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 ≤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 $= 1 - [0.011 + 0.0015\ \mathrm{WSI}]$). 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 $= (1 - [0.011 + 0.0015\ \mathrm{WSI}]) - 0.05$). For severe winters, the equation was adjusted to simulate increased mortality reported for fawns in field studies (mean winter survival $= 1 - [0.0054\ \mathrm{WSI} - 0.33]$). 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.

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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, 2010-2016.

		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
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

[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
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
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
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

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

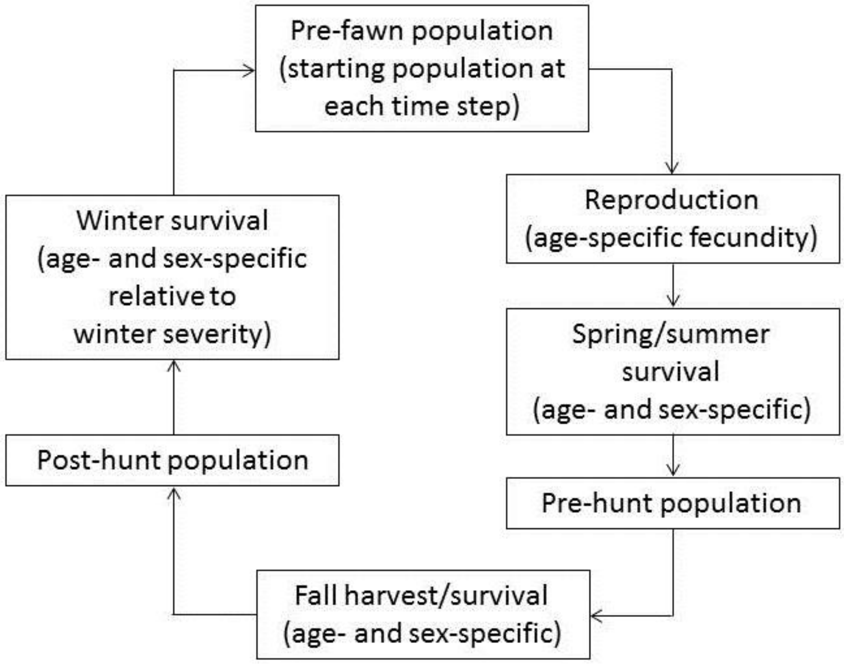
Deer Permit Area	Land area (mi²)	Pre-fawn deer density[a]						
		2010	2011	2012	2013	2014	2015	2016
261	795	2	2	3	3	4	4	6
262	677	2	2	2	3	3	3	4
263	512	9	9	11	12	11	13	17
264	669	11	11	13	15	14	16	21
265	494	8	8	9	11	11	13	16
266	617	5	5	5	6	7	8	10
267	472	6	6	7	9	7	9	12
268	228	12	11	13	15	13	15	19
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
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
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

[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
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.



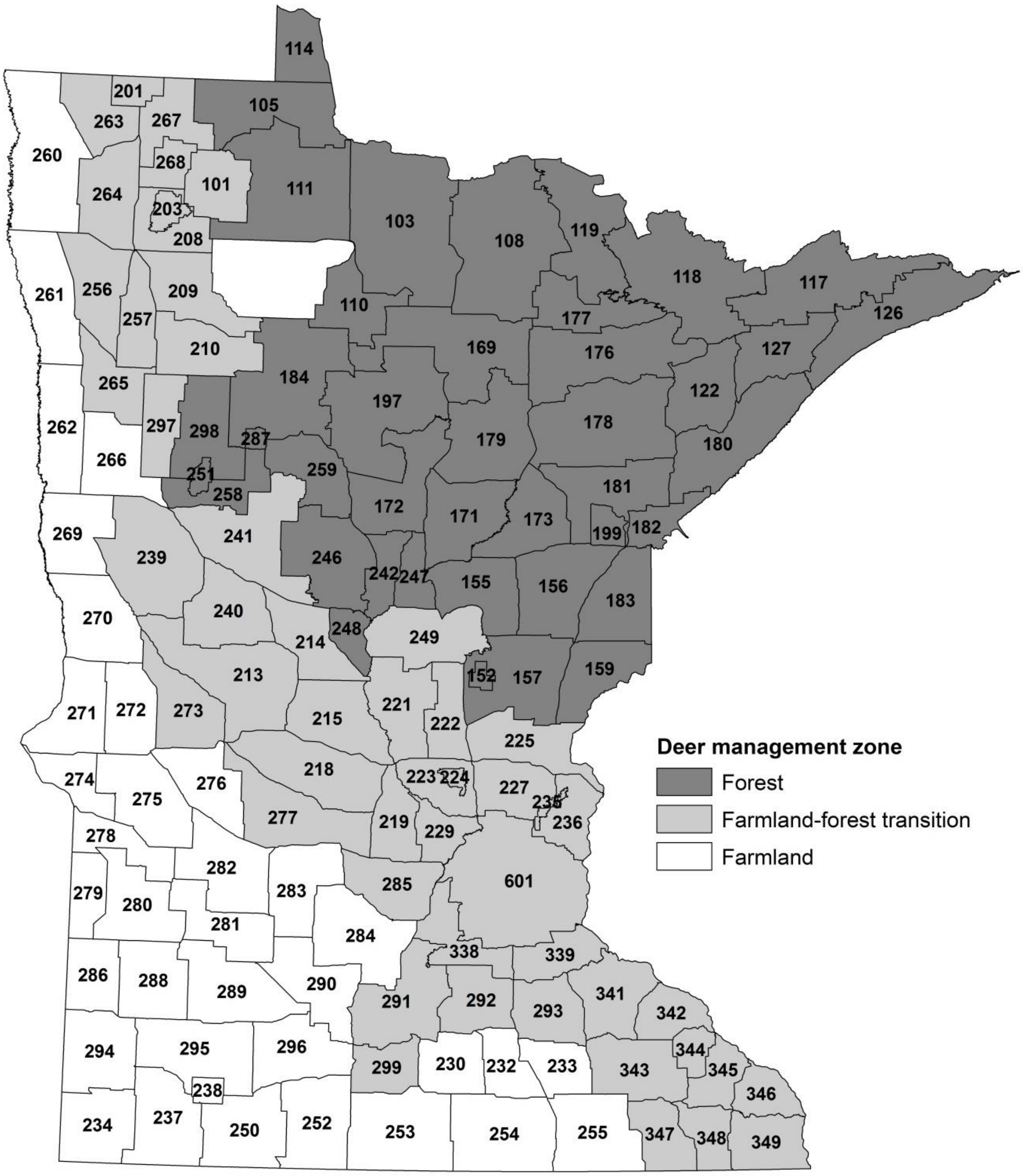


Figure 2. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2016. DPAs were assigned to forest, farmland-forest transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed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