FARMLAND WILDLIFE POPULATIONS

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2019 MINNESOTA AUGUST ROADSIDE SURVEY

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SUMMARY

The 2019 range-wide pheasant index (37.4 birds/100 mi) decreased 17% from 2018 (45.2 birds/100 mi). The brood index and proportion of hens with broods also decreased, and estimated hatch dates were one week later than the 10-year and long-term averages. Severe late-season winter snowstorms, heavy spring rains, and resulting flooding throughout much of the core pheasant range likely impacted nesting activity during the 2019 breeding season. Grassland habitat on private, state, and federally-owned lands increased by 29,903 acres statewide since 2018. The range-wide indices for eastern cottontail rabbits and gray partridge were similar to 2018 while the white-tailed deer and Sandhill crane indices increased from 2018. The mourning dove index decreased from 2018 and white-tailed jackrabbit observations continue to be historically low across our survey area.

INTRODUCTION

This report summarizes the 2019 Minnesota August Roadside Survey (ARS). Since 1955, the Minnesota Department of Natural Resources (MN DNR) wildlife and enforcement personnel have conducted the annual ARS during the first two weeks of August throughout Minnesota's farmland regions (Figure 1). The 2019 ARS consisted of 172 25-mile routes (1-4 routes/county); 152 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 mi/hr and recorded the number of pheasants, gray (Hungarian) partridge, eastern 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 (Figure 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 increased again in 2019. Statewide, 29,903 grassland habitat acres were gained since 2018. A majority of these gains occurred on private lands with acres enrolled in Reinvest in Minnesota (RIM) increasing by 4,501 acres. Likewise, acres enrolled in the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) increased by 5,307 acres and 8,198 acres respectively. Lands enrolled in the Wetlands Reserve Program (WRP) decreased by

1,617 acres statewide while RIM-WRP acres were unchanged from 2018. Publically-owned grassland habitat increased by 13,508 acres statewide since last year. Federally-owned U.S. Fish and Wildlife Service (USFWS) Waterfowl Production Areas (WPA), wildlife refuges, and conservation easements increased by 3,907 acres and state-owned Wildlife Management Areas (WMA) increased by 9,601 acres. Undisturbed grassland habitat acres in the pheasant range increased by 26,529 acres and were primarily gained on private lands with enrollment in CRP (8,654 total acres) and CREP (8,122 total acres) accounting for a majority of these gains. Public lands grassland habitat gains within the pheasant range include 3,715 acres of USFWS land and 6,378 acres of WMAs added since 2018. Protected grassland habitat accounts for 6.5% of the landscape within the pheasant range (range by agricultural region: 3.2-10.1%; Table 1), and 6.2% of the landscape statewide.

Grassland and wetland habitat conservation remains a priority concern for Minnesota. Federally-funded private-lands conservation programs, including CRP, continue to make up a large portion of protected grassland habitat in Minnesota (Figure 2). Despite the gain in private lands habitat conservation program acres in 2019, approximately 614,348 acres of CRP have been lost in Minnesota since 2007 and an additional 80,000 acres are under contracts set to expire after September 30, 2019. The 2018 Farm Bill was signed into law on December 20, 2018 and the nationwide cap for CRP enrollment was increased from 24 million to 27 million acres. Other programmatic changes to CRP were outlined intended to make the program more cost effective. Working lands programs funded under the federal Farm Bill received attention during the 2018 revision. Funding for the Environmental Quality Incentives Program (EQIP) was increased; however, funding for the Conservation Stewardship Program (CSP) will be reduced over the 10-year life of the Farm Bill. In Minnesota, 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 in the last decade. 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 2011, Minnesota's Walk-in Access (WIA) program continues to provide public hunting opportunities on private land already enrolled in existing conservation programs or has high quality natural habitat. The program has grown each year since inception, and in 2019, features more than 250 sites totaling nearly 30,000 across 47 counties in the farmland region of Minnesota. Sites are open to public hunting 1 September – 31 May where boundary signs are present. Hunters must purchase a $3 WIA Validation which allows access to all WIA lands statewide. 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. The WIA program is currently funded through a grant from the Natural Resource Conservation Service of the U.S. Department of Agriculture. Other funding sources are provided through a surcharge on nonresident hunting licenses, a one-time appropriation from the Minnesota Legislature in 2012, and donations from hunters.

WEATHER SUMMARY

Minnesota's winter 2018-2019 (1 December 2018 – 31 March 2019) was cold and snowy across the state with average temperatures 2.5-4.9°F below thirty-year averages (Table 2; Minnesota Climatology Working Group [MCWG] 2019, Climate Summary). Of particular note were air

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[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.

temperatures experienced 27-31 January 2019 when artic conditions statewide blanketed Minnesota with sub-zero temperatures and wind chills persisting over the 4-day period. Winter snow cover was widespread across the farmland zone, with snow depths exceeding six inches for at least one 2-week period in every agricultural region. In fact, snow depths exceed six inches for at least four consecutive weeks in all agricultural regions and up to 17 weeks in the Northwest region. Statewide, most of the major snow events contributing to the deep and persistent snow cover occurred during the month of February with snow cover remaining deeper than six inches throughout most of March. By April 18, 2019, snow was absent over the entire survey region.

Spring 2019 (1 April – 31 May) temperatures were 2.3-3.8°F below thirty-year averages statewide and precipitation was above normal across much of the farmland zone. The Northwest region was the only region drier than normal with the remaining agricultural regions experiencing at least one inch greater than normal precipitation. Melting snow and precipitation events combined to contribute to widespread flooding across much of the state during spring 2019.

Summer 2019 (1 June – 31 July) temperatures were 1.4-2.3°F below thirty-year averages statewide. Summer rainfall was near thirty-year averages in June and July statewide (ranging from -0.2-0.9 inches from normal across agricultural regions).

Overall, the conditions for over-winter survival of wildlife were below average to average throughout the farmland zone. Widespread deep and persistent snow cover over most of the core pheasant range combined with colder than normal temperatures may have adversely impacted adult game bird survival. Likewise, cooler than normal temperatures in the spring along with spring flooding events caused by melting snow and above-normal precipitation potentially delayed nest initiation and first nesting attempts for many bird species. However, mild summer temperatures and drier weather may have benefited birds nesting or re-nesting later in the season.

SURVEY CONDITIONS

The survey period was extended (30 July – 18 August) to allow survey routes (n = 172) to be completed in 2019. Weather conditions during the survey ranged from excellent (calm winds, heavy dew, clear sky) to moderate (light dew and overcast skies). Medium or heavy dew conditions were present at the start of 95% of the survey routes, which was up from 2018 (89%) and above the 10-year average (85%). Clear skies (<30% cloud cover) were present at the start of 86% of routes which was up slightly from 2018 (80%). Wind speeds <7 mph were recorded for 96% of the routes compared to 92% in 2018. Overall, survey conditions in 2019 were slightly wetter, less overcast, and calmer than in 2018 but similar to conditions over the long-term and were unlikely to have reduced detection rates.

SPECIES REPORTS

Ring-necked Pheasant

In 2019, the average number of pheasants observed range-wide (37.4 birds/100 mi) decreased 17% from 2018 (45.2 birds/100 mi) and was slightly lower than the 10-year average of 41.2 birds/100 mi. The index was 60% below the long-term average of 91.4 birds/100 mi (Table 3, Figure 3A). Total pheasants observed per 100 mi ranged from 8.7 birds in the Southeast agricultural region to 48.8 birds in the West Central region (Table 4). The change in the pheasant index from 2018 to 2019 varied greatly statewide with increases in the South Central (24%) and East Central (13%) regions while the Southwest region, a core area of Minnesota's pheasant range, decreased 32% from 2018. The best harvest opportunities will be in the West

Central and South Central regions but hunters will also find good opportunities in the Southwest and Central regions.

The range-wide hen index declined slightly in 2019 (6.4 hens/100 mi) compared to 2018 (7.5 hens/100 mi) and was at the 10-year average (6.2 hens/100 mi) but still 54% below the long-term average (13.3 hens/100 mi; Table 3). The hen index ranged from 1.6 hens/100 mi in the Southeast to 9.4 hens/100 mi in the West Central region. The Southwest region saw the greatest decline (46%), while the hen indices among remaining regions were equivalent to 2018.

The range-wide cock index (6.5 cocks/100 mi) did not change from 2018 or the 10-year average, but remained 40% below the long-term average of 10.5 cocks/100 mi (Table 3). The cock index ranged from 2.4 cocks/100 mi in the Southeast to 8.3 cocks/100 mi in the West Central region. The 2018 cock index increased in the East Central, South Central, and Southeast regions and decreased in the West Central and Southwest regions.

The 2019 hen-to-cock ratio (0.98) was slightly below the 2018 ratio (1.16) and still below the long-term average (1.33).

The 2019 range-wide brood index (5.4 broods/100 mi) decreased modestly from 2018 (7.3 broods/100 mi; Table 3). The index was similar to the 10-year average (6.4 broods/100 mi). Still, the brood index was 56% below the long-term average (12.1 broods/100 mi). Regional brood indices declined in all regions except for the South Central, where they remained relatively constant. The brood index ranged from 1.6 broods/100 mi in the Southeast region to 7.2 broods/100 mi in the West Central region. The average brood size in 2019 (4.6 chicks/brood) was slightly larger compared to 2018 (4.3 chicks/brood) and equivalent to the 10-year average (4.6 chicks/brood). However, the brood size index remains below the long-term average of 5.6 chicks/brood. The median hatch date (assigned using estimated brood ages from broods observed during the survey) for pheasant broods across their range was 20 June 2019 (n = 204 broods), which was nearly a week later than 2018 (14 June) and the 10-year average (12 June; Table 3).

Declines in the brood index, the number of broods/100 hens (a measure of breeding success), and later estimated hatch dates suggest that severe winter snowstorms, heavy spring rains, and resulting flooding throughout much of the core pheasant range adversely impacted nesting activity during the 2019 breeding season. Though regional and statewide pheasant indices declined, available grassland habitat and habitat quality can help mediate the impacts of annual variation in weather on local populations. Therefore, hunters may encounter good bird numbers where habitat was unaffected by severe weather and flooding, even among regions that exhibited overall declines. Expect that birds will be more difficult to locate in areas where adjacent agricultural fields were too wet to plant and in areas where fall corn and soybean harvest is delayed.

Long term, Minnesota has experienced a gradual but steady loss of habitat, especially CRP, and the impact of these losses correlates well with an overall decline in the pheasant population and harvest since the mid-2000s (Figures 2 & 3A).

Gray Partridge

The 2019 range-wide gray partridge index (2.4 birds/100 mi) was greater than in 2018 and is similar to the 10-year average (Table 3). However, the gray partridge index remains 82% below the long-term average (13.8 birds/100 mi; Table 3, Figure 3B). Indices for partridge ranged from 0 birds/100 mi in the Southeast and East Central regions to 5.4 birds/100 mi in the South Central region (Table 4). 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 Midwestern United States 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 South Central and Central regions will offer the best opportunities for harvesting gray partridge in 2019.

Cottontail Rabbit and White-tailed Jackrabbit

Range-wide, the 2019 eastern cottontail rabbit index (6.1 rabbits/100 mi) was equivalent to the index in 2018 (5.9 rabbits/100 mi) and was 11% above the 10-year average (5.4 rabbits/100 mi). The 2019 index was comparable to the long-term average (6.6 rabbits/100 mi; Table 3, Figure 4A). Regionally, the 2019 cottontail rabbit index ranged from 1.3 rabbits/100 mi in the Northwest to 14.3 rabbits/100 mi in the East Central region (Table 4). Good harvest opportunities should exist in the East Central, Central, and Southeast regions.

Single white-tailed jackrabbits were recorded on two survey routes in the West Central Region in 2019 (Table 3) yielding a range-wide index less than 0.01/100 mi. This was 98% below the long-term average of 1.6 rabbits/100 mi (Table 3, Figure 4B). The West Central region was the only region that saw no decline in the jackrabbit index (Table 3). Minnesota's jackrabbit population peaked in the late 1950s, declined to low levels in the 1980s, and has remained at low levels 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 (33.4 deer/100 mi) increased 45% from 2018 (23.0 deer/100 mi) and was 59% above the 10-year average and 168% above the long-term average (20.3 deer/100 mi and 12.0 deer/100 mi, respectively; Table 3, Figure 5A). Regional roadside indices for deer ranged from 14.6 deer/100 mi in the South Central region to 64.7 deer/100 mi in the Northwest region (Table 4).

Mourning Dove

The 2019 range-wide mourning dove index (90.8 doves/100 mi) was 29% lower than 2018 (128.5 doves/100 mi), 48% below the 10-year average (173.9 doves/100 mi), and 64% below the long-term average (257.4 doves/100 mi; Table 3, Figure 5B). Regional indices ranged from 45.7 doves/100 mi in the East Central region to 122.6 doves/100 mi in the West Central region (Table 4). The best opportunities for harvesting doves should be in the Southwest, South Central, and West Central regions.

Sandhill Crane

The 2019 roadside index of sandhill cranes was 16.6 total cranes/100 mi, a 25% increase from 2018 (13.3 total cranes/100 mi; Table 3). Regional indices ranged from 0.0 total cranes/100 mi in the Southwest region to 90.9 total cranes/100 mi in the East Central region (Table 4). The range-wide index of juveniles was 2.3 juvenile cranes/100 mi, which decreased 79% from 2017 (Table 3).

Other Species

Notable incidental sightings recorded by observers included: black bear (Marshall County), pileated woodpecker (Kandiyohi and Stearns Counties), red-headed woodpecker (Brown, Faribault, Freeborn, Kanabec, and Olmsted Counties), sharp-tailed grouse (Roseau and Polk Counties), sora rail (Chippewa County), tiger salamander (Olmsted County), trumpeter swan (Faribault and Scott Counties), and upland sandpiper (Brown County). American crow, Canada goose, and wild turkey were noted in multiple counties.

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LITERATURE CITED

Minnesota Climatology Working Group (MCWG). 2019a. MCWG Climate Summary Table. Accessed 23 August 2019.

Table 1. Abundance (total acres) and density (acres/mi^2) of undisturbed grassland habitat within Minnesota's pheasant range, 2019, by agricultural region (AGREG).

	Cropland Retirement (private lands)[a]					Public Lands				
AGREG	CRP	CREP	RIM	RIM-WRP	WRP	USFWS[b]	MNDNR[c]	Total	% of landscape	Density ac/mi^2
WC[d]	268,370	39,569	22,733	14,275	19,893	204,049	112,508	681,396	10.1	64.2
SW	117,635	27,328	20,546	2,553	576	24,333	73,552	266,523	7.0	45.1
C	133,819	16,368	41,767	7,026	2,702	92,164	52,652	346,498	5.7	36.7
SC	98,628	29,403	13,663	10,780	7,797	11,091	37,763	209,125	5.2	33.1
SE	81,500	2,904	7,294	1,070	976	36,988	56,677	187,409	5.1	32.4
EC	3,015	0	1,133	0	4	4,994	93,349	102,495	3.2	20.4
Total	702,968	115,572	107,136	35,704	31,947	373,618	426,501	1,793,447	6.5	41.6

[a] Unpublished data, Tabor Hoek, BWSR, 20 August 2019.

[b] Includes Waterfowl Production Areas (WPA), USFWS refuges, & USFWS conservation easements

[c] MN DNR Wildlife Management Areas (WMA).

[d] Does not include Norman County which is not in the historic pheasant range.

Table 2. Average temperature, snow depth, and precipitation by season and agricultural region in Minnesota, 2019.

	Agricultural Region							
	NW	WC	C	EC	SW	SC	SE	STATE
Winter (December 1 - March 31)								
Temperature (average °F)	9.3	13.8	15.1	16.4	17.1	17.4	19.0	15.0
Departure from normal (°F)[a]	-4.9	-4.2	-3.5	-2.6	-4.0	-3.3	-2.5	-3.3
Snow Depth (average inches)	13.9[b]	11.0[b]	8.0[b]	7.7[b]	8.9[b]	7.8[b]	6.8[b]	9.2[b]
Spring (April 1 - May 31)								
Temperature (average °F)	45.7	48.0	47.1	46.8	49.0	49.4	49.4	46.7
Departure from normal (°F)[a]	-3.0	-2.8	-3.8	-3.4	-3.1	-2.6	-2.3	-3.1
Precipitation (total inches)	3.7	7.2	9.67	8.7	11.4	11.5	10.3	8.3
Departure from normal (inches)[a]	-0.2	1.0	1.7[c]	1.3[c]	2.5[c]	1.9[c]	1.6[c]	1.2[c]
Summer (June 1 - July 31)								
Temperature (average °F)	51.8	54.5	54.2	53.8	56.0	55.4	55.8	53.6
Departure from normal (°F)	-1.7	-1.5	-2.0	-2.0	-1.4	-2.3	-1.7	-1.8
Precipitation (total inches)	8.2	10.0	9.7	10.3	10.2	11.6	14.0	10.6
Departure from normal (inches)[a]	-0.2	0.5	-0.1	0.1	0.3	0.3	0.9	0.2

[a] Departures calculated using 30-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, 1955-2019.

Species	Change from 2018[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
Subgroup	*n*	2018	2019	%	95% CI	*n*	2009-2018	%	95% CI	*n*	LTA	%	95% CI
Ring-necked pheasant													
Total pheasants	152	45.2	37.4	-17	±19	149	41.2	-11	±15	151	91.4	-60	±9
Cocks	152	6.5	6.5	0	±22	149	5.8	9	±19	151	10.5	-40	±13
Hens	152	7.5	6.4	-15	±19	149	6.2	-1	±17	151	13.3	-54	±11
Broods	152	7.3	5.4	-26	±18	149	6.4	-17	±15	151	12.1	-57	±11
Chicks per brood[d]	204	4.3	4.6	6			4.6	0			5.6	-18	
Broods per 100 hens	152	96.5	84.6	-12			102.6	-17			90.2	-5	
Median hatch date[d]	204	14-Jun	20-Jun				12-Jun						
Gray partridge	171	1.3	2.4	79	±166	168	2.3	4	±87	151	13.8	-82	±21
Eastern cottontail	171	5.9	6.1	2	±27	168	5.4	11	±24	151	6.6	-2	±21
White-tailed jackrabbit	171	0.1	0.0	-50	±99	168	0.1	-83	±43	151	1.6	-98	±14
White-tailed deer	171	23.0	33.4	45	±22	168	20.3	59	±20	170	12.0	168	±38
Mourning dove	171	128.5	90.8	-29	±13	168	173.9	-48	±10	151	257.4	-64	±7
Sandhill crane[e]	171	13.3	16.6	25	±54	168	11.8	17	±42				
Total cranes	171	1.3	2.3	79	±57	168	1.7	2	±39				
Juveniles	152	45.2	37.4	-17	±19	149	41.2	-11	±15	151	91	-60	±9

[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 1955-2018, except for deer (1974-2018). 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] Sample size is the total number of broods observed across all surveys rather than the number of routes run in 2019.

[e] Sandhill cranes were added to the survey in 2009; thus, long-term averages are not calculated.

Table 4. Regional trends (% change) in number of wildlife observed per 100 miles driven, Minnesota August roadside survey, 1955-2019.

Region	**Change from 2018**[a]					**Change from 10-year average**[b]				**Change from long-term average (LTA)**[c]			
Species	*n*	2018	2019	%	95% CI	*n*	2009-2018	%	95% CI	*n*	LTA	%	95% CI
Northwest[d]													
Gray partridge	19	3.8	2.1	-44	±246	19	0.7	214	±606	19	3.0	-30	±152
Eastern cottontail	19	0.6	1.3	95	±335	19	0.7	83	±239	19	0.9	47	±181
White-tailed jackrabbit	19	0.2	0.0	-100	±210	19	0.2	-100	±65	19	0.6	-100	±41
White-tailed deer	19	50.8	64.7	27	±53	19	47.1	37	±49	19	34.2	89	±66
Mourning dove	19	120.0	68.7	-43	±47	19	92.7	-26	±28	19	117.0	-41	±17
Sandhill crane[e]	19	24.3	34.3	41	±64	19	39.7	-14	±42				
West Central[f]													
Ring-necked pheasant	39	65.1	48.8	-25	±31	35	47.6	-1	±40	37	93.8	-53	±26
Gray partridge	39	0.1	1.3	1200	±2645	35	0.4	233	±693	37	8.8	-84	±39
Eastern cottontail	39	2.5	3.8	54	±91	35	2.4	44	±80	37	3.9	-16	±45
White-tailed jackrabbit	39	0.2	0.2	0.0	±145	35	0.2	-25	±147	37	2.1	-95	±23
White-tailed deer	39	29.2	43.9	51	±45	35	22.2	80	±42	37	11.8	225	±98
Mourning dove	39	162.4	122.6	-25	±33	35	225.2	-46	±19	37	353.1	-66	±14
Sandhill crane[e]	39	3.4	2.3	-31	±120	35	1.8	41	±78	37	1.9	28	±66
Central													
Ring-necked pheasant	30	48.1	39.8	-17	±31	30	37.1	7	±33	30	68.1	-42	±19
Gray partridge	30	0.7	4.0	500	±740	30	1.0	290	±437	30	8.4	-52	±64
Eastern cottontail	30	7.2	9.1	26	±55	30	4.6	99	±69	30	6.2	47	±51
White-tailed jackrabbit	30	0.0	0.0			30	0.1	-100	±113	30	1.1	-100	±21
White-tailed deer	30	13.9	31.5	127	±85	30	16.4	92	±72	30	7.4	323	±179
Mourning dove	30	103.5	78.2	-25	±37	30	161.0	-52	±20	30	218.8	-64	±15
Sandhill crane[e]	30	38.0	28.7	-25	±85	30	18.4	56	±55	30	19.3	49	±48
East Central													
Ring-necked pheasant	12	23.9	27.0	13	±51	13	40.7	-28	±22	13	81.6	-64	±23
Gray partridge	12	0.7	0.0	-100	±220	13	0.2	-100	±149	13	0.2	-100	±132
Eastern cottontail	12	12.9	14.3	11	±69	13	12.1	9	±59	13	9.2	44	±63
White-tailed jackrabbit	12	0.0	0.0			13	0.0			13	0.1	-100	±72
White-tailed deer	12	26.9	41.7	55	±64	13	21.5	95	±62	13	11.5	264	±115
Mourning dove	12	61.8	45.7	-26	±25	13	81.8	-39	±26	13	112.7	-56	±25
Sandhill crane[e]	12	34.6	90.9	163	±179	13	43.5	106	±127				

Table 4. Continued.

Region	Change from 2018[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
Species	*n*	2018	2019	%	95% CI	*n*	2009-2018	%	95% CI	*n*	LTA	%	95% CI
Southwest													
Ring-necked pheasant	19	54.1	36.8	-32	±56	19	68.3	-46	±30	19	110.4	-67	±23
Gray partridge	19	3.2	1.3	-60	±176	19	5.5	-77	±48	19	37	-97	±20
Eastern cottontail	19	3.8	1.7	-56	±94	19	5.6	-70	±35	19	7.8	-78	±21
White-tailed jackrabbit	19	0.2	0.0	-100	±210	19	0.4	-100	±58	19	3.4	-100	±22
White-tailed deer	19	17.3	21.7	26	±52	19	19.9	9	±38	19	10.6	104	±73
Mourning dove	19	180.6	92.0	-49	±30	19	236.0	-61	±19	19	299.8	-69	±17
Sandhill crane[e]	19	0.0	0.0			19	0.0						
South Central													
Ring-necked pheasant	32	35.1	43.7	24	±63	32	39.8	10	±31	32	119.3	-63	±15
Gray partridge	32	0.2	5.4	2050	±3336	32	4.9	11	±188	32	17.1	-69	±50
Eastern cottontail	32	6.0	5.4	-10	±55	32	7.3	-27	±38	32	7.7	-30	±39
White-tailed jackrabbit	32	0.0	0.0			32	0.1	-100	±73	32	1.5	-100	±25
White-tailed deer	32	7.2	14.6	102	±70	32	6.9	111	±61	32	4.3	237	±107
Mourning dove	32	128.6	114.0	-11	±23	32	221.3	-49	±30	32	248.7	-54	±11
Sandhill crane[e]	32	3.5	4.4	25	±145	32	1.4	215	±290				
Southeast													
Ring-necked pheasant	20	22.4	8.7	-61	±73	20	13	-34	±41	20	65.7	-87	±29
Gray partridge	20	2.8	0.0	-100	±154	20	3.6	-100	±67	20	12.6	-100	±32
Eastern cottontail	20	13.4	10.8	-20	±69	20	8.6	25	±79	20	8.0	35	±81
White-tailed jackrabbit	20	0.0	0.0			20	0.0	-100	±209	20	0.5	-100	±43
White-tailed deer	20	26.4	22.0	-17	±34	20	18.3	21	±34	20	11.8	86	±64
Mourning dove	20	97.8	58.0	-41	±26	20	105.7	-45	±22	20	205.8	-72	±23
Sandhill crane[e]	20	0.6	0.6	0	±267	20	0.3	115	±482				

[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 1955-2018, except for Northwest region (1982-2018) and white-tailed deer (1974-2018). Estimates based on routes (*n*) surveyed $\geq$40 years (1955-2018), except for Northwest ($\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] Sandhill cranes were added to the survey in 2009; thus, long-term averages are not calculated.

[f] Two routes were added to the West Central region in 2014.

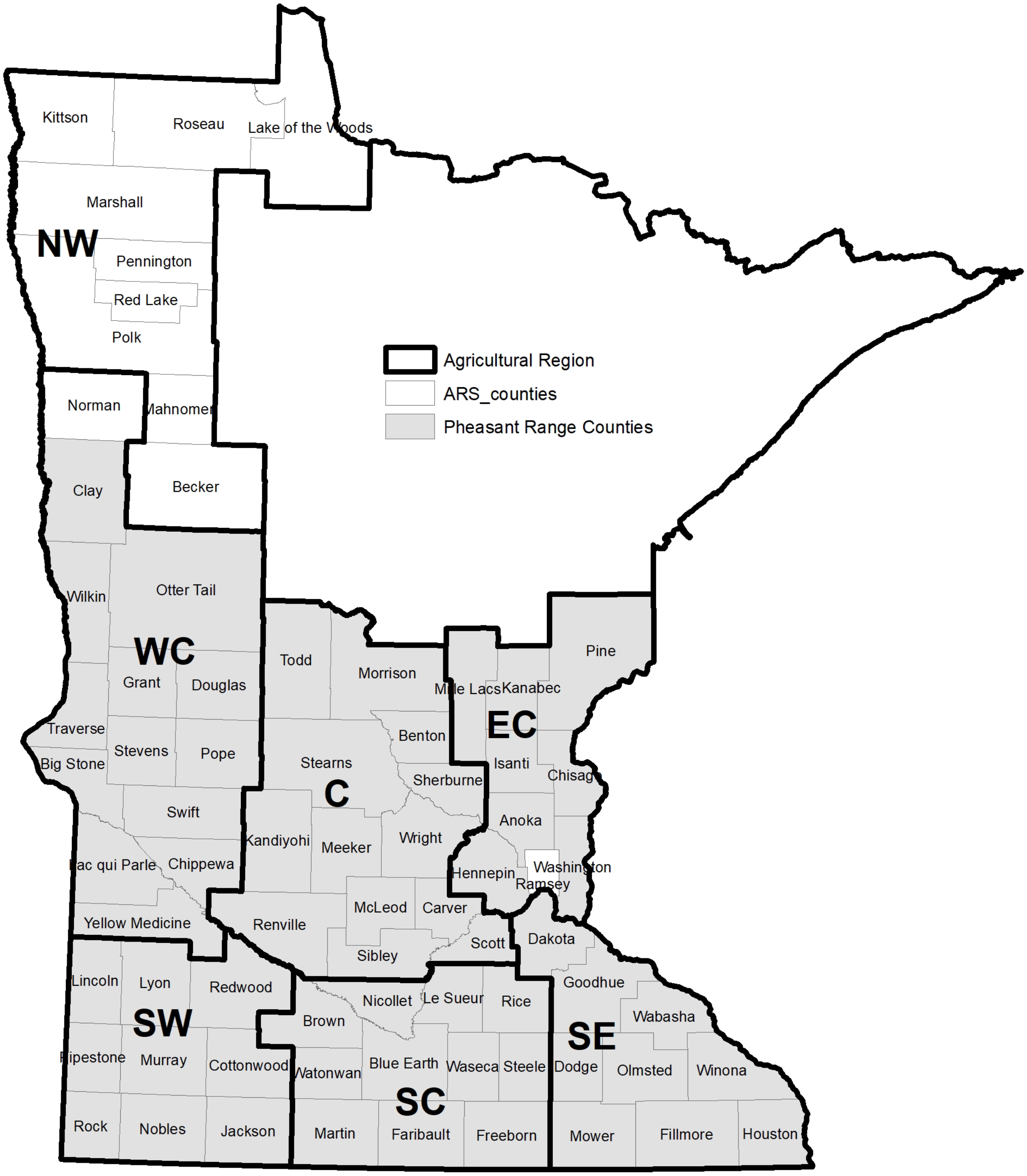


Figure 1. Survey regions and ring-necked pheasant range delineation for Minnesota's August roadside survey, 2019.

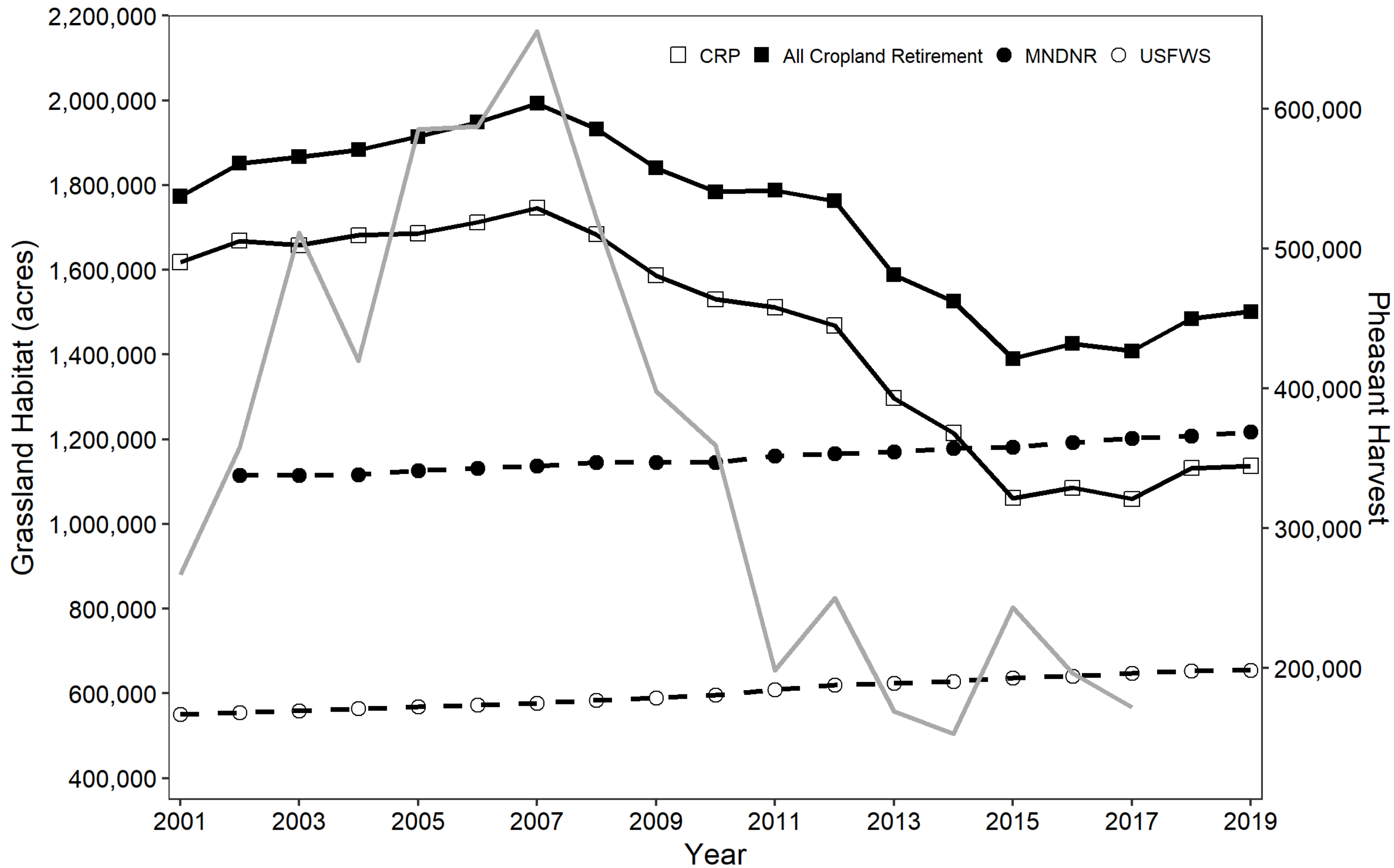
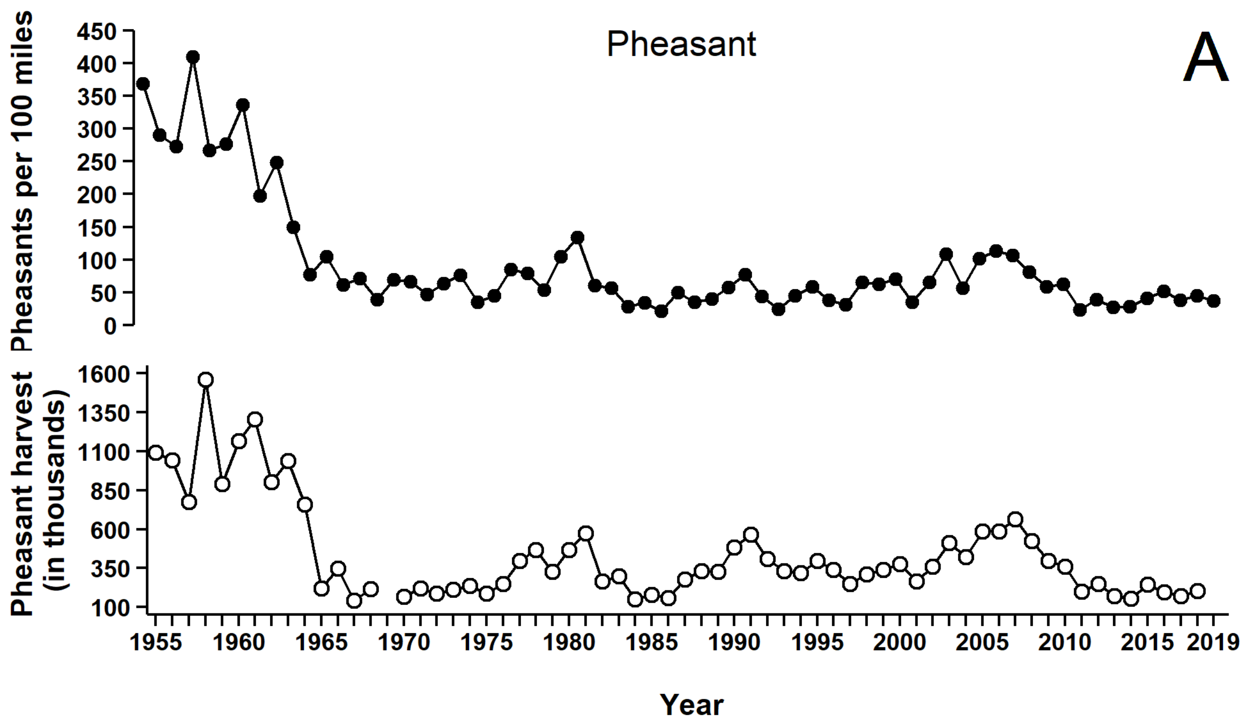


Figure 2. Acres enrolled in private (solid black lines with open and solid squares) and public (dashed black lines with open and solid circles) land habitat conservation programs vs. ring-necked pheasant harvest trends (solid gray line) in Minnesota, 2001-2019. Acres represent STATEWIDE totals. All cropland retirement includes Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Reinvest in Minnesota (RIM), Wetlands Reserve Program (WRP), and RIM-WRP.



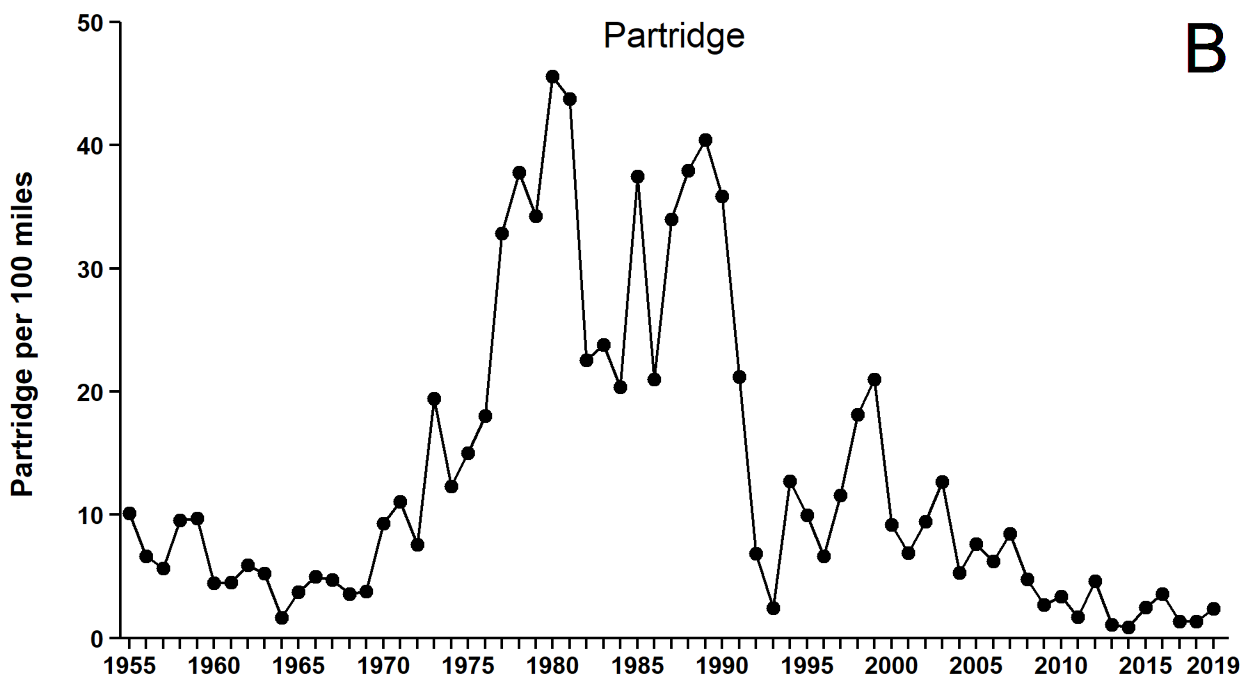


Figure 3. Range-wide index of ring-necked pheasants (A) and gray partridge (B) seen per 100 miles driven in Minnesota, 1955-2019. Does not include the Northwest region. Based on all survey routes completed.

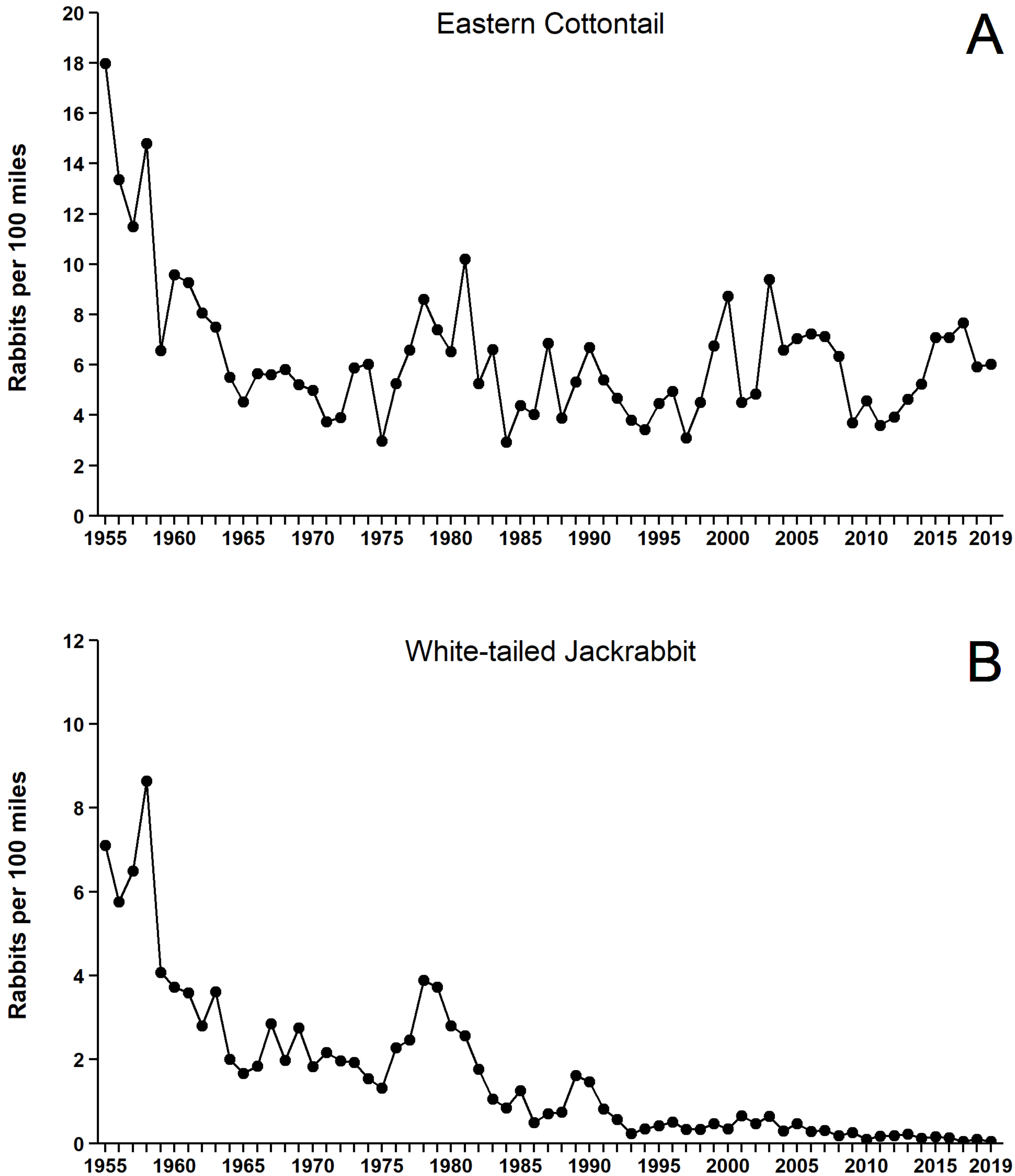
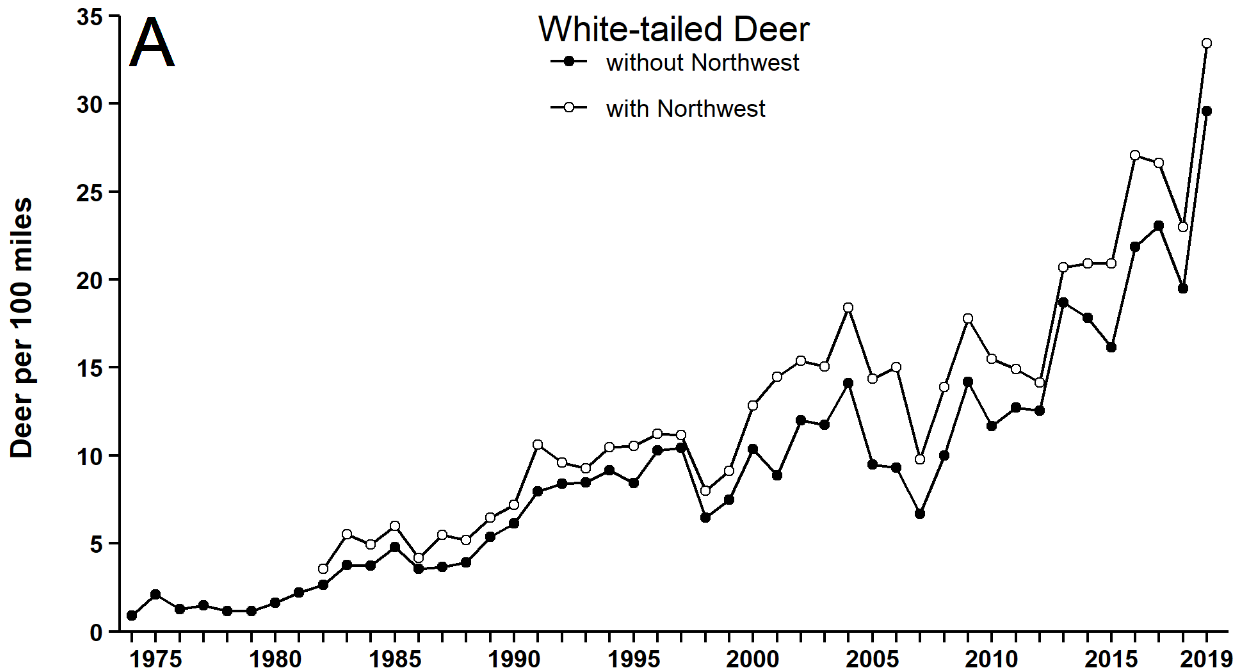


Figure 4. Range-wide index of eastern cottontail (A) and white-tailed jackrabbits (B) seen per 100 miles driven in Minnesota, 1955-2019. Does not include the Northwest region. Based on all survey routes completed.



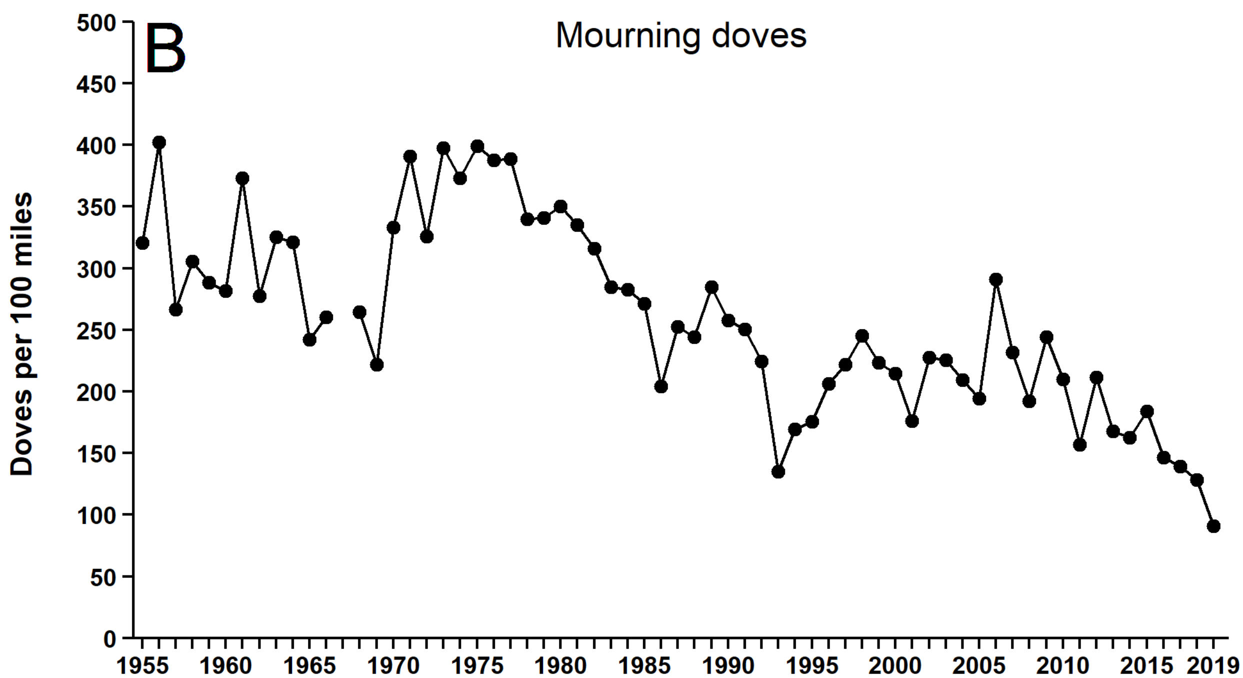


Figure 5. Range-wide index of: (A) white-tailed deer seen per 100 miles driven in Minnesota, 1974-2019, with and without the Northwest region included; and (B) mourning doves seen per 100 miles driven in Minnesota, 1955-2019. Doves were not counted in 1967 and the dove index does not include the Northwest region. Based on all survey routes completed.

DEPARTMENT OF NATURAL RESOURCES

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA – 2019

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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, MNDNR Biologists consider output from population modeling 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. This report summarizes the structure and parameters of the simulation model, and provides a description of recent trends in deer populations.

METHODS

We used a stochastic population model to simulate annual variations in deer densities within individual DPAs. We defined ranges of values for fecundity (number of offspring born per female) 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.

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 = 0.45 [SD = 0.02], adult males mean = 0.20 [SD = 0.02]). We allocated the remaining proportion (0.35) equally to young-of-year (YOY) males and females.

Within each annual cycle, we applied age-specific fecundity rates to females to estimate reproduction. We subjected all age- and sex-classes to spring/summer mortality, and the result was the pre-hunt fall population. We subtracted hunter-harvested deer from the pre-hunt population. We estimated winter mortality rates by age-class relative to winter severity, and we then applied winter mortality rates 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. We provide more detailed information about model parameter selection in the following sections.

Reproduction

We used fecundity rates, from a range of values reported for Iowa, Minnesota, and Wisconsin (Iowa DNR unpublished data, Fuller 1990, McCaffery et al. 1998, DelGiudice et al. 2007, Dunbar 2007, Grund 2011, Storm 2014, Storm 2015, Dittrich 2016). We partitioned fecundity rates by 2 age-classes of breeding females (i.e., <1 year old [YOY] when bred and ≥1 years old [adult] when bred) and allowed rates to vary by 3 eco-geographic zones (northeast, farmland and transition areas, and southeast) that reflected relative differences in climate and habitat quality. We estimated fecundity rates to be lowest in the northeast (YOYs, mean = 0.06 [SD = 0.005]; adults, mean = 1.55 [SD = 0.001]), moderate in the farmland and transition zone (YOYs, mean = 0.07 [SD = 0.017]; adults, mean = 1.71 [SD = 0.022]), and greatest in the southeast (YOYs, mean = 0.13 [SD = 0.029]; adults, mean = 1.81 [SD = 0.055]). Sex ratio of fawns at birth in most deer populations is approximately 50:50, but may vary annually (Ditchkoff 2011). Therefore, we allowed the proportion of male fawns at birth to vary uniformly between 0.48-0.52.

Spring/Summer Survival

Winter survival rates of deer 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.

We used estimates reported in the primary literature for deer in Minnesota and populations in similar habitats for fawn spring/summer survival (Wisconsin DNR unpublished data, 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, Warbington et al. 2017). We adjusted fawn survival rates to estimate the effects of winter severity on the condition of adult females during the previous winter. Mean spring/summer fawn survival values were 0.70 (SD = 0.031), 0.55 (SD = 0.037), and 0.45 (SD = 0.037) when WSI<100, 100≤WSI<180, and 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 similar 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 randomly (female = 0.96 [SD = 0.011], male = 0.97 [SD = 0.015]). 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 Recovery Rates

Hunter harvest represents the greatest source of mortality for deer populations in most DPAs in Minnesota during 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 not registered during the hunting season or they were harvested illegally (Dusek et al. 1992, Rupp et al. 2000), wounded and not recovered (Nixon et al. 2001), or died from other non-hunting causes (e.g., deer-vehicle-collision, Norton 2015). We applied a mean multiplier of 1.05 (SD = 0.002) to the numerical harvest to account for non-registered deer that died during the hunting season. Because we expect the true multiplier to be greater than 1.05, density estimates are conservative, but resulting population trends will likely be similar when different multipliers are used based on the modeling procedures.

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, Norton 2015). We estimated winter survival rates relative to winter severity based on studies conducted in Minnesota (Nelson and Mech 1986a, DelGiudice et al. 2002, Brinkman et al. 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, Norton 2015).

For adult deer, we set mean winter survival at 0.95 when WSI≤25. When WSI>25, we used an equation to calculate survival to account for increased winter severity based on previous research in Minnesota. For fawns, we set the mean winter survival rate at 0.85 when WSI≤60.When WSI was above 60 and less than 100, we applied the same equation used to calculate adult survival. However, we subtracted an additional mortality rate of 0.05 to represent lower survival of fawns versus adults. For more severe winters (100≤WSI≤240), we adjusted the equation to represent increased mortality reported for fawns in field studies. When WSI exceeded 240, we set fawn survival at 0.033. We calculated winter survival relationships 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 (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.

To determine the most appropriate initial population density, we examined the modeled population trends relative to: 1) population estimates from field surveys when available; 2) the trend in reported deer harvest; and 3) the relationship between estimated population densities and adult male harvest success. We incrementally increased and decreased the density and re-examined the modeled trend relative to the aforementioned indices to refine the initial population density. In some cases, we also adjusted other vital rates slightly in conjunction with varying initial population densities.

Because the initial population density is the primary parameter adjusted, similar population trends are fitted when the mean for parameters that are constant (with only random variation) among years (e.g., recovery rates, adult summer survival) are changed. However, the absolute density will shift similarly among years (e.g., all density estimates may be 20% greater if recovery rates are increased), because the modeler can adjust the initial density to fit the same trend. Importantly, the resulting density estimates are only unbiased when all input parameters are unbiased, but accurate trends can still be estimated even when mean values for parameters are biased.

We ran model simulations for 5 years (2014-2019) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring 2019). We performed all simulations with the R programming language (ver. 3.3.2, R Core Team 2017) and used 500 Monte Carlo simulations until we determined the most reasonable set of starting parameters. We 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 we derived the model parameters from studies of deer in Minnesota or from studies from states that have similar habitats and environmental conditions, uncertainty is inherent in modeling wild deer populations. Our modeling allowed input parameters to vary randomly to represent uncertainty that occurs in wild populations, and model outputs 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 105 of 130 DPAs in Minnesota to estimate deer densities before reproduction during spring 2019 (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 increased through 2019. Management designations in 2019 were consistent in most DPAs compared to 2018 in attempt to stabilize or reduce densities that had exceeded goals. However, some DPAs in the southwestern farmland and northeastern forest remained below goal, even with conservative hunting regulations, likely due to resource limitations. Because firearm hunting season conditions across some areas in the state were below average in 2018, antlerless harvest goals were not achieved, resulting in more deer after the hunting season than intended with hunting season regulations. Liberal antlerless seasons in 2019 will be required again to effectively manage deer populations in DPAs with average and above average productivity.

In terms of management intensity, the 2019 designations afford more antlerless deer harvest opportunities to hunters in about 17% of the DPAs versus the 2018 season. For most of the remaining DPAs, designations in 2019 were the same as 2018 and about 14% of DPA designations afforded less antlerless harvest opportunity.

Farmland Zone

Of the 36 farmland zone DPAs, 4 were within 10% of goal, 4 were at least 10% below goal, and 19 were at least 10% above goal based on modeling or buck harvest trends. Modeling deer densities in the farmland with harvest data continues to be a challenge, and relatively stable buck harvests the past 20 years suggests a stable population with limited potential for growth, likely a result of habitat constraints. We selected management designations to stabilize deer numbers with consistent regulations across years whenever possible. Most farmland DPAs (n = 24) were under a Lottery designation. Five of the DPAs required Hunter Choice and 7 were under Managed designations to stabilize or reduce 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. Of the 50 transition zone DPAs with goals, 3 were within 10% of goal, 0 were at least 10% below goal, and 38 were at least 10% above goal based on modeling or buck harvest trends. For the 2019 season designations, Lottery will be used for 3 of the DPAs, Hunter Choice for 7 DPAs, and Managed for 14 DPAs. In 18 DPAs, Intensive designations will be necessary to continue reducing deer densities toward goal level, 1 of which (DPA 343) have additional antlerless seasons. In the metro area (DPA 701) and the chronic wasting disease management zone (DPAs 645, 646, 647, 648, 649, and 655), 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. Of the 44 forest zone DPAs, 8 were within 10% of goal, 13 were at least 10% below goal, and 15 were at least 10% above goal based on modeling or buck harvest trends. For 2019 season designations, Bucks-only will be used in 2 DPAs, Lottery in 14 DPAs, Hunter Choice in 19 DPAs, Managed in 5 DPAs, Intensive in 2 DPAs, and Unlimited Antlerless in 2 DPAs.

ABRIDGED DESCRIPTIONS OF DEER HUNTING SEASON DESIGNATIONS (MNDNR 2019)

Bucks-only. All hunters, including youth and archery hunters, are restricted to harvesting only legal bucks. No antlerless deer may be harvested; limited exceptions for hunters ≥84 years of age or persons in veterans homes. The bag limit is **one** deer.

Lottery. A hunter may apply for authorization to harvest one either-sex deer during either the firearm or muzzleloader season. Archery hunters can take a deer of either sex. Under this scenario, archers, youth, and disabled hunters can kill a deer of either-sex. The bag limit is **one** deer.

Hunter Choice. The initial license is either-sex and bonus permits cannot be used. There is no antlerless permit lottery application and all hunters potentially could harvest an antlerless deer, regardless of season. The bag limit is **one** deer.

Managed. The initial license is either-sex and a maximum of **two** deer (one buck) can be taken using any combination of licenses and permits.

Intensive. The initial license is either-sex and the maximum of **three** deer (one buck) can be taken using any combination of licenses and permits.

***Early Antlerless.** A hunter could harvest **five additional** deer in these permit areas during the early antlerless season (e.g. the annual limit in an intensive permit area with an early antlerless season would be eight deer).

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Table 1. Estimated mean pre-fawn deer densities (deer/mi^2) derived from population model simulations in Minnesota deer permit areas, 2014-2019.

		Pre-fawn deer density[a]					
Deer Permit Area	Land area (mi^2)	2014	2015	2016	2017	2018	2019
101	496	8	9	11	12	14	15
103	1820	3	3	4	4	5	5
105	740	10	11	13	14	16	15
108	1655	5	5	7	7	8	8
110	529	11	12	14	15	16	16
111	1438	2	2	3	3	3	3
114	123	-	-	-	-	-	-
117	936	-	-	-	-	-	-
118	1239	4	4	4	4	4	4
119	782	5	5	6	7	7	7
126	942	3	3	3	3	3	3
130	746	3	3	4	4	4	4
131	899	-	-	-	-	-	-
132	482	4	5	5	6	7	6
133	352	7	8	9	10	10	9
152	60	-	-	-	-	-	-
155	594	15	17	20	23	25	25
156	819	10	12	13	15	16	17
157	888	20	20	22	25	19	19
159	571	12	13	15	17	19	21
169	1124	8	9	11	12	13	13
171	701	10	11	13	15	16	16
172	692	19	21	24	27	28	28
173	584	8	9	10	12	13	13
176	921	7	8	9	10	10	10
177	491	11	12	14	15	14	13
178	1195	8	9	11	13	14	14
179	857	12	13	15	16	16	15
181	629	9	10	12	14	15	16
182	278	-	-	-	-	-	-
183	664	11	12	15	18	20	21
184	1229	16	17	19	21	22	20
197	957	9	10	12	13	15	15
199	153	-	-	-	-	-	-
201	161	9	10	12	13	15	16
203	118	-	-	-	-	-	-
208	378	4	5	6	7	8	8

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

		Pre-fawn deer density[a]					
Deer Permit Area	Land area (mi^2)	2014	2015	2016	2017	2018	2019
209	639	7	8	9	10	10	10
210	615	8	8	9	10	10	9
213	1059	15	16	18	20	22	23
214	553	25	27	29	32	34	35
215	701	18	20	21	23	25	26
218	884	10	11	13	14	16	18
219	392	12	13	14	16	18	21
221	643	13	14	16	19	22	23
222	413	15	16	18	21	23	25
223	377	14	15	17	18	20	21
224	46	-	-	-	-	-	-
225	618	17	18	20	22	24	25
227	471	18	20	22	25	28	30
229	285	9	10	12	14	15	17
230	454	-	-	-	-	-	-
232	377	5	6	7	7	9	10
233	384	5	6	6	7	8	9
234	636	2	3	3	3	4	4
235	35	-	-	-	-	-	-
236	368	16	18	20	22	26	29
237	728	-	-	-	-	-	-
238	95	-	-	-	-	-	-
239	928	12	13	13	14	15	15
240	643	20	22	24	27	29	29
241	997	26	27	28	29	30	27
242	213	20	22	25	28	29	27
246	838	16	17	20	22	23	23
247	229	17	19	20	21	21	19
248	216	15	16	17	18	18	17
249	502	16	17	19	21	23	24
250	712	-	-	-	-	-	-
251	55	-	-	-	-	-	-
252	716	-	-	-	-	-	-
253	974	-	-	-	-	-	-
254	930	4	4	4	4	5	5
255	774	5	5	6	7	8	9
256	654	7	7	8	9	10	9
257	412	8	9	10	11	12	12
258	343	18	19	22	24	26	25
259	490	17	19	21	22	22	21

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

		Pre-fawn deer density[a]					
Deer Permit Area	Land area (mi^2)	2014	2015	2016	2017	2018	2019
260	1248	3	4	5	6	7	7
261	793	3	4	4	5	7	7
262	677	3	3	4	4	5	5
263	512	8	9	11	12	14	14
264	669	12	13	16	17	19	19
265	494	9	10	11	12	14	13
266	617	5	6	6	7	9	9
267	472	4	5	5	6	6	5
268	228	9	9	10	11	10	10
269	650	3	3	4	4	5	5
270	736	3	3	3	4	5	5
271	632	3	3	3	3	4	4
272	532	-	-	-	-	-	-
273	572	6	6	7	8	9	10
274	355	6	6	6	7	8	9
275	764	4	4	4	5	5	6
276	542	9	10	11	13	15	16
277	812	12	13	14	15	16	18
278	402	6	6	7	8	9	10
279	344	4	4	4	5	5	5
280	674	3	3	3	3	3	3
281	575	7	7	8	10	12	13
282	778	-	-	-	-	-	-
283	613	4	4	4	4	4	4
284	840	-	-	-	-	-	-
285	546	5	5	6	7	8	9
286	447	5	5	6	7	8	9
287	47	-	-	-	-	-	-
288	624	5	5	5	6	6	6
289	816	2	2	3	3	3	4
290	661	5	6	6	7	8	8
291	799	6	6	7	8	9	10
292	480	9	10	11	12	14	16
293	511	8	9	10	10	11	12
294	687	4	4	4	5	5	6
295	839	4	5	5	6	7	8
296	665	3	4	4	4	5	6
297	438	3	3	3	4	5	5
298	618	9	10	12	15	17	17
299	387	5	6	6	6	7	8

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

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a] 2014	2015	2016	2017	2018	2019
338	454	6	7	8	9	11	13
339	394	6	7	8	10	11	13
341	611	14	16	17	20	22	24
342	350	14	16	18	20	22	25
343	662	13	14	14	15	17	17
344	190	19	19	18	19	21	22
345	326	13	14	15	17	18	19
346	319	28	28	27	28	29	28
347	272	-	-	-	-	-	-
348	122	-	-	-	-	-	-
349	492	26	27	27	29	31	33
601	1632	-	-	-	-	-	-

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

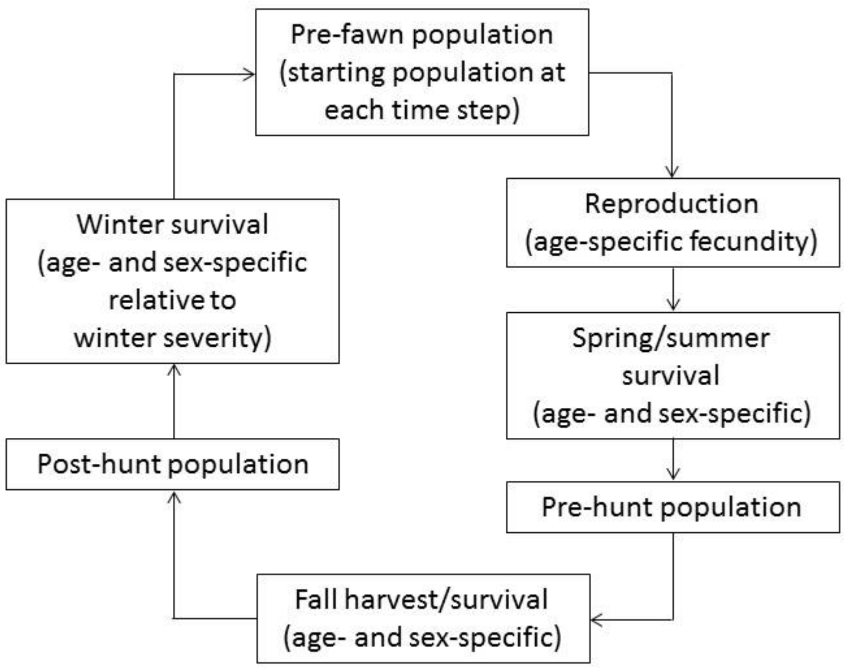

Figure 1. Model structure for simulations of white-tailed deer populations in Minnesota.

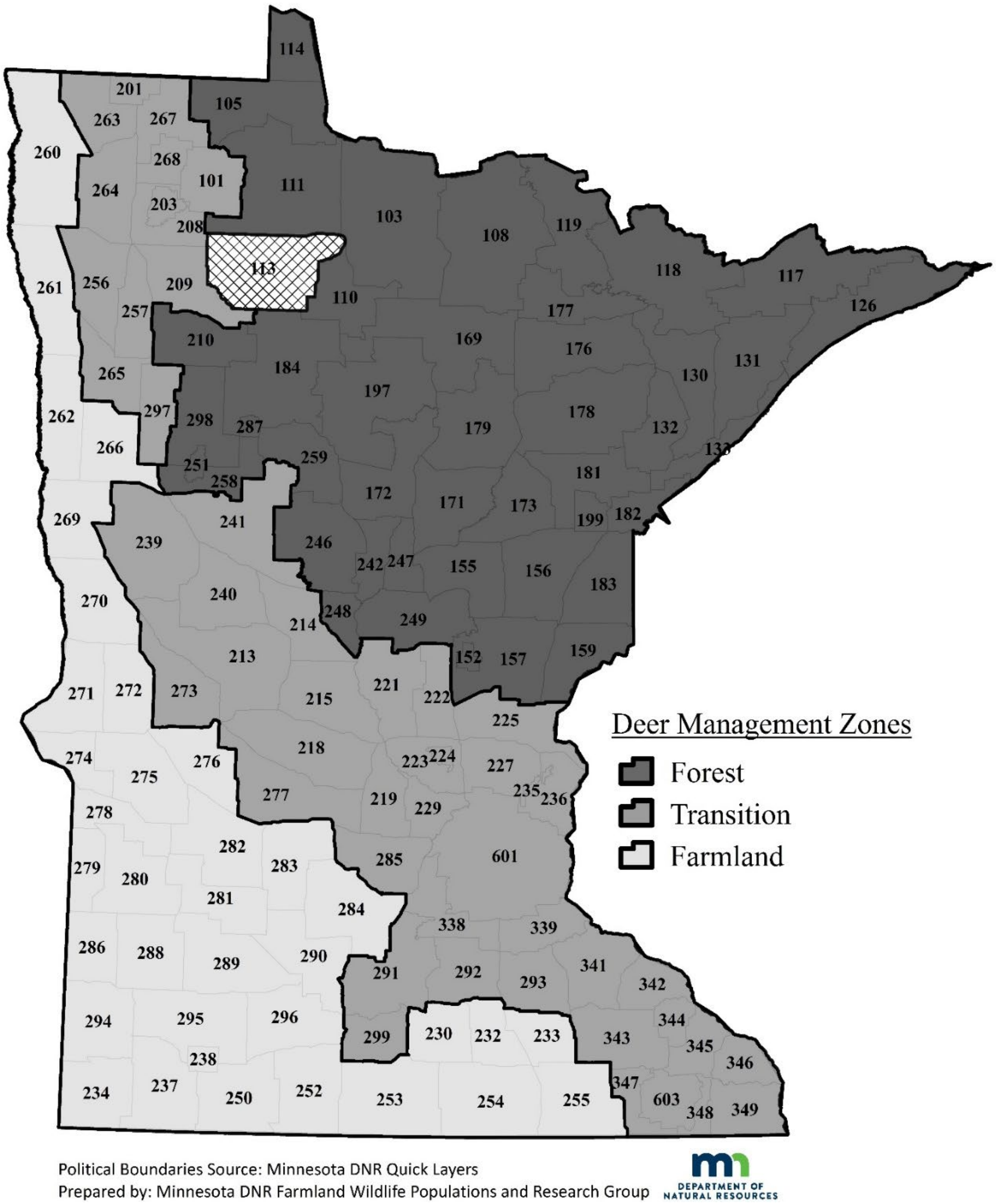

Figure 2. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2018. DPAs were assigned to forest, transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of ≥60% woody cover, transition DPAs were composed of 6%-50% woody cover, and farmland DPAs were composed of ≤5% woody cover.

2019 WHITE-TAILED DEER AERIAL SURVEYS

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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 121 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 (Norton and Giudice 2017). 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, managers should 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).

We used 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). We used these estimates within these bounds to recalibrate population models to improve population management.

METHODS

We estimated deer populations in select PAs 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, we delineated quadrats by Public Land Survey (PLS) section (640 ac) boundaries. We used regression trees (Fabrizi and Trivisano 2007, Fieberg and Lenarz 2012), the R programming language (R Core Team 2018), and R package ’stratification’ (Baillargeon and Rivest 2018) to stratify the sampling frame into 2 categories (low, high) based upon past helicopter counts of deer and abundance of woody cover within each quadrat. We derived woody cover data from the 2011 National Land Cover database (Homer et al. 2015). We used optimal allocation, R package ‘spsurvey’ (Kincaid and Olsen 2019), and a generalized random tessellation stratified procedure (GRTS; Stevens and Olsen 2004) to draw spatially balanced stratified random samples within each PA.

For comparison with a concurrent study of road-based distance-sampling surveys of deer (MNDNR, unpublished data), we also estimated deer populations in a 4-PA distance-sampling study area (DSSA), using a similar aerial survey design. However, because habitat within the DSSA was predominately row-crop agriculture with limited woody cover, we stratified this sampling frame into 3 density categories (low, medium, high) using the local wildlife manager's knowledge of deer abundance and distribution.

During all surveys, we used Bell OH-58 and MD-500E helicopters and attempted to maintain flight altitude at 200 ft (60 m) above ground level and airspeed at 50-60 mi/hr (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, we noted direction of movement 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, Inc., 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 each PA 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., low stratum quadrats or quadrats where woody cover < 80 ac [0.32 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 mi/hr [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 and the DSSA.

We computed population estimates adjusted for both sampling and sightability. We used the R package 'spsurvey' (Kincaid and Olsen 2019) 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 2019) with a finite population correction to compute stratum-specific estimates of sampling variance. We summed stratum-specific estimates by management unit (Cochran 1977:34) to compute deer abundance and density indices for each PA and the DSSA. 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

We completed 4 surveys during 2019 (Figure 1). We stratified PAs 215, 219, and 229 using the relationship between woody cover abundance per quadrat and historic deer density. We combined PAs 252, 253, 296, and 299 into a single survey area (i.e., DSSA) and we stratified each PA by expected deer density based upon input from local field staff. Mean deer density estimates for the PA surveys ranged from 15-17 deer/quadrat (90% CI = 12–19; Table 1). Within the DSSA, mean density was 6 deer/quadrat (90% CI = 5–8). Except for the DSSA, all estimates met precision goals (relative error ≤ 20%; Table 1). We observed deer in 65-80% of sample quadrats in the PA surveys and 41% of quadrats in the DSSA, with greater occupancy occurring in areas with more woody cover (Table 2). In addition, mean group size and mean number of groups per "occupied" quadrat was similar across all areas.

Estimates of sightability ranged from 0.643 (SE = 0.027) in PA 229 to 0.795 (SE = 0.016) in the DSSA and averaged 0.714 (SE = 0.076), which were similar to sightability estimates during 2010-2018 (range = 0.633-0.909; mean = 0.757). Correcting for sightability increased relative variance (CV [%]) of population estimates by 2-8%, 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. In the event when animals are unavailable, resulting population estimates would be underestimated. 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.

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Table 1. White-tailed deer population and density (deer/quadrat) estimates derived from aerial surveys in Minnesota, 2019. Summary statistics (CI, CV) are also presented. Confidence intervals for density estimates were based on α = 0.10.

Permit area	Sampling rate (%)	Sightability rate	Population estimate		CV (%)	Relative error (%)[a]	Density estimate	
			N	90% CI			$\bar{x}$	90% CI
215	20	0.656	10,180	8,808–11,552	8.2	13.5	15	13–17
219	20	0.709	6,811	5,878–7,744	8.3	13.7	17	15–19
229	20	0.643	4,119	3,366–4,872	11.1	18.3	15	12–17
DSSA[b]	6	0.795	17,275	13,628–20,922	12.8	21.1	6	5–8

[a]Relative precision of population estimate. Calculated as 90% CI bound/*N*.

[b]Distance Sampling Study Area (permit areas 252, 253, 296, 299).

Table 2. Sampling metrics from aerial surveys of white-tailed deer in Minnesota, 2019.

Permit area	Quadrats in permit area	Quadrats sampled	Quadrats occupied[a]	Deer observed	Deer groups observed	Groups / occupied quadrat		Group size / occupied quadrat		Max. quadrat count
						$\bar{x}$	Range	$\bar{x}$	Range	
215	691	139	90	1,742	360	4	1–14	5	1–35	86
219	406	82	66	1,294	324	5	1–15	4	1–26	67
229	282	57	41	671	145	4	1–8	5	1–25	70
DSSA[b]	2,714	162	67	1,652	302	5	1–14	5	1–32	109

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

[b]Distance Sampling Study Area (permit areas 252, 253, 296, 299).

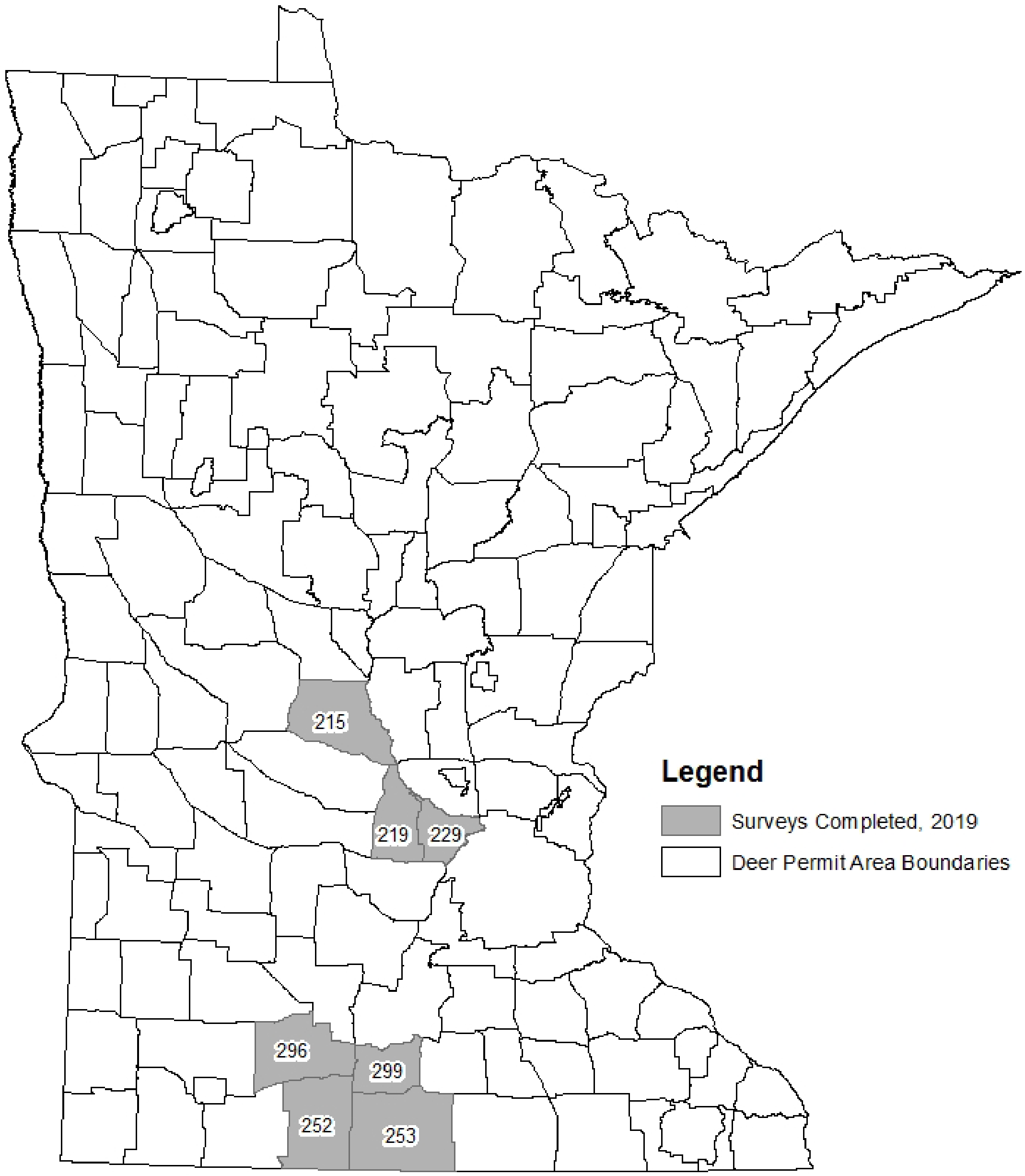

Figure 1. Permit areas (PA) flown during aerial surveys of white-tailed deer in southern Minnesota, winter 2019. PAs 252, 253, 296, and 299 were combined into a single survey area for comparison with a concurrent study using roadside distance-sampling surveys.