FARMLAND WILDLIFE POPULATIONS

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2018 MINNESOTA AUGUST ROADSIDE SURVEY

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SUMMARY OF FINDINGS

Despite late-season snowstorms and excessive spring and summer rainfall across some regions, the 2018 range-wide pheasant index (45.5 birds/100 mi) increased 19% from 2017 and was similar to the 10-year average of 44.7 birds/100 mi. Grassland habitat on private, state, and federally-owned lands increased by 82,519 acres statewide since 2017 and may have helped mitigate the extreme weather conditions in certain regions; however, nearly 297,000 acres of Conservation Reserve Program (CRP) are under contracts set to expire by September 2019. The range-wide indices for eastern cottontail rabbits and white-tailed deer declined slightly, whereas the indices for mourning doves and cranes were similar to 2017. Gray partridge and white-tailed jackrabbit observations continue to be historically low across our survey area.

INTRODUCTION

This report summarizes the 2018 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 (Figure 1). The 2018 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 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 <u>*should be interpreted cautiously*</u>.

HABITAT CONDITIONS

In Minnesota's farmland region, total undisturbed grassland habitat increased in 2018 after a slight decrease in 2017. Statewide, 82,519 habitat acres were gained; the pheasant range gained 77,876 of those acres. Undisturbed grassland acres were primarily gained on private lands with Conservation Reserve Program (CRP) enrollment (72,412 acres) accounting for a majority of these gains. Nearly all CRP gains occurred within the pheasant range (72,387 acres gained). Acres enrolled in Reinvest in Minnesota (RIM) increased by 4,306 acres in 2018 while acres enrolled in the Conservation Reserve Enhancement Program (CREP), Wetlands Reserve Program (WRP), and RIM-WRP remained relatively stable. Additionally, publically-owned grassland habitat within the farmland region also increased slightly in 2018. Federally-owned U.S. Fish and Wildlife Service (USFWS) Waterfowl Production Areas (WPA) and wildlife refuges increased by 3,664 acres and state-owned Wildlife Management Areas (WMA) increased by

6,067 acres statewide. In the pheasant range in particular, 3,015 acres of USFWS land and 3,510 acres of WMAs were added. Similar to 2017, remaining protected habitat accounts for 6.4% of the landscape within the pheasant range (range: 3.2-10.0%; 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 (Figure 2). Despite the gain in private land habitat conservation programs in 2018, approximately 614,348 acres of CRP have been lost since 2007 and an additional 296,855 acres are under contracts set to expire by September 30, 2019. The 2008 and 2014 versions of the Farm Bill placed a cap of 24 million acres nationwide on CRP and this cap remains in effect at the present time. As a result, there has been a steady decline of federally-incentivized habitat acres in recent years. The Farm Bill is up for renewal by September 30, 2018 and many conservation groups are asking for the nationwide cap on CRP to be increased (up 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 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 that is already enrolled in existing conservation programs or has high quality natural habitat. The program has grown each year since inception, and in 2018 features >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 to 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. Availability of funding sources will determine the future of this program as federal grant funding expires after 2018.

WEATHER SUMMARY

Minnesota's winter 2017-2018 (1 December 2017 – 31 March 2018) was slightly cooler across the state with average temperatures 1.3-2.4 °F below thirty-year normals (Table 2; Minnesota Climatology Working Group [MCWG] 2018, Climate Summary). Winter snow cover was variable across the farmland zone, with snow depths exceeding 6 inches for at least one 2-week period in every agricultural region except the Southwest and Southeast. Also notable were early and mid-April snowstorms which deposited several inches of snow (3-8 inches/storm) across much of the farmland zone. By April 26, 2018, snow was absent over the entire survey region.

Spring 2018 (1 April – 31 May) temperatures were 1.7-3.0 °F below thirty-year normals statewide and precipitation varied widely across the farmland regions. The West Central and Northwest regions were drier than normal whereas the South Central and Southeast regions were wetter than normal (>1 inch departure from normal). In particular, the South Central and Southeast regions had 9.1 and 9.8 inches of rain, respectively, during spring 2018.

[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.

Summer 2018 (1 June – 31 July) temperatures were near normal statewide with temperatures ≤1.2 °F above thirty-year normals across all regions. Rainfall across the state was at or above thirty-year normals in June and July (-0.3-2.0 inches from normal). Notably, the Southwest and South Central regions received significant rainfall amounts (15.0 and 13.1 inches of rain, respectively) during this season.

Overall, the conditions for over-winter survival of wildlife were average to below average throughout the farmland zone. Notably, some localized areas, including much of the core pheasant range, received excessive snowfall during the winter months, and snow events and measurable snow depths lingered into mid- to late April, potentially impacting nest initiation for many bird species. Rainfall during May and June (the prime period for nesting birds) was above normal in many areas. Combined with cooler-than-normal spring temperatures, nest success and chick survival were likely impacted.

SURVEY CONDITIONS

The survey period was extended (28 July – 18 August) to allow survey routes (n = 171) to be completed in 2018. Weather conditions during the survey ranged from excellent (calm winds, heavy dew, clear sky) to moderate (light dew and overcast skies). Medium to heavy dew conditions were present at the start of 89% of the survey routes, which was down from 2017 (96%) and below the 10-year average (94%). Clear skies (<30% cloud cover) were present at the start of 80% of routes which was down slightly from 2017 (85%). Wind speeds <7 mph were recorded for 92% of the routes compared to 97% in 2017. Overall, survey conditions in 2018 were slightly drier, more overcast, and windier than in 2017 but similar to conditions over the long-term and were unlikely to have adversely impacted detection rates.

SPECIES REPORTS

Ring-necked Pheasant

In 2018, the average number of pheasants observed range-wide (45.5 birds/100 mi) increased 19% from 2017 (38.2 birds/100 mi) and was similar to the 10-year average of 44.7 birds/100 mi. The index was 52% below the long-term average of 93.7 birds/100 mi (Table 3, Figure 3A). Total pheasants observed per 100 mi ranged from 23.6 birds in the Southeast region to 65.1 birds in the West Central region (Table 4). The pheasant index varied greatly statewide with significant increases in the Central (95%) and West Central (51%) regions while the Southwest region, a core area of Minnesota's pheasant range, increased only 5% from 2017. The South Central region was the only region that decreased (-36%) since 2017. The best harvest opportunities will be in the West Central, Southwest, and Central regions.

The range-wide hen index (7.6 hens/100 mi) increased 31% from 2017 (5.8 hens/100 mi) and was 10% above the 10-year average (6.9 hens/100 mi) but still 45% below the long-term average (13.6 hens/100 mi; Table 3). The hen index ranged from 4.0 hens/100 mi in the Southeast to 10.6 hens/100 mi in the West Central region. All regions showed at least an 18% increase (Central region increased 100%) in their hen index except the South Central region which decreased by 30%.

The range-wide cock index (6.5 cocks/100 mi) did not change from 2017 and the 10-year average but remained 40% below the long-term average of 10.7 cocks/100 mi (Table 3). The cock index ranged from 1.3 cocks/100 mi in the Southeast to 9.8 cocks/100 mi in the West Central region. The 2018 cock index varied greatly range-wide with increases in the Central (40%), West Central (30%), and Southwest (21%) regions and decreases in the South Central (-49%), Southeast (-25%), and East Central (-23%) regions.

The 2018 hen:cock ratio (1.16) was greater than the 2017 ratio (0.90) but still below the long-term average (1.33 ± 0.37) and the average (1.39 ± 0.35) for the CRP years (1987-2017).

The 2018 range-wide brood index (7.3 broods/100 mi) increased 28% from 2017 (5.7 broods/100 mi; Table 3). The index was similar to the 10-year average (6.9 broods/100 mi) but still 42% below the long-term average (12.4 broods/100 mi). Regional brood indices ranged from 3.7 broods/100 mi in the East Central region to 10.3 broods/100 mi in the West Central region. Brood indices increased in all regions (range: 8% to 112%) except in the East Central (-0.3%) and South Central (-28%) regions. The average brood size in 2018 (4.3 chicks/brood) was similar to 2017 but slightly below the 10-year average (4.6 chicks/brood) and below the long-term average of 5.4 chicks/brood. The median hatch date (assigned using estimated brood ages from broods observed during the survey) for pheasant broods across their range was 14 June 2018 (n = 277 broods), which was nearly a week later than 2017 (8 June) and a few days later than the 10-year average (12 June; Table 3).

Late-winter snowstorms (which extended into April) followed by locally heavy spring and summer rains likely impacted nesting cover and affected nesting and brood-rearing during the 2018 breeding season. In particular, median hatch dates in the Southwest (26 June) and South Central (23 June) regions were 20 and 8 days later, respectively, than 2017 and 1-2 weeks later than the 10-year and long-term averages. Although hatching in these regions was delayed, the Southwest region still increased in all indices measured compared to 2017. However, this was not the case for the South Central region which decreased in each index assessed compared to last year. The South Central region not only experienced late winter snowstorms, but also had poorly-timed and excessive rainfall during the typical period of peak hatch. Although weather typically drives year-to-year fluctuations in pheasant numbers, available grassland habitat on the landscape is correlated with longer-term population indices and can help mediate the impacts of annual variation in weather on local populations. 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 2018 range-wide gray partridge index (1.3 birds/100 mi) was similar to 2017 but remained 50% and 93% below the 10-year and long-term averages, (2.7 birds/100 mi and 14.4 birds/100 mi, respectively; Table 3, Figure 3B). Indices for partridge ranged from 0.1 birds/100 mi in the West Central region to 3.8 birds/100 mi in the Northwest 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 Southwest, Southeast, and Northwest regions will offer the best opportunities for harvesting gray partridge in 2018.

Cottontail Rabbit and White-tailed Jackrabbit

Range-wide, the 2018 eastern cottontail rabbit index (5.8 rabbits/100 mi) decreased 23% from 2017 (7.5 rabbits/100 mi) but was 13% above the 10-year average (5.3 rabbits/100 mi) and comparable to the long-term average (6.6 rabbits/100 mi; Table 3, Figure 4A). Regionally, the cottontail rabbit index ranged from 0.6 rabbits/100 mi in the Northwest to 12.9 rabbits/100 mi in the East Central region (Table 4). Good harvest opportunities should exist in the East Central and Southeast regions.

Remaining at a historic low, the number of white-tailed jackrabbits observed range-wide (0.1 rabbits/100 mi) was 95% below the long-term average of 1.6 rabbits/100 mi (Table 3, Figure 4B). 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 (23.1 deer/100 mi) decreased 13% from 2017 (26.7 deer/100 mi) but was still 19% above the 10-year average and 99% above the long-term average (19.4 deer/100 mi and 11.6 deer/100 mi, respectively; Table 3, Figure 5A). Regional roadside indices for deer ranged from 7.3 deer/100 mi in the South Central region to 50.8 deer/100 mi in the Northwest region (Table 4).

Mourning Dove

The 2018 range-wide mourning dove index (129.2 doves/100 mi) was 7% lower than 2017 (139.1 doves/100 mi), 30% below the 10-year average (181.1 doves/100 mi), and 52% below the long-term average (264.2 doves/100 mi; Table 3, Figure 5B). Regional indices ranged from 61.8 doves/100 mi in the East Central region to 180.6 doves/100 mi in the Southwest region (Table 4). The best opportunities for harvesting doves should be in the Southwest, South Central, and West Central regions.

Sandhill Crane

The 2018 roadside index of sandhill cranes was 13.4 total cranes/100 mi, an 18% increase from 2017 (11.3 total cranes/100 mi; Table 3). Regional indices ranged from 0.0 total cranes/100 mi in the Southwest region to 38.0 total cranes/100 mi in the Central region (Table 4). The range-wide index of juveniles was 1.3 juvenile cranes/100 mi, which decreased 39% from 2017 (Table 3).

Other Species

Notable incidental sightings recorded by observers included: bobcat (Pope County), Eurasian collared dove (Watonwan County), ground squirrel sp. (Red Lake County), black-billed magpie (Red Lake County), purple martin (Kandiyohi County), Eastern meadowlark (Lincoln County), osprey (Todd County), river otter (Becker County), red-headed woodpecker (Kittson, Mower, and Watonwan Counties), sharp-tailed grouse (Marshall, Polk, and Red Lake Counties), striped skunk (Houston County), upland sandpiper (Murray and Norman Counties), and American woodcock (Nobles County). American kestrel, American crow, Canada goose, coyote, northern harrier, red fox, red-tailed hawk, and wild turkey were noted in multiple counties.

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LITERATURE CITED

Minnesota Climatology Working Group (MCWG). 2018a. MCWG Climate Summary Table. Accessed 9 August 2018.

Table 1. Abundance (total acres) and density (acres/mi^2) of undisturbed grassland habitat within Minnesota's pheasant range, 2018, 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]	273,503	37,951	22,928	14,275	20,121	201,358	111,682	681,818	10.0	64.2
SW	114,563	24,784	20,573	2,553	766	24,067	71,955	259,261	6.9	43.9
C	131,043	14,380	39,917	7,026	3,078	91,621	51,378	338,443	5.6	35.8
SC	102,436	27,633	13,585	10,775	8,943	10,875	36,811	211,058	5.2	33.4
SE	69,820	2,702	7,405	1,070	976	36,988	55,619	174,580	4.7	30.1
EC	2,949	0	1,134	0	4	4,994	92,678	101,759	3.2	20.3
Total	694,314	107,450	105,542	35,699	33,887	369,903	420,123	1,766,918	6.4	41.0

[a] Unpublished data, Tabor Hoek, BWSR, 9 August 2018.
[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, 2018.

	Agricultural Region							
	NW	WC	C	EC	SW	SC	SE	STATE
Winter (December 1 - March 31)								
Temperature (average °F)	12.1	16.9	16.9	16.6	18.9	18.6	20.1	16.1
Departure from normal (°F)[a]	-1.6	-1.3	-1.9	-2.4	-2.1	-2.4	-1.6	-2.1
Snow Depth (average inches)	9.6[b]	2.8[b]	3.3[b]	5.9[b]	3.1	3.9[b]	3.1	4.5
Spring (April 1 - May 31)								
Temperature (average °F)	47.1	48.8	48.1	48.1	49.0	49.3	49.8	47.6
Departure from normal (°F)[a]	-1.7	-2.0	-3.0	-2.3	-2.9	-2.9	-2.0	-2.3
Precipitation (total inches)	2.2	2.6	4.0	4.0	6.4	9.1	9.8	5.5
Departure from normal (inches)[a]	-1.0	-1.3	-1.1	-1.0	0.1	1.1[c]	1.2[c]	-0.2
Summer (June 1 - July 31)								
Temperature (average °F)	54.1	57.0	56.3	55.9	58.6	58.3	58.4	55.9
Departure from normal (°F)	0.8	1.0	0.0	0.2	1.2	0.5	1.0	0.5
Precipitation (total inches)	7.6	11.5	10.3	10.4	15.0	13.1	10.4	11.0
Departure from normal (inches)[a]	-0.3	1.0	0.2	0.1	2.0[c]	0.6	-0.3	0.3

[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, 1955-2018.

Species / Subgroup	Change from 2017[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
	n	2017	2018	%	95% CI	*n*	2008-2017	%	95% CI	*n*	LTA	%	95% CI
Ring-necked pheasant													
Total pheasants	151	38.2	45.5	19	±25	148	44.7	2	±16.2	149	93.7	-52	±10
Cocks	151	6.4	6.5	1	±22	148	6.4	1	±15	149	10.7	-40	±13
Hens	151	5.8	7.6	31	±30	148	6.9	10	±18	149	13.6	-45	±12
Broods	151	5.7	7.3	28	±26	148	6.9	5	±17	149	12.4	-42	±12
Chicks per brood[d]	277	4.5	4.3	-5			4.6	-7			5.4	-20	
Broods per 100 hens	151	98.6	96.5	-2			100.2	-4			101.5	-5	
Median hatch date[d]	277	8 June	14 J				12 June						
Gray partridge	170	1.3	1.3	0	±114	167	2.7	-50	±50	149	14.4	-93	±16
Eastern cottontail	170	7.5	5.8	-23	±20	167	5.3	13	±24	149	6.6	0	±23
White-tailed jackrabbit	170	0.0	0.1	100	±280	167	0.2	-37	±78	149	1.6	-95	±15
White-tailed deer	170	26.7	23.1	-13	±17	167	19.4	19	±18	168	11.6	99	±32
Mourning dove	170	139.1	129.2	-7	±20	167	181.1	-30	±12	149	264.2	-52	±8
Sandhill crane[e]													
Total cranes	170	11.3	13.4	18	±61								
Juveniles	170	2.2	1.3	-39	±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 1955-2017, except for deer (1974-2017). 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 2018.
[e] 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, 1955-2018.

Region	Change from 2017[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
Species	*n*	2017	2018	%	95% CI	*n*	2008-2017	%	95% CI	*n*	LTA	%	95% CI
Northwest[d]													
Gray partridge	19	0.0	3.8			19	0.5	723	±1745	19	3.0	25	±244
Eastern cottontail	19	1.3	0.6	-49	±180	19	0.7	-3	±170	19	0.9	-24	±136
White-tailed jackrabbit	19	0.2	0.2	0	±305	19	0.2	-12	±187	19	0.6	-64	±83
White-tailed deer	19	55.2	50.8	-8	±39	19	46.5	9	±43	19	33.4	52	±53
Mourning dove	19	114.7	120.0	5	±59.3	19	89.2	35	±53	19	118.2	2	±43
Sandhill crane[e]	19	35.6	24.3	-32	±45								
West Central[f]													
Ring-necked pheasant	39	43.2	65.1	51	±62	35	50.2	37	±32	37	95.0	-32	±22
Gray partridge	39	0.0	0.1			35	0.6	-100	±101	37	9.1	-99	±21
Eastern cottontail	39	4.3	2.5	-43	±50	35	2.5	-10	±49	37	3.9	-45	±32
White-tailed jackrabbit	39	0.0	0.2			35	0.1	62	±345	37	2.1	-90	±30
White-tailed deer	39	26.7	29.2	9	±45	35	20.4	50	±44	37	11.2	161	±98
Mourning dove	39	162.1	162.4	0	±31.8	35	227.8	-32	±21	37	360.2	-55	±16
Sandhill crane[e]	39	3.3	3.4	3	±72								
Central													
Ring-necked pheasant	30	24.7	48.1	95	±76	30	38.5	25	±36	29	70.4	-31	±22
Gray partridge	30	0.5	0.7	25	±187	30	1.2	-44	±79	29	8.9	-92	±44
Eastern cottontail	30	7.2	7.2	0	±57	30	4.5	59	±69	29	6.2	21	±49
White-tailed jackrabbit	30	0.0	0.0			30	0.1	-100	±113	29	1.1	-100	±22
White-tailed deer	30	33.2	13.9	-58	±29	30	15.6	-11	±37	29	6.9	100	±104
Mourning dove	30	144.0	103.5	-28	±45	30	166.9	-38	±28	29	225.9	-58	±14
Sandhill crane[e]	30	16.1	38.0	136	±221								
East Central													
Ring-necked pheasant	12	21.3	23.9	12	±58	12	45.8	-48	±34	12	84.3	-72	±24
Gray partridge	12	1.3	0.7	-50	±255	12	0.2	300	±870	12	0.2	325	±826
Eastern cottontail	12	22.3	12.9	-42	±49	12	10.8	20	±85	12	8.6	50	±88
White-tailed jackrabbit	12	0.0	0.0			12	0.0			12	0.2	-100	±65
White-tailed deer	12	24.7	26.9	9	±42	12	20.6	30	±61	12	11.0	145	±100
Mourning dove	12	56.6	61.8	9	±42	12	83.4	-26	±25	12	116.4	-47	±28
Sandhill crane[e]	12	50.0	34.6	-31	±81								

Table 4. Continued.

Region Species	Change from 2017[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
	n	2017	2018	%	95% CI	*n*	2008-2017	%	95% CI	*n*	LTA	%	95% CI
Southwest													
Ring-necked pheasant	19	51.7	54.1	5	±57	19	78.7	-31	±34	19	112.5	-52	±21
Gray partridge	19	5.1	3.2	-38	±154	19	6.7	-53	±72	19	38.1	-92	±19
Eastern cottontail	19	5.1	3.8	-25	±78	19	5.6	-32	±50	19	7.9	-52	±40
White-tailed jackrabbit	19	0.2	0.2	0	±305	19	0.5	-58	±76	19	3.5	-94	±26
White-tailed deer	19	16.6	17.3	4	±55	19	19.4	-11	±33	19	10.4	67	±66
Mourning dove	19	165.9	180.6	9	±37	19	253.3	-29	±22	19	305.2	-41	±22
Sandhill crane[e]	19	0.0	0.0										
South Central													
Ring-necked pheasant	32	54.6	35.1	-36	±33	32	44.4	-21	±36	32	121.9	-71	±18
Gray partridge	32	0.9	0.3	-71	±104	32	5.3	-95	±63	32	17.6	-99	±21
Eastern cottontail	32	9.1	6.0	-34	±33	32	7.8	-23	±26	32	7.7	-22	±30
White-tailed jackrabbit	32	0.0	0.0			32	0.1	-100	±67	32	1.6	-100	±25
White-tailed deer	32	10.7	7.3	-33	±43	32	6.7	8	±42	32	4.1	77	±70
Mourning dove	32	167.1	128.6	-23	±70	32	235.1	-45	±35	32	253.0	-49	±12
Sandhill crane[e]	32	1.0	3.5	250	±339								
Southeast													
Ring-necked pheasant	19	19.2	23.6	23	±79	20	12.3	82	±115	20	67.4	-67	±37
Gray partridge	19	3.8	2.9	-22	±240	20	4.2	-34	±113	20	13.0	-79	±46
Eastern cottontail	19	11.3	12.8	14	±58	20	7.9	69	±86	20	7.9	70	±98
White-tailed jackrabbit	19	0.0	0.0			20	0.0			20	0.6	-100	±42
White-tailed deer	19	25.8	27.8	8	±58	20	17.0	55	±62	20	11.5	129	±99
Mourning dove	19	86.9	102.6	18	±28	20	112.0	-13	±22	20	210.0	-53	±22
Sandhill crane[e]	19	0.0	0.6										

[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 1955-2017, except for Northwest region (1982-2017) and white-tailed deer (1974-2017). Estimates based on routes (*n*) surveyed ≥40 years (1955-2017), except for Northwest (≥20 years) and white-tailed deer (≥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.

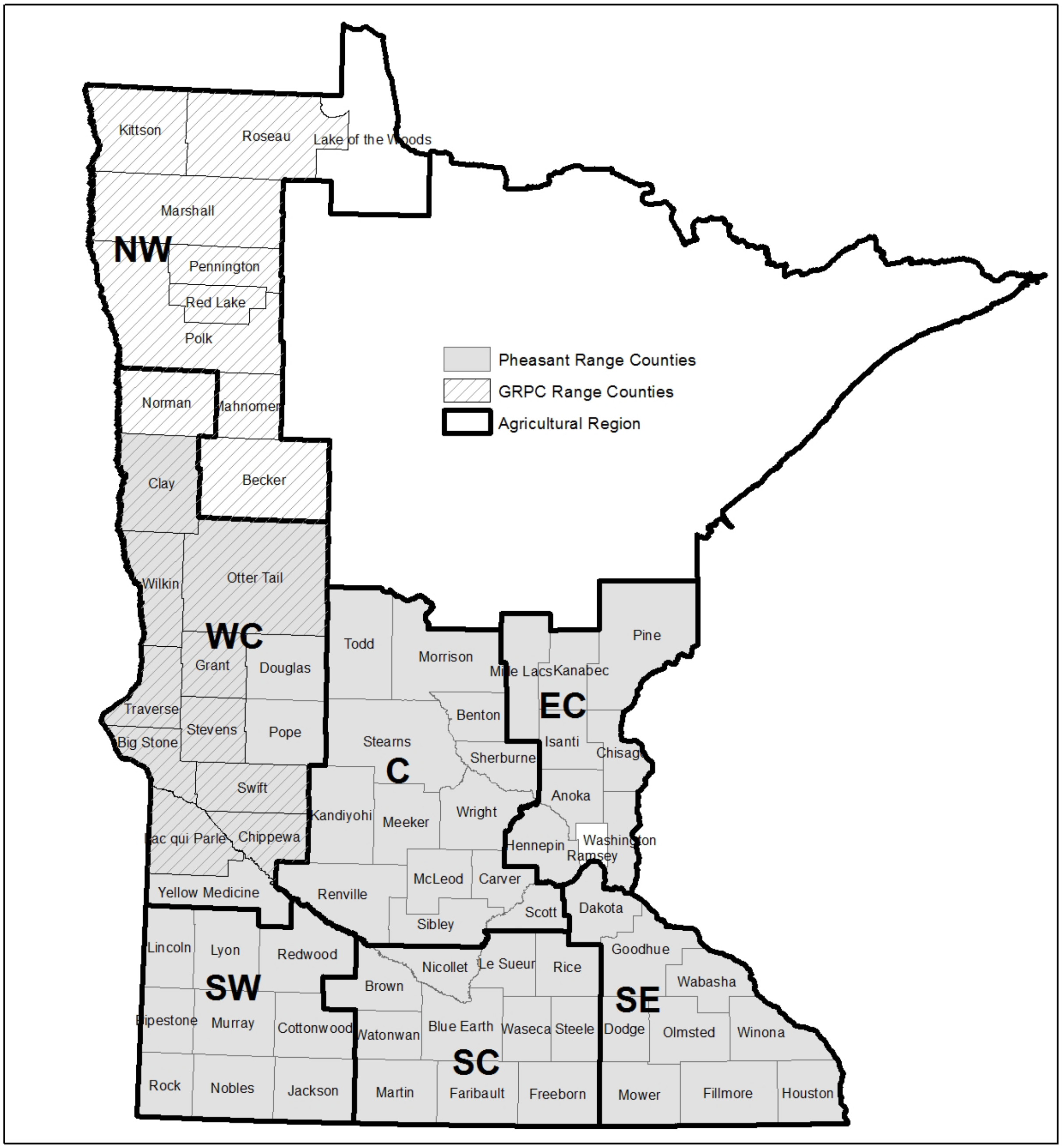


Figure 1. Survey regions and ring-necked pheasant range delineation for Minnesota's August roadside survey, 2018. The greater prairie-chicken range delineation is also shown.

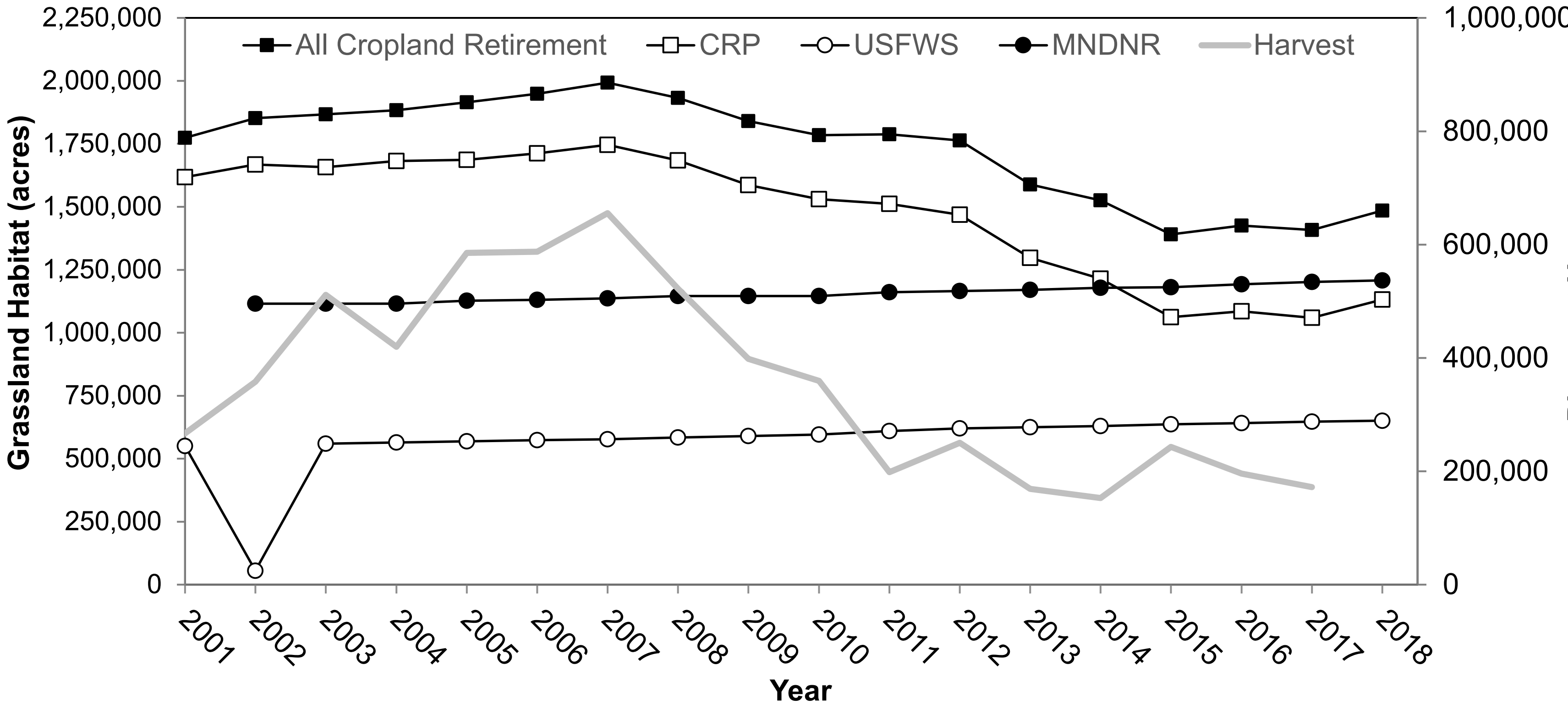


Figure 2. Acres enrolled in private (black lines with open and solid squares) and public (black lines with open and solid circles) land habitat conservation programs vs. ring-necked pheasant harvest trends (gray line with no markers) in Minnesota, 2001-2018. Acres represent STATEWIDE totals. All cropland retirement includes Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Reinvest in Minnesota (RIM), Wetlands Reserve Program (WRP), and RIM-WRP.

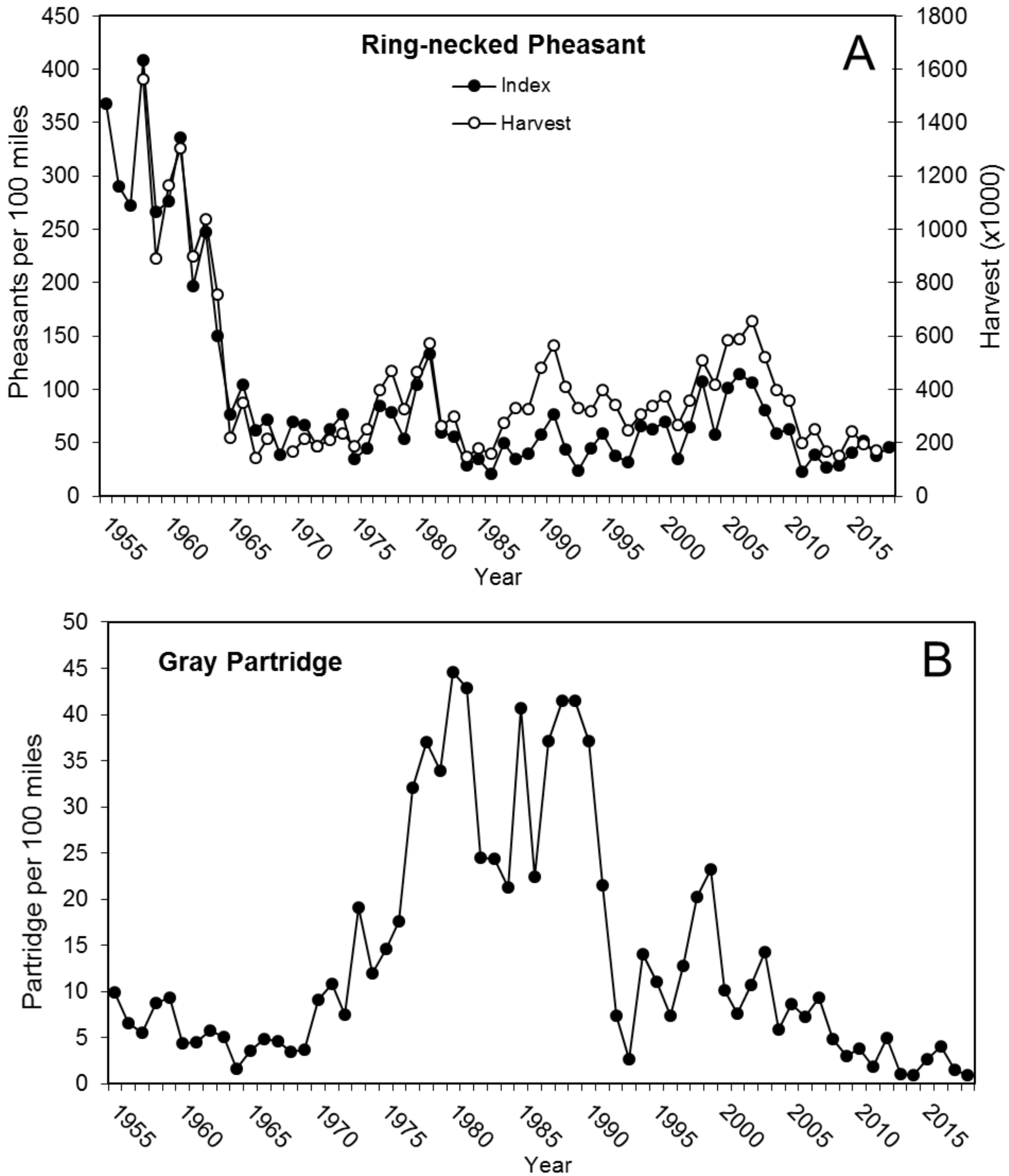


Figure 3. Range-wide index of ring-necked pheasants (A) and gray partridge (B) seen per 100 miles driven in Minnesota, 1955-2018. Does not include the Northwest region. Based on all survey routes completed.

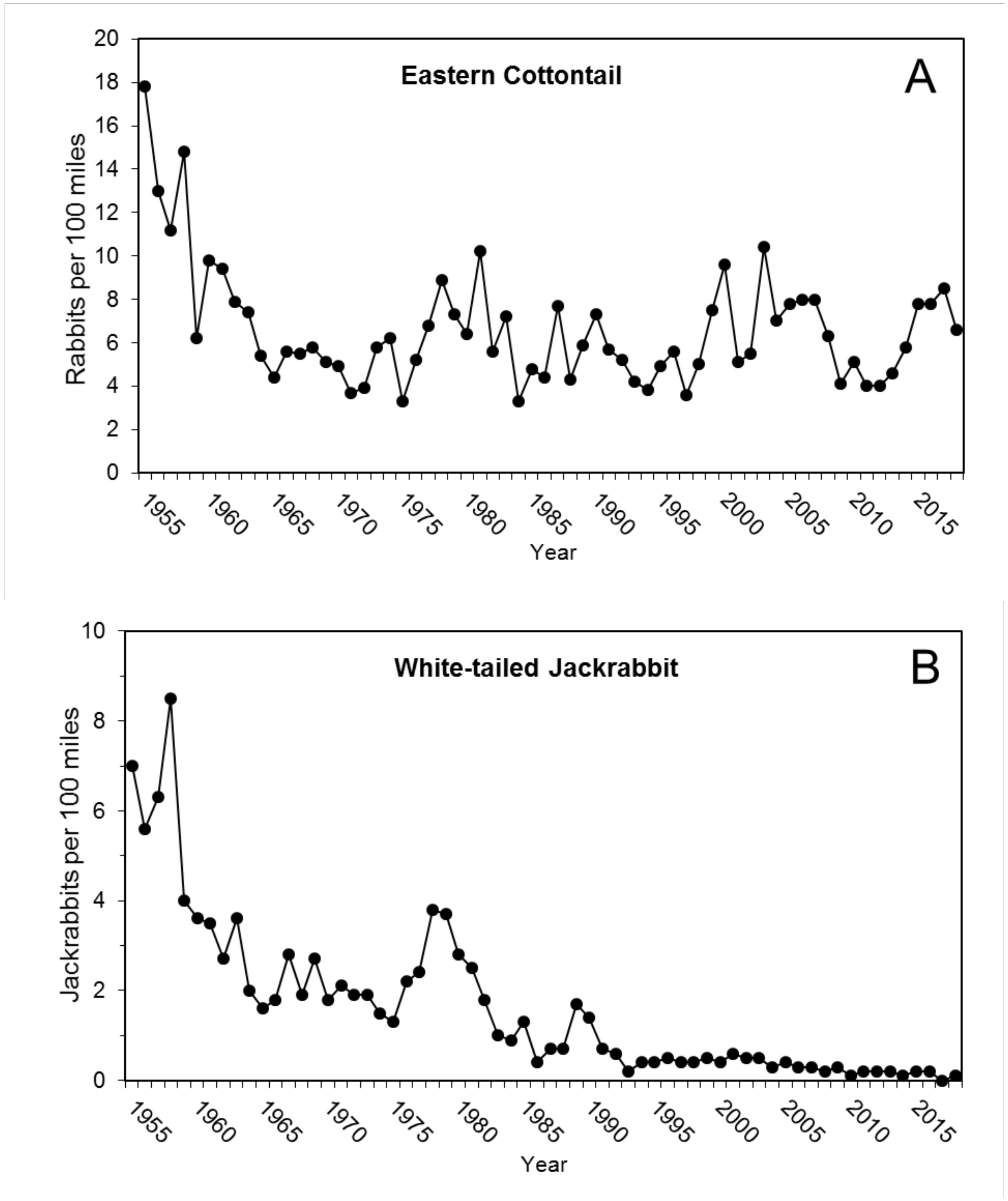
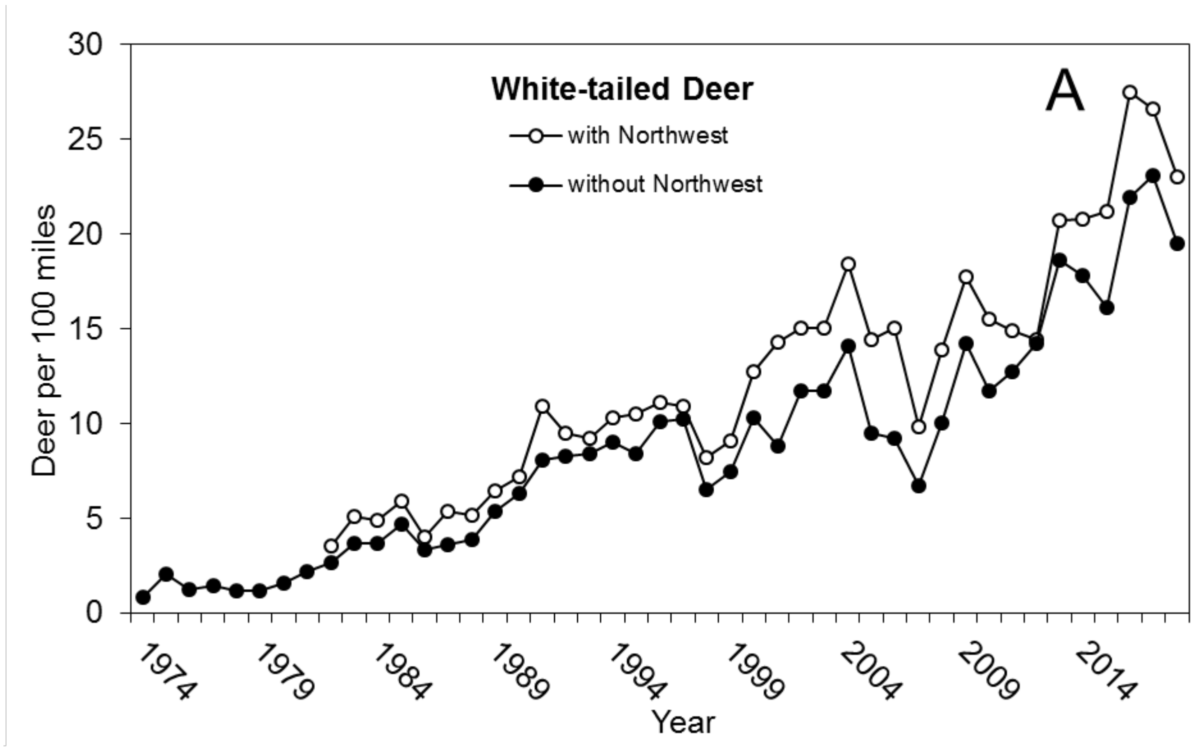


Figure 4. Range-wide index of eastern cottontail (A) and white-tailed jackrabbits (B) seen per 100 miles driven in Minnesota, 1955-2018. Does not include the Northwest region. Based on all survey routes completed.



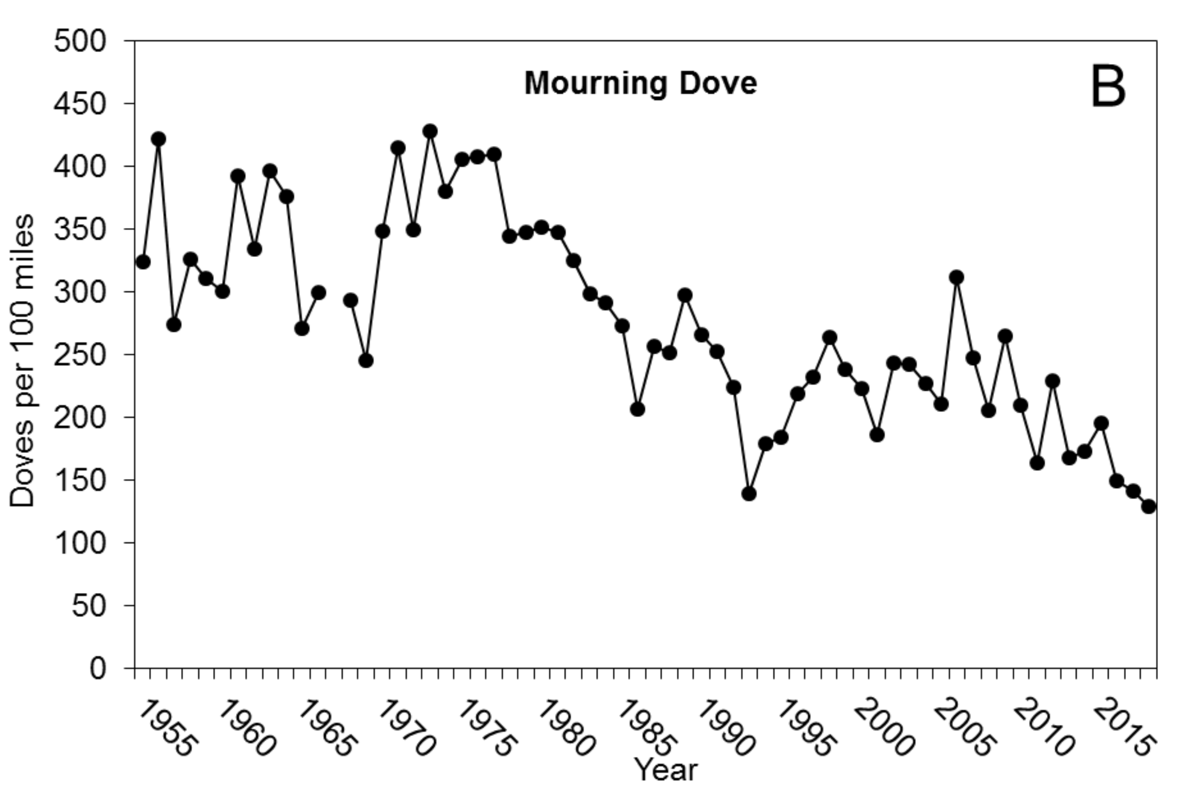


Figure 5. Range-wide index of: (A) white-tailed deer seen per 100 miles driven in Minnesota, 1974-2018, with and without the Northwest region included; and (B) mourning doves seen per 100 miles driven in Minnesota, 1955-2018. Doves were not counted in 1967 and the dove index does not include the Northwest region. Based on all survey routes completed.

DEPARTMENT OF NATURAL RESOURCES

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA - 2018

Andrew Norton, Farmland Wildlife Populations and Research Group

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. 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 imposed stochasticity by independently drawing random samples from the Normal or Uniform distribution (i.e., Monte Carlo method) for all parameters. We specified means and standard deviations to represent ranges of values for initial population proportions, fecundity, harvest recovery rates, and survival by sex- and age-classes of deer based on primary literature and studies within Minnesota. For all proportion or rate parameters (e.g., survival), we used the inverse logit transformation $\left(p = \frac{e^{\alpha}}{1+e^{\alpha}}\right)$ to constrain random values between 0 and 1.

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]). The remaining proportion (0.35) was allocated equally to young-of-year (YOY) males and females.

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 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). Fecundity rates were partitioned by 2 age-classes of breeding females (i.e., <1 year old [YOY] 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 (YOYs, mean = 0.06 [SD = 0.003]; adults, mean = 1.55 [SD = 0.078]), moderate in the farmland and transition zone (YOYs, mean = 0.08 [SD = 0.004]; adults, mean = 1.70 [SD = 0.085]), and greatest in the southeast (YOYs, mean = 0.15 [SD = 0.007]; adults, mean = 1.85 [SD = 0.092]). 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 uniformly 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.

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 (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). 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 0.70 (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 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 = 0.004], male = 0.98 [SD = 0.003]). 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

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 died during the hunting season because they were harvested illegally or not registered (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 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 a linear equation to calculate survival as a function of winter severity (mean winter survival = 1 − [0.011 + 0.0015 x WSI]) 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, 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 x WSI]) − 0.05). For more severe winters (100≤WSI≤240), the equation was adjusted to simulate increased mortality reported for fawns in field studies (mean winter survival = 1 − [0.0054 x WSI − 0.33]). When WSI exceeded 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 ≈ 0.012. 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 other vital rates in conjunction with varying initial population densities.

Because the initial population density is the primary parameter adjusted, similar population trends can be fit when the mean for parameters that are constant (with only random variation) among years (e.g., recovery rates, adult summer survival) is 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 most model simulations for 7 years (2012-2018) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring 2018). All simulations were performed with the R programming language (ver. 3.3.2, R Core Team 2017). We used 500 Monte Carlo simulations 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 104 of 130 DPAs in Minnesota to estimate deer densities before reproduction during spring 2018 (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 nearly all DPAs increased through 2017. Management designations in 2017 were liberalized in most DPAs compared to prior years in attempts 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 2018 will be required again to effectively manage deer populations in DPAs with average and above average productivity.

With the exception of northeastern Minnesota, the extended 2017-2018 winter had little effect on deer mortality and deer densities continued to increase across much of the state despite more liberal antlerless regulations in 2017. In terms of management intensity, the 2018 designations afford more antlerless deer harvest opportunities to hunters in approximately one third of the DPAs versus the 2017 season. For most of the remaining DPAs, designations in 2018 were the same as 2017, and only a few DPA designations afforded less antlerless harvest opportunity.

Farmland Zone

Of the 36 farmland zone DPAs, 10 were within 10% of goal, 12 were at least 10% below goal, and 14 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 = 25) were under a Lottery designation. Five of the DPAs required Hunter Choice and 6 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 45 transition zone DPAs with goals, 8 were within 10% of goal, 2 were at least 10% below goal, and 35 were at least 10% above goal based on modeling or buck harvest trends. For the 2018 season designations, Lottery will be used for 5 of the DPAs, Hunter Choice for 10 DPAs, and Managed for 16 DPAs. In 17 DPAs, Intensive designations will be necessary to continue reducing deer densities toward goal level, 3 of which (DPA 346, 348 and 349) have 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. Of the 44 forest zone DPAs, 16 were within 10% of goal, 9 were at least 10% below goal, and 19 were at least 10% above goal based on modeling or buck harvest trends. For 2018 season designations, Bucks-only will be used in 1 DPA, Lottery in 9 DPAs, Hunter Choice in 21 DPAs, Managed in 9 DPAs, and Intensive in 4 DPAs.

ABRIDGED DESCRIPTIONS OF DEER HUNTING SEASON DESIGNATIONS (MNDNR 2017)

Bucks-only Deer Areas – The bag limit is one legal buck total per year. Except residents of Minnesota State Veterans' Homes and hunters who are 84 or older, no antlerless deer may be harvested.

Lottery Deer Areas – The bag limit is one deer total per year. An either-sex permit is required to take an antlerless deer unless you have a youth deer license, are 84 or older or are a resident of a Minnesota State Veterans' Home.

Hunter Choice Deer Areas – The bag limit is one either-sex deer total per year.

Managed Deer Areas – The bag limit is two deer total per year, only one of which can be antlered.

Intensive Deer Areas – The bag limit is three deer total per year, only one of which can be antlered.

Unlimited Antlerless Deer Areas – There is no limit to the number of antlerless deer that may be taken.

Early or Late Antlerless Season – The bag limit is 5 additional antlerless deer during each season.

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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, 2012-2018.

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]						
		2012	2013	2014	2015	2016	2017	2018
101	496	7	7	6	7	8	9	10
103	1,820	4	4	3	3	4	4	5
105	740	12	12	9	9	11	12	13
108	1,651	7	7	5	5	6	7	8
110	529	18	16	11	11	14	15	17
111	1,438	3	3	2	3	3	4	4
114	116	-	-	-	-	-	-	-
117	927	-	-	-	-	-	-	-
118	1,220	6	6	4	4	4	5	5
119	770	8	7	4	4	5	6	7
126	942	5	5	3	3	3	3	3
130	746	5	5	3	3	4	4	4
131	899	-	-	-	-	-	-	-
132	482	8	8	5	5	6	6	7
133	352	14	13	7	7	9	10	10
152	61	-	-	-	-	-	-	-
155	593	17	16	13	14	17	19	20
156	825	16	16	10	11	13	15	16
157	673	21	21	21	21	24	27	28
159	571	18	19	14	15	18	21	24
169	1,124	13	13	8	9	11	13	14
171	701	11	11	9	10	12	13	14
172	687	20	20	16	19	21	24	25
173	584	11	11	8	7	9	10	12
176	921	13	12	8	8	10	12	13
177	480	18	17	11	11	14	15	16
178	1,195	13	12	8	8	10	12	13
179	862	21	21	13	13	16	18	18
181	629	14	14	8	9	11	13	15
182	267	-	-	-	-	-	-	-
183	663	14	15	9	10	13	15	17
184	1,229	22	20	15	16	18	20	22
197	955	14	13	9	10	12	14	16
199	148	-	-	-	-	-	-	-
201	161	9	9	7	8	9	9	10
203	118	-	-	-	-	-	-	-
208	379	5	5	4	5	6	7	7

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

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]						
		2012	2013	2014	2015	2016	2017	2018
209	640	8	9	7	7	8	9	9
210	615	12	11	8	9	10	11	12
213	1,057	14	15	15	15	17	19	21
214	554	24	25	23	23	24	26	26
215	701	17	18	17	17	19	20	22
218	884	9	10	10	10	11	13	14
219	391	11	12	12	12	13	15	17
221	642	14	15	13	13	15	17	19
222	413	18	18	15	15	17	20	22
223	376	13	15	14	14	16	17	19
224	47	-	-	-	-	-	-	-
225	618	19	20	17	17	20	22	24
227	472	18	19	17	17	19	20	22
229	284	8	9	9	10	11	13	14
230	452	-	-	-	-	-	-	-
232	377	4	5	5	5	6	7	7
233	385	4	4	4	5	5	6	6
234	636	2	2	2	2	3	3	3
235	34	-	-	-	-	-	-	-
236	370	16	17	15	16	17	19	21
237	728	-	-	-	-	-	-	-
238	95	-	-	-	-	-	-	-
239	919	13	12	11	11	12	12	13
240	643	20	21	20	19	22	23	25
241	996	29	30	25	25	26	27	27
242	214	26	26	22	23	27	30	31
246	840	18	17	14	16	18	20	21
247	228	22	22	19	20	22	24	25
248	214	21	21	18	17	19	21	22
249	502	18	19	17	16	18	21	23
250	713	-	-	-	-	-	-	-
251	55	-	-	-	-	-	-	-
252	715	-	-	-	-	-	-	-
253	974	-	-	-	-	-	-	-
254	929	4	4	4	4	4	4	5
255	774	4	4	4	5	5	6	7
256	654	7	7	6	7	8	8	9
257	412	8	9	8	8	9	10	11
258	343	21	20	17	18	20	22	24
259	490	23	20	16	17	20	22	22

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

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]						
		2012	2013	2014	2015	2016	2017	2018
260	1,249	3	3	3	4	4	5	6
261	795	2	2	2	3	3	4	4
262	677	2	3	3	3	3	4	5
263	512	7	8	6	7	9	9	10
264	669	10	10	9	10	10	11	12
265	494	8	9	8	9	10	11	11
266	617	5	5	5	5	6	7	8
267	472	5	5	4	5	6	6	7
268	228	10	10	9	10	11	11	11
269	650	2	3	3	3	3	4	5
270	748	-	-	-	-	-	-	-
271	632	-	2	2	3	3	3	4
272	531	-	-	-	-	-	-	-
273	571	5	6	6	6	7	8	9
274	354	5	5	5	5	5	6	7
275	764	3	3	3	3	3	4	4
276	542	7	8	8	9	10	12	13
277	812	11	12	12	13	14	15	17
278	402	6	6	6	6	7	8	9
279	344	4	4	4	4	4	4	4
280	675	3	2	2	2	3	3	3
281	575	5	5	6	7	8	9	10
282	778	-	-	-	-	-	-	-
283	613	-	-	-	-	-	-	-
284	838	-	-	-	-	-	-	-
285	549	5	5	6	6	7	8	10
286	446	5	5	5	5	5	6	7
287	46	-	-	-	-	-	-	-
288	625	5	5	5	5	5	5	6
289	815	2	2	2	2	2	3	3
290	662	4	5	5	5	6	7	7
291	800	6	6	6	7	7	8	9
292	479	8	9	9	10	12	13	15
293	511	8	9	8	9	10	11	12
294	686	4	4	4	4	4	4	5
295	839	4	4	4	4	4	5	6
296	667	3	3	3	3	4	4	5
297	438	3	3	3	3	3	4	5
298	618	10	9	9	10	12	14	16
299	386	5	5	5	5	6	6	7

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

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]						
		2012	2013	2014	2015	2016	2017	2018
338	454	5	5	6	6	7	8	10
339	394	6	6	6	7	7	8	10
341	612	13	13	13	14	14	15	16
342	349	14	14	14	15	15	16	17
343	663	13	13	13	13	13	13	14
344	190	19	19	18	17	16	16	17
345	323	12	13	13	14	14	15	16
346	318	27	29	30	29	28	28	29
347	434	-	-	-	-	-	-	-
348	332	-	-	-	-	-	-	-
349	490	23	25	26	27	26	27	28
601	1,625	-	-	-	-	-	-	-
603	364	-	-	-	-	-	-	-

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

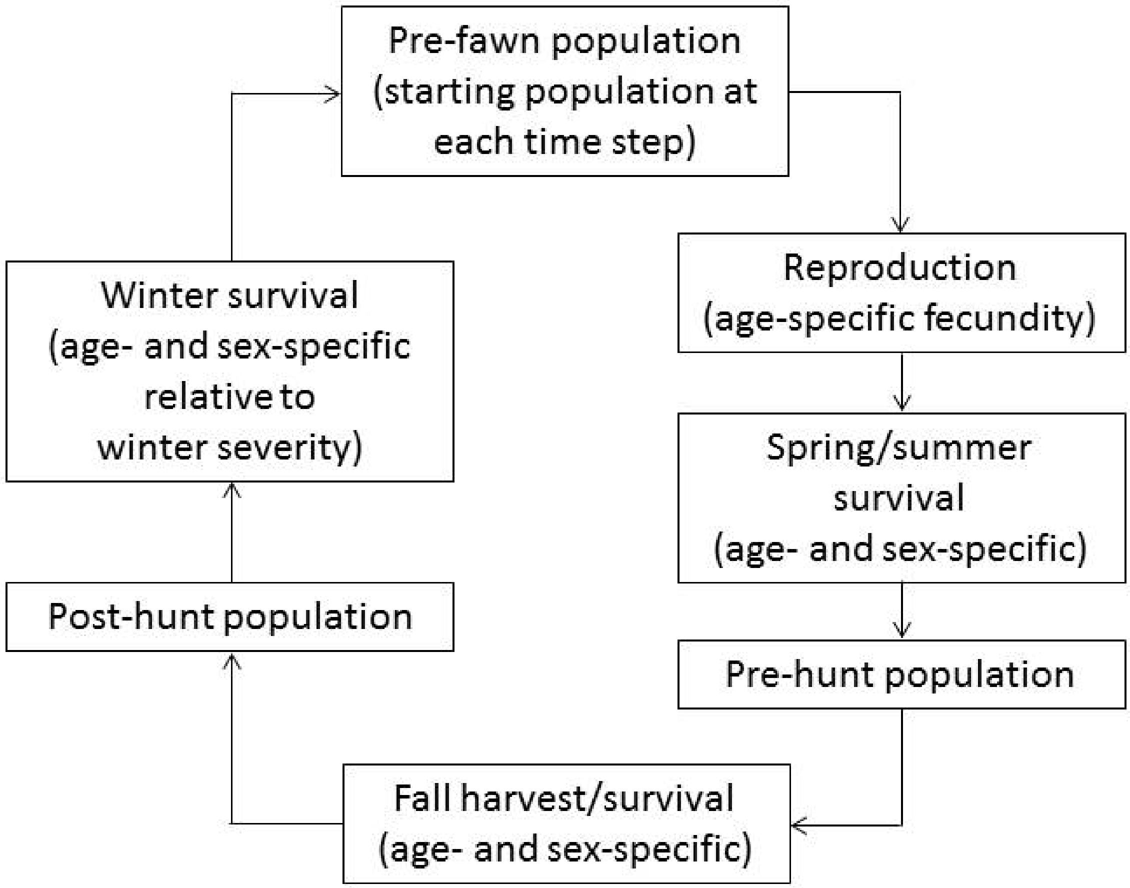

Figure 1. Model structure for simulations of white-tailed deer populations in Minnesota.

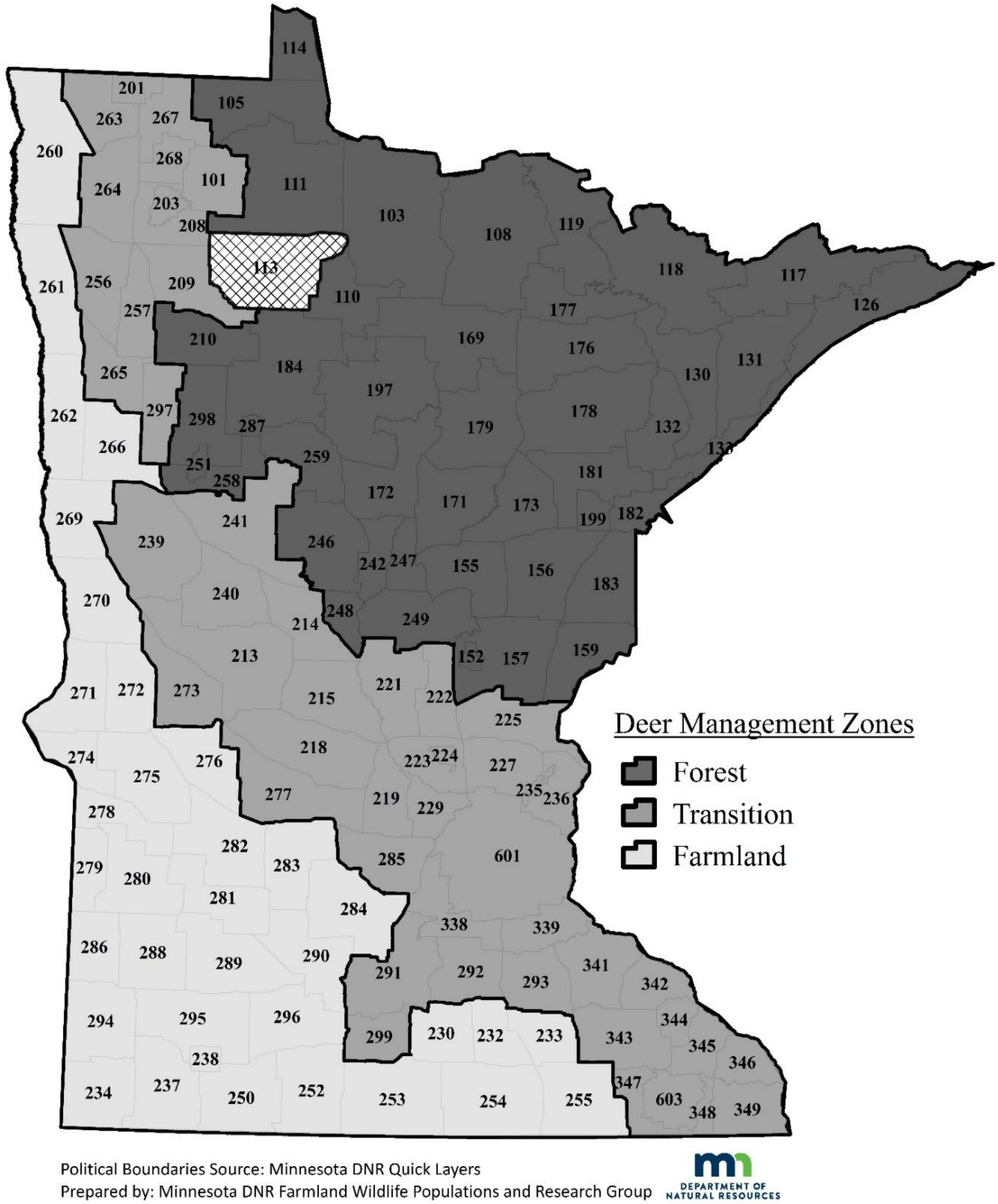

Figure 2. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2018. DPAs were assigned to forest, transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of ≥60% woody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

2018 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 111 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 2018). 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

We estimated deer populations in selected 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, quadrats were delineated by Public Land Survey (PLS) section (640 ac) boundaries. In PAs with woody cover distributed uniformly across the landscape, we used a simple random sampling frame. In PAs with abundant woody cover and past survey data, we used regression trees (Fabrizi and Trivisano 2007, Fieberg and Lenarz 2012), the R programming language (R Core Team 2017), and R package 'stratification' (Baillargeon and Rivest 2017) 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. Woody cover data were derived from the 2006 National Land Cover database (Fry et al. 2011). We used optimal allocation, R package 'spsurvey' (Kincaid and Olsen 2017), and a generalized random tessellation stratified procedure (GRTS; Stevens and Olsen 2004) to draw spatially balanced simple or stratified random samples within each PA.

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, 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 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., 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 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.

We computed population estimates adjusted for both sampling and sightability. We used the R package ‘spsurvey’ (Kincaid and Olsen 2017) 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 2017) 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. 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 5 surveys during 2017 (Figure 1). We utilized a simple random sample in PA 241, whereas PAs 214, 221, 223, and 224 were stratified using the relationship between woody cover abundance per quadrat and historic deer density. Mean deer density estimates ranged from 13-26 deer/quadrat throughout all PAs and, except for PA 224, all estimates met precision goals (relative error ≤ 20%; Table 1). Deer were observed in 64-86% of sample quadrats in the 5 surveyed areas, with greater occupancy occurring in PAs 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 0.646 (SE = 0.023) in PA 221 to 0.807 (SE = 0.017) in PA 214 and averaged 0.714 (SE = 0.076), which were similar to sightability estimates during 2010-2017 (range = 0.633-0.909; mean = 0.743). Correcting for sightability increased relative variance (CV [%]) of population estimates by 2.8-9.8%, 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. Deer population and density (deer/quadrat) estimates derived from aerial surveys in Minnesota, 2018.

Permit area	Sampling rate (%)	Sightability rate	Population estimate		CV (%)	Relative error (%)[a]	Density estimate	
			N	90% CI			Mean	90% CI
214	19	0.807	12,636	11,371 – 13,901	6.1	10.0	23	21 – 25
221	20	0.646	8,094	6,902 – 9,286	9.0	14.8	13	11 – 15
223	20	0.669	6,486	5,386 – 7,586	10.3	16.9	16	13 – 19
224	20	0.669[b]	1,468	1,027 – 1,909	18.3	30.1	14	10 – 19
241	20	0.735	26,832	24,500 – 29,164	5.3	8.7	26	24 – 28

[a]Relative precision of population estimate. Calculated as 90% CI bound/*N*.
[b]Estimate derived from permit area 223.

Table 2. Sampling metrics from aerial deer surveys in Minnesota, 2018.

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
						Mean	Range	Mean	Range	
214	548	106	91	2,135	456	5	1 – 14	5	1 – 34	84
221	620	124	79	1,465	358	5	1 – 12	4	1 – 30	68
223	405	81	55	1,061	232	4	1 – 15	5	1 – 28	74
224	103	21	17	200	53	3	1 – 8	4	1 – 13	41
241	1,024	205	177	3,947	972	5	1 – 24	4	1 – 51	107

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

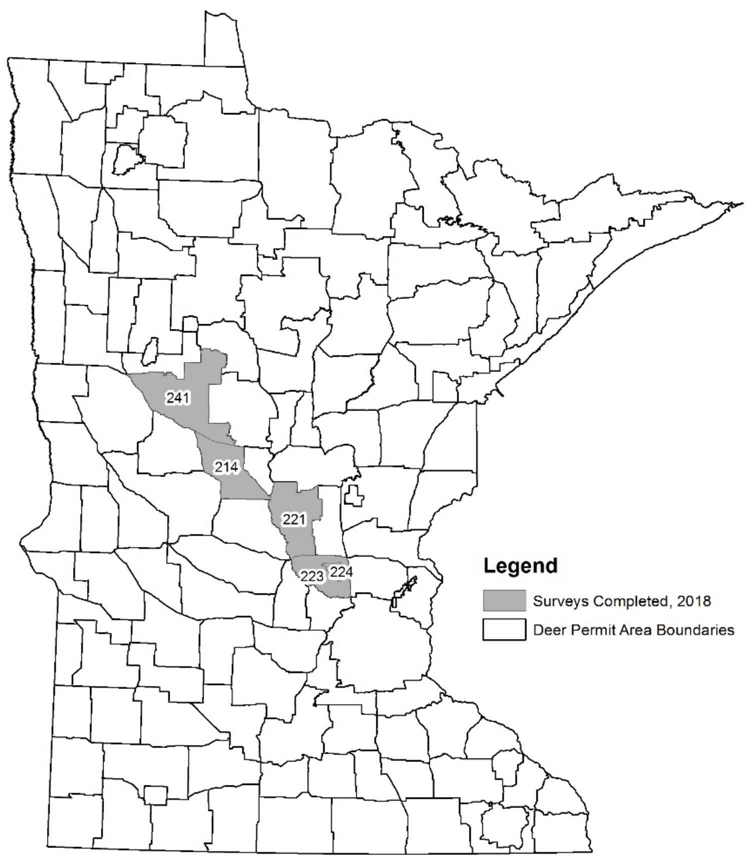

Figure 1. Aerial deer survey areas flown during winter 2018 in central Minnesota.