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

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

METHODS

MODEL STRUCTURE

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

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

REPRODUCTION

We used fecundity rates, from a range of values reported for Minnesota and Wisconsin (MNDNR unpublished data, Fuller 1990, McCaffery et al. 1998, DelGiudice et al. 2007, Dunbar 2007, Grund 2011, Wisconsin Department of Natural Resources 2014).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

SPRING/SUMMER SURVIVAL

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

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

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

FALL HARVEST AND SURVIVAL

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

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

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

WINTER SURVIVAL

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

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

MODELING PROCEDURES

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

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

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

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

RESULTS

DEER POPULATION TRENDS AND MANAGEMENT RECOMMENDATIONS

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

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

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

FARMLAND ZONE

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

FARMLAND-FOREST TRANSITION ZONE

Deer populations in the Farmland-Forest Transition Zone are highly productive due to excellent habitat and generally milder winters as compared to the Forest Zone. Historical harvests and modeled population trends suggested that Lottery designations were not sufficient to stabilize deer numbers in most transition zone DPAs as evidenced by few DPAs with Lottery recommendations. For the 2017 season, we recommended Hunter Choice for one-third of DPAs and Managed for nearly half of DPAs. In 5 DPAs, Intensive designations will be necessary in 2017 to continue reducing deer densities toward goal level, 2 of which (DPA 346 and 349) we recommended additional antlerless seasons. In the metro area (DPA 601) and the chronic wasting disease management zone (DPA 603), unlimited antlerless opportunity will be available during the legal hunting seasons.

FOREST ZONE

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

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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, 2010-2017.

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

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

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

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

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

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

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

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

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

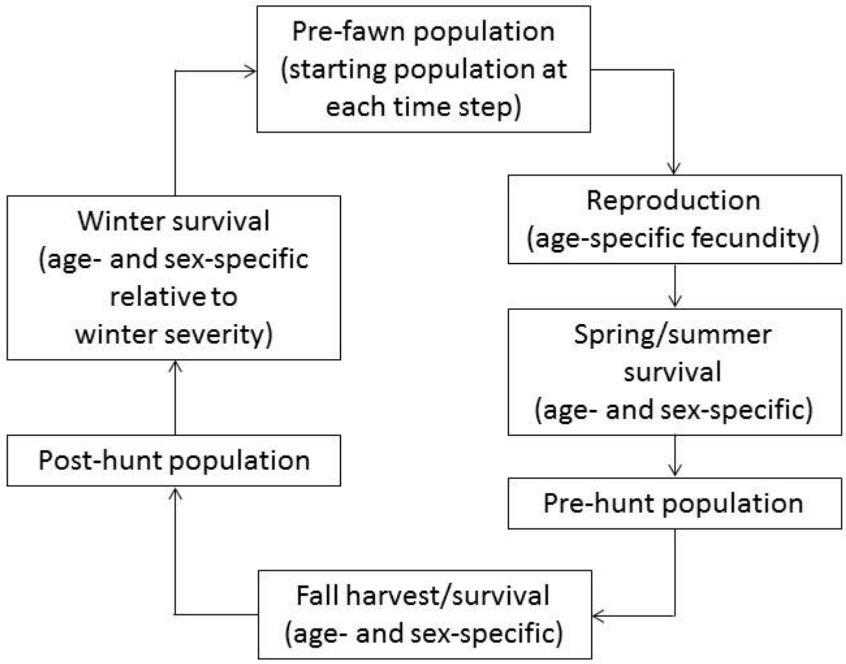
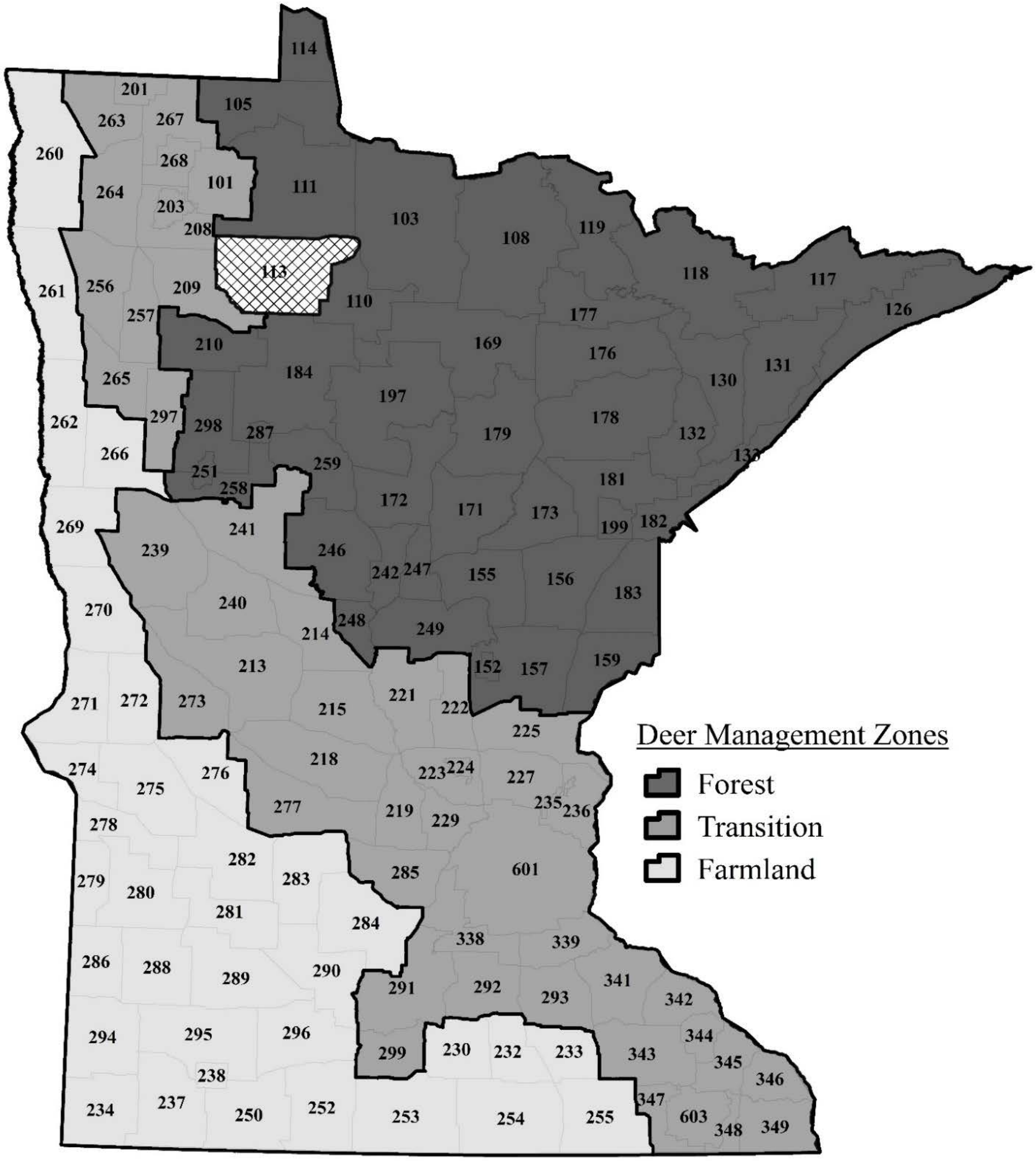


Figure 2. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2017. DPAs were assigned to forest, transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of ≥60% woody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



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