DEPARTMENT OF NATURAL RESOURCES

MONITORING POPULATION TRENDS OF WHITE-TAILED DEER IN MINNESOTA – 2022

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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).

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 and, in turn, encourage assessing the overall population trend.

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). 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 (2017-2022) with the final population estimate occurring pre-fawning for the spring following the most recent deer hunting season (i.e., spring

2022). 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 model 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 99 of 130 DPAs in Minnesota to estimate deer densities before reproduction during spring 2022 (Table 2; Figure 3).

Deer populations in most DPAs increased through 2022. Management designations in 2022 were consistent in most DPAs compared to 2021 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 = 17). Total harvest slightly decreased in 2021 from 2020. Liberal antlerless seasons in 2022 will be required again to effectively manage deer populations in DPAs with average and above average productivity while more conservative strategies will be required for those units below goal.

In terms of management intensity, the 2022 designations afford more antlerless deer harvest opportunities to hunters in about 22% of the DPAs versus the 2021 season. About 9% of DPA designations afford less antlerless harvest opportunity in 2022 compared to 2021 with a majority (69%) of designations providing the same antlerless opportunity as 2020.

Farmland Zone

We produced density estimates for 28 of 36 total farmland zone DPAs. Of the 36 DPAs in the farmland zone, 19 were at goal, 2 were below goal, and 15 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 either stabilize densities for DPAs at goal or to decrease densities for DPAs above goal. We attempt to maintain consistent regulations across years whenever possible to improve model performance. For the 2022 season designations, most farmland DPAs (n = 20) were under an Antlerless Permit Lottery designation. Five DPAs required Either Sex, 7 were under a Two-deer Limit designation, 3 were under a Three-deer Limit designation, and 1 was designated as Three-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 Antlerless Permit Lottery designations were not sufficient to stabilize deer numbers in most transition zone DPAs as evidenced by few DPAs with Antlerless Permit Lottery recommendations. We produced density estimates for 39 of the

50 transition zone DPAs. Of those 49 DPAs in the farmland-forest transition zone, 19 were at goal, 1 was below goal, and 28 were above goal based on modeling or buck harvest trends. A goal density was not established for one DPA. We selected management designations to decrease densities for DPAs above goal while attempting to maintain consistent regulations across years whenever possible to improve model performance. For the 2022 season designations, Antlerless Permit Lottery will be used for 3 DPAs, Either Sex for 2 DPAs, and a Two-deer Limit designation will be used for 10 DPAs. In 27 DPAs, a Three-deer Limit designation will be necessary to continue reducing deer densities toward goal level, 18 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. However, the most recent winter of 2021-22 was also severe and continued to decreased deer densities in some DPAs. We produced density estimates for 32 of 44 forest zone DPAs. Of the 44 DPAs in the forest zone, 22 were at goal, 17 were below goal, and 3 were above goal based on modeling or buck harvest trends. A goal density was not established for two DPAs. We selected management designations to increase densities for DPAs below goal while attempting to maintain consistent regulations across years whenever possible to improve model performance. For 2022 season designations, Bucks-only will be used in 5 DPAs, Antlerless Permit Lottery in 19 DPAs, Either Sex in 11 DPAs, a Two-deer Limit designation in 6 DPAs, and a Three-deer Limit designation in 3 DPAs (including one Early Antlerless designation).

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 **three 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, 2017-2022.

		Pre-fawn Deer Density					
Deer Modeling Unit	Land Area (mi^2)	2017	2018	2019	2020	2021	2022
1	1470	5	6	7	8	10	11
2	2026	12	13	13	15	17	18
3	2166	5	5	5	6	7	7
4	2467	5	5	5	4	5	5
5	2779	3	3	3	3	3	3
6	3750	10	11	12	13	16	18
7	3932	20	21	21	23	26	28
8	3573	13	14	13	13	15	16
9	3188	12	11	10	10	10	10
10	2348	28	29	30	34	38	42
11	2334	31	34	35	38	43	47
12	3331	23	26	27	29	33	35
13	2550	4	5	5	6	8	9
14	1456	15	18	20	24	30	35
15	3647	21	24	26	30	34	38
16	546	10	12	13	15	17	20
17	840	5	6	6	7	8	9
18	2822	6	7	7	7	8	8
19	2102	5	5	6	6	7	8
20	4314	4	5	5	6	7	8
21	3497	8	10	11	14	17	20
22	603	19	22	25	28	31	36
23	1677	24	28	29	32	35	40

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, 2017-2022.

		Pre-fawn Deer Density[a]					
Deer Permit Area	Land Area (mi2)	2017	2018	2019	2020	2021	2022
101	496	12	11	11	12	13	15
[a]104	1414	-	-	-	-	-	-
[a]105	1199	-	-	-	-	-	-
[a]107	472	-	-	-	-	-	-
[a]109	1182	-	-	-	-	-	-
110	529	19	19	18	22	24	28
111	1384	4	4	4	4	5	6
[a]114	123	-	-	-	-	-	-
117	936	0	0	0	0	0	0
118	1239	6	5	5	5	6	6
119	782	6	6	8	8	10	10
126	942	7	6	6	6	8	7
130	747	4	4	3	2	3	3
131	901	1	2	2	2	1	2
132	481	5	6	6	5	6	7
133	352	13	7	7	8	7	7
152	60	15	13	14	17	20	20
[a]155	499	-	-	-	-	-	-
156	819	12	12	10	10	10	11
157	888	30	32	33	36	44	49
159	571	14	15	13	14	15	15
[a]169	939	-	-	-	-	-	-
[a]171	740	-	-	-	-	-	-
172	688	29	28	27	25	24	31
[a]173	471	-	-	-	-	-	-
176	917	13	12	10	10	12	11
177	491	12	14	14	14	15	16
178	1192	12	13	12	13	16	17
[a]179	1024	-	-	-	-	-	-
181	629	10	10	10	8	8	7
[a]182	278	-	-	-	-	-	-
183	664	12	13	11	11	11	11
184	1235	24	25	26	26	29	30
197	973	15	16	15	15	16	18
199	153	5	6	5	5	5	5
201	161	10	10	11	11	12	13
203	118	6	6	8	6	8	11
208	378	9	9	10	11	14	16

[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[a]					
		2017	2018	2019	2020	2021	2022
209	639	11	14	14	16	18	22
210	615	14	15	16	18	24	25
213	1059	24	26	26	29	32	34
214	553	30	37	38	45	54	55
215	701	23	27	26	28	33	36
218	884	17	20	23	28	34	40
219	391	17	20	21	24	26	28
221	643	22	23	26	31	34	39
222	413	23	27	28	33	36	43
223	377	21	23	25	29	33	35
224	46	27	24	27	33	32	36
225	618	25	29	32	35	41	45
227	471	24	28	30	35	40	46
229	285	11	13	14	16	18	18
230	454	7	9	10	13	15	20
232	377	10	12	15	17	21	24
233	381	10	10	12	16	18	23
234	636	3	4	4	5	6	7
235	35	19	18	23	31	37	43
236	368	21	23	26	29	33	38
[a]237	608	-	-	-	-	-	-
238	95	9	11	11	13	15	16
239	928	18	21	22	24	26	28
240	643	30	33	34	38	42	47
241	997	36	37	40	45	49	54
246	784	27	29	26	28	31	37
248	216	25	30	32	40	46	50
249	496	26	28	29	42	48	47
250	712	5	6	7	7	8	9
251	55	14	13	14	14	18	23
252	716	4	5	6	7	8	9
253	974	6	8	8	10	12	14
254	924	8	9	12	13	17	21
[a]255	392	-	-	-	-	-	-
256	654	11	12	12	12	16	17
257	412	14	15	16	20	22	25
258	343	25	26	29	34	42	40
259	489	29	32	24	27	30	36

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

Table 2. Continued

Deer Permit Area	Land Area (mi²)	Pre-fawn Deer Density[a]					
		2017	2018	2019	2020	2021	2022
[a]260	1055	-	-	-	-	-	-
261	793	5	6	6	7	8	11
262	677	5	6	7	9	11	12
[a]263	706	-	-	-	-	-	-
264	669	14	16	16	18	21	22
265	494	13	15	15	18	22	23
266	617	8	9	10	12	14	14
267	472	7	9	9	11	14	12
268	228	19	21	19	25	26	28
269	650	4	6	6	8	9	10
270	736	3	4	4	6	7	7
271	632	4	5	6	6	8	10
272	532	4	5	5	6	7	11
273	572	12	13	15	19	22	27
274	355	5	6	5	6	7	7
[a]275	957	-	-	-	-	-	-
[a]277	1058	-	-	-	-	-	-
278	402	6	8	8	9	9	9
279	344	4	5	6	6	6	8
280	674	3	4	4	4	6	7
281	605	6	7	7	8	8	9
[a]282	1126	-	-	-	-	-	-
[a]283	337	-	-	-	-	-	-
284	840	5	6	6	7	8	9
285	546	10	12	13	15	17	20
286	447	6	6	6	7	8	8
287	47	23	18	14	11	16	14
288	624	6	6	6	6	8	8
289	816	3	3	3	4	4	5
290	661	5	6	5	6	6	7
291	799	7	7	8	8	8	8
[a]292	362	-	-	-	-	-	-
[a]293	278	-	-	-	-	-	-
294	687	5	4	5	6	6	6
[a]295	959	-	-	-	-	-	-
296	665	5	6	6	7	8	11
297	438	6	6	6	6	6	8
298	619	11	12	11	12	14	16
299	387	11	13	15	20	24	26

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

Table 2. Continued

		Pre-fawn Deer Density[a]					
Deer Permit Area	Land Area (mi^2)	2017	2018	2019	2020	2021	2022
[a]338	316	-	-	-	-	-	-
341	603	19	22	25	28	32	36
342	350	22	24	24	23	31	35
[a]343	320	-	-	-	-	-	-
344	186	19	20	23	28	28	33
[a]604	673	-	-	-	-	-	-
[a]605	1192	-	-	-	-	-	-
[a]643	351	-	-	-	-	-	-
645	330	17	19	21	23	26	30
646	319	32	37	44	46	47	52
[a]647	434	-	-	-	-	-	-
[a]648	332	-	-	-	-	-	-
649	492	28	32	31	36	39	45
[a]655	387	-	-	-	-	-	-
[a]701	1324	-	-	-	-	-	-

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

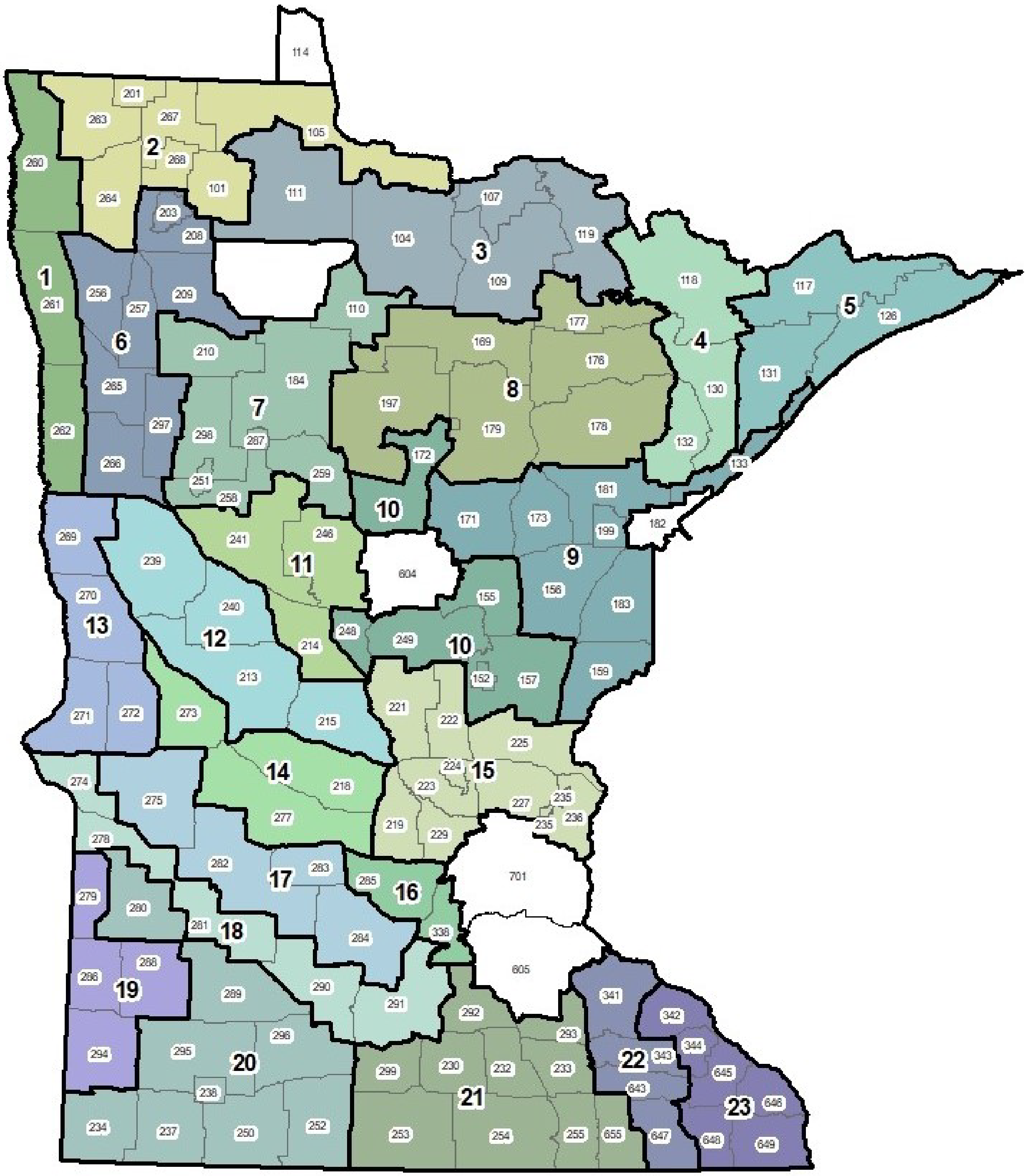

Figure 1. Deer permit areas (DPAs; 100 through 701) aggregated into deer modeling units (DMUs; 1 through 23). DPAs not colored were not included in aggregated units.

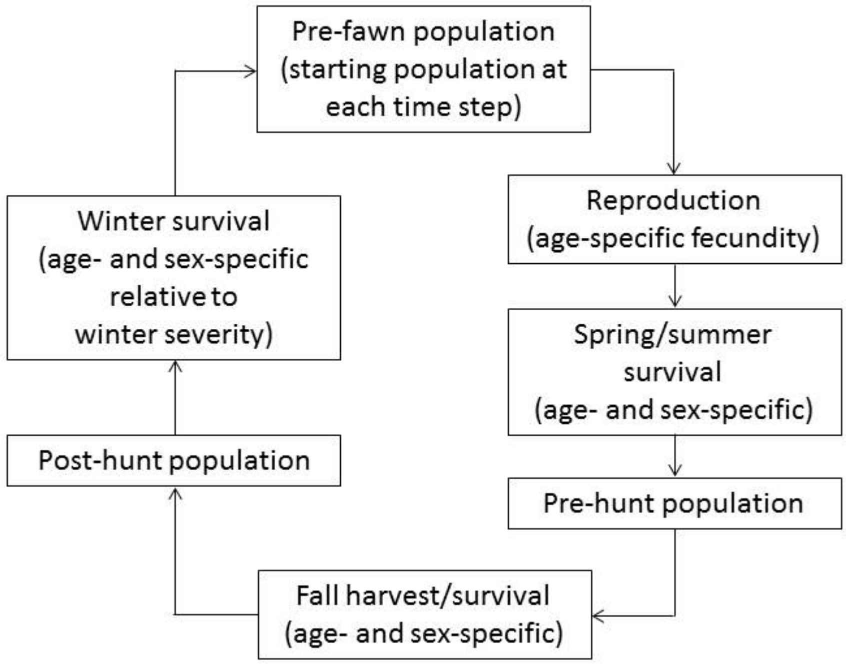

Figure 2. Model structure for simulations of white-tailed deer populations in Minnesota.

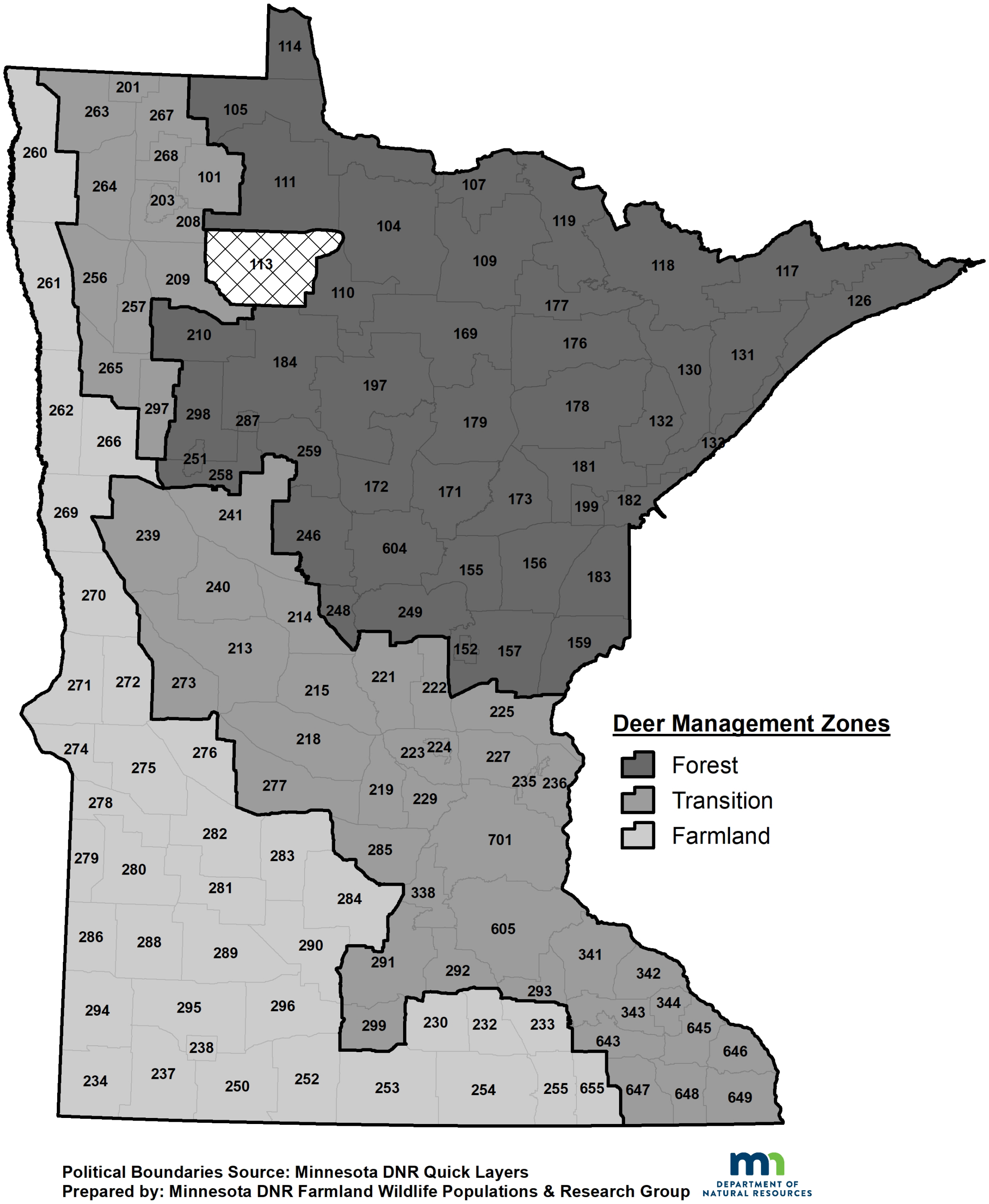

Figure 3. Deer permit areas (DPAs) in Minnesota and deer management zones used to describe deer population and harvest trends, 2022. DPAs were assigned to forest, transition, or farmland zones based on historical land cover and current woody cover. Generally, forested DPAs were composed of ≥60% woody cover, transition DPAs were composed of 6%-50% woody cover, and farmland DPAs were composed of ≤5% woody cover.