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

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INTRODUCTION

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

METHODS

We used a stochastic population model to simulate annual variations in deer densities within individual DPAs. We defined ranges of values for fecundity (number of offspring born per female) and survival by sex- and age-classes of deer based on values data obtained from studies conducted within Minnesota and supplemented from primary literature.

Model Structure

We use the spring of the initial year before reproduction occurred (Figure 1) as the starting period for each multi-year simulation. We specified an initial population density (see Modeling Procedures section) and the model then converted the initial population density into a total population size by multiplying the density by the total land area of the DPA. We set the proportion of adult deer by age- and sex-class in the initial population (adult females mean = 0.45 [SD = 0.02], adult males mean = 0.20 [SD = 0.02]). We allocated the remaining proportion (0.35) equally to young-of-year (YOY) males and females.

Within each annual cycle, we applied age-specific fecundity rates to females to estimate reproduction. We subjected all age- and sex-classes to spring/summer mortality, and the result was the pre-hunt fall population. We subtracted hunter-harvested deer from the pre-hunt population. We estimated winter mortality rates by age-class relative to winter severity, and we then applied winter mortality rates to the post-hunt population. The remaining population represented the starting population size for the next stage of the simulation. We assumed that the effects of immigration and emigration on a population within a DPA were equal.

Reproduction

We used fecundity rates from a range of values reported for Iowa, Minnesota, and Wisconsin (Iowa DNR unpublished data, Fuller 1990, McCaffery et al. 1998, DelGiudice et al. 2007, Dunbar 2007, Grund 2011, Storm 2014, Storm 2015, Dittrich 2016). We partitioned fecundity rates by 2 age-classes of breeding females (i.e., <1 year old [YOY] when bred and ≥1 years old [adult] when bred) and allowed rates to vary by 3 eco-geographic zones (northeast, farmland and transition areas, and southeast) that reflected relative differences in climate and habitat quality. We estimated fecundity rates to be lowest in the northeast (YOYs, mean = 0.06 [SD = 0.005]; adults, mean = 1.55 [SD = 0.001]), moderate in the farmland and transition zone (YOYs, mean = 0.07 [SD = 0.017]; adults, mean = 1.71 [SD = 0.022]), and greatest in the southeast (YOYs, mean = 0.13 [SD = 0.029]; adults, mean = 1.81 [SD = 0.055]). Sex ratio of fawns at birth in most deer populations is approximately 50:50, but may vary annually (Ditchkoff 2011). Therefore, we allowed the proportion of male fawns at birth to vary uniformly between 0.48-0.52.

Spring/Summer Survival

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

We used estimates reported in the primary literature for deer in Minnesota and populations in similar habitats for fawn spring/summer survival (Wisconsin DNR unpublished data, Huegel et al. 1985, Nelson and Mech 1986a, Nelson and Woolf 1987, Kunkel and Mech 1994, Brinkman et al. 2004, Vreeland et al. 2004, Rohm et al. 2007, Hiller et al. 2008, Carstensen et al. 2009, Warbington et al. 2017). We adjusted fawn survival rates to estimate the effects of winter severity on the condition of adult females during the previous winter. Mean spring/summer fawn survival values were 0.70 (SD = 0.031), 0.55 (SD = 0.037), and 0.45 (SD = 0.037) when $WSI<100$, $100 \leq WSI<180$, and $WSI \geq 180$, respectively.

Spring/summer survival rates reported in the primary literature for adult deer $\geq$1 year old were relatively high and similar for both sexes (DeYoung 2011). We used similar values for summer survival of adult deer from the population model previously used in Minnesota (Grund and Woolf 2004, Grund 2014) and allowed the values to vary randomly (female = 0.97 [SD = 0.011], male = 0.98 [SD = 0.015]). These estimates overlapped values reported in the literature for Minnesota and populations in similar habitats (Nelson and Mech 1986a, Fuller 1990, Van Deelen et al. 1997, Whitlaw et al. 1998, Brinkman et al. 2004, Grund and Woolf 2004, Grund 2011, Grovenburg et al. 2011).

Fall Harvest and Recovery Rates

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

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

We recognized that some deer were not registered during the hunting season or they were harvested illegally (Dusek et al. 1992, Rupp et al. 2000), wounded and not recovered (Nixon et al. 2001), or died from other non-hunting causes (e.g., deer-vehicle-collision, Norton 2015). We applied a mean multiplier of 1.05 (SD = 0.002) to the numerical harvest to account for non-registered deer that died during the hunting season. Because we expect the true multiplier to be greater than 1.05, density estimates are conservative, but resulting population trends will likely be similar when different multipliers are used based on the modeling procedures.

Winter Survival

Winter severity, particularly snow depth, increases risk of deer mortality via starvation and predation with fawns being more susceptible than adults (Nelson and Mech 1986b, DelGiudice et al. 2002, Norton 2015). We estimated winter survival rates relative to winter severity based on studies conducted in Minnesota (Nelson and Mech 1986a, DelGiudice et al. 2002, Brinkman et al. 2004, Grund and Woolf 2004, DelGiudice 2006, Grovenburg et al. 2011, Grund 2011). These studies reported survival rates similar to those observed in other deer populations in northern latitudes (Van Deelen et al. 1997, Whitlaw et al. 1998, DePerno et al. 2000, Dumont et al. 2000, Norton 2015).

For adult deer, we set mean winter survival at 0.95 when WSI≤25. When WSI>25, we used an equation to calculate survival to account for increased winter severity based on previous research in Minnesota. For fawns, we set the mean winter survival rate at 0.85 when WSI≤60.When WSI was above 60 and less than 100, we applied the same equation used to calculate adult survival. However, we subtracted an additional mortality rate of 0.05 to represent lower survival of fawns versus adults. For more severe winters (100≤WSI≤240), we adjusted the equation to represent increased mortality reported for fawns in field studies. When WSI exceeded 240, we set fawn survival at 0.033. We calculated winter survival relationships based on previous Minnesota research studies of radiocollared deer.

Modeling Procedures

To model each DPA, we tested several initial population densities including: 1) population estimates from field surveys when available (Haroldson 2014); 2) previous estimates from modeling (Grund 2014); or 3) a crude population estimate reconstructed from the reported harvest of adult males in the most recent deer season.

To determine the most appropriate initial population density, we examined the modeled population trends relative to: 1) population estimates from field surveys when available; 2) the trend in reported deer harvest; and 3) the relationship between estimated population densities and adult male harvest success. We incrementally increased and decreased the density and re-examined the modeled trend relative to the aforementioned indices to refine the initial population density. In some cases, we also adjusted other vital rates slightly in conjunction with varying initial population densities.

Because the initial population density is the primary parameter adjusted, similar population trends are fitted when the mean for parameters that are constant (with only random variation) among years (e.g., recovery rates, adult summer survival) are changed. However, the absolute density will shift similarly among years (e.g., all density estimates may be 20% greater if recovery rates are increased), because the modeler can adjust the initial density to fit the same trend. Importantly, the resulting density estimates are only unbiased when all input parameters are unbiased, but accurate trends can still be estimated even when mean values for parameters are biased.

We ran model simulations for 5 years (2015-2020) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring 2020). We performed all simulations with the R programming language (ver. 3.6.2, R Core Team 2019) and used 500 Monte Carlo simulations until we determined the most reasonable set of starting parameters. We then used 5,000 simulations for the final run.

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

RESULTS

Deer Population Trends and Management Recommendations

Although we derived the model parameters from studies of deer in Minnesota or from studies from states that have similar habitats and environmental conditions, uncertainty is inherent in modeling wild deer populations. Our modeling allowed input parameters to vary randomly to represent uncertainty that occurs in wild populations, and model outputs included measures of uncertainty reflecting variation among model simulations. However, for ease of interpretation, we present mean pre-fawn deer densities in this document. We conducted simulation modeling in 111 of 132 DPAs in Minnesota to estimate deer densities before reproduction during spring 2020 (Table 1, Figure 2).

Following 3 deer seasons with relatively conservative management designations and 3 winters with mild conditions across most of the state, deer populations in most DPAs increased through 2020. Management designations in 2020 were consistent in most DPAs compared to 2019 in attempt to stabilize or reduce densities that had exceeded goals. Each ecogeographic zone observed some DPAs that were below goal (southwestern farmland zone, n = 2; farmland-forest transition zone, n = 2); however, the northeastern forest region had the most DPAs below goal (n = 11), even with conservative hunting regulations, likely due to resource limitations. Although firearm hunting season conditions across some areas in the state were mostly above average in 2019, antlerless harvest goals were not achieved, resulting in more deer after the hunting season than intended with hunting season regulations. Liberal antlerless seasons in 2020 will be required again to effectively manage deer populations in DPAs with average and above average productivity.

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

Farmland Zone

We modeled 26 of 37 total farmland zone DPAs. Of those 27 modeled DPAs, 9 were at goal, 2 were below goal, and 16 were above goal based on modeling or buck harvest trends. Modeling deer densities in the farmland with harvest data continues to be a challenge, and relatively stable buck harvests the past 20 years suggests a stable population with limited potential for growth, likely a result of habitat constraints. We selected management designations to stabilize deer numbers with consistent regulations across years whenever possible. Most farmland DPAs (n = 23) were under a Lottery designation. Four of the DPAs required Hunter Choice, 8 were under Managed designations, 1 was under the Intensive designation, and 1 was designated as Unlimited Antlerless, to stabilize or reduce deer numbers at appropriate levels.

Farmland-Forest Transition Zone

Deer populations in the farmland-forest transition zone are highly productive due to excellent habitat and generally milder winters as compared to the forest zone. Historical harvests and modeled population trends suggested that Lottery designations were not sufficient to stabilize deer numbers in most transition zone DPAs as evidenced by few DPAs with Lottery recommendations. We modeled 38 of the 51 transition zone DPAs. Of those 38 modeled DPAs, 17 were at goal, 2 were below goal, and 19 were above goal based on modeling or buck harvest trends. For the 2020 season designations, Lottery will be used for 2 of the DPAs, Hunter Choice for 8 DPAs with an additional antlerless season being available in DPA 344, and Managed for 8 DPAs. In 25 DPAs, Intensive designations will be necessary to continue reducing deer densities toward goal level, 6 of which have additional antlerless seasons. In the metro area (DPA 701) and the chronic wasting disease management zone (DPAs 605, 643, 645, 646, 647, 648, and 649), Unlimited Antlerless opportunity will be available during the legal hunting seasons.

Forest Zone

Many deer populations in the forest zone with adequate habitat have recovered from the severe winter of 2013-14. We modeled 32 of the 44 forest zone DPAs. Of the 32 modeled DPAs, 13 were at goal, 11 were below goal, and 8 were above goal based on modeling or buck harvest trends. For 2020 season designations, Bucks-only will be used in 5 DPAs, Lottery in 18 DPAs, Hunter Choice in 12 DPAs, Managed in 6 DPAs, Intensive in 2 DPAs, and Unlimited Antlerless in 1 DPAs.

ABRIDGED DESCRIPTIONS OF DEER HUNTING SEASON DESIGNATIONS (MNDNR 2019)

Bucks-only. All hunters, including youth and archery hunters, are restricted to harvesting only legal bucks. No antlerless deer may be harvested; limited exceptions for hunters ≥84 years of age or persons in veterans homes. The bag limit is **one** deer.

Lottery. A hunter may apply for authorization to harvest one either-sex deer during either the firearm or muzzleloader season. Archery hunters can take a deer of either sex. Under this scenario, archers, youth, and disabled hunters can kill a deer of either-sex. The bag limit is **one** deer.

Hunter Choice. The initial license is either-sex and bonus permits cannot be used. There is no antlerless permit lottery application and all hunters potentially could harvest an antlerless deer, regardless of season. The bag limit is **one** deer.

Managed. The initial license is either-sex and a maximum of **two** deer (one buck) can be taken using any combination of licenses and permits.

Intensive. The initial license is either-sex and the maximum of **three** deer (one buck) can be taken using any combination of licenses and permits.

***Early Antlerless.** A hunter could harvest **five additional** deer in these permit areas during the early antlerless season (e.g. the annual limit in an intensive permit area with an early antlerless season would be eight deer).

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Table 1. Estimated mean pre-fawn deer densities (deer/mi^2) derived from population model simulations in Minnesota deer permit areas, 2015-2020.

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

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

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

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

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

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

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

a"-"

indicates deer permit area was not modeled

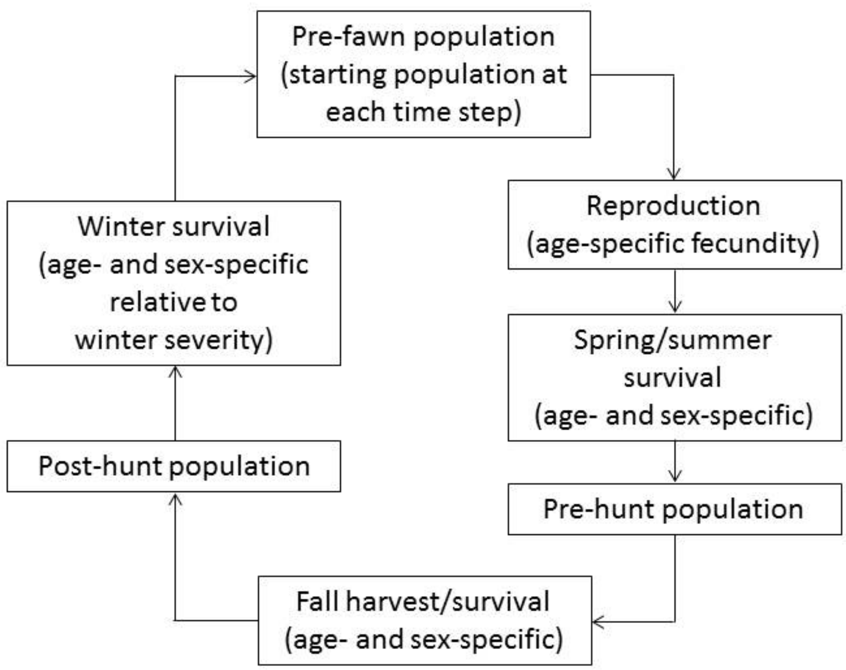
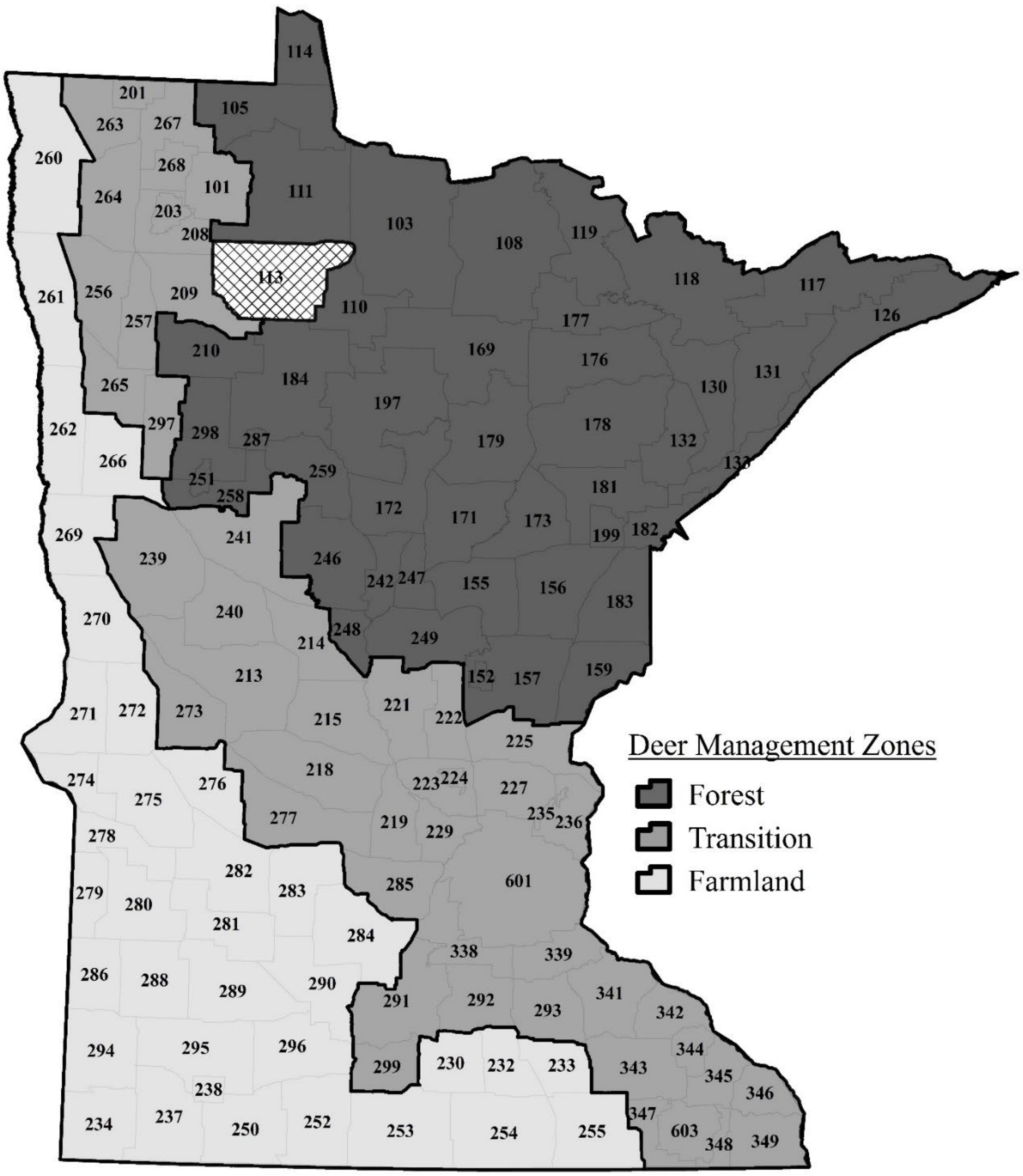


Figure 1. Model structure for simulations of white-tailed deer populations in Minnesota.



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

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