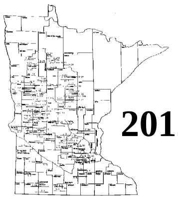
WETLAND WILDLIFE POPULATIONS

Wetland Wildlife Populations and Research
102 23rd Street
Bemidji, MN 56601
(218) 308-2282



2012 WATERFOWL BREEDING POPULATION SURVEY MINNESOTA

Steve Cordts, Minnesota DNR, Waterfowl Staff Specialist

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 2012 aerial survey portion was flown from April 30 to May 17. Spring ice-out dates were 3-4 weeks earlier than ever recorded and the majority of the state was ice-free by late March when the first spring migrant ducks arrived. Temperatures were near normal in April and May. Spring wetland conditions were very dry in early spring but improved by mid to late May after the survey was completed. Wetland numbers (Types II-V) decreased 37% compared to 2011 and were below both the 10-year (-15%) and long-term (-10%) averages.

The estimated mallard breeding population was 225,000, which was 21% lower than 2011 and 17% lower than the 10-year average but similar to the long-term average of 226,000 breeding mallards. The estimated blue-winged teal breeding population was 109,000, which was 49% lower than 2011 but statistically unchanged from last year's estimate of 214,000 blue-winged teal (P=0.27). Blue-winged teal numbers were well below both their 10-year (-48%) and long-term (-50%) averages. The combined population index of other ducks, excluding scaup, was 135,000 ducks, which was 29% lower than last year's estimate and 39% below the 10-year average and 24% below the long-term average of 178,000 other ducks. Population estimates of wood duck (45,000), ring-necked duck (30,000), northern shoveler (19,000), gadwall (11,000) and redhead (10,000) accounted for most (85%) of the total population of other ducks.

The estimate of total duck abundance (469,000), which excludes scaup, was 32% lower than last year's estimate of 687,000 ducks and was 33% below the 10-year average and 25% below the long-term average of 623,000 ducks. The estimated number of Canada geese was 158,000 and 1% higher than last year. Record numbers of goose broods were observed this year due to the early spring and early nesting effort by Canada geese. In addition, large numbers of flocks of non-breeding Canada geese were observed this year from late April until the survey was complete.

Survey timing was late due to weather delays in early May and most migrant ducks had likely moved through the state by the time the survey was started. Although there were declines in all indices of duck population abundance this year, some caution is necessary when interpreting these indices each year. The counts for total duck abundance (excluding scaup) prior to adjusting for visibility biases were 6% below the 10-year average. But the total duck population index, after adjusting for visibility biases, was 33% below the 10-year average. This was due to very low visibility correction factors obtained for all species this year that are difficult to interpret.

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:

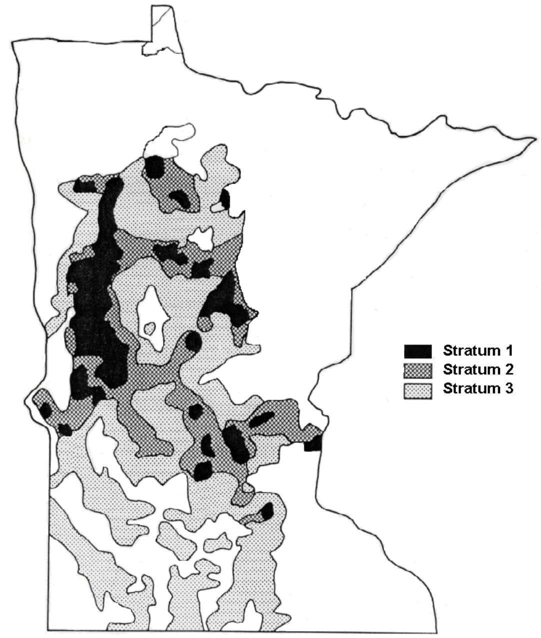


Figure. 1. Location of waterfowl breeding population survey strata in Minnesota.

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

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

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

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

All aerial transects in Strata I-III (Table 1) were flown using a Cessna 185 (N805NR). 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) that were obtained when the observer counted wetlands on both sides of the plane (0.25 mile wide transect). All wetland and waterfowl data were recorded on digital voice recorders by the pilot and observer and transcribed from the digital files.

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

The SAS computer program was modified in 1992 to obtain standard errors for mallard and blue-winged teal breeding population estimates. These calculations were based upon SAS computer code written by Graham Smith, USFWS-Office of Migratory Bird Management. Estimates for 2011 and 2012 were compared using two-tailed Z-tests.

SURVEY CHRONOLOGY: The 2012 aerial survey began on 30 April in southern Minnesota and concluded in northern Minnesota on 17 May. The survey was completed in 53 hours of flight time over 11 days. Transects were flown April 30, May 2, May 4, May 7, May 9-10, and May 13-17. Flights began no earlier than 7 AM and were completed by 1:00 PM each day. Although the survey was started earlier than normal due to the early spring, the median date for survey completion was May 13, which was 4 days later than each of the past 4 years.

WEATHER AND HABITAT CONDITIONS: For the majority of Minnesota lakes, ice out was the earliest on record by 3-4 weeks. Temperatures in March averaged 14°F above normal statewide and many weather stations reported record high temperatures nearly every day from March 10 until the end of the month. Temperatures in April averaged 3.0°F above normal statewide. April precipitation was 0.6 inches above normal statewide and ranged from 0.2 inches below normal in south central Minnesota to 1.4 inches above normal in north east and west central Minnesota. May temperatures averaged 3.3°F above normal statewide. May precipitation was 3.1 inches above normal statewide and ranged from 0.7 inches below normal in northwest Minnesota to 6.7 inches above normal in east central Minnesota (http://climate.umn.edu). Additional temperature and precipitation data are provided in Appendix A.

Spring wetland conditions were generally very dry in March and April but improved dramatically by late May. In mid-April, 99% of the state was abnormally dry to moderate drought with 24% of the state classified as severe drought. By late May, 56% of the state was under no drought designation. In April 2012, statewide topsoil moisture indices were rated as 54% very short or short and 46% adequate or surplus moisture. By late May, topsoil moisture indices indices were rated as only 5% very short or short and 95% adequate or surplus moisture. (http://droughtmonitor.unl.edu).

Planting dates for row crops were extremely early in 2012. By May 6, 73% of the corn acres had been planted statewide compared to 20% in 2011 and 53% for the previous 5-year average. By 29 May, 40% of alfalfa hay had been cut compared to 1% in 2011 and a 5-year average of 12% (Minnesota Agricultural Statistics Service Weekly Crop Weather Reports, (http://www.nass.usda.gov/mn/).

Leaf-out dates were 3-4 weeks earlier than average and impacted visibility during the survey. Wetland vegetation growth was earlier than average but not as advanced as leaf-out.

Overall, wetland numbers (Type II-V) decreased 37% from 2011 and were 15% below the 10-year average and 10% below the long-term average (Table 2; Figure 2). The number of temporary (Type 1) sheetwater wetlands was 54% below the long-term average.

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 2012 breeding population estimate of mallards was 224,965 (SE = 45,057), which was unchanged from 2011 (Z = 0.87, P = 0.39) (Table 7, Figure 3). Mallard numbers were 17% below the 10-year average and 1% below the long-term average of 226,146 mallards. In 2012, the mallard population was comprised of 74% lone males, 17% pairs, and 9% flocked mallards. The 5-year average is 81% lone males, 14% pairs, and 5% flocked mallards. The higher number of flocked mallards this year was predominantly large groups of drake mallards (>5) which indicates a late survey year.

The estimated blue-winged teal population was 108,607 (SE = 31,971), which was unchanged from 2011 (Z = 1.11, P = 0.27). Blue-winged teal numbers were 48% below the 10-year average and 50% below the long-term average (Table 7, Figure 4). The blue-winged teal population was comprised of 13% lone males, 42% pairs, and 45% flocks. This was similar to 2011 when the blue-winged teal population was comprised of 10% lone males, 43% pairs, and 47% flocks. Other duck numbers (excluding scaup) were 135,017, which was 29% lower than last year's estimate of 191,000 and 39% below the 10-year average and 24% below the long-term average (Table 7, Figure 5). Population estimates of wood duck (45,000), ring-necked duck (30,000), northern shoveler (19,000), gadwall (11,000) and redhead (10,000) accounted for most (85%) of the total population of other ducks. Scaup numbers (6,000) were the lowest on record and 83% below the 10-year average (Table 8), indicating most scaup had already migrated through the state before the survey began.

The total duck population index, excluding scaup, was 469,000, which was 32% lower than last year's index of 687,000 ducks and 33% below the 10-year average and 25% below the long-term average (Table 8, Figure 6).

Visibility Correction Factors (VCFs) for mallards, blue-winged teal, and other ducks were all lower than 2011 and lower than the 10-year average (Table 7). The mallard VCF (2.33) was 14% below the 10-year average. The blue-winged teal VCF (2.18) was 46% below the 10-year average. The VCF for other ducks (2.24) was 37% lower than the 10-year average. This was the first year since the survey started that the blue-winged teal VCF was lower than the mallard VCF. With early leaf-out and generally poor visibility from the air during the entire survey this year, the low VCFs for mallards, blue-winged teal, and other ducks make the population estimates difficult to interpret.

Canada goose numbers (uncorrected for visibility) increased 44% compared to 2011 and remained 94% above the long-term average (Table 8). The VCF for Canada geese was 1.81 and 22% below the 10-year average of 2.32. The population estimate of Canada geese (adjusted for visibility) was 158,000, which was 2% below the long-term average of 162,000 geese (Table 8, Figure 7). A total of 70 Canada goose broods were observed, which was the most ever recorded and Canada goose broods were observed each day during the survey. Numerous flocks (10-30 birds) of non-breeding Canada geese were observed this year loafing in fields and on wetlands. Typically, these flocks of non-breeding geese and failed breeders are not common until mid to late May.

The estimated coot population, uncorrected for visibility, was 26,000 in 2012 compared to 4,000 in 2011.

The estimated number of swans (likely all trumpeters) was 6,600 swans and similar to last year. This estimate is expanded for area but not visibility and lone swans are not doubled. About 1/3 of the estimate is due to 3 large (10-30 swans) flocks of non-breeding swans.

SUMMARY: Overall wetland conditions were fairly dry at the time of the survey and wetland numbers were 37% lower than 2011 and 10% below the long-term average. Mallard abundance in 2012 was 225,000 mallards, which was similar to the long-term average of 226,000 mallards. Blue-winged teal abundance (109,000) was 49% lower than 2011 (214,000) and 50% below the long-term average of 219,000. The combined population index of other ducks (135,000) was 29% lower than 2011 and 24% below the long-term average of 178,000 ducks. Total duck abundance (469,000), excluding scaup, was 32% lower than 2011 (687,000) and was 33% below the 10-year average and 25% below the long-term average. Canada goose numbers, adjusted for visibility bias, increased 1% from 2011. All indices of duck (mallard, blue-winged teal, other ducks, total ducks) abundance (unadjusted for visibility biases) were similar (5-8% lower) to their 10-year average. Visibility Correction Factors for mallard, blue-winged teal, and other ducks were very low, which contributed to the low population indices and are difficult to explain and interpret.

ACKNOWLEDGMENTS: Thanks to the ground crews and the pilot for all of their efforts.

Air Crew: Pilot/Observer: Tom Pfingsten, Conservation Officer Pilot, MNDNR, Division of Enforcement; Observer: Steve Cordts, Waterfowl Staff Specialist, MNDNR, Division of Wildlife

Ground Crew Leaders: Sean Kelly, Asst. Chief, Migratory Bird & Refuges, USFWS, Region III, Twin Cities; Wayne Brininger, USFWS, Tamarac National Wildlife Refuge; Dan Hertel and Fred Oslund, USFWS, HAPET, Fergus Falls; Paul Richert, Tom Cooper, and Jim Kelley, USFWS, Region III, Twin Cities; Kim Bousquet, USFWS, Big Stone National Wildlife Refuge; Greg Dehmer and Sally Zodrow, USFWS, Sherburne National Wildlife Refuge
Ground Crew Assistants: Brad Nylin, Minnesota Waterfowl Association; Jihadda Govan and K. Halver, USFWS, Big Stone National Wildlife Refuge; Lowell Deede and Gina Kemper, USFWS, Tamarac National Wildlife Refuge ; Ben Anderson and Paul Soler, USFWS, Sherburne National Wildlife Refuge; Joe Braun and Kelsey Norton, USFWS, HAPET, Fergus Falls; Tim Moser, USFWS, retired

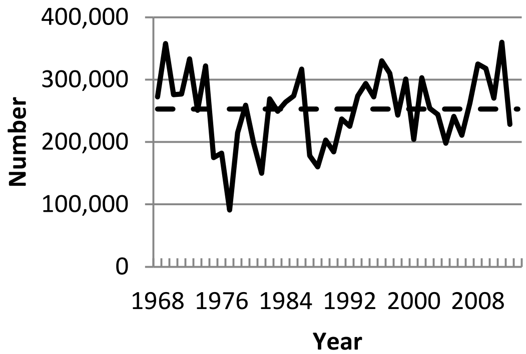


Figure 2. Number of May ponds (Types II-V) and long-term average (dashed line) in Minnesota, 1968-2012.

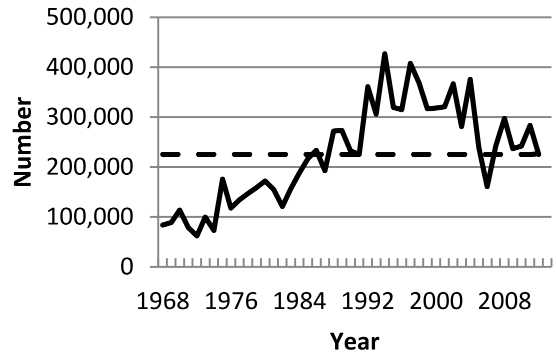


Figure 3. Mallard population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2012.

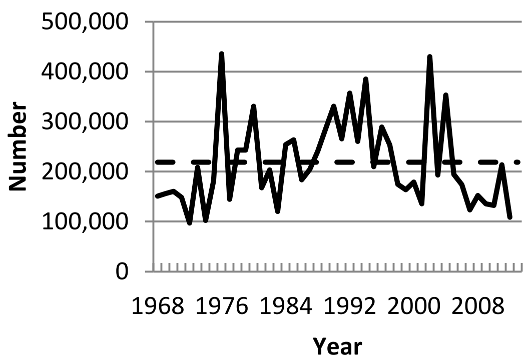


Figure 4. Blue-winged teal population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2012.

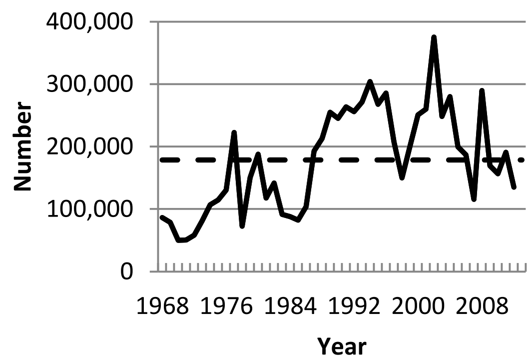


Figure 5. Other duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2012

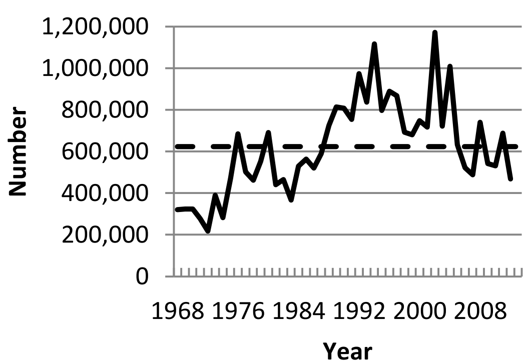


Figure 6. Total duck (excluding scaup) population estimates (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1968-2012

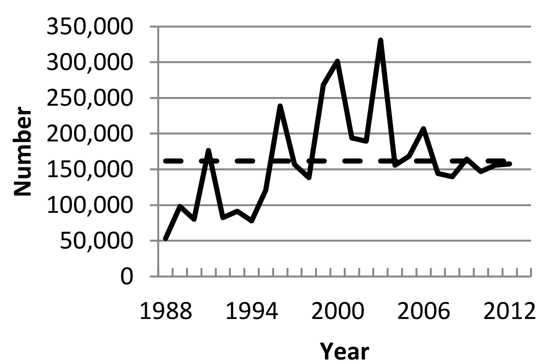


Figure 7. Canada goose population (adjusted for visibility bias) and long-term average (dashed line) in Minnesota, 1988-2012.

LITERATURE CITED:

Jessen, R. J. 1969. Waterfowl breeding ground survey, 1968. Minn. Game Research Proj. Q. Prog. Rep. 29(32):173-180.

Jessen, R. J. 1971. Waterfowl breeding ground survey, 1969. Minn. Game Research Proj. Q. Prog. Rep. 31(2):100-106.

Jessen, R. J. 1971. Waterfowl breeding ground survey, 1970. Minn. Game Research Proj. Q. Prog. Rep. 31(2):107-113.

Jessen, R. J. 1971. Waterfowl breeding ground survey, 1971. Minn. Game Research Proj. Q. Prog. Rep. 31(2):114-120.

Jessen, R. J. 1972. Waterfowl breeding ground survey, 1972. Minn. Game Research Proj. Q. Prog. Rep. 32(2):89-95.

Minnesota Conservation Department. 1968. An inventory of Minnesota Lakes. Waters Section, Division of Waters, Soils, and Minerals, Bull. No. 25. 498pp.

Maxson, S. J., and R. M. Pace. 1989. Summary and evaluation of Minnesota's waterfowl breeding population survey, 1972-1986. Minnesota Wildl. Rep. 7. 92pp.

USFWS/CWS. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. U.S. Fish and Wildlife Service and Canadian Wildlife Service.

Table 1. Survey design for Minnesota, May 2012.[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), 1968-2012.

	Year	Type I	Number of ponds[1]
	1968		272,000
	1969		358,000
	1970		276,000
	1971		277,000
	1972		333,000
	1973		251,000
	1974		322,000
	1975		175,000
	1976		182,000
	1977		91,000
	1978		215,000
	1979		259,000
	1980		198,000
	1981		150,000
	1982		269,000
	1983		249,000
	1984		264,000
	1985		274,000
	1986		317,000
	1987		178,000
	1988		160,000
	1989		203,000
	1990		184,000
	1991	82,862	237,000
	1992	10,019	225,000
	1993	199,870	274,000
	1994	123,958	294,000
	1995	140,432	272,000
	1996	147,859	330,000
	1997	30,751	310,000
	1998	20,560	243,000
	1999	152,747	301,000
	2000	5,090	204,000
	2001	66,444	303,000
	2002	30,602	254,000
	2003	34,005	244,000
	2004	9,494	198,000
	2005	30,764	241,000
	2006	56,798	211,000
	2007	32,415	262,000
	2008	69,734	325,000
	2009	39,078	318,000
	2010	26,880	270,000
	2011	89,218	360,000
	2012	30,910	228,000
Averages:	10-year	41,899	268,000
	Long-term	66,647	253,000
% change from:	2011	-65%	-37%
	10-year	-26%	-15%
	Long-term	-54%	-10%

Table 3. Minnesota waterfowl breeding populations by species for Stratum I (high wetland density), expanded for area but not visibility, 1994-2012.

	Year																		
Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dabblers:																			
Mallard	22,160	20,494	25,104	26,992	33,157	26,576	26,604	28,742	29,297	25,937	29,381	19,050	16,829	16,357	25,104	19,467	18,439	19,856	18,911
Black Duck	56	0	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0	0
Gadwall	444	1,055	1,083	611	1,111	1,777	833	1,333	944	1,250	2,111	1,166	1,444	889	1,166	1,055	1,000	167	1,389
American Wigeon	0	194	0	0	56	56	56	111	0	56	555	167	0	56	111	56	56	111	222
Green-winged Teal	278	0	278	56	333	0	278	56	278	222	444	56	56	167	278	167	56	56	56
Blue-winged Teal	9,164	7,609	6,720	6,387	8,220	6,998	11,247	7,387	14,218	9,664	23,771	9,303	5,665	5,332	9,942	5,998	7,304	4,665	5,110
Northern Shoveler	278	111	1,277	1,500	500	555	1,055	305	1,277	278	1,166	333	167	56	1,000	666	1,027	111	56
Northern Pintail	167	167	167	111	111	167	167	389	56	111	56	0	56	0	56	56	0	111	0
Wood Duck	7,359	6,831	6,498	9,497	12,302	5,582	10,219	6,720	2,888	4,499	8,081	5,498	3,555	2,666	6,665	4,277	3,999	3,416	4,138
Dabbler Subtotal	39,906	36,461	41,127	45,154	55,790	41,711	50,459	45,043	48,958	42,017	65,565	35,629	27,772	25,523	44,322	31,742	31,881	28,493	29,882
Divers:																			
Redhead	1,972	639	722	778	944	500	583	1,444	750	333	805	666	666	916	1,389	472	944	805	750
Canvasback	3,166	3,860	1,166	1,333	1,777	2,971	1,222	2,027	1,833	1,333	666	972	833	1,000	2,277	1,333	1,222	833	722
Scaup	19,661	7,192	13,829	3,416	9,247	1,750	7,415	5,832	2,444	2,055	5,971	4,110	111	555	6,276	8,553	2,777	2,222	1,055
Ring-necked Duck	3,582	1,583	3,166	2,694	2,749	2,360	4,776	2,444	2,777	1,361	5,165	1,722	2,055	1,555	21,494	6,859	3,138	4,804	2,666
Goldeneye	222	111	167	0	111	56	56	333	111	0	222	222	56	222	278	278	222	56	56
Bufflehead	444	56	278	0	56	111	56	111	222	111	389	167	222	56	1,611	833	389	278	56
Ruddy Duck	639	167	139	528	11,052	972	0	83	1,305	417	305	1,222	305	0	1,027	861	28	56	0
Hooded Merganser	111	278	611	555	389	722	500	722	555	333	278	333	555	111	666	944	555	500	555
Large Merganser	56	0	0	56	0	0	0	111	0	972	0	111	0	278	333	333	333	111	56
Diver Subtotal	29,853	13,886	20,078	9,360	26,325	9,442	14,608	13,107	9,997	6,915	13,801	9,525	4,803	4,693	35,351	20,466	9,608	9,665	5,916
Total Ducks	69,759	50,347	61,205	54,514	82,115	51,153	65,067	58,150	58,955	48,932	79,366	45,154	32,575	30,216	79,673	52,208	41,489	38,158	35,798
Other:																			
Coot	528	611	3,055	5,054	555	83	3,999	1,722	2,888	2,666	21,411	2,444	639	139	16,829	2,166	139	2,194	444
Canada Goose	12,802	14,413	12,774	10,330	16,967	19,495	22,160	24,882	24,104	22,160	23,160	22,938	21,633	29,797	18,717	16,523	16,440	13,691	26,437

Table 4. Minnesota waterfowl breeding populations by species for Stratum II (medium wetland density), expanded for area but not visibility, 1994-2012.

	Year																		
Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dabblers:																			
Mallard	42,896	42,896	48,507	54,643	53,942	52,247	49,559	44,650	43,773	34,715	44,474	26,883	25,130	24,779	27,935	23,494	21,507	30,974	29,689
Black Duck	0	0	0	0	0	0	0	117	0	0	0	0	0	0	0	0	0	0	0
Gadwall	1,403	1,052	935	468	584	1,519	3,039	1,636	701	584	3,565	584	1,052	234	3,039	1,169	1,286	935	1,987
American Wigeon	117	0	468	351	818	0	468	0	0	0	2,513	117	0	0	351	0	351	0	117
Green-winged Teal	117	0	935	234	351	117	117	117	468	234	234	0	117	0	0	234	117	0	0
Blue-winged Teal	19,227	10,636	13,851	13,792	13,208	10,578	19,637	9,701	21,390	15,955	30,624	11,513	9,000	8,416	12,740	11,104	8,474	12,390	9,000
Northern Shoveler	935	818	1,636	2,571	701	2,104	4,675	1,052	2,221	1,403	1,753	234	584	351	468	701	2,513	1,052	0
Northern Pintail	468	234	117	234	468	117	117	117	0	117	0	0	0	234	0	0	0	234	0
Wood Duck	9,409	6,662	8,708	11,338	10,520	19,753	13,792	7,831	5,143	4,558	8,766	3,273	1,753	2,221	6,546	5,260	6,312	6,955	5,143
Dabbler subtotal	74,572	62,298	75,157	83,631	80,592	86,435	91,404	65,221	73,696	57,566	91,929	42,604	37,636	36,235	51,079	41,962	40,560	52,540	45,936
Divers:																			
Redhead	3,799	1,403	1,110	1,987	935	1,636	2,805	2,455	234	584	1,110	292	175	935	935	584	760	1,578	468
Canvasback	1,052	0	234	701	117	117	935	0	468	1,052	234	0	0	1,169	468	234	117	584	117
Scaup	14,085	7,831	21,916	18,935	4,032	3,331	6,779	3,039	5,961	2,279	7,188	2,981	468	643	3,097	2,104	0	1,929	935
Ring-necked Duck	3,331	1,403	7,714	3,565	2,279	2,221	5,610	3,799	6,370	2,455	5,377	1,929	3,331	1,578	13,149	9,117	2,396	11,455	1,695
Goldeneye	701	701	1,753	818	234	935	584	468	234	234	351	117	117	0	351	584	468	468	584
Bufflehead	234	0	117	117	0	0	0	0	1,169	117	468	351	117	117	1,403	818	643	1,403	468
Ruddy Duck	409	117	58	117	0	468	0	0	1,870	2,688	0	351	58	0	0	175	409	58	234
Hooded Merganser	468	117	234	468	117	701	935	1,403	701	701	234	234	351	234	584	701	117	2,221	1,636
Large Merganser	0	0	0	0	0	0	117	117	0	0	234	351	0	0	351	0	0	234	0
Diver subtotal	24,079	11,572	33,136	26,708	7,714	9,409	17,765	11,281	17,007	10,110	15,196	6,606	4,617	4,676	20,338	14,317	4,910	19,930	6,137
Total Ducks	98,651	73,870	108,293	110,339	88,306	95,844	109,169	76,502	90,703	67,676	107,125	49,210	42,253	40,911	71,417	56,279	45,470	72,470	52,073
Other:																			
Coot	1,461	526	7,013	5,026	643	234	1,110	468	4,909	1,519	8,007	584	292	409	23,961	0	117	292	292
Canada Goose	12,565	12,682	13,559	16,364	19,812	18,585	25,831	24,604	20,688	22,091	28,461	20,688	26,825	25,890	19,753	22,675	18,935	14,201	23,260

Table 5. Minnesota waterfowl breeding populations by species for Stratum III (low wetland density), expanded for area but not visibility, 1994-2012.

	Year																		
Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dabblers:																			
Mallard	73,425	79,166	79,862	78,993	101,873	90,390	81,690	72,642	72,121	55,156	84,561	36,539	30,884	35,843	50,371	35,408	40,976	51,415	47,848
Black Duck	0	0	0	0	0	0	0	0	0	0	174	0	0	174	174	0	0	0	174
Gadwall	2,610	3,306	3,306	2,436	3,045	2,436	2,610	10,701	3,306	1,566	6,960	2,001	5,568	4,176	870	1,392	1,392	4,089	1,566
American Wigeon	1,218	0	1,044	348	696	0	522	174	1,218	174	1,566	1,044	174	348	348	174	348	1,044	174
Green-winged Teal	174	0	957	348	174	0	1,218	1,392	522	174	0	174	522	0	0	0	0	174	348
Blue-winged Teal	41,932	29,492	36,625	25,316	26,360	18,530	29,405	20,618	56,374	21,140	39,758	27,578	23,663	15,659	18,095	20,183	16,964	44,716	35,669
Northern Shoveler	2,784	5,307	12,701	11,049	4,176	4,002	20,444	10,701	6,264	870	3,828	348	522	870	4,002	2,088	6,873	2,088	8,265
Northern Pintail	696	174	870	522	870	870	696	522	0	174	348	174	174	348	174	0	174	0	174
Wood Duck	23,228	16,355	27,926	14,268	23,837	20,531	25,055	17,225	13,572	12,702	20,705	7,482	7,308	5,394	14,442	10,266	12,354	13,659	10,962
Dabbler subtotal	146,067	133,800	163,291	133,280	161,031	136,759	161,640	133,975	153,377	91,956	157,900	75,340	68,815	62,812	88,476	69,511	79,081	117,185	105,180
Divers:																			
Redhead	2,958	7,134	1,044	1,044	2,001	3,480	2,523	3,654	1,305	174	1,740	1,479	0	522	783	870	174	4,350	3,306
Canvasback	696	174	1,392	0	3,306	174	3,915	522	696	1,131	2,784	0	0	348	1,566	1,218	348	1,044	1,044
Scaup	23,924	13,397	29,840	8,787	15,137	8,961	18,182	6,873	4,611	783	17,747	5,307	1,392	696	5,481	1,914	522	5,133	696
Ring-necked Duck	5,568	1,044	12,875	3,654	2,958	1,479	8,178	8,526	7,395	1,479	5,133	10,179	6,699	1,392	8,526	6,525	3,045	6,264	9,135
Goldeneye	783	1,479	1,914	522	696	696	1,044	1,566	3,132	1,305	696	1,044	1,044	870	348	522	174	870	0
Bufflehead	696	0	1,044	174	348	0	0	0	1,218	783	2,088	0	174	696	1,218	870	174	2,871	174
Ruddy Duck	2,175	2,349	1,740	348	0	174	0	696	18,878	87	2,262	870	696	261	87	348	0	3,828	522
Hooded Merganser	696	1,044	1,566	696	696	1,218	957	174	2,175	174	1,740	1,218	870	174	696	348	1,218	1,044	1,044
Large Merganser	174	174	0	0	0	0	0	0	522	0	0	261	957	348	348	348	348	174	174
Diver subtotal	37,670	26,795	51,415	15,225	25,142	16,182	34,799	22,011	39,932	5,916	34,190	20,358	11,832	5,307	19,053	12,963	6,003	25,578	16,095
Total Ducks	183,737	160,595	214,706	148,505	186,173	152,941	196,439	155,986	193,309	97,872	192,090	95,698	80,647	68,119	107,529	82,474	85,084	142,763	121,275
Other:																			
Coot	12,788	3,828	182,953	24,620	5,133	14,702	67,684	3,132	14,007	7,134	77,427	8,613	14,702	5,742	15,137	7,047	435	1,479	25,664
Canada Goose	23,228	30,971	34,537	33,755	42,368	41,933	57,940	39,932	33,407	43,412	46,717	39,758	27,230	42,629	31,841	28,274	30,710	32,711	37,496

Table 6. Minnesota waterfowl breeding populations by species for Stratum I-III combined, expanded for area coverage but not for visibility, 1994-2012.

	Year																		
Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dabblers:																			
Mallard	138,481	142,556	153,473	160,628	188,972	169,213	157,853	146,034	145,191	115,974	158,416	82,472	72,843	76,979	103,411	78,368	80,922	102,245	96,448
Black Duck	56	0	0	0	0	0	0	117	0	0	174	56	0	174	174	0	0	0	174
Gadwall	4,457	5,413	5,324	3,515	4,740	5,733	6,482	13,670	4,951	3,400	12,635	3,752	8,064	5,298	5,075	3,616	3,677	5,191	4,941
American Wigeon	1,335	194	1,512	699	1,570	56	1,045	285	1,218	230	4,634	1,327	174	404	810	230	754	1,155	513
Green-winged Teal	569	0	2,170	638	858	117	1,613	1,564	1,267	630	678	230	694	167	278	400	172	230	404
Blue-winged Teal	70,323	47,737	57,196	45,495	47,788	36,106	60,288	37,706	91,982	46,759	94,152	48,394	38,328	29,407	40,777	37,286	32,742	61,772	49,779
Northern Shoveler	3,997	6,236	15,614	15,120	5,377	6,661	26,175	12,058	9,762	2,550	6,747	915	1,273	1,276	5,469	3,456	10,413	3,251	8,320
Northern Pintail	1,331	575	1,154	867	1,449	1,153	979	1,028	56	402	404	174	230	582	230	56	174	345	174
Wood Duck	39,996	29,848	43,132	35,103	46,659	45,866	49,067	31,777	21,603	21,759	37,553	16,253	12,616	10,281	27,652	19,802	22,664	24,029	20,242
Dabbler subtotal	260,545	232,559	279,575	262,065	297,413	264,905	303,502	244,239	276,030	191,704	315,393	153,573	134,222	124,568	183,876	143,214	151,518	198,218	180,995
Divers:																			
Redhead	8,729	9,176	2,876	3,809	3,880	5,616	5,911	7,552	2,289	1,092	3,656	2,438	842	2,373	3,107	1,926	1,878	6,733	4,523
Canvasback	4,914	4,034	2,792	2,034	5,200	3,262	6,072	2,549	2,996	3,516	3,684	972	833	2,517	4,311	2,785	1,687	2,461	1,883
Scaup	57,670	28,420	65,585	31,138	28,416	14,041	32,376	15,743	13,016	5,117	30,906	12,397	1,971	1,894	14,854	12,571	3,299	9,283	2,686
Ring-necked Duck	12,481	4,030	23,755	9,913	7,986	6,060	18,565	14,768	16,542	5,294	15,675	13,829	12,085	4,525	43,169	22,501	8,579	22,523	13,495
Goldeneye	1,706	2,291	3,834	1,340	1,041	1,687	1,684	2,367	3,477	1,539	1,269	1,383	1,216	1,092	976	1,384	864	1,393	640
Bufflehead	1,374	56	1,439	291	404	111	56	111	2,609	1,011	2,944	517	513	868	4,231	2,521	1,206	4,551	697
Ruddy Duck	3,223	2,633	1,937	993	11,052	1,613	0	779	22,054	3,192	2,567	2,443	1,060	261	1,114	1,384	437	3,942	756
Hooded Merganser	1,275	1,439	2,411	1,719	1,202	2,641	2,392	2,299	3,432	1,209	2,251	1,785	1,776	519	1,947	1,993	1,890	3,765	3,236
Large Merganser	230	174	0	56	0	0	117	228	522	972	234	723	957	626	1,032	681	681	519	230
Diver subtotal	91,602	52,253	104,629	51,293	59,181	35,031	67,173	46,396	66,937	22,942	63,186	36,487	21,253	14,675	74,741	47,746	20,521	55,170	28,146
Total Ducks	352,147	284,812	384,204	313,358	356,594	299,936	370,675	290,635	342,967	214,646	378,579	190,060	155,475	139,243	258,617	190,960	172,039	253,388	209,141
Other:																			
Coot	14,777	4,965	193,021	34,700	6,331	15,020	72,793	5,321	21,804	11,319	106,845	11,641	15,633	6,290	55,927	9,213	691	3,965	26,401
Canada Goose	48,595	58,066	60,870	60,449	79,147	80,012	105,932	89,418	78,200	87,663	98,339	83,384	75,688	98,316	70,311	67,473	66,085	60,603	87,193

Table 7. Mallard, blue-winged teal, and other duck (excluding scaup) populations in Minnesota, 1968-2012.

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

Table 7. Cont.

Year	Mallard				Blue-winged teal				Other ducks (exc. scaup)		
	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI	SE	Unad. PI	VCF	PI
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
Averages:											
10-year	101,682	2.72	272,337	36,937	52,160	4.02	210,127	47,026	65,189	3.55	221,065
Long-term	102,446	2.22	226,146	36,313	58,984	3.89	218,785	42,777	60,948	3.15	178,349
% change from											
2011	-6%	-16%	-21%	-10%	-19%	-37%	-49%	-64%	-24%	-6%	-29%
10-year average	-5%	-14%	-17%	22%	-5%	-46%	-48%	-32%	-8%	-37%	-39%
Long-term average	-6%	5%	-1%	24%	-16%	-44%	-50%	-25%	-1%	-29%	-24%

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

	Scaup			Total Ducks (exc. scaup)		Total ducks		Canada geese		
Year	Unad. PI	VCF	PI	Unad. PI	PI	Unad. PI	PI	Unad. PI	VCF	PI
1999	14,041	2.49	35,002	285,778	680,463	299,819	715,465	80,012	3.35	268,168
2000	32,376	2.1	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	5.3	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	2.7	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
Averages:										
10-year	10,531	3.55	34,796	218,866	704,233	229,362	739,030	78,606	2.32	180,264
Long-term	21,736	3.15	64,048	222,341	623,441	244,069	687,489	44,875	2.37	161,669
% change from										
2011	-71%	-6%	-73%	-15%	-32%	-17%	-33%	44%	-30%	1%
10-year average	-74%	-37%	-83%	-6%	-33%	-9%	-36%	11%	-22%	-13%
Long-term average	-88%	-29%	-91%	-7%	-25%	-14%	-31%	94%	-24%	-2%

Appendix A. Temperature and precipitation at selected cities in, or adjacent to, Minnesota May Waterfowl Survey Strata, 22 April - 20 May 2012 (Source: Minnesota Climatological Working Group, http://climate.umn.edu/cawap/nwssum/nwssum.asp).

		Temperature (F) for week ending:										Total weekly precipitation (inches)					Precipitation departure from normal
		22-April		29-April		6-May		13-May		20-May							
Region	City	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	Avg[1]	Depart[2]	22-April	29-April	6-May	13-May	20-May	1 Apri1-May 20
NW	Crookston	42.2	-1.9	51.2	3.8	56.6	6.3	56.2	3.1	62.3	6.6	0.56	0.03	0.26	0.07	0.40	-1.18
NC	Grand Rapids	36.1	-7.6	47.4	0.7	53.4	3.9	53.6	1.4	60.0	5.3	2.17	0.20	0.88	0.46	1.04	2.71
	Itasca	38.7	-2.3	48.3	4.1	m		52.8	2.7	63.2	10.4	2.92	0.02	m	0.29	0.45	0.72
WC	Alexandria	43.4	-2.1	50.8	2.2	57.2	5.7	55.0	0.8	64.8	8.1	0.97	0.18	1.09	0.16	0.68	1.82
	Fergus Falls																
	Montevideo	44.8	-1.8	51.1	1.4	60.4	7.7	56.4	1.0	67.9	9.8	1.74	0.75	2.14	0.29	1.30	2.66
	Morris	42.8	-3.0	49.9	0.9	57.8	5.8	55.2	0.4	66.6	9.2	1.59	0.19	0.80	0.13	0.15	-0.39
C	Becker	43.2	-4.7	50.0	-1.0	58.8	5.0	56.0	-0.4	66.8	8.0	1.45	0.13	4.88	0.24	1.02	2.76
	Hutchinson	44.8	-2.8	50.5	-0.1	60.6	7.4	57.5	1.6	68.4	10.0	1.70	0.24	3.75	0.24	0.50	2.97
	St. Cloud	43.8	-2.5	51.2	2.0	60.4	8.5	55.0	0.5	64.8	7.9	0.82	0.10	3.65	0.23	1.04	3.19
	Staples	Missing															
	Willmar	43.4	-3.7	49.7	-0.6	59.9	6.7	55.5	-0.4	66.0	7.4	1.28	0.26	1.28	0.28	1.36	2.77
EC	Aitkin	39.0	-4.6	46.3	-0.1	54.6	5.7	50.3	-1.1	58.8	5.0	2.58	0.03	1.15	0.49	1.37	1.81
	Cambridge																
	Msp Airport	46.4	-2.8	52.5	0.5	62.0	7.4	58.8	1.8	67.6	8.1	0.80	0.35	4.23	0.12	0.44	3.13
SW	Pipestone	47.0	0.3	51.4	1.7	60.3	7.8	53.8	-1.4	65.7	7.9	1.10	0.78	5.84	0.10	1.24	7.21
	Redwood Falls	45.4	-2.9	53.2	1.8	63.6	9.4	57.6	0.7	68.4	9.0	0.94	0.23	4.79	0.15	0.71	3.62
	Worthington	46.4	-0.1	51.9	2.4	61.6	9.2	56.2	1.1	66.8	9.0	1.24	0.49	3.11	0.17	0.47	1.95
SC	Faribault	Miss								59.1							
	Waseca	45.2	-2.6	50.8	-0.1	60.6	6.9	56.6	0.1	67.8	8.7	1.73	0.28	1.49	0.07	0	-0.20
	Winnebago	47.6	-0.5	52.4	1.4	62.6	8.8	57.5	1.0	68.6	9.5	1.47	0.58	4.47	0.08	0.19	2.50
Statewide		42.2	-3.2	49.3	0.9	57.5	6.4	54.9	1.2	64.0	7.8	1.38	0.26	2.04	0.20	0.60	

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

Waterfowl information is taken from the U.S. Fish and Wildlife Service report Waterfowl Population Status, 2012 by Kathy Fleming, Pamela Garrettson, Walt Rhodes, and Nathan Zimpfer. The entire report is available on the Division of Migratory Bird Management home page (http://www.fws.gov/migratorybirds/reports/reports.html .

Table 1. Canada goose population indices (in thousands) of the eastern prairie flock, 1971-2012 (from: U.S. Fish and Wildlife Service. 2012. Waterfowl population status, 2012. U.S. Department of the Interior, Washington, D.C. U.S.A.).

Year	Population[a]
1972	95.0
1973	116.6
1974	96.7
1975	121.5
1976	168.4
1977	110.8
1978	111.2
1979	72.8
1980	n.a.
1981	78.9
1982	96.4
1983	92.8
1984	112.0
1985	105.6
1986	126.4
1987	145.9
1988	137.0
1989	132.1
1990	163.4
1991	167.4
1992	158.4
1993	136.2
1994	136.2
1995	139.0
1996	141.0
1997	130.5
1998	99.3
1999	139.5
2000	130.0
2001	122.2
2002	152.0
2003	122.4
2004	145.5
2005	161.6
2006	134.8
2007	153.4
2008	161.1
2009	169.2
2010	172.6
2011	133.1
2012	116.3

[a] Number of indicated singles (x2) and breeding pairs.

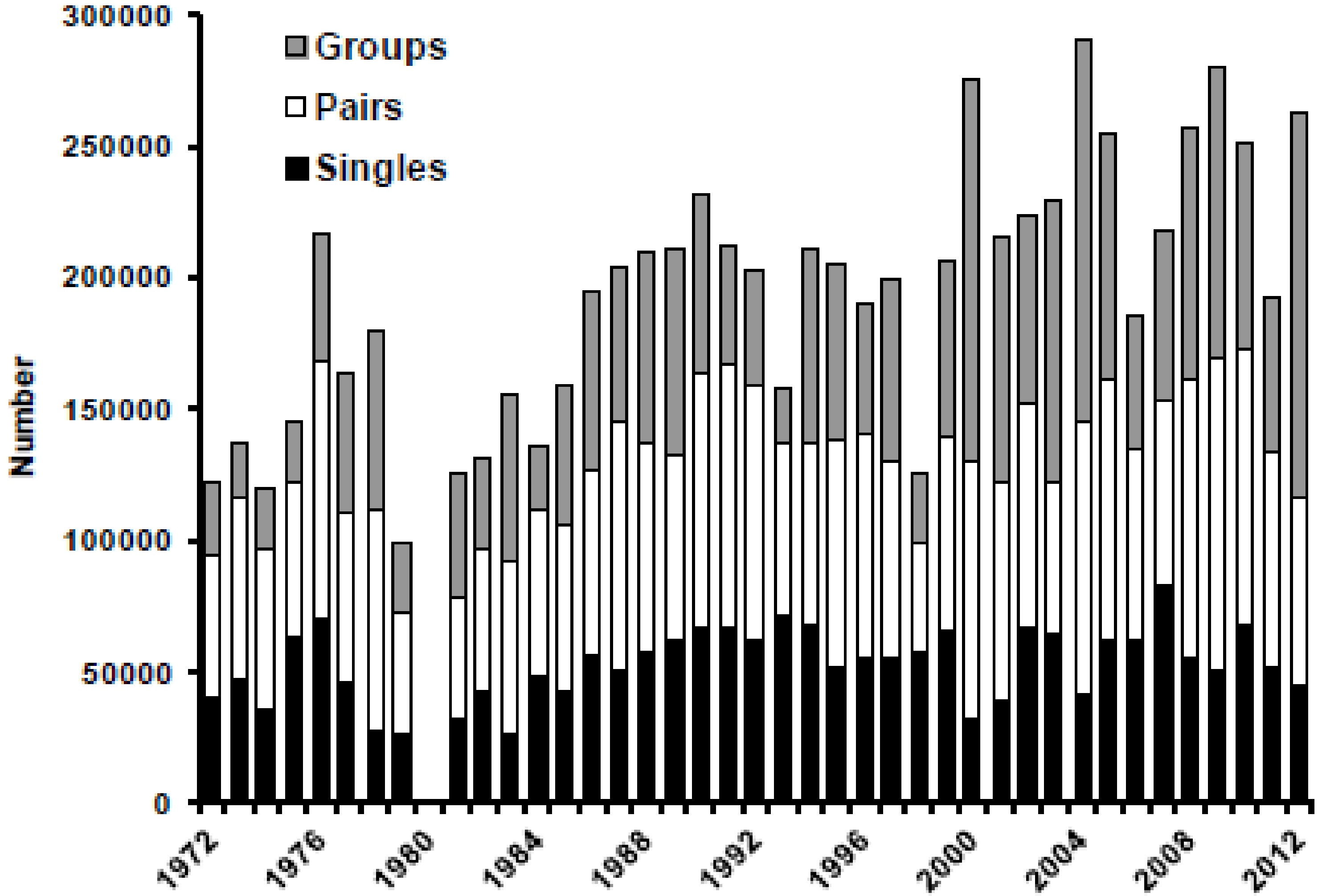


Figure 1. Breeding ground survey estimates of the Eastern Prairie Population of Canada geese, 1972-2012. (from: Baldwin, F., J. Wollenberg, and B. Lubinski. 2012. 2012 EPP Breeding Population Survey. Unpublished report prepared for the Mississippi Flyway Council Technical Section). Data not available for 1980.

Table 2. Estimated number of May ponds (adjusted for visibility) in Prairie Canada (portions of Alberta, Saskatchewan and Manitoba) 1967-2011 and north-central U.S. (North Dakota, South Dakota and Montana) 1974-2011. (from: U.S. Fish and Wildlife Service. 2011. Waterfowl population status, 2011. U.S. Department of the Interior, Washington, D.C. U.S.A.)

	Ponds (thousands)	
Year	Prairie Canada	North Central U.S.[a]
1967	4,691	--
1968	1,986	--
1969	3,548	--
1970	4,875	--
1971	4,053	--
1972	4,009	--
1973	2,950	--
1974	6,390	1,841
1975	5,320	1,911
1976	4,599	1,392
1977	2,278	771
1978	3,622	1,590
1979	4,859	1,522
1980	2,141	761
1981	1,443	683
1982	3,185	1,458
1983	3,906	1,259
1984	2,473	1,766
1985	4,283	1,327
1986	4,025	1,735
1987	2,524	1,348
1988	2,110	791
1989	1,693	1,290
1990	2,817	691
1991	2,494	706
1992	2,784	825
1993	2,261	1,351
1994	3,769	2,216
1995	3,893	2,443
1996	5,003	2,480
1997	5,061	2,397
1998	2,522	2,065
1999	3,862	2,842
2000	2,422	1,524
2001	2,747	1,893
2002	1,439	1,281
2003	3,522	1,668
2004	2,513	1,407
2005	3,921	1,461
2006	4,450	1,644
2007	5,040	1,963
2008	3,055	1,377
2009	3,568	2,866
2010	3,729	2,936
2011	4,893	3,239
2012	3,885	1,659
Average	3,457	1,651
% Change in 2012 from:		
2011	- 21	- 49
Long term Average	+ 12	+ 1

[a] No comparable survey data available for the north-central U.S. during 1967-73.

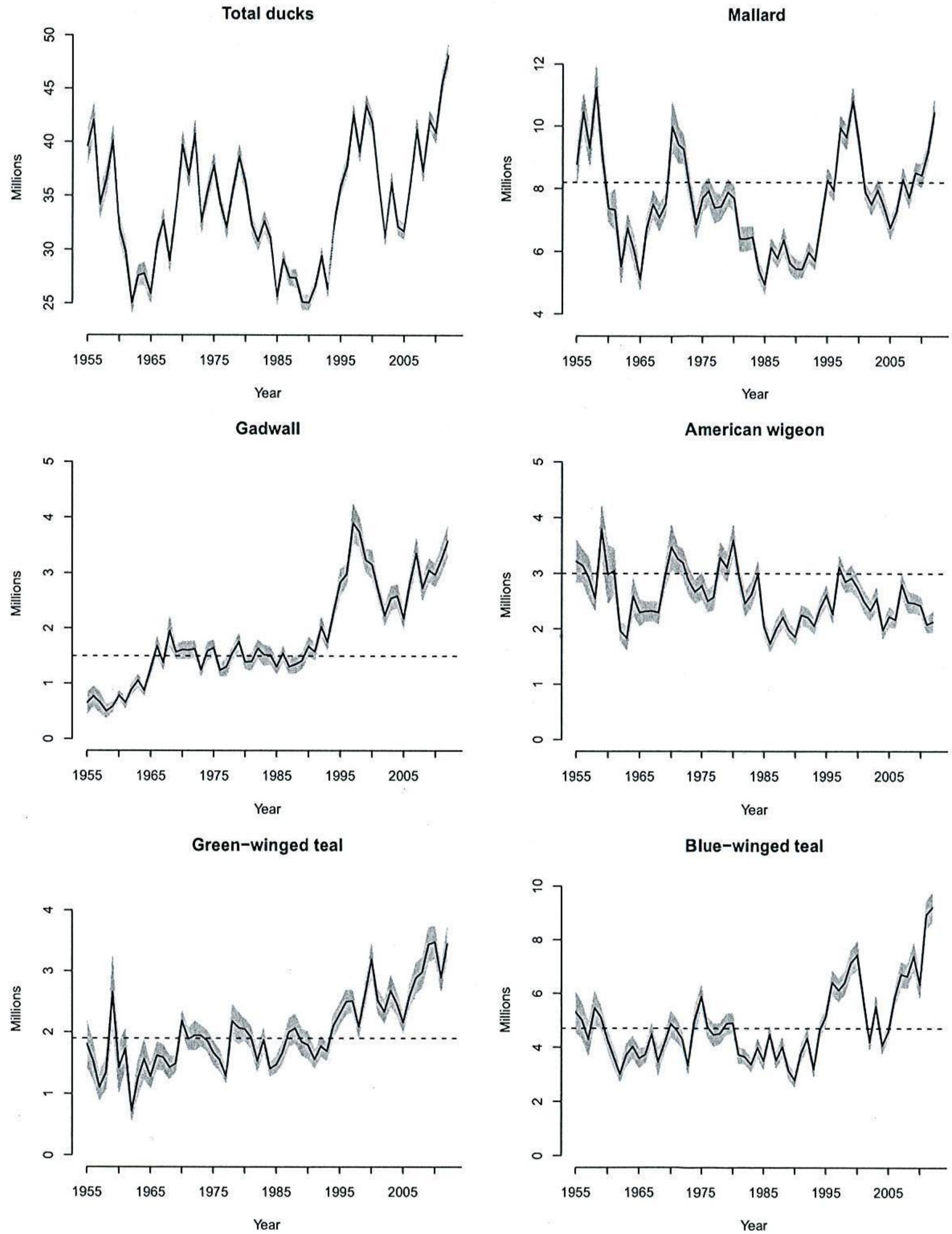


Figure 2. Estimates of North American breeding populations, 95% confidence intervals, and North American Waterfowl Management Plan population goal (dashed line) for selected species and number of water areas in May in Prairie Canada and Northcentral U.S. (from: U.S. Fish and Wildlife Service. 2012. Waterfowl population status, 2012. U.S. Department of the Interior, Washington, D.C. U.S.A.)

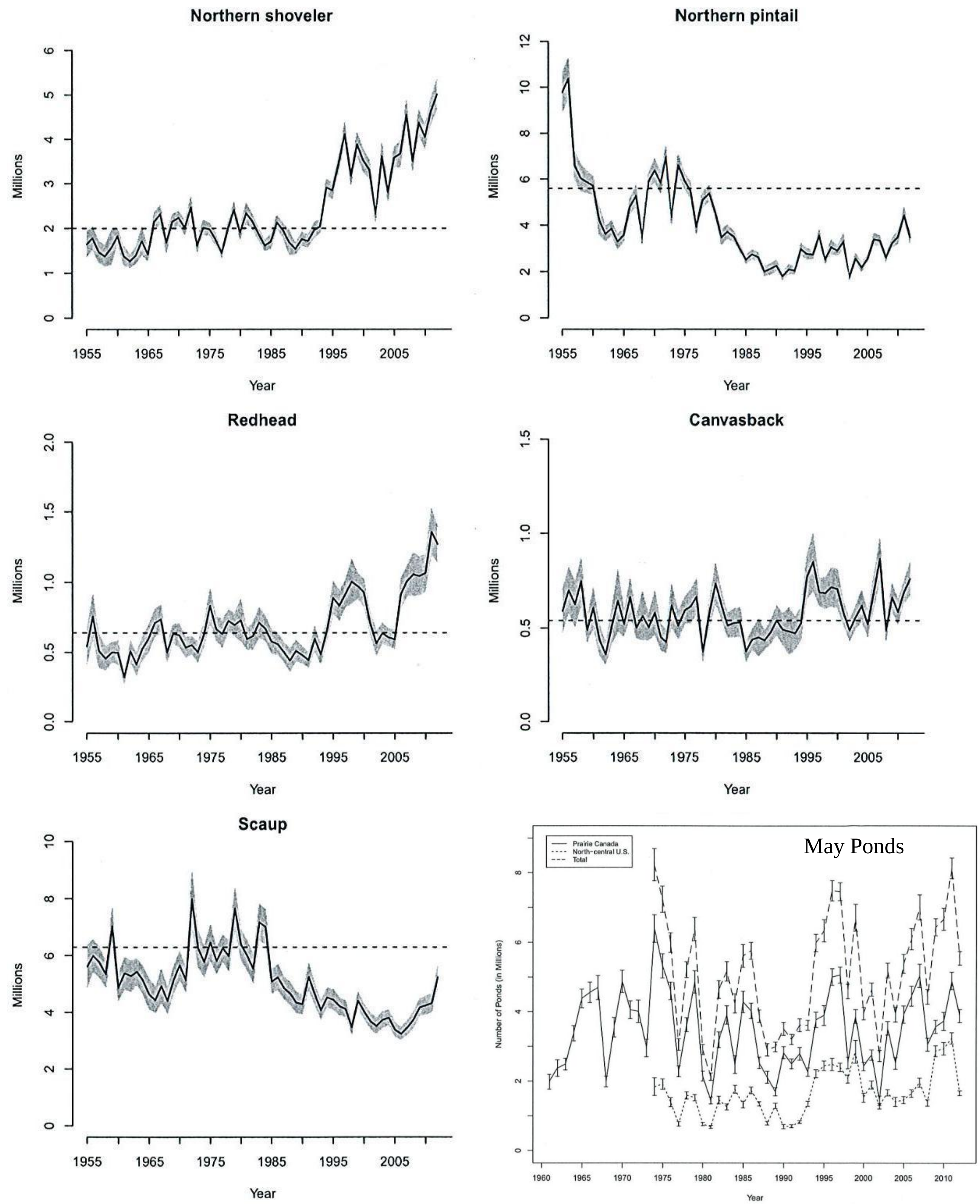


Figure 2. (continued).

2012 MINNESOTA SPRING CANADA GOOSE SURVEY

David Rave, Wetland Wildlife Populations and Research Group

INTRODUCTION

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

METHODS

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

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

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

Habitat-classification criteria for each ecoregion was:

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

Transition

No geese =	Type 3-4-5 <1 acre and rivers <8 acres or plot is all water. (n = 39,484 plots).
1-2 pairs =	Type 3-4-5 = 1-25 acres or Type 3-4-5 >25 acres, but Type 3 <15 acres or Type 3-4-5 <1 acre and rivers >8 acres. (n = 31,091 plots).
3+ pairs =	Type 3-4-5 >25 acres, but Type 3 >15 acres and plot is not all water. (n = 7,988 plots).

Forest

No geese =	Type 3-4-5 <2 acres and rivers <2 acres or plot all water. (n = 75,835 plots).
1-2 pairs =	Type 3-4-5 ≥2 acres, but not all water or Type 3-4-5 <2 acres and rivers >2 acres. (n = 51,155 plots).
3+ pairs =	None.

Plots in the "no geese class" are not flown and there are no plots in the "3+ pairs" class in the Forest ecoregion. Prior to 2011, 30 plots were randomly selected in each of the 5 remaining strata using ArcView's AlaskaPak extension, and these 150 plots were surveyed at low level using a helicopter. The stratification was modified slightly in 2011 to include a binary stratification variable (zone), which permitted a domain analysis of total geese in a proposed new hunting zone (Figure 1). Thus, the 9 strata for 2012 were Forest–12, Transition–12new, Transition–12other, Transition–3new, Transition– 3other, Prairie–12new, Prairie–12other, Prairie–3new, and Prairie–3other. Thirty plots (quartersections) were randomly selected from strata in the new zone (using proportional allocation) and 130 plots were selected from strata not in the new zone for a total of 160 sample plots (Figure 1). Ideally, the survey should be conducted during mid-incubation.

Pilot John Heineman and I flew the survey on 6 days between 16 and 23 April, 2012. Canada geese seen within plot boundaries were recorded as singles, pairs, and groups. We also recorded whether singles and pairs were observed with a nest. The number of singles and pairs was doubled when the total number of geese per plot was calculated.

RESULTS AND DISCUSSION

The total Canada goose population estimate in the surveyed area for 2012 was 416,198 (±132,344). Adding 17,500 for the Twin Cities metro area (Cooper 2004) yields a statewide estimate of 433,698 (Table 1). Relative error (95% CI half-width) was 31.8% of the estimate. The survey tallied 30.0% singles, 49.6% pairs, and 20.4% groups (Table 2). Typically, many of the pairs seen on this survey are not associated with nests and are likely nonbreeders. An index to nesting effort (i.e., Productive Geese) was obtained by combining singles and pairs associated with nests. In 2012, 35.1% of the geese seen were classified as Productive Geese (Table 2).

The 2012 Canada goose breeding population estimate for the surveyed area was similar to the 2011 estimate, although goose numbers appeared to be higher in the Transition and Forest regions (Table 1). A time-series plot suggested the goose population in the survey area has been reasonably stable over the last 12 years, with an increasing trend over the past 4 years (Figure 2). The estimated breeding population in the proposed new hunting zone was 127,220 (±64,628), which was similar to the 2011 estimate for this zone (151,699±105,319).

Weather conditions in 2012 were characterized by warmer than normal March temperatures and record early lake ice-out statewide, and normal weather throughout most of the incubation period and during the survey period. The early spring and the number of productive geese observed this year indicates that 2012 will likely be a very good year for Canada goose production. Weather conditions throughout May and June may influence goose productivity. Regardless, the 2012 Canada goose population estimate remained well above the state Canada goose population goal of 250,000 geese.

Wetland and habitat quality were variable in the state this year. Wetland conditions were drier than average throughout the state. However, timely rainfall in late April and early May moderated the dry conditions. Due to the early spring weather conditions, which will lead to large broods, and the high number of geese in the population, I expect average to above average Canada goose production throughout the state again in 2012.

ACKNOWLEDGEMENTS

Frank Martin (Univ. of MN) and Steve Maxson were instrumental in the original design of this survey. Steve also was the principal observer during the first 6 years of the survey. Tim Loesch, Christopher Pouliot, and Shelly Sentyrz set up the original 2,700 ¼-section plots using ArcView and were very helpful in getting the survey up and running in 2001. Shelly Sentyrz was also instrumental in helping to restratify plots statewide for the 2008 survey. Chris Scharenbroich provided GPS coordinates of plots to the pilot, and printed out maps of the 150 plots flown this year. John Heineman and Michael Trenholm piloted the helicopter and served as the second observer. Robert Wright provided GIS expertise. John Giudice provided statistical assistance. Christine Herwig helped with printing aerial photos. Cindy Kuettel helped with excel graphics.

LITERATURE CITED

Cooper, J. 2004. Canada goose program report 2004. Unpublished report. 20 pp.

Maxson, S.J. 2002. 2002 Minnesota Spring Canada Goose Survey. Unpublished Report.

Table 1. Spring Canada goose population estimates in Minnesota, 2001-2012.

Year	Prairie	Transition	Forest	Subtotal	95% CI	Metro	**TOTAL**
2001	77,360	95,470	92,390	265,220	±69,500	20,000	**285,220**
2002	135,850	144,900	33,940	314,690	±134,286	20,000	**334,690**
2003	106,520	121,290	56,420	284,230	±78,428	20,000	**304,230**
2004	128,501	130,609	95,636	354,747	±107,303	20,000	**374,747**
2005	113,939	149,286	57,529	320,754	±90,541	17,500	**338,254**
2006	126,042	164,085	67,994	358,071	±108,436	17,500	**375,571**
2007	137,151	99,274	25,509	261,933	±80,167	17,500	**279,433**
2008*	113,483	127,490	30,400	271,372	±69,055	17,500	**288,872**
2009	129,115	114,737	23,644	267,496	±70,607	17,500	**284,996**
2010	83,911	151,902	57,421	293,234	±70,760	17,500	**310,734**
2011	143,266	117,711	91,199	352,175	±119,814	17,500	**369,674**
2012	144,762	166,727	104,710	416,198	±132,344	17,500	**433,698**

*Prior to 2008, double-sampling for stratification was used to estimate stratum weights. The entire frame was re-stratified in 2008 (double-sampling was eliminated) and Lake of the Woods and the NW Angle were removed from the frame. The sampling frame was adjusted slightly in 2009 because of some processing errors in 2008. The population estimates for 2008-2012 are based on the updated sampling frame.

Table 2. Percent of Canada Geese seen as singles, pairs, groups, and productive geese on the Minnesota Spring Canada Goose Survey, 2001-2012.

Year	Singles[1]	Pairs[1]	Groups	Productive Geese[2]	Dates of Survey
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

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

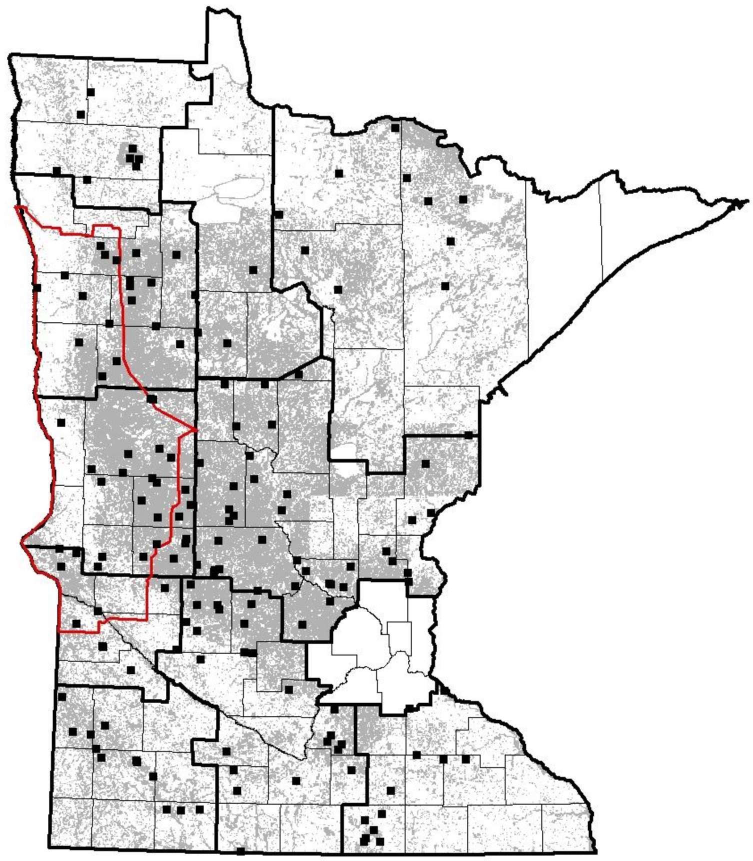


Figure 1. Location of 160 ¼ mi^2 plots surveyed for the 2012 Canada goose breeding pair survey within 3 ecoregions of Minnesota; forest, transition, and prairie. Red outlined polygon is the location of a possible "new" Early Season Canada goose hunting zone.

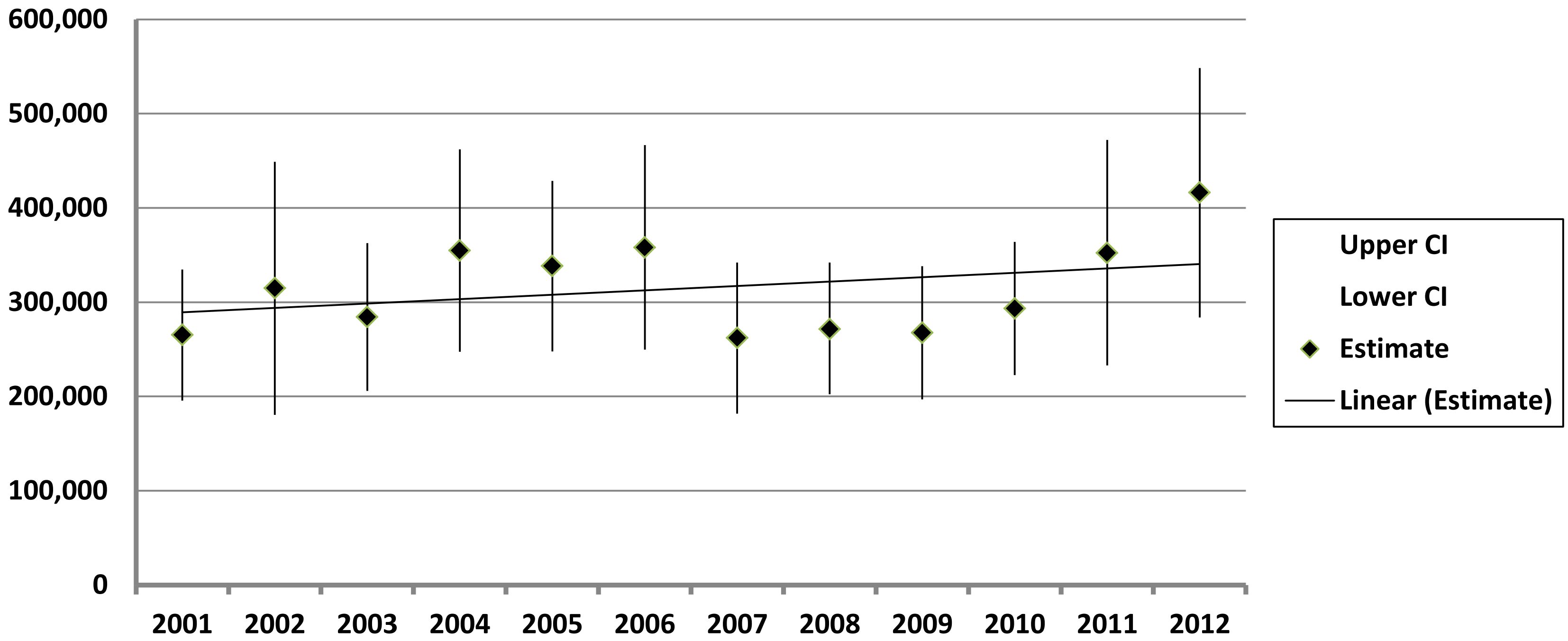


Figure 2. Spring Canada goose population estimates (±95% CI) in Minnesota, 2001-2012. (Does not include Metro area.)

Mourning dove information is taken from the U.S. Fish and Wildlife Service report by Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp. The entire report is available on the Division of Migratory Bird Management web site (http://www.fws.gov/migratorybirds/NewReportsPublications/PopulationStatus.html).

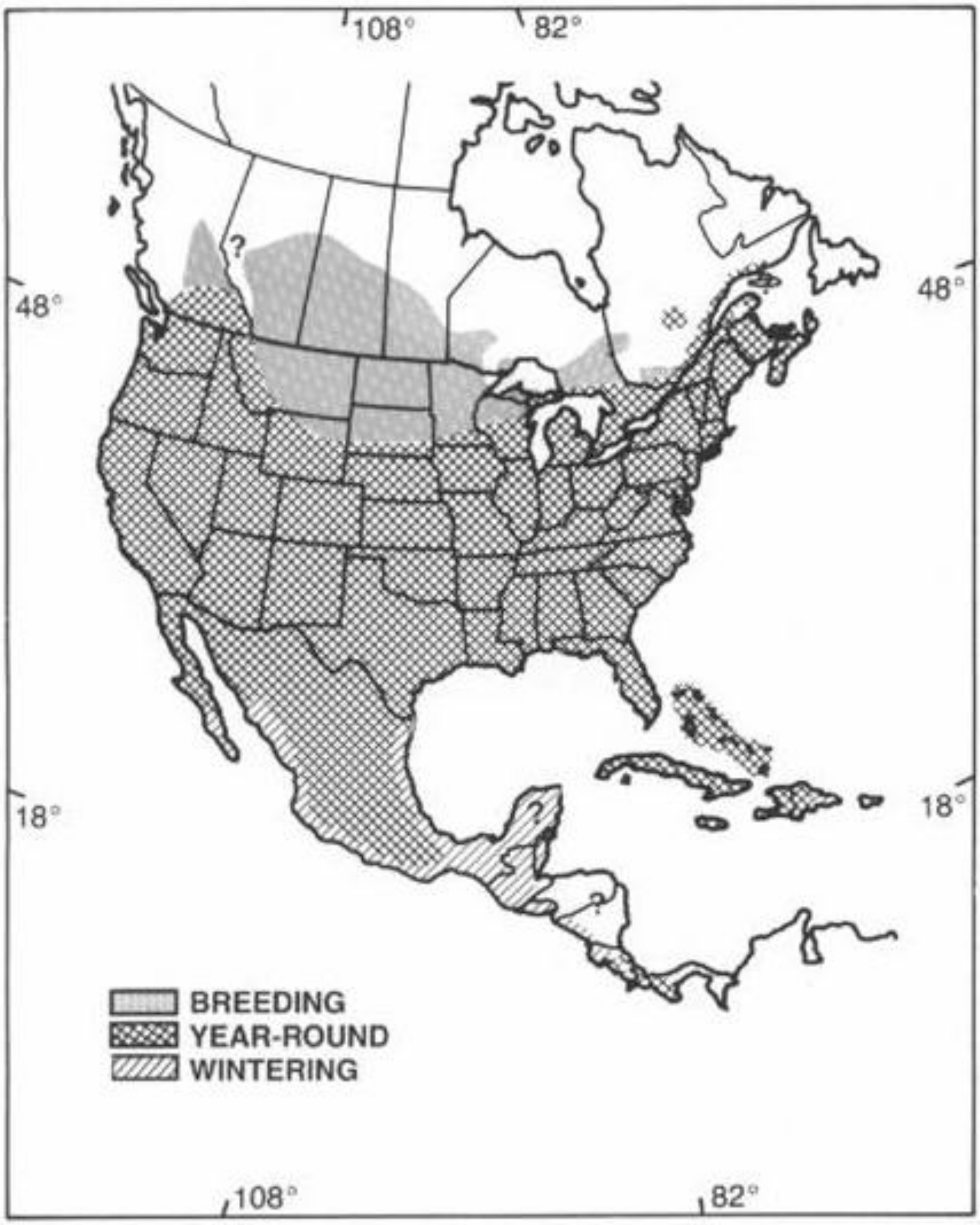


Figure 1. Breeding and wintering ranges of the mourning dove (adapted from Mirarchi and Baskett 1994). (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp.)

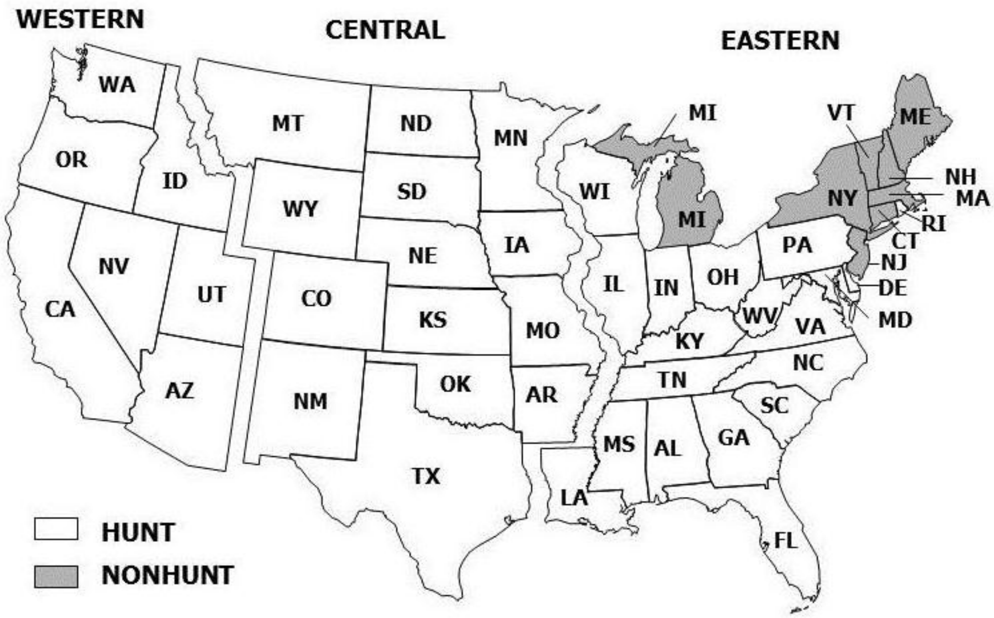


Figure 2. Mourning dove management units with 2011 hunting and non-hunting states. (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp.)

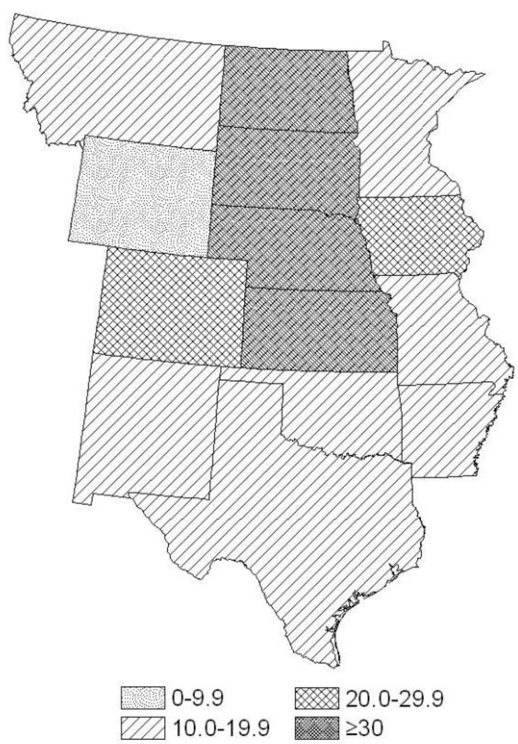


Figure 3. Mourning dove abundance in the Central Management Unit, based on the mean of the 2 CCS-heard index values from the last 2 years (2011-12). (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 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 2009, 2010 and 2011 seasons [a]. (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp.)

Management unit / State	Active Hunters			Hunter Days Afield			Total Harvest		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
CENTRAL	393,400 † [b]	406,100 †	427,700 †	1,312,700	1,362,300	1,444,800	7,474,600 ± 12	7,194,900 ± 10	7,657,700
AR	22,400 ±19	23,900 ±20	25,300 ±20	53,800 ± 26	63,300 ± 28	63,800 ±34	353,500 ± 21	446,400 ± 28	519,300 ±43
CO	20,300 ± 13	15,900 ± 14	15,300 ±14	45400 ± 18	38,400 ± 19	44,500 ±24	242,400 ± 17	172,000 ± 18	178,700 ±14
IA			5,800 ±11			19,000 ±17			56,800 ±21
KS	29,400 ± 10	28,200 ± 10	32,800 ±10	97,000 ± 14	93,900 ± 13	95,800 ±15	572,600 ± 16	511,200 ± 15	534,800 ±18
MN	6,800 ± 36	10,000 ± 42	9,400 ±49	24,100 ± 64	55,300 ± 115	25,100 ±51	61,500 ± 67	98,900 ± 58	57,300 ±40
MO	21,500 ± 16	29,300 ± 10	31,600 ±11	58,700 ± 21	75,200 ± 14	74,600 ±14	294,700 ± 26	426,000 ± 20	359,600 ±16
MT	2,500 ± 32	1,600 ± 35	2,200 ±37	6,400 ± 46	4,700 ± 44	5,900 ±47	12,700 ± 32	17,400 ± 36	14,400 ±61
NE	16,000 ± 12	15,800 ± 14	15,500 ±16	51,800 ± 15	49,700 ± 21	46,900 ±28	277,600 ± 17	276,400 ± 19	265,500 ±23
NM	7,800 ±16	5,900 ±20	6,700 ±39	35,700 ± 26	21,000 ± 20	24,600 ±49	170,200 ± 26	128,000 ± 29	76,900 ±42
ND	2,800 ± 28	3,800 ± 28	3,700 ±25	10,800 ± 50	11,800 ± 37	10,400 ±29	40,000 ± 31	54,200 ± 38	41,800 ±31
OK	18,600 ± 12	19,500 ± 14	17,100 ±15	55,500 ± 15	51,300 ± 22	54,200 ±25	378,400 ± 17	268,700 ± 28	379,400 ±33
SD	6,500 ± 19	5,000 ± 21	6,200 ±21	21,700 ± 23	14,200 ± 26	16,300 ±26	105,400 ± 24	64,300 ± 23	87,200 ±26
TX	236,600 ± 10	244,600 ± 10	253,200 ±11	846,200 ± 12	876,500 ± 10	958,600 ±16	4,945,100 ± 18	4,699,300 ± 14	5,061,100 ±13
WY	2,300 ± 27	2,700 ± 26	2,700 ±30	5,800 ± 31	7,100 ± 32	5,100 ±38	20,600 ± 31	32,100 ± 36	25,000 ±52

[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.

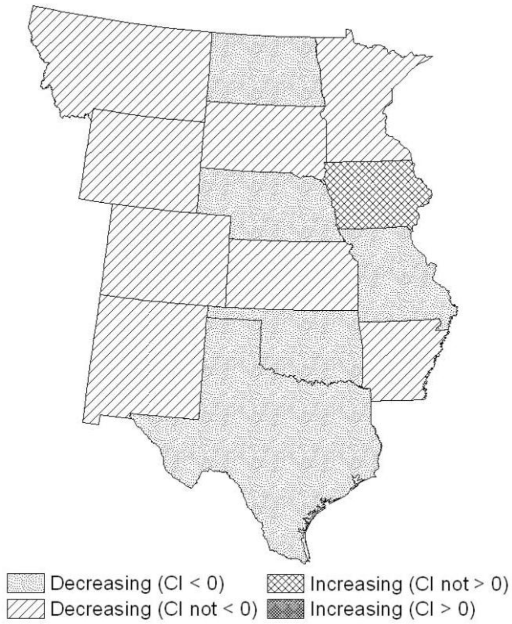


Figure 4. Trend in mourning dove abundance by state in the Central Management Unit over the last 10 years (2003-2012) based on CCS-heard data. Credible intervals (CI, 95%) that exclude zero provide evidence for an increasing or decreasing trend (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp.)

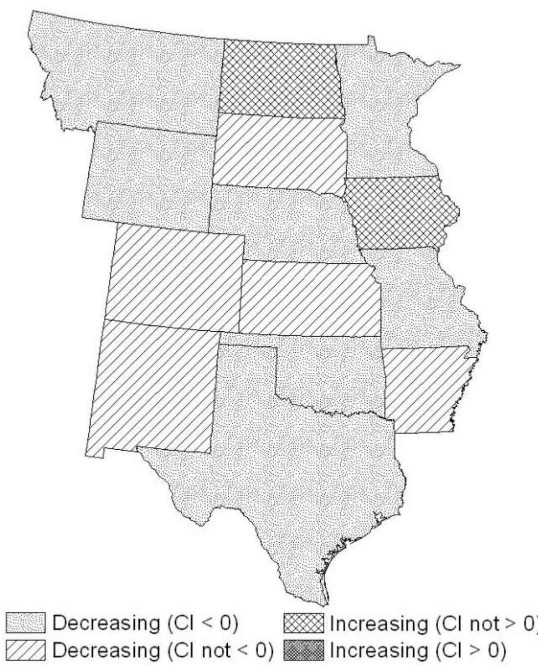


Figure 5. Trend in mourning dove abundance by state in the Central Management Unit over the last 47 years (1966-2012) based on CCS-heard data. Credible intervals (CI, 95%) that exclude zero provide evidence for an increasing or decreasing trend. (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp.)

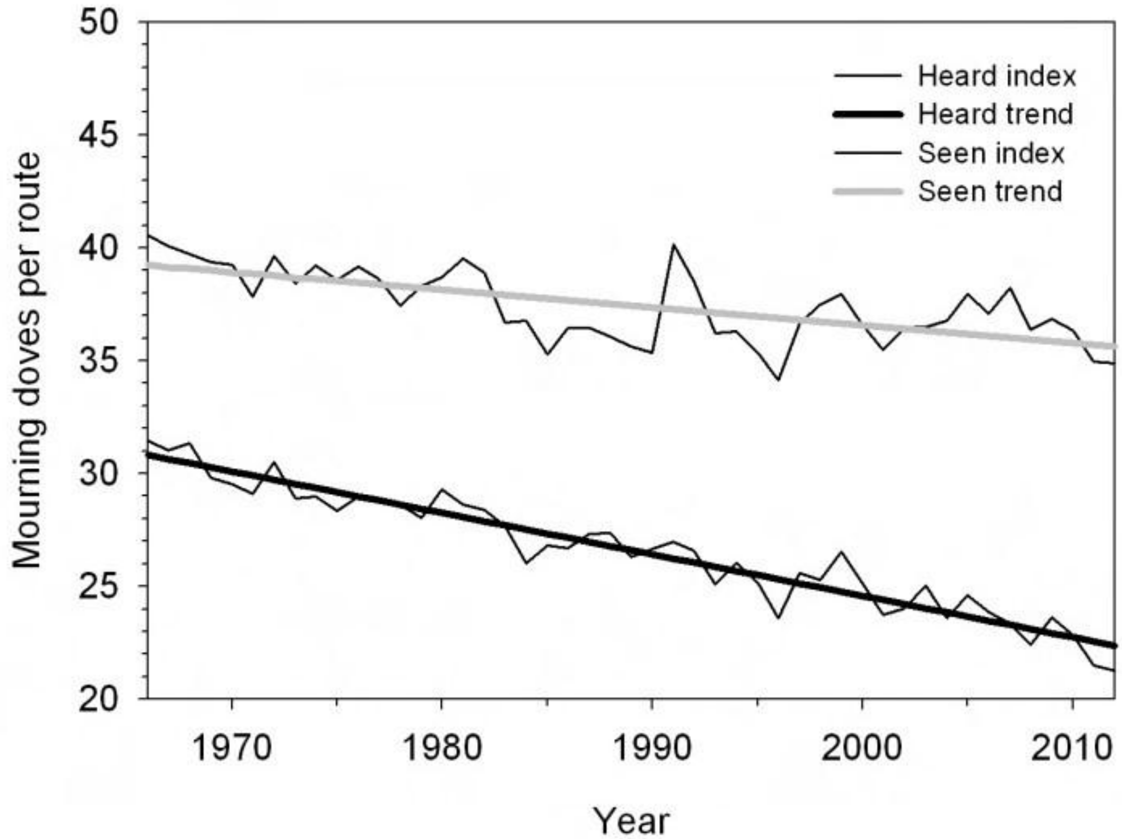


Figure 6. Mourning dove abundance indices and predicted trends in the Central Management Unit based on CCS data, 1966-2012. Trend lines are exponentiated predicted values from fitting a regression line through the log transformed annual indices. (From: Seamans, M.E., R.D. Rau, and T.A. Sanders. 2012. Mourning dove population status, 2012. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Washington, D.C. 37 pp.)

American Woodcock information is taken from the U.S. Fish and Wildlife Service report American Woodcock Population Status, 2012. Cooper, T.R. and R.D. Rau. Us. 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).

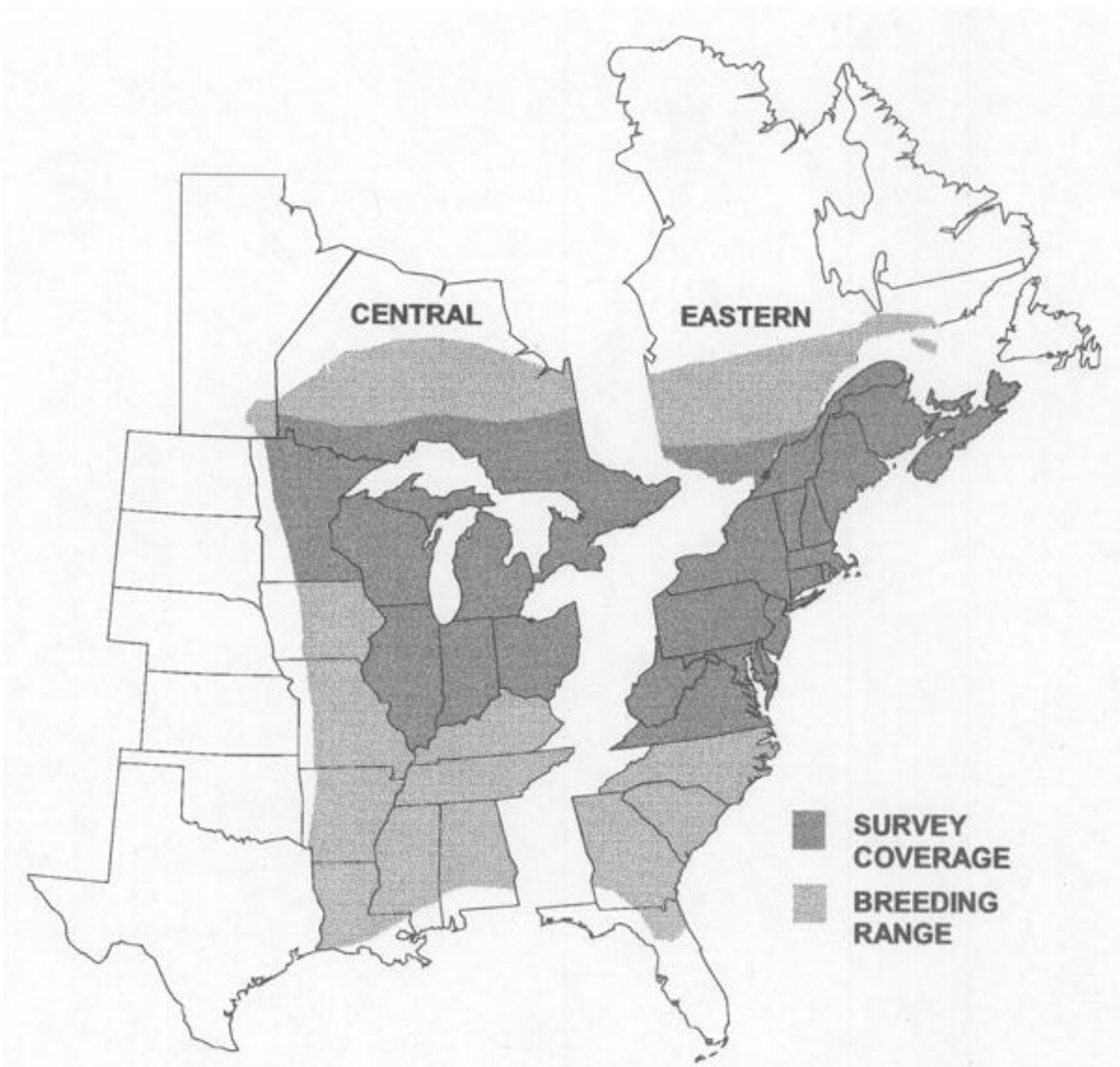


Figure 1. Woodcock management regions, breeding range, singing-ground survey coverage, (from: Cooper, T.R. and R.D. Rau. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Table 1. Short term (2011 – 12), 10 –year (2002-2012), and long-term (1968-2012) 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. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Management Unit/State	Number of Routes[b]	n[c]	(2011-12) % Change	(2002-12) % Change	(1968-12) % Change
CENTRAL	439	721	1.28	0.20	- 0.77
IL	39	45	- 38.68	- 7.59	- 1.20
IN	16	60	- 3.16	- 3.06	- 4.32
MB[d]	13	30	- 6.30	3.73	- 0.10
MI	99	151	1.75	- 0.09	- 0.86
MN	77	120	- 2.03	2.16	0.25
OH	34	72	- 1.42	- 0.54	- 1.68
ON	88	155	0.59	- 1.29	- 0.08
WI	73	118	9.34	2.96	- 0.22

[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 2012 for which data were received by 6 June, 2012.

[c] Number of routes with at least one year of non-zero data between 1968 and 2012.

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

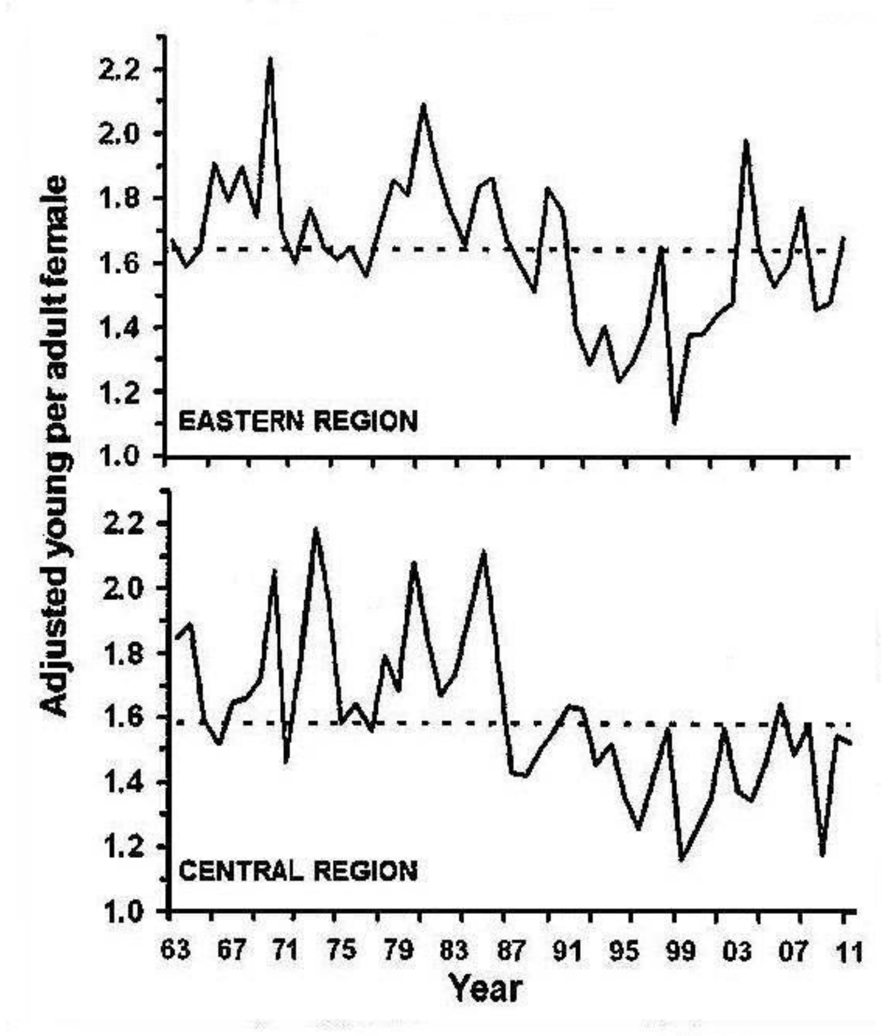


Figure 2. Weighted annual indices of American woodcock recruitment, 1963-2010. Dashed line is the 1963-2009 average. (from: Cooper, T.R. and R.D. Rau. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

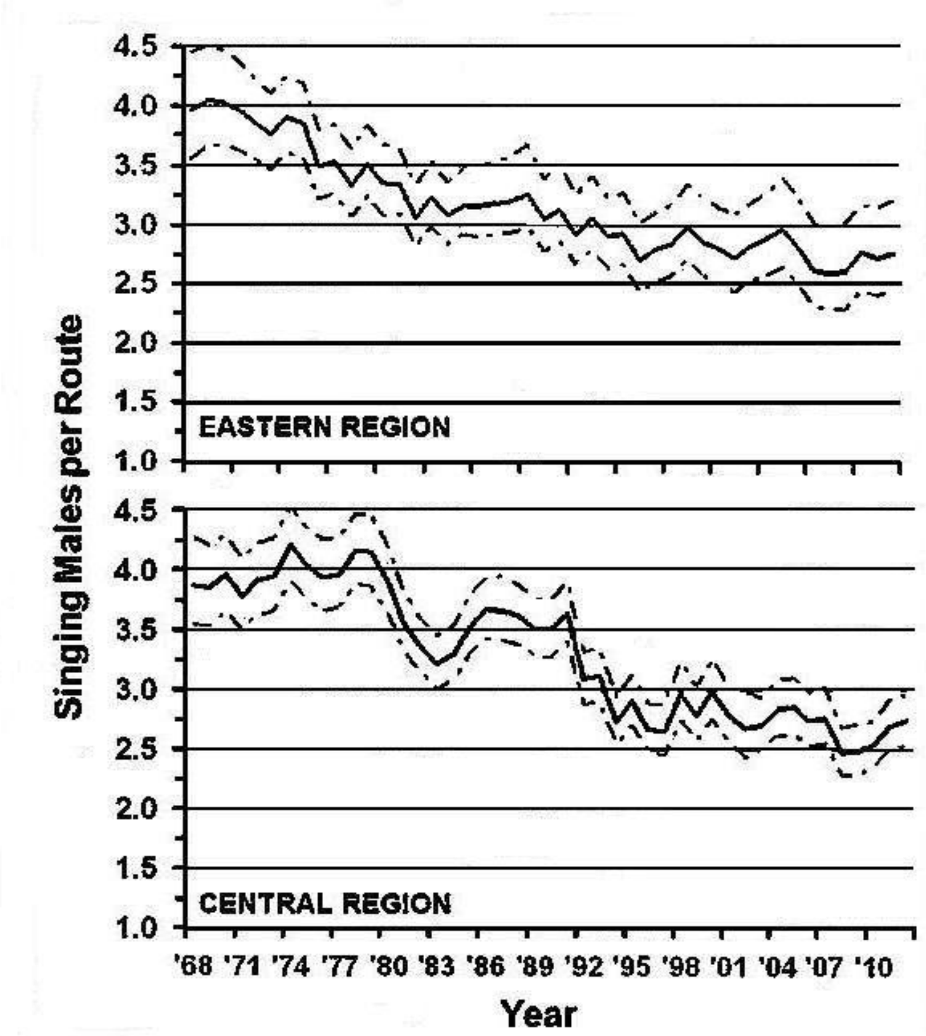


Figure 3. Annual indices of the number of woodcock heard on the Singing-ground Survey, 1968-2011. The dashed lines represent the 95th percentile credible interval. (from: Cooper, T.R. and R.D. Rau. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Table 2. Preliminary estimates of woodcock hunter numbers, days afield, and harvest for selected states, from the 2007-08, 2008-09, 2009-10 and 2010-11 Harvest Information Program surveys. Note: beginning 2008-09 all estimates rounded to the nearest 100 for harvest, hunters, and days afield. (from: Cooper, T.R. and R.D. Rau. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

Management Unit / State	Active woodcock hunters ([a])				Days afield ([a, c])				Harvest ([a, c])			
	2008-09	2009-10	2010-11	2011-12	2008-09	2009-10	2010-11	2011-12	2008-09	2009-10	2010-11	2011-12
Central Region	n.a. [b]	n.a. [b]	n.a. [b]	n.a. [b]	369,800 ± 16%	322,300 ± 14	392,400 ± 20	350,500 ± 16	174,300 ± 16%	175,100 ± 17	233,100 ± 20	231,700 ± 20
IL	2,100 ± 90%	1,800 ± 98	800 ± 171	2,900 ± 108	6,100 ± 103%	6,200 ± 91	1,200 ± 123	8,800 ± 131	4,300 ± 100%	5,300 ± 142	900 ± 106	3,700 ± 195
IN	900 ± 69%	1,100 ± 63	1,000 ± 66	1,100 ± 79	2,400 ± 63%	4,000 ± 80	3,900 ± 89	4,100 ± 86	800 ± 31%	1,700 ±79	3,000 ± 134	1,800 ± 102
MI	34,600 ± 13%	26,400 ± 15	31,100 ± 14	28,400 ± 15	156,000 ± 17%	146,200 ± 21	159,200 ± 19	144,000 ± 18	78,900 ± 17%	80,900 ± 22	93,200 ± 21	106,900 ± 28
MN	8,700 ± 37%	9,700 ± 37	13,900 ± 32	17,000 ± 29	37,900 ± 43%	38,300 ± 44	55,400 ± 33	76,900 ± 46	19,900 ± 67%	16,00 ± 48	34,800 ± 39	44,200 ± 42
OH	2,900 ± 69%	1,600 ± 82	1,800 ± 98	3,100 ± 98	10,300 ± 70%	7,200 ± 94	4,300 ± 70	10,200 ± 96	2,300 ± 68%	1,200 ± 63	1,700 ± 93	2,300 ± 74
WI	14,200 ± 24%	19,400 ± 22	14,600 ± 25	15,200 ±25	65,400 ± 35%	77,100 ±24	65,700 ± 40	69,000 ± 30	36,000 ± 27%	29,200 ± 24	42,300 ± 22	42,600 ± 31

[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.

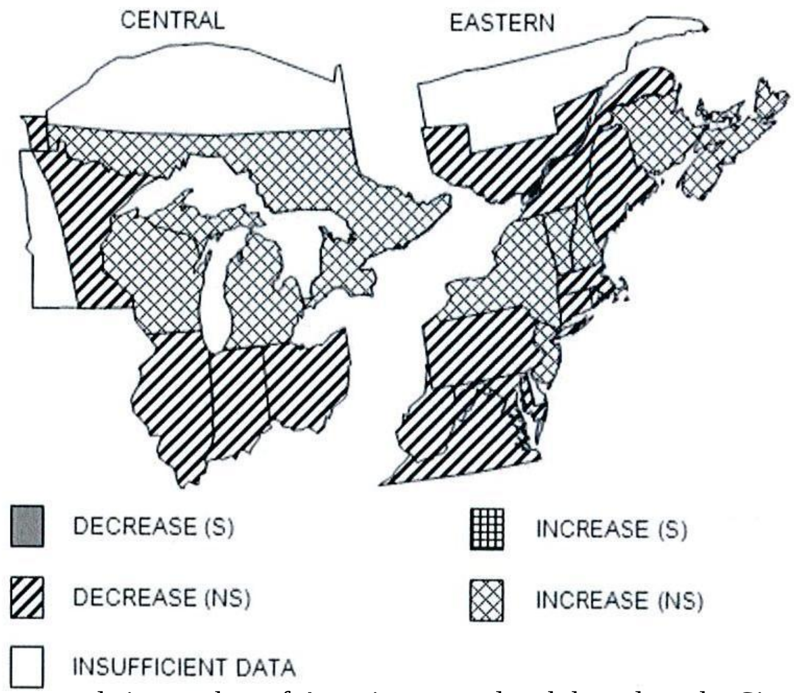


Figure 4. Short-term trends in number of American woodcock heard on the Singing-ground Survey; 2010-11, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Cooper, T.R. and R.D. Rau. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

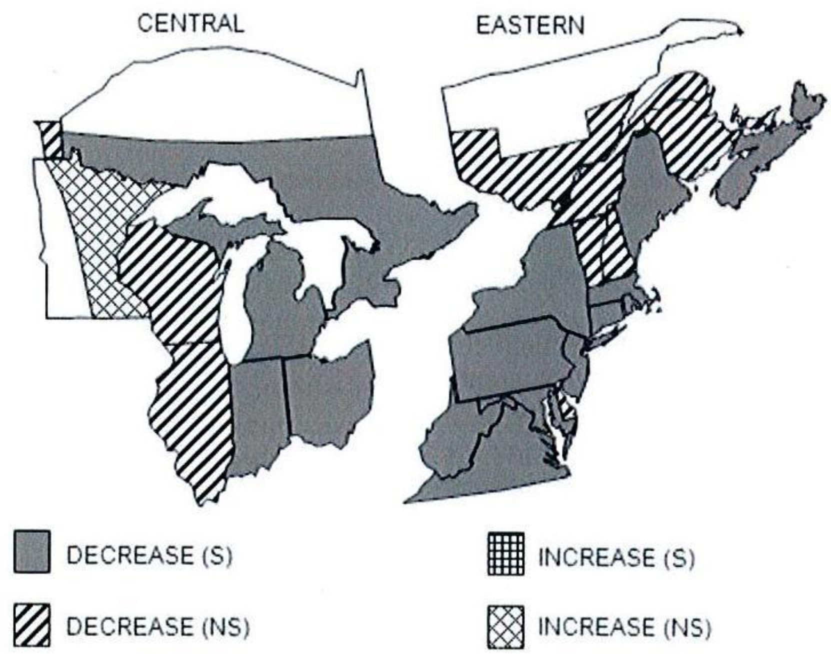


Figure 5. Long-term trends in number of American woodcock heard on the Singing-ground Survey; 1968-2011, as determined by the hierarchical modeling method. A significant trend (S) does not include zero in the 95% credible interval, while a non-significant (NS) trend does include zero. (from: Cooper, T.R. and R.D. Rau. 2012. American woodcock population status, 2012. U.S. Fish and Wildlife Service, Laurel, MD. 16 pp.).

2012 RING-NECKED DUCK BREEDING PAIR SURVEY

Jeffrey S. Lawrence, Wetland Wildlife Populations and Research Group,
John H. Giudice, Wildlife Biometrics Unit, and Erik C. Hildebrand, Wildlife Health Unit

SUMMARY OF FINDINGS

Since 2006, we have estimated numbers of ring-necked ducks in 3 Ecological Classification System (ECS) subsections containing potential ring-necked duck breeding habitat. We used helicopters to survey 234 plots, including 49 resurvey plots, in 2012. The survey was flown from 4-8 June, somewhat earlier than previous years, but well-timed based on ring-necked duck lone male to indicated breeding pair (IBP) ratios. There were an estimated 11,620 IBP (SE = 1,830) and 24,200 ring-necked ducks (SE = 3,700) in the survey area, which was similar to previous estimates, except in 2010, when the population estimate was only 11,840 breeding birds (SE = 2,520). The majority of ring-necked duck observations were in the Northern Minnesota Drift and Lake Plains ECS Section.

INTRODUCTION

Ring-necked ducks are important breeding waterfowl species in portions of Minnesota. Continental populations of ring-necked ducks have increased since the 1950s (U.S. Fish and Wildlife Service, unpublished data); however, a survey of 14 important ring-necked duck breeding lakes in north central Minnesota indicated a decline in numbers since the early 1970s (Zicus et al. 2004). This led to concern about the status of breeding ring-necked ducks in the state. Minnesota Department of Natural Resources initiated a survey in 2004 to estimate the number and distribution of breeding ring-necked ducks in Minnesota (Zicus et al. 2008). Ring-necked ducks are also important to Minnesota's waterfowl hunters and often rank 3rd most abundant duck in the annual waterfowl harvest (U.S. Fish and Wildlife Service, unpublished data).

Ring-necked ducks have been consistently surveyed in 3 Ecological Classification System (ECS) sections of Minnesota since 2006. The current survey was developed based on a pilot survey conducted in 2004-2005 (Zicus et al. 2008). Our objective was to estimate breeding pair numbers and monitor population trends for ring-necked ducks in northern Minnesota.

METHODS

We used Public Land Survey (PLS) sections (~2.6-km^2 plots, range = 1.2 – 3.0 km^2) as primary sampling units (Zicus et al. 2008). Our sampling frame consisted of PLS sections that contained any potential ring-necked duck nesting cover, which Zicus et al. (2008) defined as Minnesota GAP (MNGAP) level 4 land cover data that was either:

- Class 10 = lowlands with <10% tree crown cover and >33% cover of low-growing deciduous woody plants such as alders and willows,
- Class 14 = wetlands with <10% tree crown cover that is dominated by emergent herbaceous vegetation such as fine-leaf sedges, or
- Class 15 = wetlands with <10% tree crown cover that is dominated by emergent herbaceous vegetation such as broad-leaf sedges and/or cattails,

and was within 250 m of and adjacent to:

- Class 12 = lakes, streams, and open-water wetlands, or
- Class 13 = water bodies whose surface is covered by floating vegetation.

MNGAP class 10, 14, and 15 cover associated with lakes having a General or Recreational Development classification under the Minnesota Shoreland Zoning ordinance was excluded, because pilot surveys indicated that breeding ring-necked ducks seldom used this habitat. Plots that meet the criteria were assigned to Habitat Class 1 if they contained > median amount of this cover; otherwise they were Habitat Class 2 (Figure 1A).

Beginning in 2011, we used a generalized random tessellation stratified (GRTS) design to obtain a spatially balanced sample of plots (Stevens and Olsen 2004) instead of stratifying based upon ECS Section. The GRTS design ensures that sampling units are dispersed across the sampling frame. We used a domain analysis (Cochran 1977:34) to estimate number of IBPs and breeding ducks in each of the 3 ECS sections to compare results with previous years.

Our sample included 235 plots (96 Habitat Class 1, 90 Habitat Class 2, and 49 resample plots). This was 10 more plots than in 2011 because we inadvertently surveyed all 10 alternate plots (5 each in Habitat Class 1 and Habitat Class 2). Resample plots were randomly selected in 2010 from plots sampled in 2009 to represent a range of ring-necked duck counts and IBP (Herwig 2010). The 49 plots have been consistently surveyed since 2009 and were treated as a third stratum (sampling rate = 1).

We surveyed plots from a DNR Division of Enforcement helicopter (Bell OH-58 [Jet Ranger] or Enstrom 480B) flying ~30–45 meters above ground level (agl) and ~75–130 km/h. A 2-person survey crew (pilot + 1 observer) recorded ring-necked duck observations by sex and social status (Zicus et al. 2008). We considered pairs, lone males, and flocked males (2–5) to indicate breeding pairs (Zicus et al. 2008). The breeding population in the survey area was considered to be twice the Indicated Breeding Pairs (IBP) plus the number of unpaired females and birds in groups. We used the R libraries survey (Lumley 2009, R Development Core Team 2009) and spsurvey (Kincaid and Olsen 2011) to estimate IBP and the total breeding population. In 2008, we stopped surveying plots in 4 ECS Sections (Southern, Western, and Northern Superior Uplands, Northern Minnesota and Ontario Peatlands) and PLS sections that were expected to have low densities or no breeding ring-necked ducks (Habitat Classes 3 and 4). Population estimates from 2006 and 2007 were re-calculated to reflect the reduced sampling frame (Sousa et al. 2009).

From 2007 through 2011, observations were recorded on aerial photos and transcribed to data sheets following the survey. In 2012, observations were recorded in digital voice files, each associated with a UTM location, on a tablet computer using the DNRSurvey software program developed by Minnesota DNR Wildlife and GIS staff (Wright et al. 2011). Data were transcribed and proofed following the survey.

RESULTS

We surveyed approximately 2% of the survey plots in the Northern Minnesota Drift and Lake Plains section and Minnesota and Northeast Iowa Morainal section, and 4.2-4.8% of the Lake Agassiz, Aspen Parklands section (Table 1, Figure 1B). Ten of the 15 plots in the Lake Agassiz, Aspen Parklands section were resurvey plots.

We flew the survey on 4-8 June with the primary crew (pilot John Heineman and observer Erik Hildebrand) flying 5 days and the secondary crew (pilot Tom Pfingsten and observer Jeff Lawrence) flying 2 days (4-5 June). The survey was completed in 49.8 hours of flight time. We flew a total of 234 plots. One plot (Habitat Class 2) located in Camp Ripley was not flown due to training activity on the military base. The survey was completed earlier than other years since we began surveying plots in only 3 ECS sections (Figure 2). Survey start dates have ranged from 4-9 June, yet weather and other factors have resulted in end dates ranging from 11-17 June (9–17 June 2008, 5–12 June 2009, 7–16 June 2010, and 6–11 June 2011).

A total of 381 ring-necked ducks were detected on 70 (30%) of the 234 sample plots (Table 2). The habitat class stratification implemented by Zicus et al. (2008) continues to be effective as twice as many class 1 plots were occupied compared to class 2 plots (Figure 3). Ring-necked duck counts on occupied plots ranged from 1 to 39 birds (median = 4, mean = 5.4), but varied slightly by strata (Figure 3). Indicated breeding pairs per occupied plot ranged from 0 to 23 pairs, with average IBP/plot being highest in the "High" stratum (Figure 3). The proportion of pairs was approximately 50% of all IBP (Figure 4).

We estimated 11,620 IBP (SE = 1,830) and 24,200 ring-necked ducks (SE = 3,700) in the survey area (Table 3). These estimates were similar to previous years except 2010 (Figure 5). As in previous years, the majority of the birds were located in the Northern Minnesota Drift and Lake Plains ECS Section (Figure 6). The number of birds observed on the 49 resurvey plots was similar to previous years (Figure 7).

DISCUSSION

The population of ring-necked ducks breeding in Minnesota has remained stable for the past 7 years, with the exception of 2010. Herwig and Giudice (2011) discuss the potential reasons for the low estimate in 2010 and note that counts on the 49 resurvey plots remained relatively stable even though the population estimate declined by 50%. The timing of the survey in 2012 was good because the proportion of pairs was approximately 50% of all IBP (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987).

We have used the same habitat classification to select survey plots since 2006, but we reduced the scope of the survey in 2008 (Sousa et al. 2009). We stopped surveying portions of 4 northeastern Minnesota ECS sections (Southern, Western, and Northern Superior Uplands, Northern Minnesota and Ontario Peatlands) that accounted for about 31-33% of the population estimate in 2006 and 2007. We also stopped surveying habitat classes 3 and 4, which accounted for 9% of the population estimate in 2006 and 2007. Thus, 40% of the total Minnesota breeding ring-necked duck population in 2006-2007 was from areas we did not survey in 2008-2012. If distribution of ducks has remained similar to 2006 and 2007, the actual ring-necked duck breeding ground population in northern Minnesota may be approximately 40,000 ducks.

The core breeding range for ring-necked ducks in Minnesota is the Northern Minnesota Drift and Lake Plains ECS section. This area contains large amounts of potential ring-necked duck breeding habitat (Figure 1A) and breeding ring-necked ducks are well distributed throughout the ECS section (Figure 8). In contrast, while the Minnesota and Northeast Iowa Moranial section has substantial potential breeding habitat (Figure 1A), breeding ring-necked ducks mostly occur in the northern portion of this ECS section. The Lake Agassiz, Aspen Parklands ECS section has limited potential breeding habitat (Figure 1A), but ring-necked ducks are relatively abundant in the limited habitat. Much of the habitat is located on large tracts of public land, such as Agassiz National Wildlife Refuge and Thief Lake and Roseau River wildlife management areas. Of the 4 ECS sections we no longer survey, the Northern Superior Uplands was the most important ring-necked duck breeding area (Sousa et al. 2009).

Resample plots may provide more reliable information on population trends because the same plots are surveyed each year (i.e., sampling variation is minimized). For example, ring-necked duck counts on resample plots have been relatively stable during 2009-2012 (Figure 7), whereas the population estimate (based on all plots) for 2010 was substantially lower than previous and subsequent estimates (Figure 5). This suggests that the 2010 population estimate may have been, at least partly, an artifact of the random sample (i.e., on average a sample-based estimated will be unbiased -- but we only have 1 realization of the sampling process each year and that realization can be biased). On the other hand, only 30% of the 49 resample plots had ring-necked duck observations in any given year. Furthermore, only 39% of the resample plots were "occupied" in >1 year, and only 6% were occupied in all 4 years. Thus, the resample-plot dataset contains many zeros. Future analyses may want to consider exploring model-based approaches that utilize information from both resampled and random plots to provide more efficient estimators of population sizes and trends (e.g., Fong 1990, Bokalo et al. 1996).

This survey has provided important information to increase our understanding and allow us to properly manage ring-necked ducks in Minnesota. The ring-necked duck is the 4th most abundant breeding duck in Minnesota, following mallards, blue-winged teal, and wood ducks (Cordts 2012, this survey). When we began the pilot survey in 2004, we discussed whether population size, trend or distribution was the most important parameter to monitor the population. The original design allowed us to determine population size, thus trend, and the stratification into 6 ECS sections ensured that plots were distributed across the landscape. While it is possible the breeding ring-necked duck population was larger in Minnesota during the 1970s and 1980s as indicated by the 14-lake survey, the helicopter survey indicates that ring-necked duck breeding populations are currently stable in Minnesota. The 14 lakes ring-necked duck survey has also been relatively stable since 2006, ranging from 72-91 indicated breeding pairs (Lawrence 2011, unpublished data). We recommend continuing the aerial survey at least one more year and then decide on the role of this survey in context with other breeding waterfowl surveys in Minnesota.

ACKNOWLEDGMENTS

David Rave (2004-2007) and Christine Herwig (2008-2012) coordinated and were the lead observers for previous surveys. Pilots John Heineman and Tom Pfingsten helped with survey planning and flew the helicopters. Bob Wright set up the DNRSurvey program and Chris Scharenbroich created the navigation maps.

LITERATURE CITED

Bokalo, M., S. J. Titus, and D. P. Wiens. 1996. Sampling with partial replacement extended to include growth projections. Forest Science 42:328–334.

Cordts, S. D. 2012. 2012 Waterfowl Breeding Population Survey: Minnesota. Unpublished report. Minnesota Department of Natural Resources. 19 pages.

Fong, W-K. 1990. A Bayesian approach to successive sampling with partial replacement of units on two occasions. Biometrika 77:383-388.

Herwig, C. M. 2010. 2010 ring-necked duck breeding pair survey. Pages 143 – 157 *in* M. H. Dexter, editor. Status of Wildlife Populations, Fall 2010. Unpublished Report, Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota.

Herwig, C. and J. Giudice. 2011. 2011 ring-necked duck breeding pair survey. Pages 155-166 *in* Dexter, M.H., editor. Status of wildlife populations, fall 2011. Unpublished Report, Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota.

Kincaid, T. M. and A. R. Olsen. 2011. spsurvey: Spatial Survey Design and Analysis. R package version 2.2.

Lawrence, J. S. 2011. Ring-necked duck breeding pair counts on 14 lakes in north-central Minnesota, 1975-2011. Pages 167-173 *in* Dexter, M.H., editor. Status of wildlife populations, fall 2011. Unpublished Report, Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota.

Lumley, T. 2009. Survey analysis in R. <http://faculty.washington.edu/tlumley/survey/>. Accessed 13 April 2010.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Sousa, C. M., D. P. Rave, M. C. Zicus, J. R. Fieberg, J. H. Giudice, and R. G. Wright. 2009. 2008 ring-necked duck breeding pair survey. Pages 146 – 157 *in* M. W. DonCarlos, R. O. Kimmel, J. S. Lawrence, and M. S. Lenarz, editors. Summaries of Wildlife Research Findings 2008. Minnesota Department of Natural Resources, St. Paul.

Stevens, D. L., Jr. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of American Statistical Association 99:262–278.

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. Unpublished report.

Wright, R. G., B. S. Haroldson, and C. Pouliot. 2011. DNRSurvey – Moving Map Software for Aerial Surveys. Pages 271-275 in G. DelGiudice, G., M. Grund, J. Lawrence, and M. Lenarz, editors. Summaries of Wildlife Research Findings, 2010. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul. http://files.dnr.state.mn.us/publications/wildlife/research2010/biometrics.pdf

Zicus, M. C., R. T. Eberhardt, J. Dimatteo, and L. L. Johnson. 2004. Bemidji area ring-necked duck survey. Pages 169 – 183 *in* M. W. DonCarlos, R. O. Kimmel, J. S. Lawrence, and M. S. Lenarz, editors. Summaries of Wildlife Research Findings 2003. Minnesota Department of Natural Resources, St. Paul.

Zicus, M. C., D. P. Rave, J. R. Fieberg, J. H. Giudice, and R. G. Wright. 2008. Distribution and abundance of Minnesota breeding ring-necked ducks *Aythya collaris*. Wildfowl 58:31 – 45.

Table 1. Sampling rate by Ecological Classification System section and habitat class (1 and 2) for Minnesota's ring-necked duck breeding-pair survey, June 2006–2012.

	No. of plots surveyed (Sampling rate [%])															
	N Minnesota Drift & Lake Plains				Minnesota & NE Iowa Morainal				Lake Agassiz, Aspen Parklands				All			
	1		2		1		2		1		2		1		2	
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
2006-07	41	1.1	36	1.1	15	0.9	17	0.9	5	2.3	3	2.4	61	1.1	56	1.0
2008	83	2.2	25	0.8	31	1.9	22	1.1	9	4.2	4	3.2	123	2.2	51	1.0
2009[a]	56	1.5	47	1.4	24	1.5	27	1.4	10	4.6	10	8.1	90	1.6	84	1.6
2010[a]	67	1.8	59	1.8	32	2.0	34	1.8	15	6.9	15	12.1	114	2.0	108	2.0
2011[a]	76	2.0	64	1.9	32	2.0	38	2.0	8	3.7	7	5.6	116	2.0	109	2.0
2012[a]	75	2.0	68	2.1	37	2.3	39	2.0	9	4.2	6	4.8	121	2.1	113	2.1
N[b]	3,828		3,317		1,638		1,923		216		124		5682		5364	

[a]includes resample plots: N. MN Drift & Lake Plains = 12 class 1 and 12 class 2; MN & NE Iowa Morainal = 8 class 1 and 7 class 2; Lake Agassiz, Aspen parklands, 5 class 1 and 5 class 2

[b]Number of Public Land Survey sections by ECS section and habitat class.

Table 2. Plot occupancy, number and density of ring-necked duck observations and indicated breeding pairs in 3 Ecological Classification System sections in Minnesota, June 2006-2012.

		Plots with birds		Birds[a]			IBP[b]		
Year	No. of plots surveyed	*n*	%	Total	Per plot	Per occupied plot	Total	Per plot	Per occupied plot
2006	117	27	23	201	1.72	7.44	120	1.03	4.44
2007	117	33	28	174	1.49	5.27	101	0.86	3.06
2008	174	58	33	296	1.70	5.10	173	0.99	2.98
2009	174	57	33	273	1.57	4.79	173	0.99	3.04
2010	222	56	25	230	1.04	4.11	147	0.66	2.63
2011	225	73	32	338	1.50	4.63	220	0.98	3.01
2012	234	70	30	381	1.63	5.44	229	0.98	3.27

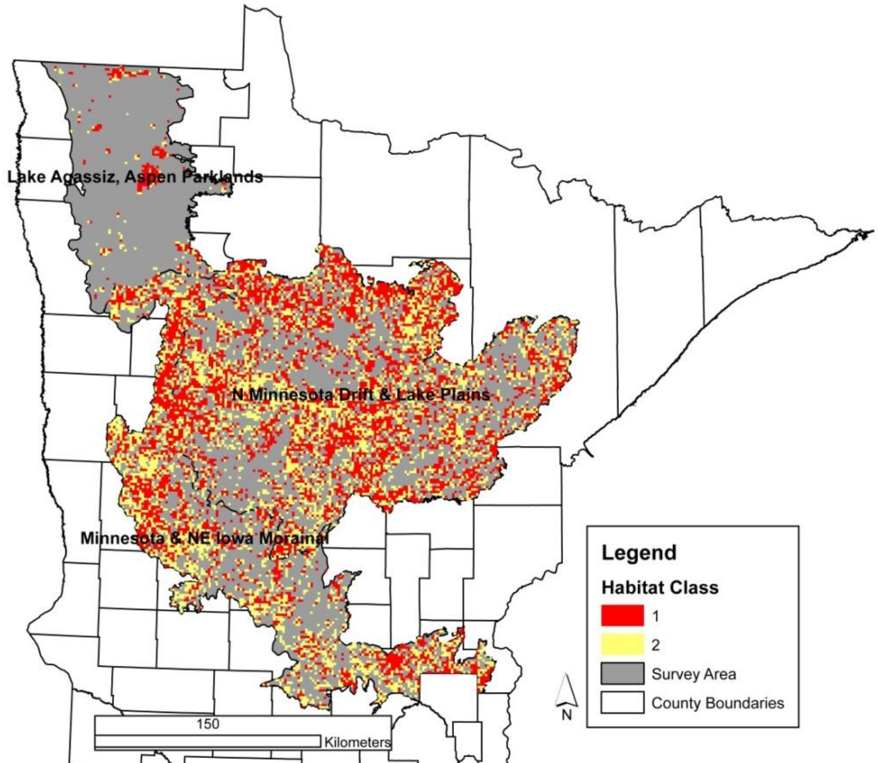
[a]Total number of ring-necked ducks counted during the survey.

[b]The number of indicated breeding pairs (IBP) is the sum of the pairs, lone males, and males in flocks of 2–5 birds.

Table 3. Breeding ground population and indicated breeding pair (IBP) estimates for ring-necked ducks in 3 Ecological Classification System sections in Minnesota, June 2006-2012.

Year	*n* sample plots	Sampling rate	Breeding Population N	Breeding Population SE	Breeding Population CI	Breeding Population Relative precision	IBP N	IBP SE	IBP CI	IBP Relative precision
2006	117	0.011	22,040	5,060	8,380	38.0	9,850	2,350	3,900	39.5
2007	117	0.011	18,530	3,470	5,750	31.0	8,700	1,730	2,870	32.9
2008	174	0.016	20,130	3,340	5,520	27.4	9,440	1,580	2,620	27.7
2009	174	0.016	22,990	3,450	5,700	24.8	10,950	1,560	2,590	23.6
2010	222	0.020	11,840	2,520	4,170	35.2	5,340	1,080	1,790	33.5
2011	225	0.020	22,730	2,760	4,540	19.9	10,400	1,330	2,180	20.9
2012	234	0.021	24,200	3,700	6,090	25.2	11,620	1,830	3,010	26.0

A



B

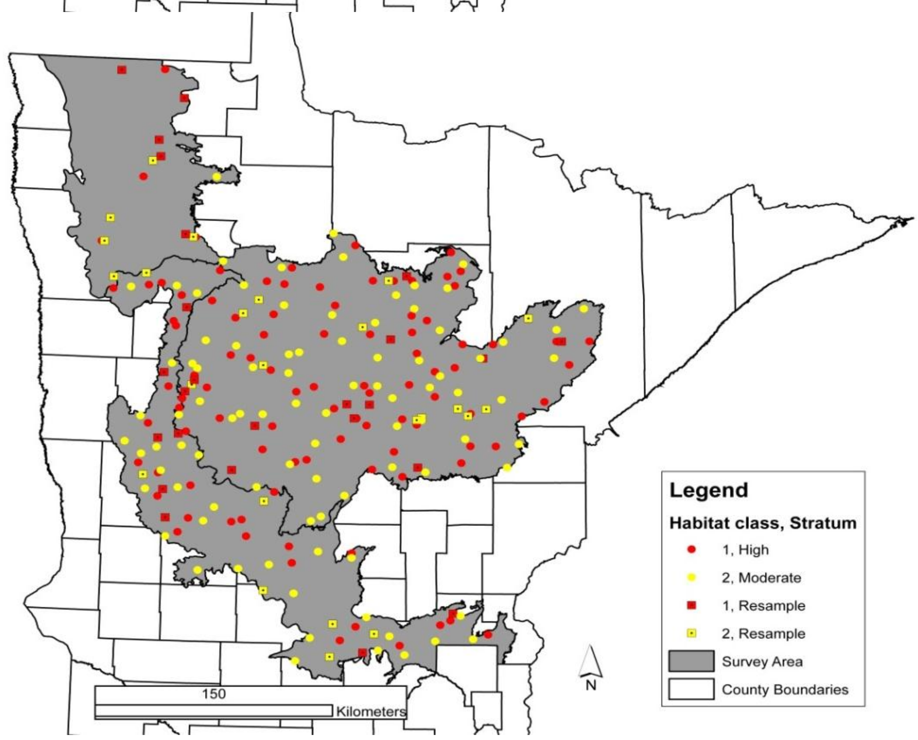


Figure 1. (A) Sampling frame showing Habitat Class 1 and 2 Public Land Survey plots for the ring-necked duck breeding population survey, 2006-2012, and (B) standard and resample plots surveyed in 2012 (enlarged for visibility) by Habitat Class.

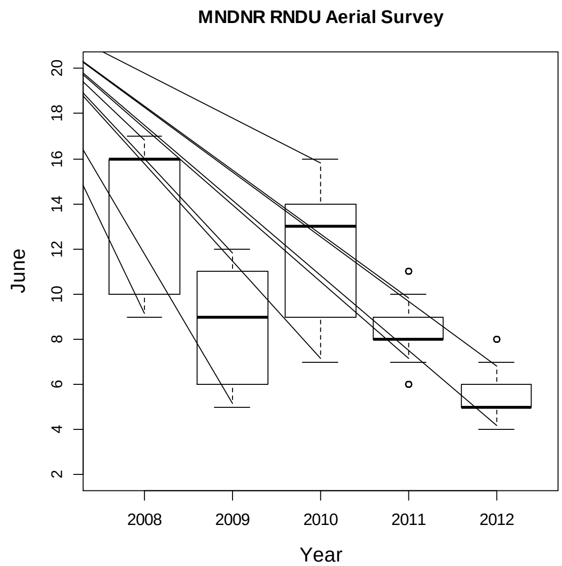


Figure 2. Box plot showing dates ring-necked duck breeding population survey plots were completed, 2008-2012.

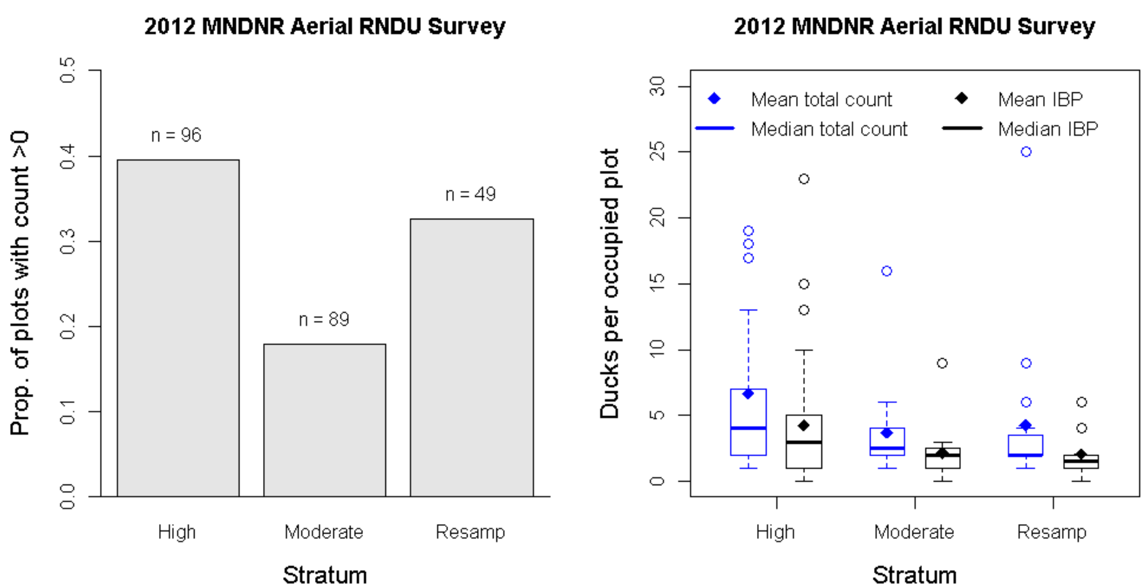


Figure 3. Proportion of occupied plots by stratum (left panel) and number of ducks per occupied plot (right panel, total count and indicated breeding pairs) during the 2012 ring-necked duck breeding population survey.

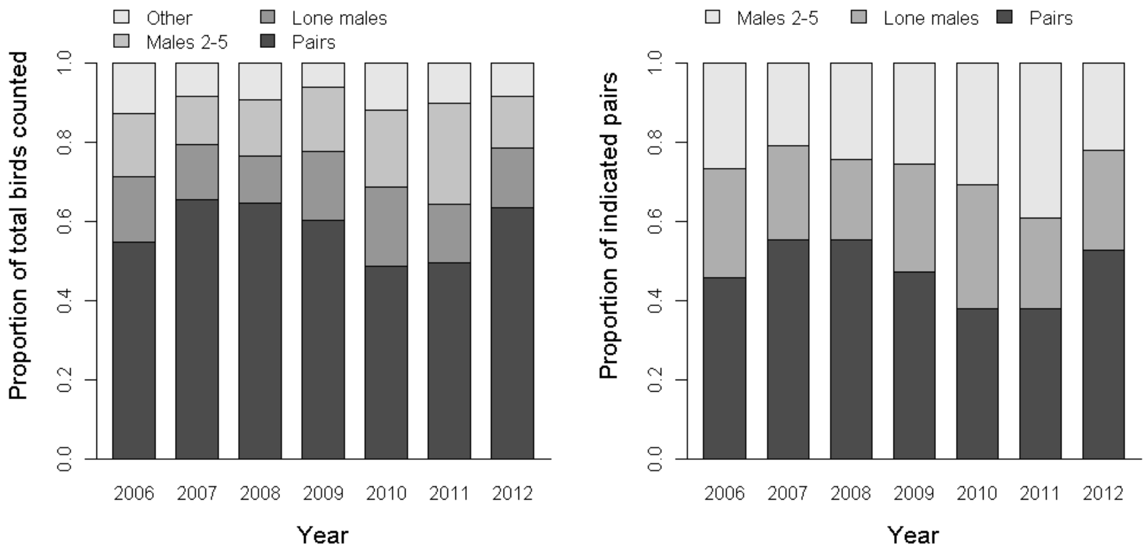


Figure 4. Social grouping of ring-necked ducks counted on the 2012 ring-necked duck breeding population survey for all ducks counted (left panel) and indicated breeding pairs (right panel).

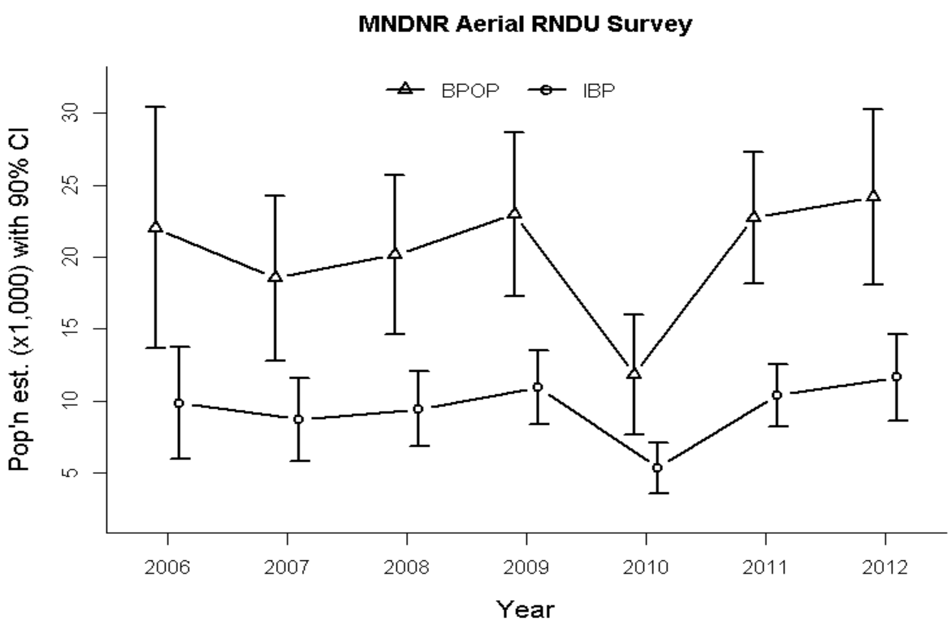


Figure 5. Estimated indicated breeding pairs (IBP) and breeding birds (BPOP) with SE bars for the habitat class 1 and 2 strata in the Minnesota ring-necked duck breeding pair survey area, June 2006–2012.

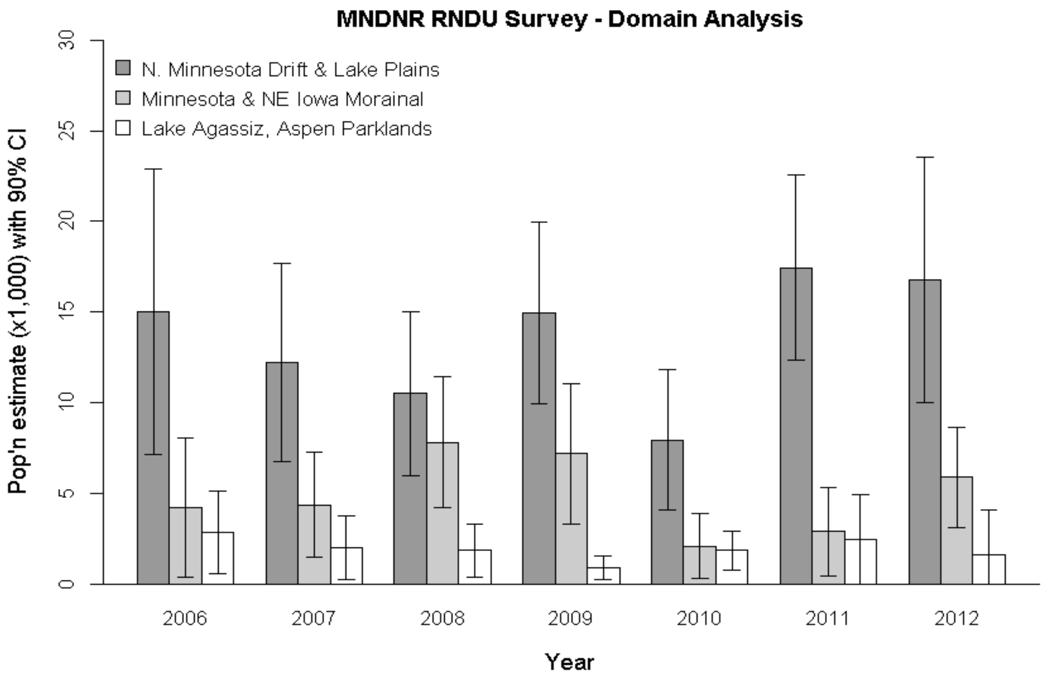


Figure 6. Distribution of Minnesota ring-necked duck breeding population by Ecological Classification System section, 2006-2012.

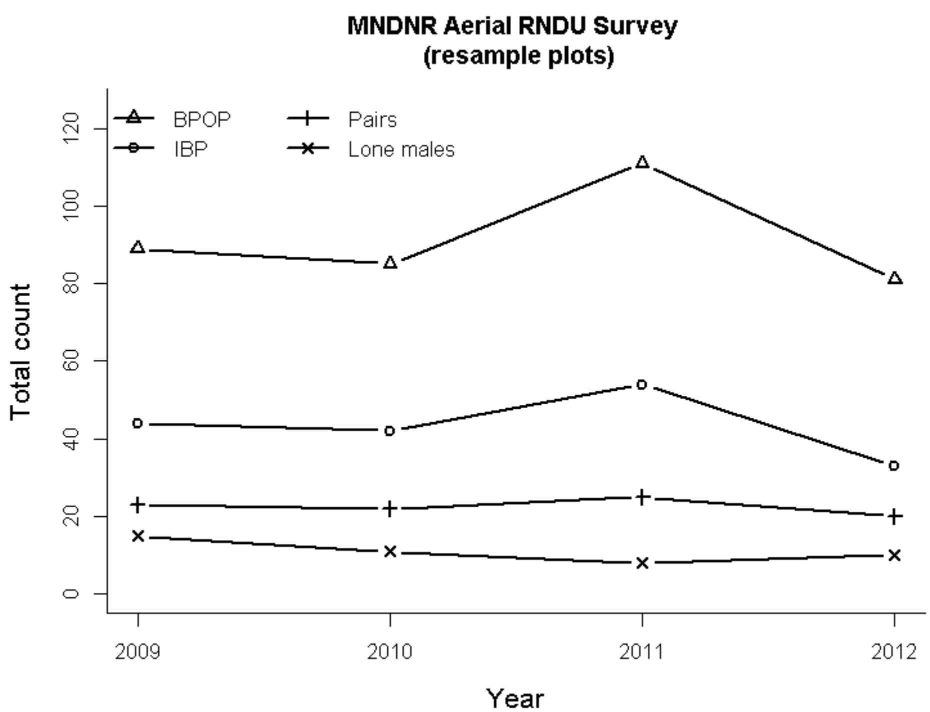


Figure 7. Number of ring-necked ducks by social grouping (breeding population [BPOP], indicated breeding pairs [IBP], lone males [LM], and pairs) for the 49 resurvey plots, 2009-2012.

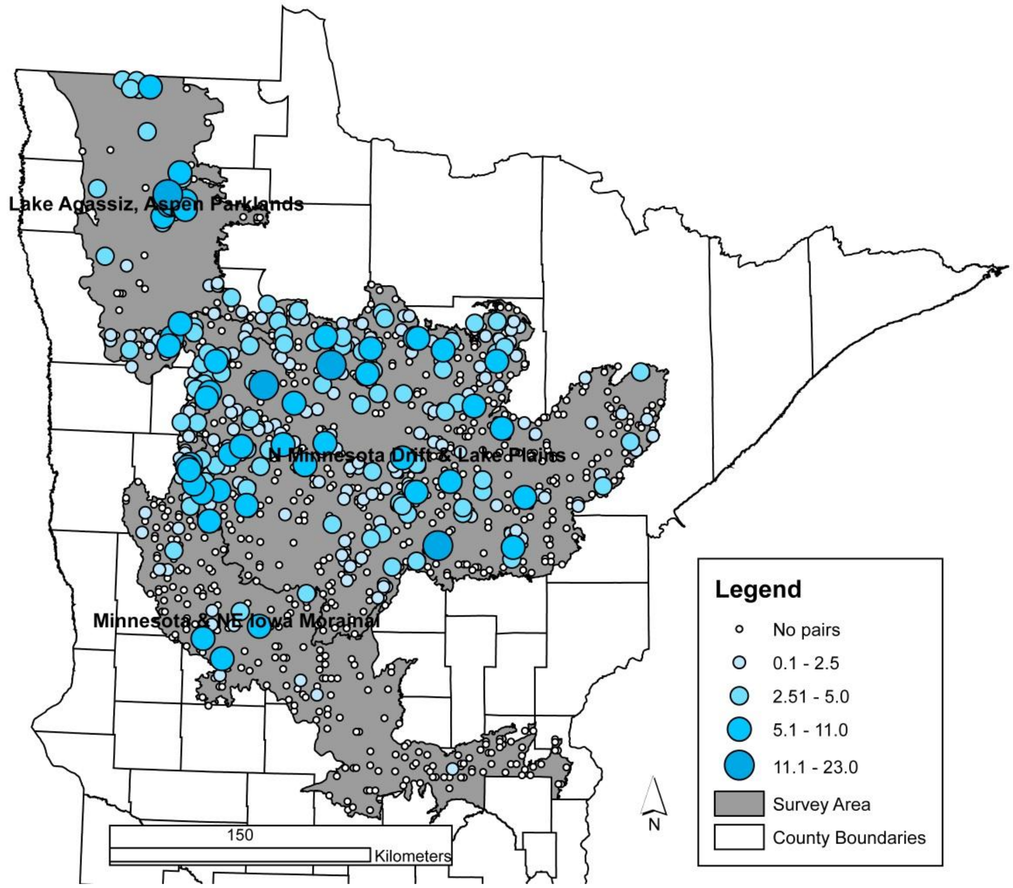


Figure 8. Sample plot locations and number of indicated breeding pairs observed/plot on the Minnesota ring-necked duck breeding pair survey, June 2006-2012. Value is IBP/year for plots surveyed > 1 year. White circles indicate plots where no indicated pairs were seen.

ESTIMATING NUMBERS OF BREEDING SANDHILL CRANES IN NORTHWEST MINNESOTA - 2012

Jeffrey S. Lawrence, Wetland Wildlife Populations and Research Group
John H. Giudice, Biometrics Unit
Gregory A. Knutsen, U.S. Fish and Wildlife Service, Agassiz National Wildlife Refuge
Robert G. Wright, Minnesota Department of Natural Resources

SUMMARY

A sandhill crane (*Grus canadensis*) hunting season was opened in northwest Minnesota in 2010. Following the initiation of the hunting season, there was some concern about the status of cranes that bred in this portion of Minnesota. Thus, it was important to determine the size of the crane population during the breeding season in the hunting zone.

We used a GIS to construct grid-based sampling frame consisting of 4-km^2 plots. We used remote-sensed land-cover data to stratify the sampling frame based on the amount of potential crane nesting habitat in each plot. We also classified plots according to ecological subsection. We used a generalized random-tessellation stratified (GRTS) design to select a spatially balanced sample of 90 plots. We also surveyed one 100-km^2 plot to evaluate questions related to plot size and crane distribution. We surveyed each sample plot once during 7-15 May 2012 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 there were 7,210 sandhill cranes (SACR) in the survey area that included the Northwest Goose-Crane Hunting Zone (NWGCZ) and adjoining Aspen Parkland habitat. This included 1,450 breeding birds, 3,010 birds in groups, and 2,750 cranes whose breeding status was unknown (i.e., singles or pairs observed without a nest or young and not exhibiting territorial or defense behavior). Most (96%) crane observations were in plots with potential SACR nesting habitat, which closely aligned with the Aspen Parkland. We will use data obtained in 2012 to improve survey stratification and design in 2013 and 2014.

INTRODUCTION

In 2010, Minnesota held its first SACR hunting season since the passage of the Migratory Bird Treaty Act in 1918. Although Midcontinent Population (MCP) SACR are hunted in several Central Flyway states (Central Flyway Webless Migratory Bird Technical Committee 2006), the season in Minnesota was unique within the United States because hunting occurs within their breeding range. MCP cranes are hunted in other areas where they breed (e.g., southeast and central Manitoba, Alaska); but, the vast majority of harvest occurs on migration, staging, and wintering areas (Krapu et al. 2011). Krapu et al. (2011) suggested that reestablishment of breeding SACR populations in the U.S. portion of the Prairie Pothole Region, where historical records indicate cranes once bred, may have been limited by crane hunting in this region.

SACR that breed in Minnesota are the greater subspecies (*G. c. tabida*). In the 1970s, SACRs bred in two distinct regions of Minnesota: MCP cranes in northwest Minnesota and Eastern Population (EP) cranes in east-central Minnesota (Henderson 1978). SACRs have since expanded their range, and currently have been reported breeding in 53 of Minnesota's 87 counties (Minnesota Ornithological Union 2011). The breeding range is now continuous between these two areas; thus, the delineation between MCP and EP cranes is unknown.

There was some concern on the potential effect of a SACR hunting season on Minnesota breeding cranes (Lawrence et al. 2011). Retrieved harvest the first 2 years of the season ranged from 765-830 cranes annually, greater than the <500 expected annual harvest. Stable isotope analysis of harvested cranes suggested that the proportion of Minnesota breeding cranes in the harvest was greater than expected, but these results need further interpretation (K. Hobson and G. Knutsen, unpublished data). In addition, crane counts in NW Minnesota from the August Roadside Survey declined following the 2010 hunting season, while they continued to increase in east-central Minnesota. While none of these pieces of information were major causes of concern, they did highlight the need to determine the size of the crane population in the SACR hunting zone.

There was no template for a large-scale, aerial survey specifically designed for breeding SACRs. 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 first year of the pilot study allowed us to evaluate survey-design considerations (e.g., stratification options and effectiveness, estimated variances, spatial correlation in counts, bias-variance-cost tradeoffs) and sampling techniques, which will be used in the second and third years to obtain a precise estimate (CI ±25%) of the number of MCP cranes breeding in northwestern Minnesota. The survey was designed to provide an estimate of the number of breeding cranes in northwest Minnesota that was within ±25% of the true population size with 90% certainty (i.e., if we could replicate the sample survey many times, 90% of the population estimates will be within ±25% of the true population size).

The breeding population size estimates obtained from this survey, combined with data on crane harvest, harvest derivation, and other parameters will allow us to better manage hunting 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.

STUDY AREA

We selected the NW Goose-Crane Hunting Zone (NWGCZ) and portions of the Aspen Parklands ecological subsection that extended beyond the NWGCZ as our primary sampling frame (Figure 1). This included the Aspen Parklands ecological subsection, northwestern portions of the Red River Prairie Subsection, and a small portion of the Agassiz Lowlands subsection.

METHODS

Sampling frame

We used ArcGIS 9.3 (Environmental Systems Research Institute, Redlands, CA) to develop an overlay grid of 4-km^2 plots for the northwestern Minnesota study area (Figure 1). The grid was rotated approximately 2.5 degrees east to orient it with Public Land Survey (PLS)-

based features such as roads and property boundaries. We treated 4-km^2 plots as the primary sampling unit (PSU) and excluded any PSUs not located entirely within the boundary of the SACR survey area (Figure 1). 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).

Sampling design

We used descriptions of crane nesting habitat in northwest Minnesota (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008), and land cover data layers contained in Minnesota Gap Analysis Project (GAP) (Drotts and Heinzen 2007) and National Land Cover Data (NLCD) (Fry et al. 2011) to identify potential nesting cover. Both the GAP and NLCD land cover layers have a cell resolution of 30 meters. We considered 3 preliminary classification scenarios: GAP1 – nesting cover defined as GAP level-4 habitat types 14 (sedge meadow) and 15 (broadleaf sedge/cattail); GAP2 – similar to to GAP1 but nesting cover also included habitat type 10 (lowland deciduous shrub); and NLCD - nesting cover defined as cover type 95 (emergent herbaceous wetland). We visually compared data layers associated with crane nest locations from the DNR Rare Natural Features database to decide which GIS data layers to use for stratification (Figure 2). We decided to use the 2006 NLCD to stratify the survey plots for the pilot year and then examine relationships of crane sightings and GIS layers to consider better stratifications in future years.

We used NLCD to quantify the amount (m^2) of potential SACR habitat in each 4-km^2 plot and 1-km^2 subplot. NLCD is a Landsat-based, 30-meter resolution, land cover database created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey (http://pubs.usgs.gov/fs/2012/3020/). For the purposes of the pilot study, we defined “SACR nesting habitat” as NLCD cover class 95 (emergent herbaceous wetland) and “other SACR habitat” as NLCD cover classes 11 (open water) and 90 (woody wetlands). We then classified each 4-km^2 plot into 4 categories:

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

NLCD plot classifications were strongly correlated with ecological subsections (Figure 1). Therefore, we stratified the sampling frame (4-km^2 plots) into 4 strata:

1. NLCD12 plots – Stratum 1 and 2 plots; 71% of sampling frame; mostly associated with Aspen Parklands and Agassiz Lowlands.
2. NLCD3 plots – 11% of sampling frame; mostly associated with Red River Prairie.
3. NLCD4 plots – 18% of sampling frame; mostly associated with Red River Prairie.
4. Espelie Township (EspTwp) – 100-km^2 survey block in Aspen Parklands and in close proximity to previous SACR research sites. Consisted of 24 NLCD-1 plots and 1 NLCD-2 plot.

We assumed that SACR density in the NLCD4 stratum was very low (approaching zero). Therefore, given time and budget constraints, we did not sample stratum NLCD4. However, we recorded UTM locations of all SACR observations, which will allow us to examine NLCD habitat associations at finer scales (e.g., 1-km^2 subplot) and explore the utility of using other land-cover data sources to stratify the sampling frame. Likewise, we expected SACR density to be low (but > 0) in the NLCD3 stratum. For NLCD12 and NLCD3 strata, we drew a spatially-balanced, Generalized Random-Tessellation Stratified (GRTS) sample (Stevens and Olsen 2004) with n = 60 (sampling rate = 2.2%) and 30 (sampling rate = 7.3%), respectively. We sampled the NLCD3 stratum at a higher rate to ensure we had a sufficient sample size to evaluate the feasibility of estimating SACR numbers in this low-density stratum. We surveyed 100% of the EspTwp stratum (n = 25 4-km^2 plots). Thus, the total sample size in 2012 was 115 4-km^2 plots (Table 2, Figure 3).

Target population(s)

Ideally, we wanted estimates of total cranes and total breeding cranes located within the SACR survey area and, possibly, separate estimates for ecological subsections and the NW Goose-Crane Zone (i.e., a domain analysis). Obtaining geographically relevant estimates was reasonably straightforward; although, in some cases, estimates were imprecise. Conversely, 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 (reluctance to fly or leave the area, broken-wing displays, etc.).
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.

Visibility bias (non-response)

To our knowledge, there is no information available on non-response rates (detection probabilities) in aerial surveys of breeding cranes. We attempted to evaluate the potential magnitude of visibility bias by using a double-sampling technique. We randomly selected a 1-km^2 subplot (that contained >0 m^2 of potential SACR nesting habitat) within each NLCD-12 4-km^2 sample plot and resurveyed these subplots immediately after completing the survey of the larger plot. We also considered line-transect and double-observer methods, but we concluded these methods were not practical given our aircraft/crew setup and survey protocols (e.g., the need to be flexible with respect to speed, altitude, flight pattern, and time [intensity] devoted to surveying different cover types).

Survey Procedures

The survey was conducted during mid-May, which is the peak incubation period for cranes in northwest Minnesota (DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008). All plots were surveyed using Bell OH-58 [Jet Ranger] containing a pilot and one observer, except the first survey day when a second observer was in the helicopter. Surveys were flown at 5-45 meters above ground level and from 10-100 km/hr, depending upon the cover. Observations were recorded in digital voice files, each associated with a UTM location, on a tablet computer using the DNRSurvey software program developed by Minnesota DNR Wildlife and GIS staff (Wright et al. 2011).

RESULTS

Survey effort

The survey was conducted over 7 days (7-11 May, 14-15 May), averaging 16 plots/day (range: 4-28) and 6 hr/day (range: 1.5-9.2 hr/day, including refueling stops). The survey team (DNR pilot John Heineman and observer Jeff Lawrence) spent an average of 9.8 min surveying a plot (range: 3-28 min), but it varied slightly by strata (Table 1). The EspTwp stratum consisted of mostly high-quality plots (> median amount of potential SACR nesting cover) and, thus, required more survey time/plot. Total transit time averaged 6 min/plot, but this included the EspTwp block where inter-plot transit time was zero and a nearby refueling truck was utilized. Refueling time averaged 36 min/stop (including an estimate of 30 minutes for end-of-day refueling) with typically 3 stops required for a full day of surveys. Average total time (survey + transit + refueling) per plot was 21 min (including EspTwp) and 22 min for NLCD-123 plots only. The survey team also conducted 27 visibility surveys. On average, visibility surveys required 4 min to complete (range: 1-7 min). Forty-five percent of total survey effort (total minutes; all activities) in 2012 was associated with surveying plots, 27% with transit time, 23% with refueling stops, and 4% with visibility surveys.

Sampling statistics

We detected SACR on 51 (44%) of the 115 sample plots (Table 2). The average count per occupied plot was 4.7 birds (SD = 6.5, range: 1 to 43). Naïve estimates of plot occupancy varied by strata (range: 13% in NLCD3 to 64% in EspTwp), but the distribution of counts per occupied plot was similar among strata (Table 2). The exception was one plot that contained 43 birds (3 groups of 7, 9 and 21 birds, 2 pairs; and 2 singles), which was an NLCD-12 plot located outside the NWGCZ.

We counted 240 SACR on sample plots, of which 48% were pairs, 15% were singles, and 37% were groups (Table 3). We observed 11 groups, which ranged in size from 3 to 21 birds. Thirty-five percent of observed pairs and singles exhibited some evidence of being breeding birds (44% of pairs and 22% of singles; Table 3). We detected 22 nests (including 1 detected during the re-survey), and eggs or young were observed at 18 nests (the status of the other 4 nests could not be determined). In addition, we observed 3 pairs with young but no nest. The spatial distribution of crane detections (including nests and incidental observations) is shown in Figure 3.

Population estimates

The estimated total number of cranes in the survey area was 7,210 (90% CI: 4,200–10,200). This is a minimum estimate because we did not adjust for detection probabilities (which are likely <1, at least for singles and pairs in dense cover). If our sample of singles and pairs exhibiting breeding behavior was representative of the relative abundance of breeding birds in the target population, then we estimated there were a minimum of 1,450 (90% CI: 1,010–1,880) breeding birds in the survey area, and another 2,750 (90% CI: 2,070–3,430) whose breeding status was uncertain (Table 4).

Approximately 96% of the estimated total birds were associated with the NLCD-12 and EspTwp strata (Table 5), which essentially represents the Aspen Parkland ecological zone. The estimated number of cranes in the NLCD-3 stratum (~Red River Valley ecological zone) was only 290 (90% CI: 50–530). The bound on the estimated total (all strata) was greater (CV = 25% and relative bound = 41%) than the usual target level for an MNDNR wildlife survey (i.e., CV = 15% and relative bound = 25%), which partly reflects the influence of 1 extremely large plot count (43 birds) on the estimated population variance. The estimated CV for breeding birds and status-unknown birds was reasonably good (<18%; Table 4). This large plot count was located outside the NWGCZ hunting zone, which resulted in an imprecise population estimate in a domain analysis of NWGCZ (n = 106 plots, pop.est = 5,060, SE = 1,150) vs. non-NWGCZ (n = 9 plots, pop.est = 2,160, SE = 1,930). Consequently, we do not have sufficient information to estimate with reasonable precision the number of SACRs in Aspen Parkland habitats located outside the NWGCZ.

Habitat associations

There were only weak relationships between plot counts (total birds) and amount of potential nesting cover as defined by NLCD and GAP cover data (Figure 4).

DISCUSSION

Survey Effort and Design Considerations

Generally, we believe the pilot year of this survey went extremely well. We had proposed to survey 125 high-quality plots (NLCD-12) and 50 low-quality plots (NLCD-34) during the first year of the pilot study (Lawrence et al. 2011). However, during the design phase we decided to scale back to 115 plots, which allowed us to evaluate the feasibility of using double-sampling to estimate visibility bias. We planned for 35 hours of helicopter time but flew 37 hours to complete the 115 plots. We were able to survey 21-28 plots on days when we flew the entire day. In 2013, we will not resurvey the 1 km^2 plots, saving approximately 1.8 hours of survey time. In addition, we may not survey in the Red River Valley, which would allow us to survey more plots in the Aspen Parkland.

We planned to begin the survey on 14 May 2012 based upon chronology of nest incubation documented in northwest Minnesota (Provost et al. 1992, Maxson et al. 2008, although DiMatteo 1991 indicated earlier nesting on Agassiz National Wildlife Refuge). Given the advanced phenology of 2012, we decided to begin the survey 1 week earlier, on 7 May 2012. Even then, some nests had already hatched based upon colts observed during the survey (Figure 5) and anecdotal reports of other colts. Therefore, we anticipate we will begin the 2013 survey no later than approximately 7 May.

Conditions in northwest Minnesota were abnormally dry when the survey was conducted in May (http://droughtmonitor.unl.edu/archive.html) and much of the potential nesting cover was dry. Typically, SACRs nest in emergent vegetation in shallow water (Figure 5, DiMatteo 1991, Provost et al. 1992, Maxson et al. 2008); although we did observe some crane nests in cover that appeared mostly dry. We do not know if cranes forgo nesting if conditions are not favorable; but in a wet year there would be additional potential nesting habitat in NW MN. Some crane nests were located in relatively small pieces of nesting cover (Figure 6).

Population Estimate

We allocated 73% of our survey effort to NLCD-12 plots, which reflected our primary objective of estimating the abundance of breeding SACR (or birds associated with reproductive habitats) in the northwest survey area. Thus, it is not surprising that population estimates for the NLCD-12 stratum and for potential breeding birds (singles and pairs) associated with nesting habitats were more precise than for estimates of grouped birds or birds associated with NLCD-3 plots. In the case of groups, many of these birds were observed in non-reproductive cover types, including agricultural fields. Thus, their distribution among plots is more difficult to predict. For example, the plot with the greatest number of birds in groups (n = 37, 42% of all birds observed in groups) was in an area on Glacial Ridge National Wildlife Refuge that was recently burned and had greened up. These areas are especially attractive to nonbreeding cranes. In the likely scenario that we do not have recently burned areas on one of the survey plots in future years, number of birds in groups will probably decline.

Most of the unknown-status pairs were likely nonbreeders, although a portion of the unknown-status singles likely had a mate on an undetected nest. Seven of the 8 singles recorded as breeders were observed on a nest; it is likely that these birds had an undetected mate in the vicinity. Three of the 8 breeding singles had possible mates (other singles) on the plot, but their behavior did not suggest we count them as pairs.

We surveyed the 100-km^2 block to evaluate how nesting cranes were spread over the landscape. The number of likely reproductively-active singles/pairs ranged from 0-2 per 4-m^2 plot, but only 1 active nest was observed on each plot (Fig 7).

Evaluation of sampling design

Post-hoc stratification analyses of plot counts suggested that NLCD or GAP data by themselves were not very effective stratification variables. Additional cover attributes may be needed to increase stratification effectiveness. For example, many crane observations were in or adjacent to agricultural fields (e.g., feeding sites) and many patches of potential nesting cover (emergent vegetation) were dry. Thus, developing an effective stratification scheme for the SACR survey may require a more sophisticated suite of habitat metrics. Our work on this aspect of the survey is just beginning. For example, we collected UTM locations for all SACR observations (including nests) and plan to examine habitat associations using various cover attributes and data layers this fall.

Estimated total birds in stratum NLCD-3 was only 290 (90% CI: 50–530) and only 4 of the 30 sample plots had counts >0. As noted previously, stratification in the pilot survey was closely associated with ecological subsections. Thus, the NLCD-3 stratum essentially reflected the sample characteristics of the Red River Prairie portion of the survey area (Figure 1). Given cost-bias-precision tradeoffs, dropping the Red River Prairie from future sampling frames is a legitimate consideration, especially if it resulted in a corresponding increase in effort (plots) in the Aspen-Parkland region (~NLCD-12 stratum). Likewise, as noted above, we will be exploring more effective stratification schemes for the Aspen Parkland region. For example, post-hoc stratification analysis suggested that, at the very least, using a cut point (for abundance of potential nesting habitats) of 102 ha to form 2 strata (NLCD-1, NLCD-2) and sampling at a higher rate in NLCD-1 (potential nesting habitat > 102 ha) would likely improve the precision of population estimates. We will further evaluate the habitat associated with crane observations and consider other options for improving the survey prior to next year. We plan to fly the survey again in May 2013.

The 4-km^2 plot size appears to be a reasonable choice based on naïve occupancy rates, survey time requirements, and bird behavior (i.e., flushing distances and flight patterns). Smaller plots (e.g., 1 km^2) would require less survey time, but total transit time would increase and the sample dataset would probably contain more "zero" counts. Conversely, the 100-km^2 EspTwp block was reasonably efficient to survey, but there are potential problems with double counting and observer fatigue. However, retaining the EspTwp block in future surveys may be beneficial for other reasons (e.g., anecdotal information on population trends from repeated surveys of the same area).

Resurveying 1-km^2 subplots was not an effective method for evaluating the potential magnitude of visibility bias in aerial survey of SACRs. Of the 37 visibility surveys, only 1 survey resulted in a "new" detection (in this case, a missed nest). Based on bird behavior noted during the survey, one could argue that detection probability p is very high ($p \rightarrow 1$) for grouped birds and birds (of any social class) feeding in open agricultural fields, whereas p for breeding cranes in emergent cover is unknown but certainly <1. Thus, the crux of the visibility issue in this case is to estimate p for breeding cranes (especially those with a nest or young). Unfortunately, it is not an easy problem to solve. Visibility bias remains an issue of interest to us, although for this case study, a conservative estimate of SACR numbers (not adjusted for visibility bias) is sufficient for planning purposes. Nevertheless, we will continue to explore the feasibility of using alternative methods to estimate detection probabilities (e.g., repeated counts, logistic model approach based on known nest locations and an independent survey team, other?).

ACKNOWLEDGEMENTS

This project was funded by a grant from the U.S. Fish and Wildlife Service Webless Migratory Bird Program and the Minnesota Department of Natural Resources. Special thanks to pilot John Heineman, who did an exceptional job flying the helicopter. We also appreciate the assistance of Pam Murphy, who drove the fuel truck, and Doug Franke, who arranged the fuel truck, from the DNR Thief River Falls Wildlife office.

LITERATURE CITED

Central Flyway Webless Migratory Bird Technical Committee. 2006. Management Guidelines for the Mid-Continent Population of Sandhill Cranes. Special Report in files of the Central Flyway Representative. Denver, Colorado.

DiMatteo, J. J. 1991. Biology of greater sandhill cranes of Agassiz National Wildlife Refuge, Marshall County, Minneosta. M.A. Thesis, St. Cloud State University. 181 pages.

Drotts, G., and D. Heinzen. 2007. The Minnesota Gap Analysis Project Final Report. Division of Fish & Wildlife and Division of Forestry, Minnesota Department of Natural Resources, St. Paul, MN.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, Photogrammetric Engineering & Remote Sensing, Vol. 77(9):858-864.

Giudice, J. H., J. R. Fieberg, M. C. Zicus, D. P. Rave, and R. G. Wright. 2010. Cost and precision functions for aerial quadrat surveys: a case study of ring-necked ducks in Minnesota. Journal of Wildlife Management 74:342-349.

Hayes, M. A., and J. A. Barzen. 2006. Dynamics of breeding and non-breeding cranes in south-central Wisconsin. Passenger Pigeon 68:345-352.

Henderson, C. L. 1978. Minnesota sandhill crane report – 1978. Unpublished report. Minnesota Deptartment of Natural Resources, St. Paul, Minnesota. 16 pages.

Krapu, G. L., D. A. Brandt, K. L. Jones, and D. H. Johnson. 2011. Geographic distribution of the Mid-continent Population of sandhill cranes and related management applications. Wildlife Monograph 175:1-38.

Lawrence, J. S., G. A. Knutsen, and J. H. Giudice. 2011. Webless Migratory Game Bird Program Request for Proposals – FY12, Estimating numbers of breeding sandhill cranes in northwest Minnesota. Unpublished funding proposal submitted to U.S. Fish and Wildlife Service. 21 pages.

Maxson, S. J., J. R. Fieberg, and M. R. Riggs. 2008. Sandhill crane nest habitat selection and factors affecting nest success in northwestern Minnesota. Proceedings of the North American Crane Workshop 10:89-96.

Minnesota Ornithological Union (MOU). 2011. MOU Species Occurrence Maps. http://www.moumn.org. Accessed October 25, 2011.

Provost, J. L., T. A. Provost, S. J. Maxson, and R. D. Crawford. 1992. Breeding biology of greater sandhill cranes on the Roseau River Wildlife Management Area, Minnesota. Proceedings North American Crane Workshop 6:69-74.

Stevens, D. L., Jr. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of American Statistical Association 99:262–278.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, New York, New York, USA.

Wright, R. G., B. S. Haroldson, and C. Pouliot. 2011. DNRSurvey – Moving Map Software for Aerial Surveys. Pages 271-275 in G. DelGiudice, G., M. Grund, J. Lawrence, and M. Lenarz, editors. Summaries of Wildlife Research Findings, 2010. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul.

http://files.dnr.state.mn.us/publications/wildlife/research2010/biometrics.pdf

Zicus, M. C., D. P. Rave, J. R. Fieberg, J. H. Giudice, and R. G. Wright. 2008. Distribution and abundance of Minnesota breeding Ring-necked Ducks *Aythya collaris*. Wildfowl 58: 31–45.

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

	Survey time			Transit time				Refueling stops				Total time (excl. visibility)		Visbility surveys		
Stratum	Total minutes	Plots	Min/ plot	Total minutes	Number transits	Min/ transit	Min/ plot	Total minutes	Number stops	Min/ stop	Min /plot	Total minutes	Min/plot	Total minutes	Number surveys	Min/ survey
NLCD-123	822	90	9.1	663	104	6.4	7.4	482	13	37.1	5.4	1,967	21.9	102	27	3.8
EspTwp	310	25	12.4	16	6	2.7	0.6	97	3	32.3	3.9	423	16.9	0	0	0
All	1,132	115	9.8	679	110	6.2	5.9	579	16	36.2	5.0	2,390	20.8	102	27	3.8

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

							Counts/occupied plot				
Stratum	nh	Nh	wh	srate	n.occ	p.occ	min	max	med	mean	SD
EspTwp	25	25	0.006	1.000	16	0.640	1	11	4	4.2	2.6
NLCD12	60	2,724	0.707	0.022	31	0.517	1	43	2	4.8	8.0
NLCD3	30	411	0.107	0.073	4	0.133	2	11	4	5.2	4.3
NLCD4	0	691	0.179	0.000							
All	115	3,851	1.000	0.030	51	0.443	1	43	2	4.7	6.5

[a]nh = sample size (4-km^2 plots), Nh = stratum size, wh = stratum weight, 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.

Table 3. Social and breeding classification of sandhill crane observations.

Social class[a]	Count	Percent of total	Percent of pairs or singles
Pairs (x2)	114	47.5	
Breeding birds	50	(20.8)	43.9
Status unknown	64	(26.7)	56.1
Singles	37	15.4	
Breeding birds	8	(3.3)	21.6
Status unknown	29	(12.1)	78.4
Groups	89	37.1	
Total	240	100	

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

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

Status	nh	Nh	n.occ	min.ct	max.ct	sig.hat	xbar.4km	SE.xbar	Nhat	SE.Nhat	LCB90Pct	UCB90Pct	cv.pct
Breeding birds[a]	115	3,160	28	1	4	0.87	0.5	0.08	1,450	260	1,010	1,880	17.9
Groups	115	3,160	9	3	37	4.59	1.0	0.49	3,010	1,550	470	5,550	51.5
Unknown[b]	115	3,160	40	1	6	1.42	0.9	0.13	2,750	420	2,070	3,430	15.3
Total	115	3,160	51	1	43	5.64	2.3	0.58	7,210	1,820	4,220	10,200	25.2

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

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

Table 5. Population estimates (Nhat) by stratum for sandhill cranes in northwest Minnesota, May 2012.

stratum	nh	Nh	n.occ	min.ct	max.ct	sig.hat	xbar.4km	SE.xbar	Nhat	SE.Nhat	LCB90Pct	UCB90Pct	cv.pct
EspTwp	25	25	16	1	11	2.88	2.7	0	70	0			
NLCD12	60	2,724	31	1	43	6.17	2.5	0.67	6,860	1,810	3,870	9,840	26.4
NLCD3	30	411	4	2	11	2.24	0.7	0.36	290	150	50	530	51.7
All	115	3,160	51	1	43	5.64	2.3	0.58	7,210	1,820	4,220	10,200	25.2

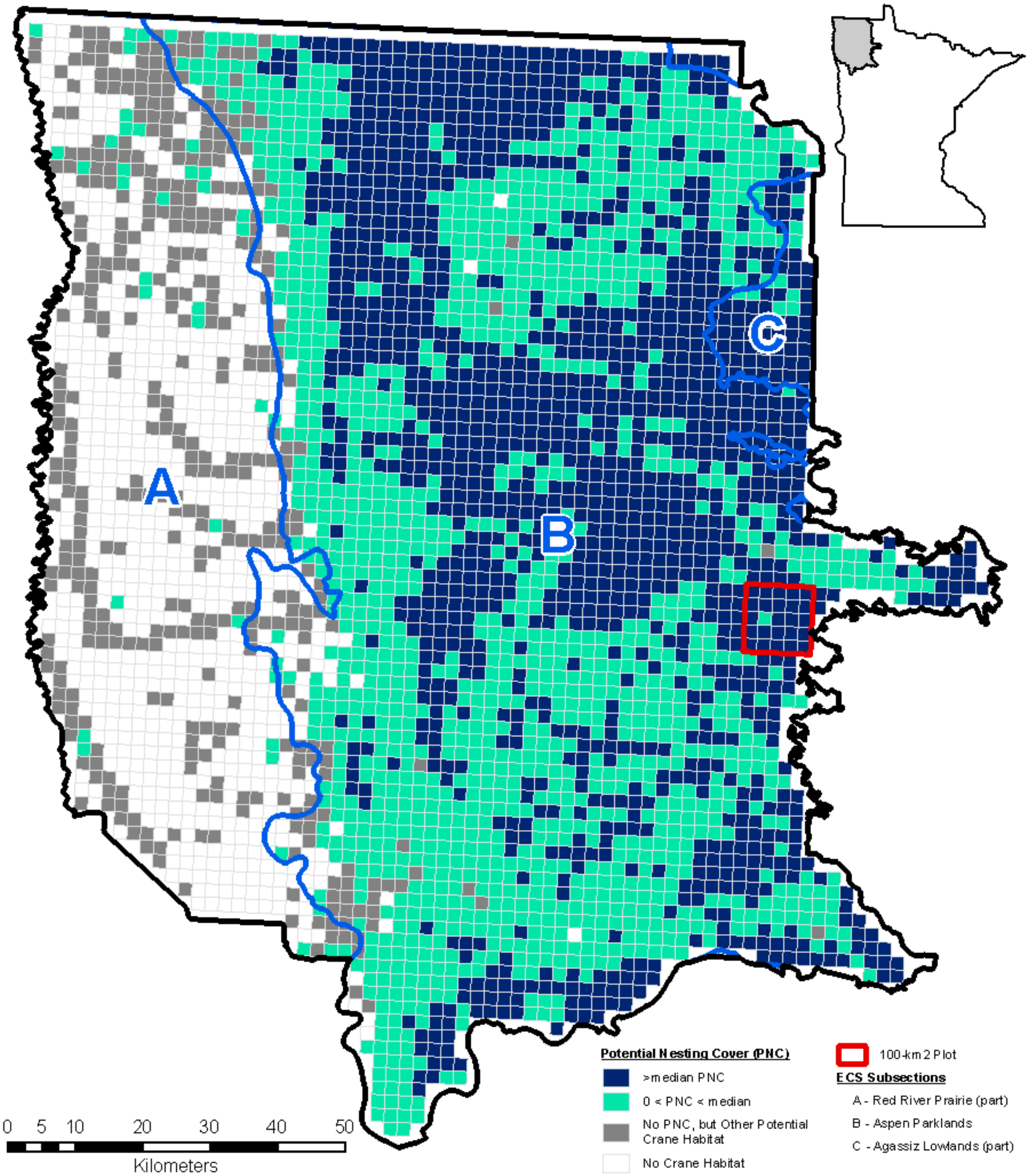


Figure 1. Sampling frame for the 2012 MNDNR spring aerial survey of sandhill cranes, northwestern Minnesota. The primary sampling unit was 4-km^2 plots. Colored squares denote plots by strata as defined by National Land Cover Data: dark blue = NLCD-1 (>median amount of potential crane nesting cover), 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.

Figure 2. Comparison of land cover GIS layers with a known 1991 sandhill crane nest (blue dot), Section 16, Poplar Grove Township, Marshall County, MN. (left: GAP land cover, middle: 2010 color aerial photo, right: 2006 National Land Cover Data).

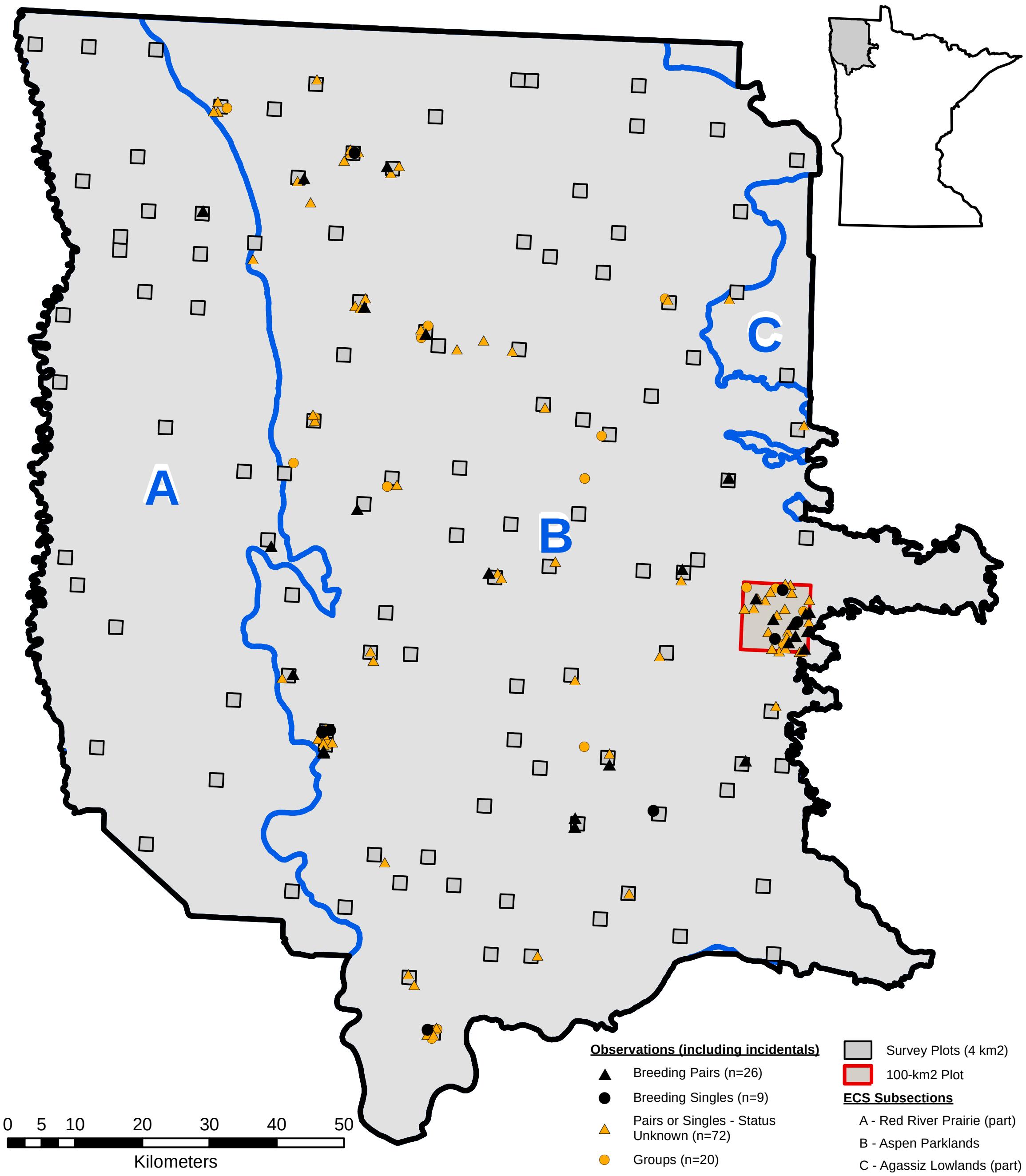


Figure 3. Distribution of sample plots (n = 115) and sandhill crane observations by type (including incidental sightings) in the 2012 MNDNR spring aerial survey, northwestern Minnesota. Each sample plot was 4 km^2 and the SACR survey area was 16,350 km^2.

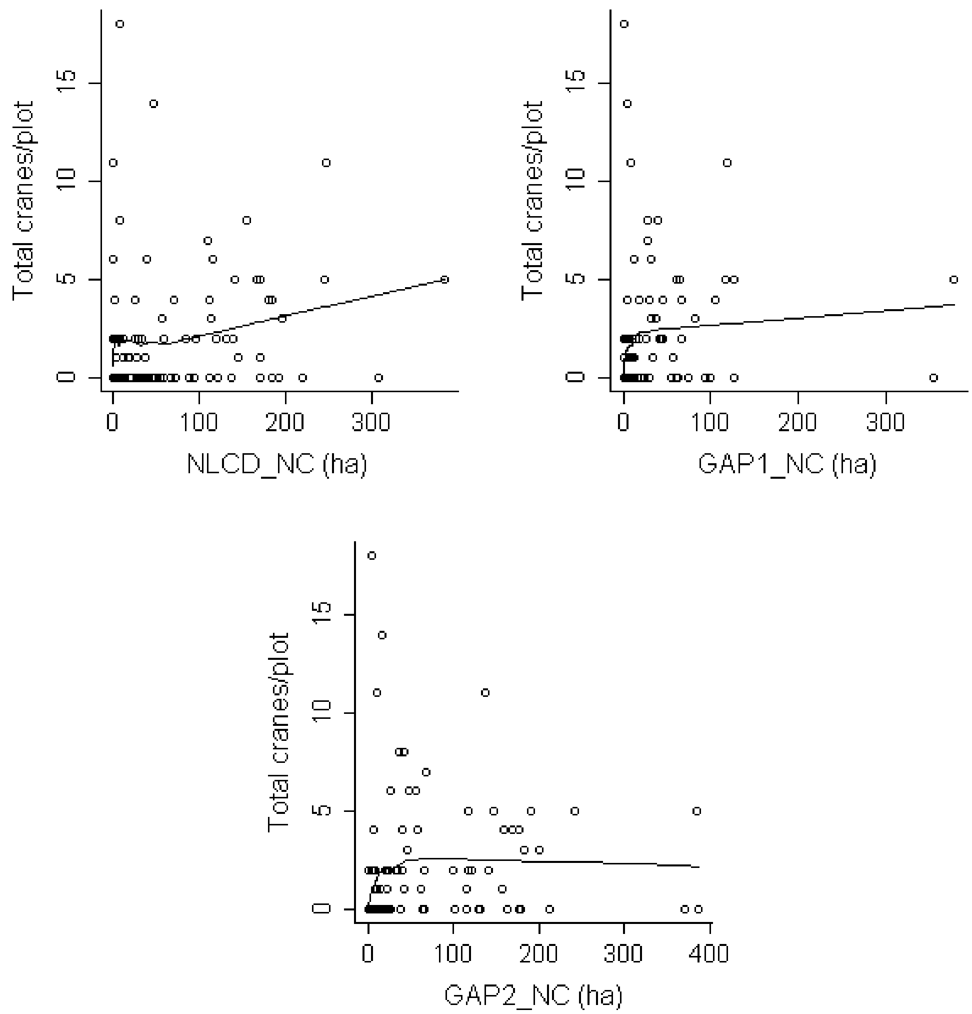


Figure 4. Relationships between sandhill crane observations and habitat abundance (as defined by NLCD and GAP classification schemes) based on 114 4-km2 plots surveyed in May 2012, northwest Minnesota. The graphs do not show 1 plot with 43 cranes, which contained 73, 129, and 149 ha of NLCD_NC, GAP1_NC, and GAP2_NC habitats, respectively.

Figure 5. Crane nest and colt in northwestern Minnesota, May, 2012.

Figure 6. A sandhill crane nest was located near the arrow in the wetland, Northwest Minnesota, May 2012.

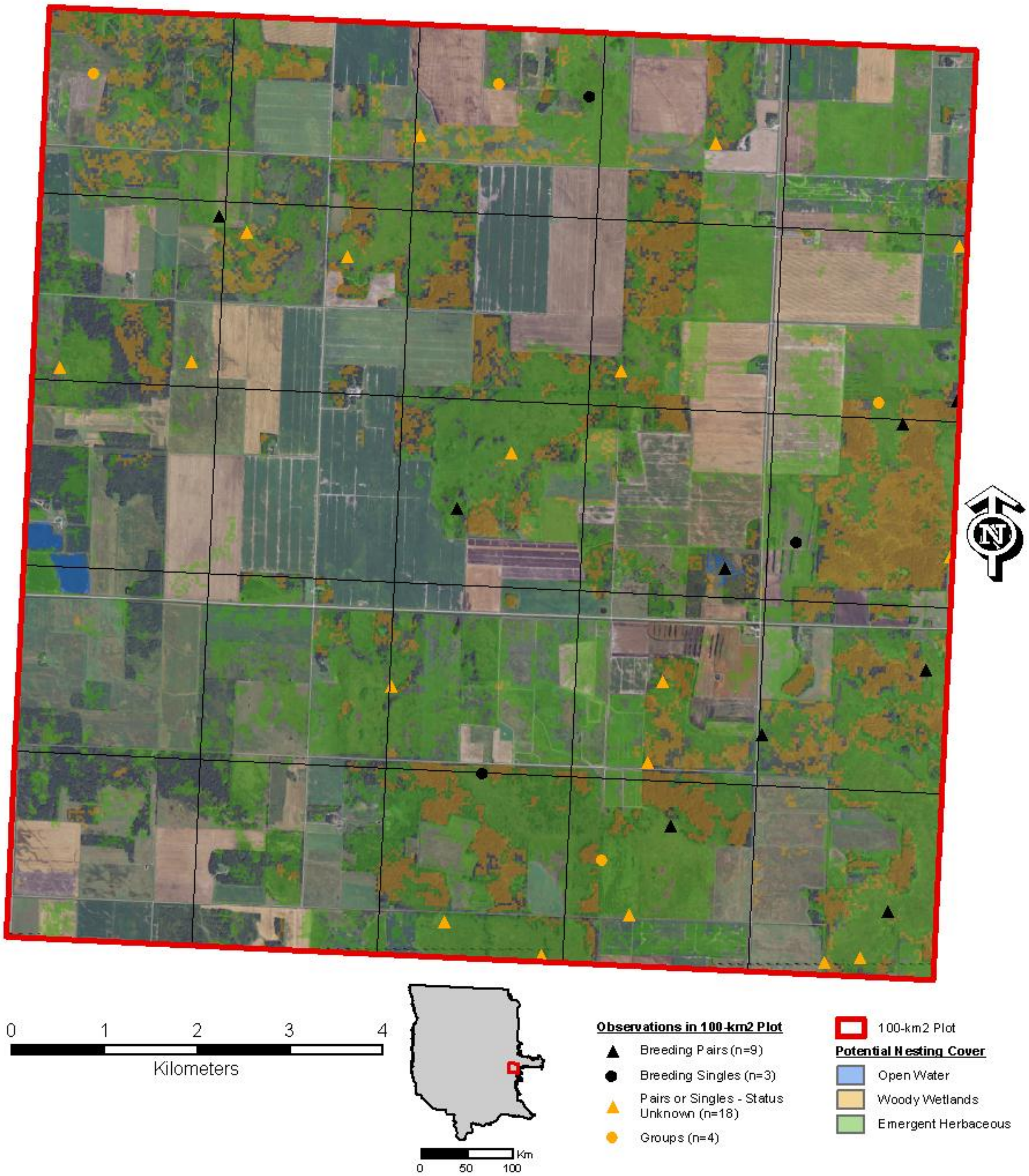


Figure 7. Location of sandhill crane observations, by social status, in a 100 km^2 plot overlaying Espelie Township, Marshall County, Minnesota, May 2012.