DEPARTMENT OF
NATURAL RESOURCES

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA – 2021

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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 to explore the impacts of various hunting regulations on populations, to understand historical deer herd dynamics, and to predict relative population sizes. 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 modeled density estimates and harvest recommendations.

METHODS

Prior to 2019, we modeled deer populations at the deer permit area (DPA) level. However, with over 130 DPAs, this was a major annual undertaking that limited the time the modeler could devote to each modeling unit, including exploring the sensitivity of the model in each case. Furthermore, we typically lacked empirical data on population vital rates (other than harvest) at the DPA scale and it would be cost prohibitive to collect such data. Conversely, collecting annual or periodic population data over larger modeling units might be feasible. Therefore, beginning in 2019, we consolidated DPAs into deer modeling units (DMUs; Figure 1). DMUs are generally consistent with goal-setting blocks (GSBs), except some DMUs may contain less than the full set of DPAs within a GSB if there were major boundary changes in the last 5 years (which makes it difficult to interpret harvest data and population trends). However, we recognize that annual regulatory decisions still occur at the DPA level and we need to link DMU-level modeling results to DPA-level decision making. Therefore, we used the annual proportional buck harvest in each DPA to convert DMU population estimates to DPA-level density estimates, which we acknowledge is a simplification of factors that can influence variation in deer densities among DPAs and years. Thus, we advise caution when interpreting annual DPA-level estimates of absolute density.

Model Structure

We used the spring of the initial year before reproduction occurred (Figure 2) 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 DMU. 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 approximately equally (with some small variation for primary sex ratio) 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 also 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 DMU 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). Minnesota Information Technology (MNIT) Services/MNDNR staff calculate an annual winter severity index (WSI) in each DPA based on snow depth and minimum daily temperatures. 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.

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≤WSI<180, and 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 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 stochastically (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 et al. 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.

Modeling Procedures

Simulation models can be sensitive to the parameter for initial population size (e.g., Grund 2014). Therefore, we used density estimates from last year's models as starting points for this year's models. However, we explored alternative starting values in cases where the simulated population was growing or declining at an unrealistic rate (e.g., due to adding new harvest data and, possibly, removing harvest data that are now outside the modeling window). This can lead to some discrepancies with previously reported model estimates, which is not an ideal situation. However, it reflects an important limitation of simulation models. Thus, we advise caution when interpreting estimates of absolute density (vs. population trends).

We ran model simulations for 5 years (2016-2021) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring

2021). 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.

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 stochastically to represent natural variation 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 for 23 DMUs (Table 1) and derived subsequent density estimates in 106 of 131 DPAs in Minnesota to estimate deer densities before reproduction during spring 2021 (Table 2; Figure 3).

Deer populations in most DPAs increased through 2021. Management designations in 2021 were consistent in most DPAs compared to 2020 in an 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 = 1; northeastern forest region, n = 4). Although firearm hunting season conditions across some areas in the state were mostly below average in 2020 due to abnormally high temperatures during opening weekend, total harvest increased in 2020 from 2019. Regardless, liberal antlerless seasons in 2021 will be required again to effectively manage deer populations in DPAs with average and above average productivity.

In terms of management intensity, the 2021 designations afford more antlerless deer harvest opportunities to hunters in about 12% of the DPAs versus the 2020 season. About 5% of DPA designations afford less antlerless harvest opportunity in 2021 compared to 2019 with a majority (83%) of designations providing the same antlerless opportunity as 2020.

Farmland Zone

We produced density estimates for 34 of 37 total farmland zone DPAs. Of those 34 DPAs, 24 were at goal, 2 were below goal, and 8 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 = 22) were under a Lottery designation. Four of the DPAs required Hunter Choice, 7 were under Managed designations, 3 were under the Intensive designation, and 1 was designated as Five Deer Limit with an Early Antlerless season, 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 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 produced density estimates for 40 of the 50 transition zone DPAs. Of those 40 DPAs, 10 were at goal, 1 was below goal, and 12 were above goal based on modeling.

Establishing whether the remaining 17 DPAs for which we derived density estimates for were at goal was not feasible because outdated goals (will undergo goal setting in 2021 or 2022) were not directly comparable to current density estimates derived from the DMU model. For the 2021 season designations, Lottery will be used for 3 DPAs, Hunter Choice for 4 DPAs, and Managed for 7 DPAs. In 28 DPAs, Intensive designations will be necessary to continue reducing deer densities toward goal level, 10 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), a Five Deer Limit with an Early Antlerless season 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 produced density estimates for 32 of 44 forest zone DPAs. Of the 32 DPAs, 9 were at goal and 4 were below goal based on modeling or buck harvest trends. Establishing whether the remaining 19 DPAs (for which we derived density estimates) were at goal was not feasible because outdated goals (will undergo goal setting in 2021 or 2022) were not directly comparable to current density estimates derived from the DMU model. For 2021 season designations, Bucks-only will be used in 5 DPAs, Lottery in 19 DPAs, Hunter Choice in 11 DPAs, Managed in 6 DPAs, Intensive in 2 DPAs, and Five Deer Limit with an Early Antlerless Season in 1 DPA.

ABRIDGED DESCRIPTIONS OF DEER HUNTING SEASON DESIGNATIONS (MNDNR 2021)

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.

Antlerless Permit 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.

Either Sex. 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.

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

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

Five-deer Limit. The initial license is either-sex and the maximum of five deer (one buck, except the SE 600-series) 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) for deer management units (DMUs) derived from population model simulations in Minnesota, 2016-2021.

		Pre-fawn Deer Density					
Deer Management Unit	Land Area (mi^2)	2016	2017	2018	2019	2020	2021
1	1470	4	5	6	6	8	9
2	2027	11	12	13	14	16	18
[a]3a	1384	4	4	5	5	6	8
[a]3b	782	6	6	7	7	7	8
4	2466	4	5	5	4	4	5
5	2779	3	3	3	3	3	4
6	3750	8	10	11	11	12	15
7	3926	18	20	22	21	23	27
8	5537	12	13	14	13	14	17
9	3772	11	11	12	12	12	14
[a]10a	692	23	26	27	26	29	34
[a]10b	1667	25	30	33	36	43	51
11	1549	30	32	34	33	35	38
12	3331	20	23	25	25	28	30
13	2550	4	4	5	5	7	8
14	2810	13	15	17	18	22	26
15	3648	18	21	24	26	29	33
16	546	8	10	11	13	15	18
17	2995	4	5	5	6	6	7
18	2792	6	6	7	7	8	8
19	2102	5	5	6	6	7	8
20	5881	4	4	5	6	7	8
21	3505	6	8	9	10	12	15
22	603	17	19	22	24	28	31
[a]23a	540	20	22	25	28	32	37
[a]23b	1137	23	25	27	29	31	34

[a]Indicates DPAs with major boundary changes were not included within the specified DMU and thus the DMU was divided into a and b for modeling purposes.

Table 2. Estimated mean pre-fawn deer densities (deer/mi^2) for deer permit areas based on population model simulations in Minnesota deer management units, 2016-2021.

		Pre-fawn Deer Density					
Deer Permit Area	Land Area (mi^2)	2016	2017	2018	2019	2020	2021
101	496	10	12	11	12	12	13
[a]104	1414	-	-	-	-	-	-
[a]105	1199	-	-	-	-	-	-
[a]107	472	-	-	-	-	-	-
[a]109	1182	-	-	-	-	-	-
110	529	15	18	18	18	21	23
111	1438	4	4	5	5	6	8
[a]114	123	-	-	-	-	-	-
117	936	1	0.4	0.5	0.3	0.4	0.6
118	1239	5	5	5	5	5	6
[a]119	782	-	-	-	-	-	-
126	942	6	7	6	6	6	8
130	747	3	3	4	3	2	3
131	901	1	1	2	2	2	1
132	481	4	5	6	5	5	6
133	352	12	14	8	8	10	10
152	60	14	16	14	16	19	22
[a]155	499	-	-	-	-	-	-
156	819	11	12	13	12	13	14
157	888	25	32	35	38	41	51
159	571	14	14	16	16	17	22
169	1124	10	12	12	12	14	15
[a]171	627	-	-	-	-	-	-
[a]172	692	-	-	-	-	-	-
173	584	8	8	8	8	8	7
176	917	12	13	11	11	10	13
177	491	12	12	13	14	14	17
178	1192	10	12	13	12	13	18
179	857	17	17	20	18	20	23
181	629	9	10	10	12	11	12
[a]182	278	-	-	-	-	-	-
183	664	10	12	14	13	14	16
184	1229	21	23	24	25	25	27
197	957	14	15	16	16	16	18
199	153	5	6	6	6	7	7
201	161	10	10	10	12	11	12
203	118	7	6	6	7	5	7
208	378	8	8	8	9	10	13

[a]Indicates deer permit area was not included in DMU population model.

Table 2. Continued

		Pre-fawn Deer Density					
Deer Permit Area	Land Area (mi^2)	2016	2017	2018	2019	2020	2021
209	639	9	11	13	13	15	17
210	615	12	13	15	15	18	23
213	1059	21	23	25	25	28	30
214	553	28	29	34	33	35	40
215	701	20	22	26	25	26	31
218	884	12	14	16	18	21	25
219	392	17	17	19	20	23	25
221	643	16	21	23	26	30	34
222	413	19	22	26	28	32	36
223	377	19	21	23	25	28	32
224	46	19	26	24	26	32	31
225	618	21	25	29	32	35	40
227	471	23	24	27	30	34	39
229	285	10	11	13	14	16	17
230	454	6	7	8	9	12	14
232	377	8	10	11	13	15	18
233	384	6	9	9	11	14	16
234	636	3	3	4	5	6	6
235	35	20	19	18	22	30	35
236	368	20	21	23	26	29	32
237	728	3	4	4	5	6	7
238	95	8	9	11	11	13	16
239	928	16	18	20	21	23	24
240	643	26	29	32	33	36	39
241	997	31	34	34	34	35	36
[a]246	784	-	-	-	-	-	-
248	216	29	27	32	36	45	53
249	502	25	28	31	33	48	54
250	712	4	5	6	7	7	9
251	55	17	14	13	14	13	17
252	716	4	4	5	6	7	8
253	974	5	6	7	8	9	10
254	930	7	7	8	10	12	15
[a]255	392	-	-	-	-	-	-
256	654	9	11	12	11	12	14
257	412	10	13	14	15	18	20
258	343	24	24	25	28	32	39
259	490	25	28	31	23	26	28

[a]Indicates deer permit area was not included in DMU population model.

Table 2. Continued

Deer Permit Area	Land Area (mi^2)	Pre-fawn Deer Density 2016	2017	2018	2019	2020	2021
[a]260	1055	-	-	-	-	-	-
261	793	4	5	6	6	7	8
262	677	5	5	6	7	9	11
[a]263	706	-	-	-	-	-	-
264	669	14	14	16	17	18	22
265	494	11	12	14	14	17	20
266	617	7	8	8	10	11	13
267	472	7	8	9	10	11	14
268	228	17	19	21	19	26	27
269	650	4	5	6	6	8	9
270	736	3	3	4	4	6	7
271	632	4	4	6	6	6	9
272	532	4	4	5	5	7	7
273	572	8	10	11	12	15	16
274	355	5	5	6	5	6	7
275	764	5	6	7	7	8	9
276	542	10	12	15	16	18	20
277	812	18	20	22	26	31	38
278	402	7	7	8	9	10	10
279	344	5	5	6	6	7	7
280	674	3	3	4	4	4	6
281	575	6	7	7	7	8	9
282	778	2	2	2	2	3	3
283	613	5	6	6	7	8	10
284	840	4	5	5	6	7	7
285	546	8	10	11	13	15	19
286	447	5	6	6	6	7	9
287	47	15	22	17	13	11	16
288	624	5	6	6	7	7	8
289	816	3	3	4	3	4	4
290	661	5	5	6	6	7	7
291	799	7	8	8	8	8	9
[a]292	362	-	-	-	-	-	-
[a]293	278	-	-	-	-	-	-
294	687	5	5	5	5	6	6
295	839	6	6	7	8	9	11
296	665	4	5	6	6	7	9
297	438	5	5	6	6	6	5
298	619	10	11	11	11	12	13
299	387	9	10	12	14	17	21

[a]Indicates deer permit area was not included in DMU population model.

Table 2. Continued

		Pre-fawn Deer Density					
Deer Permit Area	Land Area (mi^2)	2016	2017	2018	2019	2020	2021
[a]338	316	-	-	-	-	-	-
341	603	17	19	22	24	28	31
342	350	19	23	27	28	30	39
[a]343	320	-	-	-	-	-	-
344	190	21	20	22	27	36	34
[a]604	673	-	-	-	-	-	-
[a]643	351	-	-	-	-	-	-
645	326	14	16	17	19	20	23
646	319	29	31	33	40	40	41
[a]647	434	-	-	-	-	-	-
[a]648	122	-	-	-	-	-	-
649	492	25	27	29	28	31	35
[a]655	387	-	-	-	-	-	-
[a]701	1324	-	-	-	-	-	-

[a]Indicates deer permit area was not included in DMU population model.

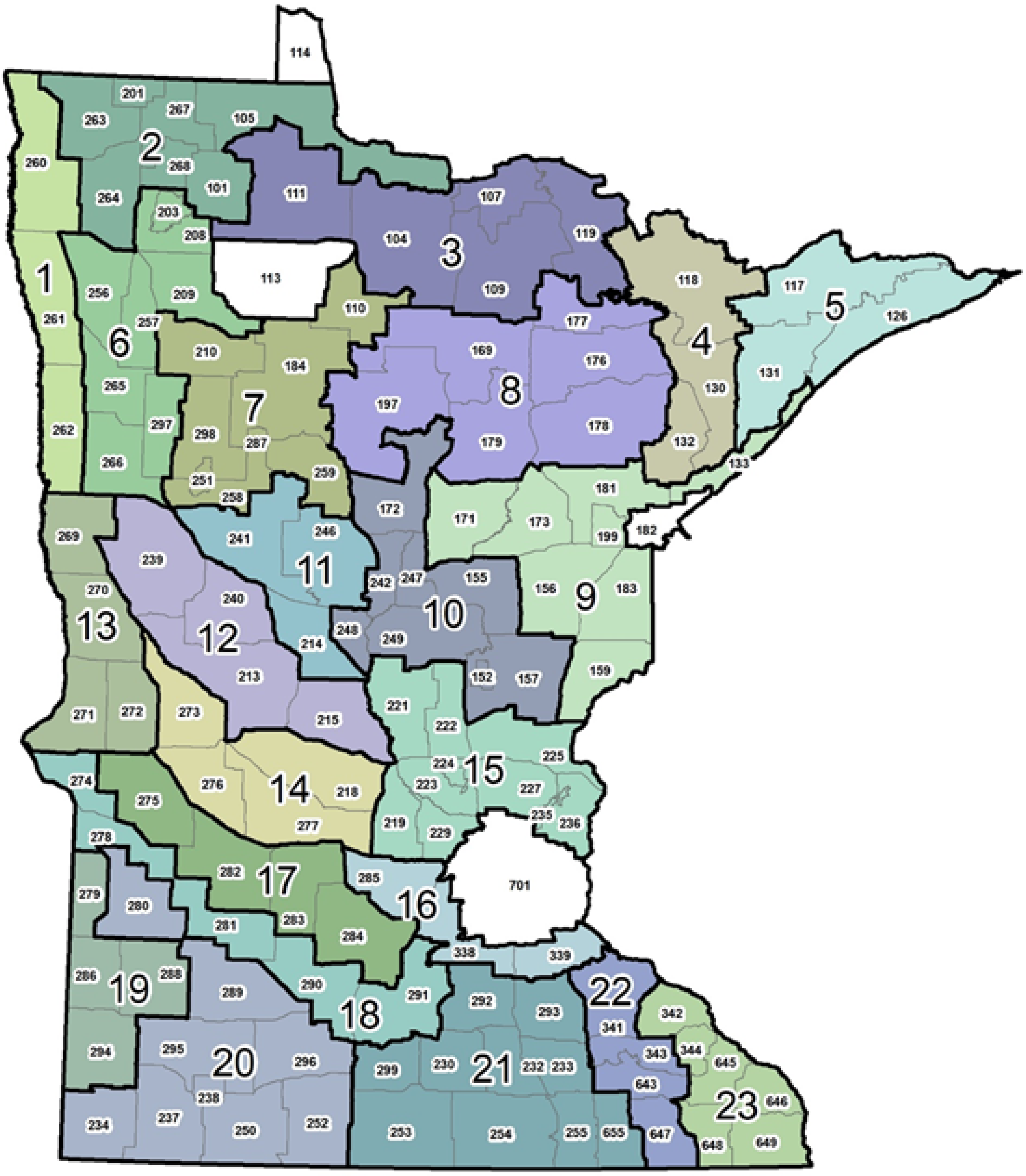

Figure 1. Deer permit areas (DPAs; 100 through 701) aggregated into deer modeling units (DMUs; 1 through 23). DPAs not colored were not included in aggregated units.

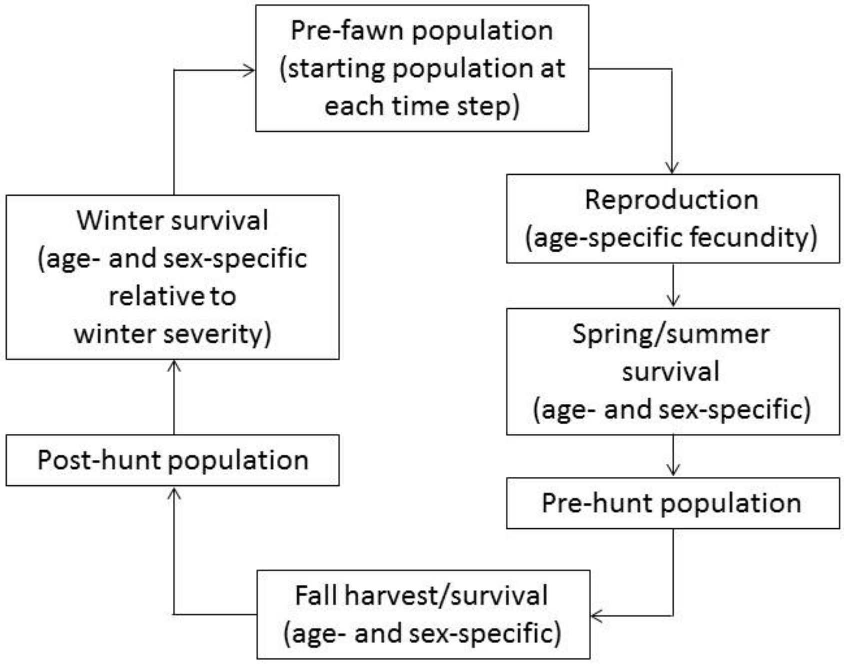

Figure 2. Model structure for simulations of white-tailed deer populations in Minnesota.

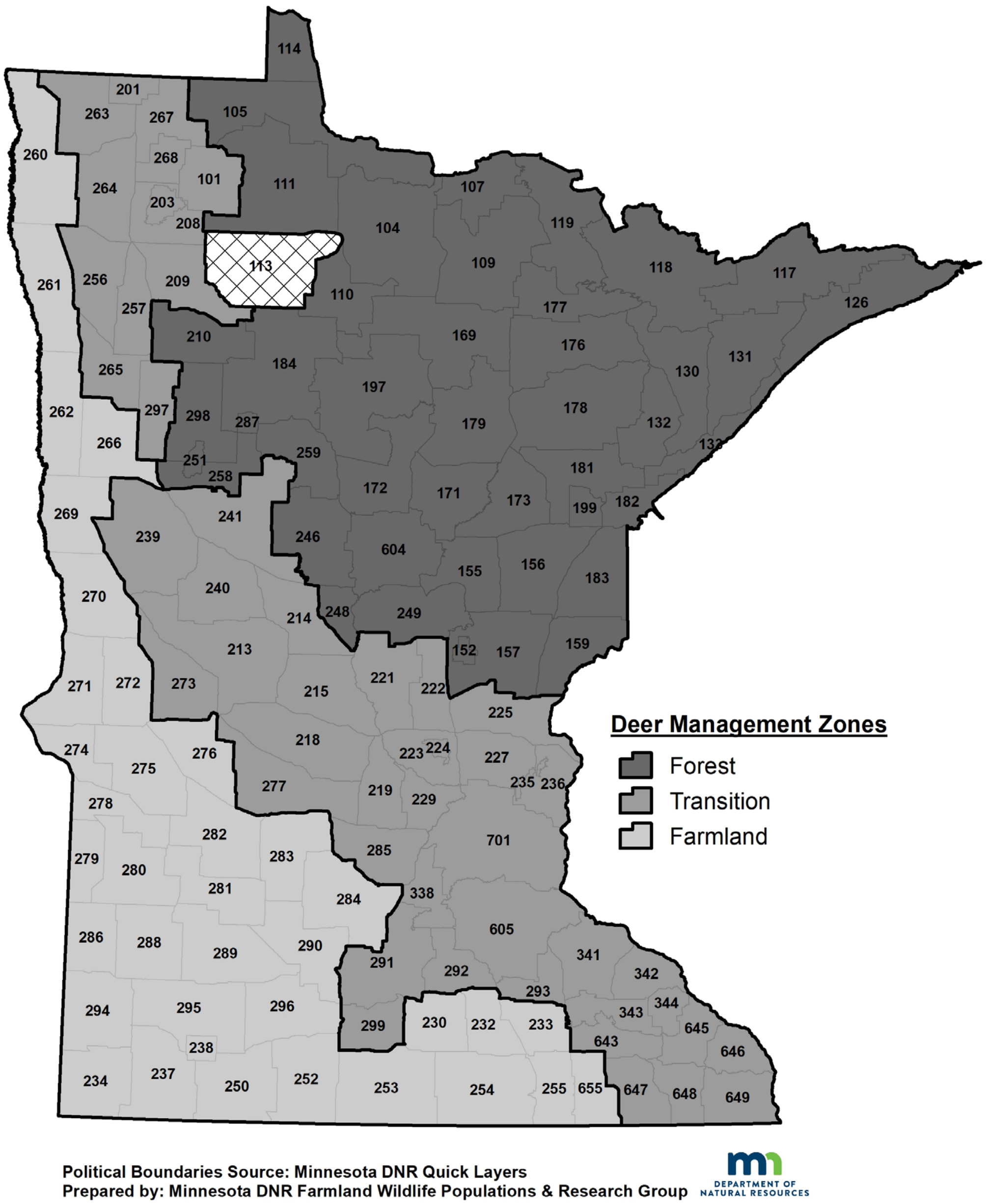

Figure 3. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2021. DPAs were assigned to forest, transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of $\geq$60% woody cover, transition DPAs were composed of 6%-50% woody cover, and farmland DPAs were composed of $\leq$5% woody cover.