WETLAND WILDLIFE POPULATIONS

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2015 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 2015 aerial survey portion was flown from May 4 to May 30. The survey was the longest on record due to poor weather in mid-May. Spring ice-out dates were ~2 weeks earlier than average across the state. Temperatures were above normal and precipitation was below normal in March and April. Temperatures in May were near normal but precipitation was well above normal across the state. Spring wetland conditions were poor in early May at the start of the survey but improved some by the end of May when the survey was completed. Overall, wetland numbers (Types II-V) decreased 36% compared to 2014 and were below both the 10-year (-22%) and long-term (-13%) averages. The number of temporary wetlands (Type 1) was 64% below the long-term average.

The 2015 estimated mallard breeding population was 206,000, which was 20% lower than last year's estimate of 257,000 mallards, but statistically unchanged (P=0.45). Mallard numbers were 17% below the 10-year average and 10% below the long-term average of 228,000 breeding mallards. The estimated blue-winged teal population was 169,000, which was 66% higher than last year's estimate of 102,000 blue-winged teal, but statistically unchanged (P=0.28). Blue-winged teal numbers were 14% above the 10-year average and 21% below the long-term average of 212,000 blue-winged teal. The combined population index of other ducks, excluding scaup, was 149,000 ducks, which was 29% higher than last year's estimate and 17% below the 10-year average and 16% below the long-term average of 177,000 other ducks.

The estimate of total duck abundance (524,000), which excludes scaup, was 10% higher than last year's estimate of 474,000 ducks and was 9% below the 10-year average and 15% below the long-term average of 618,000 ducks. The estimated number of Canada geese was 162,000 and 62% higher than last year and 2% above the 10-year average.

METHODS

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

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

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

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

Areas with less than two basins per township are not

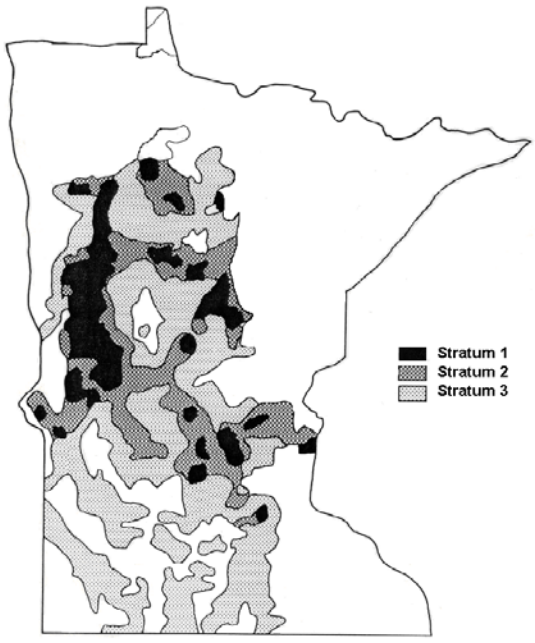

Figure 1. Location of waterfowl breeding population survey strata in Minnesota.

surveyed. Strata boundaries were based upon "An Inventory of Minnesota Lakes" (Minnesota Conserv. Dept. 1968:12). Standard procedures for the survey follow those outlined in "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Populations and Habitat Surveys in North America" (USFWS/CWS 1987). Changes in survey methodology were described in the 1989 Minnesota Waterfowl Breeding Population Survey report. Pond and waterfowl data for 1968-74 were calculated from Jessen (1969-72) and Maxson and Pace (1989).

All aerial transects in Strata I-III (Table 1) were flown using an American Champion Scout. Past surveys have been flown with a Cessna 185 but the Scout performed well for the survey. Wetlands were counted on only the observer's side of the plane (0.125 mile wide transect); a correction factor obtained in 1989 (123,000/203,000 = 0.606) was used to adjust previous estimates (1968-88) of wetland abundance (Type II-V; Table 2) that were obtained when the observer counted wetlands on both sides of the plane (0.25 mile wide transect). All wetland and waterfowl data were recorded on digital voice recorders and transcribed by the observer from the digital files. 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 2014 and 2015 were compared using two-tailed Z-tests.

SURVEY CHRONOLOGY

The 2015 aerial survey began on 4 May in southern Minnesota and concluded in northern Minnesota on 30 May. Transects were flown on 9 days, May 4-5, May 9, May 19-20, May 22, May 27-28, and May 30 and completed in 63 flight hours. Flights began near 7 AM and were completed by 12:30 PM each day. The median date for survey completion was May 20, which was similar to last year but one of the latest on record.

WEATHER AND HABITAT CONDITIONS

For the majority of Minnesota lakes, ice out was 1-2 weeks earlier than the historical median dates. Temperatures in March averaged 2°F above normal and precipitation was 0.9 inches below normal statewide. Temperatures in April averaged 1.6°F above normal and precipitation was 0.6 inches below normal statewide. Temperatures in May averaged 0.9°F below normal statewide and precipitation was 1.8 inches above normal statewide (http://climate.umn.edu). Additional temperature and precipitation data are provided in Appendix A.

Wetland conditions in early spring 2015 were extremely dry but improved some by late May. In early May 2015, 40% of the state was classified as severe drought, 54% was moderate drought, 1% was abnormally dry, and 4% of the state was under no drought designation. By early June 2015, 0% of the state was classified as severe drought, 12% was moderate drought, 39% was abnormally dry, and 49% of the state was under no drought designation. In early May 2015, statewide topsoil moisture indices were rated as 6% very short, 39% short, 55% adequate and 0% surplus moisture. By early June 2015, statewide topsoil moisture indices were rated as 0% very short, 1% short, 87% adequate and 13% surplus moisture (http://droughtmonitor.unl.edu).

Planting dates for row crops were extremely early in 2015. By May 3, about 83% of the corn acres had been planted statewide compared to 7% in 2014 and 34% for the previous 5-year average. By June 1, 12% of alfalfa hay had been cut compared to 5% in 2014 and a 5-year average of 23% (Minnesota Agricultural Statistics Service Weekly Crop Weather Reports, (http://www.nass.usda.gov/mn/).

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

Wetland numbers (Type II-V) decreased 36% from 2014 and were 22% below the 10-year average and 13% below the long-term average (Table 2; Figure 2). The number of temporary (Type 1) sheet water wetlands was 64% below the long-term average. In general, wetland conditions improved some during the survey with significant rain events in mid-May across the survey area.

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 2015 breeding population estimate of mallards was 206,230 (SE = 37,498), which was 20% lower than the 2014 estimate of 257,000 mallards, but statistically unchanged (Z = 0.76, P = 0.45) (Table 7, Figure 3). Mallard numbers were 17% below the 10-year average and 10% below the long-term average of 228,000 mallards. In 2015, the mallard population was comprised of 68% lone or flocked males, 19% pairs, and 13% flocked mallards. The 5-year average is 71% lone or flocked males, 21% pairs, and 8% flocked mallards.

The estimated blue-winged teal population was 168,615 (SE = 56,787), which was 66% higher than the 2014 estimate of 101,640 blue-winged teal, but statistically unchanged (Z = 1.09, P = 0.28). Blue-winged teal numbers were 14% above the 10-year average and 21% below the long-term average (Table 7, Figure 4). The blue-winged teal population was comprised of 10% lone males, 43% pairs, and 47% flocks. The long-term average is 18% lone males, 54% pairs, and 29% flocks.

The combined population estimate of other ducks (excluding scaup) was 149,330 which was 29% above last year's estimate of 115,750 other ducks and 17% below the 10-year average and 16% 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 (35,000) were 46% above the 10-year average and 43% below the long-term average.

The total duck population index, excluding scaup, was 524,000 ducks and was 10% above last year's index of 474,000 ducks and 9% below the 10-year average and 15% below the long-term average (Table 8, Figure 6).

The population index for total ducks was 559,000 ducks, which was 7% below the 10-year average and 18% below the long-term average.

Visibility Correction Factors (VCFs) were lower for mallards in 2015 than 2014 but higher for blue-winged teal, other ducks, and Canada geese in 2015 compared to 2014 (Table 7, Table 8). The mallard VCF (2.17) was 6% below last year's estimate and 20% below the 10-year average. The blue-winged teal VCF (5.04) was 58% above last year's estimate and 32% above the 10-year average. The VCF for other ducks (3.22) was 44% above last year's estimate and 3% above the 10-year average. The VCF for Canada geese (1.75) was 11% above last year's estimate and 17% below the 10-year average.

The population estimate of Canada geese (adjusted for visibility) was 162,000, which was 2% above the 10-year average (Table 8, Figure 7). There were considerably more geese observed in flocks (>10 geese) this year compared to previous years. The goose population was comprised of 60% lone or paired Canada

geese and 40% flocked geese. In 2013, the goose population was comprised of 77% lone or paired Canada geese and 23% flocked geese. These flocked Canada geese could be non-breeding Minnesota resident geese, early molt migrant Canada geese from states south of Minnesota, or even late migrant Canada geese moving to Canada. A total of 23 Canada goose broods were observed, compared to 13 in 2014, 5 in 2013 and 70 in 2012.

The estimated coot population, uncorrected for visibility, was 10,000 compared to 19,000 in 2014.

The estimated number of swans (likely trumpeters) was 12,575 swans compared to last year's estimate of 7,700 (Table 6). Lone swans are not doubled and the estimate is expanded for area but not visibility, although visibility of swans is extremely high. Trumpeter swans continue to expand their range and dramatically increase in number.

SUMMARY

Ice out was about 2 weeks earlier than average across the state in 2015. Temperatures in March and April were above normal and precipitation was below normal. Temperatures in May were near average but precipitation was well above average. Wetland conditions were below average across the survey area. Overall, wetland numbers were 36% lower than last year and 13% below the long-term average. Mallard abundance in 2015 was 206,000 mallards, which was 20% lower than last year and 17% below the 10-year average and 10% below the long-term average of 228,000 breeding mallards. Blue-winged teal abundance (169,000) was 66% higher than 2014 but 21% below the long-term average of 212,000 blue-winged teal. The combined population index of other ducks (149,000) was 29% higher than 2014 and 16% below the long-term average of 178,000 other ducks. Total duck abundance (524,000), excluding scaup, was 10% higher than 2014 and was 15% below the long-term average. Canada goose numbers adjusted for visibility bias increased 62% from 2014.

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

Air Crew:

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

Ground Crew Assistants: Rich Olsen, Minnesota DNR; Lowell Deede, USFWS, Tamarac National Wildlife Refuge; Tyler Zimmerman and Jordan Swart, USFWS, HAPET, Fergus Falls; Paul Richert and Steve Lewis, USFWS, Region III, Twin Cities; K. Svendsgaard, J. Rorah, K. Rittenhouse, E. Broich, Kris Spaeth, and John Riens, USFWS, Sherburne National Wildlife Refuge

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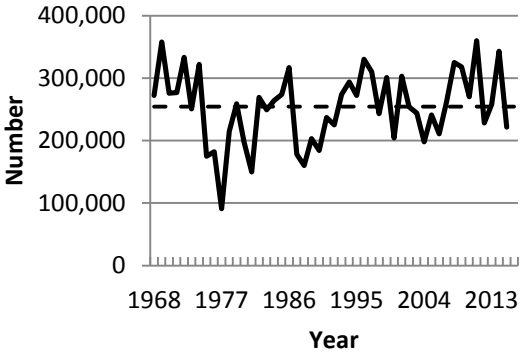

Figure 2. Number of May ponds (Types II-V) and long-term average (dashed line) in Minnesota, 1968-2015.

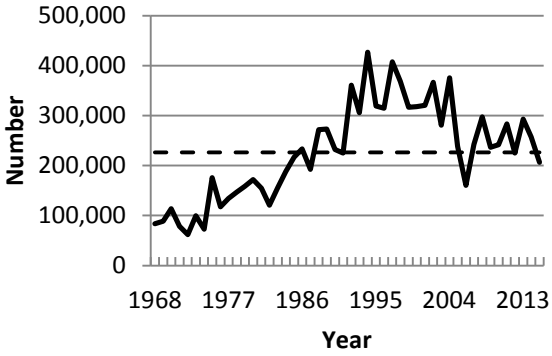

Figure 3. Mallard population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2015.

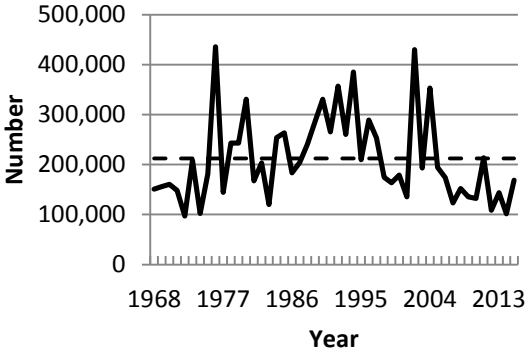

Figure 4. Blue-winged teal population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2015.

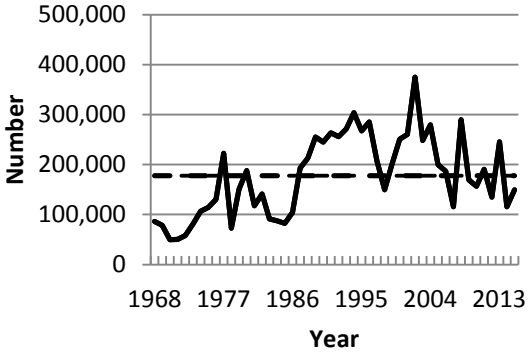

Figure 5. Other duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2015

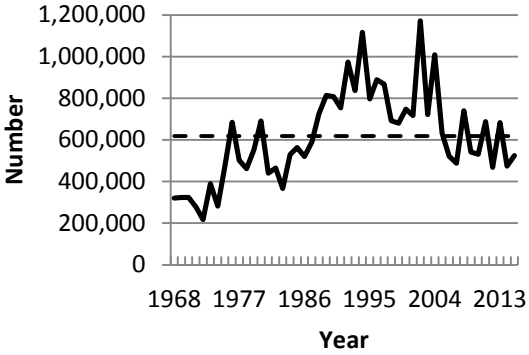

Figure 6. Total duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2015

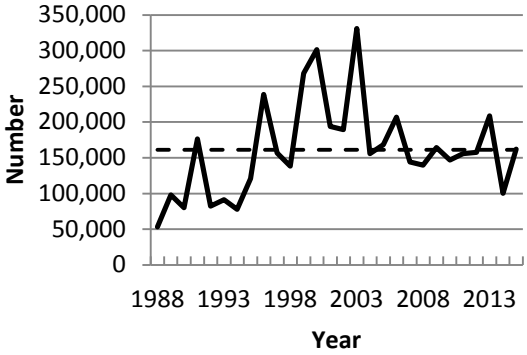

Figure 7. Canada goose population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1988-2015.

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Table 1. Survey design for Minnesota, May 2015.[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), 1968-2015.

Year	Number of Ponds[1]		Year	Type 1 wetlands	Number of Ponds[1]
1968	272,000		1991	82,862	237,000
1969	358,000		1992	10,019	225,000
1970	276,000		1993	199,870	274,000
1971	277,000		1994	123,958	294,000
1972	333,000		1995	140,432	272,000
1973	251,000		1996	147,859	330,000
1974	322,000		1997	30,751	310,000
1975	175,000		1998	20,560	243,000
1976	182,000		1999	152,747	301,000
1977	91,000		2000	5,090	204,000
1978	215,000		2001	66,444	303,000
1979	259,000		2002	30,602	254,000
1980	198,000		2003	34,005	244,000
1981	150,000		2004	9,494	198,000
1982	269,000		2005	30,764	241,000
1983	249,000		2006	56,798	211,000
1984	264,000		2007	32,415	262,000
1985	274,000		2008	69,734	325,000
1986	317,000		2009	39,078	318,000
1987	178,000		2010	26,880	270,000
1988	160,000		2011	89,218	360,000
1989	203,000		2012	30,910	228,000
1990	184,000		2013	9,813	258,000
			2014	54,300	343,000
			2015	22,056	220,000
		Averages:	10-year	44,000	282,000
			Long-term	61,000	254,000
		% change from:	2014	-59%	-36%
			10-year	-50%	-22%
			Long-term	-64%	-13%

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

Table 3. Minnesota waterfowl breeding populations by species for Stratum I (high wetland density), expanded for area but not visibility, 1997-2015.

Species	Year																		
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dabblers:																			
Mallard	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	19,633
Black Duck	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0	0	333	167	222
Gadwall	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	1,083
American Wigeon	0	56	56	56	111	0	56	555	167	0	56	111	56	56	111	222	222	167	111
Green-winged Teal	56	333	0	278	56	278	222	444	56	56	167	278	167	56	56	56	0	0	56
Blue-winged Teal	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	4,360
Northern Shoveler	1,500	500	555	1,055	305	1,277	278	1,166	333	167	56	1,000	666	1,027	111	56	333	722	111
Northern Pintail	111	111	167	167	389	56	111	56	0	56	0	56	56	0	111	0	111	167	222
Wood Duck	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	2,222
Dabbler Subtotal	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	28,020
Divers:																			
Redhead	778	944	500	583	1,444	750	333	805	666	666	916	1,389	472	944	805	750	861	1,333	583
Canvasback	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	1,027
Scaup	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	5,526
Ring-necked Duck	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	3,110
Goldeneye	0	111	56	56	333	111	0	222	222	56	222	278	278	222	56	56	333	444	278
Bufflehead	0	56	111	56	111	222	111	389	167	222	56	1,611	833	389	278	56	611	56	278
Ruddy Duck	528	11,052	972	0	83	1,305	417	305	1,222	305	0	1,027	861	28	56	0	305	111	694
Hooded Merganser	555	389	722	500	722	555	333	278	333	555	111	666	944	555	500	555	333	666	1,000
Large Merganser	56	0	0	0	111	0	972	0	111	0	278	333	333	333	111	56	222	139	167
Diver Subtotal	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	12,663
Total Ducks	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	40,683
Other:																			
Coot	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	1,972
Canada Goose	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	23,077
Swan	0	56	139	0	0	111	1,000	305	417	861	389	694	500	694	1,611	1,277	2,944	1,944	2,472

Table 4. Minnesota waterfowl breeding populations by species for Stratum II (medium wetland density), expanded for area but not visibility, 1997-2015.

Species	Year																		
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dabblers:																			
Mallard	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	24,078
Black Duck	0	0	0	0	117	0	0	0	0	0	0	0	0	0	0	0	0	0	117
Gadwall	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	818
American Wigeon	351	818	0	468	0	0	0	2,513	117	0	0	351	0	351	0	117	234	0	234
Green-winged Teal	234	351	117	117	117	468	234	234	0	117	0	0	234	117	0	0	117	351	584
Blue-winged Teal	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	5,026
Northern Shoveler	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	877
Northern Pintail	234	468	117	117	117	0	117	0	0	0	234	0	0	0	234	0	0	117	0
Wood Duck	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	1,753
Dabbler subtotal	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	33,487
Divers:																			
Redhead	1,987	935	1,636	2,805	2,455	234	584	1,110	292	175	935	935	584	760	1,578	468	468	526	468
Canvasback	701	117	117	935	0	468	1,052	234	0	0	1,169	468	234	117	584	117	935	1,286	1,169
Scaup	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	4,909
Ring-necked Duck	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	4,325
Goldeneye	818	234	935	584	468	234	234	351	117	117	0	351	584	468	468	584	935	1,519	935
Bufflehead	117	0	0	0	0	1,169	117	468	351	117	117	1,403	818	643	1,403	468	0	818	0
Ruddy Duck	117	0	468	0	0	1,870	2,688	0	351	58	0	0	175	409	58	234	117	0	351
Hooded Merganser	468	117	701	935	1,403	701	701	234	234	351	234	584	701	117	2,221	1,636	701	234	1,169
Large Merganser	0	0	0	117	117	0	0	234	351	0	0	351	0	0	234	0	234	117	234
Diver subtotal	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	13,560
Total Ducks	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	47,047
Other:																			
Coot	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	0
Canada Goose	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	24,312
Swan	175	117	117	58	117	292	994	701	1,461	994	468	1,519	2,922	2,279	7,188	3,507	6,604	3,740	5,318

Table 5. Minnesota waterfowl breeding populations by species for Stratum III (low wetland density), expanded for area but not visibility, 1997-2015.

	Year																		
Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dabblers:																			
Mallard	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	51,154
Black Duck	0	0	0	0	0	0	0	174	0	0	174	174	0	0	0	174	174	0	0
Gadwall	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	2,088
American Wigeon	348	696	0	522	174	1,218	174	1,566	1,044	174	348	348	174	348	1,044	174	348	174	1,566
Green-winged Teal	348	174	0	1,218	1,392	522	174	0	174	522	0	0	0	0	174	348	696	0	348
Blue-winged Teal	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	24,098
Northern Shoveler	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	1,914
Northern Pintail	522	870	870	696	522	0	174	348	174	174	348	174	0	174	0	174	174	0	174
Wood Duck	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	8,265
Dabbler subtotal	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	89,607
Divers:																			
Redhead	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	1,305
Canvasback	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	696
Scaup	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	435
Ring-necked Duck	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	3,480
Goldeneye	522	696	696	1,044	1,566	3,132	1,305	696	1,044	1,044	870	348	522	174	870	0	348	174	1,218
Bufflehead	174	348	0	0	0	1,218	783	2,088	0	174	696	1,218	870	174	2,871	174	3,915	4,698	522
Ruddy Duck	348	0	174	0	696	18,878	87	2,262	870	696	261	87	348	0	3,828	522	522	174	0
Hooded Merganser	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	522
Large Merganser	0	0	0	0	0	522	0	0	261	957	348	348	348	348	174	174	0	0	0
Diver subtotal	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	8,178
Total Ducks	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	97,785
Other:																			
Coot	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	7,917
Canada Goose	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	43,498
Swan	87	0	348	348	174	0	348	348	522	2,001	1,218	609	1,914	2,175	1,827	1,827	2,088	2,001	4,785

Table 6. Minnesota waterfowl breeding populations by species for Stratum I-III combined, expanded for area coverage but not for visibility, 1997-2015.

	Year																		
Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dabblers:																			
Mallard	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	94,866
Black Duck	0	0	0	0	117	0	0	174	56	0	174	174	0	0	0	174	507	167	339
Gadwall	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	3,989
American Wigeon	699	1,570	56	1,045	285	1,218	230	4,634	1,327	174	404	810	230	754	1,155	513	804	341	1,911
Green-winged Teal	638	858	117	1,613	1,564	1,267	630	678	230	694	167	278	400	172	230	404	813	351	988
Blue-winged Teal	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	33,484
Northern Shoveler	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	2,902
Northern Pintail	867	1,449	1,153	979	1,028	56	402	404	174	230	582	230	56	174	345	174	285	284	396
Wood Duck	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	12,240
Dabbler subtotal	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	151,115
Divers:																			
Redhead	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	2,356
Canvasback	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	2,892
Scaup	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	10,870
Ring-necked Duck	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	10,915
Goldeneye	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	2,431
Bufflehead	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	800
Ruddy Duck	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	1,045
Hooded Merganser	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	2,691
Large Merganser	56	0	0	117	228	522	972	234	723	957	626	1,032	681	681	519	230	456	256	400
Diver subtotal	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	34,400
Total Ducks	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	185,515
Other:																			
Coot	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	9,888
Canada Goose	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	90,887
Swan	262	172	604	406	291	403	2,341	1,355	2,400	3,855	2,074	2,823	5,336	5,148	10,626	6,611	11,500	7,700	12,575

Table 7. Mallard, blue-winged teal, and other duck (excluding scaup) populations in Minnesota, 1968-2015.

	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

Table 7. Cont.

	Mallard				Blue-winged teal				Other ducks (exc. scaup)		
Year	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI
1993	123,771	2.47	305,838	31,103	64,670	4.02	260,070	36,307	82,612	3.28	271,263
1994	138,482	3.08	426,455	66,240	70,324	5.48	385,256	82,580	85,671	3.55	303,847
1995	142,557	2.24	319,433	48,124	47,737	4.40	210,043	40,531	66,096	4.05	267,668
1996	153,473	2.05	314,816	53,461	57,196	5.05	288,913	64,064	107,950	2.64	285,328
1997	160,629	2.54	407,413	65,771	45,496	5.57	253,408	67,526	76,095	2.72	207,316
1998	188,972	1.95	368,450	61,513	47,788	3.66	174,848	33,855	91,478	1.64	149,786
1999	169,213	1.87	316,394	51,651	36,106	4.53	163,499	36,124	80,459	2.49	200,570
2000	157,853	2.02	318,134	36,857	60,288	2.97	179,055	32,189	120,158	2.09	250,590
2001	146,034	2.20	320,560	39,541	37,706	3.60	135,742	19,631	91,152	2.85	260,051
2002	145,191	2.53	366,625	46,264	91,982	4.67	429,934	87,312	92,778	4.04	374,978
2003	115,974	2.42	280,517	34,556	46,759	4.13	193,269	36,176	46,796	5.30	248,019
2004	158,416	2.37	375,313	57,591	94,152	3.75	353,209	56,539	95,105	2.94	279,802
2005	82,472	2.89	238,500	28,595	48,394	4.01	194,125	37,358	46,797	4.26	199,355
2006	72,843	2.21	160,715	24,230	38,328	4.53	173,674	60,353	42,333	4.41	186,719
2007	76,979	3.15	242,481	30,020	29,407	4.20	123,588	20,055	30,963	3.73	115,390
2008	103,411	2.88	297,565	27,787	40,777	3.74	152,359	24,157	99,575	2.91	289,629
2009	78,368	3.02	236,436	36,539	37,286	3.63	135,262	32,155	62,725	2.70	169,568
2010	80,922	2.99	241,884	33,940	32,742	4.04	132,261	27,430	55,076	2.84	156,599
2011	102,245	2.77	283,329	49,845	61,772	3.46	213,584	88,720	79,743	2.39	190,586
2012	96,448	2.33	224,965	45,057	49,779	2.18	108,607	31,971	60,228	2.24	135,017
2013	111,208	2.64	293,239	58,463	27,194	5.29	143,927	46,635	68,804	3.57	245,729
2014	111,408	2.31	256,996	55,366	31,979	3.18	101,640	24,089	51,619	2.24	115,751
2015	94,866	2.17	206,229	37,498	33,484	5.04	168,615	56,787	46,295	3.23	149,330
Averages:											
10-year	91,630	2.72	247,611	38,984	39,766	3.83	147,903	39,292	59,786	3.13	180,434
Long-term	102,696	2.23	228,204	37,701	57,527	3.87	212,356	42,065	60,901	3.12	177,529

Table 7. Cont.

	Mallard				Blue-winged teal				Other ducks (exc. scaup)		
Year	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI
% change from 2014	-15%	-6%	-20%	-32%	5%	58%	66%	136%	-10%	44%	29%
10-year average	4%	-20%	-17%	-4%	-16%	32%	14%	45%	-23%	3%	-17%
Long-term average	-8%	-3%	-10%	-1%	-42%	30%	-21%	35%	-24%	3%	-16%

Table 8. Scaup, total ducks (excluding scaup), total ducks, and Canada goose populations in Minnesota, 1968-2015.

	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

Table 8. Cont.

	Scaup			Total Ducks (exc. scaup)		Total ducks		Canada geese		
Year	Unad. PI	VCF	PI	Unad. PI	PI	Unad. PI	PI	Unad. PI	VCF	PI
1991	40,727	2.81	114,480	313,595	753,710	354,322	868,191	42,231	4.18	176,465
1992	66,071	2.33	153,939	347,012	973,323	413,083	1,127,262	33,965	2.43	82,486
1993	11,801	3.28	38,750	271,053	837,172	282,854	875,921	43,858	2.08	91,369
1994	57,670	3.55	204,536	294,477	1,115,558	352,147	1,320,095	48,595	1.68	77,878
1995	28,421	4.05	115,096	256,390	797,144	284,811	912,241	58,065	2.08	120,775
1996	65,585	2.64	173,351	318,619	889,057	384,204	1,062,408	60,870	3.92	238,708
1997	31,138	2.72	84,834	282,220	868,137	313,358	952,971	60,449	2.59	156,817
1998	28,416	1.64	46,528	328,238	693,084	356,654	739,612	79,147	1.75	138,507
1999	14,041	2.49	35,002	285,778	680,463	299,819	715,465	80,012	3.35	268,168
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

Table 8. Cont.

	Scaup			Total Ducks (exc. scaup)		Total ducks		Canada geese		
Year	Unad. PI	VCF	PI	Unad. PI	PI	Unad. PI	PI	Unad. PI	VCF	PI
2014	6,517	2.24	14,614	195,006	474,387	201,523	489,001	63,857	1.57	100,255
2015	10,870	3.23	35,062	174,645	524,174	185,515	559,236	90,887	1.77	160,427
Averages:										
10-year	7,739	3.13	24,051	191,217	576,654	198,922	600,705	76,715	2.10	159,312
Long-term	20,798	3.12	61,305	221,099	618,240	241,890	679,545	47,449	2.31	160,994
% change from 2014	67%	44%	140%	-10%	10%	-8%	14%	42%	13%	60%
10-year average	40%	3%	46%	-9%	-9%	-7%	-7%	18%	-16%	1%
Long-term average	-48%	3%	-43%	-21%	-15%	-23%	-18%	92%	-24%	0%

Appendix A. Temperature and precipitation at selected cities in, or adjacent to, Minnesota May Waterfowl Survey Strata, 3 May - 31 May 2015 (Source: Minnesota Climatological Working Group, http://climate.umn.edu/cawap/nwssum/nwssum.asp).

		Temperature (F) for week ending:										Total weekly precipitation (inches)				
		3-May		10-May		17-May		24-May		31-May						
Region	City	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	3-May	10-May	17-May	24-May	31-May
NW	Crookston	56.2	7.0	52.7	0.7	48.1	-6.4	49.4	-7.5	58.5	-0.8	0.15	0.12	1.80	0.38	0.31
	Itasca	52.0	5.8	51.1	2.0	44.9	-6.6	m	m	m	m	0.24	0.60	3.15	m	m
NC	Grand Rapids	54.8	6.1	49.9	-1.5	47.5	-6.2	51.2	-4.7	56.8	-1.2	0.05	1.33	2.67	0.14	1.90
	Park Rapids	56.4	8.1	51.3	0.3	51.1	-2.2	52.7	-2.6	58.6	1.3	0.21	1.32	3.62	0.21	1.94
WC	Montevideo	54.7	3.0	55.2	0.6	53.2	-3.9	52.4	-7.0	61.3	-0.4	0.11	0.97	4.81	0.72	1.28
	Morris	56.6	5.6	55.3	1.5	51.1	-5.1	51.9	-6.7	60.8	-0.1	0.14	0.31	5.24	1.03	1.04
C	Willmar	m	m	m	m	m	m	m	m	m	m	0.24	0.57	2.43	0.55	0.53
	St. Cloud	54.7	3.4	54.9	1.1	53.2	-2.8	51.2	-6.8	59.1	-0.9	0.06	1.67	3.45	0.52	0.33
EC	Aitkin	51.1	2.8	51.4	0.8	50.0	-2.9	51.1	-3.8	m	m	0.10	0.79	1.81	0.63	m
	Msp Airport	59.3	5.2	60.4	4.0	56.4	-2.2	55.1	-5.6	62.8	0.1	0.06	1.11	0.57	0.52	1.29
SW	Marshall	59.5	7.0	58.2	2.9	55.5	-2.3	55.1	-5.0	62.3	-0.1	0.00	0.60	1.83	0.09	0.80
	Worthington	54.6	3.2	56.1	1.9	53.5	-3.3	52.0	-7.2	60.1	-1.4	0.07	0.95	1.38	0.47	2.34
SC	Waseca	55.4	2.6	60.1	4.6	55.3	-2.8	53.5	-7.0	62.7	-0.1	0.10	0.49	1.18	0.87	2.11
	New Ulm	53.8	m	57.6	m	54.3	m	51.9	m	61.2	m	0.31	1.00	2.20	0.38	1.59
Statewide		54.5	4.0	55.5	2.3	51.5	-4.0	52.2	-5.6	59.9	0.0	0.09	0.89	1.97	0.52	0.79

[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, 2015 by Joshua Dooley, 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/birds/surveys-and-data/reports-and-publications.php).

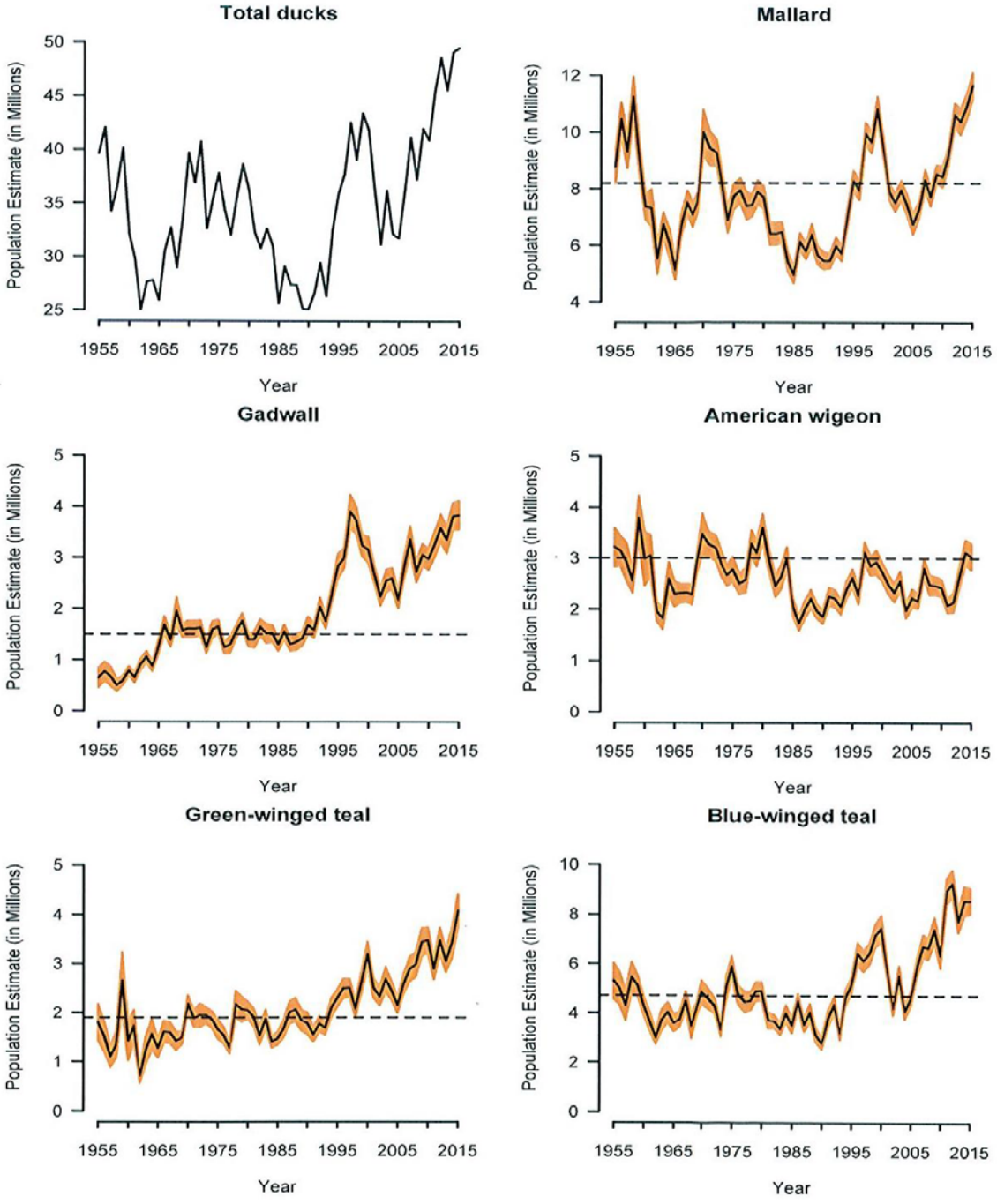

Figure 1 Estimates of North American breeding populations, 90% confidence intervals, and North American Waterfowl Management Plan population goal (dashed line) for selected species and number of water areas in May in Prairie Canada and Northcentral U.S (from: U.S. Fish and Wildlife Service 2015).

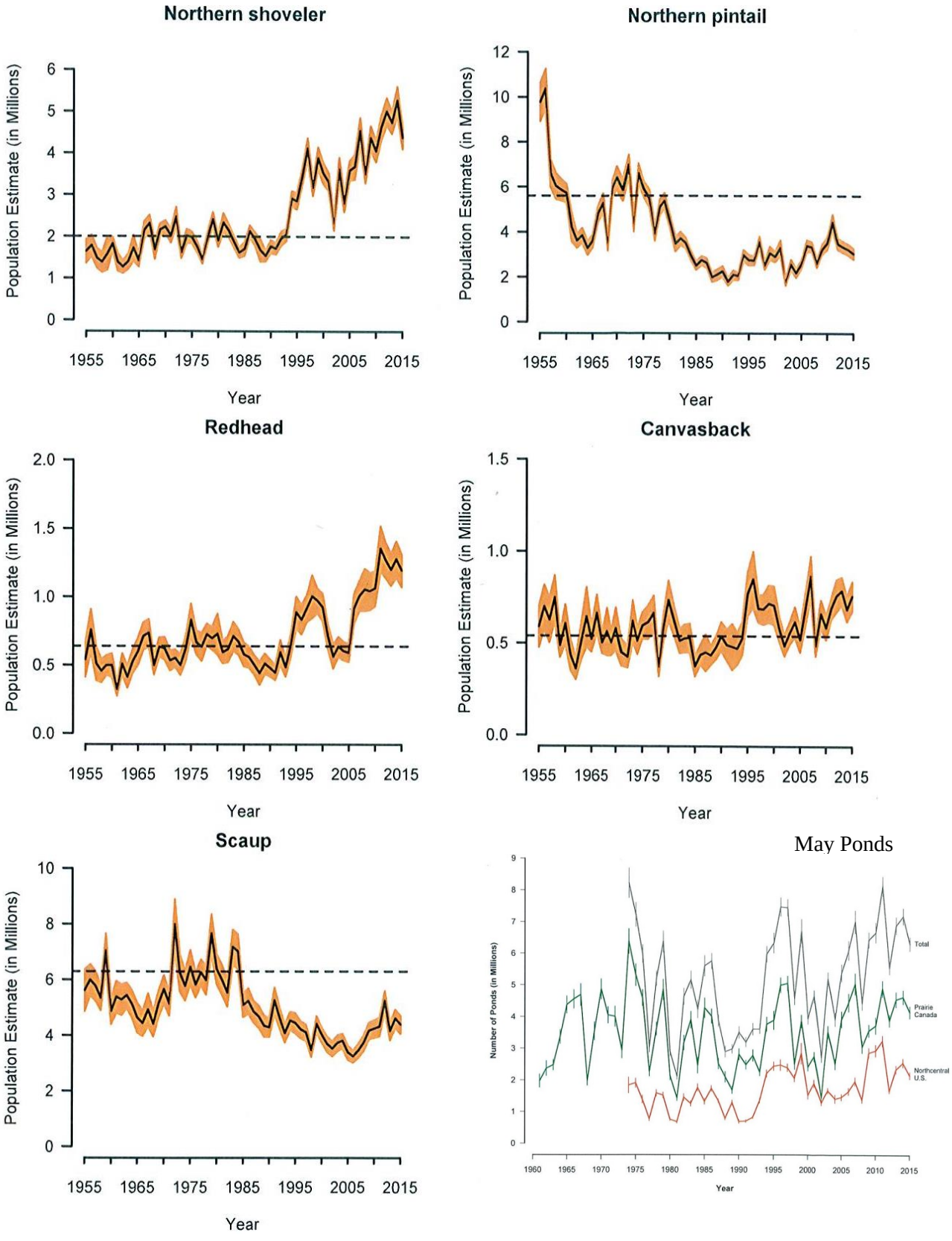

Figure 1 (continued).

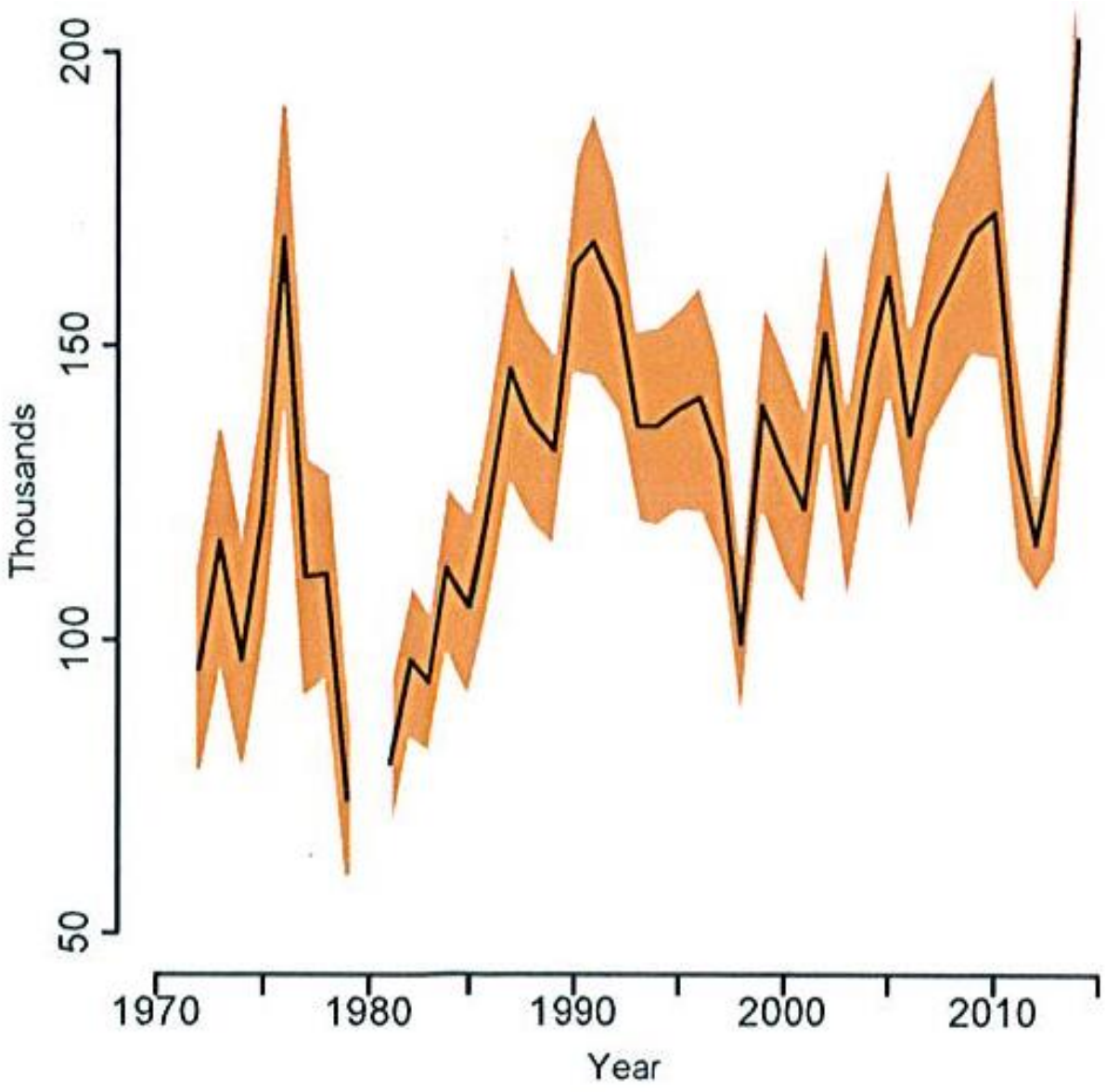

Figure 2. Estimated numbers (and 95% confidence intervals) of Eastern Prairie Population (indicated pairs) Canada geese. (from: U.S. Fish and Wildlife Service 2015).

2015 MINNESOTA SPRING CANADA GOOSE SURVEY

Rebecca Peak, Wetland Wildlife Populations and Research Group

INTRODUCTION

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

METHODS

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

From 2002–2007, they used a double sampling design. First, Maxson (2002) randomly selected 900 plots within each ecoregion, which yielded a sampling frame of 2,700 total plots (Table 1). Maxson (2002) used National Wetland Inventory Circular 39 data and DNR 1:24000 lakes GIS layers to stratify plots by habitat quality using the following classification variables: 1) total acres of type 3, 4, and 5 wetlands; 2) total acres of type 3 wetlands; total acres of 1:24000 lakes and; 4) total acres of riverine habitat. This sampling design yielded 9 strata (Table 1) defined by the expected number of pairs of resident Canada geese: 1) no nesting habitat – expect no geese, 2) limited nesting habitat – habitat capable of supporting 1 or 2 pairs of geese, 3) prime nesting habitat – habitat capable of supporting 3 or more pairs. They did not survey plots in the "0 pairs" strata and the Forest ecoregion ≥3 pairs habitat-quality stratum did not contain any plots (Table 1). They implemented the second part of the double sampling design by randomly selecting 30 plots from the remaining 5 strata to survey each season, for a sample size of 150 plots.

Rave (2008) eliminated the double sampling design and randomly selected 30 plots per strata from the entire sampling frame excluding the "0" pairs strata (n = 128,031 plots; Table 1). He also excluded Lake of the Woods and the Northwest Angle from the Forest ecoregion. They used the same stratification criteria and field protocols to survey resident Canada geese for all years. Thus, results should be comparable among years.

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

Ideally, we fly the survey plots during mid-incubation. Pilot Tom Pfingsten and I conducted the survey on 8 days between 20–29 April 2015, which are the average start and end dates for the past fourteen years. We recorded Canada geese seen within plot boundaries as singles, pairs, or groups. We also recorded whether singles and pairs were observed with a nest. To calculate total number of resident Canada geese, we doubled the number of singles and pairs.

RESULTS AND DISCUSSION

The analysis yielded a population estimate (± 95% CI) of 249,988 (± 61,291) resident Canada geese for the sampling frame. The 2015 resident Canada goose population estimate was comparable to estimates calculated for 2013 and 2014 (Table 2). Relative error (95% CI half-width) was 24.5% of the estimate. The large annual confidence intervals do not indicate differences between any years, but a general pattern indicates an increase in population size from 2001 to 2006 and then again from 2007 to 2012, with population declines in 2007 and 2013 (Figure 2). The population has been generally stable at a lower level the last 3 years. Canada goose population estimates were similar to 2014 in all 3 Ecoregions (Table 2).

The 2015 population estimate (± 95% CI) in the proposed Intensive Harvest Zone (Fig. 1) was 79,945 (±22,032). This was similar to the estimates (± 95% CI) from 2011-2014 for this zone: 151,669 (+105,319), 127,220 (+64,628), 79,701 (+24,619), and 93,600 (±54,300), respectively. An estimated 32% of these geese were associated with the Intensive Goose Hunting zone in 2015, compared to 43, 31, 32, and 38% from 2011-2014.

We added 17,500 geese for the Twin Cities metro area (Cooper 2004), which yielded a statewide population estimate of 267,488 resident Canada geese (Table 2). The 2015 statewide population estimate represents the fifteenth consecutive year that this estimate has been above the state Canada goose population goal of 250,000 resident Canada geese.

Of the total number of Canada geese we detected, 38.5% were singles, 56.4% pairs, and 5.1% groups (Table 3). We combined singles and pairs associated with nests to develop an index to nesting effort and used it to calculate a productivity estimate of 41.6% (Table 3). The proportion of productive Canada geese for 2015 was comparable to the estimates for 2013 and 2014 (Table 3). Weather conditions throughout May and June were important factors affecting Canada goose productivity.

Mean ambient temperature in Minnesota during April 2015 was 54.2° F, which was 3.4° F above the century average (National Oceanic and Atmospheric Administration 2015). Median lake ice-out date for 2015 was 12 April (17 March–30 April, n = 100), which was 6 days earlier than median lake ice-out date previously recorded across the state (median = 18 April, 29 March–12 May, n = 100) (Minnesota Department of Natural Resources 2015). Our goal was to survey plots during mid-incubation. The above average temperature and early lake ice out suggests many pairs should have been in the incubation stage of the nesting cycle when we conducted the survey.

ACKNOWLEDGMENTS

Chris Scharenbroich assisted in randomly selecting plots and provided GPS coordinates of plots to the pilot. Tom Pfingsten piloted the helicopter and served as the second observer. Dave Rave provided guidance on conducting surveys and historical context for the surveys. John Giudice provided statistical support. John Giudice, Jeff Lawrence, and Dave Rave reviewed an earlier version of this report. This project was funded in part by the Wildlife Restoration (Pittman-Robertson) Program.

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Table 1. Sampling frames used to conduct spring Canada goose surveys in Minnesota from 2001–2007 (*n* = 2,700 plots) and 2008–2015 (*n* = 304,929 plots). Ecoregion is the combination of provinces across the state. Strata are determined by type and acres (ac) of wetlands and rivers per quarter section plot.

Ecoregion	Strata	National Wetland Inventory Data	*N* plots in sample frame by period	
			2001–2007[a]	2008–2015[b,c]
Prairie	0 pairs	Type 3, 4, and 5 wetlands <0.5 ac and rivers <10.0 ac all water	476	61,597
	1–2 pairs	Type 4 and 5 wetlands >0.5 ac but type 3 <15.0 ac or type 3, 4, and 5 <0.5 ac and rivers >10.0 ac all water	344	30,751
	≥3 pairs	Type 3 >15.0 ac but plot not all water	80	9,533
Transition	0 pairs	Type 3, 4, and 5 wetlands <1.0 ac and rivers <8.0 ac or plot all water	377	39,484
	1–2 pairs	Type 3, 4, and 5 wetlands 1.0–25.0 ac or >25.0 ac, but type 3 <15.0 ac or type 3, 4, and 5 <1.0 ac and rivers >8.0 ac	428	29,048
	≥3 pairs	Type 3, 4, and 5 wetlands >25.0 ac, but type 3 >15.0 ac and plot not all water	95	8,015
Forest	0 pairs	Type 3, 4, and 5 wetlands <2.0 ac and rivers <2.0 ac or plot all water	510	75,835
	1–2 pairs	Type 3, 4, and 5 wetlands >2.0 ac but plot not all water or type 3, 4, and 5 <2.0 ac and rivers >2.0 ac	390	50,666
	≥3 pairs	None	0	0
Total			2,700	304,929

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

[b]-The entire sampling frame was re-stratified in 2008 and Lake of the Woods and the NW Angle were removed from the sampling frame. The sampling frame was adjusted slightly in 2009 because of some processing errors in 2008. The population estimates for 2008–2015 are based on the updated sampling frame.

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

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

	N geese by ecoregion						
Year	Prairie	Transition	Forest	Combined	95% CI	Metro	Statewide
2001	77,360	95,470	92,390	265,220	69,500	20,000	285,220
2002	135,850	144,900	33,940	314,690	134,286	20,000	334,690
2003	106,520	121,290	56,420	284,230	78,428	20,000	304,230
2004	128,501	130,609	95,636	354,747	107,303	20,000	374,747
2005	113,939	149,286	57,529	320,754	90,541	17,500	338,254
2006	126,042	164,085	67,994	358,071	108,436	17,500	375,571
2007	137,151	99,274	25,509	261,933	80,167	17,500	279,433
2008	113,483	127,490	30,400	271,372	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
2015	97,847	114,986	37,156	249,988	61,291	17,500	267,488

Table 3. Percent of singles, pairs, groups, and an index to nesting effort (i.e. productive Canada geese) on the Minnesota spring Canada goose survey, 2001–2015.

Year	Singles[a]	Pairs[a]	Groups	Productive Canada geese[b]	Survey period
2001	27.0	63.9	9.1	36.4	4/14 to 5/02/2001
2002	30.7	52.0	17.2	41.5	4/26 to 5/11/2002
2003	27.9	58.2	13.9	29.3	4/22 to 5/01/2003
2004	26.5	57.5	16.0	35.5	4/22 to 5/04/2004
2005	33.0	50.2	16.8	40.7	4/20 to 5/03/2005
2006	43.5	45.9	10.6	50.3	4/24 to 5/05/2006
2007	31.0	51.5	17.5	36.2	4/23 to 4/28/2007
2008	38.4	55.4	6.2	42.6	4/23 to 5/05/2008
2009	41.8	50.7	7.5	45.2	4/21 to 5/01/2009
2010	42.5	48.2	9.3	46.6	4/15 to 4/20/2010
2011	50.3	47.2	2.6	55.7	4/21 to 4/29/2011
2012	30.0	49.6	20.4	35.1	4/16 to 4/23/2012
2013	27.0	68.0	5.0	30.0	5/06 to 5/14/2013
2014	39.3	55.1	5.6	44.0	4/21 to 5/04/2014
2015	38.5	56.4	5.1	41.6	4/20 to 4/29/2015

[a] Singles and pairs were doubled before calculating proportions
[b] Productive Canada geese = singles + pairs with nests

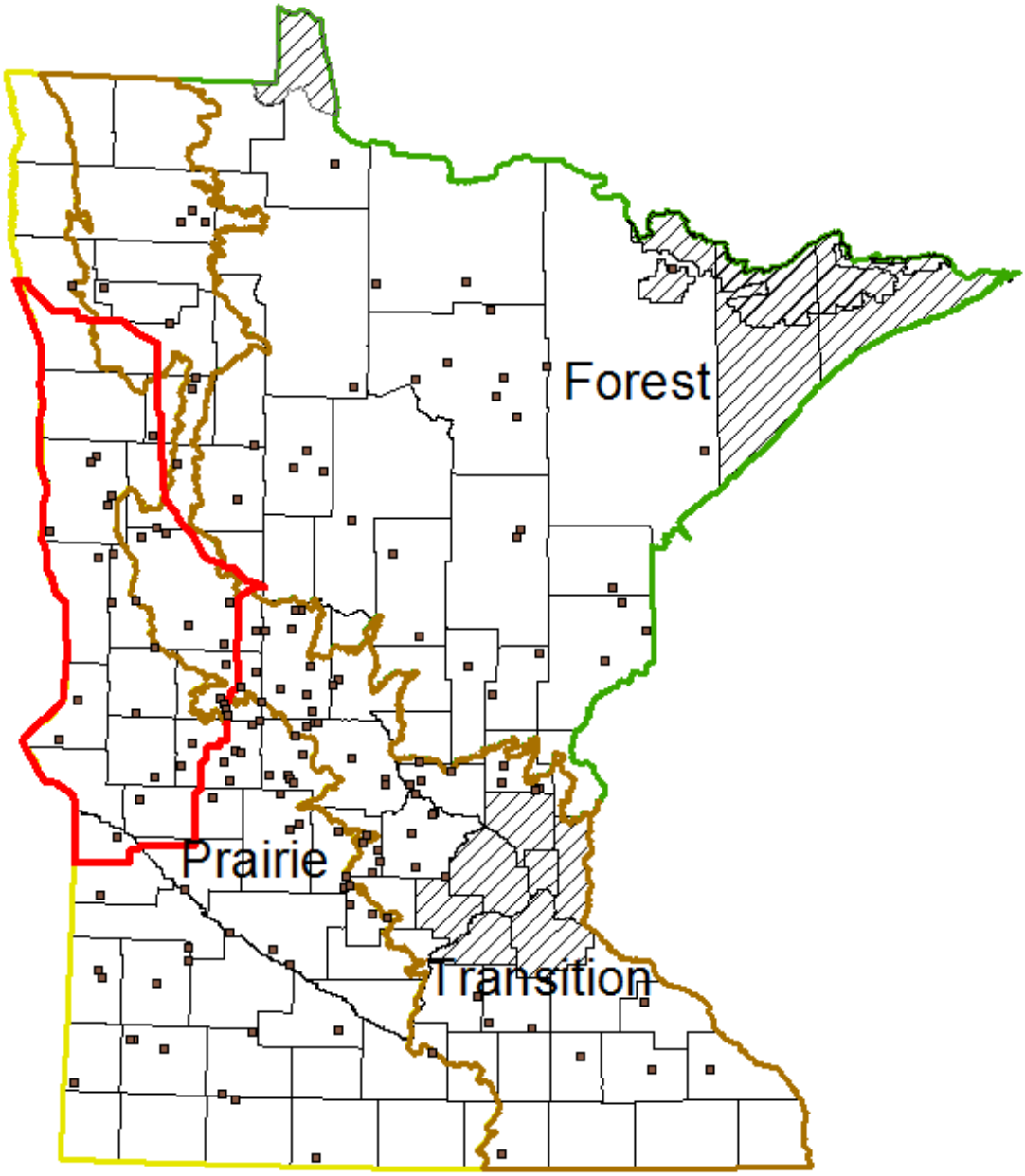

Figure 1. Location of 160 quarter section plots surveyed during the 2015 spring Canada goose survey. Plots are distributed among the Prairie, Transition, and Forest ecoregions. Cross-hatched areas were not included in the survey. The polygon delineated in red designates the location of the proposed Intensive Canada goose hunting zone in 2011.

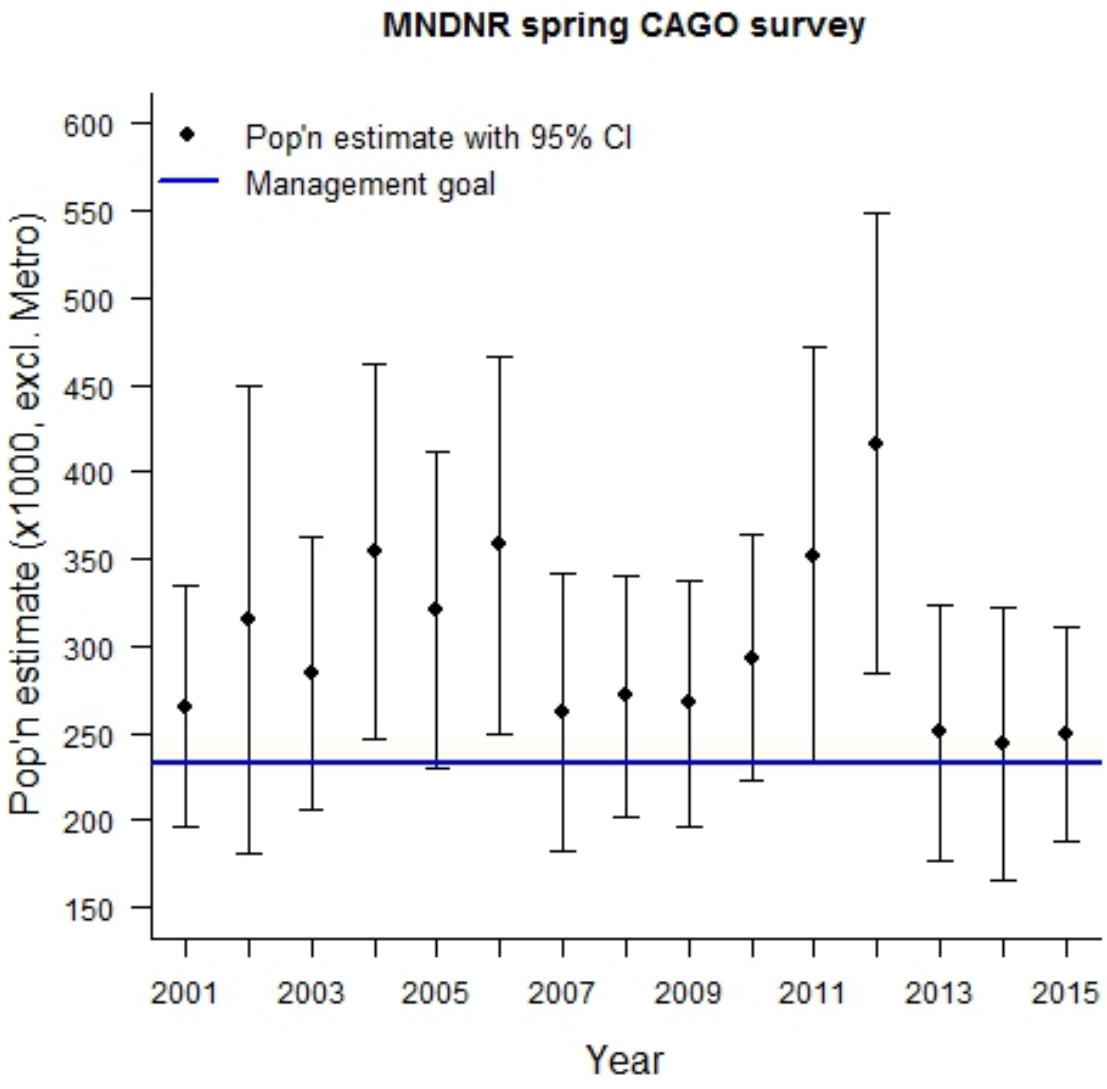

Figure 2. Resident Canada goose population estimates (± 95% CI) in Minnesota (excluding Metro), 2001–2015. The management goal is 250,000 Canada geese (250,000 – 17,500 Metro geese = 232,500).

Mourning dove information is taken from the U.S. Fish and Wildlife Service report by Seamans, M.E. 2015. Mourning dove population status, 2015. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 22 pp. The entire report is available on the Division of Migratory Bird Management web site

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

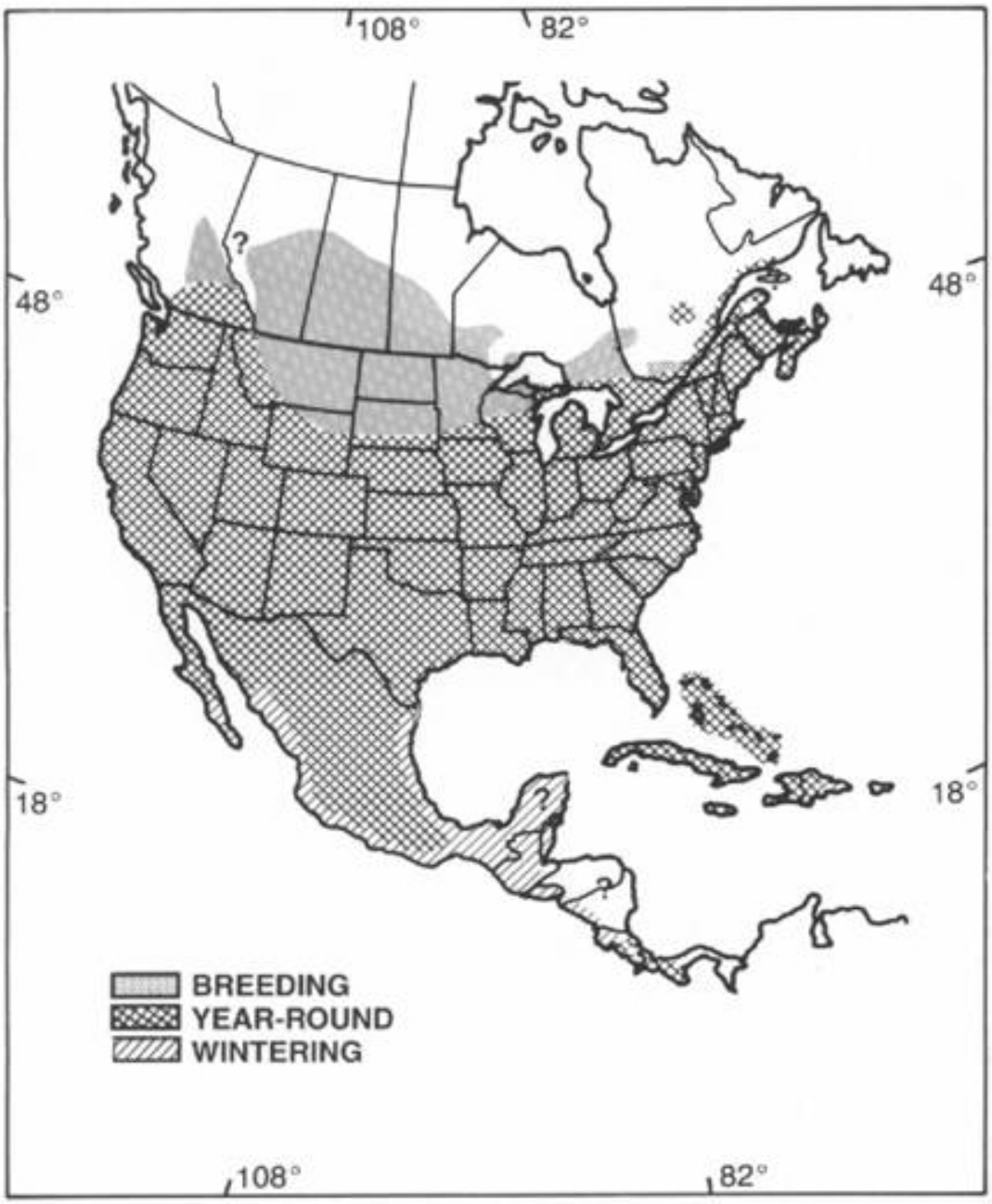

Figure 1. Breeding and wintering ranges of the mourning dove (adapted from Mirarchi and Baskett 1994). (From: Seamans, M.E. 2015. Mourning dove population status, 2015. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 22 pp.)

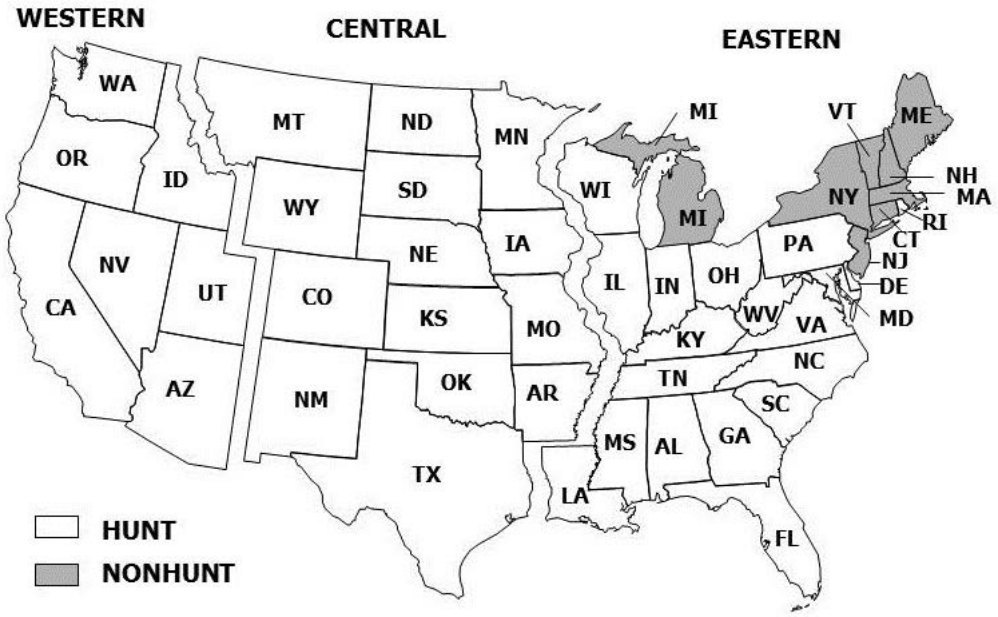

Figure 2. Mourning dove management units with 2014 hunting and non-hunting states. (From: Seamans, M.E. 2015. Mourning dove population status, 2015. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 22 pp.)

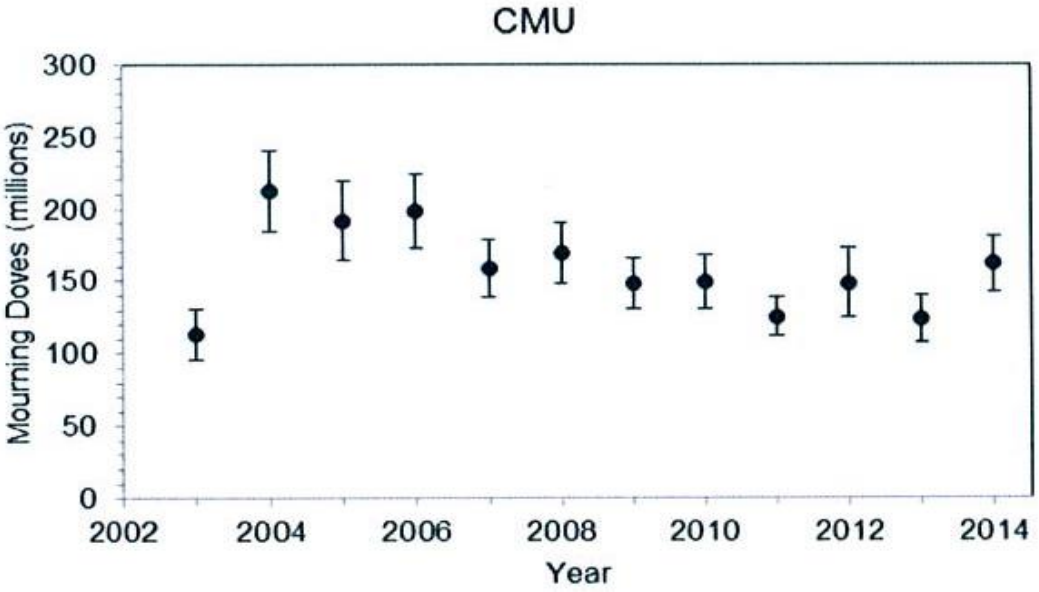

Figure 3. Estimates and 95% confidence intervals of mourning dove absolute abundance in the Central Management Unit (CMU), 2003-14. Estimates based on band recovery and harvest data. (From: Seamans, M.E. 2015. Mourning dove population status, 2015. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 22 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 2012, 2013 and 2014 seasons [a]. (From: Seamans, M.E. 2015. Mourning dove population status, 2015. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 22 pp.)

Management unit / State	Active Hunters			Hunter Days Afield			Total Harvest		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
CENTRAL	338,700 †	353,000 †	427,100 †	1,108,700 ±11	1,185,300±10	1,333,600 ± 9	6,361,600 ±14	6,236,000 ±11	7,654,700 ±10
AR	21,400 ±22	8,900 ±42	19,900 ±21	57,600 ±26	30,100 ±57	47,900 ±28	494,200 ±30	155,900 ±46	347,900 ±29
CO	17,000 ±18	15,600 ±15	14,400 ±14	43,800 ±26	36,900 ±19	27,800 ±16	204,300 ±26	176,900 ±25	173,100 ±19
IA	†[b]	12,900 ±9	9,200 ±9	†[b]	49,400 ±14	27,100 ±12	†[b]	214, 300 ±16	130,000 ±13
KS	12,200 ±39	31,900 ±12	26,200 ±10	49,100 ±52	93,000 ±16	70,700 ±14	244,800 ±62	504,400 ±18	485,300 ±18
MN	6,800 ±52	7,700 ±53	6,900 ±51	21,600 ±48	17,000 ±39	20,200 ±59	65,400 ±75	53,500 ±30	54,800 ±29
MO	23,800 ±29	36,400 ±11	24,100 ±12	51,400 ±50	104,500 ±18	62,200 ±15	296,600 ±81	587,600 ±28	374,000 ±17
MT	200 ±87	1,700 ±46	1,400 ±42	500 ±120	2,900 ±41	2,900 ±41	2,600 ±161	12,000 ± 41	8,500 ±37
NE	13,200 ±17	13,500 ±16	9,700 ±12	39,000 ±17	39,300 ±19	26,700 ±13	223,400 ±20	239,800 ±24	172,900 ±15
NM	9,000 ±11	6,500 ±9	7,600 ±10	38,000 ±17	23,700 ±13	24,100 ±15	160,100 ±17	123,000 ±15	115,200 ±15
ND	4,900 ±30	6,300 ±28	3,900 ±25	17,400 ±36	16,400 ±29	11,900 ±30	78,900 ±37	88,200 ±37	47,600 ±23
OK	15,700 ±14	23,300 ±13	19,100 ±13	49,200 ±19	69,400 ±24	56,900 ±24	349,700 ±26	421,200 ±25	417,900 ±21
SD	4,500 ±22	6,200 ±22	6,400 ±21	14,700 ±28	17,500 ±26	17,500 ±24	65,500 ±28	118,300 ±31	106,800 ±25
TX	207,200 ±13	178,900 ±13	276,800 ±10	720,200 ±16	677,900 ±16	934,300 ±13	4,150,800 ±20	3,506,700 ±18	5,199,400 ±14
WY	2,700 ±32	3,100 ±19	1,500 ±26	6,300 ±38	7,200 ±19	3,400 ±23	25,300 ±40	34,200 ±19	21,100 ±25

[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, 2015. 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).

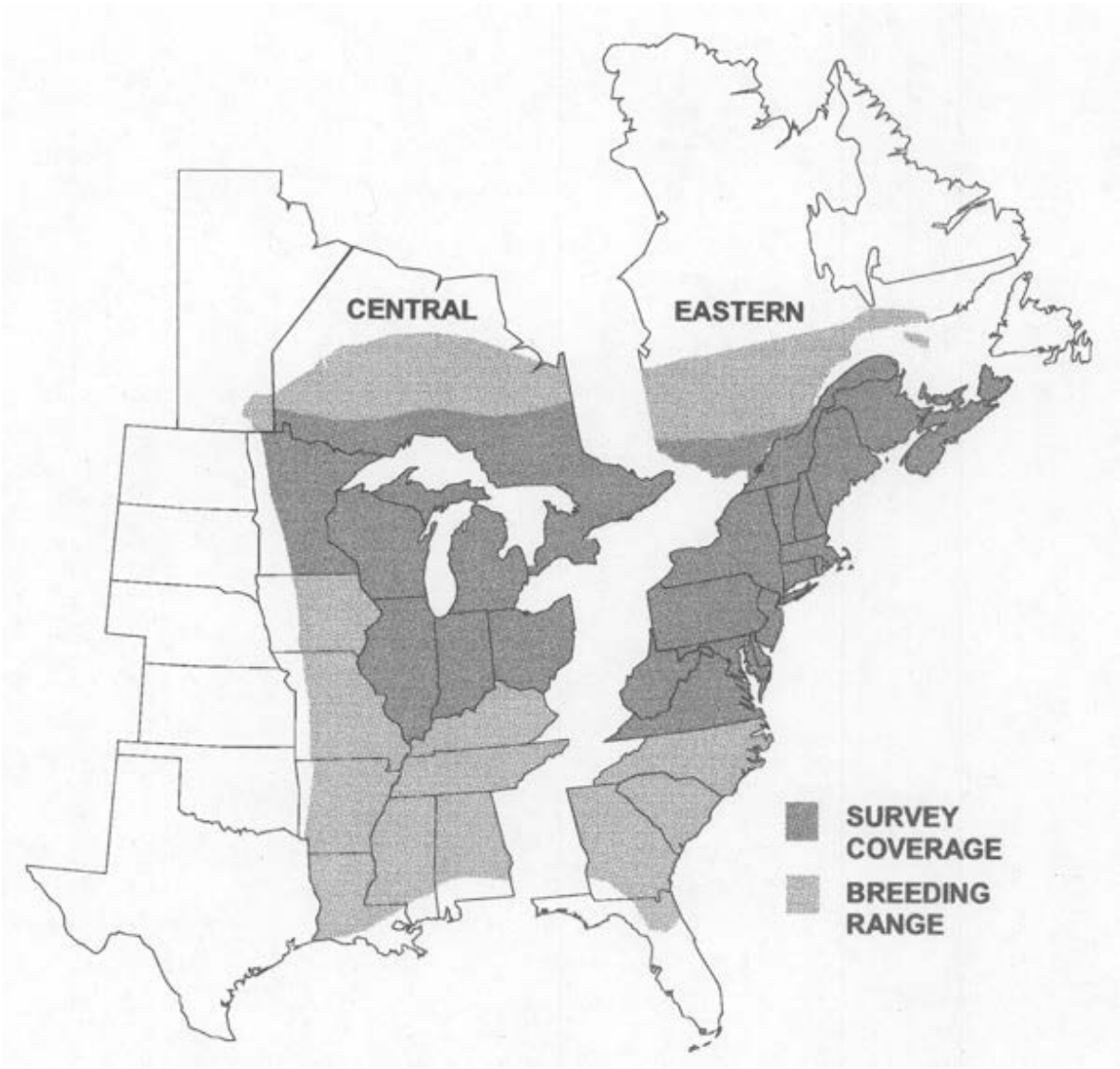

Figure 1. Woodcock management regions, breeding range, singing-ground survey coverage, (from: Cooper, T.R. and R.D. Rau. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Table 1. Short term (2014 – 15), 10 –year (2005-2015), and long-term (1968-2015) 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. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Management Unit/State	Number of Routes[b]	n[c]	2014-15			2005-15			1968-15		
			% Change	95% CI[d] lower	upper	% Change	95% CI[d] lower	upper	% Change	95% CI[d] lower	upper
CENTRAL	440	735	6.32	-1.29	14.66	- 0.72	-1.54	0.11	- 0.71	-0.95	-0.47
IL	13	46	79.98	-44.49	577.55	3.16	- 7.62	16.21	0.27	-2.45	3.43
IN	18	61	- 6.78	-47.11	56.86	- 4.74	-10.26	0.09	- 4.19	-5.47	-3.00
MB[e]	23	30	14.79	-12.71	55.89	0.33	- 3.00	3.77	0.11	-1.51	1.94
MI	109	153	-0.86	-12.91	12.89	- 0.25	- 1.65	1.17	- 0.69	-1.07	-0.31
MN	75	121	28.12	8.39	51.50	0.53	- 1.17	2.31	0.40	-0.20	1.03
OH	41	73	8.98	-15.76	45.27	- 0.80	- 3.62	2.25	- 1.25	-2.00	-0.47
ON	80	160	-3.98	-17.55	11.63	- 2.25	- 4.02	-0.50	- 0.95	-1.42	-0.46
WI	81	121	16.65	-2.21	39.02	- 0.21	- 2.07	1.68	- 0.34	-0.85	0.19

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

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

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

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

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

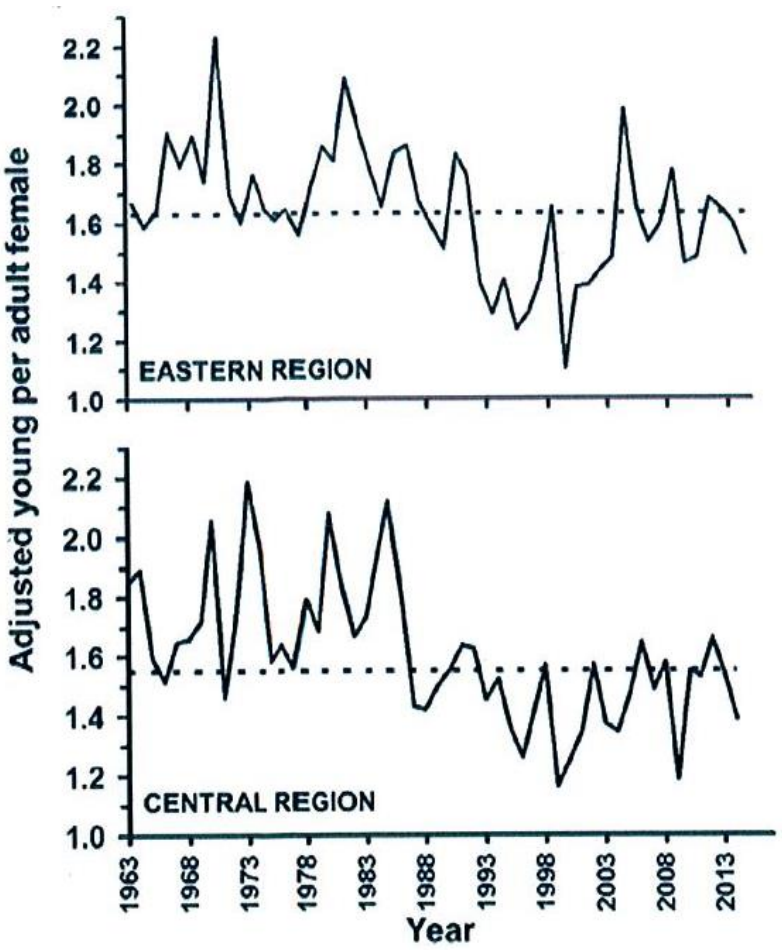

Figure 2. Weighted annual indices of American woodcock recruitment, 1963-2014. Dashed line is the 1963-2013 average. (from: Cooper, T.R. and R.D. Rau. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

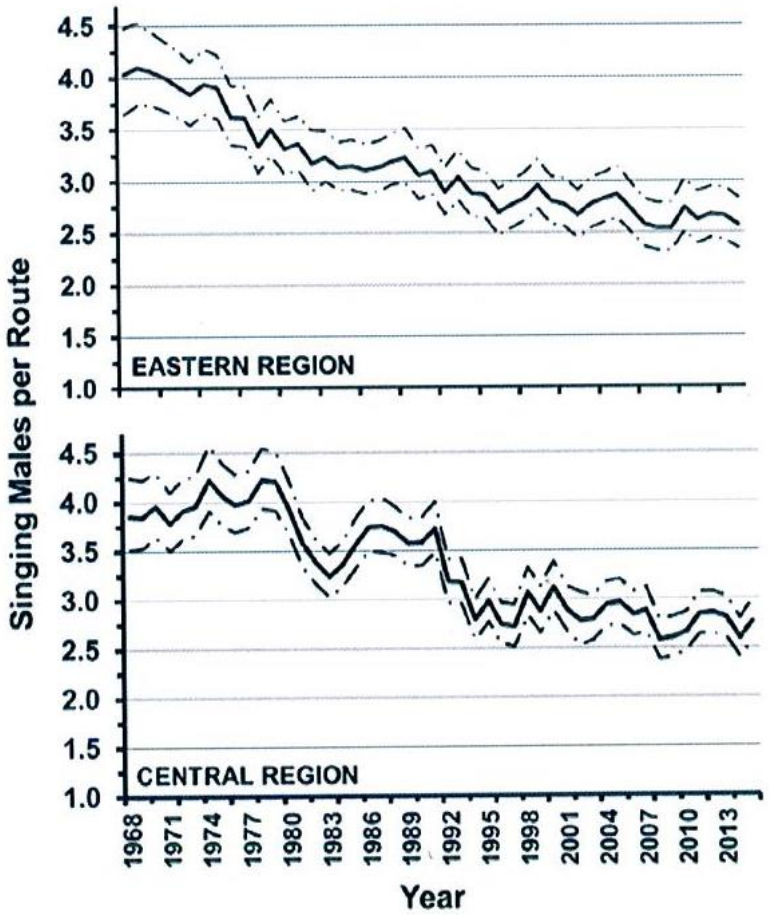

Figure 3. Annual indices of the number of woodcock heard on the Singing-ground Survey, 1968-2015. The dashed lines represent the 95th percentile credible interval. (from: Cooper, T.R. and R.D. Rau. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Table 2. Preliminary estimates of woodcock hunter numbers, days afield, and harvest for selected states, from the 2011-12, 2012-13, 2013-14 and 2014-15 Harvest Information Program surveys. (from: Cooper, T.R. and R.D. Rau. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Management Unit / State	Active woodcock hunters ([a])				Days afield ([a, c])				Harvest ([a, c])			
	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15
Central Region	n.a. [b]	n.a. [b]	n.a. [b]	n.a. [b]	350,500 ± 16	276,900 ± 16	306,100 ± 20	227,600 ±13.6	231,700 ± 20	193,100 ± 23	180,600 ± 20	141,500 ± 23
IL	2,900 ± 108	900 ± 175	1,600 ± 128	800 ± 169	8,800 ± 131	3,500 ± 172	3,400 ± 119	2,600 ± 162	3,700 ± 195	1,900 ± 160	1,000 ± 142	300 ± 132
IN	1,100 ± 79	400 ± 119	700 ± 77	300 ± 99.7	4,100 ± 86	1,500 ± 122	1,600 ± 58	900 ± 88.1	1,800 ± 102	600 ± 84	1,400 ± 84	700 ± 43
MI	28,400 ± 15	25,700 ± 17	30,000 ± 19	19,400 ± 21.1	144,000 ± 18	121,400 ± 22	123,700 ± 24	87,500 ± 19.1	106,900 ± 28	74,100 ± 28	79,300 ± 28	53,500 ± 29
MN	17,000 ± 29	11,200 ± 36	10,900 ± 37	13,500 ±33.5	76,900 ± 46	40,400 ± 34	74,700 ± 62	47,500 ± 31.8	44,200 ± 42	31,000 ± 59	18,600 ± 57	23,900 ± 45
OH	3,100 ± 98	600 ± 115	3,000 ± 63	1,600 ± 85.4	10,200 ± 96	2,600 ± 83	8,600 ± 64	4,500 ± 94.2	2,300 ± 74	1,500 ± 80	8,600 ± 85	300 ± 90
WI	15,200 ±25	13,700 ± 28	14,500 ± 27	16,200 ± 25	69,000 ± 30	58,000 ± 33	60,000 ± 31	66,400 ± 26.9	42,600 ± 31	40,400 ± 37	38,400 ± 24	49,300 ± 45

[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.

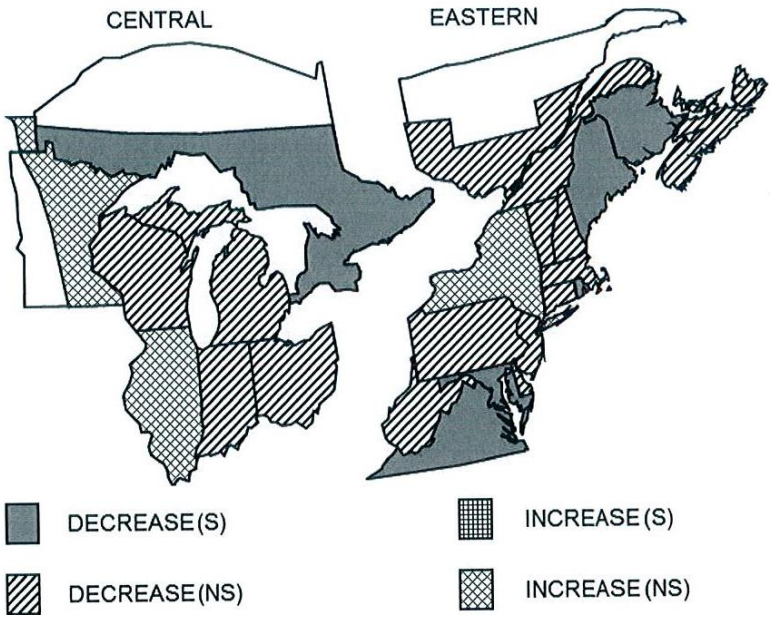

Figure 4. Ten-year trends in number of American woodcock heard on the Singing-ground Survey; 2005-15, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Cooper, T.R. and R.D. Rau. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

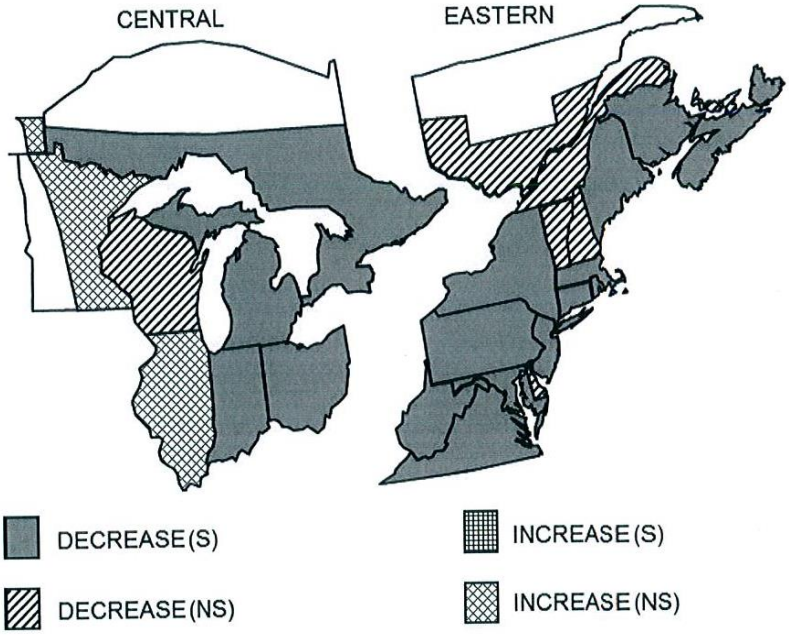

Figure 5. Long-term trends in number of American woodcock heard on the Singing-ground Survey; 1968-2015, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Cooper, T.R. and R.D. Rau. 2015. American woodcock population status, 2015. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

2015 NORTHWEST MINNESOTA SANDHILL CRANE BREEDING GROUND SURVEY

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SUMMARY

We conducted an annual sandhill crane (SACR, *Grus canadensis*) breeding population survey in northwest Minnesota during 2012-2015. After the first year of the survey, we excluded the portion of the Red River Prairie Ecological Classification System (ECS) Subsection from the survey area due to low crane numbers in the agricultural landscape. We used 4 km^2 plots as the primary sampling unit. In 2015, we used a split-panel design and surveyed 129 plots: 69 plots that we surveyed in 2012 were revisited and a spatially balanced sample of 60 new plots selected using a generalized random-tessellation stratified (GRTS) design. We surveyed each sample plot once during May using a 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, and 4,845 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 4 years (2012-2015). Habitat conditions were different with dry conditions in 2012 and wet conditions in 2013-2015. Survey conditions were very dry at the beginning of the survey in 2013 and 2015, but major precipitation events resulted in wet conditions for the majority of the survey. We believe that timing of the survey and arrival of nonbreeding cranes on the breeding grounds may have influenced the counts in 2014 and 2015.

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 2012-2015, present population estimates for the 4 years, and discuss future survey plans.

STUDY AREA

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

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

METHODS

Sampling frame

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

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

Sampling design

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

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

- Stratum 1 (NLCD-1): > median amount of nesting habitat,
- Stratum 2 (NLCD-2): 0 < m2 of nesting habitat < median,
- Stratum 3 (NLCD-3): nesting habitat = 0 but other SACR habitat > 0, or

- Stratum 4 (NLCD-4): no SACR habitat.

We selected 60 plots from Stratum 1 and 2 combined and 30 plots from Stratum 3. We assumed that SACR density in the NLCD4 stratum was very low (approaching zero) and did not sample Stratum 4. We also surveyed a 100 km^2 plot (25 plots) generally overlaying Espelie Township to better understand distribution of cranes within good nesting habitat.

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

In 2015, we modified the sampling design to provide a more powerful measure of change. Specifically, we employed a split-panel sampling design (Warren 1994, Urquhart and Kincaid 1999) that consisted of 69 "revisit" plots and 60 "new" plots (Figure 3). Revisit plots were originally selected and surveyed in 2012, and consisted of 58 stratum 1-2 plots, 6 stratum 3 plots, and 5 randomly-selected plots of the original 25 Espelie Township plots. The "new" plots were drawn from the remaining 2,884 stratum 1, 2, and 3 plots in the reduced sampling frame using a spatially balanced simple random sampling design. We treated the 2 panels as strata, with inclusion probabilities = 1 for plots in the revisit stratum, and used the GRTS design-based estimator (Kincaid and Olsen 2013) to compute sampling statistics and estimates of population size. We also used a mixed-model framework to generate model-assisted estimates of total and breeding SACR abundance during 2012 to 2015. We used plot counts as our response variable and the model contained fixed effects for strata and random effects for year and plot. We fit the model using the lme4 package (Bates et al. 2014) in R (R Core Team 2014). We weighted the predicted mean count for each stratum and year by stratum weights and multiplied by N (sampling frame size) to obtain model-assisted population estimates. We used a bootstrap procedure to obtain confidence intervals for the model-assisted population estimates. More specifically, we bootstrapped 200 sample datasets using with-replacement sampling of plots from each stratum and year, and then refit our mixed model to each bootstrap dataset to generate 200 population estimates for each year and target population (total and breeding SACR). We used the distribution of bootstrapped population estimates to compute percentile confidence intervals (90% CI). Because we only had 2 years (2012 and 2015) where our sample of revisit plots were surveyed, we did not attempt to include a slope parameter for year in our mixed model (i.e., to quantify the population trend). Instead, we treated revisit plots as a paired sample and compared mean change in plot counts and naïve occupancy between 2012 and 2015, which correspond to the first and last years in our time series.

Target population(s)

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

1. *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.

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] helicopter 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. In 2015, we used DNRSurvey ver. 2.11, an ArcGIS addin developed by Minnesota DNR Wildlife and MN.IT Services GIS staff.

RESULTS

Survey effort

The 2015 survey was conducted on 5 days (5, 6, 12, 20, and 21 May) during a 17-day period. We averaged 26 plots/day (range: 11-38). The survey timing (Figure 4) almost encompassed the range of previous surveys and started 2 days earlier than other years (5 May) but ended only 2 days before our latest survey end date in 2013. The survey team (DNR pilot Brad Maas and observer Jeff Lawrence) spent an average of 9 min surveying each plot (range: 2 – 19 min), about 2 minutes longer that the in 2013 and 2014, and 1 minute shorter than in 2012 (Table 1).

Sampling statistics

We detected SACR on 64 (50%) of the 129 sample plots in 2015 compared to 32% in 2014 and approximately 45% in 2012 and 2013 (Table 2). Cranes were observed on 58% of the 60 randomly-selected plots in 2015. The average count per 'occupied' plot (>=1 SACR observed) was 2.8 birds, which was similar to last year's mean (2.4) but less than the conditional mean plot count in 2012 (4.9) and 2013 (4.4). In 2015 we counted 175 SACR on sample plots, of which 59% were pairs, 27% were singles, and 13% were in groups (Table 3). We observed 5 groups on sample plots, which ranged in size from 3 to 8 birds. We saw relatively more grouped SACR in 2012 (37% of cranes observed) and 2013 (42%) than in 2014-2015 (15% and 13%, respectively; Table 3b). About 22% of observed pairs and singles exhibited some evidence of being breeding birds, which was lower than previous years (Table 3). In 2015 we detected 20 nests, similar to the 20 nests each in 2012-2013 and 17 nests in 2014.

Population estimates and distribution

The estimated total number of cranes in the survey area in 2015 was 4,835 (90% CI: 3,516-6,153), which was similar to the 2013 estimate (5,547; 90% CI: 3,582-7,511) and greater than the 2014 estimate (2,285; 90% CI: 1,716-2,855; Table 4). 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, then the estimated total number of breeding SACR in the survey area in 2015 was 1,069 (90% CI: 674-1,465), which again was similar to the 2013 estimate (950; 90% CI: 691-1,210) and greater than the 2014 estimate (591; 90% CI: 368-813; Table 4). The number of estimate breeding and unknown status (single and paired) cranes was similar in 2012 and 2015 (Figure 5).

A model-assisted analysis of the survey data suggested population estimates from 2014 were likely biased low (Figure 6). In both cases (design-based vs. model-assisted estimates) the estimated mean annual change in IBB and total birds during 2012-2015 was approximately -14% and -17%/yr, respectively. However, in all cases the slope of the trend line was not significantly different from zero (t-tests, $P > 0.25$). The lack of statistical significance in this case is not unexpected given we only have 4 data points (years).

A more powerful metric of change is a comparison of the 69 plots surveyed in 2012 and 2015 (i.e., revisit plots). The number of single cranes observed on these plots was the same in 2012 and 2015 ($n = 24$ in each year), but the number of pairs declined from 43 to 22 and the number of birds in groups declined from 73 to 8. On average, we counted -0.41 and -1.55 fewer IBB/plot and total SACR/plot, respectively, in 2015 compared to

2012. These differences were statistically significant in both cases (paired t-tests, df = 68, P <= 0.025). In terms of naive occupancy (probability of observing >=1 SACR | probability of detection=1), 67% of revisit plots did not change state from 2012 to 2015, but 22% changed from occupied to unoccupied and only 12% changed from unoccupied to occupied. Thus, there was a net decrease in naive probability of occupancy from 0.53 (90% CI: 0.39-0.73) in 2012 to 0.39 (90% CI: 0.19-0.51) in 2015.

Habitat associations

The relationships between SACR plot counts (2012-2015) and remote-sensing habitat metrics were very weak (Figure 7). Conversely, the probability of observing >=1 SACR was positively associated with the amount of nesting cover in the plot (Figure 8).

DISCUSSION

Survey effort and design considerations

In 2015, conditions started similar to 2012 (similar start date, drought conditions). In 2012, drought conditions persisted. In 2015, significant rainfall on May 17-18 changes conditions to very wet with flooded basins and standing waters in some fields. This was similar to the change in habitat conditions we observed in 2013. Spring phenology has varied each year, too. We had record early spring phenology in 2012, very late phenology in 2013 and 2014, and closer to average phenology in 2015. We have tried to time the survey for peak crane nest incubation, but these annual changes have made this difficult. Timing of the SACR survey may be critical to getting consistent results.

Population estimate

The number of indicated breeding cranes (IBB) and total cranes have shown a downward trend during the 4-year period we have conducted surveys, but some of this decline may be due to other factors such as survey timing and habitat conditions. The number of breeders and unknown cranes (singles and pairs) was approximately 4,100 in both 2012, the year of the highest population count, and 2015. The model-assisted estimate suggests that the 2014 count was biased low, but additional years of data may be necessary to better understand this annual variation.

The most powerful measure of change in crane numbers was the decline in the number of cranes observed on same plots between 2012 and 2015. Cranes have strong philopatry to their nesting territories (Krapu et al. 2011, Gerber et al. 2014), and we would expect similar numbers of IBB on the same plots if populations were stable. However, other factors influencing recruitment (e.g. flooded nests due to heavy precipitation in 2015) may influence the number of cranes seen on these plots. In addition, we recorded the same numbers of singles on these plots. Most singles are assumed to have a nesting mate nearby that was either undetected on the plot or off plot. The number of pairs on these plots in 2015 (n=22) was about ½ the number in 2012 (n=43), but we suspect many pairs have not started breeding yet. Cranes in groups have been included in our population estimates, yet the uneven distribution of groups makes them difficult to survey using the plot based design. In addition, plot data and anecdotal evidence suggests that groups were not present in large numbers on the northwest Minnesota breeding grounds when we conducted the survey in 2014 and 2015. The low number of groups observed in 2015 suggests that many nonbreeders had not yet returned to the breeding grounds and this may apply to nonbreeding pairs, too.

We will continue to report the total breeding population including groups, yet the 4 breeding ground surveys conducted to date suggest that return dates for the nonbreeding component of the crane population may be highly variable. Cranes in groups, some cranes in pairs, and likely a few singles would comprise the nonbreeding component of the population. While the number of nonbreeding pairs returning in May maybe variable, we believe the total number of cranes observed as singles and pairs will provide the most reliable measure of the crane population in Northwest Minnesota.

We plan to conduct the survey again in May 2016.

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Table 1. Survey effort (minutes) by activity for an aerial survey of sandhill cranes in Minnesota, May 2012-2015.

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

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

Table 2. Sampling statistics[a] for an aerial survey of sandhill cranes in northwestern Minnesota, May 2012-2015.

								Counts/occupied plot				
Year	Strata	Sampling allocation[b]	n	N	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	115	2,953	0.039	49	0.43	1	46	3	4.4	1.06
2014	1	SRS	115	2,953	0.039	37	0.32	1	10	2	2.4	0.31
2015	2	SP-SRS	129	2,953	0.044	64	0.50	1	14	2	2.8	0.45

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

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

Table 3. Social and breeding classification of sandhill crane observations, 2012-2015.

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

[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).

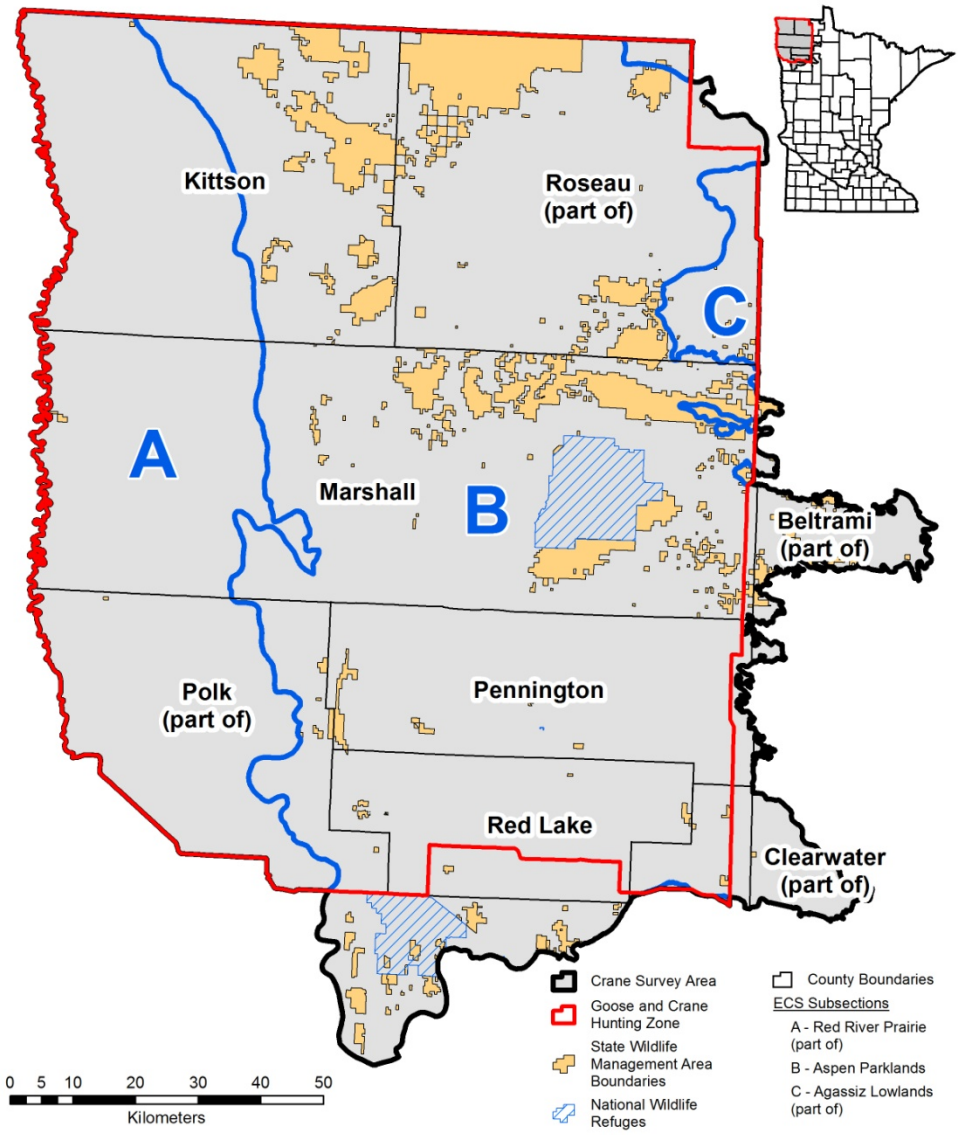
Table 4. Population estimates (N) by indicated breeding status for sandhill cranes in northwestern Minnesota, May 2012-2015.

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
2015	Without Red River Valley	Breeding birds[b]	129	2,953	21	1	3	0.4	0.08	1,069	240	674	1,465	22
		Groups	129	2,953	5	3	8	0.2	0.13	729	398	75	1,383	55
		Status unknown[c]	129	2,953	52	1	9	1.0	0.16	3,036	481	2,245	3,827	16
		Total	129	2,953	64	1	14	1.6	0.27	4,845	801	3,516	6,153	17

[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.


Kittson
Roseau
(part of)
C
A
Marshall
B
Beltrami
(part of)
Polk
(part of)
Pennington
Red Lake
Clearwater
(part of)
0 5 10 20 30 40 50
Kilometers
Crane Survey Area
Goose and Crane Hunting Zone
State Wildlife Management Area Boundaries
National Wildlife Refuges
County Boundaries
ECS Subsections
A - Red River Prairie (part of)
B - Aspen Parklands
C - Agassiz Lowlands (part of)

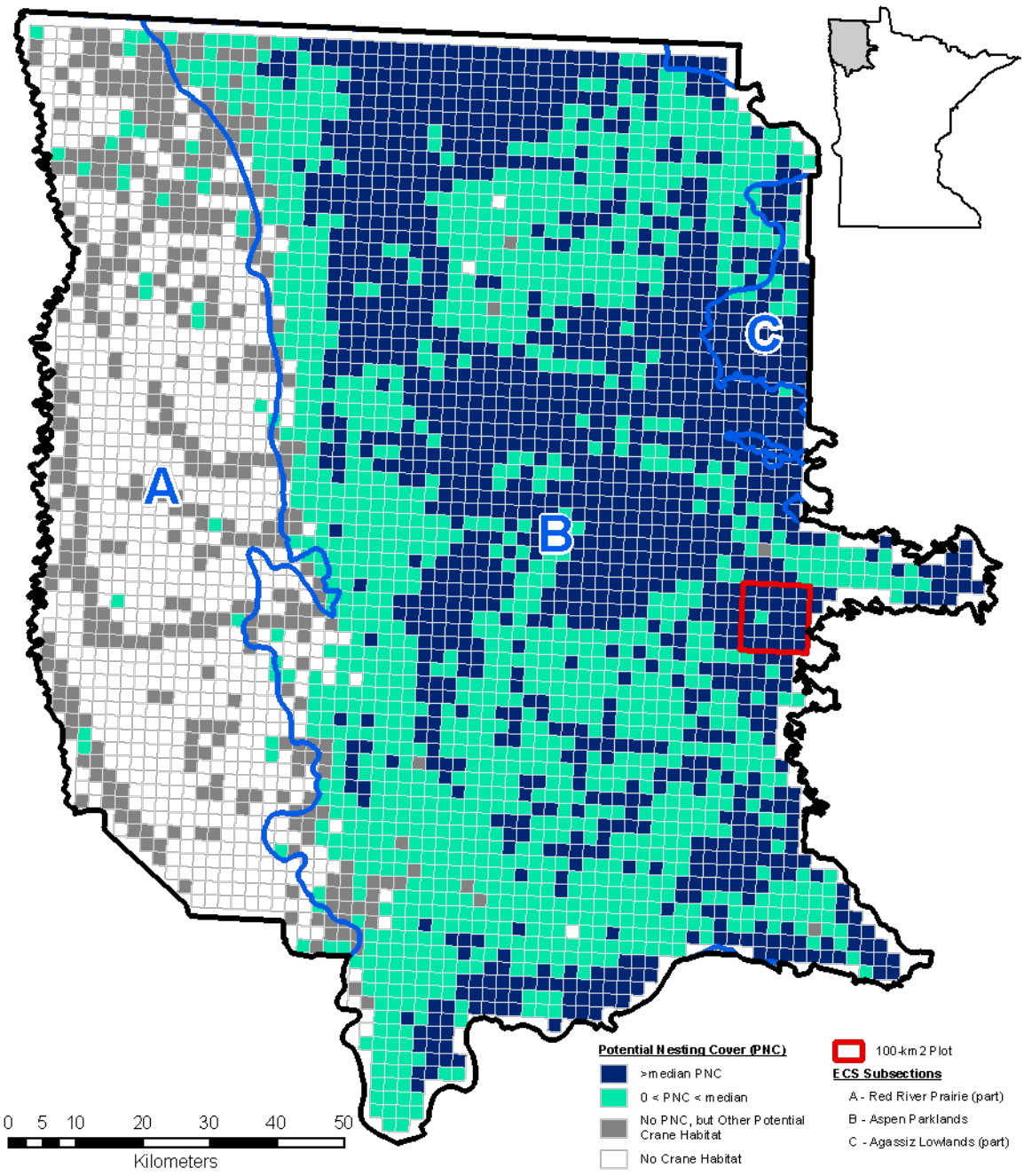


Figure 2. Sampling frame for the spring aerial survey of sandhill cranes, northwestern Minnesota. The primary sampling unit was 4-km^2 plots. Colored squares denote plots by strata as defined by National Land Cover Data: dark blue = NLCD-1 (>median amount of potential crane nesting cover [PNC]), turquoise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

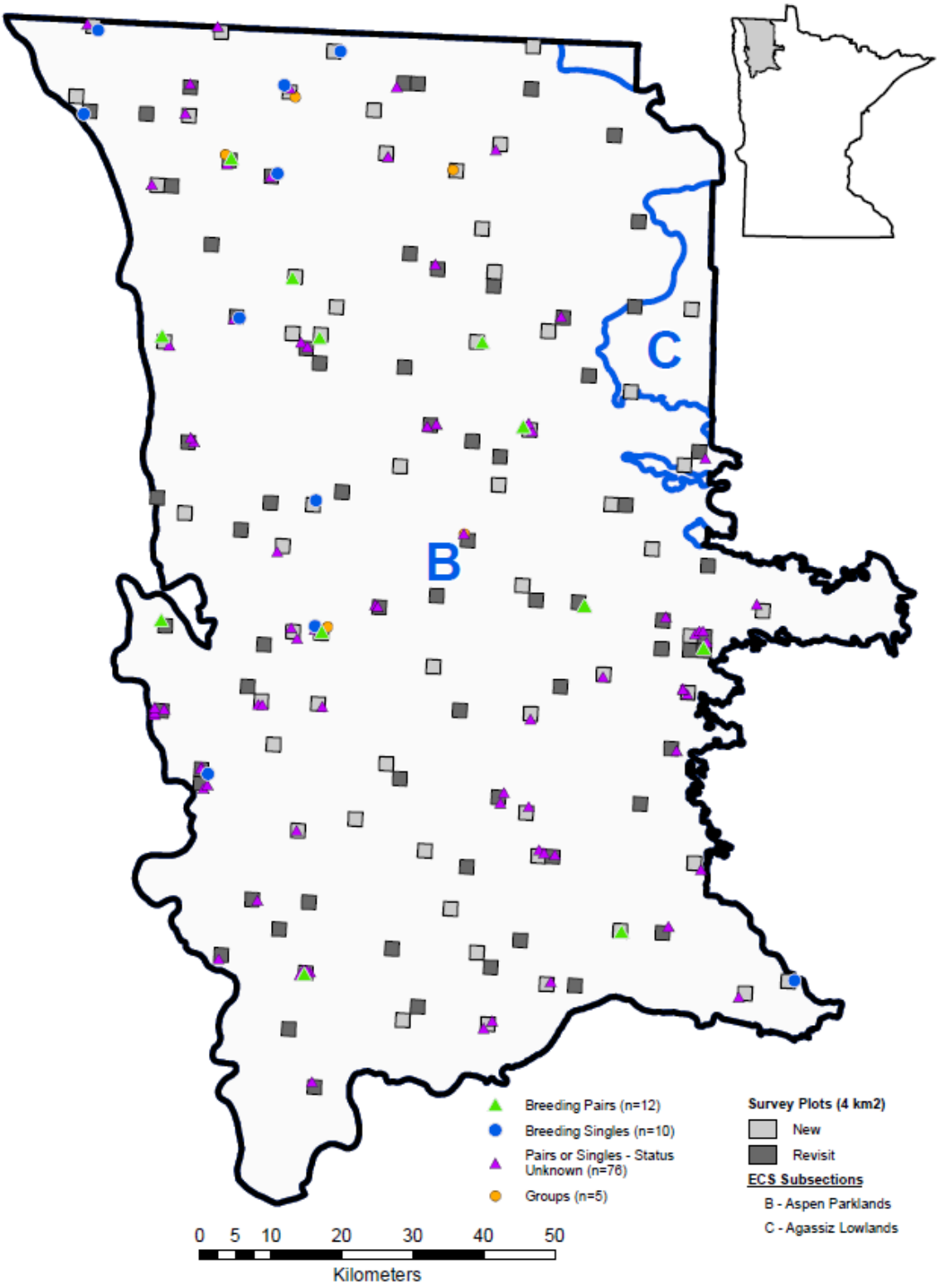


Figure 3. Distribution of sample plots (n = 129) and sandhill crane observations by type in the 2015 MNDNR spring aerial survey, northwestern Minnesota. Each sample plot was 4 km2 and the SACR survey area was 11,812 km2.

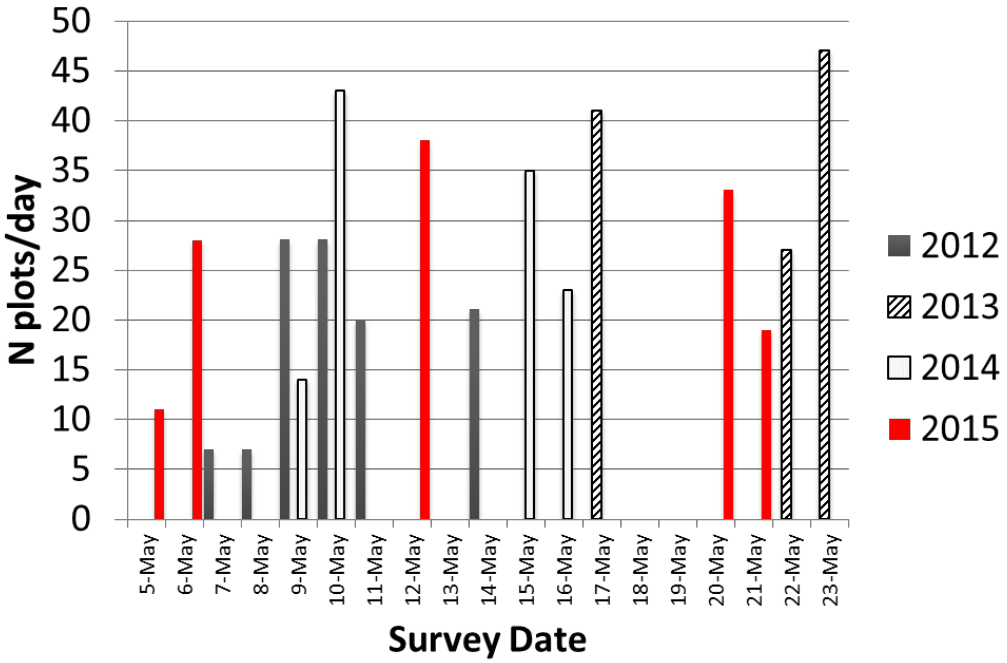


Figure 4. Number of plots surveyed by calendar date during the Northwestern Minnesota Sandhill Crane breeding population survey, 2012-2015. 115 plots were flown each year from 2012 to 2014 and 129 were flown in 2015.

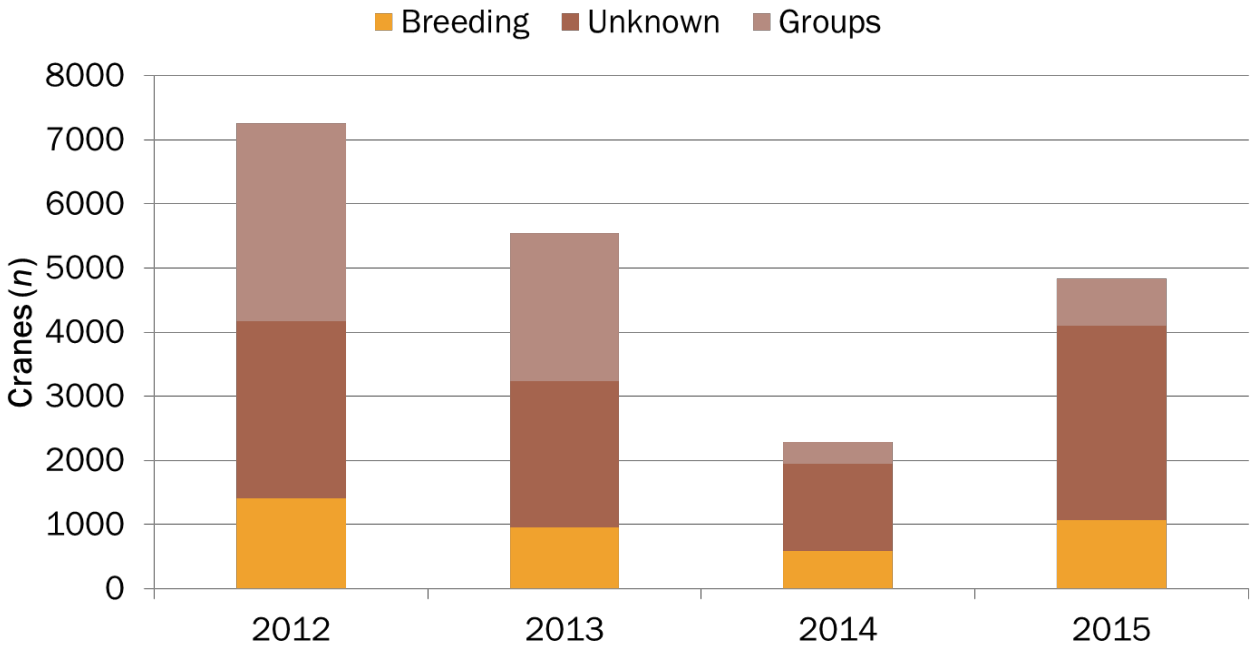


Figure 5. Number of cranes by social grouping in the Aspen Parklands survey area of northwestern Minnesota, 2012-2015.

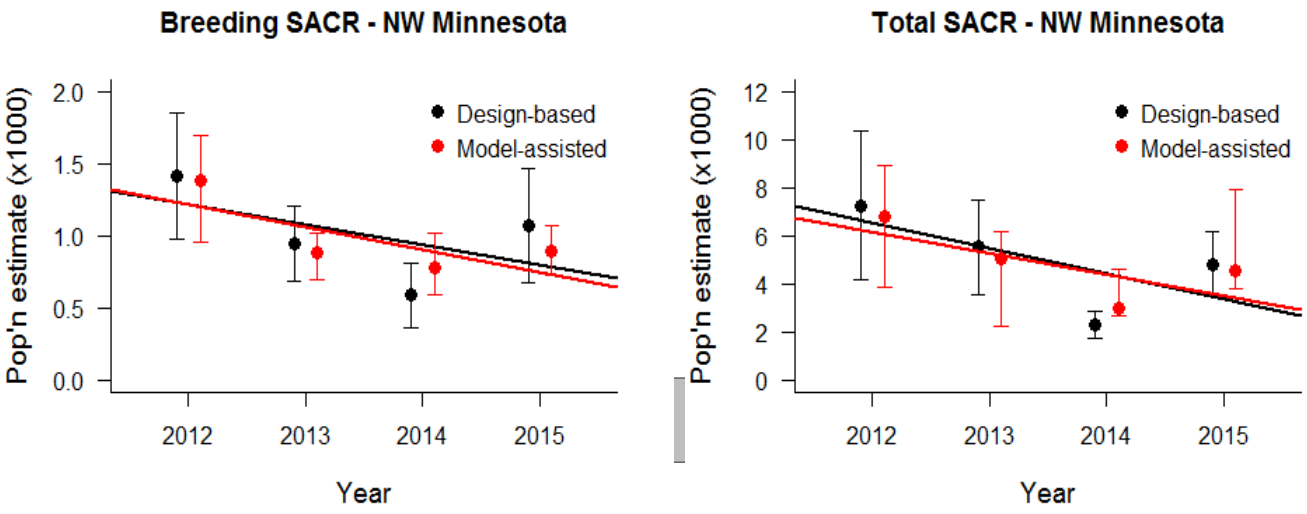


Figure 6. Design-based and model-assisted estimates of breeding sandhill cranes (SACR) and total breeding ground population in the Aspen Parklands survey area of northwestern Minnesota, 2012-2015. See text for explanation of the methods.

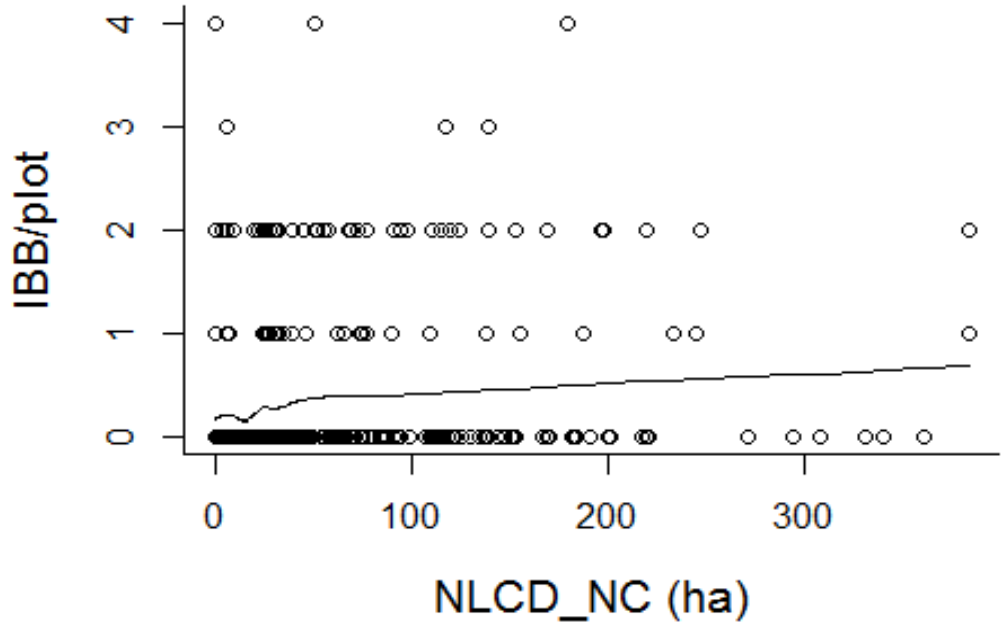


Figure 7. Relationship between Indicated Breeding Birds [IBB]) sandhill crane observations and habitat abundance (as defined by NLCD classification schemes [see text]) based on 448 4-km2 plots surveyed in northwest Minnesota, 2102-2015.

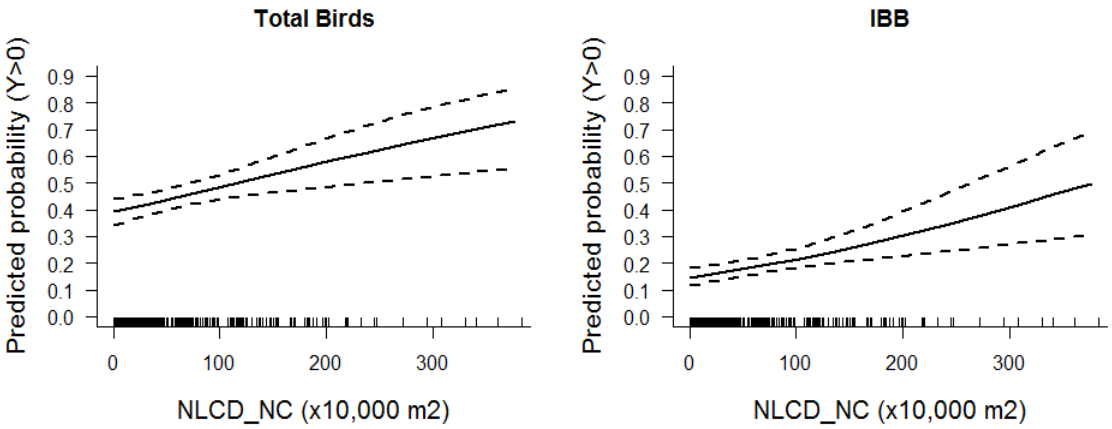


Figure 8. Relationship between sandhill crane occurrence (total SACR and Indicated Breeding Pairs [IBB]) and habitat abundance (as defined by NLCD classification schemes [see text]) based on 448 4-km2 plots surveyed in northwest Minnesota, 2102-2015.