FARMLAND WILDLIFE POPULATIONS

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2016 MINNESOTA AUGUST ROADSIDE SURVEY

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SUMMARY OF FINDINGS

An increase in grassland habitat acres combined with another relatively mild winter and favorable breeding season conditions led to increases in Minnesota's 2016 population indices for ring-necked pheasants and gray partridge. However, indices for both species remain below their long-term averages. Range-wide indices for cottontail rabbits and sandhill cranes were similar to 2015 but the index for juvenile cranes increased. The mourning dove index decreased in 2016 and remained below the long-term average. The white-tailed deer index increased and remains well above the long-term average.

For the first time since 2011, total acres of undisturbed grassland habitat increased across Minnesota's farmland region. Overall, 54,495 acres were gained statewide since 2015, including 24,307 acres of Conservation Reserve Program (CRP) habitat. Acres either held nearly steady or increased in all other private land conservation programs. Publically-owned grassland habitat also increased in 2016. Net habitat gains occurred in the pheasant range (61,525 acres) whereas the prairie chicken range (mostly represented by the Northwest region) lost 957 acres. The winter of 2015-16 was the second consecutive mild winter, and most regions had minimal snow during March. Spring and early summer temperatures varied widely but, on average, temperatures were at or above normal from April-June. Several regions were drier than normal but many areas in the southern regions had above-normal rainfall in May and June. Overall, weather conditions led to good overwinter survival and good nesting and brood-rearing conditions.

The 2016 range-wide pheasant index (52.1 birds/100 mi) increased 29% from 2015 but was 14% below the 10-year average and 48% below the long-term average. Although Minnesota's pheasant population has been declining since the mid-2000s in conjunction with a loss of CRP acres, this year marks the third consecutive year with an increase in the overall index. This increase can be attributed to the back-to-back mild winters, good nesting season conditions, and the gain in acres of habitat. The hen index (7.9 hens/100 mi) increased 31% from 2015 but was 16% below the 10-year average. The cock index (5.9 cocks/100 mi) increased 21% from 2015 but was 21% below the 10-year average. The hen:cock ratio (1.35) was greater than 2015 (1.27) and closer to the 1.42 average ratio for the CRP years (1987-2015). The pheasant brood index (8.7 broods/100 mi) increased 39% from last year but remained 7% below the 10-year average and 34% below the long-term average. Average brood size in 2016 (4.4 chicks/brood) was down slightly from the 2015 index and the 10-year average (both indices = 4.7 chicks/brood) and was 20% below the long-term average (5.5 chicks/brood). The range-wide median estimated hatch date for pheasants was 11 June 2016 but, notably, the median estimated hatch dates were later in the South Central (17 June) and Southwest (22 June) regions where rainfall early in the season may have interrupted nesting. Good harvest opportunities should be available in all regions except the Southeast.

The gray partridge index (3.7 birds/100 mi) increased 62% in 2016 and was similar to the 10-year average but 72% below the long-term average. Partridge observations were highest in the Southwest, South Central, and Southeast regions. The eastern cottontail rabbit index (7.2 rabbits/100 mi) was similar to 2015 and was above the 10-year and long-term averages (34% and 18%, respectively). Cottontail rabbit indices were highest in the East Central, South Central, and Southeast regions. The white-tailed jackrabbit index (0.1 rabbits/100 mi) did not change from last year and was 90% below the long-term average. The jackrabbit population declined to low levels in

the 1980s due to changes in agricultural land use and has not recovered. The white-tailed deer index (27.5 deer/100 mi) increased 30% from 2015 and was well above the 10-year and long-term averages (67% and 149%, respectively). The mourning dove index (144.1 doves/100 mi) decreased 22% from 2015 and was 29% below the 10-year average and 44% below the long-term average. Mourning dove counts were highest in the West Central, Southwest, Central, and South Central regions. Range-wide, the total sandhill crane index (15.7 total cranes/100 mi) was similar and the juvenile index (2.2 juvenile cranes/100 mi) increased 62% from 2015.

INTRODUCTION

This report summarizes the 2016 Minnesota August Roadside Survey (ARS). Since 1955, the ARS has been conducted annually during the first two weeks of August by Minnesota Department of Natural Resources (MN DNR) wildlife and enforcement personnel throughout Minnesota's farmland regions (Fig. 1). The 2016 ARS consisted of 172 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 at 15-20 miles/hour and recorded the number of pheasants, gray (Hungarian) partridge, cottontail rabbits, white-tailed jackrabbits, and other wildlife they observed. Counts conducted on cool, clear, calm mornings with heavy dew yield the most consistent results because wildlife (especially pheasants, gray partridge, and rabbits) move to warm, dry areas (e.g., gravel roads) during early-morning hours. These data provide an **index of relative abundance** that are used to monitor annual changes and long-term trends in regional and range-wide populations. Results are reported by agricultural region (Fig. 1) and range-wide; however, population indices for species with low detection rates are imprecise and *should be interpreted cautiously*.

HABITAT CONDITIONS[1]

In Minnesota's farmland region, total undisturbed grassland habitat acres increased last year for the first time since 2011. Statewide, 54,495 habitat acres were gained (pheasant range: 61,525 net acres; prairie chicken range: -957 net acres). Conservation Reserve Program (CRP) enrollment increased by 24,307 acres overall. Gains in CRP occurred within the pheasant range (37,263 acres) whereas losses of CRP occurred in the prairie chicken range (-8,331 acres, primarily in the Northwest region). Acres enrolled in the Conservation Reserve Enhancement Program (CREP) held nearly steady in 2016 while acres enrolled in Reinvest in Minnesota (RIM), Wetlands Reserve Program (WRP), and RIM-WRP increased statewide (7,765 acres, 1,029 acres, and 2,356 acres, respectively). Publically-owned acres also increased in 2016. Federally-owned Waterfowl Production Areas (WPA) and U.S. Fish and Wildlife Service (USFWS) refuges increased by 7,384 acres and state-owned Wildlife Management Areas (WMA) increased by 11,673 acres overall. More WMA acres were gained in the pheasant range (10,104 acres) than the prairie chicken range (1,536 acres). The USFWS added 6,219 acres of habitat in the pheasant range and 2,593 acres in the prairie chicken range. Similar to 2015, remaining protected habitat accounts for 6.1% of the landscape within the pheasant range (range: 3.1-9.8%; Table 1).

Grassland and wetland habitat conservation remains a priority concern for Minnesota. Private-land conservation programs, including CRP, continue to make up the largest portion of protected grassland habitat in the state (Fig. 2) but approximately 393,000 acres of CRP are set to expire by

[1] An active CREP acreage report could not be obtained from the Farm Service Agency (FSA). Therefore, total statewide CRP acres reported for 2016 were reduced by 70,778 acres to avoid double-counting with CREP acres for which there are still active contracts.

2018. Recent low corn and soybean prices have increased landowner interest in farmland retirement programs; however, the current federal Farm Bill limits the number of acres that can be enrolled in CRP and the most recent CRP-sign up resulted in a low acceptance rate in Minnesota (i.e., only 9% of acres offered were accepted). Funding from the Legacy Amendment[2] has helped partially offset habitat losses but the pace has not kept up with the rate of CRP losses. Minnesota's Prairie Conservation Plan and Pheasant Summit Action Plan both offer a blueprint for moving forward with grassland and wetland habitat conservation strategies in the farmland regions, thereby helping partners prioritize lands acquired with Legacy Amendment funding.

Started in 2012, Minnesota's Walk-in Access (WIA) program continues to provide public hunting opportunities on private land that is already enrolled in existing conservation programs or has high quality natural habitat. In 2015, the U.S. Department of Agriculture (USDA) awarded a 3-year, $1.67 million grant to help continue funding of the WIA program. As of August 2016, 216 sites are enrolled in the program for a total of 21,436 acres of private land that are open to public hunting. Sites are spread across the Southwest, South Central, West Central, Central, and Northwest regions of Minnesota. Walk-in Access sites are open for public hunting from September 1 – May 31 where boundary signs are present. Hunters must purchase a $3 WIA Validation to legally access WIA lands. For more information on the WIA program, including the code of conduct for WIA lands, a printable atlas of enrolled sites by county, aerial photos of each site, interactive maps, and Global Positioning System (GPS) downloads, visit the WIA program website. Minnesota DNR is still seeking permanent funding to continue the program into the future.

WEATHER SUMMARY

Minnesota's winter 2015-2016 was generally mild with warmer than normal temperatures and near normal precipitation amounts. Monthly temperatures averaged 6.0° F above normal (range: 1.7° F to 9.7° F) across all farmland regions from December through March (Minnesota Climatology Working Group [MCWG], Climate Summary Table). Although snow cover was fairly continuous from late December through February throughout the farmland zone, snow depths exceeding 6 inches were intermittent across regions (MCWG, MCWG Climate Summary, Weekly snow depth maps). All regions except the Northwest were nearly snow-free for most of March.

Spring temperatures and precipitation varied widely across the farmland regions. On average, temperatures were at or above normal for May and June. The Northwest, West Central, and East Central regions were drier than normal during May and June whereas localized areas in the Southwest region were wetter than normal. July had near-normal temperatures but was wetter than normal. Averaged across all regions, July rainfall amounts were 2.69 inches above normal (range: 1.36 inches to 3.52 inches).

Overall, the conditions for over-winter survival of wildlife were above average throughout the farmland zone for the second year in a row. Although some localized areas received excessive rainfall during May and June (the prime period for nesting birds), temperatures were above average which would have been beneficial for chick survival and brood-rearing. Additionally, hens had plenty of time to re-nest if they lost their early-season nest attempts due to flooding.

[2] 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.

SURVEY CONDITIONS

The survey period was extended (28 July – 17 August) to allow all survey routes (n=172) to be completed in 2016. Weather conditions during the survey ranged from excellent (calm winds, heavy dew, clear sky) to medium (light dew and overcast skies). Medium to heavy dew conditions were present at the start of 97% of the survey routes which was comparable to 2015 (98%) and slightly above the 10-year average (93%). Similar to 2015, clear skies (<30% cloud cover) were present at the start of 82% of routes. Wind speeds <7 mph were recorded for 94% of the routes which was less favorable than 2015 (100%). Notably, several observers reported flooded road right-of-ways due to rainfall events before and during the survey period which may have reduced detectability of some species, particularly pheasants, partridge, and cottontail rabbits.

RING-NECKED PHEASANT

In 2016, the average number of pheasants observed (52.1 birds/100 mi) increased 29% from 2015 but was 14% below the 10-year average (Table 2, Fig. 3A) and 48% below the long-term average. Total pheasants observed per 100 mi ranged from 17.9 birds in the Southeast region to 96.0 birds in the Southwest region (Table 3). The pheasant index showed substantial increases in the Central (72%) and South Central (70%) regions. Regional indices also increased in the East Central (27%), Southwest (25%), and West Central (10%) regions. Good harvest opportunities should exist in all regions with the exception of the Southeast where the index declined 31% compared to 2015.

The range-wide hen index (7.9 hens/100 mi) increased 31% from 2015 but was 16% below the 10-year average and 45% below the long-term average (Table 2). The hen index ranged from 2.9 hens/100 mi in the Southeast to 13.7 hens/100 mi in the Southwest. The 2016 hen index in the East Central region was similar to 2015 but increased in the West Central (19%), Southwest (20%), South Central (65%), and Central (77%) regions. The hen index declined 22% in the Southeast region.

Across their range, the cock index (5.9 cocks/100 mi) increased 21% from 2015 but remained 21% below the 10-year average and 47% below the long-term average (Table 2). The cock index ranged from 0.6 cocks/100 mi in the Southeast to 9.9 cocks/100 mi in the Southwest. The 2016 indices increased in the South Central (26%), Southwest (47%), and East Central (83%) regions and remained similar to 2015 in the West Central, Central, and Southeast regions.

The 2016 hen:cock ratio (1.35) was greater than the 2015 ratio (1.27) and closer to the average (1.42 ± 0.35) for the CRP years (1987-2015).

The 2016 range-wide brood index (8.7 broods/100 mi) increased 39% from last year (Table 2). The index was 7% below the 10-year average and 34% below the long-term average. Regional brood indices ranged from 3.6 broods/100 mi in the Southeast to 15.6 broods/100 mi in the Southwest. Brood indices increased in all regions (range: 14% to 103%) except the Southeast which remained similar to 2015's index. The average brood size in 2016 (4.4 chicks/brood) was down slightly from the 2015 index and the 10-year average (both indices = 4.7 chicks/brood) and was 20% below the long-term average (5.5 chicks/brood). The median estimated hatch date for pheasant broods across their range was 11 June 2016 (n = 330 broods), which was similar to the 10-year average (12 June; Table 2). Notably, the median estimated hatch dates were later in the South Central (17 June) and Southwest (22 June) regions where rainfall may have disrupted early-season nest attempts.

The pheasant population has declined since the mid-2000s in conjunction with the loss of CRP acres (Fig. 2 & 3A) but 2016 represents the third consecutive year with an increase in the overall index. This increase can be mostly attributed to back-to-back mild winters combined with good weather conditions for nesting and brood-rearing but the gain in grassland habitat acres is also important. Winter conditions for pheasants are considered severe when the temperature is ≤0° F and snow depths exceed 6 inches. Heavier rains in some regions during May and June might have forced hens to re-nest but the above-normal temperatures were beneficial to brood-rearing and chick survival. One exception is the Southeast region, which has been hampered in consecutive years by late-season snowstorms and/or heavy rain events during the nesting season. The Southeast region also has the second lowest total of undisturbed grassland habitat acres within Minnesota's pheasant range (Table 1). The combination of poor weather conditions and lack of abundant habitat combine to make it difficult for the pheasant population to increase in this region of the state.

GRAY PARTRIDGE

The range-wide gray partridge index (3.7 birds/100 mi) increased 62% from 2015 and was similar to the 10-year average but remained 72% below the long-term average (Table 2, Fig. 3B). No partridge were observed in the Northwest, West Central, or East Central regions. Indices in regions where they were observed ranged from 2.5 birds/100 mi in the Central region to 9.7 birds/100 mi in the Southwest region.

Intensified agricultural land use (e.g., corn and soybeans) has reduced the amount of suitable habitat for gray partridge in Minnesota. Additionally, gray partridge in their native range (southeastern Europe and northern Asia) are associated with arid climates and their reproductive success in the Midwest is limited except during successive dry years. Thus, gray partridge are more adversely affected by excessive rainfall during the breeding season compared to pheasants. The Southwest, South Central, and Southeast regions will offer the best opportunities for harvesting gray partridge in 2016.

COTTONTAIL RABBIT AND WHITE-TAILED JACKRABBIT

The range-wide eastern cottontail rabbit index (7.2 rabbits/100 mi) was similar to 2015 and was 34% above the 10-year average and 18% above the long-term average (Table 2, Fig. 4A). The cottontail rabbit index ranged from 2.1 rabbits/100 mi in the Northwest to 21.5 rabbits/100 mi in the East Central region (Table 3). Good harvest opportunities should exist in the East Central, South Central, and Southeast regions.

Remaining at a historic low, the number of white-tailed jackrabbits observed (0.1 rabbits/100 mi) was 90% below the long-term average (1.7 rabbits/100 mi; Table 2, Fig. 4B). Minnesota's jackrabbit population peaked in the late 1950s, declined to low levels in the 1980s, and has continued to decline since then. The long-term decline in jackrabbits is due to the loss of their preferred habitats (i.e., pasture, hayfields, and small grains). The greatest potential for white-tailed jackrabbit hunting will be in the Southwest or West Central regions (Table 3).

WHITE-TAILED DEER

The white-tailed deer index (27.5 deer/100 mi) increased 30% from 2015 and was 67% above the 10-year average and 149% above the long-term average (Table 2, Fig. 5A). Roadside indices for deer ranged from 7.5 deer/100 mi in the South Central region to 69.0 deer/100 mi in the Northwest (Table 3).

MOURNING DOVE

The index for mourning doves (144.1 doves/100 mi) was 22% lower than 2015, 29% below the 10-year average, and 44% below the long-term average (Table 2, Fig. 5B). The index ranged from 62.9 doves/100 mi in the East Central region to 189.8 doves/100 mi in the West Central region. The best opportunities for harvesting doves should be in the West Central, Southwest, Central, and South Central regions.

SANDHILL CRANE

The 2016 range-wide index of sandhill cranes was 15.7 total cranes/100 mi which was similar to 2015 (Table 2). Regional indices ranged from 0.0 total cranes/100 mi in the Southwest to 65.2 total cranes/100 mi in the Northwest (Table 3). The range-wide index of juveniles was 2.2 juvenile cranes/100 mi which was 62% greater than 2015 (1.3 juvenile cranes/100 mi; Table 2). Juvenile cranes were observed in all regions except the Southwest.

OTHER SPECIES

Notable incidental sightings included: badger (Watonwan County), black bear (Todd County), beaver (Nobles County), black-billed magpie (Polk and Red Lake Counties), fisher (Todd County), merlin (Polk County), mink (Chippewa and Waseca Counties), northern harrier (Martin, Nobles, Polk, and Red Lake Counties), osprey (Wright County), pileated woodpecker (Stearns County), common raven (Red Lake County), red-headed woodpecker (Faribault and Redwood Counties), striped skunk (Becker, Faribault, Grant, and Red Lake Counties), and upland sandpiper (Cottonwood County). American kestrels, Canada geese, coyotes, domestic cats, red fox, red-tailed hawks, and wild turkeys were also noted in multiple counties.

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LITERATURE CITED

Minnesota Climatology Working Group (MCWG). 2016. MCWG Weekly Snow Depth and Snow Depth Ranking Maps. Accessed on August 19, 2016.

Minnesota Climatology Working Group (MCWG). 2016. MCWG Climate Summary Table. Accessed on August 19, 2016.

Table 1. Abundance (total acres) and density (acres/mi2) of undisturbed grassland habitat within Minnesota's pheasant range, 2016[a], by agricultural region (AGREG).

	Cropland Retirement								% of	Density
AGREG	CRP[b]	CREP	RIM	RIM-WRP	WRP	USFWS[c]	MNDNR[d]	Total	Landscape	ac/mi2
WC[e]	263,694	37,688	22,695	14,275	20,255	196,148	110,294	665,049	9.8	62.7
SW	98,585	24,764	19,809	2,556	766	23,090	69,508	239,078	6.3	40.3
C	126,050	14,326	34,370	6,591	3,339	90,100	49,726	324,502	5.4	34.6
SC	88,050	27,633	13,327	10,288	8,785	9,494	34,238	191,815	4.7	30.1
SE	67,622	2,706	7,360	1,070	985	36,754	53,158	169,655	4.6	29.4
EC	3,354	0	1,131	0	4	4,994	91,197	100,680	3.1	19.8
Total	647,355	107,117	98,692	34,780	34,133	360,580	408,121	1,690,778	6.1	39.0

[a] Unpublished data, Tabor Hoek, BWSR, 16 August 2016.

[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. Range-wide trends (% change) in number of wildlife observed per 100 miles driven, Minnesota August roadside survey, 1955-2016.

Species	**Change from 2015[a]**					**Change from 10-year average[b]**				**Change from long-term average[c]**			
Subgroup	*n*	2015	2016	%	95% CI	*n*	2006-15	%	95% CI	*n*	LTA	%	95% CI
Ring-necked pheasant													
Total pheasants	149	40.7	52.1	29	±21	148	58.4	-14	±13	149	95.3	-48	±10
Cocks	149	4.9	5.9	21	±23	148	7.3	-21	±14	149	10.8	-47	±12
Hens	149	6.1	7.9	31	±24	148	9.0	-16	±14	149	13.8	-45	±11
Broods	149	6.3	8.7	39	±26	148	9.1	-7	±14	149	12.6	-34	±12
Chicks per brood	330	4.7	4.4	-7			4.7	-7			5.5	-20	
Broods per 100 hens	149	103.0	109.6	7			100.2	9			101.4	8	
Median hatch date	330	9 June	11 June				12 June						
Gray partridge	168	2.3	3.7	62	±89	167	3.6	2	±58	149	14.7	-72	±19
Eastern cottontail	168	7.1	7.2	1	±24	167	5.4	34	±24	149	6.6	18	±22
White-tailed jackrabbit	168	0.1	0.1	51	±140	167	0.2	-23	±66	149	1.7	-90	±14
White-tailed deer	168	21.2	27.5	30	±23	167	16.5	67	±26	168	10.9	149	±40
Mourning dove	168	184.2	144.1	-22	±16	167	203.2	-29	±11	149	267.2	-44	±8
Sandhill crane[d]													
Total cranes	168	16.0	15.7	-2	±26								
Juveniles	168	1.3	2.2	62	±57								

[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 1955-2015, except for deer (1974-2015). Estimates for all species except deer based on routes (*n*) surveyed ≥40 years; estimates for deer based on routes surveyed ≥25 years. Thus, Northwest region (8 counties in Northwest were added to survey in 1982) included only for deer.

[d]Cranes were added to the survey in 2009; thus, 10-year and long-term averages are not calculated.

Table 3. Regional trends (% change) in number of wildlife observed per 100 miles driven, Minnesota August roadside survey, 1955-2016.

Region	Change from 2015[a]					Change from 10-year average[b]				Change from long-term average[c]			
Species	*n*	2015	2016	%	95% CI	*n*	2006-15	%	95% CI	*n*	LTA	%	95% CI
Northwest[d]													
Gray partridge	19	0.8	0.0	-100	±144	19	0.6	-100	±101	19	3.2	-100	±66
Eastern cottontail	19	1.3	2.1	64	±153	19	0.5	277	±315	19	0.8	155	±199
White-tailed jackrabbit	19	0.2	0.0	-100	±210	19	0.3	-100	±64	19	0.6	-100	±42
White-tailed deer	19	58.7	69.0	18	±53	19	43.4	59	±67	19	32.2	114	±80
Mourning dove	19	85.3	116.2	36	±52	19	89.7	30	±54	19	118.4	-2	±38
Sandhill crane[e]	19	65.7	65.2	-1	±37								
West Central[f]													
Ring-necked pheasant	39	46.3	50.8	10	±38	35	67.5	-30	±22	37	96.9	-54	±15
Gray partridge	39	0.2	0.0	-100	±202	35	0.8	-100	±96	37	9.4	-100	±21
Eastern cottontail	39	2.6	3.4	32	±67	35	2.6	31	±56	37	3.9	-18	±32
White-tailed jackrabbit	39	0.1	0.3	200	±405	35	0.2	97	±209	37	2.2	-85	±26
White-tailed deer	39	17.4	31.5	81	±58	35	15.9	110	±58	37	10.4	205	±104
Mourning dove	39	281.4	189.8	-33	±23	35	245.6	-22	±18	37	366.5	-48	±13
Sandhill crane	39	3.7	1.7	-53	±92								
Central													
Ring-necked pheasant	27	26.7	45.8	72	±74	29	48.3	-11	±39	28	70.9	-39	±26
Gray partridge	27	0.0	2.5			29	1.3	87	±297	28	9.1	-73	±47
Eastern cottontail	27	4.6	7.3	58	±78	29	4.7	46	±85	28	6.2	15	±62
White-tailed jackrabbit	27	0.0	0.0			29	0.1	-100	±97	28	1.1	-100	±23
White-tailed deer	27	20.4	23.3	14	±39	29	11.5	94	±60	28	6.2	260	±132
Mourning dove	27	123.1	145.1	18	±67	29	176.6	-16	±37	28	227.6	-33	±31
Sandhill crane	27	20.3	25.5	25	±64								
East Central													
Ring-necked pheasant	13	46.2	54.1	27	±56	13	53.8	1	±52	13	85.0	-36	±42
Gray partridge	13	0.0	0.0			13	0.0			13	0.1	-100	±147
Eastern cottontail	13	8.8	21.5	143	±103	13	10.3	109	±80	13	8.7	148	±102
White-tailed jackrabbit	13	0.0	0.0			13	0.0			13	0.2	-100	±64
White-tailed deer	13	22.4	30.1	34	±41	13	17.3	74	±67	13	10.1	198	±116
Mourning dove	13	75.2	62.9	-16	±41	13	101.3	-38	±20	13	116.4	-46	±27
Sandhill crane	13	54.6	42.3	-23	±66								

Table 3. Continued.

Region / Species	Change from 2015 n	2015	2016	%	95% CI	Change from 10-year average n	2006-15	%	95% CI	Change from long-term average n	LTA	%	95% CI
Southwest													
Ring-necked pheasant	19	76.4	96.0	26	±55	19	110.4	-13	±31	19	113.8	-16	±33
Gray partridge	19	1.9	9.7	411	±732	19	10.7	-9	±140	19	39.1	-75	±36
Eastern cottontail	19	10.7	6.1	-43	±61	19	6.1	0	±69	19	8.0	-24	±51
White-tailed jackrabbit	19	0.4	0.4	0	±153	19	0.7	-41	±106	19	3.6	-88	±20
White-tailed deer	19	18.5	27.8	50	±73	19	17.1	62	±64	19	10.1	176	±110
Mourning dove	19	263.8	182.1	-31	±37	19	307.2	-41	±18	19	309.7	-41	±21
Sandhill crane	19	0.0	0.0										
South Central													
Ring-necked pheasant	32	31.0	52.6	70	±48	32	56.2	-6	±25	32	124.3	-58	±17
Gray partridge	32	6.1	7.5	22	±83	32	7.0	7	±72	32	18.1	-59	±39
Eastern cottontail	32	11.6	9.5	-18	±39	32	8.1	18	±38	32	7.7	24	±36
White-tailed jackrabbit	32	0.0	0.1			32	0.1	0	±224	32	1.6	-92	±27
White-tailed deer	32	6.1	7.5	22	±66	32	5.8	29	±59	32	3.9	94	±87
Mourning dove	32	199.9	144.1	-28	±44	32	264.1	-45	±27	32	256.4	-44	±8
Sandhill crane	32	0.9	2.1	143	±165								
Southeast													
Ring-necked pheasant	19	26.0	17.9	-31	±64	20	14.3	19	±67	20	69.1	-75	±35
Gray partridge	19	6.5	6.5	0	±106	20	5.2	20	±156	20	13.2	-53	±58
Eastern cottontail	19	13.4	7.5	-44	±45	20	7.5	0	±42	20	7.8	-6	±50
White-tailed jackrabbit	19	0.0	0.0			20	0.0			20	0.6	-100	±42
White-tailed deer	19	19.1	14.9	-22	±67	20	15.3	0	±52	20	10.9	42	±56
Mourning dove	19	133.1	94.3	-29	±34	20	145.9	-37	±17	20	214.1	-57	±18
Sandhill crane	19	0.4	1.5	246	±365								

[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 1955-2015, except for Northwest region (1982-2015) and white-tailed deer (1974-2015). Estimates based on routes (*n*) surveyed ≥40 years (1955-2015), 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.

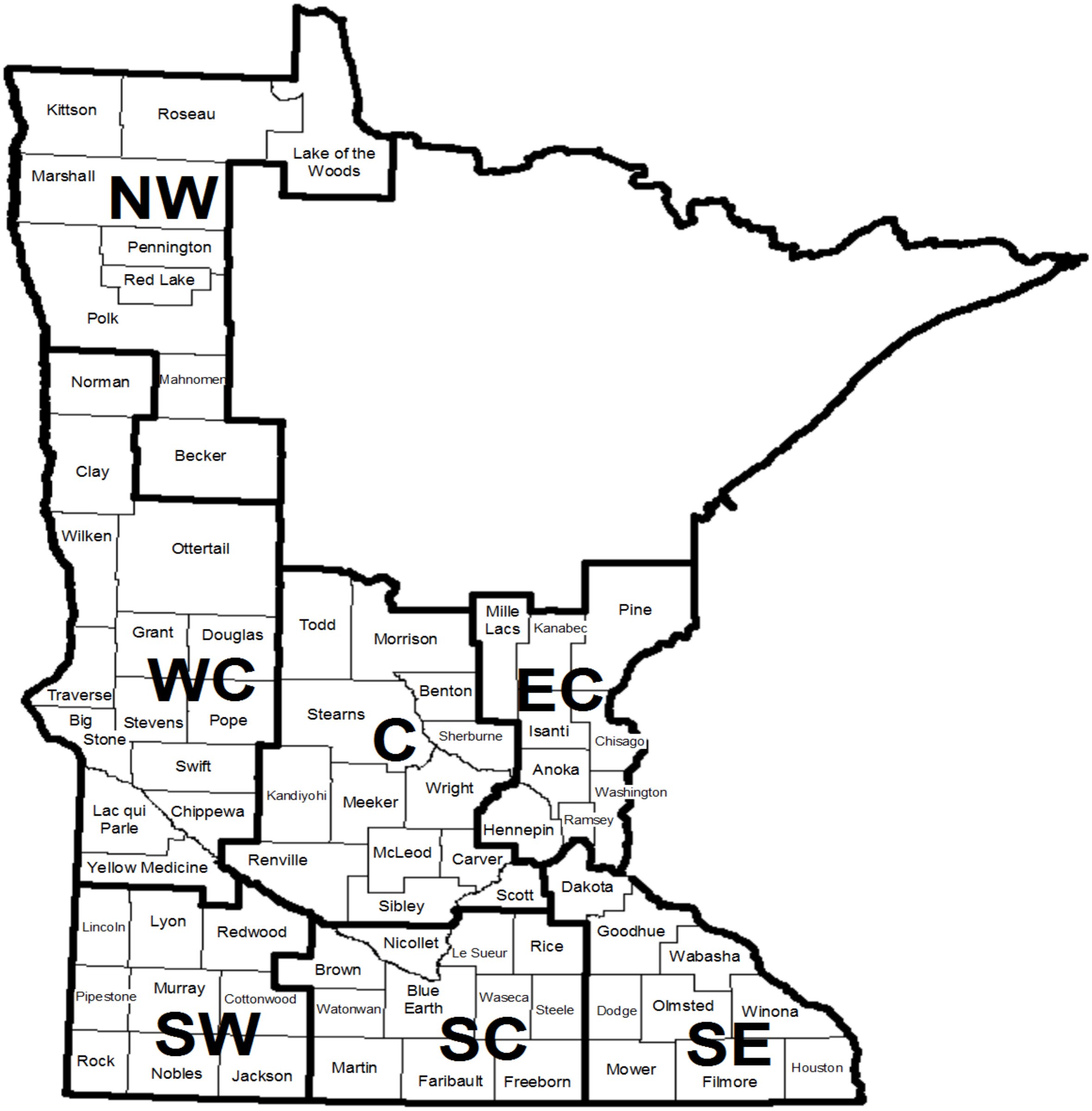


Figure 1. Survey regions for Minnesota's August roadside survey, 2016.

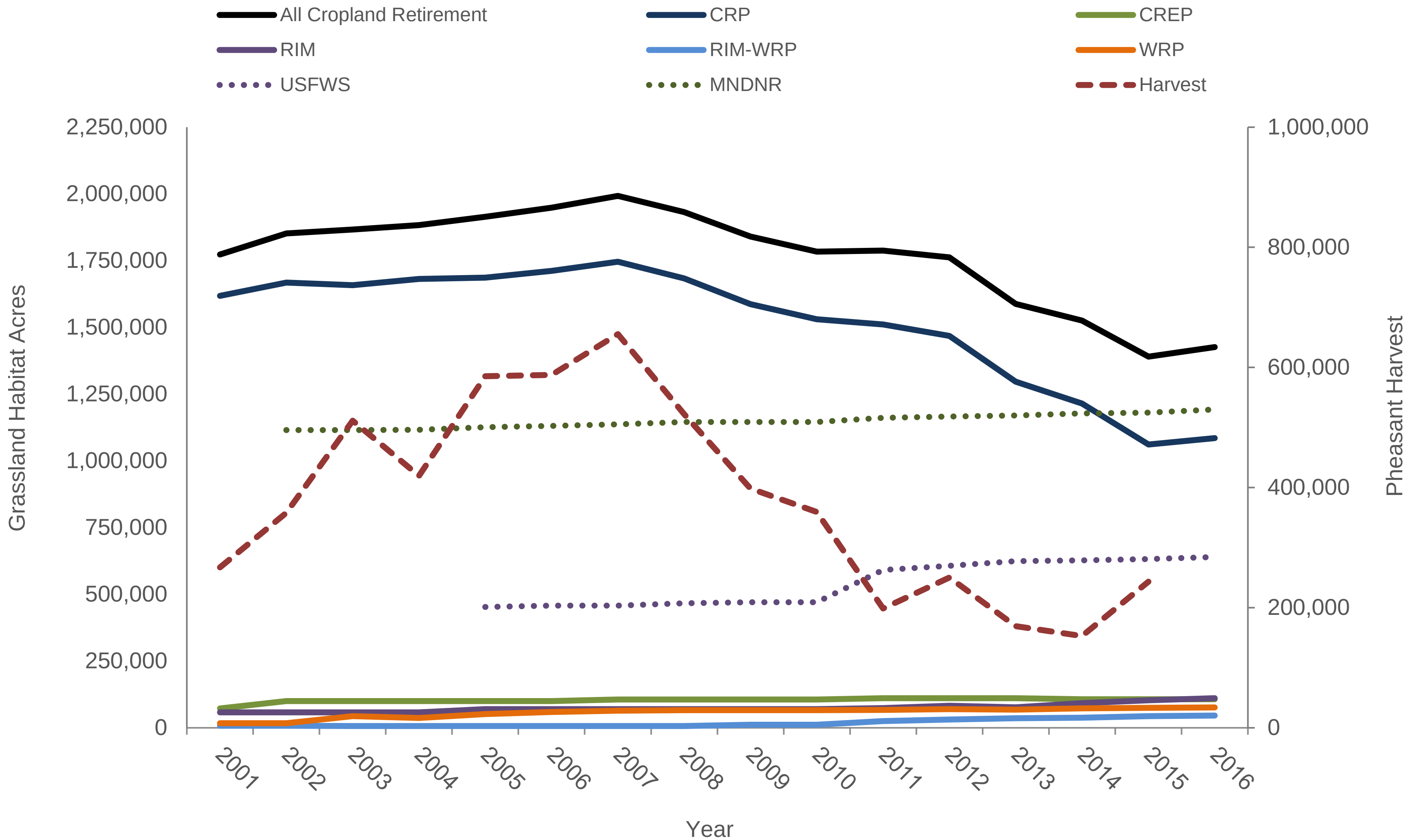
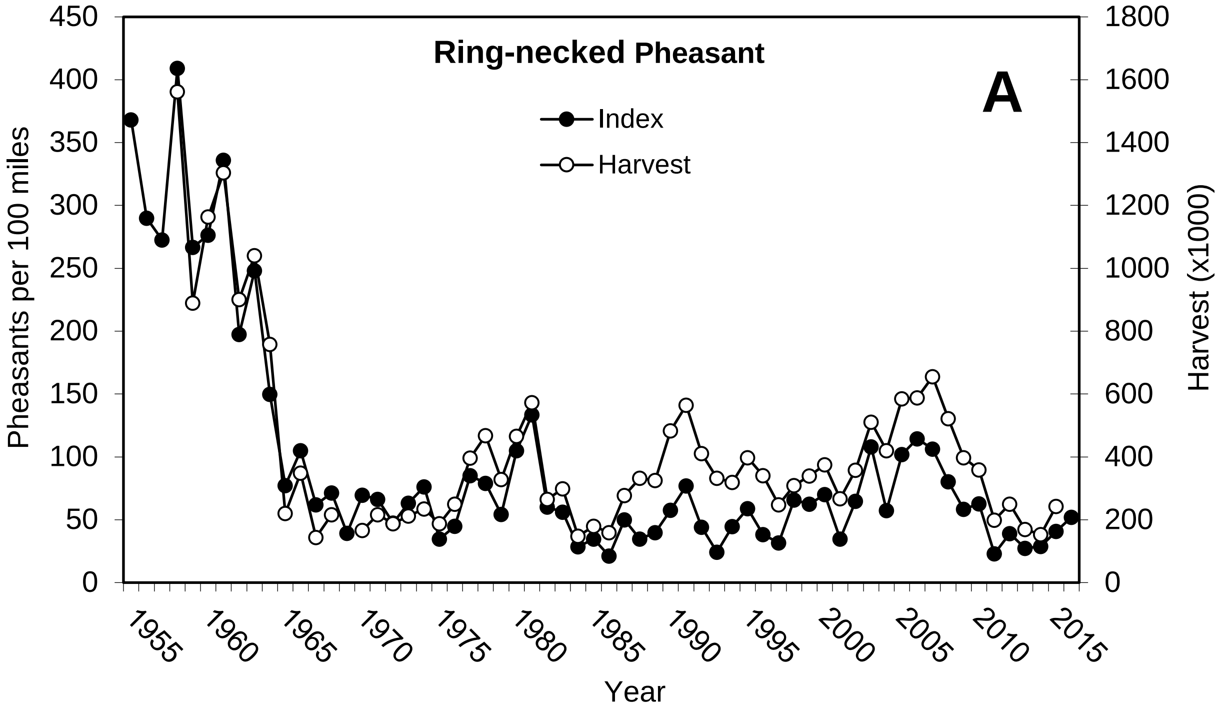


Figure 2. Acres enrolled in private and public land habitat conservation programs vs. ring-necked pheasant harvest trends in Minnesota, 2001-2016. Acres are calculated for the **entire state**.



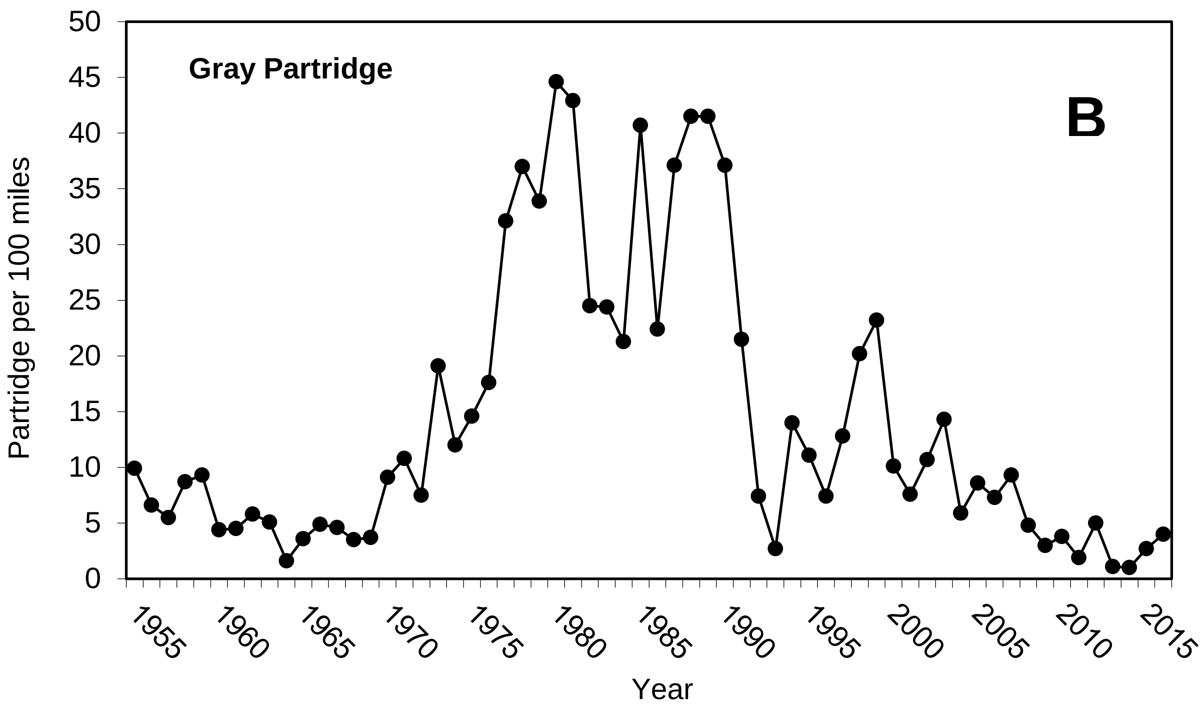


Figure 3. Range-wide index of ring-necked pheasants (**A**) and gray partridge (**B**) seen per 100 miles driven in Minnesota, 1955-2016. Does not include the Northwest region. Based on all survey routes completed.

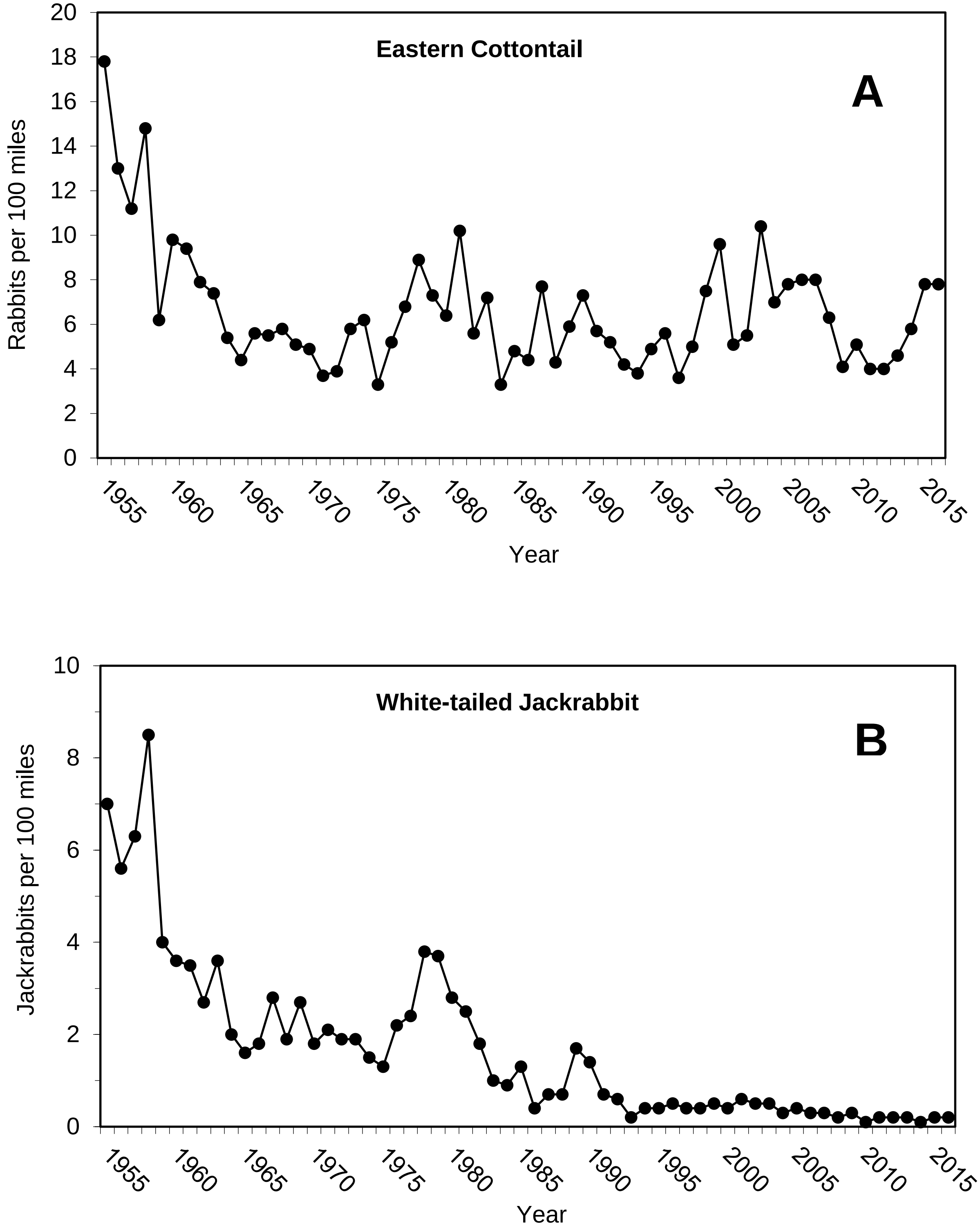
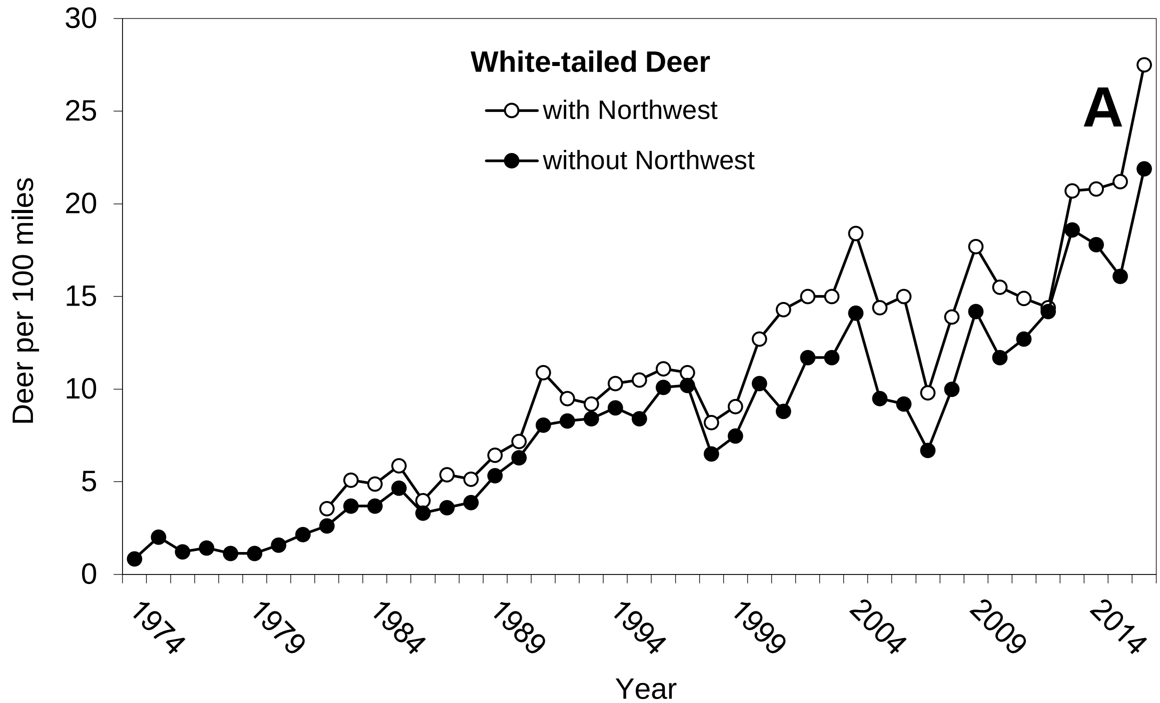


Figure 4. Range-wide index of eastern cottontail (A) and white-tailed jackrabbits (B) seen per 100 miles driven in Minnesota, 1955-2016. Does not include the Northwest region. Based on all survey routes completed.



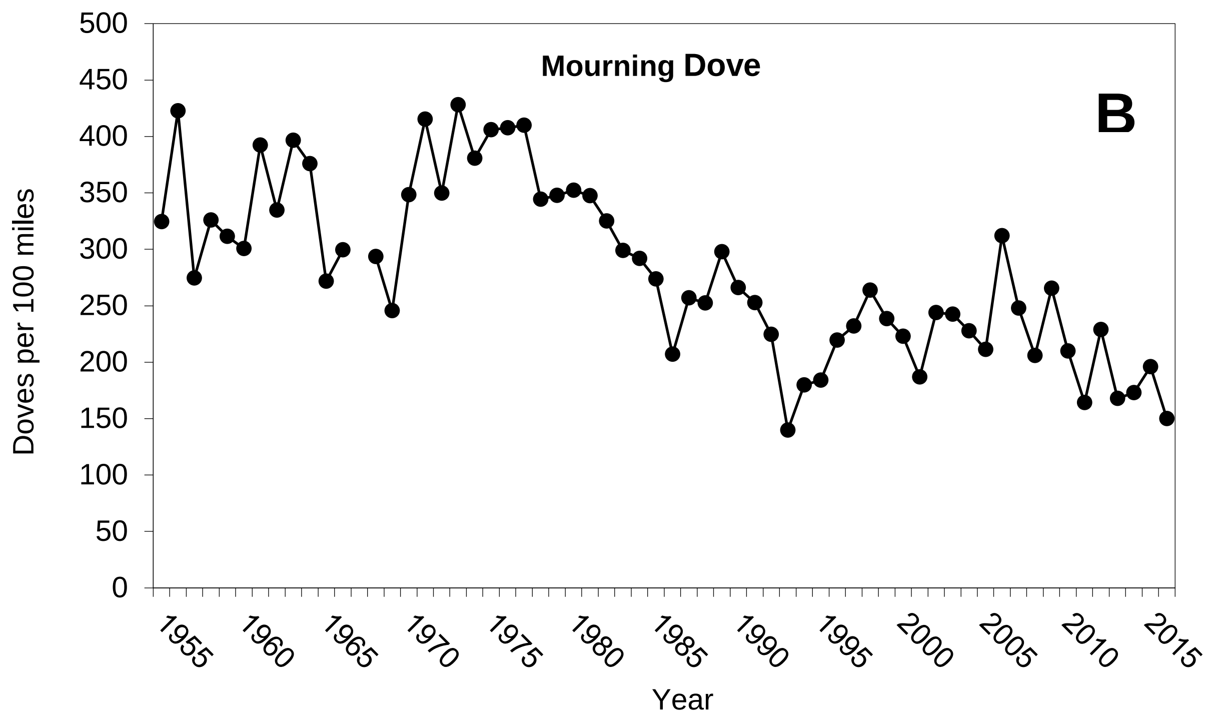


Figure 5. Range-wide index of: **(A)** white-tailed deer seen per 100 miles driven in Minnesota, 1974-2016, with and without the Northwest region included; and **(B)** mourning doves seen per 100 miles driven in Minnesota, 1955-2016. Doves were not counted in 1967 and the dove index does not include the Northwest region. Based on all survey routes completed.

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA - 2016

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INTRODUCTION

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

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

METHODS

Model Structure

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

Within each annual cycle, we applied age-specific fecundity rates to females to estimate reproduction. All age- and sex-classes were subjected to spring/summer mortality, and the result was the pre-hunt fall population. Deer harvested 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, which were within a range of values reported for Minnesota and Wisconsin (MNDNR unpublished data, Fuller 1990, McCaffery et al. 1998, DelGiudice et al. 2007, Dunbar 2007, Grund 2011, Wisconsin Department of Natural Resources 2014). Fecundity rates were partitioned by 2 age-classes of breeding females (i.e., yearlings <1.0

years old when bred and adults ≥1.0 years old when bred) and were allowed to vary by 3 eco-geographic zones (northeast, farmland-forest transition areas, southeast) that reflected relative differences in habitat quality. Fecundity rates were estimated to be lowest in the northeast (yearlings, mean = 0.06 [SD = 0.01]; adults, mean = 1.55 [SD = 0.03]), moderate in the farmland-forest transition zone (yearlings, mean = 0.10 [SD = 0.01]; adults, mean = 1.75 [SD = 0.03]), and greatest in the southeast (yearlings, mean = 0.15 [SD = 0.01]; adults, mean = 1.85 [SD = 0.03]). The sex ratio of fawns at birth in most deer populations is approximately 50:50, but may vary annually (Ditchkoff 2011). We allowed the proportion of male fawns at birth to vary between 0.48-0.52.

Spring/Summer Survival

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

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

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

Fall Harvest and Survival

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

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

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

Winter Survival

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

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

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. To further refine the initial population density, we incrementally increased and decreased the density and re-examined the modeled trend relative to the aforementioned indices. In some cases, we also adjusted spring/summer survival of adult females ≤0.10 in conjunction with varying initial population densities.

We ran each model simulation for 7 years (2010-2016) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring 2016). All simulations were performed with the R programming language (ver. 3.1.2, R Core Team 2015). We used 500 Monte Carlo simulations (simulated draws from the stochastic distributions) until the most reasonable set of starting parameters was determined, and then used 5,000 simulations for the final run.

It is not logistically or financially feasible to conduct field studies on deer populations across all DPAs with regularity to estimate model input parameters. Population modeling requires researchers to make assumptions about these data based on prior studies (Hansen 2011). Since 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 112 of 128 DPAs in Minnesota to estimate deer densities before reproduction during spring 2016 (Table 1, Figure 2).

Following 2 deer seasons with relatively conservative management designations and 2 winters with mild conditions across most of the state, deer populations in most DPAs have increased. Fewer opportunities to harvest deer with either-sex permits in 2014 protected female deer and fawn males from harvest. This allowed a carry-over of fawn males, which were antlered bucks legal for harvest during the 2015 season. In 2015, buck harvest was more than 98,000 deer, which was >5% above the average for the previous 5 years. Consistent with this trend, substantial numbers of female deer were protected from harvest during 2014 and 2015, and population growth was accelerated.

Deer populations in most DPAs were approaching goal levels by spring 2016, and recommendations from MNDNR research for the 2016 deer season were aimed at identifying consistent regulations to stabilize deer densities. In terms of management intensity, the 2016 research recommendations would afford approximately 14% more antlerless deer harvest opportunities to hunters versus the 2015 season.

Farmland Zone

Deer populations in the majority of farmland DPAs were near goal levels. Antlerless harvest in the farmland was closely tied to the number of either-sex permits. We selected management designations to stabilize deer numbers with consistent regulations across years whenever possible. Two-thirds of DPAs in the farmland region were recommended for moderate to high allocations of either-sex permits. In the southeastern farmland, Hunters Choice and Managed designations were required to stabilize deer numbers at appropriate levels.

Farmland-Forest Transition Zone

Deer populations in the Farmland-Forest Transition Zone are highly productive due to excellent habitat and generally milder winters as compared to the Forest Zone. Historical harvests and modeled population trends suggested that Lottery designations were not sufficient to stabilize deer numbers in most transition zone DPAs. For the 2016 season, 50% of transition zone DPAs were recommended for Hunters Choice and another 25% were recommended for Managed. In DPAs 346 and 349, Intensive designations with DPA-wide early antlerless seasons will be necessary in 2016 to continue reducing deer densities toward goal levels.

Forest Zone

Many deer populations in the Forest Zone were still recovering from the severe winter of 2013-14. Five DPAs were recommended for Bucks Only in 2016, and one-third were recommended for a low allocation of either-sex permits. Four DPAs in the moose range were recommended for Hunters Choice. With relatively low hunter numbers in DPAs 117, 127, and 126, it is necessary to provide hunters with sufficient opportunities to harvest antlerless deer to maintain deer densities near goal levels over time. Most DPAs in the southern Forest Zone were recommended for moderate Lottery levels to begin stabilizing deer populations.

LITERATURE CITED

BRINKMAN, T. J., J. A. JENKS, C. S. DEPERNO, B. S. HAROLDSON, and R. G. OSBORN. 2004. Survival of white-tailed deer in an intensively farmed region of Minnesota. Wildlife Society Bulletin 32:1-7.

CARSTENSEN, M., G. D. DELGIUDICE, B. A. SAMPSON, and D. W. KUEHN. 2009. Survival, birth characteristics, and cause-specific mortality of white-tailed deer neonates. Journal of Wildlife Management 73:175-183.

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

DELGIUDICE, G. D., J. FIEBERG, M. R. RIGGS, M. CARSTENSEN POWELL, and W. PAN. 2006. A long-term age-specific survival analysis of female white-tailed deer. Journal of Wildlife Management 70:1556-1568.

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

DEPERNO, C. S., J. A. JENKS, S. L. GRIFFIN, and L. A. RICE. 2000. Female survival rates in a declining white-tailed deer population. Wildlife Society Bulletin 28:1030-1037.

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

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

DUMONT, A., M. CRETE, J. OUELLET, J. HUOT, and J. LAMOUREUX. 2000. Population dynamics of northern white-tailed deer during mild winters: evidence of regulation by food competition. Canadian Journal of Zoology 78:764-776.

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

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

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

GROVENBURG, T. W., C. N. JACQUES, C. S. DEPERNO, R. W. KLAVER, and J. A. JENKS. 2011. Female white-tailed deer survival across ecoregions in Minnesota and South Dakota. American Midland Naturalist 165:426-435.

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

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

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

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

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

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

HILLER, T. L., H. CAMPA, S. WINTERSTEIN, and B. A. RUDOLPH. 2008. Survival and space use of fawn white-tailed deer in southern Michigan. American Midland Naturalist 159:403-412.

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

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

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

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

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

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

NIXON, C. M., L. P. HANSEN, P. A. BREWER, and J. E. CHELSVIG. 1991. Ecology of white-tailed deer in an intensively farmed region of Illinois. Wildlife Monographs 118.

NIXON, C. M., L. P. HANSEN, P. A. BREWER, J. E. CHELSVIG, T. L. ESKER, D. ETTER, J. B. SULLIVAN, R. G. KOERKENMEIER, and P. C. MANKIN. 2001. Survival of white-tailed deer in intensively farmed areas of Illinois. Canadian Journal of Zoology 79:581-588.

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

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

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

VAN DEELEN, T. R., H. CAMPA, J. B. HAUFLER, and P. D. THOMPSON. 1997. Mortality patterns of white-tailed deer in Michigan's upper Peninsula. Journal of Wildlife Management 61:903-910.

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

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

WHITLAW, H. A., W. B. BALLARD, D. L. SABINE, S. J. YOUNG, R. A. JENKINS, and G. J. FORBES. 1998. Survival and cause-specific mortality rates of adult white-tailed deer in New Brunswick. Journal of Wildlife Management 62:1335-134.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES. 2014. County deer advisory council deer metrics, Adams County, fall 2014. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Table 1. Estimated mean pre-fawn deer densities (deer/mi^2) derived from population model simulations in Minnesota deer permit areas, 2010-2016.

		Pre-fawn deer density[a]						
Deer Permit Area	Land area (mi^2)	2010	2011	2012	2013	2014	2015	2016
101	496	-	-	-	-	-	-	-
103	1820	4	4	4	4	3	3	4
105	740	15	14	17	17	13	14	17
108	1651	6	6	7	7	5	5	7
110	529	18	16	17	15	11	11	14
111	1438	3	3	3	3	2	3	3
114	116	-	-	-	-	-	-	-
117	927	-	-	-	-	-	-	-
118	1220	5	5	5	5	4	4	4
119	770	8	7	8	8	5	5	7
122	603	6	5	5	5	3	4	5
126	942	4	4	4	5	3	3	3
127	564	-	-	-	-	-	-	-
152	61	-	-	-	-	-	-	-
155	593	17	17	18	19	16	18	23
156	825	16	16	16	15	10	10	12
157	673	21	21	21	22	23	24	28
159	571	17	16	16	17	12	14	16
169	1124	13	12	14	13	9	10	12
171	701	12	12	13	13	11	12	15
172	687	20	21	21	23	20	23	28

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

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]						
		2010	2011	2012	2013	2014	2015	2016
173	584	10	10	11	11	8	8	10
176	1113	13	12	14	14	9	10	13
177	480	22	19	20	20	13	14	17
178	1280	16	13	13	13	8	8	10
179	862	20	18	18	18	11	11	13
180	977	12	9	10	10	5	6	7
181	708	18	15	14	14	9	10	13
182	267	-	-	-	-	-	-	-
183	663	14	14	15	16	11	11	15
184	1229	22	21	23	22	17	19	23
197	955	13	12	13	12	9	10	12
199	148	-	-	-	-	-	-	-
201	161	-	-	-	-	-	-	-
203	83	-	-	-	-	-	-	-
208	414	6	6	6	6	6	7	9
209	640	9	9	9	9	7	8	9
210	615	15	13	14	13	10	11	13
213	1057	15	14	15	17	18	20	25
214	554	22	23	26	27	25	26	30
215	701	15	16	18	19	19	20	22
218	884	8	9	9	10	10	11	13
219	391	11	12	12	14	15	17	19
221	642	14	14	15	16	14	14	18

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

Deer Permit Area	Land area (mi^2)	Pre-fawn deer density[a]						
		2010	2011	2012	2013	2014	2015	2016
222	413	16	16	17	17	15	15	18
223	376	11	12	13	15	15	16	18
224	47	-	-	-	-	-	-	-
225	618	18	18	19	21	19	20	24
227	472	17	18	19	20	18	20	22
229	284	7	7	8	9	10	12	15
230	452	4	4	4	4	4	4	4
232	377	6	5	6	6	6	7	8
233	385	5	4	4	5	5	5	5
234	636	2	2	2	3	3	3	3
235	34	-	-	-	-	-	-	-
236	370	16	16	16	17	16	17	19
237	728	2	2	3	3	3	3	3
238	95	-	-	-	-	-	-	-
239	919	14	14	15	16	16	18	21
240	643	21	21	23	25	25	26	31
241	996	33	33	36	40	35	38	44
242	214	22	21	21	19	15	14	15
246	840	16	17	17	17	16	18	22
247	228	18	19	20	20	18	19	23
248	214	19	19	20	19	16	16	18
249	502	17	16	17	18	16	16	20
250	713	3	3	3	4	4	5	6

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

		Pre-fawn deer density[a]						
Deer Permit Area	Land area (mi^2)	2010	2011	2012	2013	2014	2015	2016
251	55	-	-	-	-	-	-	-
252	715	3	3	4	4	5	5	7
253	974	3	3	4	4	5	6	7
254	929	4	4	4	4	4	5	5
255	774	4	4	5	5	5	6	7
256	654	7	7	7	8	8	9	10
257	412	9	9	10	11	10	11	13
258	343	23	22	25	26	23	26	34
259	490	28	27	29	28	23	27	34
260	1249	3	3	4	4	4	5	6
261	795	2	2	3	3	4	4	6
262	677	2	2	2	3	3	3	4
263	512	9	9	11	12	11	13	17
264	669	11	11	13	15	14	16	21
265	494	8	8	9	11	11	13	16
266	617	5	5	5	6	7	8	10
267	472	6	6	7	9	7	9	12
268	228	12	11	13	15	13	15	19
269	650	3	3	3	3	3	4	5
270	748	2	2	2	2	2	3	4
271	632	3	3	3	3	4	5	7
272	531	2	2	2	3	3	4	5
273	571	6	6	6	6	7	9	11

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

		Pre-fawn deer density[a]						
Deer Permit Area	Land area (mi^2)	2010	2011	2012	2013	2014	2015	2016
274	354	5	4	5	6	7	8	10
275	764	4	3	3	4	4	5	6
276	542	8	7	8	9	9	10	12
277	812	12	11	12	15	17	21	25
278	402	6	6	6	8	9	11	15
279	344	4	4	4	5	5	5	6
280	675	2	2	2	3	3	3	4
281	575	6	5	5	6	7	8	9
282	778	2	2	2	2	2	3	4
283	613	4	3	4	4	5	5	7
284	838	3	3	3	4	5	5	7
285	549	5	5	5	6	6	6	
286	446	5	5	5	6	6	7	8
287	46	-	-	-	-	-	-	-
288	625	6	6	6	6	6	6	7
289	815	2	2	2	3	3	4	4
290	662	5	5	5	5	6	6	7
291	800	6	6	6	7	7	8	9
292	479	8	8	8	10	11	13	16
293	511	9	8	8	9	9	9	10
294	686	3	3	4	4	5	5	6
295	839	4	4	4	5	6	7	8
296	667	4	4	4	5	5	6	7

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

		Pre-fawn deer density[a]						
Deer Permit Area	Land area (mi^2)	2010	2011	2012	2013	2014	2015	2016
297	438	3	3	4	4	4	5	6
298	618	10	9	10	10	9	12	15
299	386	5	5	6	6	7	8	8
338	454	5	6	6	6	6	7	7
339	394	6	6	7	7	8	8	9
341	612	13	13	13	14	14	16	18
342	349	16	17	17	17	17	19	20
343	663	12	12	13	14	14	14	14
344	190	-	-	-	-	-	-	-
345	323	11	12	13	15	15	16	18
346	318	28	31	32	34	34	32	29
347	434	9	10	11	11	11	11	12
348	332	16	16	17	17	16	16	17
349	490	23	25	25	26	26	24	20
601	1625	-	-	-	-	-	-	-

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

Figure 1. Model structure for simulations of white-tailed deer populations in Minnesota, 2015.

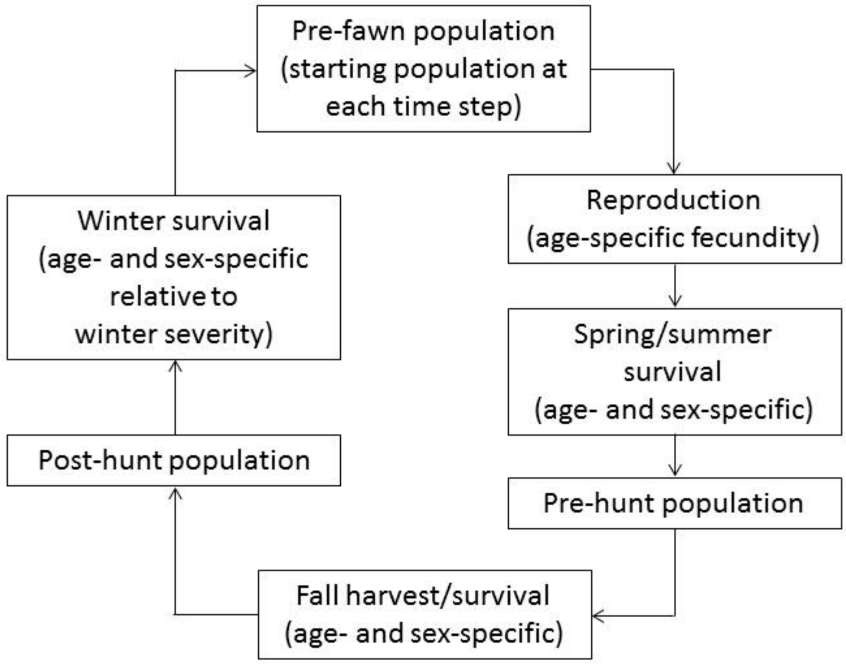
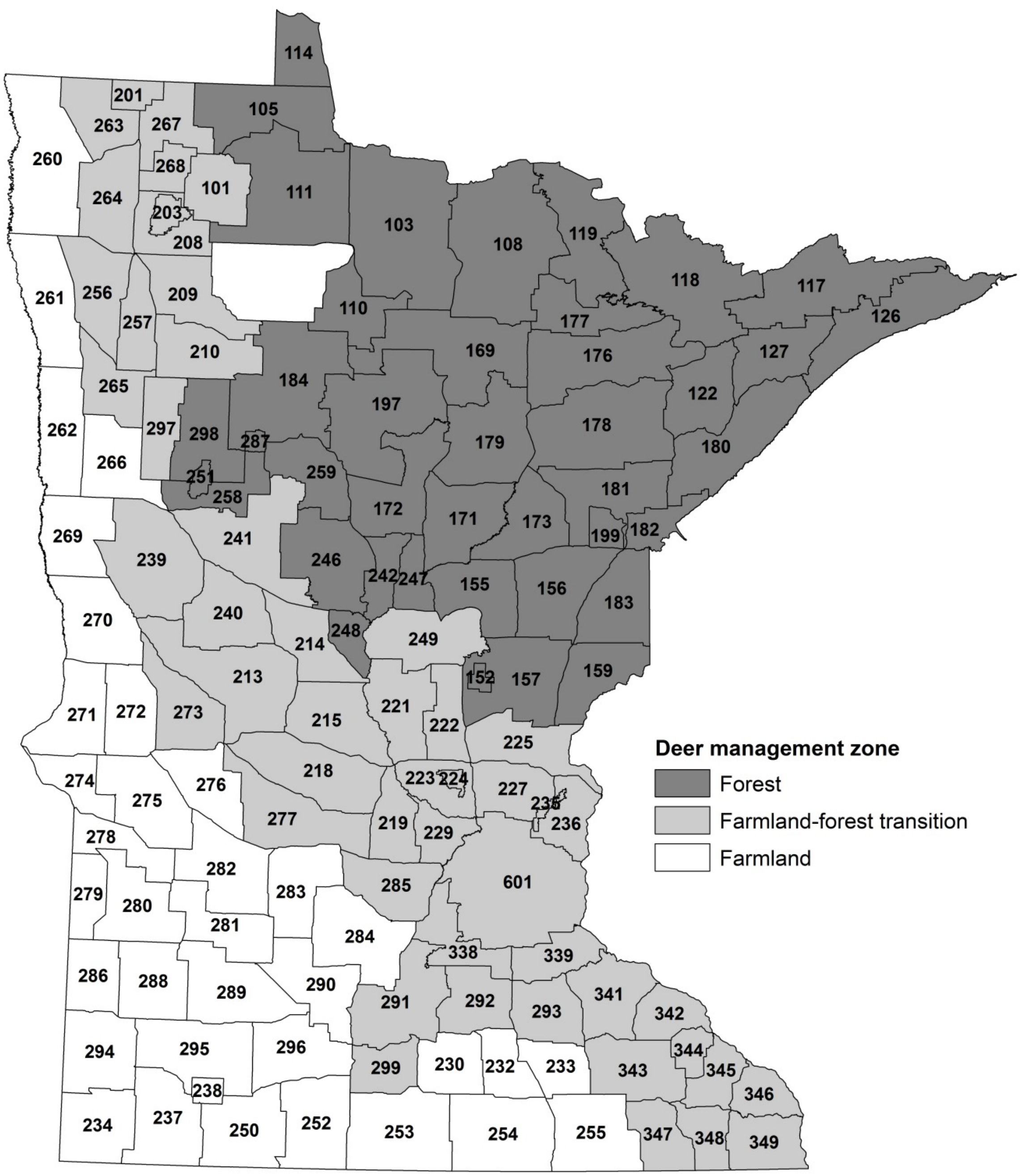


Figure 2. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2016. DPAs were assigned to forest, farmland-forest transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of >60% woody cover, farmland-forest transition DPAs were composed of 6%-50% woody cover, and farmland DPAs were composed of <5% woody cover.



2016 WHITE-TAILED DEER SURVEYS

Brian S. Haroldson, Farmland Wildlife Populations and Research Group

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 112 permit areas (PA) to estimate and track changes in white-tailed deer (*Odocoileus virginianus*) abundance and, subsequently, to aid in developing harvest recommendations to manage deer populations toward goal levels. In general, model inputs include estimates of initial population size, 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 that were within 20% of the true population size with 90% confidence (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. heimonus*; Bartmann et al. 1986) in a variety of habitat types. Within each PA, quadrats were delineated by Public Land Survey section 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 2012), and R package ’stratification’ (Baillargeon and Rivest 2012) 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). In some PAs, an additional stratum was constructed to encompass State Park boundaries where applicable. We used optimal allocation, R package ‘spsurvey’ (Kincaid and Olsen 2012), 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 helicopters and attempted to maintain flight altitude at 60 m above ground level and airspeed at 64-80 km/hr. A pilot and 2 observers searched for deer along transects spaced at 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 minimize visibility bias, we completed surveys during winter (January-February) when snow cover measured at least 15 cm and we varied survey intensity as a function of cover and deer numbers (Gasaway et al. 1986). We estimated deer abundance using R package ‘spsurvey’ (Kincaid and Olsen 2012). 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).

We implemented double sampling (Eberhardt and Simmons 1987, Thompson 2002) on a subsample of quadrats in each PA to estimate sightability of deer from the helicopter. For each PA, we sorted the sample of survey quadrats by woody cover abundance, excluded quadrats likely to contain no deer (e.g., low stratum quadrats or quadrats where woody cover < 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 (48-64 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.

RESULTS AND DISCUSSION

We completed 5 surveys during 2016 (Table 1). We utilized a simple random sample in PA 248 after stratifying by ownership (e.g., Camp Ripley Military Reservation, other), whereas PAs 341, 343, 345, and 347 were stratified using the relationship between woody cover abundance per quadrat and historic deer density. In PAs 248, 343, and 347, sampling rate exceeded 20% to incorporate additional quadrats within Camp Ripley Military Reservation, Chester Woods County Park, and Forestville State Park, respectively. Deer density estimates ranged from 11-18 deer/mi^2 throughout all PAs and, except for PA 345, all estimates met precision goals (relative error $\leq$ 20%). Deer were observed in 59-82% of sample quadrats in the 5 surveyed areas, with greater occupancy generally 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 0.697 (SE = 0.026) in PA 248 to 0.800 (SE = 0.019) in PA 347 and averaged 0.734 (SE = 0.048), which were similar to sightability estimates during 2009-2014 (range = 0.633-0.909). Correcting for sightability increased relative variance (CV [%]) of population estimates by 3.9-8.0%, which was a reasonable tradeoff between decreased bias and increased variance, although costs associated with the sightability surveys are also important. However, we caution that our sightability estimates are conditional on animals being available for detection (Johnson 2008, Nichols et al. 2009). Unfortunately, like many other wildlife surveys, we have no estimates of availability or how it varies over space and time. Our approach also assumes that sightability is constant across animals and quadrats. Heterogeneity in detection probabilities can lead to biased estimates of abundance. Common methods for correcting for heterogeneous detection probabilities include distance sampling, mark-recapture methods, and logistic-regression sightability models (based on radio-marked animals). We did not have marked animals in our populations, and relatively high densities of deer in our survey areas would present serious logistical and statistical problems for distance-sampling and double-observer methods. Therefore, our double-sampling approach is a reasonable alternative to using unadjusted counts or applying more complicated methods whose assumptions are tenuous. Nevertheless, our "adjusted" population estimates must still be viewed as approximations to the truth.

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LITERATURE CITED

Baillargeon, S., and L. Rivest. 2012. Stratification: univariate stratification of survey populations. R package ver. 2.2-3. <http://CRAN.R-project.org/package=stratification>. Accessed November 2012.

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

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

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

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

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

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

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

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

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

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

Kincaid, T. M., and A. R. Olsen. 2012. Spsurvey: spatial survey design and analysis. R package version 2.5. <http://www.epa.gov/nheerl/arm>. Accessed March 2016.

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

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

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

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

R Core Team. 2012. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org>. Accessed March 2016.

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

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

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

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

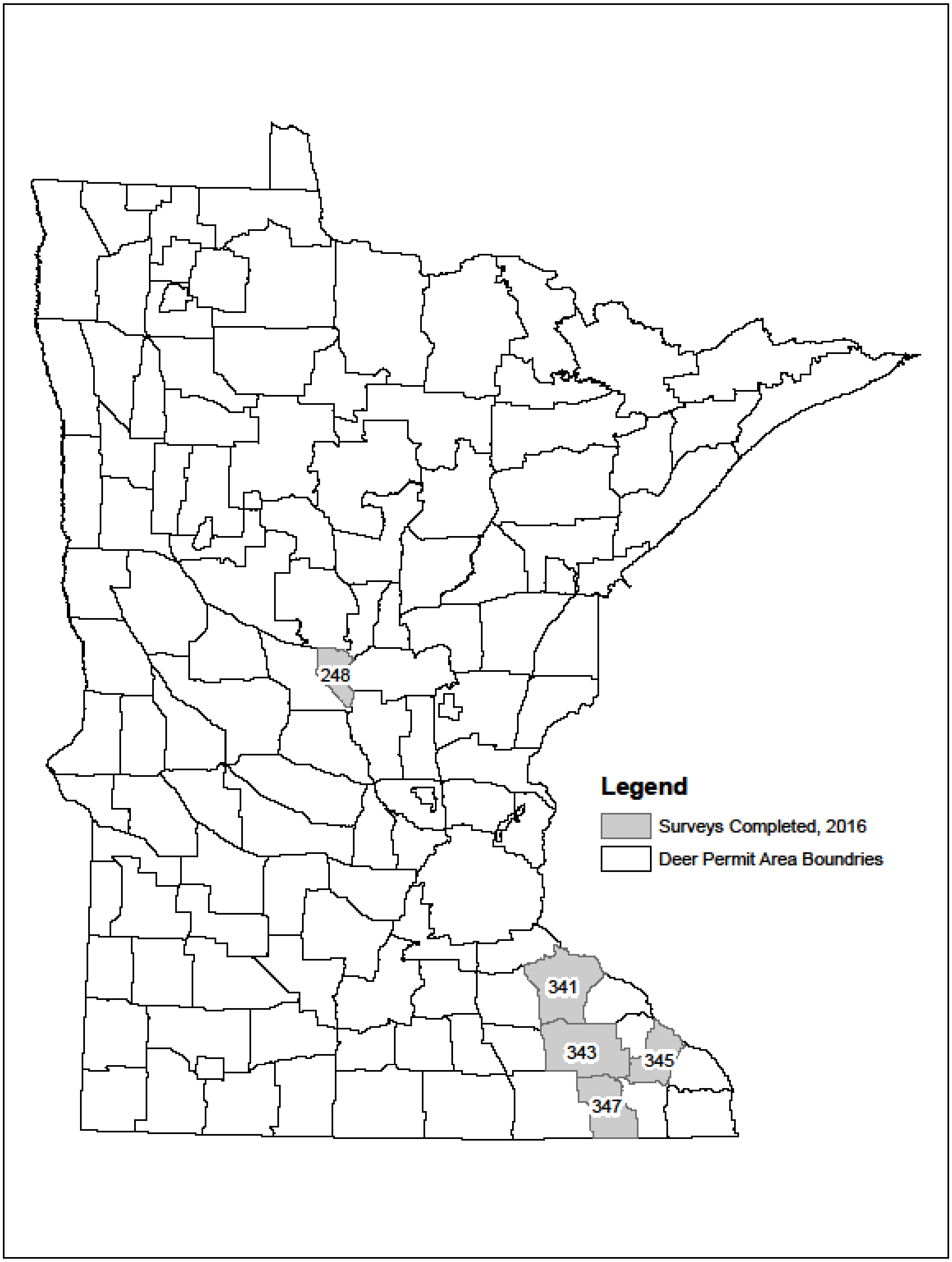

Figure 1. Aerial deer surveys completed in Minnesota, 2016

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Table 1. Deer population and density (deer/mi^2) estimates derived from aerial surveys in Minnesota, 2016.

Permit area	Sampling rate	Detection rate	Population estimate		CV (%)	Relative error (%)[a]	Density estimate	
			N	90% CI			Mean	90% CI
248	0.23[b]	0.697	3,709	3,093 – 4,325	10.1	16.6	17	14 – 20
341	0.20	0.751	11,503	10,475 – 12,531	5.4	8.9	18	17 – 20
343	0.22[c]	0.717	9,268	8,170 – 10,366	7.2	11.8	15	13 – 17
345	0.20	0.703	6,162	4,806 – 7,518	13.4	22.0	18	14 – 22
347	0.24[d]	0.800	4,596	3,949 – 5,243	8.6	14.1	11	9 – 12

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

[b]Includes a 29% sampling rate within Camp Ripley Military Reservation.

[c]Includes Chester Woods County Park.

[d]Includes Forestville State Park.

Table 2. Sampling metrics from aerial deer surveys in Minnesota, 2016.

Permit area	Quadrats in permit area	Quadrats sampled	Quadrats occupied[a]	Deer observed	Deer groups observed	Groups / occupied quadrat		Group size / occupied quadrat		Maximum quadrat count
						mean	range	mean	range	
248	218	51	42	604	183	4	1-14	3	1-11	57
341	626	126	98	2,366	702	7	1-22	3	1-20	94
343	627	137	84	2,334	460	5	1-18	5	1-32	114
345	338	68	40	1,004	236	6	1-20	4	1-21	102
347	433	102	63	1,373	307	5	1-14	4	1-38	70

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