White Buffalo Inc.
Conserving Native Species and Ecosystems

# YEAR FOUR
# SUMMARY REPORT

**2019-20 Deer Research Program**

**Ann Arbor, Michigan**

**26 May 2020**

**Submitted by**

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## Executive Summary

Ann Arbor is a challenging situation for deer managers. The City is nearly built out, and the predominant development pattern is single-family homes surrounded by wooded corridors with no hunting and no non-human predators. This development pattern creates excellent deer habitat. The directive set by the City included improving forest health/regeneration in natural areas, a reduction in deer-vehicle collisions (DVCs), achieving a 75% satisfaction level among residents, and gathering data to inform future management decisions. The primary objective in Year 4 (2019/2020) was to assess the complementary effect of lethal management in larger wooded areas proximate to sterilization efforts that occurred in dense suburban neighborhoods.

Sterilization study areas were in the south (bounded by Nichols Arboretum and Huron Hills Golf Course and Huron Parkway Nature Area), north (bordered by Cedar Bend Nature Area and Leslie Park Golf Course), and east (bounded by Plymouth Rd., US-23, Concordia University, and Narrow Gauge Way Park). While sterilization efforts were conducted during the first three years of the program, no sterilization efforts were conducted as part of the efforts in Year 4 due to permit restrictions.

In Year 4, sharpshooting activities occurred from 2 – 22 January 2020 at 18 sites, and 109 deer were culled. We used suppressed .223 caliber rifles, shot from elevated positions to ensure a steep angle of trajectory, and followed the American Veterinary Medical Association's *Guidelines for the Depopulation of Animals* (2019). Results from the sharpshooting sites included: Barton/Foster: 14, Bird Hills: 17, Buttonbush: 5, Cedar Bend: 6, Concordia: 5, Foxfire: 5, Huron NA: 6, Leslie GC/W: 7, Newport: 11, Ruthven: 4, South Pond: 0, Nichols Arboretum: 6, and UM Other: 23.

A helicopter survey was conducted on 21 January 2020 using the same methods as in Year 3, however in addition to Wards 1 and 2, Wards 3, 4, and 5 were flown comprehensively. The survey detected 214 deer (137 in City limits), compared to 298 (224 in City limits) in Year 3, and 315 (289 in City limits) in Year 1. This is a 53% population reduction, using direct counts, within City limits from Year 1. As in previous years, we used a correction factor to account for the detection rate of individual deer in various environments. After applying this correction factor, we determined there were ~145 deer in Wards 1 and 2, 69 of which were in the sterilization study areas (South Study Area: 50, North Study Area: 6, East Study Area: 13). There were ~13 deer/mile$^2$ on average (145 deer in ~11.1 mile$^2$) in Wards 1 and 2. In areas with good sharpshooting access outside of the sterilization study sites, there were ~11 deer/mile$^2$ remaining (~76 deer in ~7 mile$^2$). Given the ~38 untreated adult females in Wards 1 and 2, we expect an additional ~42 fawns to be recruited into the population, raising the total to about 187 individuals by fall 2020. This level of recruitment will result in ~17 deer/mile$^2$.

Camera surveys were used to estimate the number of deer in the SSA after culling operations. An estimated population in the SSA was determined to be ~50 deer (~31 deer per

mile$^2$), with ~88% of the adult females sterilized. Aligned with the total population reduction, the doe:fawn ratio has declined from 1.1 (2017) to 0.15 (2018) to 0.11 (2019) and remained at 0.11 in 2020.

0n 13 December 2018, the Michigan House of Representatives passed a bill that prohibits the Michigan Department of Natural Resources from issuing deer sterilization permits until 2022. This bill removes the option for additional non-lethal deer management in Ann Arbor. With no adequate lethal management sites in the SSA and minimal home range overlap with adjoining sharpshooting areas (e.g., Arboretum and HPNA), without sterilization as a tool, we would have had no impact in the SSA, and the population would have likely increased from the Year 1 baseline. If surgical sterilization is not permitted in the immediate future, the local deer population in the SSA will increase negating the significant reduction accomplished over the past four years.

In summary, over four years we have demonstrated a 47% reduction in the SSA (94 deer in 2017, 63 in 2018, 46 in 2019, 50 in 2020) and a 60% reduction in the NSA (15, 10, 12, 6) with no deer mortality or human safety issues. In addition, we have documented a 58% reduction in deer abundance in Wards 1 and 2 outside of the southern and northern surgical sterilization areas. Of importance to note, we observed similar population impacts with lethal and non-lethal methods, and the surgical sterilization areas would have received negligible population impacts from a "sharpshooting only" program. Therefore, program success was the result of using combined methods.

## Introduction

Ann Arbor is located in central Michigan and consists of approximately 27.8 miles$^2$ of total land area. The municipality represents one of the most challenging situations for deer managers. Much of the community's land area is covered with single-family homes surrounded by wooded corridors (121,477 people with 47,524 households as of the 2017 census). This development pattern provides excellent deer habitat and, at the same time, can be restrictive to the implementation of some deer management options. This type of deer habitat exists primarily in Wards 1 and 2 and covers approximately 40% of the land area within the municipal boundaries. There is no hunting permitted within the community, and there are no non-human predators present that are capable of limiting a deer population. Given these favorable conditions, the deer population in the community has increased to a level that is incompatible with City objectives. Previously, only limited management actions had been used to control the deer population, including a sharpshooting effort in winter 2016 that resulted in 63 deer culled.

In the first year of our research (2017), we used a combination of methods to assess their impact on the local deer population under Scientific Collectors Permit (#1600), culling 96 deer and sterilizing 54 female deer. During Year 2, we culled 115 deer and surgically sterilized 18

female deer. During Year 3, we culled 112 deer and surgically sterilized six female deer. During Year 4, we culled 109 deer, and no sterilization efforts occurred.

Our Year 4 observations remain consistent with the pre-implementation assessment. In Ann Arbor's more densely developed neighborhoods, the capture and surgical sterilization method has proven to be a very effective method to control deer abundance, whereas, in other areas with sizable open spaces and fewer roads, sharpshooting is the most cost-effective method to control deer abundance. There are areas in the City with an abundance of deer that do not have suitably discreet shooting locations because they contain only small wooded Parks to conduct shooting operations, and any activity would be highly visible. With the elimination of sterilization as an option, these more densely developed areas will likely continue to be impacted by deer, and there is no viable solution for managing the population.

The research objectives continue to be guided by a City Council directive. Our objectives include improving forest health/regeneration, a reduction in DVCs, a 75% public satisfaction level for residents in all five Wards, and gathering data to inform future management decisions. Meeting these objectives will require an adaptive process whereby annual data collection will direct future strategic use of field methods.

## Study Areas

Sharpshooting locations were distributed throughout Wards 1 and 2 in Year 4 (Figure 1). Our goal was to have 3-4 evenly spaced sharpshooting locations per square mile in areas of suitable deer habitat and use additional sites on an as-needed basis in regions with more isolated pockets of deer. Additionally, we focused on access to suitable areas around the sterilization sites to prevent the immigration of deer into the sterilization areas.

In Years 1 - 3, sterilization efforts occurred in three areas where deer were abundant, and housing density was high. The sterilization sites included: 1) the area bounded by the Huron River to the northeast, the Nichols Arboretum to the northwest, Washtenaw Avenue to the southwest, and Huron Parkway to the east (South Study Area, hereafter, SSA), 2) the area bounded by Skydale Drive to the north, Route 23 and the Huron River to the west and south, and Black Pond Woods Nature Area, Murfin Avenue/Upland Drive to the east (North Study Area, hereafter NSA), and 3) the area bounded by Plymouth Rd. to the north, US-23 to the east, Concordia University to the south, and Narrow Gauge Way Park/Green Rd. to the west (East Study Area, hereafter ESA) (Figure 2). The Nichols Arboretum and Huron Parkway Nature Area (HPNA) served as sharpshooting areas proximate to the SSA. In the NSA, Cedar Bend Nature Area and Leslie Park Golf Course served as proximate sharpshooting areas. Narrow Gauge Park and Concordia University served as sharpshooting areas proximate to the ESA. During Year 4, no sterilization efforts occurred. Under the existing permit, we had one sterilization tag

remaining and could not justify the cost of implementing sterilization efforts to handle one individual.

**Figure 1.** Distribution of sharpshooting locations in Wards 1 and 2 in Ann Arbor, Michigan 2020.

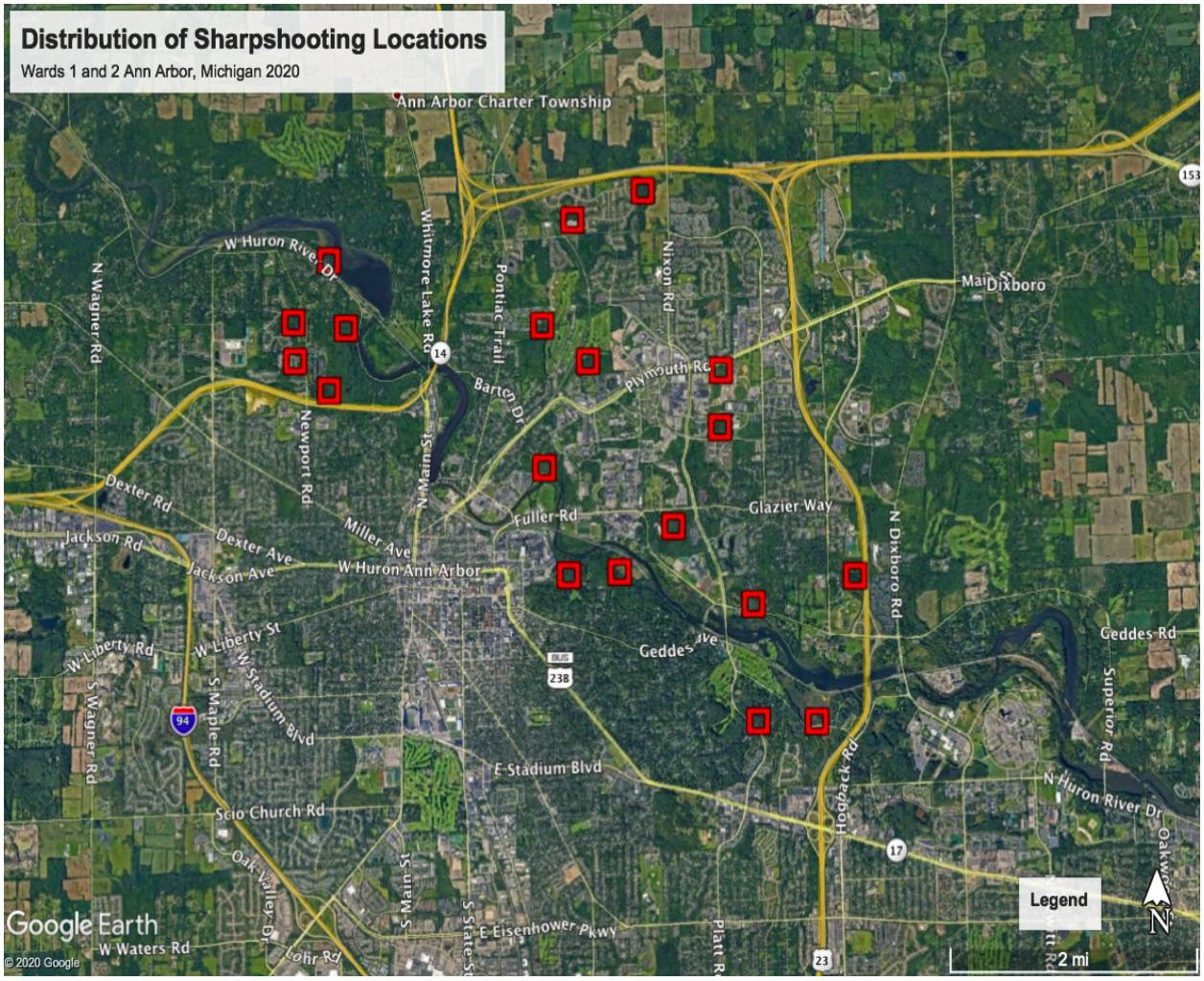


**Figure 2.** Delineation of surgical sterilization study areas in Ann Arbor, Michigan.

## Methods

### Sharpshooting

We followed the operations protocol outlined in the proposal, contract, and Michigan Department of Natural Resources (MDNR) Scientific Collection Permit (SCP) #1600. Pre-baiting was conducted from 14 December 2019 through 1 January 2020. Sharpshooting efforts were conducted from 2 - 22 January 2020. The conditions outlined in our sharpshooting protocol were met. We used suppressed .223 caliber rifles, shot from elevated positions to ensure a steep angle of trajectory, and all deer were shot following AVMA guidelines for euthanizing animals with firearms. Eighteen sites were used throughout the area of operation.

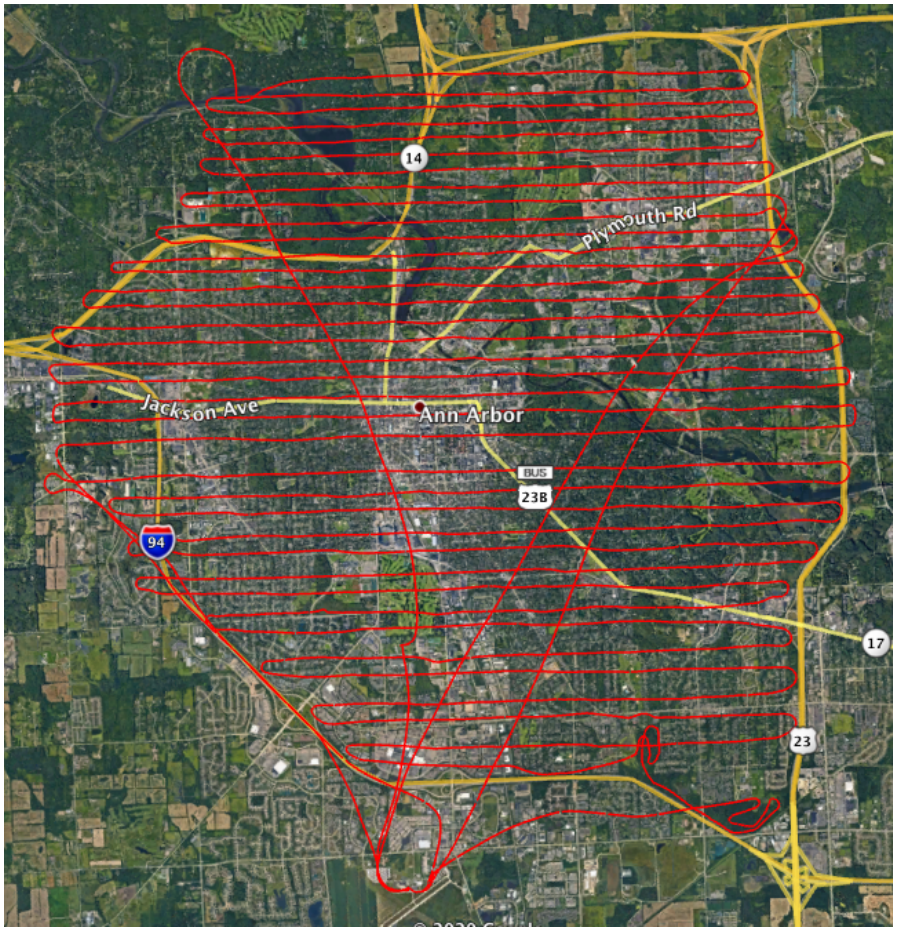
### Sterilization

No sterilization efforts were conducted during Year 4. Implementation costs to capture the one remaining deer permitted under SCP #1600 precluded execution. With no viable means to extend the number of permitted sterilizations, this portion of the project was terminated one year prematurely.

### Helicopter Survey

Prior to initiating the helicopter survey, transects were delineated and entered into the GPS moving map software (ExpertGPS) (Figure 3). East-West transects were spaced at ~200 yd intervals, which resulted in a total of 38 flight lines. On 21 January 2020, a Robinson 66 helicopter was used to fly transects at an elevation of 200-300 feet above ground level and an airspeed of 25 - 30 mph. Both observers counted all visible deer out to 100 yds from their respective sides of the aircraft. A pilot and a navigator ensured all transects were flown accurately. The navigator used a GPS with a moving map to verify the accuracy of all transects. The number of deer detected were tallied as deer were observed along flight lines. In open forest areas with good visibility, the above methodologies produce an ~80% detection rate (Beringer et al. 1998). Under less ideal conditions, often present in suburban landscapes, the detection rate can be significantly lower (e.g., <50%) (DeNicola, unpublished data). We adjusted the number of animals detected with a correction factor based on the detection rate appropriate for the conditions.

**Figure 3.** Helicopter survey transects flown on 21 January 2020 in Ann Arbor, Michigan.




## Camera Survey

After culling efforts were completed, a camera survey was conducted from 22 January - 20 February 2020 to provide a population estimate in the SSA. In previous years, the helicopter survey detected relatively few deer in the SSA due to development density and associated visibility. For the camera survey, we used Moultrie White Flash cameras (Moultrie Feeders, Alabaster, AL, USA) set on motion activated single shot with a 5-minute delay to optimize capture rates. Camera coverage of ~1/150 acres was used with one camera placed in each of 7 blocks. Each camera was elevated 0.6 m and oriented north. Cameras were retrieved once ~300 photos were obtained from each baited location or after 27 days had passed. Each picture was carefully studied, all legible ear tag numbers were documented, and individual males were identified based on antler pattern. We recorded the total number of deer, the number of unmarked adult females, the number of antlered males, the number of fawns, and the number of unidentifiable marked deer in each photo. From these photographic data, the total number of times individual marked deer were observed was entered into the program NOREMARK (White

1996), along with the total number of unmarked deer observations, and the total number of marked deer known to be alive in the population during the survey. We also used the same calculation method as Jacobson et al. (1997) to estimate the number of antlered males. We used the camera data and Lincoln-Petersen Estimator (LPE) to determine the ratio of tagged to untagged females, total adult females, and fawns (Curtis et al. 2009, Eberhardt 1969). Finally, we estimated the population based on our field observations and camera data. In summary, we used four different methods to estimate the total deer population: Jacobson's buck:doe ratios (BDR) estimator, LPE, program NOREMARK, and population reconstruction based on intensive field operations.

## Results

### Sharpshooting

We worked eighteen days to harvest 109 deer (Appendix A). The overall harvest demographics are summarized in Table 1. Harvest by day is outlined in Table 2, and harvest based on location is outlined in Table 3. We expended 517.75 person-hours for the sharpshooting activities (109 deer harvested), resulting in 4.76 person-hours per deer harvested.

There were 19 bait sites selected and prepared, and 18 of these sites were used for sharpshooting as part of the 2020 Ann Arbor deer research program. One site was removed from the site list due to a lack of consistent deer activity (Oakwoods). One site was used one time with no harvest occurring. Harvest results from specific sites ranged from 0 - 14.

**Table 1.** Sex of deer harvested in Ann Arbor, Michigan from 2 - 22 January 2020.

| Age | # Male (%) | # Female (%) | # Combined (%) |
|---|---|---|---|
| Yearling/Adult | 33 (30) | 37 (34) | 70 (64) |
| Fawns | 19 (18) | 20 (18) | 39 (36) |
| Total | 52 (48) | 57 (52) | 109 (100) |

**Table 2.** The number of deer harvested by day 2 - 22 January 2020 in Ann Arbor, Michigan.

| Date | # Harvested |
|---|---|
| 1/2/20 | 9 |
| 1/3/20 | 7 |
| 1/4/20 | 8 |
| 1/5/20 | 12 |
| 1/6/20 | 6 |
| 1/7/20 | 5 |
| 1/8/20 | 6 |
| 1/9/20 | 12 |
| 1/10/20 | 1 |
| 1/11/20 | Weather Day Off |
| 1/12/20 | 3 |
| 1/13/20 | 8 |
| 1/14/20 | 1 |
| 1/15/20 | 9 |
| 1/16/20 | 5 |
| 1/17/20 | 0 |
| 1/18/20 | Weather Day Off |
| 1/19/20 | 8 |
| 1/20/20 | 0 |
| 1/21/20 | 3 |
| 1/22/20 | 6 |

**Table 3.** Deer harvest by location from 2 - 22 January 2020 in Ann Arbor, Michigan.

| Location | # Harvested |
|---|---|
| Barton/Foster | 14 |
| Bird Hills | 17 |
| Buttonbush | 5 |
| Concordia | 5 |
| Foxfire | 5 |
| Huron NA | 6 |
| Leslie | 7 |
| Ruthven | 4 |
| Newport Rd | 11 |
| Cedar Bend | 6 |
| South Pond | 0 |
| Nichols Arboretum | 6 |
| UM Other | 23 |

## Helicopter Survey

The helicopter survey detected 214 individual deer, of which 137 were located within the City limits at the time of the survey (all five Wards). This count represents a decrease of ~39% in the number of deer within the municipal limits as compared with last year's helicopter survey (224 in 2019) and a 53% population reduction since Year 1 (289 in City limits). Total counts (including those observed just outside the City limit) declined by 28%, 298 as compared to 214, in 2019 and 2020, respectively. The number of deer located outside of the City north of the Huron River and west of Highway 23/14 was similar to the previous years (56 in 2018, 74 in 2019, 63 in 2020). Flight conditions for the 2020 survey were very good, so we used the same detection rates (~80%) as in 2019, excluding the highly developed areas in the SSA. The camera survey in the SSA determined that there were ~50 deer utilizing the area. Observations from the helicopter survey in the SSA only detected 13 deer, resulting in a detection rate of ~26%.

There were 98 deer observed in Wards 1 and 2 (Table 4) (180 in 2017, 172 in 2018, and 171 in 2019), 28 deer observed in Ward 3 (11 in 2017, 19 in 2018, and 24 in 2019), 5 deer in Ward 4 (8 in 2017, 23 in 2018, and 21 in 2019), and 12 deer in Ward 5 (6 in 2017, 6 in 2018, and 8 in 2019).

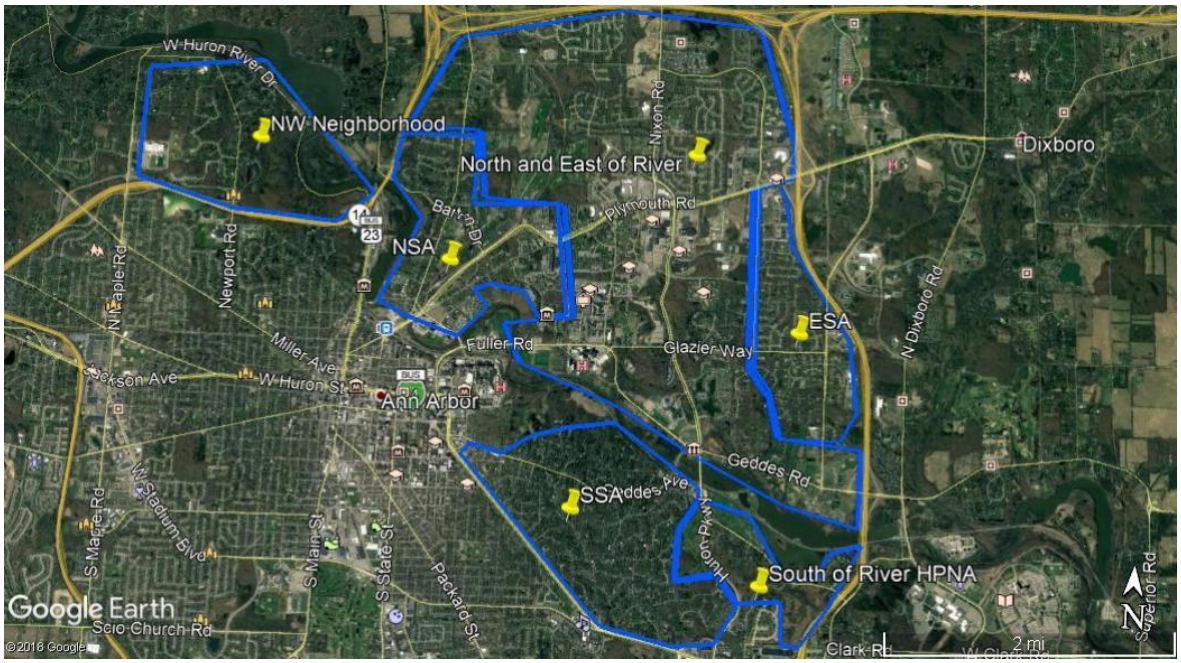
**Table 4.** Deer abundance determined during the helicopter survey, within delineated zones in Wards 1 and 2, with an incorporated correction factor (CF).

| Area | # Deer x CF = Total | Deer/mile$^2$ |
|---|---|---|
| Northwest Neighborhood - Skyline (west of river) | 16 X 80% CF = 19 | 1.2 mile$^2$ = 16 deer/mile$^2$ |
| South of River - Huron Parkway NA | 6 X 80% CF = 7 | 0.5 mile$^2$ = 14 deer/mile$^2$ |
| North and East of River | 47 X 80% CF = 57 | 5.8 mile$^2$ = 10 deer/mile$^2$ |
| ESA | 11 X 80% CF = 13 | 0.8 mile$^2$ = 17 deer/mile$^2$ |
| NSA | ~6 (Helicopter and field observations) | 1.2 mile$^2$ = 5 deer/mile$^2$ |
| SSA | Camera survey = ~50 | 1.6 mile$^2$ = 31 deer/mile$^2$ |

Using the correction factor, we estimated there were ~152 deer in Wards 1 and 2, 69 of which were in the sterilization study areas (SSA: 50, NSA: 6, ESA: 13) (Figure 4). There were ~13.7 deer/mile$^2$ on average (152 deer in ~11.1 mile$^2$) in Wards 1 and 2. In areas with sharpshooting access outside of the sterilization study areas, there were ~11 deer/mile$^2$ remaining (~83 deer in ~7.5 mile$^2$). Given ~38 untreated adult females, we expect an additional ~42 fawns to be recruited/added to the population next fall in Wards 1 and 2, raising the deer population in Wards 1 and 2 to about 194 deer by fall 2020. This level of recruitment will result in ~17 deer/mile$^2$.

In 2020, helicopter observations were conducted systematically in Wards 3-5 as opposed to previous years when targeted observations occurred. Observation locations remained consistent with past years, even though the method was more thorough. Upward trends in deer numbers continued in Wards 3 and 5, where we have observed the deer population double over the last four years. In Ward 4, the observations dropped dramatically from 21 the previous year to 5 in 2020. It is likely that due to low detection rates in highly developed areas, the deer in Ward 4 were missed during the helicopter count. Based on the amount of development in Wards 3, 4, and 5, we would assume our detection rate in this part of the community would be similar to that of the SSA (~30% on average over the past four years). Using a correction factor of 3.3 would project the deer population outside of Wards 1 and 2 at ~148. Minimally, there are 45 deer present based on direct observations.

**Figure 4.** Helicopter survey area covering Wards 1 and 2 in Ann Arbor, Michigan, with delineated areas based on detection rates.




**Camera Survey**

We obtained a total of 1,381 pictures from the seven baited camera sites, which included observations of 2,470 deer. There were 1,561 photos of tagged females as compared to 356 images of antlered males (Table 5). We observed 94% (30 of 32) of the tagged adult females in photos that were alive and presumed present in the study area during the survey.

Using the BDR estimator and an adjustment for camera bias, we estimated 55 deer in the SSA, including 20% adult males (n = 11), and 80% antlerless deer (40 adult females and four fawns = 44) (Table 6). When analyzing the photos using the BDR estimator, we examined the average number of photos of each tagged adult female as compared to the average number of photos of individual adult males. We observed there were 0.6 times more photos of tagged adult females than antlered males (e.g., this represents a higher likelihood to observe females on bait). We adjusted the number of males and fawns derived using this method with a correction factor of 0.6 to account for this camera bias. Based on observations in the field, even with the correction factor, there is a positive bias in the number of female photos and the number of females estimated using this method.

When analyzing the pictures using the LPE (32 tagged adult females, four untagged adult females, and four fawns = 40 antlerless deer), and adding the number of individual antlered males identified (n = 11), the total estimate was 51 deer.

**Table 5.** Camera survey data collected from 22 January - 20 February 2020 in Ann Arbor, Michigan, used for BDR, LPE, NOREMARK, and population reconstruction estimators.

| Site | # Photos | Total Deer Observations | Tagged Adult Female | Untagged Adult Female | Adult Male | Fawns |
|---|---|---|---|---|---|---|
| 1 | 66 | 127 | 101 | 2 | 15 | 1 |
| 2 | 134 | 177 | 172 | 0 | 0 | 0 |
| 3 | 300 | 503 | 352 | 43 | 63 | 24 |
| 4 | 183 | 407 | 311 | 26 | 21 | 3 |
| 5 | 300 | 404 | 77 | 40 | 245 | 21 |
| 6 | 166 | 386 | 135 | 67 | 4 | 129 |
| 7 | 232 | 466 | 413 | 3 | 8 | 3 |
| Total | 1381 | 2470 | 1561 | 181 | 356 | 181 |

**Table 6.** 2020 deer population estimates after sharpshooting efforts using BDR, LPE, NOREMARK, and population reconstruction estimators for the SSA in Ann Arbor, Michigan.

| Estimation Method | Estimated Parameters |
|---|---|
| **January 2020 camera survey** | 1,381 observations |
| Adult female:antlered male ratio in photos | 1:0.18 |
| Adult female:fawn ratio in photos | 1:0.09* |
| Number of antlered males | 11 |
| Tagged adult female:untagged female ratio in photos | 1:0.12 |
| **Population estimates** | |
| BDR estimator (Jacobson et al. 1997) | 55** |
| LPE | 51 |
| Bowden's ratio estimator (NOREMARK) | 50*** |
| Population reconstruction | 50 |

* Adult female: fawn in photos was lower than the ratio seen in estimates using known individuals (0.11).
** Estimate removed from average due to inflation of adult female total.
*** Adult females = 35 (95% CI: 34-37), plus 11 known adult males and ~4 fawns, total 50

We ran the NOREMARK program using Bowden's ratio estimator and included all of the tagged adult females potentially in the area (n = 32). If a tagged animal was missing from the camera survey this session but was not missing in December 2018, we included the individual as

potentially available for sighting (n = 2). The adult female deer population (tagged and untagged) was estimated to be 35 (95% CI: 34-37). We then added the number of individual antlered males identified using the BDR estimator (n = 11), added the number of fawns estimated using LPE, and determined the total deer abundance was 50 in the SSA.

Using the population reconstruction method, we projected 50 deer in the SSA. There were 32 tagged adult female deer presumed alive at the time of the survey (#47 was sighted near Bluffs Nature Area near the time of the survey and is considered not available in the area), four untagged adult females, four fawns (one female fawn, two male fawns, one unknown fawn), and 11 adult males. Using LPE, NOREMARK, and the population reconstruction method to estimate the herd density, we found an average estimated density of ~31 deer/mile$^2$ (SSA area = ~1.6 mile$^2$). We also determined that ~88% of the adult females in the SSA (32 tagged adult females and four untagged adult females) were sterilized upon completion of the camera survey.

## Discussion

Our primary objective was to assess the complementary effect of lethal management in larger wooded areas proximate to sterilization efforts in dense suburban neighborhoods. We have demonstrated a ~47% reduction in the SSA (94 deer in 2017, 63 in 2018, 46 in 2019, 50 in 2020) and a 60% reduction in the NSA (15, 10, 12, 6). In addition, there should be significant impact reductions in nearly all areas where we had sharpshooting access given the 58% reduction in the remainder of Wards 1 and 2. In Year 4, we collected additional data to help the City Council move forward with future management decisions, including a fourth helicopter and camera survey, cost summaries for each research project component, and further demonstration of feasibility and effectiveness of the respective research actions.

**Sterilization**

We are aware of four untreated adult females in the SSA. Based on field observations, we believe that the 32 adult females sterilized represent >88% of the adult females in this zone. After sharpshooting efforts, we estimate there to be 50 deer in the SSA (estimated using camera survey) and 6 in the NSA (estimated using helicopter survey and field observations). The increase in the number of non-sterilized adult females in the SSA is concerning. Without the ability to capture and sterilize these deer, we expect the deer population to increase in the SSA in 2020-21. The recruitment (e.g., new surviving fawns) from these four deer will likely exceed any mortalities that occur, and result in a net deer population gain in the SSA next year. The legislative change in 2018 prevents MDNR from issuing additional sterilization permits until 2022. This will result in substantial setbacks in the SSA where sharpshooting access has minimal effect on the local deer. The limited number of unsterilized females in the NSA should ensure a continued low recruitment rate and contribute to ongoing population declines in this

area. A limited number of females were sterilized in the ESA, and this likely had minimal impact on the reduction of recruitment rates.

No deer died during capture or surgical procedures. In addition, capture and handling procedures are safe for the public as well as the professionals involved. Finally, there were no complaints from the public during field operations demonstrating surgical sterilization is acceptable to the public and compatible for use in densely developed suburban environments.

**Sharpshooting**

In Year 4, we eliminated two sharpshooting sites that were active in 2019. These sites were removed due to field observations, low deer numbers in the area during the January 2019 helicopter survey, and the potential for public interference based on two prior years. No new shooting locations were added during Year 4, and all work was conducted exclusively in Wards 1 and 2. We continue to see an abundance of deer on the northern and western boundaries of Ward 1, although the numbers are much better on the western edge than in previous years. The western section of Ward 1 contains many unannexed Township properties, and the Township did not participate in the deer management program. Additional flexibility in field operations allowed by the University of Michigan enabled us to meet management objectives and resulted in greater harvest efficiency than anticipated on North Campus.

The number of harvested deer decreased slightly from Year 3 (112) to Year 4 (109). The overall harvest efficiency was similar to Year 3 (Year 1: 21 person-days, Year 2: 43 person-days, Year 3: 38 person-days, Year 4: 38 person-days). One incident of bait site tampering was witnessed and documented. The Ann Arbor Police Department followed up on the report, and after discussing the event with the responsible party, no additional bait site tampering occurred. Several residents in Ann Arbor were found to be illegally feeding deer. The Ann Arbor Police Department and the MDNR were notified. Subsequently, they informed the parties of Ann Arbor's feeding ordinance, as well as the statewide ban on feeding deer due to Chronic Wasting Disease concerns.

As expected, given past deer abundance, the sites in the NW portion of Ward 1 were the most productive, resulting in 38.5% of the overall harvest. One location in Ward 1 was responsible for ~13% of the total harvest. The wooded open space bordering Skyline High School remains problematic. The NW neighborhood deer that were observed inside the Ann Arbor municipal boundary during the helicopter survey were seen on Skyline High School property during the sharpshooting effort (Figure 5). Our site access in that area did not impact deer residing in the school open space. The addition of a new private site in this area or cooperation by the School Board would help address this deer population. Unfortunately, our attempts to gain access to private property proximate to the school have not been successful.

**Figure 5.** 2020 Deer observations on Skyline High School property in Ann Arbor, Michigan.


The number of deer engaged at Nichols Arboretum during Year 4 was similar to Year 2. One untagged adult female and her fawn were removed along with four adult males. The number of adult males removed from the site was similar to Year 3. Surveillance of the active bait sites within the Arboretum indicated less overall activity than previous years. Only two sterilized deer were actively utilizing the Arboretum during removal efforts. This differs from previous years when some sterilized deer were observed in the Arboretum during removal efforts.

Harvest at HPNA was ~25% lower than in previous years, and 60% less than in Year 2. Six known deer remained in this area after the 2020 program. These deer are known to reside on the far eastern edge of the municipality, and their activity was sporadic at the shooting location. During the 2020 program, 50% of the seated attempts at this location resulted in no harvest.

The total harvest on the University of Michigan property in 2020 was 37.5% lower than 2019, with 29 and 40 deer removed, respectively. After the program concluded, two deer were known to be in the area bounded by Plymouth Road to the north, Green Road to the east, Huron Parkway to the West, and Glazier Way to the South. This was a vast improvement over the 2018 survey when 32 deer were known to reside in this area.

The sharpshooting site at the Cedar Bend Nature Area contributed to the removal of six deer. Continued lethal management in this area will likely help prevent the repopulation of the NSA.

The site at Narrow Gauge Way Park (NGWP) was abandoned due to consistent interference at the shooting location in prior years. An adjustment was made to access these deer at other proximate sharpshooting locations. While the change resulted in moderate success, the residents around NGWP will continue to be impacted by the remaining deer. The helicopter survey revealed ten deer, one of the largest concentrations in the City.

Sites in the north-central and northeast regions of the City showed minimal harvest numbers as a result of low deer densities. Camera data, the helicopter survey, and field observations supported this outcome.

**Combined Methods**

At the conclusion of Year 4, few deer were remaining in the open spaces adjacent to the surgical sterilization study sites (e.g., Nichols Arboretum (SSA), HPNA (SSA), Leslie Golf Course (NSA), and Cedar Bend (NSA). The low deer densities in these areas should minimize any influx of untagged females into the NSA and SSA areas in the near-term. The one exception is the area south of the SSA, where County Farm Park provides suitable deer habitat, and no deer management actions are implemented. This situation will allow for the increased risk of deer ingress into the SSA, as was observed this past year. It is assumed that one of the adult females observed during the camera survey on the southern end of the SSA, is the result of an overlapping home range with the County Farm Park area. Continued lethal management on the perimeter of each sterilization area, where we have access, will be critical to ensure repopulation does not occur given our inability to continue sterilization efforts.

Porter et al. (2004) demonstrated strong philopatry of female white-tailed deer. Our data appears to support this. Minimal ingress has occurred in the SSA and NSA as well as the adjacent sharpshooting areas. For example, only four adult female deer have been harvested on the two sites bordering the SSA over the last two years. Two adult females were harvested from HPNA in 2019 (no adult females harvested in the Nichols Arboretum). During 2020, one adult female was harvested in the Arboretum and one in HPNA. These data suggest that deer are not infiltrating the areas surrounding the NSA and SSA and, in turn, the study areas themselves. Possibly a more important aspect of this philopatric behavior is that the vast majority of the deer in the SSA are not moving into areas where they would have the potential to be lethally removed. Overall, the rate of immigration is similar to what we have experienced at other surgical sterilization research programs that do not have sharpshooting on the perimeter (Table 7).

**Table 7.** Population demographics derived from population estimates and field operations for three surgical sterilization study sites from 2014 - 2020.

**Ann Arbor, Michigan, USA[1]**

| Estimate Date | Population Total | Deer/km$^2$ | Sterilized | Decline from Prior Year | Adult Males | Doe:Fawn | Antlerless Immigrants |
|---|---|---|---|---|---|---|---|
| Feb 2017 | 94 | 22.0 | 91% | | 6 | 1.1 | |
| Jan 2018 | 70 | 16.3 | 96% | 26% | 4 | 0.16 | 1 |
| Dec 2018 | 54 | 12.9 | 97% | 23% | 5 | 0.11 | 1 |
| Mar 2020 | 50 | 11.7 | 88% | 7% | 11 | 0.11 | 2 |

Total Decline 47%

[1] Totals represent post sharpshooting data.

**Clifton neighborhood parks, Cincinnati, OH, USA**

| Estimate Date | Population Total | Deer/km$^2$ | Sterilized | Decline from Prior Year | Adult Males | Doe:Fawn | Antlerless Immigrants |
|---|---|---|---|---|---|---|---|
| Dec 2015 | 99 | 41.4 | 86% | | 32 | 0.62 | |
| Jan 2017 | 83 | 34.4 | 89% | 17% | 29 | 0.15 | 1 |
| Jan 2018 | 80 | 33.3 | 91% | 3% | 23 | 0.12 | 1 |
| Feb 2019 | 74 | 30.8 | 94% | 8% | 14 | 0.18 | 2 |
| Feb 2020 | 72 | 29.9 | 98% | 3% | 16 | 0.10 | 1 |

Total Decline 28%

**City of Fairfax, Virginia, USA**

| Estimate Date | Population Total | Deer/km$^2$ | Sterilized | Decline from Prior Year | Adult Males | Doe:Fawn | Antlerless Immigrants |
|---|---|---|---|---|---|---|---|
| Jan 2014 | 91 | 5.5 | 31% | | 6 | 1.3 | |
| Feb 2015 | 66 | 4.0 | 91% | 28% | 9 | 0.53 | |
| Dec 2015 | 53 | 3.2 | 93% | 20% | 16 | 0.23 | |
| Dec 2016 | 48 | 2.9 | 84% | 9% | 15 | 0.10 | 1 |
| Jan 2018 | 40 | 2.4 | 91% | 17% | 13 | 0.17 | |

Total Decline 56%

At the completion of Year 4, no known unsterilized female deer remained in the NSA. The risk of ingress does exist from the northeast and southeast sides of the study area. Both areas have known populations of unsterilized deer to serve as reservoirs, but to date, we have had adequate access to address these localized deer herds lethally. The SSA presents a more significant challenge, given our inability to continue sterilization treatments. With four known adult female deer likely to recruit fawns this spring (4 fawns were recruited this past winter), it is expected that the deer population will grow in the SSA. Given we cannot continue sterilization in these areas, it will be important in the future to focus on lethal management activities at nearby sites to minimize repopulation from home range overlap and occasional immigration.

**Cost Analysis**

The overall cost of the sterilization effort was $159,815.26, over four years, resulting in a 49% reduction in deer within the 2.8 mi$^2$ area of the SSA and NSA. Sharpshooting efforts cost $255,800.49, over the four years, resulting in a 58% reduction in deer over an 8.3 mi$^2$ area outside of the northern and southern surgical sterilization areas (Wards 1 and 2). While the generalization could be made that it cost 2-3 times as much to sterilize deer as to sharpshoot (e.g., cost per area for similar outcome), this would not accurately portray the nuance of the situation. There are very few options to manage deer in areas like the SSA. Small lot size, with relatively little open space, limits the areas where one can safely and discreetly operate with firearms and archery equipment. This development pattern, combined with a female deer population that exhibits strong philopatry, limits management options to trapping (either sterilizing or euthanizing) or remote anesthesia (either sterilizing or euthanizing) within the

existing non-lethal areas. In hindsight, and as we predicted, if sharpshooting were applied exclusively surrounding the SSA, there would have been minimal, if any, population impact inside the SSA. The population would have likely continued to increase from the initial population, given the documented recruitment rates and relative mortality. This constraint will continue to apply to any lethal management approach, including hunting.

**Population Estimates - Helicopter and Camera Surveys**

There was a marked decrease in the number of deer (137 versus 224) within the municipal limits as compared to last year's helicopter survey. Total helicopter counts also decreased (~28%; 214 versus 298). In particular, there was a significant reduction in Wards 1 and 2 deer abundance. It should be noted that deer abundance is increasing in Wards 3 - 5, where minimal sharpshooting activities have occurred.

The camera survey estimates projected the population in the SSA to be 31 deer/mile$^2$ after sharpshooting efforts (22% antlered males, 70% adult females, 8% fawns). This represents a 47% decrease since 2017 (59 deer/mile$^2$ to 31 deer/mile$^2$). We estimate that ~88% of adult females were sterilized in the SSA; four untreated adult females and one known female fawn are in the area. Since the start of the program, there have been 15 mortalities between the NSA and SSA (10 DVCs, 5 unknown cause and 1 (#32) euthanized), and nine missing (#4, 5, 10, 11, 18, 38, 40, 42, 44, 46, 48, 58, 62 and 69) from the camera survey for two years and not observed in the field.

In summary, there are ~13 deer/mile$^2$ on average in Wards 1 and 2 (152 deer in ~11.1 mile$^2$), with a concentration on the Skyline School property.

**Fawn Recruitment**

The average doe:fawn ratio across the three methods in the SSA was ~0.11 (~36 adult females – includes 32 tagged adult females, ~ four untagged adult females, and ~four fawns) reflecting a marked reduction over the 2017 recruitment ratio of 1.1.

Given the estimated number of untreated adult females (~40% of ~113 [outside of sterilization areas] = ~45 fertile adult females; and a recruitment rate of ~1.0 (doe:fawn from 2020 harvest data)), we expect an additional ~45 fawns to be recruited/added to the population next fall in Wards 1 and 2. Significant growth also is expected in Wards 3-5, given the population increase since the project inception, and as is expected in unmanaged deer populations that have not reached biological carrying capacity.

**Future Management Considerations**

After completion of the four-year research project, there are a few key insights to help direct local deer management moving forward. We have successfully impacted most areas of Wards 1 and 2 by combining sharpshooting and surgical sterilization methods. However, the

area adjacent to Skyline High School in the NW neighborhoods continues to be a focal challenge. High deer densities in the Township abutting the municipal line and lack of access to shooting locations near the school have resulted in modest impacts from deer management activities in this area. The two residents who volunteered their properties last year saw a dramatic decrease in the number of deer they observed between the end of Year 3 and the beginning of Year 4. The localized impact is substantial, but on a broader scale, we need to find additional access points in this area. We are near maintenance level densities (i.e., management objectives are being met) in the rest of Wards 1 and 2, with pockets of deer in Wards 3, 4, and 5 that should be addressed before densities increase to problematic levels. For example, Natural Areas Preservation received complaints from residents in Wards 3 and 5 expressing concerns regarding numerous deer in and around their neighborhoods. The concern in Ward 3 was centered around Scarlett Woods and Pittsview Drive/Charing Cross, whereas many as 11 deer in one herd have been observed. The complaint from Ward 5 noted ten deer in the area south of M-14, west of Main Street, north of Miller Avenue, and east of Newport Road.

Moving forward in the SSA, if surgical sterilization is not permitted next year (i.e., winter 2020-21), then non-traditional lethal management could be considered for the remaining non-sterilized deer. If the remaining non-sterilized females are allowed to reproduce, in a matter of 2-3 years, the deer population will grow nearing pre-research levels. Options could include, but not be limited to, capture and euthanasia. The two most common mechanisms utilized for this approach are dart and euthanize, and drop-net and euthanize. Both options have pitfalls. With the use of drop-netting, previously sterilized deer may be captured and subjected to the stress of capture and release (if it is decided not to euthanize them as well). With dart and euthanasia, although you can target specific untreated females, the meat cannot be donated for consumption and must be disposed of because the animals are exposed to capture drugs.

## Acknowledgments

First and foremost, this project would not have been possible without the support of the Ann Arbor City Council. In addition, we are grateful to the following individuals and organizations that provided critical support prior to and during the research project:

- City of Ann Arbor officials: Tom Crawford, Derek Delacourt, Doug Forsyth, Lisa Wondrash as well as, Michael Hahn, Dave Borneman and his staff
- Ann Arbor Police Department
- MDNR, especially Chad Stewart and Stephen Beyer
- University of Michigan and its Division of Public Safety and Security
- Robert McGee for coordinating volunteers and logistical support for sterilization efforts
- Dr. Katie Dyer and Dr. Matt Dyer for providing surgical support and veterinary logistics

## Literature Cited


Beringer, J., L. P. Hansen, and 0. Sexton. 1998. Detection rates of white-tailed deer with a helicopter over snow. Wildlife Society Bulletin 26:24-28.

Curtis, P. D., B. Bazartseren, P. M. Mattison, and J. R. Boulanger. 2009. Estimating deer abundance in suburban areas with infrared-triggered cameras. Human–Wildlife Conflicts 3:116–128.

DeNicola, A. J., D. Etter, and T. Almendinger. 2008. Demographics of non-hunted white-tailed deer populations in suburban areas. Human-Wildlife Conflicts 2:102-109.

Eberhardt, L.L. 1969. Population estimates from recapture frequencies. Journal of Wildlife Management 33:28-39.

Jacobson, H. A., J. C. Kroll, R. W. Browning, B. H. Koerth, and M. H. Conway. 1997. Infrared-triggered cameras for censusing white-tailed deer. Wildlife Society Bulletin 25:547–556.

Porter, W. F., H. B. Underwood, and J. L. Woodard. 2004. Movement behavior, dispersal, and the potential for localized management of deer in a suburban environment. Journal of Wildlife Management 68:247–256.

White, G. C. 1996. NOREMARK: Population estimation from mark-resighting surveys. Wildlife Society Bulletin 24:50–52.

## Appendix A

Deer harvest data from 2 - 22 January 2020 from Ann Arbor, Michigan.

| Date | Tag Number | Age | Sex | Location |
|---|---|---|---|---|
| 1/2/20 | 125863 | F | M | Huron |
| 1/2/20 | 125864 | A | F | Huron |
| 1/2/20 | 125865 | A | M | Huron |
| 1/2/20 | 125866 | A | M | Barton |
| 1/2/20 | 125867 | F | F | Barton |
| 1/2/20 | 125868 | A | F | Barton |
| 1/2/20 | 125853 | A | F | Barton |
| 1/2/20 | 125854 | A | F | Barton |
| 1/2/20 | 125855 | A | F | Barton |
| 1/3/20 | 125856 | A | F | Foxfire |
| 1/3/20 | 125857 | A | M | Foxfire |
| 1/3/20 | 125869 | A | M | Newport N |
| 1/3/20 | 125870 | A | M | Newport N |
| 1/3/20 | 125871 | A | M | Newport N |
| 1/3/20 | 125872 | A | M | Newport N |
| 1/3/20 | 125873 | A | M | Newport N |
| 1/4/20 | 125873 | A | F | Bird Hills S |
| 1/4/20 | 125874 | A | F | Bird Hills S |
| 1/4/20 | 125875 | Y | M | Bird Hills S |
| 1/4/20 | 125876 | Y | M | Bird Hills S |
| 1/4/20 | 125877 | Y | M | Bird Hills S |
| 1/4/20 | 125878 | F | M | Bird Hills S |
| 1/4/20 | 125860 | F | M | Leslie E |
| 1/4/20 | 125862 | A | F | Leslie E |
| 1/5/20 | 125858 | A | F | UM Hubbard |
| 1/5/20 | 125859 | A | F | UM Hubbard |

| | | | | |
|---|---|---|---|---|
| 1/5/20 | 125882 | A | F | UM Hubbard |
| 1/5/20 | 125883 | F | M | UM Hubbard |
| 1/5/20 | 125884 | A | F | UM Hubbard |
| 1/5/20 | 125897 | F | F | UM Hubbard |
| 1/5/20 | 125880 | A | F | UM Glaizer |
| 1/5/20 | 125881 | Y | M | UM Glaizer |
| 1/5/20 | 125885 | F | M | UM Glaizer |
| 1/5/20 | 125886 | A | F | UM Glaizer |
| 1/5/20 | 125887 | F | F | UM Glaizer |
| 1/5/20 | 125890 | F | F | UM Glaizer |
| 1/6/20 | 125891 | Y | M | Arboretum |
| 1/6/20 | 125907 | F | F | Button Bush |
| 1/6/20 | 125908 | F | M | Button Bush |
| 1/6/20 | 125909 | A | F | Button Bush |
| 1/6/20 | 125910 | A | F | Button Bush |
| 1/6/20 | 125911 | F | F | Button Bush |
| 1/7/20 | 125912 | A | M | Barton |
| 1/7/20 | 125892 | A | F | Newport S |
| 1/7/20 | 125893 | A | F | Newport S |
| 1/7/20 | 125894 | F | M | Newport S |
| 1/7/20 | 125895 | F | F | Newport S |
| 1/8/20 | 125922 | F | M | Ruthven |
| 1/8/20 | 125923 | A | F | Ruthven |
| 1/8/20 | 125889 | A | F | Ruthven |
| 1/8/20 | 125896 | A | M | Ruthven |
| 1/8/20 | 125918 | A | M | Concordia |
| 1/8/20 | 125919 | A | F | Concordia |
| 1/9/20 | 125861 | F | M | Barton |
| 1/9/20 | 125888 | A | F | Barton |

| | | | | |
|---|---|---|---|---|
| 1/9/20 | 125913 | F | F | Barton |
| 1/9/20 | 125914 | F | M | Barton |
| 1/9/20 | 125916 | A | F | Barton |
| 1/9/20 | 125915 | A | F | Barton |
| 1/9/20 | 125921 | F | F | Barton |
| 1/9/20 | 125899 | F | M | Bird Hills N |
| 1/9/20 | 125898 | A | M | Bird Hills N |
| 1/9/20 | 125900 | A | F | Bird Hills N |
| 1/9/20 | 125901 | A | F | Bird Hills N |
| 1/9/20 | 125902 | F | F | Bird Hills N |
| 1/10/20 | 125917 | A | M | Foxfire |
| 1/12/20 | 125929 | Y | M | UM Glaizer |
| 1/12/20 | 125930 | Y | M | UM Glaizer |
| 1/12/20 | 125903 | Y | M | UM Plymouth |
| 1/13/20 | 125904 | A | M | Arboretum |
| 1/13/20 | 125905 | F | F | Arboretum |
| 1/13/20 | 125906 | A | F | Arboretum |
| 1/13/20 | 125920 | Y | M | Arboretum |
| 1/13/20 | 125924 | F | M | Arboretum |
| 1/13/20 | 125931 | A | F | UM Hubbard |
| 1/13/20 | 125932 | F | F | UM Hubbard |
| 1/13/20 | 125933 | F | F | UM Hubbard |
| 1/14/20 | 125925 | F | M | Newport N |
| 1/15/20 | 125926 | F | F | Bird Hills N |
| 1/15/20 | 125927 | F | F | Bird Hills N |
| 1/15/20 | 125928 | A | F | Bird Hills N |
| 1/15/20 | 125943 | F | M | Bird Hills N |
| 1/15/20 | 125944 | F | F | Bird Hills N |
| 1/15/20 | 125945 | F | F | Bird Hills N |

| | | | | |
|---|---|---|---|---|
| 1/15/20 | 125934 | Y | M | Huron |
| 1/15/20 | 125935 | Y | M | Huron |
| 1/15/20 | 125936 | Y | M | Huron |
| 1/16/20 | 125946 | A | M | Leslie E |
| 1/16/20 | 125947 | F | M | Leslie E |
| 1/16/20 | 125948 | F | M | Leslie E |
| 1/16/20 | 125949 | A | F | Leslie E |
| 1/16/20 | 125953 | F | F | Leslie E |
| 1/19/20 | 125954 | A | M | Cedar Bend |
| 1/19/20 | 125955 | Y | M | Cedar Bend |
| 1/19/20 | 125956 | Y | M | Cedar Bend |
| 1/19/20 | 125957 | F | M | Cedar Bend |
| 1/19/20 | 125958 | F | M | Cedar Bend |
| 1/19/20 | 125959 | A | F | Cedar Bend |
| 1/19/20 | 125951 | F | F | UM Hubbard |
| 1/19/20 | 125952 | A | F | UM Hubbard |
| 1/21/20 | 125940 | A | M | Foxfire |
| 1/21/20 | 125941 | A | M | Foxfire |
| 1/21/20 | 125960 | A | M | Newport N |
| 1/22/20 | 125961 | F | M | Concordia |
| 1/22/20 | 125962 | F | F | Concordia |
| 1/22/20 | 125963 | A | F | Concordia |
| 1/22/20 | 125937 | A | F | UM Glaizer |
| 1/22/20 | 125942 | A | F | UM Glaizer |
| 1/22/20 | 125950 | A | F | UM Glaizer |