FARMLAND WILDLIFE POPULATIONS

Farmland Wildlife Populations and Research Group
35365 800th Avenue
Madelia, MN 56062-9744
(507) 642-8478

DEPARTMENT OF
NATURAL RESOURCES

2017 MINNESOTA AUGUST ROADSIDE SURVEY

Lindsey N. Messinger & Nicole M. Davros, Farmland Wildlife Populations and Research Group

SUMMARY OF FINDINGS

A decrease in grassland habitat acres (primarily Conservation Reserve Program (CRP) lands) is likely linked to a decrease in Minnesota's 2017 population indices for ring-necked pheasants and gray partridge. The 2017 range-wide pheasant index (38.1 birds/100 miles) was 26% below the 2016 index. Indices for pheasants and gray partridge were both below their 10-year and long-term averages. Range-wide indices for cottontail rabbits and white-tailed deer were similar to 2016. The white-tailed jackrabbit, mourning dove, and sandhill crane indices decreased in 2017 and mourning dove indices remained below their 10-year and long-term averages.

INTRODUCTION

This report summarizes the 2017 Minnesota August Roadside Survey (ARS). Since 1955, the ARS has been conducted annually during the first two weeks of August by Minnesota Department of Natural Resources (MN DNR) wildlife and enforcement personnel throughout Minnesota's farmland regions (Fig. 1). The 2017 ARS consisted of 171 25-mile routes (1-4 routes/county); 151 routes were located in the ring-necked pheasant range.

Observers drove each route during the early morning (starting at or near sunrise) at 15-20 miles/hour and recorded the number of pheasants, gray (Hungarian) partridge, cottontail rabbits, white-tailed jackrabbits, white-tailed deer, mourning doves, sandhill cranes, and other wildlife they observed including information on sex and age of these species. Counts conducted on cool, clear, calm mornings with heavy dew yield the most consistent results because wildlife (especially pheasants, gray partridge, and rabbits) move to warm, dry areas (e.g., gravel roads) during early-morning hours. These data provide an index of relative abundance that are used to monitor annual changes and long-term trends in regional and range-wide populations. Results are reported by agricultural region (Fig. 1) and range-wide; however, population indices for species with low detection rates (e.g., white-tailed jackrabbits) are imprecise and should be interpreted cautiously.

Habitat Conditions

In Minnesota's farmland region, total undisturbed grassland habitat decreased in 2017 after a slight increase in 2016. Statewide, 5,244 habitat acres were lost since 2016 (pheasant range: 8,637 acres lost; greater prairie-chicken range: 5,660 acres lost). Conservation Reserve Program (CRP) enrollment decreased by 26,327 acres overall. CRP losses occurred within both the pheasant range (25,428 acres lost) and prairie-chicken range (9,880 acres lost). Acres enrolled in the Conservation Reserve Enhancement Program (CREP) held nearly steady in 2017 while acres enrolled in Reinvest in Minnesota (RIM), Wetlands Reserve Program (WRP), and RIM-WRP increased statewide (5,731 acres, 1,059 acres, and 1,914 acres, respectively). Despite loss of privately-owned undisturbed grassland habitat, publically-owned grassland habitat within the farmland regions increased in 2017. Federally-owned Waterfowl Production Areas (WPA) and U.S. Fish and Wildlife Service (USFWS) refuges increased by 3,040 acres and state-owned Wildlife Management Areas (WMA) increased by 9,269 acres. More WMA acres were gained in the pheasant range (8,492 acres) than the prairie-chicken range (816 acres). The USFWS added 2,422 acres of habitat in the pheasant range and 1,424 acres in the prairie-chicken range. Similar to 2016, remaining protected habitat accounts for 6.1% of the landscape within the pheasant range (range:

3-10%; Table 1).

Grassland and wetland habitat conservation remains a priority concern for Minnesota. Private-land conservation programs, including CRP, continue to make up a large portion of protected grassland habitat in the state (Fig. 2) but approximately 686,800 acres of CRP have been lost since 2007. The 2012 version of the Farm Bill placed a cap of 24 million acres nationwide on CRP, leading to a steady decline of habitat acres in recent years. The Farm Bill is up for renewal in 2018 and many conservation groups are asking for the nationwide cap on CRP to be increased to 40 million acres. Funding from the Legacy Amendment[1] has helped partially offset habitat losses but the pace has not kept up with the rate of CRP losses. Minnesota's Prairie Conservation Plan and Pheasant Summit Action Plan both offer a blueprint for moving forward with grassland and wetland habitat conservation strategies in the farmland regions, thereby helping partners prioritize lands acquired with Legacy Amendment funding.

Started in 2012, Minnesota's Walk-in Access (WIA) program continues to provide public hunting opportunities on private land that is already enrolled in existing conservation programs or has high quality natural habitat. In 2015, the U.S. Department of Agriculture (USDA) awarded a 3-year, $1.67 million grant to assist in the continued funding of the WIA program. As of July 2017, 232 sites totaling 26,756 acres spread across the Farmland regions of Minnesota were enrolled in the program and open to public hunting September 1 – May 31 where boundary signs are present. Hunters must purchase a $3 WIA Validation to legally access WIA lands. For more information on the WIA program, including the code of conduct for WIA lands, a printable atlas of enrolled sites by county, aerial photos of each site, interactive maps, and Global Positioning System (GPS) downloads, visit the WIA program website. Minnesota DNR is still seeking permanent funding to continue the program into the future.

Weather Summary

Minnesota's winter 2016-2017 (1 December 2016 – 31 March 2017) was warmer across the state with average temperatures 3.4 - 4.0°F above thirty-year normals (Table 2; Minnesota Climatology Working Group [MCWG] 2017a, Climate Summary). Winter snow cover was variable across the farmland zone, but snow depths exceeding 6 inches lasted several weeks in the Northwest and West Central regions (MCWG 2017b, MCWG Climate Summary). By March, snow depths of less than 1.5 inches were recorded across the state except for the Northwest.

Spring (1 April – 31 May) temperatures were at or below thirty-year normals statewide and precipitation varied widely across the farmland regions. The Central and East Central regions experienced higher than normal rainfall (>1 inch departure from normal) with 8.1 and 8.4 inches of rain during spring 2017 respectively.

Summer (1 June – 31 July) was warm and dry across the state with temperatures 2.3 – 4.1 °F above thirty-year normal temperatures. Rainfall across the state was near or below average during June and July. Overall, the conditions for over-winter survival of wildlife were average to above average throughout the farmland zone. Although some localized areas received excessive snowfall during the winter months, these snow events were localized and outside the core pheasant range. Rainfall during May and June (the prime period for nesting birds) was above normal in some areas and normal- to cooler-than-normal temperatures may have impacted nest success and chick survival, especially early in the nesting season.

Survey Conditions

The survey period was extended (28 July – 19 August) to allow survey routes (n=171) to be

[1]Minnesota's Legacy Amendment, passed in 2008, is a 25-year constitutional amendment that increases the state sales tax by 3/8 of 1%. A large portion of the funding generated by this amendment is dedicated to protecting drinking water sources and protecting, enhancing, and restoring wetlands, prairies, and other wildlife habitat.

completed in 2017. Weather conditions during the survey ranged from excellent (calm winds, heavy dew, clear sky) to medium (light dew and overcast skies). Medium to heavy dew conditions were present at the start of 96% of the survey routes which was comparable to 2016 (97%) and slightly above the 10-year average (93%). Similar to 2016, clear skies (<30% cloud cover) were present at the start of 85% of routes. Wind speeds <7 mph were recorded for 97% of the routes.

Ring-Necked Pheasant

In 2017, the average number of pheasants observed range-wide (38.1 birds/100 mi) decreased 26% from 2016 and was 32% below the 10-year average and 62% below the long-term average (Table 3, Fig. 3A). Total pheasants observed per 100 mi ranged from 19.2 birds in the Southeast region to 54.6 birds in the South Central region (Table 4). The pheasant index showed substantial decreases in the Central (42%), East Central (61%) and Southwest (46%) regions. The best harvest opportunities will be in the West Central, Southwest, and South Central regions.

The range-wide hen index (5.8 hens/100 mi) decreased 26% from 2016 and was 34% below the 10-year average and 61% below the long-term average (Table 3). The hen index ranged from 2.3 hens/100 mi in the Southeast to 7.9 hens/100 mi in the South Central region. The 2017 hen index in all regions decreased since 2016 with the Southwest (-50.8%), East Central (-42.8%), and Central (-40.4%) regions showing the greatest percent change.

Across their range, the cock index (6.4 cocks/100 mi) increased 11% from 2016 but remained 8% below the 10-year average and 41% below the long-term average (Table 3). The cock index ranged from 1.7 cocks/100 mi in the Southeast to 8.6 cocks/100 mi in the South Central region. The 2017 indices increased in the Central (52.2%) and South Central (43.7%) regions while decreasing in the Southwest region (-29.8%). Indices were similar to 2016 in the West Central, East Central, and Southeast regions.

The 2017 hen:cock ratio (0.9) was less than the 2016 ratio (1.35) and was well below the average (1.40 ± 0.35) for the CRP years (1987-2017).

The 2017 range-wide brood index (5.7 broods/100 mi) decreased 34% from 2016 (Table 3). The index was 35% below the 10-year average and 57% below the long-term average. Regional brood indices ranged from 3.3 broods/100 mi in the Central region to 8.4 broods/100 mi in the Southwest. Brood indices decreased in all regions (range: -17.4% to -55.5%). The average brood size in 2017 (4.5 chicks/brood) was similar to 2016 and the 10-year average. However, the average brood size in 2017 was still 17% below the long-term average of 5.4 chicks/brood. The median estimated hatch date for pheasant broods across their range (8 June 2017, n = 217 broods) was slightly earlier than in 2016 (11 June) and the 10-year average (12 June; Table 3).

Although weather can drive year-to-year fluctuations in pheasant numbers, the amount of habitat on the landscape drives the longer term trends. Mild winters and breeding season weather conditions helped increase the pheasant indices over the past few years; however, the gradual but steady loss of habitat, especially CRP, has led to an overall decline in the pheasant population and harvest since the mid-2000s (Fig 2. & 3A).

Gray Partridge

The range-wide gray partridge index (1.3 birds/100 mi) decreased 63% from 2016 and was 60% and 90% below the 10-year and long-term averages, respectively (Table 3, Fig. 3B). No partridge were observed in the Northwest or West Central regions in 2017 (Table 4). Indices in regions where they were observed ranged from 0.5 birds/100 mi in the Central region to 5.1 birds/100 mi in the Southwest region. Intensified agricultural land use (e.g., corn and soybeans) has reduced the amount of suitable habitat for gray partridge in Minnesota. Additionally, gray partridge in their native range (southeastern Europe and northern Asia) are associated with arid climates and their reproductive success in the Midwest is limited except during successive dry years. Thus, gray partridge are more adversely affected by excessive rainfall during the breeding season compared to pheasants. The Southwest and Southeast regions will offer the best opportunities for harvesting gray partridge in 2017.

Cottontail Rabbit And White-Tailed Jackrabbit

Range-wide, the eastern cottontail rabbit index (7.7 rabbits/100 mi) increased 8% from 2016 and was 45% above the 10-year average and 28% above the long-term average (Table 3, Fig. 4A). Regionally, the cottontail rabbit index ranged from 1.3 rabbits/100 mi in the Northwest to 23.1 rabbits/100 mi in the East Central region (Table 4). Good harvest opportunities should exist in the Central, East Central, South Central, and Southeast regions.

At a historic low, the number of white-tailed jackrabbits observed range-wide (0.0 rabbits/100 mi) was 98% below the long-term average (1.7 rabbits/100 mi; Table 3, Fig. 4B). Minnesota's jackrabbit population peaked in the late 1950s, declined to low levels in the 1980s, and has continued to decline since then. The long-term decline in jackrabbits can primarily be attributed to loss of preferred habitats (i.e., pasture, hayfields, and small grains).

White-Tailed Deer

The white-tailed deer index (26.6 deer/100 mi) was similar to 2016 and was 52% above the 10-year average and 137% above the long-term average (Table 3, Fig. 5A). Regional roadside indices for deer ranged from 10.7 deer/100 mi in the South Central region to 55.2 deer/100 mi in the Northwest (Table 4).

Mourning Dove

The range-wide mourning dove index (138.9 doves/100 mi) was 6% lower than 2016, 28% below the 10-year average, and 46% below the long-term average (Table 3, Fig. 5B). Regional indices ranged from 60.3 doves/100 mi in the East Central region to 167.1 doves/100 mi in the South Central region (Table 4). The best opportunities for harvesting doves should be in the West Central, Southwest, and South Central regions.

Sandhill Crane

The 2017 roadside index of sandhill cranes was 11.9 total cranes/100 mi which decreased 23% from 2016 (Table 3). Regional indices ranged from 0.0 total cranes/100 mi in the Southeast and Southwest regions to 55.4 total cranes/100 mi in the East Central region (Table 4). The range-wide index of juveniles was 2.4 juvenile cranes/100 mi which increased slightly from 2016 (Table 3).

Other Species

Notable incidental sightings included: alder flycatcher (Polk County), American bittern (Todd County), badger (Swift County), black-billed magpie (Polk and Red Lake Counties), elk (Kittson County), greater prairie chicken (Clay County), green heron (Dodge County), mink (McLeod, Stearns, and Stevens Counties), pileated woodpecker (Red Lake County), red-headed woodpecker (Redwood and Renville Counties), sharp-tailed grouse (Kittson and Red Lake Counties), sora (Murray County), tiger salamander (Freeborn County), trumpeter swan (Kandiyohi County), and upland sandpiper (Pipestone County). American kestrels, American crow, bald eagles, Canada geese, coyotes, domestic cats, northern harrier, red fox, red-tailed hawks, and wild turkeys were also noted in multiple counties.

ACKNOWLEDGMENTS

We thank the many cooperators for their help in completing routes. This survey is simply not possible without their efforts. Tonya Klinkner was invaluable in providing logistical assistance and completing data entry. Tabor Hoek of the Minnesota Board of Water and Soil Resources provided enrollment data on cropland retirement programs in Minnesota, Kim Hennings (MN DNR) provided updated MN DNR land acquisition information, and Tamra Adams of the U.S. Fish and Wildlife Service provided federal land acquisition data. John Giudice reviewed an earlier draft of this report.

This work was funded in part through the Federal Aid in Wildlife Restoration Act.

LITERATURE CITED

Minnesota Climatology Working Group (MCWG). 2017a. MCWG Climate Summary Table. Accessed 9 August 2017.

Minnesota Climatology Working Group (MCWG). 2017b. MCWG Snow Depth and Snow Depth Ranking Maps. Accessed 9 August 2017.

Table 1. Abundance (total acres) and density (acres/mi2) of undisturbed grassland habitat within Minnesota's pheasant range, 2017, by agricultural region (AGREG).

	Cropland Retirement [a]					Public Lands			% of	Density
AGREG	CRP[b]	CREP	RIM	RIM-WRP	WRP	USFWS[c]	MNDNR[d]	Total	Landscape	ac/mi^2
WC[e]	246,470	37,755	22,975	14,275	20,124	197,750	110,747	650,096	10.0	61.0
SW	97,103	24,770	20,627	2,553	766	23,444	71,502	240,765	6.0	41.0
C	121,621	14,326	37,575	7,026	3,028	90,520	50,966	325,062	5.0	34.0
SC	86,665	27,633	13,585	10,703	8,981	9,494	36,310	193,371	5.0	31.0
SE	67,119	2,706	7,405	1,070	1,581	36,801	55,259	171,941	5.0	30.0
EC	2,949	0	1,131	0	4	4,993	91,829	100,906	3.0	20.0
Total	621,927	107,190	103,298	35,627	34,484	363,002	416,613	1,682,141	6.1	39.0

[a] Unpublished data, Tabor Hoek, BWSR, 16 August 2017.
[b] Acres reduced to account for estimated active CREP contracts reported within CREP column.
[c] Includes Waterfowl Production Areas (WPA) and USFWS refuges.
[d] MN DNR Wildlife Management Areas (WMA).
[e] Does not include Norman County.

Table 2. Average temperature, snow depth, and precipitation by season and agricultural region in Minnesota, 2017.

	Agricultural Region							
	NW	**WC**	**C**	**EC**	**SW**	**SC**	**SE**	**STATE**
Winter (December 1 - March 31)								
Temperature (average °F)	17.4	21.5	22.7	22.7	24.3	25.0	23.4	21.8
Departure from normal (°F)[a]	3.6	3.6	4.0	3.6	3.4	3.9	3.5	3.5
Snow Depth (average inches)	9.0[b]	2.9[b]	2.2	2.3	1.8	2.2	3.1	3.9
Spring (April 1 - May 31)								
Temperature (average °F)	48.9	50.7	50.8	50.0	51.4	52.8	50.5	49.8
Departure from normal (°F)[a]	0.1	-0.1	-0.3	-0.4	-0.4	0.5	-0.2	-0.2
Precipitation (total inches)	2.6	5.2	8.1	8.4	7.1	7.6	7.1	7.1
Departure from normal (inches)[a]	-0.8	0.1	1.1[c]	1.2[c]	0.4	0.2	0.6	0.6
Summer (June 1 - July 31)								
Temperature (average °F)	56.0	57.1	57.1	56.4	58.7	59.7	58.4	56.9
Departure from normal (°F)	4.1	2.7	2.4	2.3	2.8	3.4	3.2	2.8
Precipitation (total inches)	6.4	7.7	8.4	9.4	7.0	8.3	9.8	8.9
Departure from normal (inches)[a]	-0.3	-0.2	-0.2	0.1	-0.5	-0.5	0.1	0.0

[a] Departures calculated using thirty year NOAA average (1981-2010) over respective time period.
[b] At least one two-week period with snow depth exceeding 6 inches.
[c] Precipitation >1 inch above normal.

Table 3. Range-wide trends (% change) in number of wildlife observed per 100 miles driven, Minnesota August roadside survey, 1955-2017.

Species	**Change from 2016[a]**					**Change from 10-year average [b]**				**Change from long-term average (LTA)[c]**			
Subgroup	*n*	2016	2017	%	95% CI	*n*	2007-16	%	95% CI	*n*	LTA	%	95% CI
Ring-necked pheasant													
Total pheasants	152	51.4	38.1	-26	±18	148	52.3	-32	±13	149	94.6	-62	±9
Cocks	152	5.8	6.4	11	±25	148	6.9	-8	±17	149	10.7	-41	±13
Hens	152	7.8	5.8	-26	±20	148	8.1	-34	±15	149	13.7	-61	±10
Broods	152	8.6	5.7	-34	±16	148	8.2	-35	±12	149	12.5	-57	±9
Chicks per brood	217	4.4	4.5	4			4.6	-2			5.4	-17	
Broods per 100 hens	152	109.6	98.6	-10			101.1	-2			101.5	-3	
Median hatch date	217	11 J	8 June				12 June						
Gray partridge	171	3.6	1.3	-63	±65	167	3.4	-60	±43	149	14.4	-90	±17
Eastern cottontail	171	7.1	7.7	8	±22	167	5.3	45	±22	149	6.6	28	±22
White-tailed jackrabbit	171	0.1	0.0	-67	±93	167	0.2	-73	±51	149	1.7	-98	±14
White-tailed deer	171	27.2	26.6	-2	±17	167	17.7	52	±20	168	11.3	137	±32
Mourning dove	171	147.0	138.9	-6	±18	167	190.8	-28	±10	149	265.6	-46	±11
Sandhill crane[d]													
Total cranes	171	15.4	11.9	-23	±48								
Juveniles	171	2.1	2.4	10	±51								

[a] Includes Northwest region, except for pheasants. Estimates based on routes (*n*) surveyed in both years.
[b] Includes Northwest region, except for pheasants. Estimates based on routes (*n*) surveyed at least 9 of 10 years.
[c] LTA = long-term average during years 1955-2016, except for deer (1974-2016). Estimates for all species except deer based on routes (*n*) surveyed ≥40 years; estimates for deer based on routes surveyed ≥25 years. Thus, Northwest region (8 counties in Northwest were added to survey in 1982) included only for deer.
[d] Cranes were added to the survey in 2009; thus, 10-year and long-term averages are not calculated.

Table 4. Regional trends (% change) in number of wildlife observed per 100 miles driven, Minnesota August roadside survey, 1955-2017.

Region / Species	Change from 2016[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
	n	2016	2017	%	95% CI	*n*	2007-16	%	95% CI	*n*	LTA	%	95% CI
Northwest[d]													
Gray partridge	19	0.0	0.0			19	0.6	-100	±101	19	3.1	-100	±60
Eastern cottontail	19	2.1	1.3	-39	±117	19	0.6	116	±315	19	0.8	50	±197
White-tailed jackrabbit	19	0.0	0.2			19	0.2	-3	±225	19	0.6	-64	±92
White-tailed deer	19	69.0	55.2	-20	±37	19	44.4	24	±33	19	32.9	68	±35
Mourning dove	19	116.2	114.7	-1	±59	19	87.8	31	±82	19	118.3	-3	±64
Sandhill crane[e]	19	65.2	35.6	-45	±102								
West Central[f]													
Ring-necked pheasant	39	50.8	43.2	-15	±34	35	59.4	-45	±31	37	96.1	-64	±18
Gray partridge	39	0.0	0.0			35	0.8	-100	±97	37	9.2	-100	±21
Eastern cottontail	39	3.4	4.3	28	±65	35	2.6	66	±89	37	3.9	2	±59
White-tailed jackrabbit	39	0.3	0.0	-100	±114	35	0.2	-100	±66	37	2.2	-100	±19
White-tailed deer	39	31.5	26.7	-15	±35	35	18.1	55	±52	37	10.8	147	±82
Mourning dove	39	189.8	162.1	-15	±28	35	233.9	-31	±19	37	363.5	-55	±13
Sandhill crane	39	1.7	3.2	83	±204								
Central													
Ring-necked pheasant	30	42.7	24.7	-42	±46	30	43.3	-43	±31	29	71.2	-64	±20
Gray partridge	30	2.3	0.5	-77	±151	30	1.5	-63	±42	29	9.0	-94	±41
Eastern cottontail	30	6.7	7.2	8	±69	30	4.4	65	±66	29	6.2	16	±47
White-tailed jackrabbit	30	0.0	0.0			30	0.1	-100	±99	29	1.2	-100	±22
White-tailed deer	30	21.7	33.2	53	±42	30	12.7	161	±83	29	6.8	403	±186
Mourning dove	30	160.8	144.0	-11	±52	30	174.1	-17	±34	29	227.3	-35	±27
Sandhill crane	30	22.9	16.1	-30	±45								
East Central													
Ring-necked pheasant	13	54.1	20.9	-61	±53	13	50.9	-59	±24	13	84.5	-75	±22
Gray partridge	13	0.0	1.2			13	0.0			13	0.1		
Eastern cottontail	13	21.5	23.1	7	±53	13	11.7	97	±66	13	8.9	159	±82
White-tailed jackrabbit	13	0.0	0.0			13	0.0			13	0.2	-100	±64
White-tailed deer	13	30.1	24.6	-18	±43	13	19.2	28	±63	13	10.4	136	±99
Mourning dove	13	62.9	60.3	-4	±33	13	92.4	-35	±29	13	115.5	-48	±29
Sandhill crane	13	42.3	55.4	31	±63								

Table 4. Continued.

Region	Change from 2016[a]					Change from 10-year average [b]				Change from long-term average (LTA)[c]			
Species	*n*	2016	2017	%	95% CI	*n*	2007-16	%	95% CI	*n*	LTA	%	95% CI
Southwest													
Ring-necked pheasant	19	96.0	51.7	-46	±44	19	95.8	-46	±24	19	113.6	-54	±21
Gray partridge	19	9.7	5.1	-48	±159	19	8.8	-42	±77	19	38.6	-87	±26
Eastern cottontail	19	6.1	5.1	-17	±80	19	5.6	-10	±47	19	8.0	-37	±41
White-tailed jackrabbit	19	0.4	0.2	-50	±185	19	0.6	-66	±103	19	3.6	-94	±21
White-tailed deer	19	27.8	16.6	-40	±46	19	18.6	-11	±35	19	10.2	63	±62
Mourning dove	19	182.1	165.9	-9	±28	19	272.0	-39	±15	19	307.5	-46	±19
Sandhill crane	19	0.0	0.0										
South Central													
Ring-necked pheasant	32	52.6	54.6	4	±35	32	51.1	7	±25	32	123.1	-56	±19
Gray partridge	32	7.5	0.9	-88	±85	32	6.6	-87	±57	32	17.9	-95	±21
Eastern cottontail	32	9.5	9.1	-4	±38	32	8.2	11	±33	32	7.7	18	±38
White-tailed jackrabbit	32	0.1	0.0	-100	±204	32	0.1	-100	±69	32	1.6	-100	±25
White-tailed deer	32	7.5	10.7	43	±63	32	6.1	76	±66	32	4.0	166	±104
Mourning dove	32	144.1	167.1	16	±62	32	249.5	-33	±19	32	254.4	-34	±38
Sandhill crane	32	2.1	1.0	-53	±107								
Southeast													
Ring-necked pheasant	19	17.9	19.2	7	±63	19	13.3	45	±83	19	67.2	-72	±32
Gray partridge	19	6.5	3.8	-42	±171	19	5.5	-31	±171	19	12.6	-70	±67
Eastern cottontail	19	7.5	11.3	50	±60	19	7.4	54	±47	19	7.7	46	±56
White-tailed jackrabbit	19	0.0	0.0			19	0.0			19	0.5	-100	±46
White-tailed deer	19	15.6	25.8	66	±94	19	15.6	65	±63	19	11.4	126	±88
Mourning dove	19	95.2	86.9	-9	±33	19	127.9	-32	±20	19	212.7	-59	±22
Sandhill crane	19	1.5	0.0	-100	±160								

[a] Based on routes (*n*) surveyed in both years.
[b] Based on routes (*n*) surveyed at least 9 of 10 years.
[c] LTA = long-term average during years 1955-2016, except for Northwest region (1982-2016) and white-tailed deer (1974-2016). Estimates based on routes (*n*) surveyed $\geq$40 years (1955-2016), except for Northwest ($\geq$20 years) and white-tailed deer ($\geq$25 years).
[d] Eight Northwestern counties (19 routes) were added to the August roadside survey in 1982.
[e] Cranes were added to the survey in 2009; thus, 10-year and long-term averages are not calculated.
[f] Two routes were added to the West Central region in 2014.

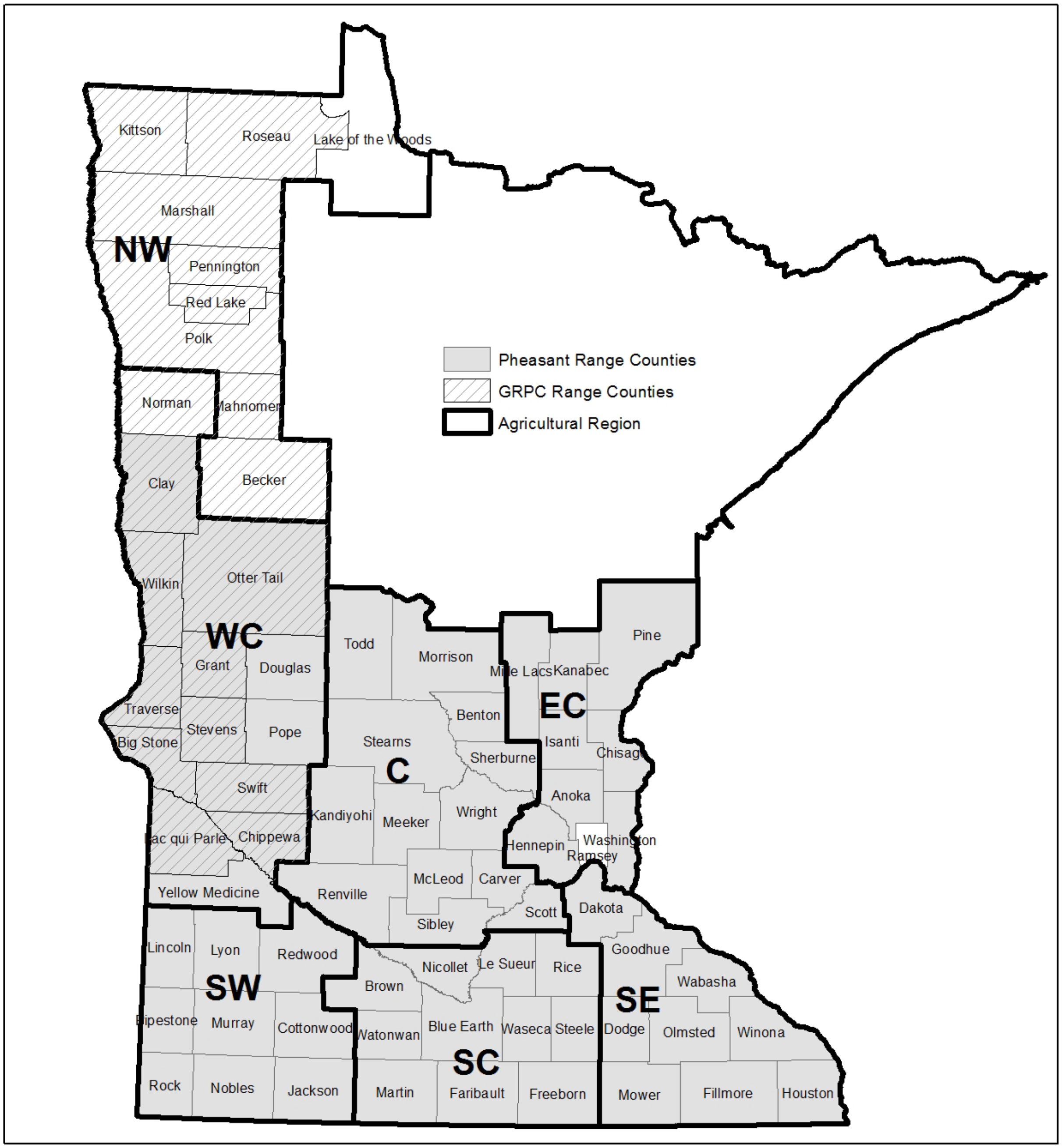


Figure 1. Survey regions, ring-necked pheasant range, and greater prairie-chicken (GRPC) range delineations for Minnesota's August roadside survey, 2017.

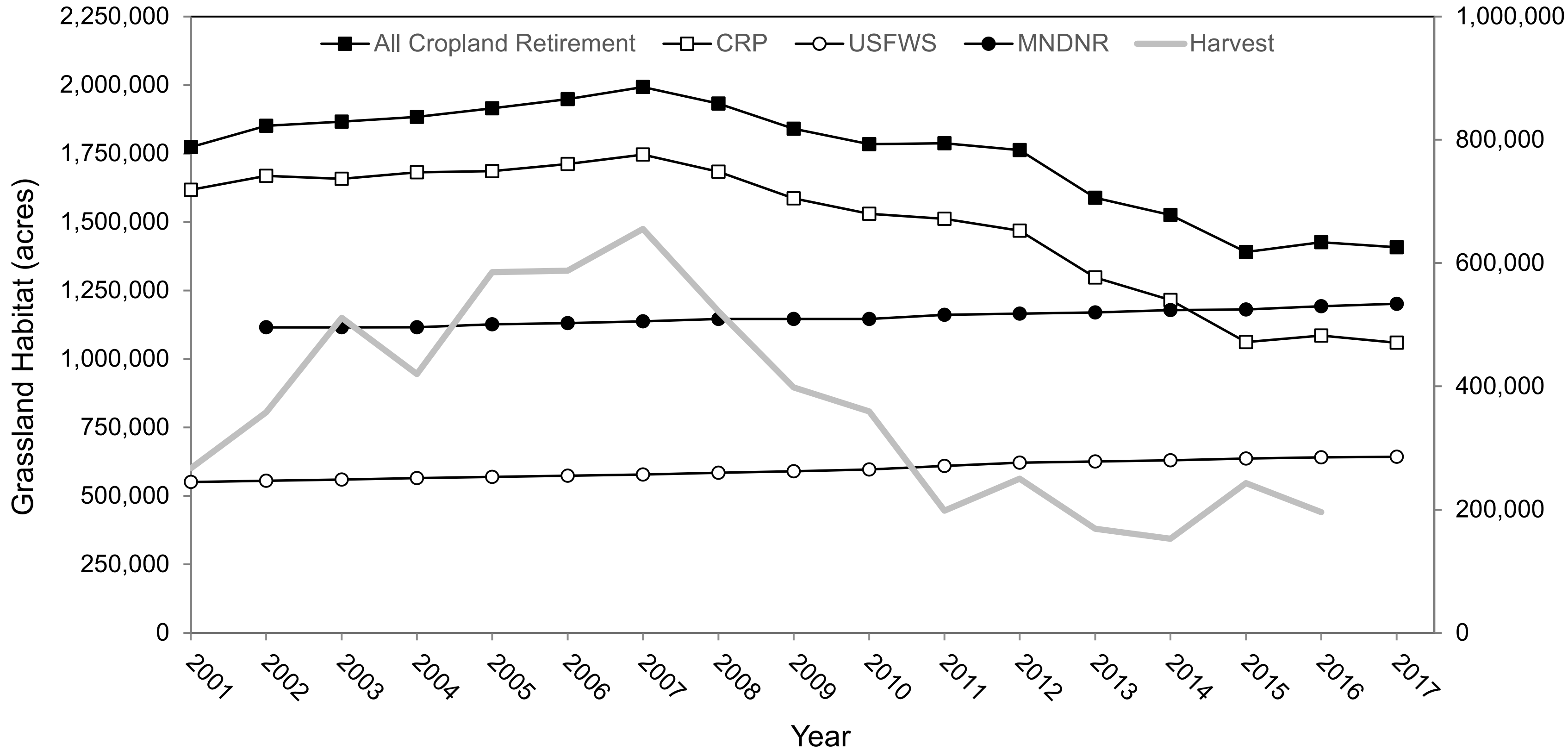
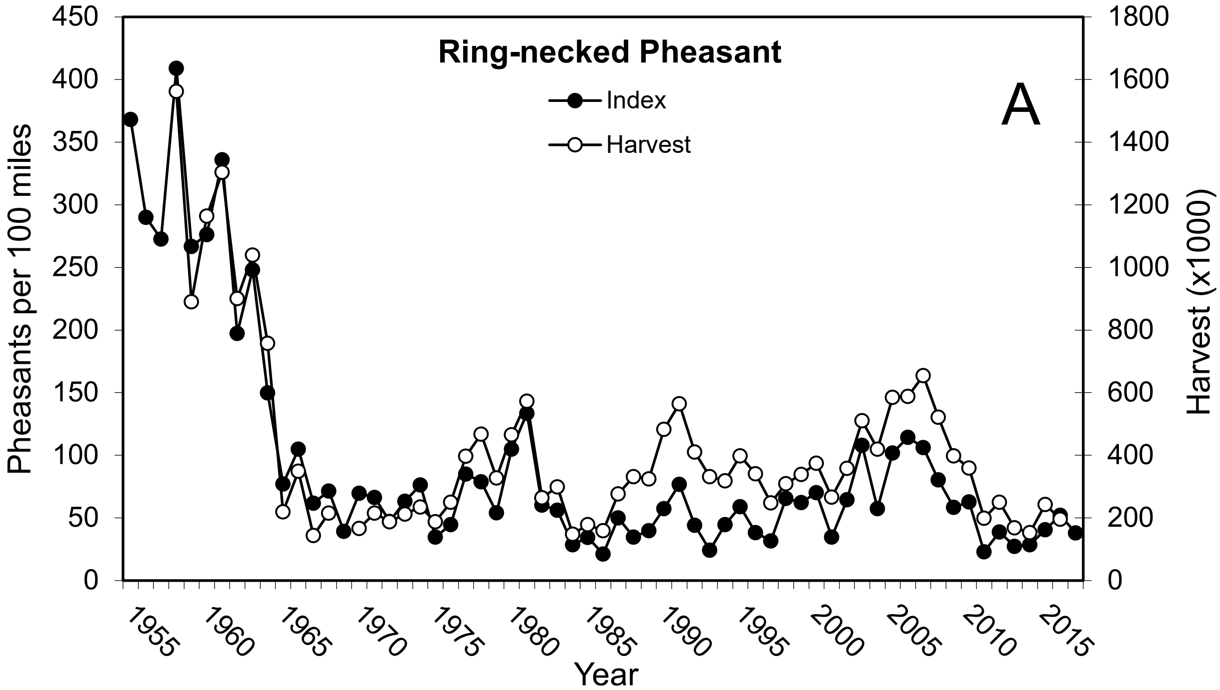


Figure 2. Acres enrolled in private (lines with open and solid squares) and public (lines with open and solid circles) land habitat conservation programs vs. ring-necked pheasant harvest trends (line with no markers) in Minnesota, 2001-2017. Acres represent STATEWIDE totals. All cropland retirement includes Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Reinvest in Minnesota (RIM), Wetlands Reserve Program (WRP), and RIM-WRP.



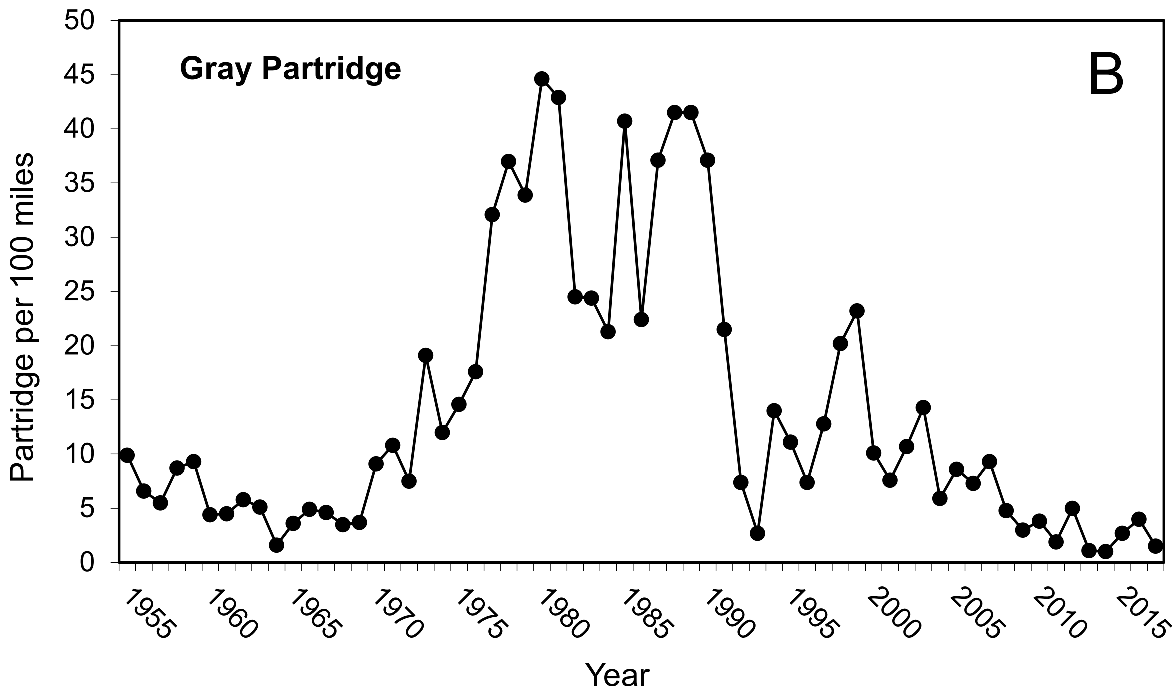


Figure 3. Range-wide index of ring-necked pheasants (A) and gray partridge (B) seen per 100 miles driven in Minnesota, 1955-2017. Does not include the Northwest region. Based on all survey routes completed.

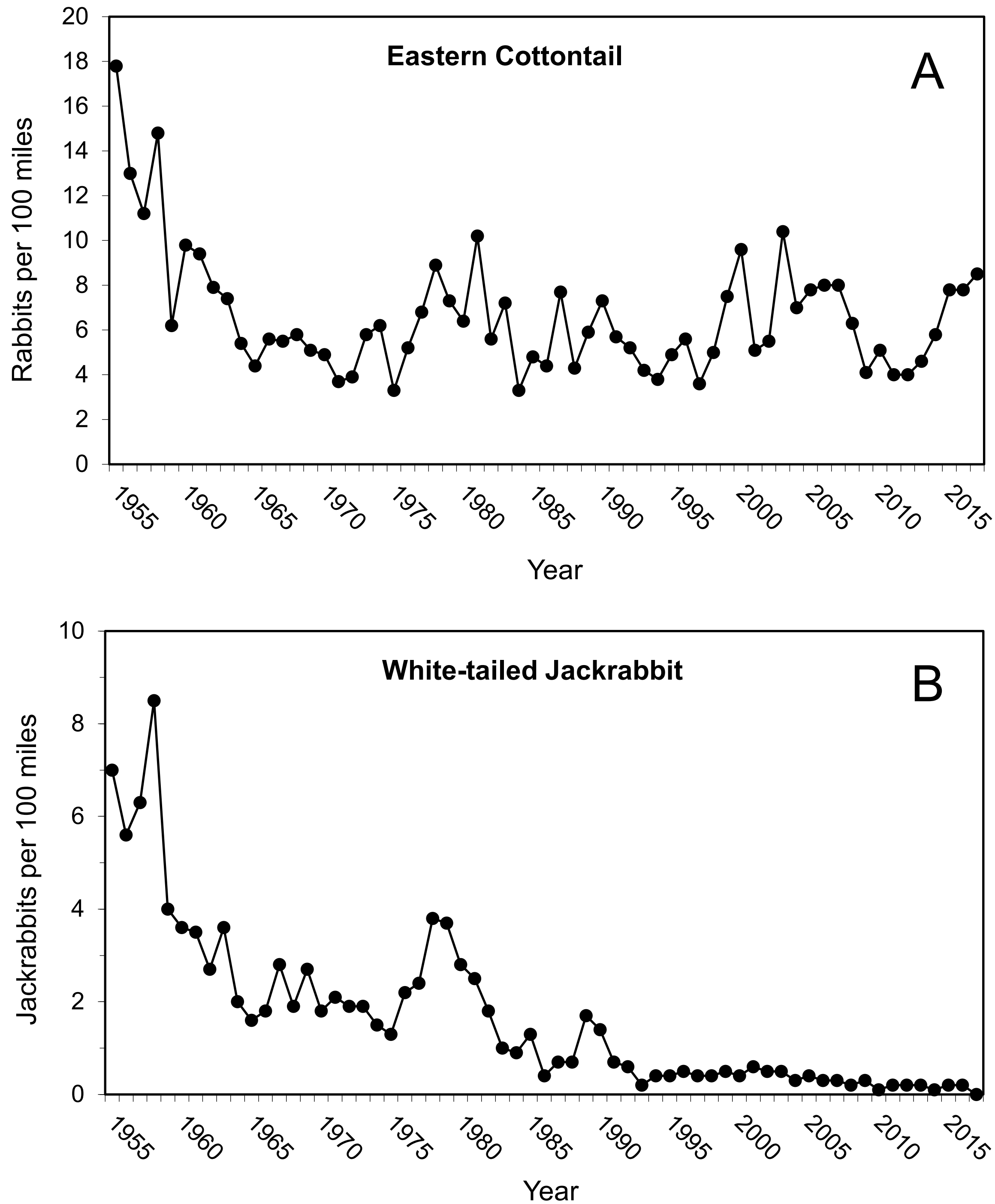
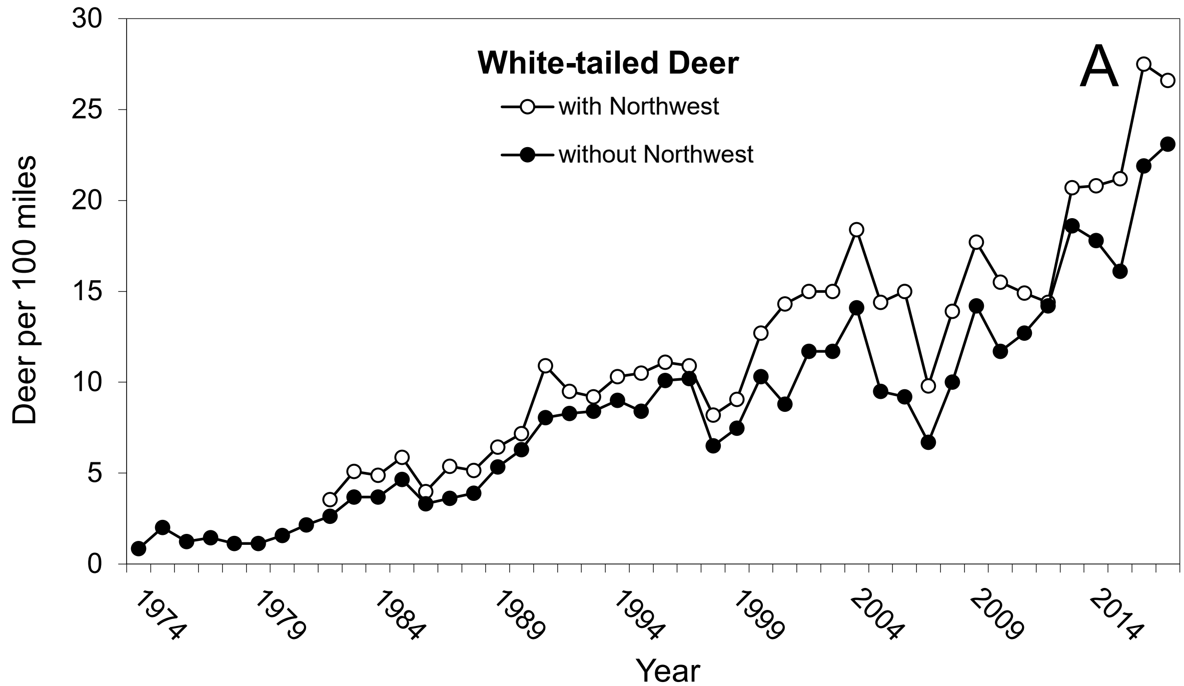


Figure 4. Range-wide index of eastern cottontail (A) and white-tailed jackrabbits (B) seen per 100 miles driven in Minnesota, 1955-2017. Does not include the Northwest region. Based on all survey routes completed.



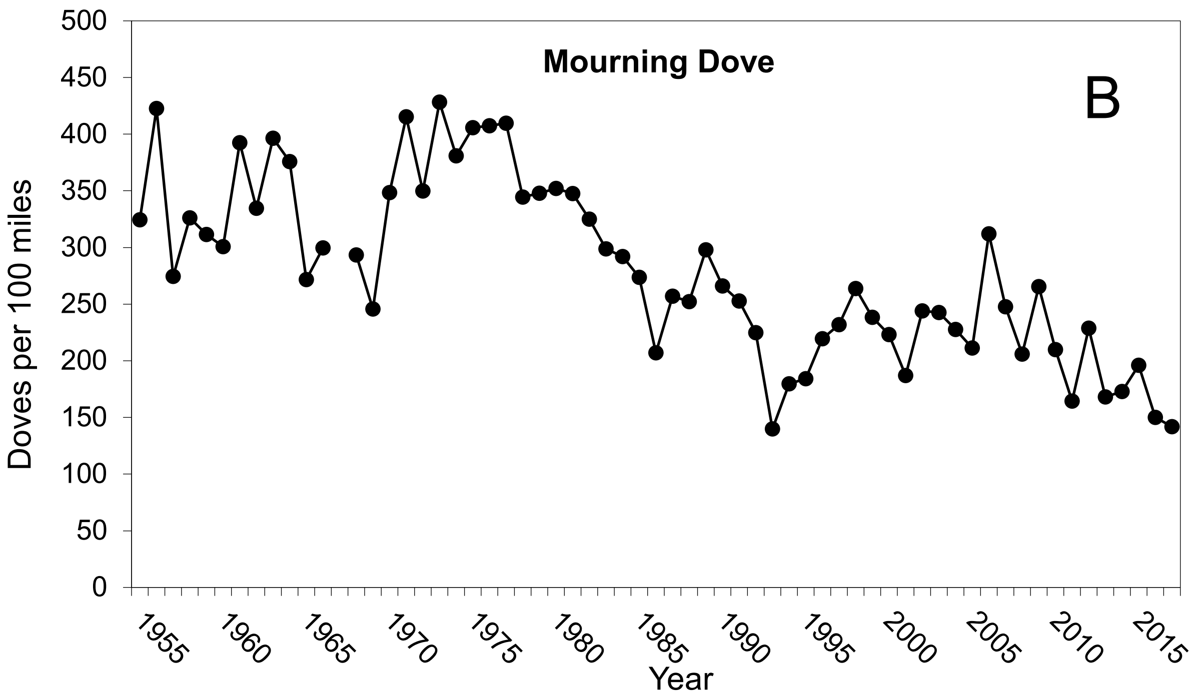


Figure 5. Range-wide index of: (A) white-tailed deer seen per 100 miles driven in Minnesota, 1974-2017, with and without the Northwest region included; and (B) mourning doves seen per 100 miles driven in Minnesota, 1955-2017. Doves were not counted in 1967 and the dove index does not include the Northwest region. Based on all survey routes completed.

DEPARTMENT OF NATURAL RESOURCES

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA - 2017

Andrew Norton, Farmland Wildlife Populations and Research Group

John H. Giudice, Wildlife Biometrics Unit

INTRODUCTION

Hunting is the primary method used to manage white-tailed deer (*Odocoileus virginianus*) populations in Minnesota. Minnesota Department of Natural Resources (MNDNR) sets hunting regulations annually to adjust deer harvest to meet management goals. MNDNR wildlife researchers conduct simulation modeling of deer populations within deer permit areas (DPAs) to understand historical deer herd dynamics, predict population sizes, and to explore the impacts of various hunting regulations on populations. To aid in decision-making, the output from population modeling is considered along with deer harvest metrics, hunter success rates, surveys of hunter and landowner satisfaction with deer populations, and deer population goals set through a public process.

We used a stochastic population model to simulate annual variations in deer densities within individual DPAs. We defined ranges of values for fecundity and survival by sex- and age-classes of deer based on values from the primary literature and data from studies within Minnesota. This report summarizes the structure and parameters of the simulation model, and provides a description of recent trends in deer populations.

METHODS

Model Structure

We started each multi-year simulation in spring of the initial year before reproduction occurred (Figure 1). We specified an initial population density (see more about selection of initial population densities in Modeling Procedures section), and the model converted the initial population density into a total population size by multiplying the density by the total land area of the DPA. We set the proportion of adult deer by age- and sex-class in the initial population (adult females mean = 0.40 [SD = 0.02], adult males mean = 0.25 [SD = 0.02]).

Within each annual cycle, we applied age-specific fecundity rates to females to estimate reproduction. All age- and sex-classes were subjected to spring/summer mortality, and the result was the pre-hunt fall population. Deer that died as a result of hunting were subtracted from the pre-hunt population. Winter mortality rates were estimated by age-class relative to the severity of winter, and were applied to the post-hunt population. The remaining population represented the starting population size for the next stage of the simulation. We assumed that the effects of immigration and emigration on a population within a DPA were equal. In the following, we provide more detailed information about the selection of model parameters.

Reproduction

We used fecundity rates, from a range of values reported for Minnesota and Wisconsin (MNDNR unpublished data, Fuller 1990, McCaffery et al. 1998, DelGiudice et al. 2007, Dunbar 2007, Grund 2011, Wisconsin Department of Natural Resources 2014). Fecundity rates were partitioned by 2 age-classes of breeding females (i.e., <1 year old [yearling] when bred and ≥1 years old [adult] when bred) and were allowed to vary by 3 eco-geographic zones (northeast, farmland and transition areas, southeast) that reflected relative differences in climate and habitat quality. Fecundity rates were estimated to be lowest in the northeast (yearlings, mean = 0.06 [SD = 0.01]; adults, mean = 1.55 [SD = 0.03]), moderate in the farmland and transition zone (yearlings, mean = 0.10 [SD = 0.01]; adults, mean = 1.75 [SD = 0.03]), and greatest in the southeast (yearlings, mean = 0.15 [SD = 0.01]; adults, mean = 1.85 [SD = 0.03]). The sex ratio of fawns at birth in most deer populations is approximately 50:50, but may vary annually (Ditchkoff 2011). We allowed the proportion of male fawns at birth to vary between 0.48-0.52.

Spring/Summer Survival

Survival rates of deer during winter are dependent on the severity of winter conditions (Fuller 1990, DelGiudice et al. 2002). Likewise, the condition of breeding females following winter may directly influence survival of their newborn fawns (Verme 1977, Nixon et al. 1991, Carstensen et al. 2009). MNDNR calculates a winter severity index (WSI) in each DPA annually based on snow depth and minimum daily temperatures. WSI was calculated weekly by staff from Minnesota Information Technology Services at MNDNR. From 1 November through 31 May, 1 point was added to the WSI for each day with snow depths ≥ 15 in (38.1 cm). One point was also added to the WSI for each day when temperatures were ≤0^0 F (-17.8^0 C). Therefore, the WSI accumulated 0, 1, or 2 points each day in a DPA. Winters were considered mild when the WSI was <100 and severe when WSI was ≥180.

We used estimates of spring/summer survival of fawns, from values reported in the primary literature for deer in Minnesota and populations in similar habitats (Huegel et al. 1985, Nelson and Mech 1986a, Nelson and Woolf 1987, Kunkel and Mech 1994, Brinkman et al. 2004, Vreeland et al. 2004, Rohm et al. 2007, Hiller et al. 2008, Carstensen et al. 2009). Fawn survival rates were adjusted to approximate the effects of winter severity on the condition of adult females during the previous winter. Mean spring/summer survival values for fawns were 0.80 (SD = 0.03), 0.65 (SD = 0.03), and 0.45 (SD = 0.03) following mild (WSI <100), moderate (100≤ WSI <180), and severe winters (WSI ≥180), respectively.

Spring/summer survival rates reported in the primary literature for adult deer ≥1 year old were relatively high and similar for both sexes (DeYoung 2011). We used default values for summer survival of adult deer from the population model previously used in Minnesota (Grund and Woolf 2004, Grund 2014) and allowed the values to vary stochastically (female = 0.97 [SD = 0.01], male = 0.98 [SD = 0.01]). These estimates overlapped values reported in the literature for Minnesota and populations in similar habitats (Nelson and Mech 1986a, Fuller 1990, Van Deelen et al. 1997, Whitlaw et al. 1998, Brinkman et al. 2004, Grund and Woolf 2004, Grund 2011, Grovenburg et al. 2011).

Fall Harvest and Survival

In most DPAs in Minnesota, hunter harvest represents the greatest source of mortality for deer populations in the fall (Fuller 1990, DelGiudice et al. 2006, Grovenburg et al. 2011).

We obtained harvest data from the MNDNR Electronic Licensing System. Hunters were required to register deer within 48 hours after harvest, indicate in which DPA the deer was harvested, and classify the deer as adult male, adult female, fawn male, or fawn female. We pooled harvest data for the archery, firearms, and muzzleloader seasons, special hunts, and harvest reported by Native American Tribes within DPAs.

We recognized that some deer were killed but not registered because hunters did not complete the registration process (Rupp et al. 2000), wounding loss occurred (i.e., deer was not recovered by the hunter and thus was not reported; Nixon et al. 2001), and deer were harvested illegally (Dusek et al. 1992). We applied a mean multiplier of 1.05 to the numerical harvest to account for non-registered deer.

Winter Survival

Winter severity, particularly snow depth, increases risk of deer mortality via starvation and predation, and fawns are more susceptible than adults (Nelson and Mech 1986b, DelGiudice et al. 2002). We estimated winter survival rates relative to winter severity based on studies conducted in Minnesota (Nelson and Mech 1986a, DelGiudice et al. 2002, Brinkman 2004, Grund and Woolf 2004, DelGiudice 2006, Grovenburg et al. 2011, Grund 2011). These studies reported survival rates similar to those observed in other deer populations in northern latitudes (Van Deelen et al. 1997, Whitlaw et al. 1998, DePerno et al. 2000, Dumont et al. 2000).

For adult deer, we set mean winter survival at 0.95 during mild winters. For moderate to severe winters, we used a linear equation to calculate survival as a function of winter severity (mean winter survival = $1 - [0.011 + 0.0015\ WSI]$) based on previous research in Minnesota. For fawns, we set the mean winter survival rate at 0.85 during mild winters. For moderate winters, the linear equation to calculate adult survival was used. However, an additional mortality rate of 0.05 was subtracted to simulate parallel but lower survival of fawns versus adults (mean winter survival = $(1 - [0.011 + 0.0015\ WSI]) - 0.05$). For severe winters, the equation was adjusted to simulate increased mortality reported for fawns in field studies (mean winter survival = $1 - [0.0054\ WSI - 0.33]$). For extremely severe winters (WSI >240), we set fawn survival at 0.033. We then allowed winter survival (for both fawns and adults) in any given model iteration to vary stochastically about the predicted mean using SD ≈ 0.02. Winter survival relationships were parameterized based on previous Minnesota research studies of radiocollared deer.

Modeling Procedures

To model each DPA, we tested several initial population densities including: 1) population estimates from field surveys when available for the starting year of the simulation (Haroldson 2014); 2) previous estimates from modeling (Grund 2014); or 3) a crude population estimate reconstructed from the reported harvest of adult males in the most recent deer season and given assumptions about the harvest rate of adult males, the proportion of adult males in the pre-hunt population, and the proportion of adults in the pre-hunt population.

To determine the most appropriate initial population density, we examined the modeled population trends relative to: 1) population estimates from field surveys when available within the years modeled; 2) the trend in reported deer harvest; and 3) the relationship between estimated population densities and adult male harvest success. To further refine the initial population density, we incrementally increased and decreased the density and re-examined the modeled trend relative to the aforementioned indices. In some cases, we also adjusted spring/summer survival of adult females ≤0.10 in conjunction with varying initial population densities.

We ran most model simulations for 8 years (2010-2017) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring 2017). All simulations were performed with the R programming language (ver. 3.3.2, R Core Team 2017). We used 500 Monte Carlo simulations (simulated draws from the stochastic distributions) until the most reasonable set of starting parameters was determined, and then used 5,000 simulations for the final run.

It is not logistically or financially feasible to conduct field studies on deer populations across all DPAs with regularity to estimate model input parameters. Population modeling requires researchers to make assumptions about these data based on prior studies (Hansen 2011). Because model input data rely on broad generalizations about herd demographics and survival rates, models simulating deer populations in small geographic areas would not be realistic. Grund and Woolf (2004) demonstrated that modeling small deer herds increased variability in model estimates, thus decreasing the ability to consider model outputs in making management decisions. Therefore, we did not model populations in DPAs that were small in area or where harvest data were limited.

RESULTS

Deer Population Trends and Management Recommendations

Although the parameters included in the model were derived from studies of deer in Minnesota or from studies in similar habitats and environmental conditions, uncertainty is inherent in modeling the dynamics of free-ranging deer populations. Our modeling allowed input parameters to vary stochastically to simulate uncertainty, and model outputs also included measures of uncertainty reflecting variation among model simulations. However, for ease of interpretation, we present mean pre-fawn deer densities in this document. We conducted simulation modeling in 121 of 130 DPAs in Minnesota to estimate deer densities before reproduction during spring 2017 (Table 1, Figure 2).

Following 3 deer seasons with relatively conservative management designations and 3 winters with mild conditions across most of the state, deer populations in most DPAs have increased. Fewer opportunities to harvest deer with either-sex permits in 2014, 2015, and 2016 protected female deer and fawn males from harvest. This allowed a carry-over of fawn males, which became antlered bucks legal for harvest during the 2015 and 2016 seasons. In 2016, buck harvest was more than 100,000 deer, which was >10% above the average for the previous 5 years. Consistent with this trend, substantial numbers of female deer were protected from harvest during 2014 to 2016, and population growth was accelerated.

Deer populations in most DPAs were approaching goal levels by spring 2016, and recommendations from MNDNR research for the 2016 deer season were aimed at identifying consistent regulations to begin to stabilize deer densities. Following another mild winter in 2016-2017, deer densities continued to increase across much of the state despite more liberal antlerless regulations in 2016. In terms of management intensity, the 2017 research recommendations would afford more antlerless deer harvest opportunities to hunters in approximately half of the DPAs versus the 2016 season. For most of the remaining DPAs, research recommendations in 2017 were the same as 2016, and only a few DPA recommendations afforded less antlerless harvest opportunity.

Farmland Zone

Deer populations in the majority of farmland DPAs were near goal levels. Antlerless harvest in the farmland zone was closely tied to the number of either-sex permits. We selected management designations to stabilize deer numbers with consistent regulations across years whenever possible. In most DPAs in the farmland region we recommended a lottery designation, with moderate to high allocations of either-sex permits. Less than 20% of the DPAs required Hunter Choice and Managed designations to stabilize deer numbers at appropriate levels.

Farmland-Forest Transition Zone

Deer populations in the Farmland-Forest Transition Zone are highly productive due to excellent habitat and generally milder winters as compared to the Forest Zone. Historical harvests and modeled population trends suggested that Lottery designations were not sufficient to stabilize deer numbers in most transition zone DPAs as evidenced by few DPAs with Lottery recommendations. For the 2017 season, we recommended Hunter Choice for one-third of DPAs and Managed for nearly half of DPAs. In 5 DPAs, Intensive designations will be necessary in

2017 to continue reducing deer densities toward goal level, 2 of which (DPA 346 and 349) we recommended additional antlerless seasons. In the metro area (DPA 601) and the chronic wasting disease management zone (DPA 603), unlimited antlerless opportunity will be available during the legal hunting seasons.

Forest Zone

Many deer populations in the Forest Zone with adequate habitat have recovered from the severe winter of 2013-14. For 2017, we recommended Bucks Only in 1 DPA, Lottery (with low to moderate allocation of either-sex permits) in nearly half of the DPAs, Hunter Choice in over one-third of DPAs, Managed in 4 DPAs, and Intensive in the DPA encompassing Duluth.

LITERATURE CITED

Brinkman, T. J., J. A. Jenks, C. S. DePerno, B. S. Haroldson, and R. G. Osborn. 2004. Survival of white-tailed deer in an intensively farmed region of Minnesota. Wildlife Society Bulletin 32:1-7.

Carstensen, M., G. D. DelGiudice, B. A. Sampson, and D. W. Kuehn. 2009. Survival, birth characteristics, and cause-specific mortality of white-tailed deer neonates. Journal of Wildlife Management 73:175-183.

DelGiudice, G. D., M. R. Riggs, P. Joly, and W. Pan. 2002. Winter severity, survival, and cause-specific mortality of female white-tailed deer in north-central Minnesota. Journal of Wildlife Management 66:698-717.

DelGiudice, G. D., J. Fieberg, M. R. Riggs, M. Carstensen Powell, and W. Pan. 2006. A long-term age-specific survival analysis of female white-tailed deer. Journal of Wildlife Management 70:1556-1568.

DelGiudice, G. D., M. S. Lenarz, and M. Carstensen Powell. 2007. Age-specific fertility and fecundity in northern free-ranging white-tailed deer: evidence for reproductive senescence? Journal of Mammalogy 88:427-435.

DePerno, C. S., J. A. Jenks, S. L. Griffin, and L. A. Rice. 2000. Female survival rates in a declining white-tailed deer population. Wildlife Society Bulletin 28:1030-1037.

DeYoung, C. A. 2011. Population dynamics. Pages 147-180 *in* D. G. Hewitt, editor. Biology and management of white-tailed deer. CRC, Boca Raton, Florida, USA.

Ditchkoff, S. S. 2011. Anatomy and physiology. Pages 43-73 *in* D. G. Hewitt, editor. Biology and management of white-tailed deer. CRC, Boca Raton, Florida, USA.

Dumont, A., M. Crete, J. Ouellet, J. Huot, and J. Lamoureux. 2000. Population dynamics of northern white-tailed deer during mild winters: evidence of regulation by food competition. Canadian Journal of Zoology 78:764-776.

Dunbar, E. 2007. Fetus survey data of white-tailed deer in the farmland/transition zone of Minnesota-2007. Pages 29-34 in M. H. Dexter, editor. Status of wildlife populations, fall 2007. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota. 302 pp.

Dusek, G. L., A. K. Wood, and S. T. Stewart. 1992. Spatial and temporal patterns of mortality among female white-tailed deer. Journal of Wildlife Management 56:645-650.

Fuller, T. K. 1990. Dynamics of a declining white-tailed deer population in north-central Minnesota. Wildlife Monographs 110.

Grovenburg, T. W., C. N. Jacques, C. S. DePerno, R. W. Klaver, and J. A. Jenks. 2011. Female white-tailed deer survival across ecoregions in Minnesota and South Dakota. American Midland Naturalist 165:426-435.

Grund, M. D., and A. Woolf. 2004. Development and evaluation of an accounting model for estimating deer population sizes. Ecological Modelling 180:345-357.

Grund, M. D. 2011. Survival analysis and computer simulations of lethal and contraceptive management strategies for urban deer. Human-Wildlife Interactions 5:23-31.

Grund, M. D. 2014. Monitoring population trends of white-tailed deer in Minnesota-2014. Pages 18-28 *in* M. H. Dexter, editor. Status of wildlife populations, fall 2014. Unpublished report. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota. 328 pp.

Hansen, L. 2011. Extensive management. Pages 409-452 *in* D. G. Hewitt, editor. Biology and management of white-tailed deer. CRC, Boca Raton, Florida, USA.

Haroldson, B. S. 2014. 2014 white-tailed deer surveys. Pages 29-34 *in* M. H. Dexter, editor. Status of wildlife populations, fall 2014. Unpublished report. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota. 328 pp.

Huegel, C. N., R. B. Dahlgren, and H. L. Gladfelter. 1985. Mortality of white-tailed deer fawns in south-central Iowa. Journal of Wildlife Management 49:377-380.

Hiller, T. L., H. Campa, S. Winterstein, and B. A. Rudolph. 2008. Survival and space use of fawn white-tailed deer in southern Michigan. American Midland Naturalist 159:403-412.

Kunkel, K. E., and L. D. Mech. 1994. Wolf and bear predation on white-tailed deer fawns in northeastern Minnesota. Canadian Journal of Zoology 72:1557-1565.

McCaffery, K. R., J. E. Ashbrenner, and R. E. Rolley. 1998. Deer reproduction in Wisconsin. Transactions of the Wisconsin Academy of Sciences, Art, and Letters 86:249-261.

Murkowski, A. 2016. 2015 Minnesota deer harvest report. <http://files.dnr.state.mn.us/wildlife/deer/reports/harvest/deerharvest_2015.pdf>. Accessed 30 June 2016.

Nelson, M. E., and L. D. Mech. 1986a. Mortality of white-tailed deer in northeastern Minnesota. Journal of Wildlife Management 50:691-698.

Nelson, M. E., and L. D. Mech. 1986b. Relationship between snow depth and gray wolf predation on white-tailed deer. Journal of Wildlife Management 50:471-474.

Nelson, T. A., and A. Woolf. 1987. Mortality of white-tailed deer fawns in southern Illinois. Journal of Wildlife Management 51:326-329.

Nixon, C. M., L. P. Hansen, P. A. Brewer, and J. E. Chelsvig. 1991. Ecology of white-tailed deer in an intensively farmed region of Illinois. Wildlife Monographs 118.

Nixon, C. M., L. P. Hansen, P. A. Brewer, J. E. Chelsvig, T. L. Esker, D. Etter, J. B. Sullivan, R. G. Koerkenmeier, and P. C. Mankin. 2001. Survival of white-tailed deer in intensively farmed areas of Illinois. Canadian Journal of Zoology 79:581-588.

R CORE TEAM. 2015. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/>.

Rohm, J. H., C. K. Nielson, and A. Woolf. 2007. Survival of white-tailed deer fawns in southern Illinois. Journal of Wildlife Management 71:851-860.

Rupp, S. P., W. B. Ballard, and M. C. Wallace. 2000. A nationwide evaluation of deer hunter harvest survey techniques. Wildlife Society Bulletin 28:570-578.

Van Deelen, T. R., H. Campa, J. B. Haufler, and P. D. Thompson. 1997. Mortality patterns of white-tailed deer in Michigan's upper Peninsula. Journal of Wildlife Management 61:903-910.

Verme, L. J. 1977. Assessment of natal mortality in upper Michigan deer. Journal of Wildlife Management 41:700-708.

Vreeland, J. K., D. R. Diefenbach, and B. D. Wallingford. 2004. Survival rates, mortality rates, and habitats of Pennsylvania white-tailed deer fawns. Wildlife Society Bulletin 32:542-553.

Whitlaw, H. A., W. B. Ballard, D. L. Sabine, S. J. Young, R. A. Jenkins, and G. J. Forbes. 1998. Survival and cause-specific mortality rates of adult white-tailed deer in New Brunswick. Journal of Wildlife Management 62:1335-134.

Wisconsin Department of Natural Resources. 2014. County deer advisory council deer metrics, Adams County, fall 2014. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Table 1. Estimated mean pre-fawn deer densities (deer/mi^2) derived from population model simulations in Minnesota deer permit areas, 2010-2017.

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]							
		2010	2011	2012	2013	2014	2015	2016	2017
101	496	8	7	8	9	8	9	11	13
103	1,820	4	3	4	4	3	3	4	5
105	740	13	12	13	14	10	10	13	15
108	1,651	7	6	7	7	5	5	7	8
110	529	18	16	17	15	11	11	14	16
111	1,438	3	2	3	3	2	2	3	3
114	116	-	-	-	-	-	-	-	-
117	927	-	-	-	-	-	-	-	-
118	1,220	5	5	5	5	4	4	4	5
119	770	9	7	8	8	5	6	7	8
126	942	5	4	4	5	3	3	3	3
130	746	7	5	5	5	3	3	4	5
131	899	5	4	4	4	2	2	2	2
132	482	10	8	8	7	4	5	6	7
133	352	18	14	14	13	7	8	9	11
152	61	12	12	12	13	11	13	16	20
155	593	16	16	17	18	15	17	21	26
156	825	16	16	16	16	10	10	13	15
157	673	21	20	20	20	20	21	23	26
159	571	17	16	16	17	12	13	16	19
169	1,124	14	12	14	13	9	10	13	15
171	701	12	12	12	12	10	12	14	16
172	687	20	20	21	22	19	21	26	32
173	584	10	10	11	11	8	8	10	12
176	921	12	10	11	11	7	8	10	12
177	480	20	17	17	17	11	11	14	16
178	1,195	16	14	13	13	8	8	11	13
179	862	20	18	18	18	11	11	13	14
181	629	18	15	13	14	8	9	12	15
182	267	-	-	-	-	-	-	-	-
183	663	14	14	15	16	11	12	15	19
184	1,229	21	20	22	20	16	17	21	25
197	955	13	12	13	12	9	10	12	15
199	148	9	9	10	10	7	8	10	13
201	161	10	9	10	12	9	11	13	15
203	118	12	13	16	27	28	24	32	40
208	379	5	5	5	5	4	5	7	8

[a] "-" indicates deer permit area was not modeled.

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]							
		2010	2011	2012	2013	2014	2015	2016	2017
209	640	9	8	8	9	7	7	9	10
210	615	13	11	11	10	8	8	9	10
213	1,057	15	13	14	15	16	18	20	23
214	554	24	24	26	27	25	27	29	32
215	701	16	16	18	19	18	20	22	24
218	884	9	9	10	11	11	12	13	15
219	391	11	12	12	13	13	14	16	18
221	642	14	14	15	15	13	14	16	19
222	413	17	17	18	17	14	15	17	20
223	376	12	13	13	15	14	16	18	20
224	47	16	16	16	18	18	21	25	31
225	618	18	18	18	19	16	18	20	22
227	472	18	19	20	20	18	20	21	24
229	284	7	8	8	9	10	12	14	18
230	452	3	4	3	3	3	3	4	4
232	377	5	5	5	5	6	6	8	9
233	385	5	4	5	5	5	5	6	6
234	636	-	-	2	2	2	2	3	3
235	34	-	-	-	-	-	-	-	-
236	370	17	17	17	18	16	18	20	23
237	728	-	-	3	3	2	3	3	3
238	95	-	-	-	-	-	-	-	-
239	919	14	12	13	12	12	12	13	14
240	643	21	20	21	22	20	22	24	26
241	996	28	28	29	31	26	27	29	32
242	214	24	24	24	24	20	20	24	27
246	840	17	17	17	17	16	18	22	27
247	228	19	19	20	20	17	19	21	23
248	214	20	19	20	19	15	15	16	17
249	502	17	16	16	18	16	16	19	23
250	713	-	-	3	3	3	3	3	4
251	55	-	-	-	-	-	-	-	-
252	715	3	3	3	3	3	3	4	4
253	974	3	3	3	3	3	3	4	4
254	929	4	4	4	4	4	4	4	5
255	774	4	4	5	5	5	6	6	7
256	654	6	6	6	7	7	7	8	10
257	412	8	8	8	9	8	8	10	12
258	343	23	20	23	21	18	20	22	25
259	490	24	23	22	21	16	19	22	26

[a] "-" indicates deer permit area was not modeled.

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]							
		2010	2011	2012	2013	2014	2015	2016	2017
260	1,249	3	3	3	4	3	4	5	6
261	795	2	2	2	3	3	4	5	6
262	677	3	2	3	3	3	3	4	4
263	512	8	7	9	10	8	10	13	16
264	669	10	10	11	13	12	14	17	20
265	494	8	7	8	9	9	10	12	15
266	617	5	4	5	5	5	6	7	9
267	472	4	4	4	5	4	5	6	7
268	228	10	9	9	10	8	9	11	13
269	650	3	3	3	3	3	3	4	4
270	748	2	2	2	2	3	3	3	4
271	632	3	2	2	2	3	3	3	4
272	531	3	2	2	2	2	3	3	4
273	571	-	6	6	6	6	7	8	9
274	354	-	5	5	5	6	6	7	8
275	764	-	4	4	4	4	4	4	5
276	542	8	7	8	8	9	10	11	13
277	812	12	11	11	12	13	14	15	16
278	402	-	7	6	6	6	6	7	8
279	344	-	5	5	5	4	4	4	5
280	675	3	3	3	3	3	3	3	3
281	575	5	5	5	6	7	8	9	11
282	778	2	1	2	2	2	2	3	3
283	613	-	3	3	4	4	4	4	5
284	838	-	-	4	3	3	3	3	4
285	549	5	4	4	5	5	6	6	8
286	446	-	-	5	5	5	5	6	7
287	46	-	-	-	-	-	-	-	-
288	625	-	-	6	5	5	5	5	6
289	815	2	2	2	2	2	3	3	4
290	662	5	5	5	5	5	6	6	7
291	800	6	6	6	6	6	7	8	9
292	479	8	7	8	9	10	12	14	17
293	511	8	7	7	8	8	9	11	12
294	686	-	4	4	4	4	5	5	6
295	839	-	-	4	4	4	5	5	6
296	667	3	3	3	3	3	4	5	5
297	438	3	3	3	3	3	3	4	5
298	618	10	8	10	10	9	11	14	18
299	386	5	5	5	5	5	6	6	7

[a] "-" indicates deer permit area was not modeled.

Deer Permit Area	Land area (mi²)	Pre-fawn deer density[a]							
		2010	2011	2012	2013	2014	2015	2016	2017
338	454	5	5	6	6	6	7	8	10
339	394	6	6	6	7	7	7	8	9
341	612	16	15	15	15	15	15	16	17
342	349	17	17	17	17	17	18	19	21
343	663	13	13	13	13	13	13	13	14
344	190	20	20	20	21	20	19	19	20
345	323	12	12	13	15	15	17	19	21
346	318	29	32	32	34	34	33	31	29
347	434	9	10	10	11	11	11	12	13
348	332	18	18	19	20	20	21	24	24
349	490	24	25	26	27	28	27	25	24
601	1,625	-	-	-	-	-	-	-	-
603	372	-	-	-	-	-	-	-	-

[a] "-" indicates deer permit area was not modeled.

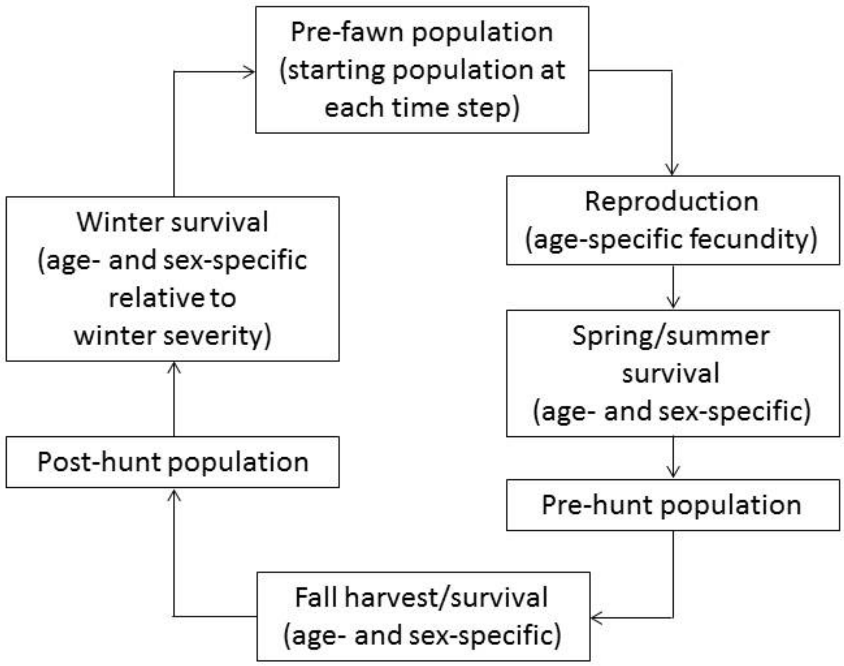


Figure 1. Model structure for simulations of white-tailed deer populations in Minnesota.

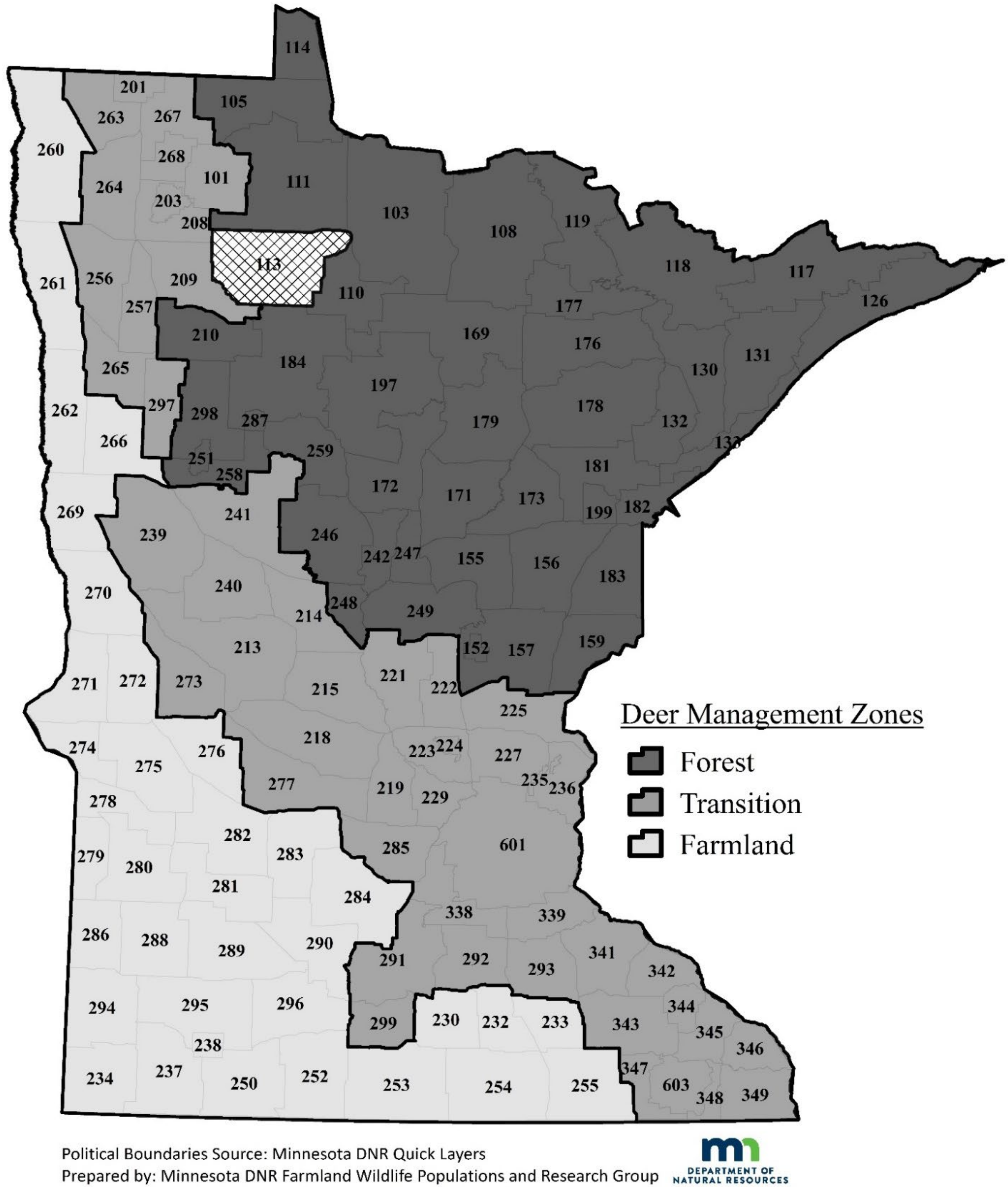


Figure 2. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2017. DPAs were assigned to forest, transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of >60% woody cover, transition DPAs were composed of 6%-50% woody cover, and farmland DPAs were composed of <5% woody cover.

2017 WHITE-TAILED DEER SURVEYS

Brian S. Haroldson, Farmland Wildlife Populations and Research Group

John H. Giudice, Wildlife Biometrics Unit

INTRODUCTION

Management goals for animal populations are frequently expressed in terms of population size (Lancia et al. 1994). Accurate estimates of animal abundance allow for documentation of population trends, provide the basis for setting harvest quotas (Miller et al. 1997), and permit assessment of population and habitat management programs (Storm et al. 1992).

The Minnesota Department of Natural Resources (MNDNR) uses simulation modeling within 115 permit areas (PA) to estimate and track changes in white-tailed deer (*Odocoileus virginianus*) abundance and, subsequently, to aid in developing harvest recommendations to manage deer populations toward goal levels. In general, model inputs include estimates of initial population size, reported harvest, and spatial and temporal estimates of survival and reproduction for various age and sex cohorts. Because simulated population estimates are subject to drift as model input errors accumulate over time, it is recommended that managers collect additional data to develop ancillary indices of changes in deer populations or periodically recalibrate models with independent deer population estimates (Grund and Woolf 2004).

Our objective was to use aerial surveys by helicopter to provide independent estimates of deer abundance in select deer PAs, where the 90% confidence interval bound on each estimate was within 20% of the estimate (Lancia et al. 1994). Estimates within these bounds were used to recalibrate population models to improve population management.

METHODS

After the discovery of chronic wasting disease (CWD) in 3 hunter-killed white-tailed deer in southeast Minnesota during November-December 2016, a CWD survey area was created, incorporating portions of PA 343, 345, 347, and 348 (Figure 1). We estimated deer populations in the CWD area plus PA 348 using a quadrat-based, aerial survey design. Quadrat surveys have been used to estimate populations of caribou (*Rangifer tarandus*; Siniff and Skoog 1964), moose (*Alces alces*; Evans et al. 1966), and mule deer (*O. hemionus*; Bartmann et al. 1986) in a variety of habitat types. Within each area, quadrats were delineated by Public Land Survey (PLS) section (640 ac) boundaries. We used a stratified, spatially-balanced sampling design, with geographic subunits and woody cover as stratification variables. Geographic subunits included:

1. Core 1 – 12 PLS sections surrounding kill locations of first 2 CWD positive deer (Figure 1);
2. Core 2 – 9 PLS sections surrounding kill location of third CWD positive deer;
3. West – formerly part of PA 347;
4. Central – formerly part of PA 348;
5. North – formerly part of PAs 343 and 345;
6. East – residual part of PA 348;

We used regression trees (Fabrizi and Trivisano 2007, Fieberg and Lenarz 2012), the R programming language (R Core Team 2016), and R package 'stratification' (Baillargeon and Rivest 2016) to classify the PLS sections within each geographic subunit, excluding the 2 Core units, as "low" or "high" based upon past helicopter counts of deer and abundance of woody cover within each section. Woody cover data were derived from the 2006 National Land Cover Database (Fry et al. 2011). Thus, our design had 10 mutually exclusive strata. We used optimal allocation, R package 'spsurvey' (Kincaid and Olsen 2016), and a generalized random tessellation stratified procedure (GRTS; Stevens and Olsen 2004) to draw random samples among strata within each survey area.

During both surveys, we used an MD-500E helicopter, a new addition to the MNDNR fleet, and attempted to maintain flight altitude at 200 ft (60 m) above ground level and airspeed at 50-60 mph (80-97 km/hr). A pilot and 2 observers searched for deer along transects spaced at 0.17-mi (270-m) intervals until they were confident all "available" deer were observed. When animals fled the helicopter, direction of movement was noted to avoid double counting. We used a real-time, moving-map software program (DNRSurvey; Haroldson et al. 2015), coupled to a global positioning system receiver and a convertible tablet computer, to guide transect navigation and record deer locations, direction of movement, and aircraft flight paths directly to ArcGIS (Environmental Systems Research Institute, Redlands, CA) shapefiles. To maximize sightability, we completed surveys during winter when snow cover measured at least 6 in (15 cm) and we varied survey intensity as a function of cover and deer numbers (Gasaway et al. 1986).

We implemented double sampling (Eberhardt and Simmons 1987, Thompson 2002) on a subsample of quadrats within the combined survey areas to estimate sightability of deer from the helicopter. We sorted the sample of survey quadrats by woody cover abundance, excluded quadrats likely to contain no deer (e.g., quadrats where woody cover < 40 ac [0.17 km^2]), and selected a 4% systematic subsample of sightability quadrats. Immediately after completing the operational survey on each sightability quadrat, a second more intensive survey was flown at reduced speed (40-50 mph [64-80 km/hr) to identify animals that were missed (but assumed available) on the first survey (Gasaway et al. 1986). We used geo-referenced deer locations, group size, and movement information from DNRSurvey (Haroldson et al. 2015) to "mark" deer (groups) observed in the operational survey and help estimate the number of "new" (missed) animals detected in the sightability survey. We used a binary logistic model to estimate average detection probabilities (i.e., the conditional probability of detection given animals are present in the sampling unit and available for detection) for each PA.

We used the R package 'spsurvey' (Kincaid and Olsen 2016) to compute deer abundance and density (mean count per quadrat) indices within each stratum, where indices were expanded for sampling but not sightability. We used the local mean variance estimator (Kincaid and Olsen 2016) with a finite population correction to compute stratum-specific estimates of sampling variance. We summed stratum-specific estimates by management unit (simple domain analysis, where domains did not cross stratum boundaries; Cochran 1977:34) to compute deer abundance and density indices for PA 348 (composed of 6 strata) and the CWD survey area (composed of 8 strata). We used a Horvitz-Thompson estimator (Thompson 2002:53, Fieberg and Giudice 2008) to convert population indices to population estimates (adjusted for sightability), and the Delta method (Seber 1982:9) to compute the variance. We evaluated precision using coefficient of variation (CV), defined as standard deviation of the population estimate divided by the population estimate, and relative error, defined as the 90% confidence interval bound divided by the population estimate (Krebs 1999).

RESULTS AND DISCUSSION

Due to limited snow cover, we completed only 1 recalibration survey (PA 348) during winter 2016-2017 (Table 1). Results from the CWD survey are reported online. Within PA 348, the survey crew observed 2,069 deer on 78 quadrats for a mean density of 27 deer/quadrat (range = 0 to 115 deer/quadrat). Deer were observed in 91% of sample quadrats (Table 2). Mean density on quadrats with at least 1 deer detection was 29 deer/quadrat. In addition, mean group size was 4 and mean number of groups per "occupied" quadrat was 7.

We collected visibility data on 18 quadrats, with 16 of those quadrats containing deer (mean = 26 deer/quadrat; range = 2 to 56). The number of deer missed on the initial survey of each sightability quadrat ranged from 0 to 9 (mean = 4). Overall, mean estimated sightability was 0.85 (SE = 0.017), which was slightly higher than mean sightability for aerial deer surveys in adjoining PAs in the past (mean = 0.74). This may reflect increased observer visibility afforded by the new helicopter, but more visibility surveys must be conducted with this aircraft to validate this observation. Correcting for sightability increased relative variance (CV [%]) of population estimates by 3%, which was a reasonable tradeoff between decreased bias and increased variance, although costs associated with the sightability surveys are also important. However, we caution that our sightability estimates are conditional on animals being available for detection (Johnson 2008, Nichols et al. 2009). Unfortunately, like many other wildlife surveys, we have no estimates of availability or how it varies over space and time. Our approach also assumes that sightability is constant across animals and quadrats. Heterogeneity in detection probabilities can lead to biased estimates of abundance. Common methods for correcting for heterogeneous detection probabilities include distance sampling, mark-recapture methods, and logistic-regression sightability models (based on radio-marked animals). We did not have marked animals in our populations, and relatively high densities of deer in our survey areas would present logistical and statistical problems for distance sampling and double-observer methods (Nichols et al 2000, Bart et al 2004). Therefore, our double-sampling approach is a reasonable alternative to using unadjusted counts or applying more complicated methods whose assumptions are difficult to attain in practice. Nevertheless, our population estimates must still be viewed as approximations to the truth.

ACKNOWLEDGMENTS

We thank R. Tebo for assistance in conducting the surveys and B. Maas for piloting the helicopter. A. Norton and N. Davros reviewed an earlier draft of this report. Deer surveys were funded in part under the Federal Aid in Wildlife Restoration Act.

LITERATURE CITED

Baillargeon, S., and L. Rivest. 2016. Stratification: univariate stratification of survey populations. R package ver. 3.3. <http://CRAN.R-project.org/package=stratification>. Accessed December 2016.

Bart, J., S. Droege, P. Geissler, B. Peterjohn, and C. J. Ralph. 2004. Density estimation in wildlife surveys. Wildlife Society Bulletin 32:1242-1247.

Bartmann, R. M., L. H. Carpenter, R. A. Garrott, and D. C. Bowden. 1986. Accuracy of helicopter counts of mule deer in pinyon-juniper woodland. Wildlife Society Bulletin 14:356-363.

Cochran, W. G. 1977. Sampling techniques. Third edition. John Wiley & Sons, New York, New York, USA.

Eberhardt, L. L., and M. A. Simmons. 1987. Calibrating population indices by double sampling. Journal of Wildlife Management 51:665-675.

Evans, C. D., W. A. Troyer, and C. J. Lensink. 1966. Aerial census of moose by quadrat sampling units. Journal of Wildlife Management 30:767-776.

Fabrizi, E., and C. Trivisano. 2007. Efficient stratification based on nonparametric regression methods. Journal of Official Statistics 23:35-50.

Fieberg, J. R., and J. H. Giudice. 2008. Variance of stratified survey estimators with probability of detection adjustments. Journal of Wildlife Management 72:837-844.

Fieberg, J. R., and M. S. Lenarz. 2012. Comparing stratification schemes for aerial moose surveys. Alces 48:79-87.

Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold, and J. Wickham. 2011. Completion of the 2006 national land cover database for the conterminous United States. Photogrammetric Engineering and Remote Sensing 77:858-864.

Gasaway, W. C., S. D. Dubois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Papers of the University of Alaska 22, Fairbanks, Alaska, USA.

Grund, M. D., and A. Woolf. 2004. Development and evaluation of an accounting model for estimating deer population sizes. Ecological Modeling 180:345-357.

Haroldson, B. S., R. G. Wright, and C. Pouliot. 2015. DNRSurvey User Guide 2.30.01. <http://www.dnr.state.mn.us/mis/gis/DNRSurvey/DNRSurvey.html>.

Johnson, D. H. 2008. In defense of indices: the case study of bird surveys. Journal of Wildlife Management 72:857-868.

Kincaid, T. M., and A. R. Olsen. 2016. Spsurvey: spatial survey design and analysis. R package version 3.3. <http://www.epa.gov/nheerl/arm>. Accessed December 2016.

Krebs, C. J. 1999. Ecological methodology. Second edition. Benjamin/Cummings, Menlo Park, California, USA.

Lancia, R. A., J. D. Nichols, and K. H. Pollock. 1994. Estimating the number of animals in wildlife populations. Pages 215-253 *in* T. A. Bookhout, editor. Research and management techniques for wildlife and habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland.

Miller, S. D., G. C. White, R. A. Sellers, H. V. Reynolds, J. W. Schoen, K. Titus, V. G. Barnes, Jr., R. B. Smith, R. R. Nelson, W. B. Ballard, and C. C. Schwarz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs 133.

Nichols, J. D., J. E. Hines, J. R. Sauer, F. W. Fallon, J. E. Fallon, and P. J. Heglund. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk 117:393-408.

Nichols, J. D., L. Thomas, and P. B. Conn. 2009. Inferences about landbird abundance from count data: recent advances and future directions. Pages 201-235 *in* D. L. Thompson, E. G. Cooch, and M. J. Conroy, editors. Environmental and ecological statistics: modeling demographic processes in marked populations. Volume 3. Springer, New York, New York, USA.

R Core Team. 2016. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org>. Accessed December 2016.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Second edition. The Blackburn Press, Caldwell, New Jersey, USA.

Siniff, D. B., and R. O. Skoog. 1964. Aerial censusing of caribou using stratified random sampling. Journal of Wildlife Management 28:397-401.

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

Storm, G. L., D. F. Cottam, R. H. Yahner, and J. D. Nichols. 1992. A comparison of 2 techniques for estimating deer density. Wildlife Society Bulletin 20:197-203.

Thompson, S. K. 2002. Sampling. Second edition. John Wiley & Sons, New York, New York, USA.

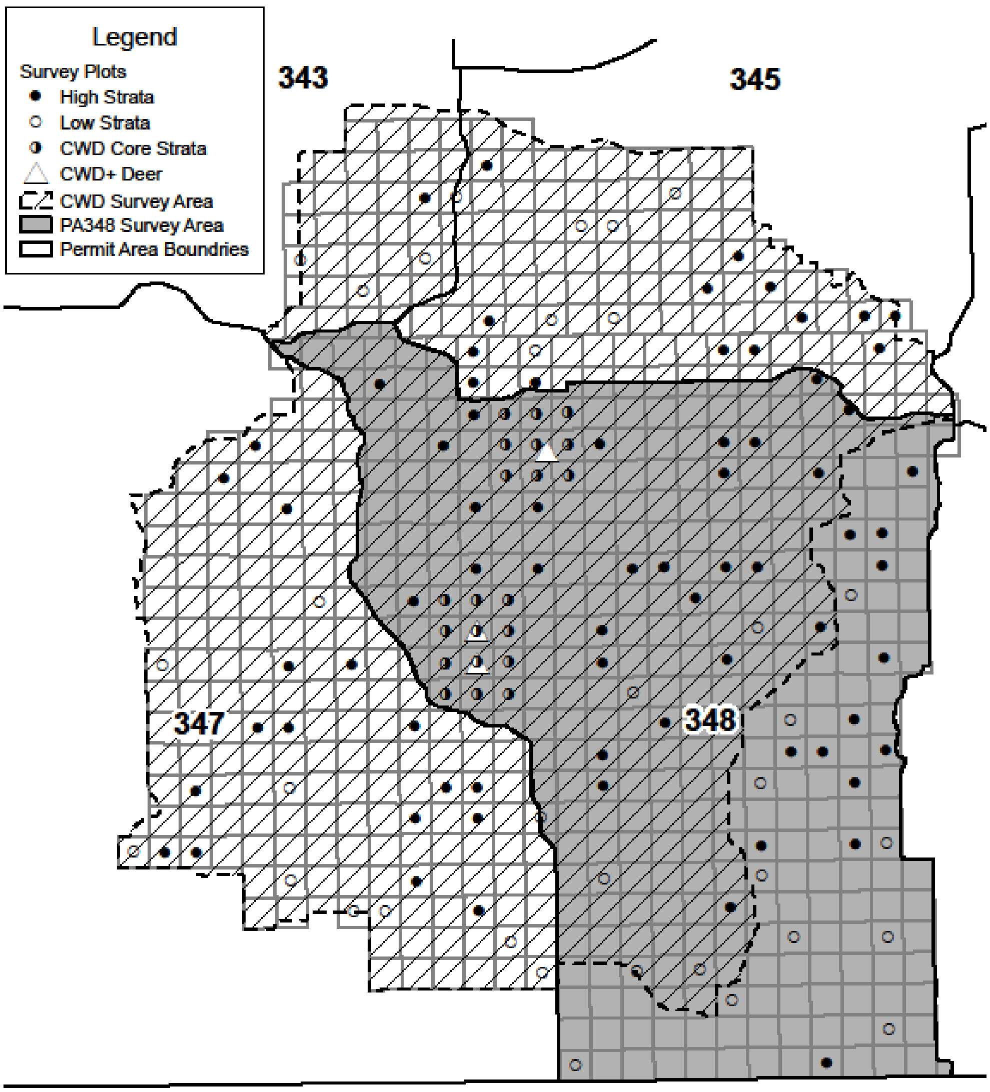


Figure 1. Survey areas flown during winter 2016-2017 in southeast Minnesota. Hatched area denotes chronic wasting disease survey area, incorporating portions of deer permit areas (PA) 343, 345, 347, and 348. Shaded area denotes PA 348 survey area.

Table 1. Deer population and density (deer/quadrat) estimates derived from aerial surveys in Minnesota, 2017.

Permit area	Domain	Sampling rate	Population estimate		CV (%)	Relative error (%)[a]	Density estimate	
			N	90% CI			Mean	90% CI
348	Central	0.26[b]	5,171	4,633 – 5,709	8.1	10.4	26	23 – 29
	East	0.20	3,459	2,649 – 4,269	18.3	23.4	28	21 – 35
	All	0.24	8,630	7,645 – 9,615	8.9	11.4	27	24 – 30

[a] Relative precision of population estimate. Calculated as 90% CI bound/*N*.
[b] Includes 'Core1' and 'Core2' geographic subunits.

Table 2. Sampling metrics from aerial deer surveys in Minnesota, 2017.

Permit area	Domain Quadrats in domain	Quadrats sampled	Quadrats occupied[a] Deer	Observed Deer	groups	observed	Groups / occupied quadrat		Group size / occupied quadrat		Maximum quadrat count
							mean	range	mean	range	
348	Central	202	53	47	1,395	341	7	1-18	4	1-23	97
	East	124	25	24	674	185	8	1-20	4	1-16	115
	All	326	78	71	2,069	526	7	1-20	4	1-23	115

[a] Number of quadrats with ≥1 deer observed.