (Figures 4, 5) even though potential nesting cover was distributed throughout the area (Figure 2).

DISCUSSION

Survey effort and design considerations

We selected the survey area based upon 2 main considerations: we wanted to use ECS subsections as the basic survey area and we wanted to cover a sizable portion of what was believed to be the range (1970s) of EP cranes in Minnesota (Johnson 1976) prior to the recent expansion. We knew there were likely higher densities of cranes west of the survey area, but the 2 ECS subsections we selected were believed to have good numbers of nesting SACR based upon the Minnesota Breeding Bird Atlas and anecdotal information. We did expect to find cranes throughout the survey area; however, all the cranes we observed were in the western half of the survey area. There was potential nesting habitat throughout the eastern (southern Carlton, Pine, Chisago, and extreme eastern Isanti Counties) and northern (e.g. southern Aitkin & northern Kanabec Counties) part of the survey area (Figure 2) where cranes were not observed. Either those habitats had become too wet and flooded, or breeding cranes are still expanding north and east from the central core range. We observed cranes on many of the plots in Sherburne, southern Kanabec, central and western Isanti, Mille Lacs, Morrison, and Crow Wing Counties. The core breeding area within the survey area was Morrison, Mille Lacs, and southern Crow Wing counties. If we repeat the survey in the future, we will consider including Todd, Ottertail and Wadena counties instead of Carlton, Pine and Chisago counties.

The landscape was extremely wet and high water levels may have influenced crane distribution and nesting. We observed sites that appeared to be excellent crane habitat but did not have nesting cranes. Some of these sites may have been dry earlier in the nesting season, or may have been non-core breeding range. Some nests may have been flooded as much of the precipitation occurred after crane nest initiation.

The phenology was late this year and the EC MN survey was flown on similar dates as the 2013 NW MN survey (Figure 6). We were concerned that the NW MN survey was flown too early this year relative to the phenology (Lawrence et al. 2014) and this may have contributed to the lack of SACR groups observed during the survey. The EC MN survey should have been timed better this year due to the late phenology; however, some colts had already hatched. Normally colts have been first observed near 15 May in EC MN; but, in 2014 we did not see the first colts until the 20-21 May. If this survey were repeated, it should be scheduled prior to the NW survey.

A higher proportion of SACR observations in the EC survey area were breeding birds (0.57) compared to NW MN, where 30% were actively breeding this year (Lawrence et al. 2014). The proportion actively breeding in NW MN has been <0.38 in all 3 years. Only 1 group (n = 3) was observed in the EC survey and the proportion of birds in groups in NW MN was less this year than the previous 2 years. Cranes typically begin breeding at 2-3 years of age (Gerber et al. 2014) so a substantial portion of the population should be nonbreeders. In NW MN, about 40% of the cranes observed in the first 2 years of the survey were in groups. In all years, a

substantial portion of the pairs were likely nonbreeders. We speculated that the earlier NW MN survey in 2014 relative to the late phenology this year may have resulted in fewer nonbreeders (groups) being present on the breeding grounds (Lawrence et al. 2014); yet only 1 group was observed in EC MN even though the survey was later and some colts were already observed. The EC aerial survey crew also noted that they did not see groups of cranes while flying between plots, suggesting they were elsewhere. We do not know the reason for the apparent lack of nonbreeders observed in 2014.

As noted in the NW MN report, timing of the SACR survey may be critical to getting consistent results. However, the 2014 EC MN survey was flown consistent with the 2012 crane breeding activity (i.e. most nesting, a few colts); yet groups were not present. Additional surveys and perhaps studies with marked cranes (satellite transmitters) may be necessary to determine the nuances of crane arrival on the breeding grounds in the spring and their influence on subsequent survey results.

Population estimate

The number of cranes in the survey area was 1,924. Crane density on occupied plots (2.2 cranes/occupied plot) was similar to the 2014 density in NW MN (2.4). No cranes were observed on about ½ of the survey area during this survey. In future surveys, we could delineate areas where we believe there are more breeding cranes.

Survey evaluation

The amount of potential nesting cover per plot did not explain crane density in EC MN. This was likely due to the definition of nesting cover we used in the survey as most plots contained at least some nesting cover. Additional years of data would be needed to develop a potential stratification variable.

The lack of crane groups suggests that this portion of the overall population may have not been present on the survey area in 2014. Alternatively, they may have not been present on the plots; however, we did not observe as many cranes during transit between plots in 2014, suggesting that some nonbreeders had not yet reached the breeding grounds.

The pilot year of this survey provided useful information on cranes in EC MN. This knowledge could be used to design a better sandhill crane breeding population survey if there was a defined need in the future.

ACKNOWLEDGEMENTS

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Table 1. Social and breeding classification of sandhill crane observations in east-central Minnesota, 2014.

Social class[a]	Count	Count by breeding status	Percent of total	Percent of pairs or singles
Pairs (x2)	26		48.1	
Breeding birds		14	(25.9)	53.8
Status unknown		12	(22.2)	46.2
Singles	25		46.3	
Breeding birds		15	(27.8)	60.0
Status unknown		10	(18.5)	40.0
Groups	3		5.6	
Total	54		100	

[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 (reluctance to fly or leave the area, broken-wing displays, etc.); 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 2. Population estimate (N) by indicated breeding status for sandhill cranes in east-central Minnesota, May 2014.

Status	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 %
Breeding birds[a]	115	4,098	17	1	3	0.3	0.05	1,033	205	696	1,371	20
Groups	115	4,098	1	3	3	0.0	0.02	107	92	3	259	86
Status unknown[b]	115	4,098	12	1	5	0.2	0.05	784	210	438	1,130	27
Total	115	4,098	24	1	6	0.5	0.08	1,924	334	1,375	2,473	17

[a]Singles and pairs (x2) with a nest or young, or exhibiting some type of breeding or territorial behavior.

[b]Singles and pairs (x2) without a nest or young, and no behavioral evidence that they were breeding birds.

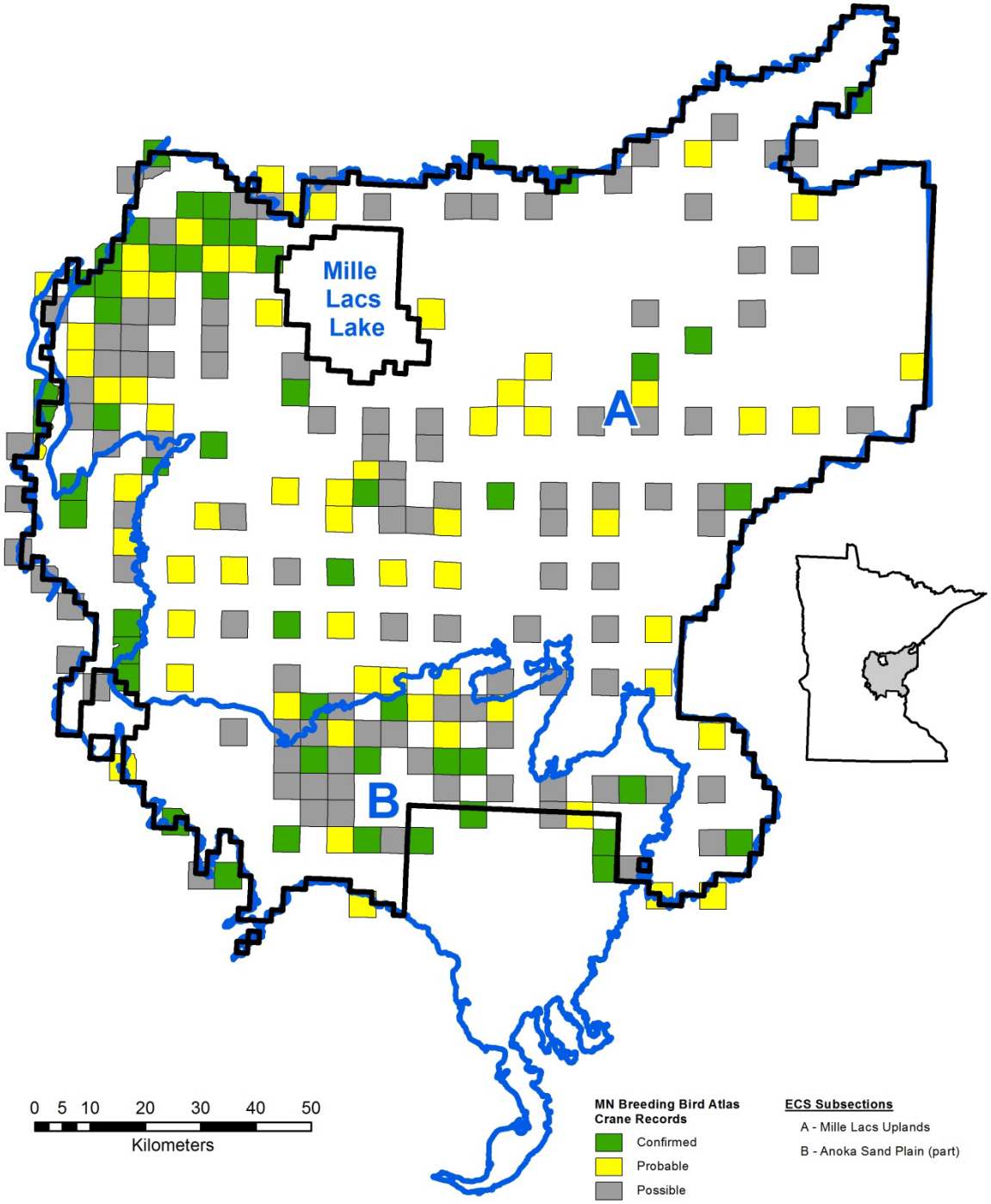

Figure 2. Location of east-central Minnesota sandhill crane survey area (heavy black line) relative to Ecological Classification System (ECS) subsections. A portion of the Anoka Sand Plain extending to the south was not surveyed because it was in the Twin Cities Metropolitan area. Minnesota Breeding Bird Atlas townships that were surveyed and contained sandhill cranes are shown.

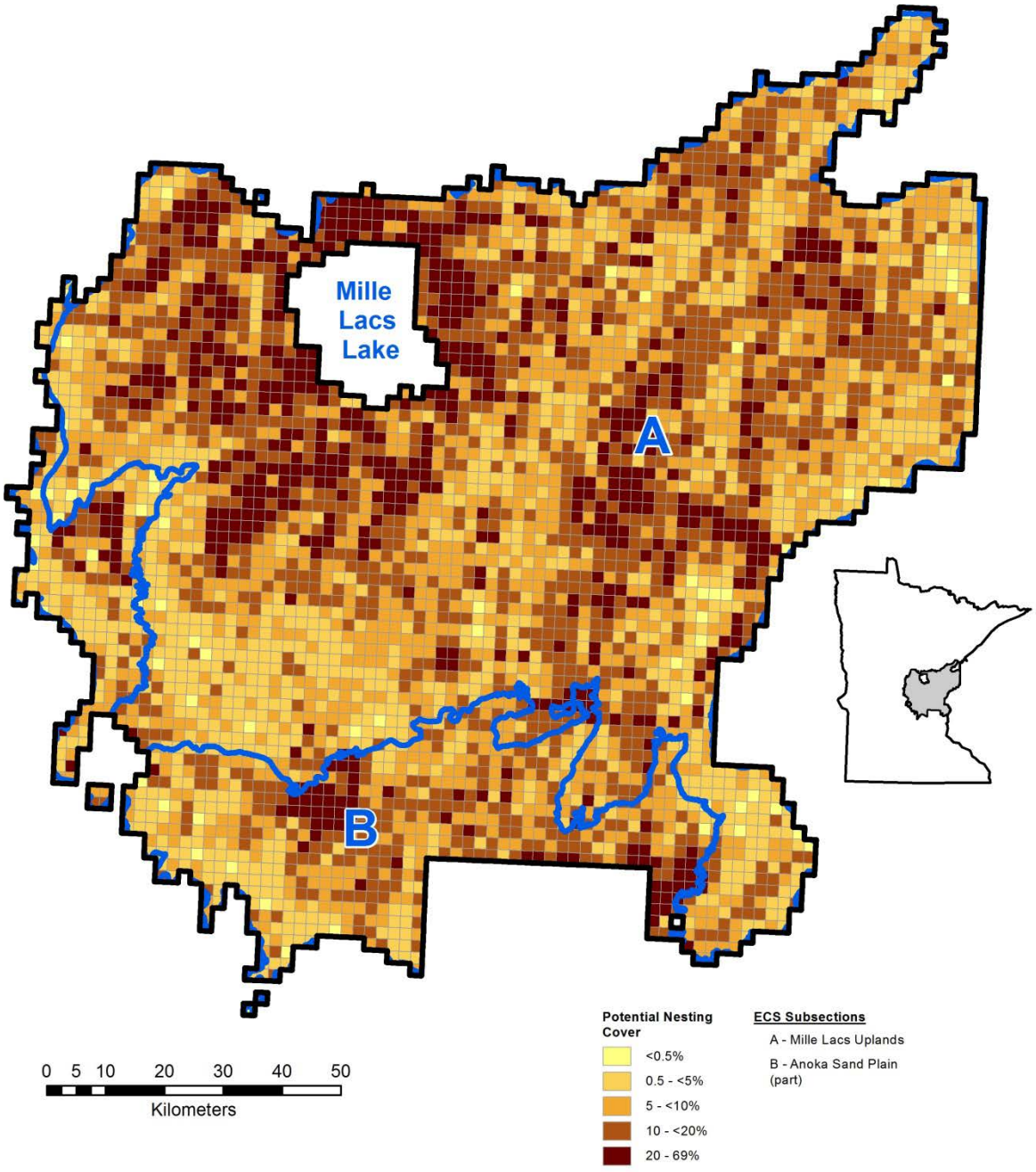

Figure 2. Percent of potential nesting cover (NLCD emergent herbaceous wetland) by primary sampling unit (4-km^2 plots) in the sandhill crane May survey area, east-central Minnesota.

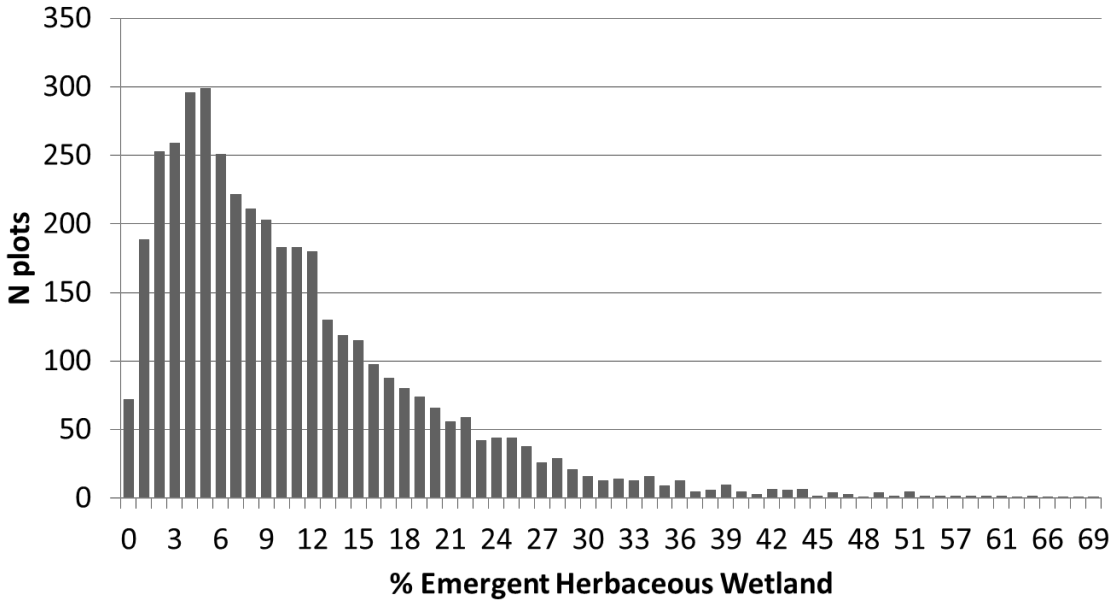

Figure 3. Number of plots by percent of National Land Cover Data cover class 95 (emergent herbaceous wetland) habitat in the plot, east central Minnesota sandhill crane survey area, 2014.

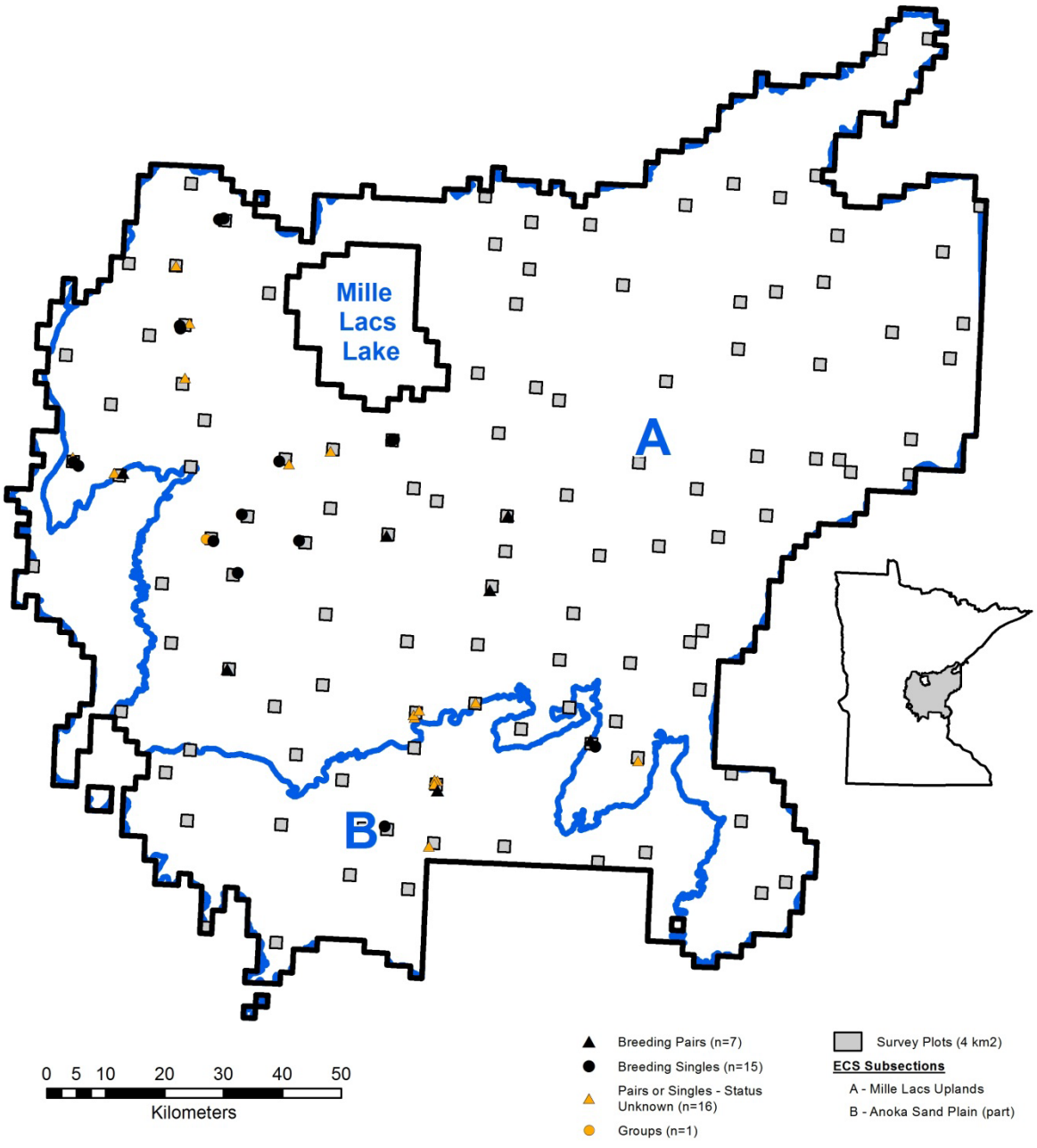

Figure 4. Distribution of sample plots (n = 115) and sandhill crane observations by type in the 2014 MNDNR spring aerial survey, east-central Minnesota. Each sample plot was 4 km^2 and the SACR survey area was 16,362 km^2.

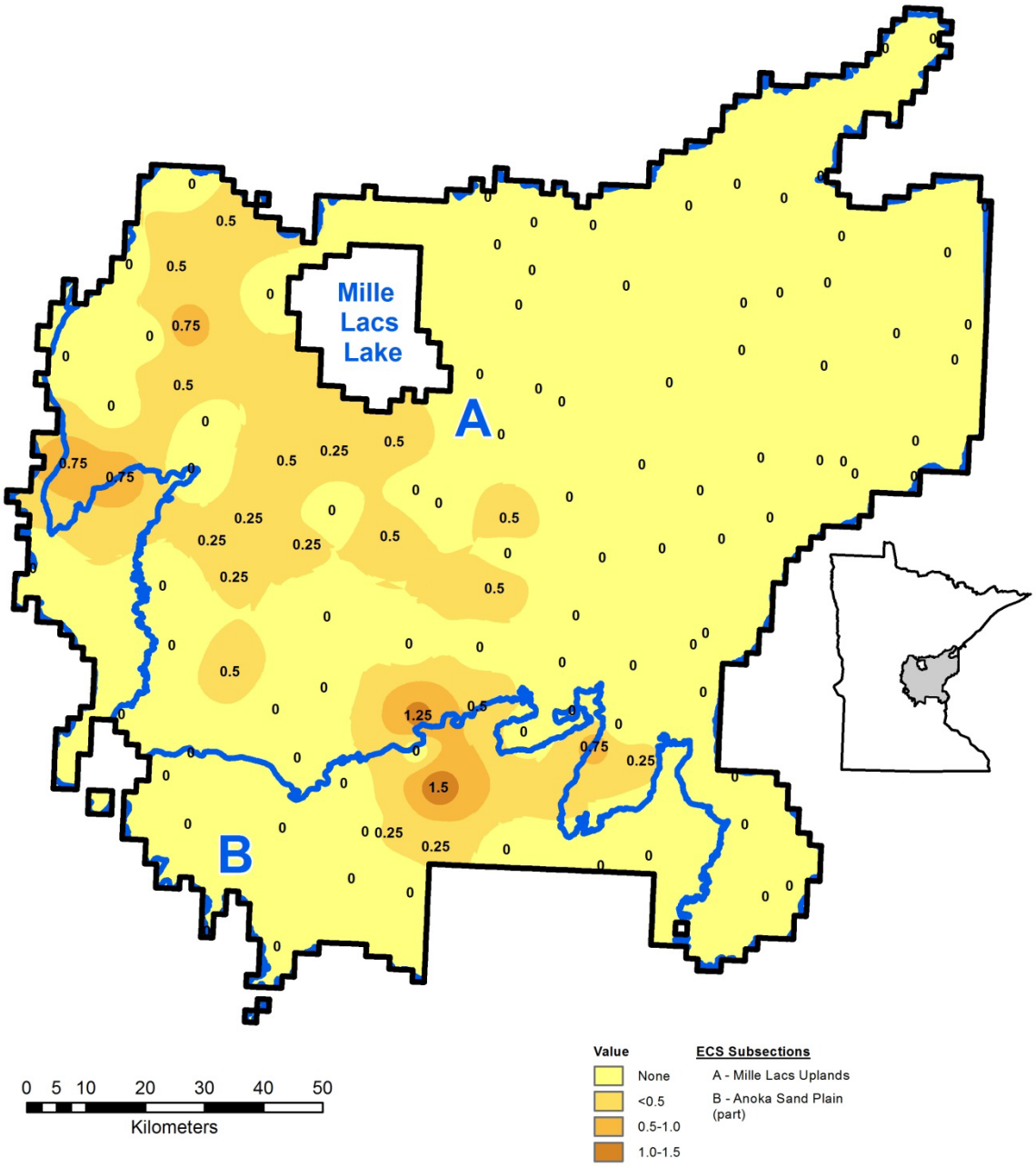

Figure 5. Densities (cranes/km^2) of breeding sandhill cranes (singles + pairs) in the east-central Minnesota crane survey area, 2014.

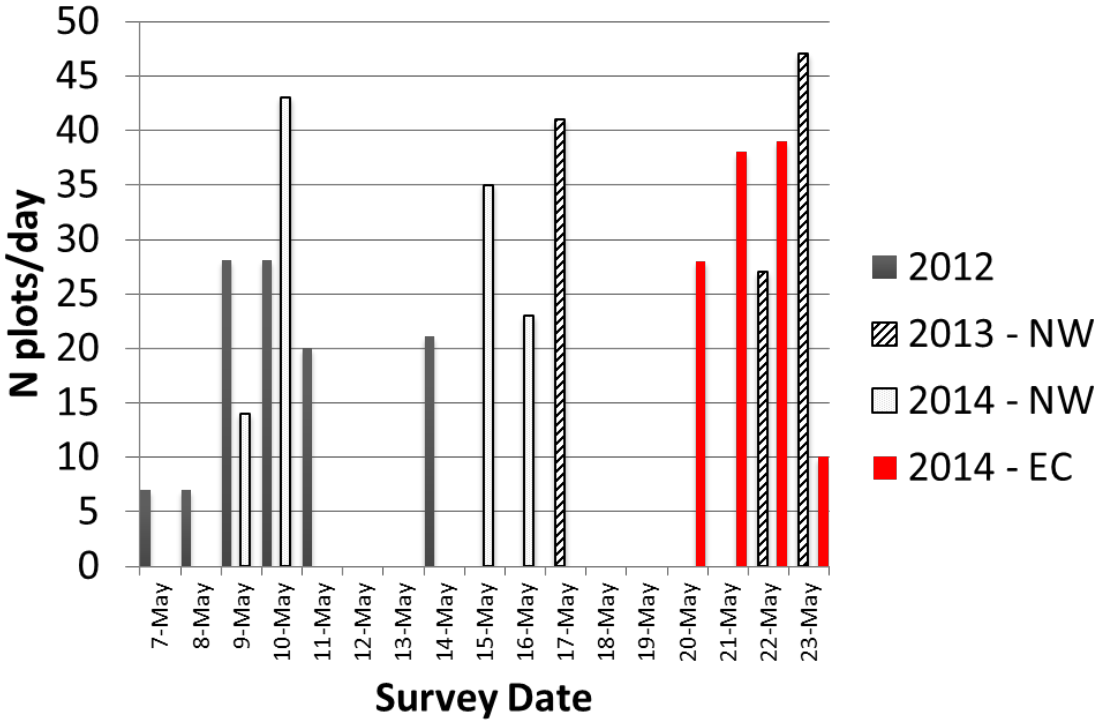

Figure 6. Number of plots surveyed by calendar date during the northwest (2012-2014, Lawrence et al. 2014) and east-central (2014) Minnesota sandhill crane breeding population survey. A total of 115 plots were flown in each area and year.