FARMLAND WILDLIFE POPULATIONS

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2020 MINNESOTA AUGUST ROADSIDE SURVEY

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SUMMARY OF FINDINGS

INTRODUCTION

Since 1955, the Minnesota Department of Natural Resources (MN DNR) wildlife and enforcement personnel have conducted the annual August Roadside Survey (ARS) during the first two weeks of August throughout Minnesota's farmland regions (Figure 1). Initially developed to provide indices of common upland game species (ring-necked pheasant, grey (Hungarian) partridge, eastern cotton-tail rabbits, white-tailed jackrabbits, and mourning doves, the survey now formally indexes white-tailed deer and sandhill cranes. The current ARS includes 172 survey routes in 70 counties throughout Minnesota. The results of the annual survey are made publicly available in the annual August Roadside Survey report (e.g. Lyons 2020).

OBJECTIVES

1. Index game birds and other wildlife within the historic "pheasant range" of Minnesota.
2. Analyze results provide public information about population trends of focal species.
3. Summarize weather and habitat conditions that may impact population trends of pheasants or other focal species

METHODS

Survey protocol

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, and sandhill cranes they observed including information on sex and age of these species. Surveys are only performed on mornings with dew, cloud cover less than 60%, and wind speeds under 10mph. 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 and range-wide; however, population indices for species with low detection rates (e.g., white-tailed jackrabbits) are imprecise and unreliable.

Observers recorded the number of male (rooster), female (hen), and juvenile pheasants, whether the females were present with a brood, and the estimated age of the chicks in the brood. The same measurements were recorded for gray partridge, but adult birds were not sexed because they are not sexually dimorphic. Age and sex were recorded for both white-tailed deer and sandhill cranes when observed. Observers only reported a total count (no sex or age information) for mourning doves and rabbits.

Habitat data collection

We queried the MNDNR GIS database files of Wildlife Management Areas and summed the total area of parcels by county to obtain an estimate of protected habitat. Due to difficulties in classifying vegetation types from remotely-sensed data products, this estimate includes areas that are unsuitable upland habitat (i.e. closed-canopy forest). Aquatic Management Areas and State Parks were not included in this tally as we assume they do not make a meaningful contribution to upland habitat within the state. We obtained information on additional public lands, primarily National Wildlife Refuges and Waterfowl Production Areas from the U.S. Fish and Wildlife Service. Finally, we obtained estimates of potential upland habitat on private lands from the Minnesota Board of Water and Soil Resources. These lands were enrolled in state or federal programs that retire cropland temporarily (e.g. Conservation Reserve Program) or permanently (e.g. Conservation Reserve Enhancement Program, Reinvest in Minnesota, etc.).

Weather data collection

We obtained precipitation and temperature data summaries from the Midwest Regional Climate Center ([MRCC]; 2020) for each of the agricultural regions covered by the ARS. We used weekly maps of interpolated snow depth, provided by the Minnesota State Climatology Office, to compute the mean snow depth for the winter season (December 1 through March 31) in each agricultural region.

Analysis

We computed averages and annual change 10-yr, and long-term (since 1955) trend statistics for each of the focal species. We computed statistics at the state and regional scale, though results from regional analyses are more heavily biased due to the smaller sample sizes. In the analysis, we treated each year and route combination as an independent sample when computing annual change and trend statistics. Thus, the average proportional change for the state or region is the mean of proportional changes at the route level. Confidence intervals were calculated using critical values from Students T-distribution.

We calculated additional statics for pheasants, including the mean estimated hatch date and proportion of hens with a brood. We estimated the mean hatch date back calculating the hatch date for each brood based on its estimated age during the survey. We used the proportion of hens with broods as an index of breeding success among hens.

RESULTS

Habitat Conditions

Habitat on private lands increased by almost 16,000 acres in 2020. The availability of a general Conservation Reserve Program (CRP) sign-up led to a 10,000 acre net increase in CRP acres state wide. Reinvest in Minnesota (RIM), Wetland Reserve Program (WRP), and RIM-WRP all saw modest increases in the total number of acres, while the Conservation Reserve Enhancement Program (CREP) experienced a net decrease in habitat acres. Publicly owned habitat also increased in 2020. Federally-managed U.S. Fish and Wildlife Service (USFWS) Waterfowl Production Areas (WPA), wildlife refuges, and conservation easements increased by almost 20,000 acres. Beginning in 2020, a new data source was used to track habitat managed by MN DNR as Wildlife Management Areas (WMA). Therefore, no comparisons or estimates of habitat change are provided for MN DNR-managed property this year. Protected habitat accounts for 6.1% of the landscape within the pheasant range (range by agricultural regions: 3.4-9.8%; Table 1).

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 2020, features more than 250 sites totaling nearly 30,000 acres across 47 counties in the farmland regions 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, 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 on the WIA program website. The WIA program is primarily funded through a grant from the Natural Resources Conservation Service of the U.S. Department of Agriculture. Other funding sources include a surcharge on nonresident hunting licenses, a one-time appropriation from the Minnesota Legislature in 2012, and donations from hunters.

Weather Summary

Overall, the weather conditions for pheasants were favorable in 2020. Winter conditions were milder, with above average temperatures and shallower snowpack compared to 2019 (Table 2). Though spring temperatures were below the 30-year (1981-2010) averages, precipitation was also below average (Table 2). Summer temperatures were above and precipitation was generally near their respective 30-year averages (Table 2). The absence of spring snow storms and generally drier conditions throughout the breeding season enabled game bird populations to rebound from 2019. Weather data were obtained from the Midwest Regional Climate Center ([MRCC]; 2020).

Survey Conditions

Weather conditions during surveys were generally excellent. Surveyors reported heavier dew conditions, clearer skies, less wind, and cooler temperature than previous years. Collectively, detection of pheasants and their broods was higher than average in 2020.

Species Reports

Ring-necked Pheasant

The pheasant index increased 42% in 2020 (53.5 birds/100mi) compared to 2019 (37.6 birds/100mi; Table 3, Figure 2A). Although pheasant counts increased across all sex and age categories from 2019, the increase in the number of broods seen (+47%) was the primary driver of the overall increase in the index (Table 3). The 2020 roadside counts of pheasants within all sex and age categories also exceeded the 10-year averages (range: +21%, +37%; Table 3). The number of broods seen in 2020 also exceeded the 10-year average (+35%; Table 3), though the 10-year average now excludes recent peaks in pheasant abundance during the mid-late 2000s. Still, counts of pheasants among all classes remained below the long-term average (range: -33%, -44%; Table 3, Figure 2A). The ratio of broods per 100 hens, an indicator of breeding success, was greater than 2019 (+25%), the 10-year average (+6%) and the long-term average (+20%; Table 3). The number of chicks per brood also increased compared to 2019 (+6%) but remained below the long-term average (-15%; Table 3). Generally, this suggests that while pheasant numbers overall have declined in the long-term, breeding success of females has increased.

Annual changes in roadside counts among regions generally mirrored statewide trends. Pheasant numbers increased in most regions (range: +9%, +146%) with the greatest increase occurring in the Southwest region (+146%; Table 4). The boom in pheasant counts also resulted in 2020 indices being at or near the 10-year average (range: +35%, +57%), though the East Central and Southeast regions remained below their 10-year averages (-17% and -9%, respectively; Table 4). Hunting opportunities should be excellent throughout the farmland region in 2020.

Gray Partridge

The 2020 range-wide gray partridge index (3.7 birds/100mi) was greater than 2019 (+52%) and the 10-year average (+60%) but remained below the long-term average (-72%; Table 3, Figure 2B). Although the partridge index remained below the long-term averages in all regions, annual changes varied considerably among regions (Table 4). Gray partridge numbers increased in the Southeast (where no partridge were reported in 2019) and South Central regions (+30%), but were greatest in the Southwest region (+649%; Table 4). Gray partridge thrive in more arid grasslands, similar to their native range. Thus, the increase in the partridge index may be attributable to a drier than average breeding season across much of the farmland region. The Southwest, South Central, and Southeast regions will offer the best opportunities for harvesting gray partridge in 2020 (Table 4).

Cottontail Rabbit and White-tailed Jackrabbit

The 2020 eastern cottontail rabbit index (4.7 rabbits/100mi) decreased from 2019 (-23%) and remains below the 10-year average (-15%) and the long-term average (-22%; Table 3, Figure 3A). Most regions reported declines in the cottontail index (range: -16%, -42%; Table 4). Only the Southwest region reported an increase in 2020 (+225%; Table 4). The best rabbit hunting opportunities will be in the East Central and Southeast regions, though hunters may also find good opportunities in the Central and Southwest Regions.

Single white-tailed jackrabbits were recorded on three survey routes in the West Central and Southwest regions in 2020 (Table 3) yielding a range-wide index of 0.1/100 mi. Although similar to 2019 when two jackrabbits were reported, the index remains >90% below the long-term average of 1.5 rabbits/100 mi (Table 3, Figure 3B). 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 (e.g., pasture, hayfields, and small grains).

White-tailed Deer

The 2020 white-tailed deer index (30.0 deer/100 mi) fell slightly (-8%) from 2019 (32.6 deer/100 mi) but remained above the 10-year average (+42%) and the long-term average (+150%; Table 3, Figure 4A). Regional indices for deer declined in the West Central, East Central, Southwest regions (range: -17%, -28%) but remained relatively constant in the Northwest, Southeast, and South Central regions (Table 4). Only the Central region reported an increase in the deer index (Table 4).

Mourning Dove

The 2020 range-wide mourning dove index (110.6 doves/100 mi) increased (+21%) compared to 2019, but remained below the 10-year (-31%) and long-term averages (-56%; Table 3, Figure 4B). The dove index increased across the majority of regions (range: +16%, +34%) compared to 2019, but stayed relatively constant in the East Central region (Table 4). The best opportunities for harvesting doves should be in the Southwest, South Central, and West Central regions.

Sandhill Crane

The 2020 roadside index of sandhill cranes (13.6 total cranes/100mi) decreased (-16%) from 2019 (Table 3). The decrease from 2019 was greater among juvenile cranes (-30%). The total crane index remains above the 10-year average (+14%), while the juvenile index is slightly below (-3%). Though the West Central, South Central, and Southeast regions reported either minor increases or no real change in the index value, the crane index is generally low in these regions (Table 4). The majority of cranes are reported in the Northwest, East Central and Central regions which exhibited either no change or a decline in 2020 (range: -48%, 1.8%;

Table 4). Still, most regional crane indices remain at or above the 10-year average, though the Northwest and East Central regions are now below. Cranes have not yet been reported in roadside counts in the Southwest region.

Other Species

Notable incidental sightings recorded by observers included: Great Egrets (Rice and Watonwan counties), prairie chickens (Clay County), red-headed woodpeckers (Mower, Redwood, Renville, and Watonwan counties), sharp-tailed grouse (Red Lake, Roseau, and Polk counties), trumpeter swans (Kandiyohi and Sibley counties), and upland sandpipers (Murray, Freeborn, and Renville counties). American crows, Canada geese, American kestrels, and wild turkeys were reported in multiple counties.

ACKNOWLEDGMENTS

We thank the many cooperators for completing the routes required for this survey; without their efforts, this survey would not be possible. Tonya Klinkner was invaluable in providing logistical assistance and entering route data. Jason Beckler (Minnesota Board of Water and Soil Resources) provided enrollment data on cropland retirement programs in Minnesota. Allison McCluskey (U.S. Fish and Wildlife Service) provided federal land acquisition data. Nicole Davros, John Giudice, and Margaret Dexter (MN DNR) reviewed an earlier draft of this report. This work was funded in part through the Federal Aid in Wildlife Restoration Act.

LITERATURE CITED

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Table 1. Abundance (total acres) and density (acres/mi²) 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/mi²
WC	290,586	37,951	24,808	18,092	20,840	208,979	120,623	721,878	9.8	62.8
SW	114,563	24,784	20,573	2,553	766	24,954	65,858	254,050	6.7	13.1
C	132,684	14,380	39,966	7,026	3,078	92,508	58,407	348,049	5.4	34.9
SC	102,436	27,633	13,585	10,775	8,942	11,272	36,046	210,689	5.2	33.4
SE	69,820	2,702	7,405	1,070	976	37,028	56,067	175,068	4.7	30.2
EC	3,248	0	7,943	0	4	19,692	168,839	199,726	3.4	21.7
Total	713,337	107,450	114,280	39,516	34,606	394,433	505,840	1,909,460	6.1	39.2

[a] Unpublished data, Tabor Hoek, BWSR, 25 August 2020.

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

[c] MN DNR Wildlife Management Areas (WMA). The data source for this field was changed in 2020 and comparisons to previous years are not valid.

Table 2. Average temperature, snow depth, and precipitation by season and agricultural region in Minnesota, 2020.

	Agricultural Region							
	NW	WC	C	EC	SW	SC	SE	STATE
Winter (December 1 - March 31)								
Temperature (average °F)	14.4	19.6	20.9	20.4	22.8	23.6	23.6	20.8
Departure from normal (°F)[a]	0.7	1.8	2.1	2.5	1.9	2.4	2.4	2
Snow Depth (average inches)	12.9	8.5	6.9	8	4.4	5.1	4.7	7.2
Spring (April 1 - May 31)								
Temperature (average °F)	44.6	47.8	49	47	48.8	50	50	48.2
Departure from normal (°F)[a]	-3.5	-2.8	-1.9	-2.1	-2.9	-2.2	-2.2	-2.5
Precipitation (total inches)	1.3	1.4	1.6	1.6	2.3	2.9	3.5	2.1
Departure from normal (inches)[a]	-0.8	-1.2	-1.3	-1.3	-0.9	-0.6	-0.2	-0.9
Summer (June 1 - July 31)								
Temperature (average °F)	69.6	71.8	71.4	69.6	73	72.8	72.8	71.6
Departure from normal (°F)	3.6	3.4	2.8	2.9	3.5	2.9	2.9	3.1
Precipitation (total inches)	5.7	4.2	4.7	4.7	3.7	4.4	4.7	4.6
Departure from normal (inches)[a]	1.9	0.4	0.5	0.5	-0.3	0	0.2	0.5

[a] Departures calculated using 30-year NOAA average (1981-2010) over respective time period.

Table 3. Range-wide trends (% change) in number of wildlife observed per 100 miles driven, Minnesota August roadside survey, 1955-2020.

Species	Change from 2019[a]					Change from 10-year average[b]				Change from long-term average (LTA)[c]			
Subgroup	*n*	2019	2020	%	95% CI	*n*	2010-2019	%	95% CI	*n*	LTA	%	95% CI
Ring-necked pheasant													
Total pheasants	153	37.6	53.5	42	±25	149	38.9	37	±20	151	91.4	-42	±10
Cocks	153	6.5	6.9	7	±21	149	5.7	21	±22	151	10.5	-35	±13
Hens	153	6.3	7.5	18	±23	149	5.9	28	±19	151	13.3	-44	±10
Broods	153	5.5	8.1	47	±28	149	6.1	35	±19	151	12.1	-33	±11
Broods per 100 hens	153	84.3	105.2	25			101.5	6			88.4	21	
Chicks per brood[d]	301	4.6	5.0	7			4.6	6			5.7	-15	
Median hatch date[d]	301	20-Jun	8-Jun				12-Jun						
Gray partridge	169	2.4	3.7	52	±82	165	2.3	60	±84	151	13.6	-72	±16
Eastern cottontail	169	6.1	4.7	-23	±32	165	5.7	-15	±34	151	6.6	-22	±30
White-tailed jackrabbit	169	0	0.1	50	±4171	165	0.1	-35	±1756	151	1.5	-95	±129
White-tailed deer	169	32.6	30.0	-8	±6.	165	21.2	42	±9	167	11.9	150	±17
Mourning dove	169	91.3	110.6	21	±2	165	159.7	-31	±1	151	255.1	-56	±1
Sandhill crane[e]													
Total cranes	169	16.2	13.6	-16	±12	165	12.2	14	±16				
Juveniles	169	2.5	1.7	-30	±80	165	1.8	-3	±108				

[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 1955-2019, except for deer (1974-2019). 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, 1955-2020.

Region	**Change from 2019**[a]					**Change from 10-year average**[b]				**Change from long-term average (LTA)**[c]			
Species	*n*	2019	2020	%	95% CI	*n*	2010-2019	%	95% CI	*n*	LTA	%	95% CI
Northwest[d]													
Gray partridge	16	2.5	2.5	0	±85	16	1.0	145	±209	16	3.2	-23	±66
Eastern cottontail	16	1.5	1.2	-17	±142	16	0.9	32	±225	16	1.0	21	±207
White-tailed jackrabbit	16	0	0			16	0.1	-100	±1426	16	0.5	-100	±416
White-tailed deer	16	61.5	61.0	-1	±4	16	47.7	28	±5	16	34.2	78	±6
Mourning dove	16	69.1	80.0	16	±3	16	94.8	-16	±2	16	116.9	-32	±2
Sandhill crane[e]	16	29.2	29.7	2	±7	16	39.7	-25	±5				
West Central[f]													
Ring-necked pheasant	39	48.8	63.3	30	±4	35	45.4	40	±5	37	93.2	-36	±2
Gray partridge	39	1.3	0.2	-85	±152	35	0.5	-54	±413	37	8.6	-98	±24
Eastern cottontail	39	3.8	2.4	-38	±53	35	2.5	7	±83	37	3.8	-35	±53
White-tailed jackrabbit	39	0.2	0.1	-50	±987	35	0.2	-25	±1334	37	2.0	-95	±100
White-tailed deer	39	43.9	36.5	-17	±5	35	24.5	52	±8	37	12.4	193	±16
Mourning dove	39	122.6	144.3	18	±2	35	205.4	-31	±1	37	349.8	-60	±1
Sandhill crane[e]	39	2.3	6.7	186	±87	35	2.1	253	±96				
Central													
Ring-necked pheasant	30	39.8	55.4	39	±5	30	35.2	57	±6	30	67.9	-18	±3
Gray partridge	30	4.0	2.8	-30	±51	30	1.3	108	±152	30	8.3	-66	±25
Eastern cottontail	30	9.1	5.5	-40	±23	30	5.2	6	±40	30	6.2	-12	±33
White-tailed jackrabbit	30	0	0			30	0.1			30	1.1	-100	±188
White-tailed deer	30	31.5	35.1	11	±7	30	18.7	88	±11	30	8.1	336	±25
Mourning dove	30	78.2	95.8	23	±3	30	143.1	-33	±1	30	216.8	-56	±1
Sandhill crane[e]	30	28.7	26.9	-6	±7	30	20.5	31	±10				
East Central													
Ring-necked pheasant	13	29.3	32	9	±7	13	38.7	-17	±6	13	80.8	-60	±3
Gray partridge	13	0	0			13	0.2			13	0.2	-100	±1423
Eastern cottontail	13	13.2	7.7	-42	±17	13	13.1	-41	±17	13	9.2	-17	±24
White-tailed jackrabbit	13	0	0			13	0			13	0.1	-100	±1493
White-tailed deer	13	41.8	30.7	-27	±5	13	24.2	27	±9	13	11.9	158	±18
Mourning dove	13	49.8	49.5	-1	±4	13	75.2	-34	±3	13	111.6	-56	±2
Sandhill crane[e]	13	89.5	47	-48	±2	13	48.6	-3	±5				

Table 4. Continued.

Region	**Change from 2019**[a]					**Change from 10-year average**[b]				**Change from long-term average (LTA)**[c]			
Species	*n*	2019	2020	%	95% CI	*n*	2009-2019	%	95% CI	*n*	LTA	%	95% CI
Southwest													
Ring-necked pheasant	19	36.8	90.5	146	±6	19	60.4	50	±4	19	110.1	-18	±2
Gray partridge	19	1.3	9.5	649	±166	19	4.8	99	±44	19	36.5	-74	±6
Eastern cottontail	19	1.7	5.5	225	±125	19	5.1	7	±41	19	7.7	-29	±27
White-tailed jackrabbit	19	0	0.4			19	0.3	33	±665	19	3.4	-88	±63
White-tailed deer	19	21.7	15.6	-28	±10	19	20.2	-23	±10	19	10.7	45	±20
Mourning dove	19	92.0	123.6	34	±2	19	212.4	-42	±1	19	297.1	-58	±1
Sandhill crane[e]	19	0	0			19	0						
South Central													
Ring-necked pheasant	32	43.7	52.6	21	±5	32	38.9	35	±5	32	118.2	-56	±2
Gray partridge	32	5.4	7	30	±38	32	4.6	51	±44	32	16.9	-59	±12
Eastern cottontail	32	5.4	4.5	-16	±38	32	7.4	-39	±28	32	7.6	-41	±27
White-tailed jackrabbit	32	0	0			32	0.1	-100	±2053	32	1.5	-100	±135
White-tailed deer	32	14.6	14.1	-3	±14	32	7.8	82	±26	32	4.6	209	±45
Mourning dove	32	114.0	138.5	22	±2	32	199.7	-31	±1	32	247.0	-44	±1
Sandhill crane[e]	32	4.4	4.1	-6	±47	32	1.8	129	±113				
Southeast													
Ring-necked pheasant	20	8.7	11.8	37	±24	20	13.0	-9	±16	20	64.9	-82	±3
Gray partridge	20	0	4.2			20	3.6	18	±59	20	12.4	-66	±17
Eastern cottontail	20	10.8	8.8	-18	±19	20	9.3	-5	±23	20	8.0	10	±26
White-tailed jackrabbit	20	0	0			20	0	0		20	0.5	-100	±409
White-tailed deer	20	22.0	23.4	6	±10	20	18.3	28	±12	20	12.1	94	±17
Mourning dove	20	58.0	74.5	29	±4	20	97.3	-23	±2	20	203.7	-63	±1
Sandhill crane[e]	20	0.6	0.8	33	±349	20	0.3	136	±618				

[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 1955-2019, except for Northwest region (1982-2019) and white-tailed deer (1974-2019). Estimates based on routes (*n*) surveyed ≥40 years (1955-2019), 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] 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.

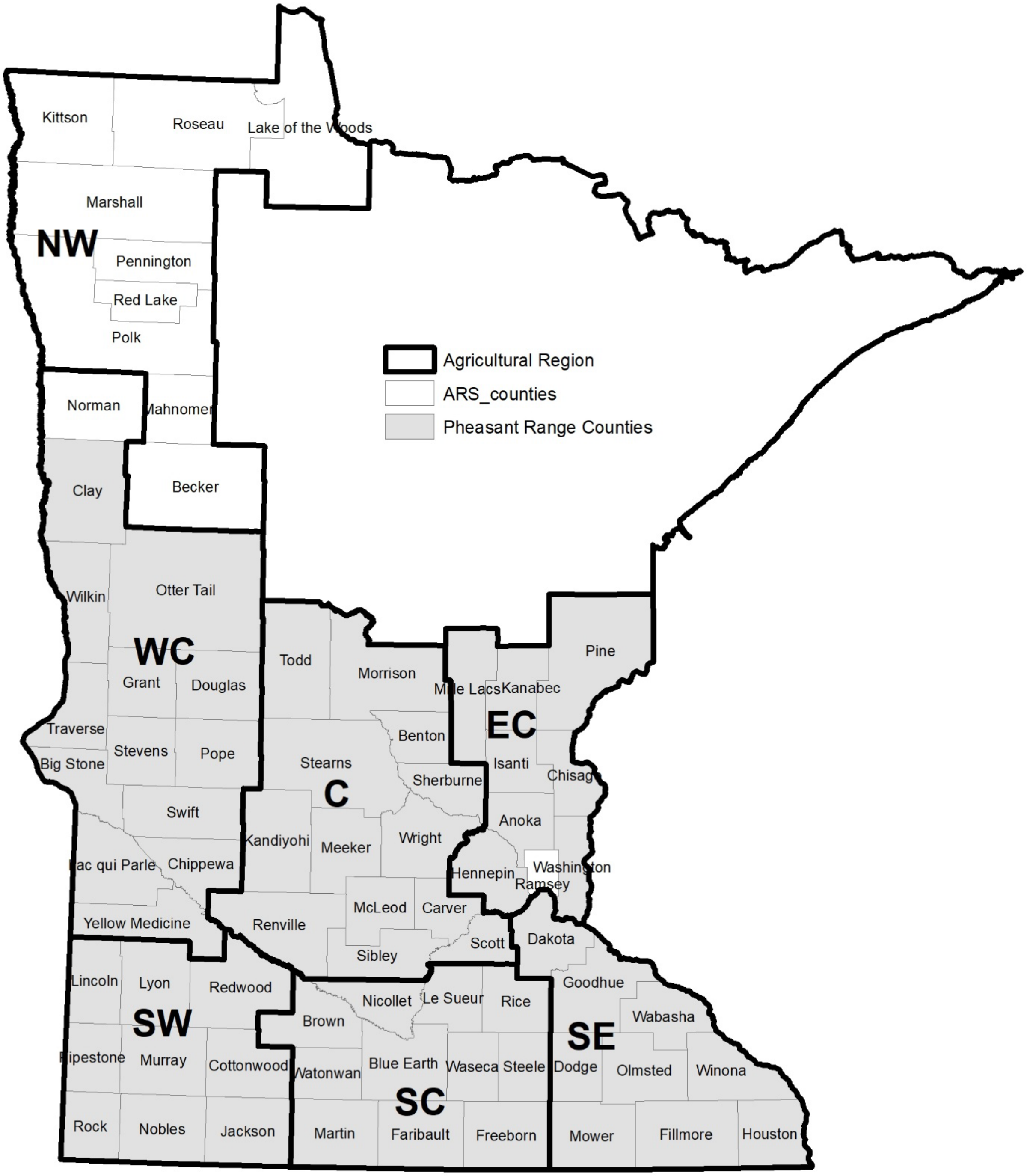


Figure 1. Survey regions and ring-necked pheasant range delineation for Minnesota's August roadside survey, 2020

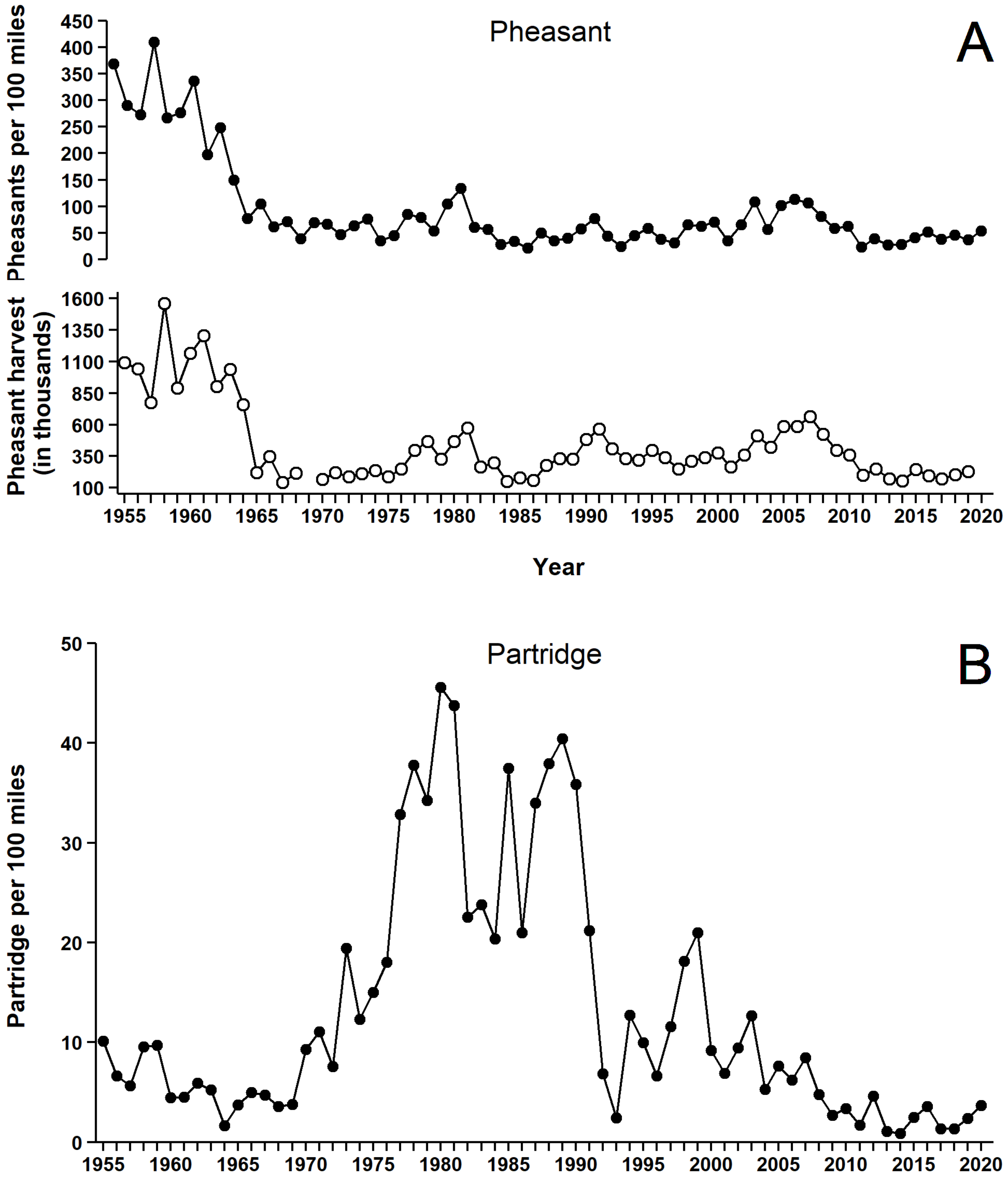
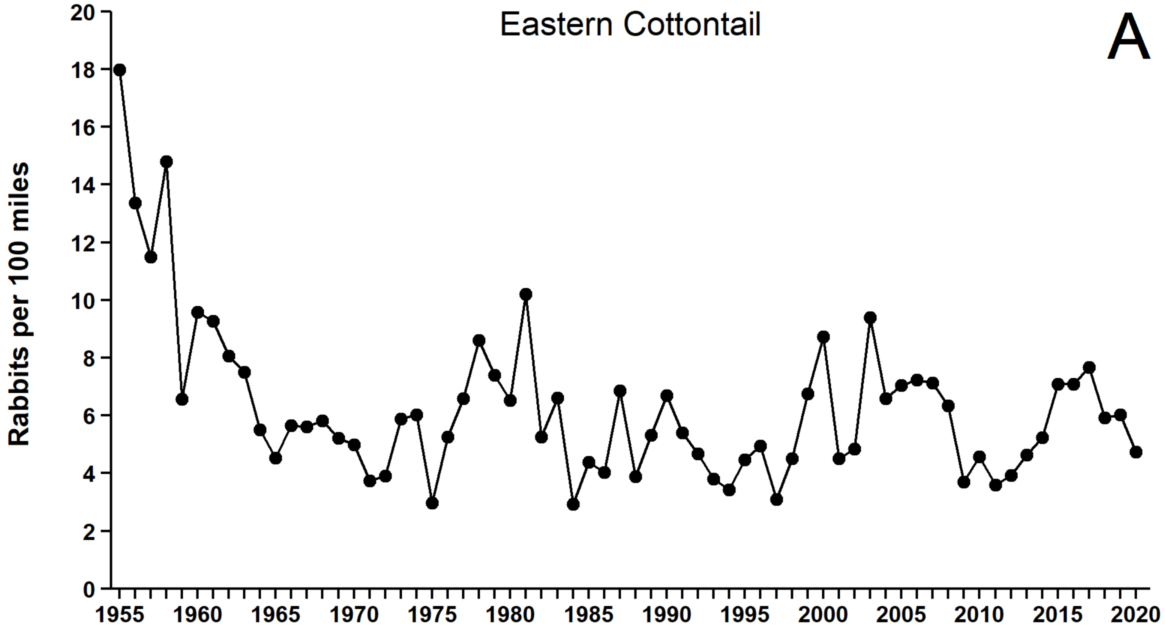


Figure 2. Range-wide index of ring-necked pheasants (A) and gray partridge (B) seen per 100 miles driven in Minnesota, 1955-2020. Does not include the Northwest region. Based on all survey routes completed.



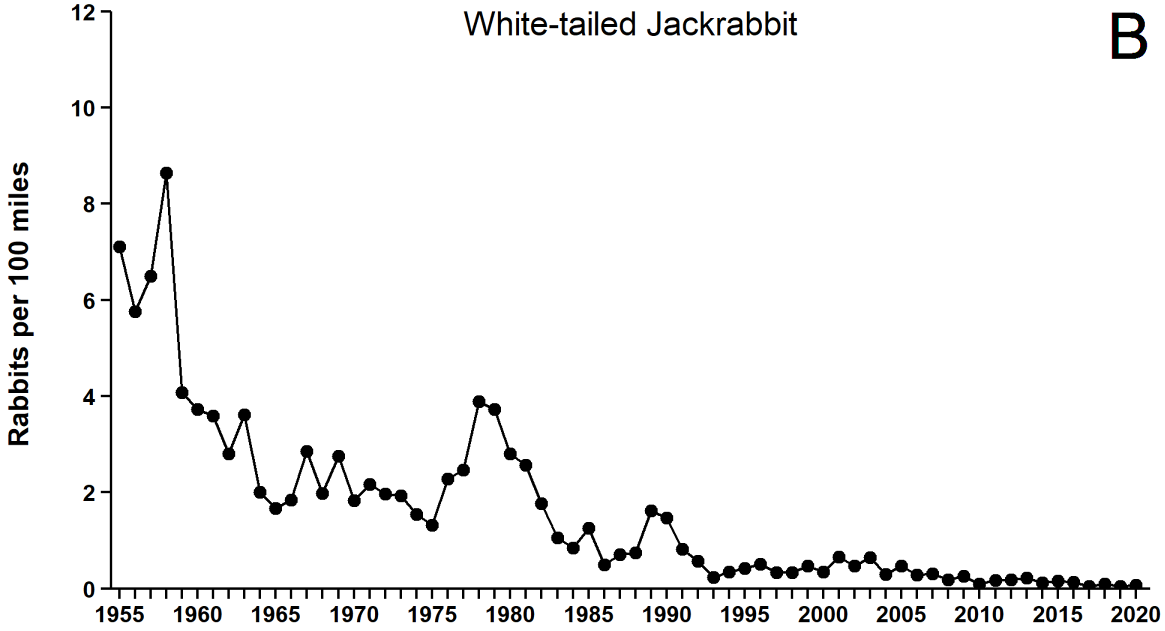


Figure 3. Range-wide index of eastern cottontail (A) and white-tailed jackrabbits (B) seen per 100 miles driven in Minnesota, 1955-2020. Does not include the Northwest region. Based on all survey routes completed.

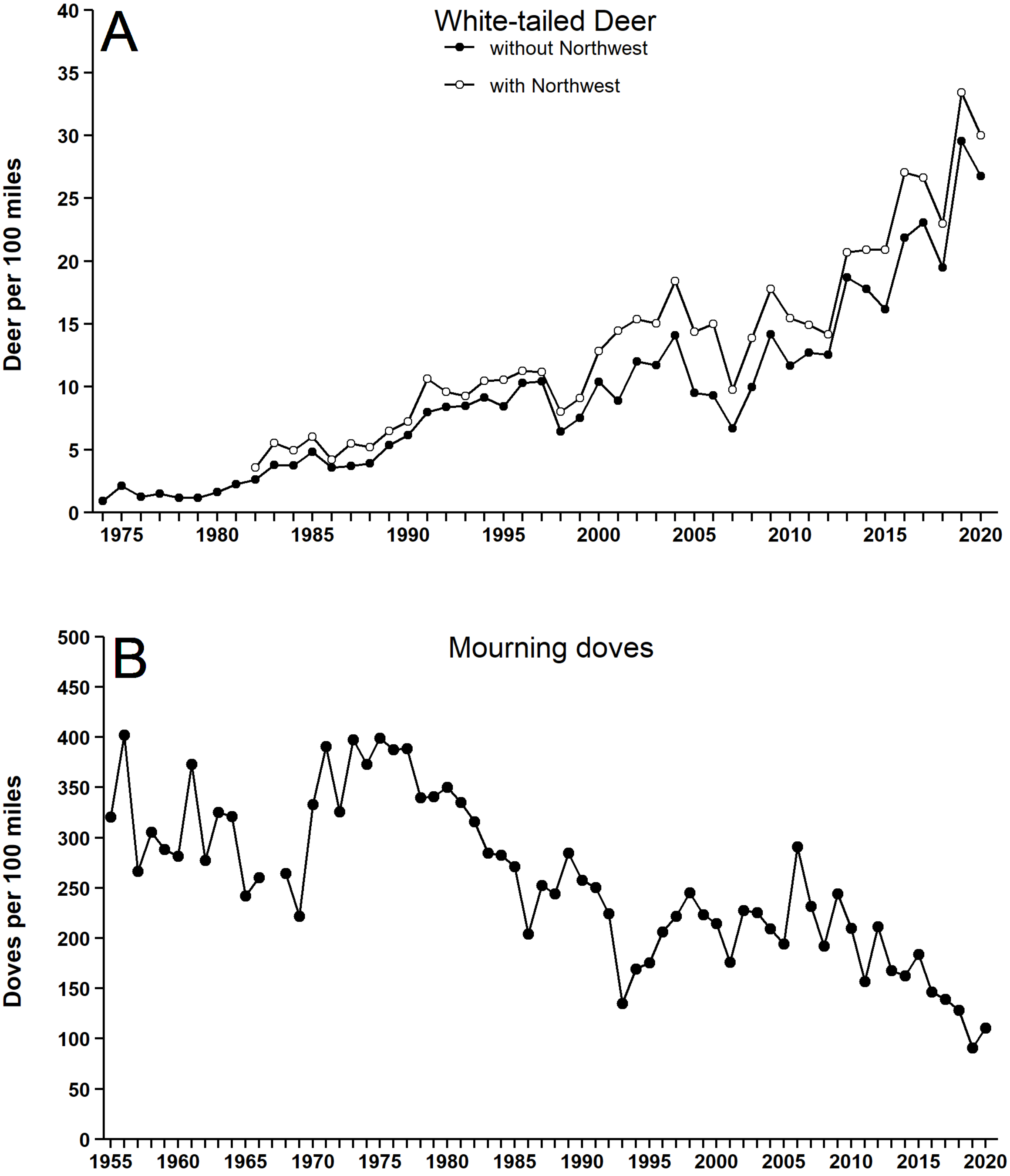


Figure 4. Range-wide index of: (A) white-tailed deer seen per 100 miles driven in Minnesota, 1974-2020, with and without the Northwest region included; and (B) mourning doves seen per 100 miles driven in Minnesota, 1955-2020. Doves were not counted in 1967 and the dove index does not include the Northwest region. Based on all survey routes completed.

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA – 2020

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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 annual hunting regulations 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 data obtained from studies conducted within Minnesota and supplemented from primary literature.

Model Structure

We use the spring of the initial year before reproduction occurred (Figure 1) as the starting period for each multi-year simulation. We specified an initial population density (see Modeling Procedures section) and the model then 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.

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 an annual winter severity index (WSI) in each DPA 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 $\geq$15 in (38.1 cm). One point was also added to the WSI for each day when temperatures were $\leq 0^0$ 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 $WSI<100$, $100 \leq WSI<180$, and $WSI \geq 180$, respectively.

Spring/summer survival rates reported in the primary literature for adult deer $\geq$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 = 0.97 [SD = 0.011], male = 0.98 [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 with fawns being 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 (2015-2020) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring 2020). We performed all simulations with the R programming language (ver. 3.6.2, R Core Team 2019) 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 regularly on deer populations across all DPAs 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 111 of 132 DPAs in Minnesota to estimate deer densities before reproduction during spring 2020 (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 2020. Management designations in 2020 were consistent in most DPAs compared to 2019 in attempt to stabilize or reduce densities that had exceeded goals. Each ecogeographic zone observed some DPAs that were below goal (southwestern farmland zone, n = 2; farmland-forest transition zone, n = 2); however, the northeastern forest region had the most DPAs below goal (n = 11), even with conservative hunting regulations, likely due to resource limitations. Although firearm hunting season conditions across some areas in the state were mostly above average in 2019, antlerless harvest goals were not achieved, resulting in more deer after the hunting season than intended with hunting season regulations. Liberal antlerless seasons in 2020 will be required again to effectively manage deer populations in DPAs with average and above average productivity.

In terms of management intensity, the 2020 designations afford more antlerless deer harvest opportunities to hunters in about 21% of the DPAs versus the 2019 season. For most of the remaining DPAs, designations in 2020 were the same as 2019 and about 12% of DPA designations afforded less antlerless harvest opportunity.

Farmland Zone

We modeled 26 of 37 total farmland zone DPAs. Of those 27 modeled DPAs, 9 were at goal, 2 were below goal, and 16 were 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 = 23) were under a Lottery designation. Four of the DPAs required Hunter Choice, 8 were under Managed designations, 1 was under the Intensive designation, and 1 was designated as Unlimited Antlerless, 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. We modeled 38 of the 51 transition zone DPAs. Of those 38 modeled DPAs, 17 were at goal, 2 were below goal, and 19 were above goal based on modeling or buck harvest trends. For the 2020 season designations, Lottery will be used for 2 of the DPAs, Hunter Choice for 8 DPAs with an additional antlerless season being available in DPA 344, and Managed for 8 DPAs. In 25 DPAs, Intensive designations will be necessary to continue reducing deer densities toward goal level, 6 of which have additional antlerless seasons. In the metro area (DPA 701) and the chronic wasting disease management zone (DPAs 605, 643, 645, 646, 647, 648, and 649), 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. We modeled 32 of the 44 forest zone DPAs. Of the 32 modeled DPAs, 13 were at goal, 11 were below goal, and 8 were above goal based on modeling or buck harvest trends. For 2020 season designations, Bucks-only will be used in 5 DPAs, Lottery in 18 DPAs, Hunter Choice in 12 DPAs, Managed in 6 DPAs, Intensive in 2 DPAs, and Unlimited Antlerless in 1 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, 2015-2020.

		Pre-fawn Deer Density[a]					
Deer Permit Area	Land Area (mi2)	2015	2016	2017	2018	2019	2020
101	496	9	11	12	14	15	17
103	1820	3	4	4	5	5	5
105	740	11	13	14	15	15	16
108	1655	5	6	7	8	8	9
110	529	12	14	15	15	15	16
111	1438	2	3	3	3	3	4
114	123	-	-	-	-	-	-
117	936	7	7	8	8	7	7
118	1239	4	4	4	4	4	4
119	782	5	6	7	7	7	7
126	942	3	3	3	3	3	3
130	747	-	-	3	3	3	3
131	901	-	-	4	4	4	4
132	481	-	-	5	5	5	5
133	352	-	-	8	8	7	6
152	60	-	-	-	-	-	-
155	594	17	20	23	25	25	28
156	819	12	13	15	16	16	18
157	888	20	23	25	19	19	21
159	571	13	15	17	19	21	24
169	1124	9	11	12	13	13	14
171	701	11	13	15	15	15	18
172	692	21	24	27	28	27	31
173	584	9	10	12	13	13	16
176	917	8	9	9	10	9	9
177	491	12	14	15	14	13	13
178	1192	9	11	12	14	13	15
179	857	13	14	16	15	14	15
181	629	10	12	14	15	15	17
182	278	-	-	-	-	-	-
183	664	12	15	18	20	21	22
184	1229	17	19	20	21	20	20
197	957	10	12	13	14	15	17
199	153	-	-	-	-	-	-
201	161	10	12	13	15	16	19
203	118	-	-	-	-	-	-
208	378	5	6	7	8	8	9

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

		Pre-fawn Deer Density[a]					
Deer Permit Area	Land Area (mi2)	2015	2016	2017	2018	2019	2020
209	639	8	9	10	11	11	12
210	615	8	9	10	10	9	10
213	1059	16	17	18	20	20	21
214	553	27	30	33	35	35	38
215	701	20	21	24	26	27	30
218	884	11	13	15	17	19	23
219	392	13	15	17	19	22	26
221	643	14	17	20	22	24	26
222	413	16	18	21	24	26	29
223	377	15	17	18	21	22	24
224	46	-	-	-	-	-	-
225	618	18	20	22	24	26	29
227	471	20	22	25	28	31	35
229	285	10	12	14	15	17	19
230	454	-	-	-	-	-	-
232	377	6	7	8	9	10	12
233	384	6	6	7	8	9	11
234	636	3	3	3	4	4	5
235	35	-	-	-	-	-	-
236	368	18	20	23	26	29	34
237	728	-	-	-	-	-	-
238	95	-	-	-	-	-	-
239	928	13	14	15	16	16	17
240	643	22	24	27	29	29	30
241	997	27	29	30	31	29	29
242	213	22	25	28	29	27	29
246	838	17	20	22	23	23	25
247	229	19	21	21	21	19	19
248	216	16	17	19	19	18	20
249	502	17	19	22	24	25	29
250	712	-	-	-	-	-	-
251	55	-	-	-	-	-	-
252	716	-	-	-	-	-	-
253	974	-	-	-	-	-	-
254	930	4	4	4	5	5	5
255	392	5	6	7	8	10	11
256	654	7	8	9	10	10	11
257	412	9	10	11	13	13	14
258	343	19	21	23	25	24	25
259	490	19	21	22	22	21	24

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

		Pre-fawn Deer Density[a]					
Deer Permit Area	Land Area (mi2)	2015	2016	2017	2018	2019	2020
260	1248	4	5	6	7	7	9
261	793	4	5	6	7	7	9
262	677	3	4	4	5	5	6
263	512	9	11	12	13	14	15
264	669	13	15	17	19	19	22
265	494	10	11	13	14	13	14
266	617	6	6	7	8	9	10
267	472	5	5	6	6	5	5
268	228	10	11	11	10	10	10
269	650	3	4	4	5	6	7
270	736	-	-	-	-	-	-
271	632	3	3	3	4	4	5
272	532	-	-	-	-	-	-
273	572	6	7	7	8	9	11
274	355	6	6	7	8	9	10
275	764	4	4	5	5	6	7
276	542	10	11	13	15	16	19
277	812	14	14	15	17	18	21
278	402	6	7	7	8	9	10
279	344	4	4	4	5	5	5
280	674	3	3	3	3	3	4
281	575	7	9	10	12	13	16
282	778	-	-	-	-	-	-
283	613	4	4	4	4	4	5
284	840	-	-	-	-	-	-
285	546	5	6	6	8	9	10
286	447	5	6	7	8	9	10
287	47	-	-	-	-	-	-
288	624	5	5	6	6	6	7
289	816	2	3	3	3	4	4
290	661	6	6	7	8	9	10
291	799	6	7	7	8	9	11
292	480	10	11	13	14	16	18
293	511	9	10	10	11	12	13
294	687	4	4	5	5	5	6
295	839	5	5	6	7	8	9
296	665	4	4	4	5	6	7
297	438	3	3	4	5	5	5
298	619	10	12	15	16	17	19
299	387	6	6	6	7	8	9

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

		Pre-fawn Deer Density[a]					
Deer Permit Area	Land Area (mi2)	2015	2016	2017	2018	2019	2020
338	454	7	8	10	12	15	18
339	394	7	8	10	12	14	16
341	611	16	18	21	24	27	31
342	351	16	18	20	24	26	31
343	320	14	15	16	18	19	20
344	190	19	19	20	22	24	25
643	351	14	15	16	18	19	21
645	326	14	16	17	19	20	22
646	319	28	28	29	30	30	30
647	434	-	-	-	-	-	-
648	122	-	-	-	-	-	-
649	492	27	29	31	34	38	42
655	387	5	6	7	8	9	12
701	1632	-	-	-	-	-	-

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

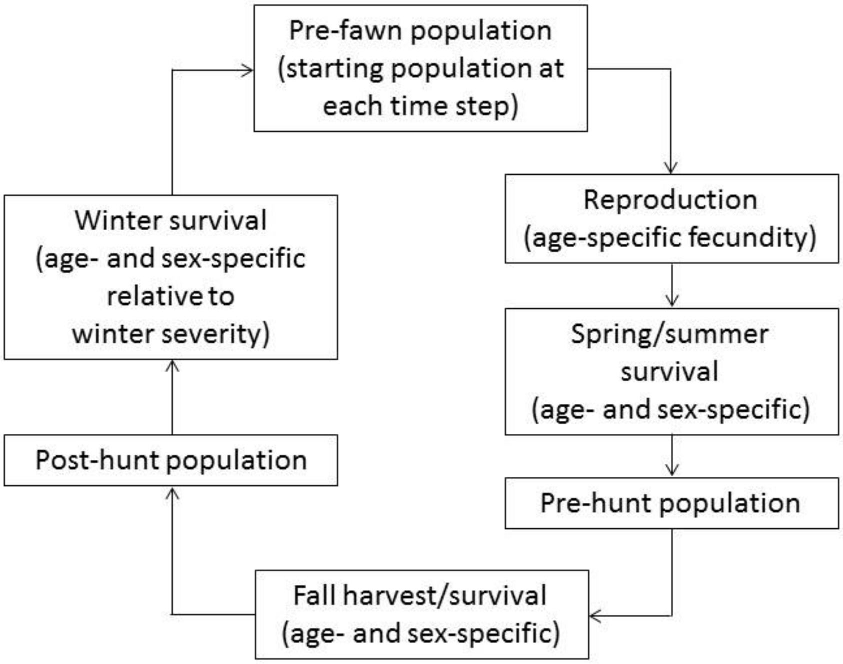
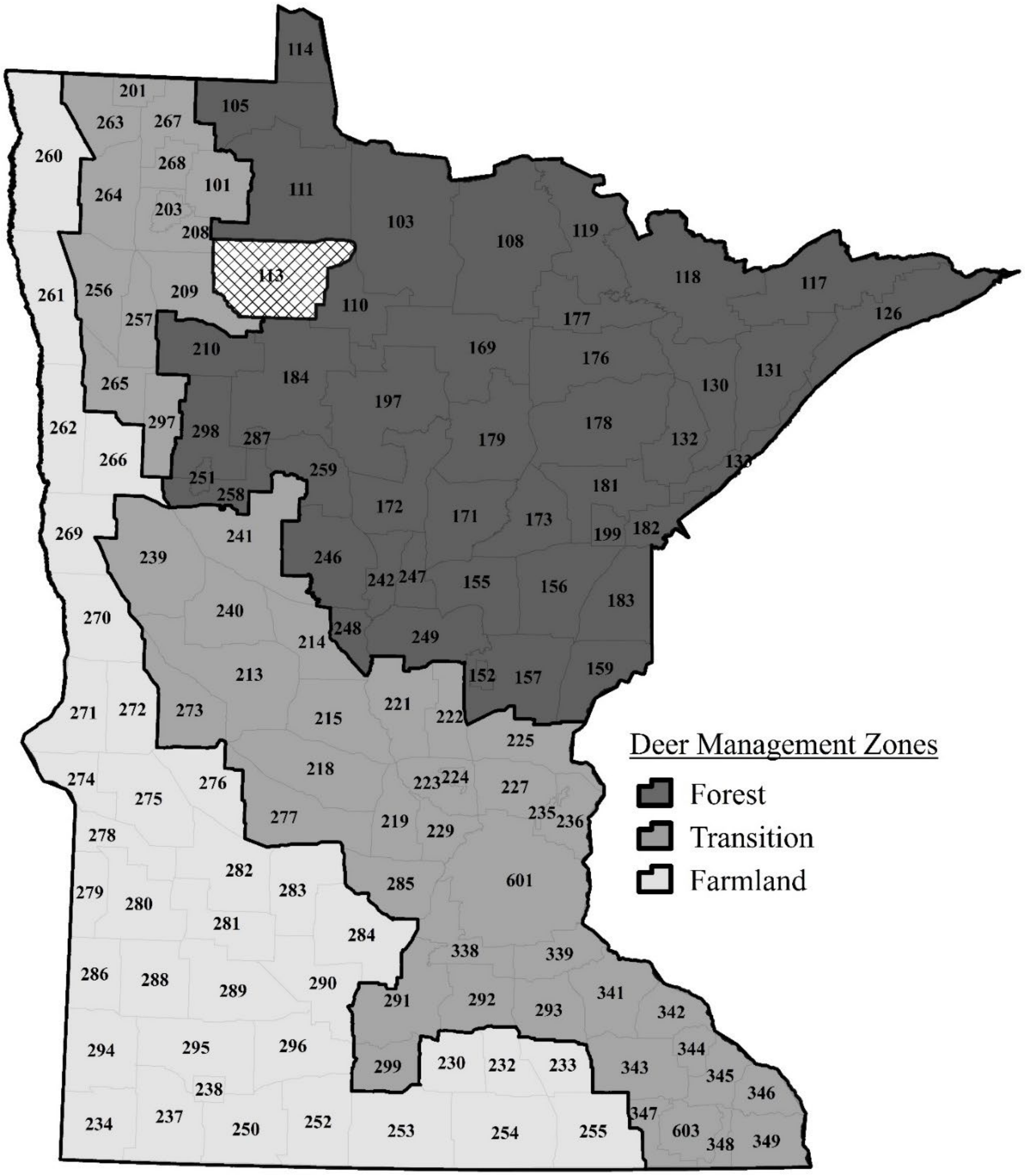


Figure 1. Model structure for simulations of white-tailed deer populations in Minnesota.



Political Boundaries Source: Minnesota DNR Quick Layers
Prepared by: Minnesota DNR Farmland Wildlife Populations and Research Group

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.

2020 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 a harvest-based population model to estimate and track changes in white-tailed deer (*Odocoileus virginianus*) abundance and, subsequently, to aid in developing annual harvest recommendations to manage deer populations toward goal levels (Michel and Giudice 2019). Currently, MNDNR collects annual data on winter severity, hunter-reported harvest, and hunter effort (license sales) at the deer permit area (DPA) scale. Reliability of harvest-based models can be improved by incorporating annual information on spatial and temporal variation in survival and reproduction rates and other model parameters. However, collection of such data is generally cost-prohibitive, especially at the DPA scale.

An alternative approach would be to collect independent recurrent information on population abundance or trends, which could be used to calibrate the population model. One potential approach in the farmland zone is road-based distance-sampling surveys. We used aerial surveys by helicopter to provide independent estimates of deer abundance to compare with a concurrent study of road-based distance-sampling surveys (Giudice et al. 2018).

METHODS

We estimated deer populations in a 4-DPA distance-sampling study area (DSSA) 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. We delineated quadrats by Public Land Survey (PLS) section (640 ac) boundaries. We used the R programming language (R Core Team 2019) and R package ’stratification’ (Rivest and Baillargeon 2017) to stratify the sampling frame into 3 categories (low, medium, high) based upon abundance of woody cover within each quadrat and the local wildlife manager’s knowledge of winter deer abundance and distribution. 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 a spatially balanced stratified random sample of quadrats. For the DSSA, we surveyed the same sample of plots in 2019 and 2020.

During both 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 the DSSA to estimate sightability of deer from the helicopter. We sorted the sample of survey quadrats by woody cover abundance 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 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 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 to compute deer abundance and density indices for 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). Our aerial survey precision goal was having a 90% confidence interval bound that was within 20% of the abundance estimate (Lancia et al. 1994).

RESULTS AND DISCUSSION

We completed surveys within the DSSA during January 2019 and February 2020 (Figure 1). Estimated mean deer density was 7 deer/mi^2 (90% CI = 5–8) during both years. Both estimates exceeded precision goals (relative error ≤ 20%; Table 1). We observed deer in 40-41% of quadrats, 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 between years.

Estimates of sightability within the DSSA ranged from 0.779 (SE = 0.069) in 2020 to 0.785 (SE = 0.070) in 2019, which were similar to sightability estimates from historic DPA-level surveys within the farmland zone during 2010-2018 (range = 0.633-0.909; mean = 0.757; Haroldson and Giudice 2019). Correcting for sightability increased relative variance (CV [%]) of population estimates by ~18%, 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). 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 within the distance sampling study area (DSSA)[a], south-central Minnesota, 2019–2020. Summary statistics (CI, CV) are also presented. Confidence intervals for density estimates were based on α = 0.10.

Year	Sampling rate (%)	Sightability rate	Population estimate		CV (%)	Relative error (%)[b]	Density estimate	
			N	90% CI			$\bar{x}$	90% CI
2019	6	0.785	17,837	13,461–22,213	14.9	24.5	7	5–8
2020	6	0.779	17,884	14,045–21,723	13.0	21.4	7	5–8

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

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

Table 2. Sampling metrics from aerial surveys of white-tailed deer within the distance sampling study area (DSSA)[a], south-central Minnesota, 2019–2020.

Year	Quadrats in deer permit areas	Quadrats sampled	Quadrats occupied[b]	Deer observed	Deer groups observed	Groups / occupied quadrat		Group size / occupied quadrat		Max. quadrat count
						$\bar{x}$	Range	$\bar{x}$	Range	
2019	2,714	162	67	1,652	302	5	1–14	5	1–32	109
2020	2,714	163	66	1,801	247	4	1–12	7	1–87	111

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

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

Figure 1. Deer permit areas (DPAs) flown during aerial surveys of white-tailed deer in southern Minnesota, winter 2019–2020. DPAs 252, 253, 296, and 299 were combined into a single survey area for comparison with a concurrent study using roadside distance-sampling surveys.