2015 Project Abstract
For the Period Ending June 30, 2020

PROJECT TITLE: Deer movement related to potential CWD prion transmission
PROJECT MANAGER: Christopher S. Jennelle
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2015, Chp. 76, Sec. 2, Subd. 10

APPROPRIATION AMOUNT: $ 449,557
AMOUNT SPENT: $ 449,556
AMOUNT REMAINING: $ 0.12

Sound bite of Project Outcomes and Results
This project provided a foundation for understanding deer movements in southeastern Minnesota that can facilitate spread of chronic wasting disease. Deer had westward movement trajectories, underscoring risk of CWD spread towards the Minnesota interior. In southeastern Minnesota, hunting is the primary source of mortality for yearling deer.

Overall Project Outcome and Results
We quantified dispersal and migratory movements of wild white-tailed deer (*Odocoileus virginianus*) in southeastern Minnesota that are relevant to understanding the potential spread of chronic wasting disease (CWD). After detection of CWD in fall 2016 in Fillmore County, we sought to determine potential pathways of CWD spread on the landscape via wild deer movements and estimate general causes of deer mortality in southeastern Minnesota. Since March 2018, we captured and fitted GPS collars to 226 deer and continue to monitor 72 animals. The main causes of mortality were hunting and vehicle collision in the yearling to 3-year-old deer composing our sample, which underscores the importance of harvest management as a valuable tool to control CWD in southeastern Minnesota. Average annual survival for females and males was 0.73 and 0.54, respectively, and these low survival estimates likely reflect effective liberalized harvest regulations within the study area to manage CWD.

We found that 26% of females and 43% of males dispersed between their natal and adult home range, and surprisingly 15% of females and 6% of males underwent seasonal migration between summer and winter ranges. The average dispersal distance for females and males was 20.0 km and 22.8 km, respectively, while that for migratory females and males was 12.8 km and 17.7 km, respectively. We also observed extreme dispersal distances of 116 km and 97 km, respectively, for a female and male. Both sexes tended to disperse westward, although a pattern was unclear for migratory animals. Deer were more likely to avoid agricultural landscape during dispersal and migration, although we did not observe consistent habitat characteristics along movement paths. The southwest to northwest trajectory of dispersal movements underscores increased risk of CWD spread to the Minnesota interior. This information will be vital for prioritizing and guiding CWD management efforts in and around southeastern Minnesota.

Project Results Use and Dissemination
Over the course of this project, we have had 23 articles, interviews, or media reports pertaining to this study. MNDNR staff have given at least 14 professional presentations regarding this study to state, federal, and University audiences. We have also created [a dedicated webpage](https://www.dnr.state.mn.us/cwd/deer-movement-study.html) devoted to providing background and updates

to this study. We have outreached to over 250 private landowners in southeastern Minnesota as part of the process of obtaining permission to access private property for deer capture and GPS-collaring efforts. We have provided regular updates and interactive maps to participating landowners, interested citizens, and hunters who have submitted harvested collared deer to us. We are in the process now of creating an interactive map of select study deer to go live on our webpage that will allow the public to better engage with the amazing movement data we have collected thus far. We have written three DNR agency reports of this project thus far, and are in the process of writing manuscripts for publication. We will continue to collect data for deer with active GPS collars, and we intend to collar about 45 additional deer in early 2021 as a final cohort for this study.

Environment and Natural Resources Trust Fund (ENRTF)

M.L. 2017 LCCMR Work Plan Final Report

Date of Submission: August 15, 2020
Final report
Date of Work Plan Approval: January 11, 2018
Project Completion Date: 06/30/2020

PROJECT TITLE: Deer movement related to potential CWD prion transmission

Project Manager: Christopher S. Jennelle
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Location: Fillmore, Houston, Mower, Olmsted, Winona. Southeastern Minnesota will be impacted by the study.

Total ENRTF Project Budget:

ENRTF Appropriation:	**$449,557**
Amount Spent:	**$449,556**
Balance:	**$0.12**

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 10 - Emerging Issues Account as extended M. L. 2017, Chap. 96, Sec. 2, Subd. 18 as extended M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 20 as extended by M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 19

Appropriation Language:

$1,000,000 the first year is from the trust fund to an emerging issues account authorized in Minnesota Statutes, section 116P.08, subdivision 4, paragraph (d)

M. L. 2017, Chp. 96, Sec. 2, Subd. 18. Carryforward; Extension
(a) The availability of the appropriations for the following projects are extended to June 30, 2018:
(8) Laws 2015, chapter 76, section 2, subdivision 10, Emerging Issues Account.

M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 20. Carryforward; Extension
(a) The availability of the appropriations for the following projects are extended to June 30, 2019:
(9) Laws 2015, chapter 76, section 2, subdivision 10, Emerging Issues Account.

M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 19, Subd. 19 Carryforward; Extension
(a) The availability of the appropriations for the following projects is extended to June 30, 2020:
(4) Laws 2015, chapter 76, section 2, subdivision 10, Emerging Issues Account;

I. PROJECT TITLE: Deer movement related to potential CWD prion transmission

II. PROJECT STATEMENT:

In November 2016, MNDNR discovered chronic wasting disease (CWD) in wild white-tailed deer of southeastern Minnesota. In total, 11 positives were found in two spatial clusters approximately 5 miles apart (Figure 1 – see part IX), which motivates research to 1) understand potential pathways of CWD landscape spread, and 2) increase our likelihood of managing the outbreak in this and other areas. We propose to study deer movement ecology as it relates to potential prion transmission in southeastern Minnesota in and around the newly established disease management zone (DPA 603) (Figure 2 – see part IX). From September 2016 through March 2017, 4,142 deer were sampled for CWD, and the data suggests we have discovered the disease in the early stage of the outbreak. This timing offers the best chance of management success because once the disease becomes established, it will be difficult if not impossible to eliminate CWD from the deer population. A growing body of research suggests that in the long-term, CWD causes deer population decline and has the potential to cross species barriers.

We received ENRTF Emerging Issues funding (M.L. 2015, Chp. 76, Sec. 2, Subd. 10) which will allow the Minnesota Department of Natural Resources (MNDNR) to purchase GPS collars and acquire satellite data downloads, supplies, and a contract for helicopter captures of 115 white-tailed deer (*Odocoileus virginianus*) in March 2018, 64 deer in February 2019, and 90 deer in January 2020. Wild deer are most efficiently captured during winter because they tend to form herds that are more easily encountered, as compared to other seasons. Ideally, at least one year of data will be needed for a basic understanding of seasonal movements (assuming that weather patterns in 2018 fall under what is considered to be typical). With the addition of $99,557 from the LCCMR Emerging Issues fund, we will be able to extend the study another year and be able to provide a better understanding of deer dispersal patterns in the study area. This information will provide the basis for guiding future CWD surveillance and management activities in the region.

As infected and non-infected deer interact and move across the landscape, they transmit infectious prions through direct contact with other deer or indirectly through environmental deposition. Limited information exists about deer contact rates and their relationship to transmission rates, especially in areas recently infected. The presumed main driver of spatial spread among wild deer is movement. Currently, there is no research that demonstrates the extent to which potentially infected deer move across the landscape and interact with each other in southeastern Minnesota.

Deer behavior and movements vary by biological and environmental conditions, along with deer population demographics and social structure. Two types of movement likely facilitate disease spread across the landscape, recurrent seasonal movements and one-time dispersal or foray events. The most substantial long-distance movements involve dispersal from birth to adult ranges, most likely to occur in 1-year-old deer. Because deer densities can be altered by management actions, a better understanding of both deer density and movement tendencies related to density will enhance our ability to effectively manage disease risk in the Minnesota deer population. The importance of this research is underscored by the increased risk of disease spread from Wisconsin and Iowa, and our findings will help the MNDNR understand those risk factors as well.

Project objectives:

1) **Document dispersal patterns and estimate movements of juvenile (≈1 year old) males and females, and adult males (>2 year old)**

   Deer will be fitted with Global Positioning System (GPS) collars to obtain multiple locations on a daily basis. We will determine movement patterns and activity ranges of deer during biologically critical time periods of the year; namely spring, fall, and winter. We will focus on juvenile deer because they are the most likely to disperse to new areas and adult males because they are three times more likely to be infected that other sex or age classes.

2) **CWD spatial pathways mapping to inform future surveillance and management**

We will use GPS location data to evaluate how movement propensities of deer are correlated with landscape characteristics and deer densities in the study area. This will be used to create a predictive deer movement map, which will inform future surveillance and probable pathways of spatial CWD spread.

3) **Determination of cause-specific mortality**

The GPS collar technology will permit detection of likely mortalities, and we will estimate cause-specific mortality rates by generalized categories (e.g., harvested, vehicle collision, predation) and incorporate those estimates into population models to improve accuracy and understanding of deer population dynamics in southeastern Minnesota.

III. OVERALL PROJECT STATUS UPDATES:

Amendment request (11/17/2017):

Our bid for helicopter capture of our sample of 115 white-tailed deer was quoted (Hells Canyon Helicopters) for less than we budgeted for, leaving approximately $52,000.00 remaining in our capture budget for activity 1. In addition, our quote for satellite data download (activity 1) was quoted as $35,063.50 from the selected company Lotek. Our original budget was $57,500.00, which leaves $17,521.50 in this line item. Our quote for GPS collars from Lotek (activity 1), was $4,915.00 above our budgeted cost of $172,500.00. We would like to transfer $4915.00 from the satellite data budget to cover the collar costs, and add an additional $3000.00 for possible extra shipping costs. This leaves $66,521.50 extra remaining in the helicopter capture and satellite data line items. We request permission to use this additional funding to hire a 50% unclassified FTE (Natural Resource Specialist I) dedicated to all field efforts, landowner communications, and data management. Specifically, we are considering a period of hire starting December 2017 and extending through June 2019 (19 months). The cost of the specialist will be $43,000 ($2263/month), with a dedicated truck costing $10,415.50 (0.55/mile with 230 miles/week for 82.33 weeks), field supplies costing $1000, and travel expenses including lodging and food allowance costing $12,103. As a consequence of our request, we ask permission to extend the period over which we can spend these funds through June 30, 2019.

Amendment approved by LCCMR on 1/11/18; extension contingent on Legislative approval.

Amendment request (01/19/2018):

With the addition of $99,557.00 from the LCCMR Emerging Issues account (M.L. 2015, Chp. 76, Sec. 2, Subd. 10), we have modified our work plan to incorporate another year of capture and deployment of Lotek LiteTrack TL330 expandable GPS Iridium collars on 33 juvenile male deer in the study area (Year 1: $177,415 Year 2: $48,807). These funds will also cover the cost of an additional year of data download fees (year 1: $35,063.50, Year 2: $35,063.50), the cost of helicopter capture through Hells Canyon Helicopters Inc. (Year 1: $40,000 Year 2: $11,478.39), the cost of a DNR-owned spotter fixed-wing aircraft to ensure project safety and adherence to study design (Year 1: $12,000 Year 2: $7,200), a 25% unclassified FTE Natural Resource Specialist I (Year 1 50% FTE: $43,000.64 Year 2: 25% FTE: $13,579.15), travel expenses for this FTE (Year 1 50% FTE: $12,208.83 Year 2

25% FTE: $4,209.54), and expenses for DNR staff assisting in capture during the 2nd year capture period not to exceed 5 days (Year 1: 3,580 Year 2: $1,660). Please note that we amended the fixed-wing aircraft spotter plane cost to reflect accurate fees for its use from $250.00 per hour to $300.00 per hour, and this change has been incorporated into the budget. Also, in order to balance the budget, we reduced some of the expenses built into the previous approved 1/11/18 budget.

Amendment Approved by LCCMR 1/23/2018

Project Status as of April 15, 2018:

Deer Permit Area 603 Update: During the fall 2017 hunt in the disease management zone (DPA 603), there were 1,183 hunter-harvested deer that were >1.5 years old and sampled for CWD. Of these, six additional animals were confirmed positive with CWD (5 males and 1 female), bringing the total number of wild deer confirmed with CWD to 17 since the 2016 outbreak began in southeastern Minnesota (Figure 3 – see part IX). Of particular concern are two CWD-positive detections in Forestville State Park, which may indicate westward expansion of the disease. MNDNR organized a taxidermist network to augment the check station CWD sampling effort and secured 33 samples from high-value animals (adult males) in DPA 603. Following the regular season hunt, the MNDNR also held a special late season hunt (Jan.6-14 2018) and issued landowner shooting permits (Feb.10-Mar.9 2018), which contributed approximately 300 additional samples for surveillance – all of which resulted in no CWD detected.

Project Update: We secured permissions to use 105,473 acres of property, consisting of private (67,924 ac) and public (37,549 ac) lands, for search and capture of white-tailed deer in southeastern MN (Figure 4 – see section IX). We could not have achieved our sampling goals without the enormous outpouring of support from private landowners in the study area (>200). From March 18-23, 2018, we captured 111 white-tailed deer (*Odocoileus virginianus*) in our study area (Figure 4 – see section IX). Of these 111 - one juvenile male was able to kick off its collar twice and escaped without being re-collared, and 1 adult male accidentally broke its neck upon being captured. Of the 109 deer captured with successfully deployed collars, three animals (2 juvenile males and 1 adult male) were able to kick their collars off within the first week, reducing our sample size to 106. Of these 106 collared deer, by April 15, 2018, nine deer have died. Mortality sources include suspected coyote predation (n=2), suspected vehicle collision (n=1), suspected disease (n=1), and suspected capture–related (4-5). Final necropsy results are still pending to confirm causes of mortality. This leaves 97 GPS-collared deer on the air that we are currently tracking and includes 44 juvenile males, 21 adult males, 31 juvenile females, and 1 adult female. Of the original 115 collars purchased from Lotek Inc., we returned three because of GPS malfunctioning issues, and are in the process of returning an additional 4 collars due to collar structural malfunctions prior to deployment in the field. As such, we are being re-invoiced by Lotek Inc., and have not spent any ENTRF Emerging Issues funding on collars yet. We have established databases for capturing updated movement and mortalities, and are monitoring all 97 GPS-collared animals daily. As a highlight of the initial movement information we have collected; we found that seven deer have traveled into Iowa, and it’s not clear yet if they have established an adult range there. Of these seven deer, they include three juvenile males, one juvenile female, and three adult males. Although some animals have experienced mortality thus far, we will not have sufficient data for robust statistical analysis of survival until the next reporting period.

Project Status as of December 01, 2018:

Deer Permit Area 603 Update: As of November 30 2018 in the disease management zone (DPA 603), there were 1,196 hunter-harvested deer that were >1.5 years old and sampled for CWD. Of these, 1,085 samples were tested and CWD was not detected, 104 samples were tested with results still pending, and eight additional animals were confirmed positive with CWD (all males). In addition, two additional males were detected with CWD just outside DPA 603 (in DPA 347). Thus, the total number of wild deer confirmed with CWD in and around

DPA 603 since 2016 is 27 with one additional suspect case pending confirmation (Figure 3 – see part IX). Of particular concern are the two CWD-positive detections outside of DPA 603 and an additional CWD-positive in Forestville State Park, which may indicate expansion of the disease. Two of the CWD-positive detections were deer found dead and another two were obtained from our taxidermist network (to augment the check station CWD sampling effort). The MNDNR is currently planning for the next phase of CWD management actions in DPA 603.

Project Update: As of November 30 2018, of the original 109 collared and released deer, 30 are actively being monitored, 12 slipped free of their collars, 23 have died, and 44 collars were deactivated because of hardware malfunction. The deer currently being monitored include 11 juvenile females, 6 adult males, and 13 juvenile males. We have experienced significant technical problems with the GPS hardware; of the original 115 GPS collars purchased, 3 were immediately sent back to the manufacturer after failed initial testing, 44 had to be deactivated on animals in the field because of hardware failure, and the expansion mechanism (that allows for neck growth during the rut period) for 11 juvenile male collars failed and led to these collars falling off of deer. Of the 23 collared and released deer in the study that have died thus far, mortality sources include coyote predation (n=3), vehicle collision (n=3), disease (n=1), capture–related (n=5), and hunter harvest (n=11).

Despite technical difficulties with GPS collars, we have been able to discover interesting movement dynamics. Prior to the dispersal period between April and July 2018, we estimated the average winter home range size as 1.60 km^2 for juvenile females, 2.96 km^2 for adult males, and 2.28 km^2 for juvenile males. Preliminary assessment of dispersal suggests that dispersal probability of juvenile females (45%, n=20) was slightly greater than juvenile males (32%, n=31) in spring 2018, although this difference was not statistically significant ($p = 0.41$). The average apparent dispersal distance travelled was 28 km (n=9) and 16 km (n=10) for juvenile females and juvenile males, respectively. Interestingly, when two outliers are removed from juvenile female cohort (linear travel distances of 40 and 77 miles), the average apparent spring dispersal distance decreases to about 9km for juvenile females, which is more in accordance with our expectations.

The greatest linear travel distance for spring dispersal that we have recorded was a juvenile female that travelled from slightly southwest of Forestville State Park to just east of Cannon Falls. She is currently still on the air, and appears to have established an adult home range in the area. Approximately 10 of our collared deer either made forays or dispersed to northern Iowa. We have found that several of these deer have made back-and-forth movements between states.

Amendment Request (12/18/2018)

Given the technical difficulties we have experienced with our first release cohort of GPS-collared deer, the manufacturer, Lotek, is warrantying at least 68 collars. As such, we do not have to use the remaining LCCMR Emerging Issues funding for purchase of our round 2 of collar releases. By the end of June 30, 2019, we expect to have approximately $130,000 remaining in our account, and request a legislative extension until June 30 2020 to spend these allocated funds for the project. We have modified our work plan to incorporate a third year of capture and deployment of GPS Iridium collars for approximately 40 juvenile female and 40 juvenile male deer in the study area (Year 3: $1500.00/collar x 80 collars = $120,000). Any remaining funds available would be allocated to covering the cost of GPS data acquisition. As it stands, our sample sizes for GPS-collared are small relative to the objectives of the study. An additional year of capturing, collaring, and tracking deer in the study area will significantly influence our success in being able to draw stronger conclusions about patterns of deer movement in southeastern Minnesota, where CWD incidence in wild deer has increased. We could not have foreseen the problems we experienced with the current batch of GPS collars, and hope that LCCMR will grant us permission to extend the funding period for this project.

Amendment pending further LCCMR and legislative action as of **01/15/19**

Legislative extension signed into law **05/31/19**

Project Status as of May 1, 2019:

Deer Permit Area 603 (and surrounding areas) Update: At the close of the fall hunting seasons, MNDNR was able to test 4,373 deer for CWD in southeast MN and found 14 new cases, including 11 within DPA 603, 2 in DPA 347, and 1 in DPA 346. This increase in both CWD prevalence and spread prompted additional harvest and culling opportunities during winter (Jan-Mar) and 1,988 more deer were tested, bringing the total number of confirmed cases from fall 2016 to present to 50 (Figure 3 – see part IX). Of particular concern are the increasing number of CWD-positive detections outside of DPA 603, which will entail an expansion of CWD management efforts. The MNDNR is currently planning for the next phase of CWD management actions in southeastern Minnesota, as well as in north-central Minnesota where a CWD-positive wild deer was found in close proximity to a different CWD positive captive deer farm in Crow Wing County.

Project Update: As of April 19 2019, we are only able to monitor 14 animals (7 females and 7 males) from the original collared cohort of 109 deer. Of the 2018 capture group, 34 deer (8 females and 26 males) have died with mortality sources including agency-culled (n=4), vehicle collision (n=4), capture-related and unknown (12), and hunter harvest (n=14). A total of 73 collars had to be deactivated because of hardware failure (either collar expansion or internal electronics failure).

From September through December 2018, most of the fawns from the March 2018 release cohort were expected to have established an adult home range. Using data from the available deer in the study, we found that 36% of females (n=4/11) and 15% (n=4/26) of males underwent excursions (linear movements greater than 4 km) from their adult home range. On average, females traveled about 6 km and males traveled about 19 km. So, although females had a higher likelihood of making excursions from their home range, they traveled a shorter distance on average compared with males.

From Feb. 18-21, 2019, we captured and outfitted 64 additional deer with GPS collars: 39 female fawns and 25 male fawns (Figure 4 – see part IX). Ahead of our capture period, we secured permissions to access 115,259 acres of property, consisting of private (72,398 ac) and public (42,861ac) lands. This area of Minnesota is mostly held in private hands, and capture success was largely dependent on developing positive relationships with landowners and seeking their collaboration.

During the capture period, three male fawns and one female fawn were able to kick off their collars just after initial collar fitting, but we were able to retrieve them and redeploy on other animals. One female fawn accidentally broke its neck upon capture and we were able to donate the meat to the Share the Harvest program. As of April 19, 2019, 34 does and 23 bucks from the second year release cohort are actively being monitored, while five females and one male have died. We suspect that one of these animals died from capture myopathy based on necropsy evidence at the UMN Veterinary Diagnostic Lab. One male was able to kick off his collar within about a month following capture. There have been no collar failures to date from the second release cohort.

Amendment Request as of (05/01/2019)

We had $11,237 in surplus funds left over from the Professional/Technical/Service Contracts budget item MNDNR Law Enforcement (please see associated budget update Excel file). We request to shift these funds to our Helicopter captures budget item to pay off the remaining balance of $9932, as we did not expect this deficit (we incurred more expense than anticipated because of weather-related delays and extra time needed to capture and collar the desired sex ratio of deer in our second year of the study). In addition, we request to shift

$657 from MNDNR Law Enforcement to the GPS collars line item (Equipment) and $648 to the capture crew travel expenses line item so that this balance can be paid off as well.

Amendment Approved by LCCMR **05/10/19**.

Project Status as of October 15, 2019:

Deer Permit Area 603 (and surrounding areas) Update: The total number of confirmed cases of CWD in wild deer in southeast Minnesota from fall 2016 to present remains at 50 (Figure 3 – see part IX). Given MNDNR concern about the increasing number of CWD-positive detections outside of DPA 603, there has been considerable revision in our management strategy and expansion of CWD management efforts (Figure 5 – see part IX). Deer Permit Area (DPA) 603 has officially been dissolved, and seven DPAs (643, 645, 646, 647, 648, 649, and 655) have been re-designated as the South East CWD Management Zone. Surrounding this Management Zone, there are three newly designated DPAs (255, 343, and 344) as the South East CWD Control Zone. These new zones were established to liberalize harvest regulations and achieve three goals: (1) increase harvest of CWD positive deer to reduce disease prevalence, (2) reduce overall deer density to lower the number of susceptible deer on the landscape, and (3) reduce emigration from the area and mitigate disease spread across the landscape. To further reduce the risks of disease spread through movement of potentially infected carcasses, there are carcass movement restrictions in both CWD Management and Control Zones. The MNDNR has also created an Adopt-A-Dumpster program whose purpose is to facilitate collection of deer carcass waste and reduce the risk of CWD-positive carcass remains staying on the landscape where infectious prions may persist or be spread by scavengers.

Project Update: As of October 3 2019, we are monitoring 63 animals (35 females and 28 males) with nine from the first release cohort of 2018 and 54 from the second release cohort in 2019.

To date, there have been 46 known mortalities of GPS collared deer, which include 17 females and 29 males. The sources of mortality include hunter harvest (n=14), vehicle collision (n=6), agency-culled (n=4), poor health (n=6), unknown cause (n=4), and capture-related issues (12). A total of 81 collars have been deactivated because of hardware failure (either collar expansion or internal electronics failure). Due to these failures, we were (are) not able to document the fates of these animals, and our recorded mortalities likely underestimate the true number of collared deer that have died in the field.

Prior to the spring dispersal period between April 15 and July 15 2019, the average winter home range size of fawns captured in February 2019 was similar to fawns captured in 2018 at 1.84 km^2 for females and 2.65 km^2 for males. During the spring dispersal period of 2019, female deer had a higher than expected apparent dispersal probability (44%, n=15/34), although it was comparable with males (46%, n=10/22). These proportions were not appreciably different than estimates from 2018. The median dispersal distance travelled was 10.1 km (n=15) and 11.2 km (n=10) for females and males, respectively. These estimates align almost exactly with estimates from 2018 when females and males traveled a median distance of 12 km and 12.5 km, respectively. Given our small sample sizes and non-normal distribution of dispersal distances, we choose to use the median (as opposed to mean) as a measure of central tendency. Such non-normality causes extreme outliers (which we have) to skew distance distributions, artificially inflating the mean.

Of the fawns captured and collared in 2019, we found that two males and one female have apparently dispersed to Iowa, although it is not clear yet if they have established an adult range in that state. We saw similar movements from several animals in the 2018 release cohort that appeared to be seasonal movements between Minnesota winter and Iowa summer ranges. The longest linear movement we have recorded for a dispersing female yearling in 2019 was 29 miles, and for dispersing yearling males, it was about 50 miles.

We are planning for additional capture and GPS-collaring of 90 fawns (45 female and 45 male) in late January/early February 2020 in the study area. We are in the process of bidding for an aerial wildlife capture company who will conduct the actual deer captures, and are firming up logistical plans for the upcoming capture season. We are also in the process of contacting and updating existing landowner collaborators who have given us permission to access their properties for deer captures. Given the South East CWD Management Zone has expanded, we will expand the scope of our study area to include more of Winona and Houston Counties (Figure 6 – see section IX). This will also entail contacting additional landowners to secure permission to access more properties for deer capture and collaring efforts.

Amendment Request as of (10/15/2019)

We would like to shift $20,533 from the Professional/Technical/Service Contracts budget item for Lotek Wireless GPS data (please see associated budget update in 2019-10-15 Budget.xlsx) into the Equipment/Tools/Supplies budget line towards purchasing our new order of GPS collars scheduled for release on 90 fawns in our study area in January 2020. As previously reported, we experienced substantial failures of our first year collars (n=80) after they were deployed in the field. Losing so many collars resulted in much less money spent for our GPS data budget item than expected, and there is no way we will be able to spend the remainder of the current budget allocation of $70,127 for GPS data collection. Likewise, we would like to shift $25,417 from the Personnel budget item for the 50% FTE Natural Resource Specialist position into the Equipment/Tools/Supplies budget line towards purchasing our new order of GPS collars (with revised remaining balance of $58,964). Again, with the substantial failure of first year GPS collars (n=80), the field efforts required for the Specialist were reduced and resulted in budget savings for this line item. Given the level of effort we expect will be required for the Specialist, we have revised our Activity 1 budget accordingly. These budget modifications will ensure that we make the most efficient use of the valuable Emerging Issues Account funds that we were awarded for this project.

Amendment Approved by LCCMR **10/25/19**

Project Status as of April 15, 2020:

CWD update: The total number of confirmed cases of CWD in wild deer in Minnesota from 2010 to present is 88 (Figure 3 – see part IX). Between July 1, 2019 through March 27, 2020 a total of 18,543 deer were tested for CWD with 36 positive detections. During hunter-harvested surveillance in fall 2019, A total of 17,717 deer were tested; 544 deer in the Central surveillance zone with no new detections, 3,966 deer in the North-central surveillance zone with no new detections, and 13,207 deer in the Southeast Management zone with 26 CWD positive detections. In southeastern Minnesota, MNDNR took additional management actions over the winter, which included distributing landowner shooting permits and focusing USDA agency culling in close proximity to locations where CWD positive deer were detected previously. From landowner shooting permits, 37 additional deer were harvested and tested with no new CWD detections, while USDA agency culling efforts yielded 463 harvested deer and 7 CWD detections. Opportunistic sampling of symptomatic deer continues to occur year-round across the state; in 2019, 356 opportunistic deer were tested with 3 positive detections (1 found dead in Houston County during the fall, 1 found dead in Fillmore county during USDA culling operations, and 1 reported sick in Dakota county). Given there have been no CWD detections in wild deer in the Central surveillance zone over the last three harvest seasons since a deer from a captive cervid farm tested positive for CWD in 2017, surveillance efforts will be discontinued in the future. Furthermore, the recreational deer feeding ban will be lifted in Kandiyohi, Meeker, Wright, and McLoud counties as of July 1 2020.

Unfortunately, new detections of the disease have recently occurred in 3 new areas of the state: 1) In December 2019, a CWD positive deer was detected within a small cervid farm in Douglas County, 2) In January 2020, CWD was also detected in a Pine County cervid farm, with a direct link to the Douglas County farm, and 3) In March

2020, a wild deer exhibiting symptoms consistent with CWD tested positive in Dakota County, about 100 miles from the southeastern epicenter in Preston, MN. In response to these recent events, the recreational deer feeding ban will be extended to Douglas, Pope, Pine, Carlton, Kanabec, Isanti, and Chisago counties. Surveillance efforts will also be expanded this upcoming fall to include the new area where CWD has been discovered.

Project Update: As of April 15 2020, we continue to monitor 29 animals (19 females and 10 males) collared in 2019. All animals collared in 2018 either have collars that are no longer transmitting data (n=46) or have died (n=49). To date, 81 study deer have died, with sources of mortality including hunter harvest (n=33), capture-related issues (n=14), unknown cause (n=12), vehicle collision (n=10), complications due to leg injury (n=5), agency culling (n=4), and likely predation (n=3).

From September through December 2019, most of the fawns from the February 2019 cohort were expected to have established an adult home range. During fall, deer may leave their home ranges to make excursions or expand their home ranges (males) as they search for mating opportunities with females. We found that fall home ranges were larger than summer home ranges for deer collared in 2018 and 2019. Home range size varied greatly among individual deer, but generally increased between summer and fall. Home ranges of females more than doubled in size, from an average of 1.37 km^2 (± 1.54 km^2 standard deviation [SD]) during the summer (n = 47) to an average of 3.35 km^2 (± 4.46 SD; n=42) during the fall. Males also expanded their adult home ranges from an average of 1.88 km^2 (± 2.24 km^2 SD n=56) to an average of 4.29 km^2 (± 3.73 km^2 SD; n =53). Expansion of home ranges during the fall likely represents increased movement by males in search of mating opportunities and, potentially, matched movement from females as they also seek males.

From Feb. 09-12, 2020, we captured and collared 52 deer: 29 female fawns and 23 male fawns (Figure 4 – see part IX). We carried out capture operations across 132,113 acres of private (n=62,696 ac) and public (n=69,251 ac) lands in southeastern Minnesota. This area of Minnesota is primarily privately owned, and capture success was largely dependent on developing positive relationships with 193 landowners.

At the outset of the capture period, our goal was to capture and collar 90 deer (45 of each sex). Unfortunately, we were unable to meet this goal because the helicopter capture company (HeliWild LLC.) experienced significant difficulties in the field and did not capture deer at a rate that would ensure completion of the quota within a timely manner. Due to HeliWild's own scheduling constraints, they discontinued capture operations before meeting their contractual obligations; however, they had planned to return to finish capturing deer in March. Unfortunately, when March arrived they changed plans and returned to South Africa (one of their bases of operation). Consequently, we were unable to meet our capture goals for 2020 and have 42 GPS collars available for future captures.

During the capture period, 2 male fawns and 2 female fawn were able to kick off their collars just after initial collar fitting, but we were able to retrieve collars for redeployment on other animals. As of April 15, 2020, we are monitoring 29 does and 19 bucks from the third year cohort. We recorded 4 mortalities from the 2020 cohort, and suspect that 2 of these animals died from capture myopathy based on necropsy evidence at the UMN Veterinary Diagnostic Lab and the other 2 apparently were killed by predators. There have been no collar failures to date from the 2020 cohort.

Overall Project Outcomes and Results

We quantified dispersal and migratory movements of wild white-tailed deer in southeastern Minnesota that are relevant to understanding the potential spread of chronic wasting disease . After detection of CWD in fall 2016 in Fillmore County, we sought to determine potential pathways of CWD spread on the landscape via wild deer movements and estimate general causes of deer mortality in southeastern Minnesota. Since March 2018, we captured and fitted GPS collars to 226 deer and continue to monitor 72 animals. The main causes of mortality were hunting and vehicle collision in the yearling to 3-year-old deer composing our sample, which underscores the importance of harvest management as a valuable tool to control CWD in southeastern Minnesota. Average annual survival for females and males was 0.73 and 0.54, respectively, and these low survival estimates likely reflect effective liberalized harvest regulations within the study area to manage CWD. We found that 26% of females and 43% of males dispersed between their natal and adult home range, and surprisingly 15% of females and 6% of males underwent seasonal migration between summer and winter ranges. The average dispersal distance for females and males was 20.0 km and 22.8 km, respectively, while that for migratory females and males was 12.8 km and 17.7 km, respectively. We also observed extreme dispersal distances of 116 km and 97 km, respectively, for a female and male. Both sexes tended to disperse westward, although a pattern was unclear for migratory animals. Deer were more likely to avoid agricultural landscape during dispersal and migration, although we did not observe consistent habitat characteristics along movement paths. The southwest to northwest trajectory of dispersal movements underscores increased risk of CWD spread to the Minnesota interior. This information will be vital for prioritizing and guiding CWD management efforts in and around southeastern Minnesota.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Capture, placement of GPS collars on deer, and collection of daily movements

Description: We will capture two age classes of deer (fawns and adults) and fit them with iridium GPS collars, which assign spatial location from multiple satellites. We will set GPS collars to collect multiple daily locations of deer for up to two years. We will estimate annual home ranges, seasonal home ranges, and dispersal patterns of both yearling (fawns will transition to the yearling age class around June) and adult deer. Collar technology is advanced enough so that collars can be reprogrammed seasonally to identify precise movements from natal range and temporary/permanent emigration to new areas.

Summary Budget Information for Activity 1:		
	ENRTF Budget:	**$ 449,557**
	Amount Spent:	**$ 449,556**
	Balance:	**$ 0.12**

Outcome	Completion Date
1. Capture and GPS-collar 90 white-tailed deer fawns (60 male/30 female) and 25 adult male white-tailed deer.	03/31/2018
2. Capture and GPS-collar 64 white-tailed deer; 32 female and 32 male fawns	03/31/2019
3. Capture and GPS-collar 80 white-tailed deer; 40 female and 40 male fawns	03/31/2020

Activity 1 Status as of April 15, 2018: From March 18-23, 2018, we captured 111 white-tailed deer (*Odocoileus virginianus*) in our study area in southeastern MN (Figure 4 – see section IX). Of these 111 - one juvenile male was able to kick off its collar twice and escaped without being re-collared, and 1 adult male accidentally broke its neck upon being captured. Of the 109 deer captured with successfully deployed collars, three animals (2 juvenile males and 1 adult male) were able to kick their collars off within the first week reducing our sample size to 106. Of these 106 collared deer, by April 15, 2018, nine deer have died. Mortality sources include suspected coyote predation (n=2), suspected vehicle collision (n=1), suspected disease (n=1), and suspected capture–related (4-5). Final necropsy results are still pending to confirm causes of mortality. This leaves 97 GPS-collared deer on the air that we are currently tracking and includes 44 juvenile males, 21 adult males, 31 juvenile females, and 1 adult female. As a highlight of the initial movement information we have collected; we found that seven deer have traveled into Iowa, and it's not clear yet if they have established an adult range there. Of these seven deer, they include three juvenile males, one juvenile female, and three adult males.

Activity 1 Status as of December 01, 2018: We have been planning for additional capture of 32 juvenile female and 30 juvenile male deer in late January 2019 in the study area. We have contracted with a new aerial wildlife capture company (Quicksilver), and are making plans for the upcoming capture season.

To address the hardware failures we have experienced with the first cohort of collars, we have changed the model of GPS collar that we are using for female deer. The model chosen, Lotek Iridium 420, has a proven track record of success with deer collared for movement ecology research in Wisconsin. For juvenile male collars, the GPS hardware of collars has been updated by the manufacturer.

Since the start of archery season on September 15, 2018 we have been able to visually inspect the wear of 12 different collars on deer in this study. Of these, 10 (5 adult males, 3 juvenile males, and 2 juvenile females) were shot by a hunter, 1 (juvenile male) died in a vehicle collision, and 1 (juvenile female) was found dead by the public. While the wear around the necks of juvenile females was normal, we found that the collar fit on 3 of 5 adult males was very tight and caused lacerations and skin infection. Similarly, the collar fit for one of the juvenile males was very tight and caused skin damage and infection. A second juvenile male at some point must have stepped-through its collar causing a very tight collar fit around the neck and under the front armpit – this caused skin laceration and infection in the animal's armpit area. The vehicle killed juvenile male had normal collar wear, but the collar was noted as being quite high on the neck. This recently acquired information is cause for concern for the design of the male collars in the study.

We place very high value on each animal's well-being in our study and we seek to minimize stress and discomfort that they may experience. In order to protect juvenile male deer in future collar deployments, we have made significant changes to the design of the collars that allow more flexibility in the expansion material, and increase the overall collar circumference by 12%. Furthermore, we are working with the collar manufacturer to attach both a timed release drop-off mechanism (at a pre-defined time in the future the collar will drop off of the animal) and a line-of-sight drop-off mechanism (can be triggered with line-of-sight to an animal from an aircraft) to collars. These mechanisms increase assurance that if there is any indication of collar expansion problems, we can track and release collars from study animals. There is a chance the manufacturer will not be able to produce these juvenile male collars in time for our late January 2019 capture and collar period. If this is the case, we will not be deploying collars on juvenile males in January.

Activity 1 Status as of May 01, 2019: From Feb. 18-21, 2019, we captured and outfitted 64 additional deer with Iridium GPS collars: 39 female fawns and 25 male fawns (Figure 4 – see part IX). Ahead of our capture period, we secured permissions to access 115,259 acres of property, consisting of private (72,398 ac) and public (42,861ac) lands – over 180 mi^2. Most of our study area is held in private hands, and like the first year, our capture success was largely dependent on developing positive relationships with landowners and seeking their collaboration. We spoke with and secured permission to access the private properties of 224 landowning families in the study area. During the capture period, three male fawns and one female fawn were able to kick off their collars just after initial collar fitting, and thankfully we were able to retrieve them and redeploy those collars on other animals. One female fawn accidentally broke its neck upon capture, and we were able to donate the meat from this animal to the Share the Harvest donation program. As of April 19, 2019, 34 does and 23 bucks from the second year release cohort are actively being monitored, while five females and one male have died. One animal was suspected to have died due to capture myopathy based on examination at the UMN Veterinary Diagnostic Lab. One other male was able to kick its collar off within about a month of capture.

For all 64 collars, we had the collar manufacturer (Lotek) install timed-release drop-off mechanisms, which after 130 weeks (2.5 years) will cause the collars to fall off of the animals. At that time, any remaining collars can be retrieved and potentially re-furbished. In addition, for male collars, we included a line-of-sight mechanism that permits the collars to be detached remotely with a special hand-held receiver and line of sight to the animal (within 200m). We added this feature on male collars because male necks expand and contract with season, and during the rut when their necks largest in diameter, there is a risk that collars could be too tight if the expansion mechanism fails. If during the rut when hunters are in the field and may come across collared deer with suspected tight collar issues, we can make efforts to locate and remotely release these collars from deer in the welfare interest of the animal.

Due to hardware problems, we experienced with the first release cohort in March 2018, the manufacturer (Lotek) warrantied 73 collars and provided us with replacements at no cost. The manufacturer made modifications to on-board software, corrected quality-control issues with production of the collars, and modified the expansion design of male collars (by our direction and input) to improve performance of the equipment. There have been no collar failures to date from the second release cohort, which so far suggests that the modifications made to improve the collar performance have been successful.

Activity 1 Status as of October 15, 2019: As of October 7 2019, we have experienced one confirmed GPS-collar failure of the 64 deer released with collars in 2019; this collar is under warranty and will be replaced by the manufacturer (Lotek Wireless Inc.). This situation is much improved compared to the first generation of GPS collars that we released, of which about 70% failed due to collar expansion or hardware problems. We are actively monitoring 63 GPS-collared deer, 54 (32 females and 22 males) released in 2019 and 9 (3 females and 6 males) released in 2018.

We are planning for additional capture and GPS-collaring of 90 fawns (45 female and 45 male) in late January/early February 2020 in the study area. We are in the process of bidding for an aerial wildlife capture company who will conduct the actual deer captures, and are firming up logistical plans for the upcoming capture season. We are also in the process of contacting and updating existing landowner collaborators who have given us permission to access their properties for deer captures. Given the South East CWD Management Zone has expanded, we will expand the scope of our study area to include more of Winona and Houston Counties (Figure 6 – see section IX).

Activity 1 Status as of April 15, 2020: From Feb. 8-12, 2020, we captured and outfitted 56 additional deer with Iridium GPS collars: 31 female fawns and 25 male fawns (Figure 4 – see part IX). Ahead of our capture period, we secured permissions to access 132,113 acres of private (n=62,696 ac) and public (n=69,251 ac) lands – over 260 mi^2. Most of our study area is held in private hands, and our capture success during the last three years has been dependent on developing positive relationships with landowners and seeking their collaboration. We spoke with and secured permission to access the private properties of 193 landowning families for the 2020 capture period, including several families that had not participated in previous years.

Our goal was to capture and collar 90 deer (45 of each sex) and this shortfall occurred because the helicopter capture company (HeliWild LLC.) experienced significant difficulties in the field and did not capture deer at a rate that would ensure completion of the quota within a timely manner. HeliWild's team had difficulty identifying fawns (the focal age group for captures) in the field, which significantly slowed down their capture progress. This may be due in part to the large size of white-tailed deer fawns in southeastern Minnesota and the capture crew's lack of familiarity with deer sizes in this part of the USA. Their unanticipated low capture rate and scheduled jobs after us caused them to pause operations until March 2020. They initially told us they were planning to come back to Minnesota in March to finish capturing and collaring the remaining animals. When March arrived they changed plans and returned to South Africa (one of their bases of operation), leaving us with 42 GPS collars that are yet to be deployed. We are evaluating alternative plans to potentially deploy these remaining collars on deer next year.

During the capture period, 2 male fawns and 2 female fawn were able to kick off their collars just after initial collar fitting resulting in a final 2020 cohort of 52 fawns (n=29 females, 23 males). As of April 15, 2020, we are monitoring 29 female and 19 male fawns from the third year cohort. Four males died within the first month of capture, and we suspect that 2 of these animals died from capture myopathy based on necropsy evidence at the UMN Veterinary Diagnostic Lab. There have been no collar failures to date from the 2020 cohort. In total, we are actively monitoring 77 collared deer from the last 2 years of the study, including 19 females and 10 males who were collared in February 2019.

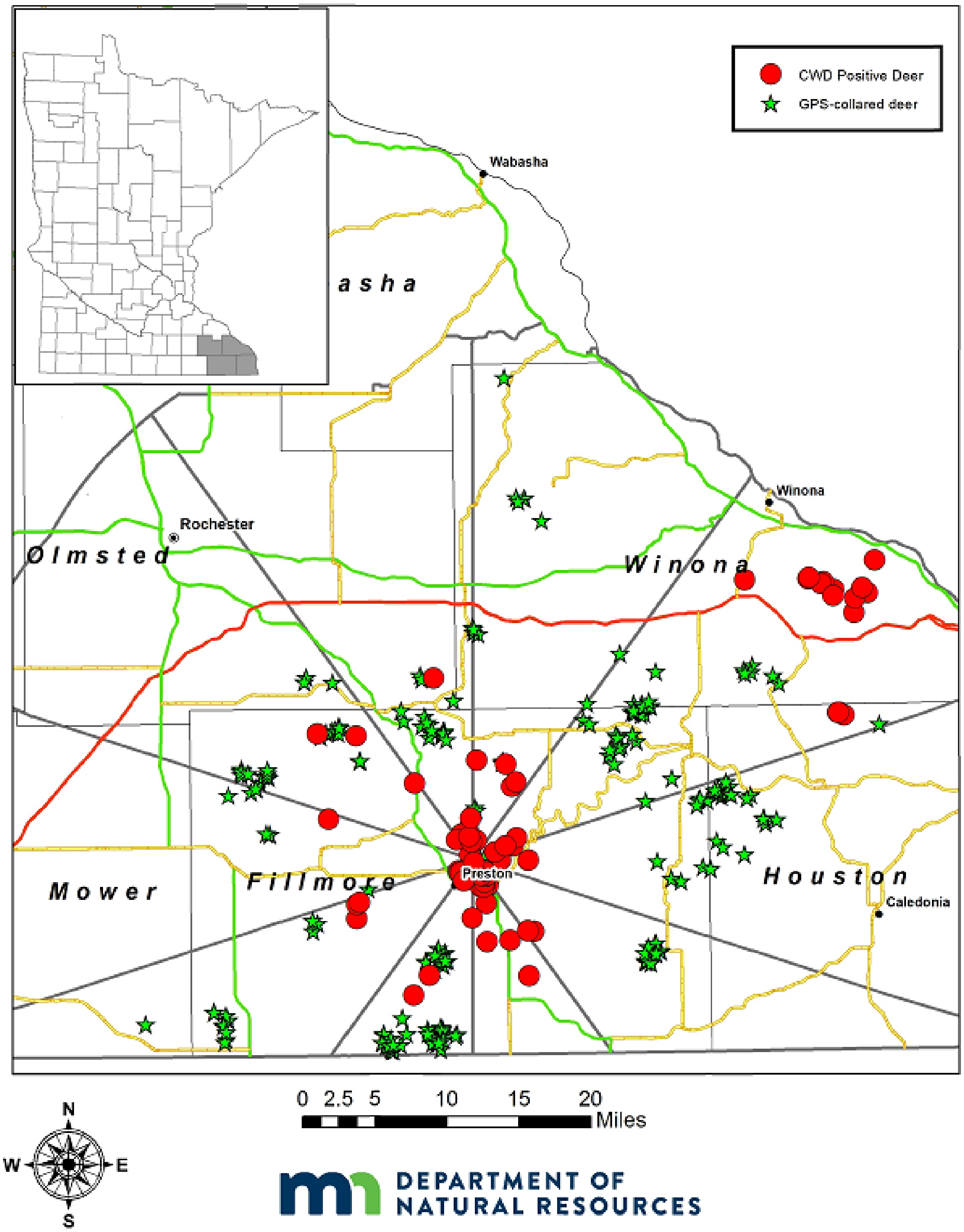
As in 2019, we had the collar manufacturer (Lotek) install timed-release drop-off mechanisms, which cause the collars to fall off the animals after 130 weeks (2.5 years). Male collars also have a line-of-sight mechanism that permits collars to be detached remotely with a special hand-held receiver and line of sight to the animal (within 200m). During the fall rut, the necks of males expand and there is a risk that collars may become too tight. If hunters or other members of the public observe a male with a tight collar, we can locate the animal and remotely release the collar in the interest of the welfare of the animal.

The manufacturer made modifications to on-board software, corrected quality-control issues with production of the collars, and modified the expansion design of male collars (by our direction and input) to improve performance of the equipment. These collars have performed better than those manufactured in 2018; however, 9 collars from the 2019 cohort have stopped transmitting data and have been deactivated. Hunters harvested 7 deer from the 2019 capture cohort, giving DNR staff the opportunity to examine harvested deer for signs of poor collar fit or failed expansion. Fortunately, the redesigned collars appear to fit deer well, demonstrating that our modified collar expansion design was a significant improvement from the manufacturer's original design. To date, all collars deployed in 2020 are performing as expected.

Final Report Summary

This marks the third year of our multi-year study (2018-2020) to investigate the movement dynamics of wild white-tailed deer (*Odocoileus virginianus*) in southeastern Minnesota. As of July 30 2020, we continue to monitor 72 animals (45 females, 27 males) that remain available for tracking. Within a study area of approximately 2,000 square miles centered on Preston, MN, we have captured and fitted 226 deer with GPS collars to track their movement dynamics through time (Figure 1). By centering our capture efforts in and around the southeastern CWD Management Zone, we were able to monitor deer activity and movement dynamics in the beginning stages of the CWD outbreak and management response. This design allowed us to determine trends in movement trajectories that can guide management efforts in the short to medium term.

Over the course of the study, 40% of GPS collars failed (n = 90/226) within 12 months of being fitted to a deer. Although the manufacturer warrantied these collars, collar malfunctions resulted in a significant loss of deer location data that otherwise would have been obtained. To address this loss, as well as the incomplete capture season in February 2020, we plan to conduct capture efforts again with a wildlife capture company in early 2021 to deploy the remaining 45 GPS collars. With this last capture effort, we plan to deploy GPS-collars on deer in Winona and Houston Counties, where more disease has recently been detected. This area represents an important gap in our sampling design that will yield important information about possible deer movements between Minnesota and Wisconsin.



DEPARTMENT OF NATURAL RESOURCES

Figure 1. Spatial distribution of all deer captured and GPS-collared in southeastern Minnesota during March 2018 (n=109), February 2019 (n=64), and February 2020 (n=52). We captured deer on private and public lands, with a goal of capturing equal sex ratios across each quadrant. Green stars represent the locations where white-tailed deer were captured, fitted with GPS collars, and released. Also presented is the spatial distribution of wild white-tailed deer confirmed with CWD infection in southeastern Minnesota as of 07/26/20. There have been 85 wild white-tailed deer confirmed positive with CWD in southeastern Minnesota since fall 2016.

ACTIVITY 2: CWD spatial pathways mapping to inform future surveillance and management

Description: We will quantify GIS land cover data, temporal covariates, and deer density and demographic information for southeastern Minnesota in order to temporally relate deer resource use and movement tendencies with landscape features and population demographics. We will produce a deer movement propensity map stratified by age and sex cohort, which will be used in directing future CWD surveillance and management efforts. This work is being completed as part of MNDNR's in-kind services to be applied to the project with other funds, as listed in Section VI. B.

Summary Budget Information for Activity 2: **ENRTF Budget: $ 0**
Amount Spent: $ 0
Balance: $ 0

Outcome	**Completion Date**
1. Collect and characterize relevant GIS data	03/31/2018
2. Estimate activity ranges and dispersal probabilities with deer location data. Construct a CWD spatial pathway map based on year 1 data.	06/30/2019
3. Estimate activity ranges and dispersal probabilities with deer location data. Construct a CWD spatial pathway map based on year 2 data.	06/30/2020
4. Report findings in research summaries and prepare peer-reviewed publications	10/31/2020

Activity 2 Status as of April 15, 2018: We are in the process of collecting and characterizing relevant GIS data layers to use in our characterization of spatial heterogeneity on the landscape. This process is organic and evolving and we seek to use the most recently updated and spatially fine-scale GIS coverages available.

Activity 2 Status as of December 01, 2018: As of November 26, 2018, we have amassed over 130,000 records of deer location data. Prior to the dispersal period between April and July 2018, we estimated the average winter home range size as 1.60 km^2 for juvenile females, 2.96 km^2 for adult males, and 2.28 km^2 for juvenile males. These winter home range estimates align with our expectations of deer activity at this time of year. Contrary to our expectations, juvenile female deer had higher apparent dispersal probability (40%, n=20) than juvenile males (28%, n=29) in spring 2018, although this difference was not statistically significant ($p = 0.41$). The average apparent dispersal distance travelled was 30.4 km (n=8) and 14.6 km (n=8) for juvenile females and juvenile males, respectively. Interestingly, when two outliers are removed from juvenile female cohort (linear travel distances of 40 and 77 miles), the average apparent spring dispersal distance decreases to about 10km for juvenile females, which is more in accordance with our expectations. Although sample sizes for apparent dispersing animals was small (n=16), more formal analyses of spring dispersal is pending. The data also suggests that only 17% of our adult male sample underwent appreciable foray movements (n=2). Approximately ten (several animals had less than three locations just inside the border of Iowa that may represent GPS error) of our collared deer either made forays or dispersed to northern Iowa. We have found that several of these deer have made back-and-forth movements between states.

Activity 2 Status as of May 1, 2019: From September through December 2018, we expected most of the fawns from the March 2018 release cohort to have set up an adult home range. Using data from the available deer in the study (n=37), we found that 36% of females (n=4/11) and 15% (n=4/26) of males underwent excursions (linear movements greater than 4 km) from their adult home range. On average, females traveled about 6 km and males traveled about 19 km. Although females had a higher likelihood of making excursions from their home range, they traveled a shorter distance on average compared with males. About two-thirds of animals that underwent excursions made some form of return movement to their adult home range. Two of the four males that underwent excursions traveled south into Iowa during spring 2018 and returned to their capture locations in late August/September 2018. These movements may reflect some type of seasonal migratory behavior and we need additional data to draw firmer conclusions about these movement patterns.

Activity 2 Status as of October 15, 2019: As of October 7, 2019, we have amassed over 450,000 records of deer location data from all of our collared animals. Prior to the spring dispersal period between April 15 and July 15 2019, the average winter home range size of fawns captured in February 2019 was similar to fawns captured in 2018 at 1.84 km^2 for females and 2.65 km^2 for males. During the spring dispersal period of 2019, female deer had a higher than expected apparent dispersal probability (44%, n=15/34), although it was comparable with males (46%, n=10/22). These proportions were not appreciably different than estimates from 2018. The median dispersal distance travelled was 10.1 km (n=15) and 11.2 km (n=10) for females and males, respectively. These estimates align almost exactly with estimates from 2018 when females and males traveled a median distance of 12 km and 12.5 km, respectively. Given our small sample sizes and non-normal distribution of dispersal distances, we choose to use the median (as opposed to mean) as a measure of central tendency. Such non-normality causes extreme outliers (which we have) to skew distance distributions, artificially inflating the mean.

Of the fawns captured and collared in 2019, we found that two males and one female have apparently dispersed to Iowa, although it is not clear yet if they have established an adult range in that state. We saw similar movements from several animals in the 2018 release cohort that appeared to be seasonal movements between Minnesota winter and Iowa summer ranges. The longest linear movement we have recorded for a dispersing female yearling in 2019 was 29 miles, and for dispersing yearling males, it was about 50 miles.

Activity 2 Status as of April 15, 2020: After filtering GPS locations for quality control and removing censored individuals, we have amassed over 375,000 records of deer location data from all of our collared animals. Prior to spring dispersal, the average winter home range size of fawns captured in February 2020 were similar to fawns captured in previous years at 1.70 km^2 (± 1.28 km^2 SD; n=28) for females and an average of 2.02 km^2 (± 0.92 km^2 SD; n=15). Currently, 2 females and 4 males have left their natal home ranges and appear to be in the process of dispersing. Although spring dispersal typically occurs between mid-April through mid-July, deer exhibit variation in dispersal timing and behavior. As of April 15, 2020, 9 females and 4 males captured in February 2020 have dispersed or appear to be in the process of dispersing. We do not have estimates on dispersal distances for these animals at this time, as it is unclear if they have established adult home ranges at this time or are still in the exploratory phase of a dispersal event. We also expect additional animals to begin dispersal movements between April and June.

As observed in previous years, 4 males and 2 females appear to dispersing to Iowa, in the same region that deer established adult home ranges in 2019. However, as in previous years, it is unknown yet if these movements represent permanent dispersals to Iowa or if seasonal movements between Iowa and southern Minnesota. The longest linear movement we have recorded for a dispersing female yearling in 2019 was 29 miles, and for dispersing yearling males, it was about 50 miles.

Final Report Summary:

Over the course of this study, we have recorded over 380,000 deer locations used to estimate wild white-tailed deer activity and dispersal patterns in southeastern Minnesota. We vetted all recorded spatial locations before use in any analysis because the accuracy of a location is influenced by the number of satellites available to communicate with a collar and how a deer is juxtaposed in the landscape (i.e., influence of physical barriers); thus, any point was omitted if less than three satellites were used to derive its location. Locational accuracy of GPS-collars may be influenced by elevation, landform (ridgelines vs. ravines), and land cover (forests vs. open fields). In order to better understand and correct for these potential errors, we tested collar locational accuracy in the field using 9 test collars and a Trimble GPS unit. We placed collars in 3 different land covers (forest, open fields, edges) and at relatively low (ravine) and high (ridge/hilltops) locations that were representative of the study area. Across all land cover and elevation scenarios, average location error was 14 (+/- 15) m away from the true location and did not differ significantly among cover types or different elevations. Given these relatively small error rates and our vetting process, analyses of home range size, movement, and habitat selection are unlikely to be biased by poor data quality.

Home range dynamics

Home range dynamics may influence the transmission and spread of CWD locally through both indirect (i.e., shedding prions in the environment) and direct (nose-to-nose) contact with infected deer (Magle et al. 2015). After removing locations during dispersal or travel periods, we estimated the size of the 95% kernel density isopleth, the area in which the deer spent 95% of its time (hereafter, *home range*). For ease of interpretation, we assigned each location to a season using average dates of first and last snowfall, along with average growing season dates; growing season (GS): 01 May – 31 Aug., fall (FA): 01 Sept.- 15 Nov., and winter (WN): 16 Nov.- 30 April. We calculated seasonal home ranges to evaluate the hypothesis that home ranges would expand in the fall, as both sexes increased movements in search of potential mates. However, to compare to other studies, we also calculated the annual home range size for each deer by averaging seasonal home range sizes. We evaluated differences in the size of home ranges by sex, season, year and land cover using linear mixed effects models.

Of 148 deer monitored in 2018 and 2019, 127 survived long enough to collect sufficient GPS location data to estimate home range for at least one season (62 females and 65 males). Females (1.75 km^2; CI: 1.37-2.13) and males (2.21 km^2 ; CI: 1.72-2.70) had similar average annual home range sizes that were consistent with home range estimates for deer throughout the Midwest (Walters et al. 2009). Home ranges were larger in the fall compared to both the growing season [β_{GS} = -1.75 ± 0.34; CI: -2.43-(-1.08)] and winter [β_{WN} = -1.16 ± 0.37; CI: -1.89-(-0.43); Figure 2], possibly reflecting mate-seeking behaviors that led to an expansion of home range boundaries. Deer were most often located in forests within home ranges, especially in winter, when deer spent a significantly greater amount of time in forest compared to other seasons (β_{WN}= 0.15 ± 0.02, p < 0.001; Figure 3). In addition to seasonal differences, home range size increased with increasing proportions of row-crop agriculture within home ranges (β_{crop} = 2.46 ± 0.68; 95% CI: 1.13-3.78).

Our estimates of home range size are well within estimates for white-tailed deer in other regions of the Midwest and eastern U.S. (Walter et al. 2009, Magle et al. 2015, Walter et al. 2018). Home range size is influenced by several environmental factors, including forest connectivity and landscape composition (Magle et al. 2015, Walter et al. 2018). In south central Wisconsin, a mixed agricultural-forested region similar to our study area, Magle et al. (2015) also found that home ranges increased with increasing proportions of agricultural land cover within the home range. In southeastern Minnesota, the predominance of row-crop agriculture, especially in the western portion of the study area, naturally results in larger home ranges, as deer must travel farther to meet food and cover needs found in forests and open habitats.

Natal dispersal

Although home range dynamics can influence transmission and spread of CWD locally, long distance dispersal and migratory movements have the potential to introduce CWD to new populations. Excluding the 2020 cohort from analysis, we found 34% of collared deer made permanent movements away from their natal home ranges. A slightly higher proportion of males (43%, n = 23/54) dispersed compared to females (26%, n = 16/61), but this difference was not significant (χ^2 = 2.73, p = 0.10). Females and males dispersed an average distance of 20.0 km (CI: 5.67-30.10) and 22.8 km (CI: 11.70-32.30), respectively (Table 1). Dispersal distance did not differ between males and females (β_{Male} = 0.11 ± 0.33, p = 0.73) or by year (β = 0.08 ± 0.35, p = 0.82). While males tended to spend more time along a dispersal path (about 15 days) compared to females (about 6 days), median dispersal dates between the sexes were nearly identical at the end of May (Table 1). Likewise 70% of males and about 90% of females dispersed in the spring, compared to fall. These findings taken together suggest that females were just as likely to disperse from their natal range, traveled approximately the same average distance, and with similar timing compared to males.

The majority of natal dispersers (72%; n = 28/39) traveled less than 20 km before establishing an adult home range and did not leave the southeastern CWD management zone (Figure 4). The boundaries of the current CWD Management Zone appear to encompass the majority of deer that would disperse from Fillmore County, the apparent prevalence remains very low at 1%. However, we observed more extreme dispersal distances by both sexes, with the maximum linear distance traveled by a female and male of 116 km and 97 km, respectively. While these extreme distances are outliers, deer have been reported to travel similar long distances in other agricultural landscapes (Kernahan et al. 1994, Nixon et al. 2007) and could serve as a source of CWD introduction into new areas. In other work done in agricultural landscapes of Illinois, average dispersal distances were approximately 30 km and males and females dispersed at approximately equal rates (Nixon et al. 2007). Importantly, deer with a natal home range on the periphery of the Management or Control Zones are likely to disperse out of these zones, and therefore, have the potential to transmit CWD to populations to the west and north of the study area. A recurring problem in the management of CWD is the delineation of an appropriately-sized management zone, and based on these results maintaining a distance of at least 32 km (or 20 miles) between the boundary of the southeast CWD management zone and the nearest CWD positive would theoretically contain 80% of dispersing deer. We stress that this conclusion is only defensible for the study area in southeastern Minnesota, as deer likely have different movement dynamics in different regions of the state, particularly as a function of underlying landscape and habitat characteristics.

Of the 39 deer that dispersed, 82% (n = 32/39) traveled in a westward direction (Figure 4). This pattern of westward movement from the center of the study area is consistent with the pattern of spread of CWD-positive hunter-harvested deer in recent years (Figure 5). These findings suggest that the risk of CWD spread from the core area centered on Preston, MN is greatest to the west and northwest along the forest-agriculture transition zone. In particular, long-distance dispersers, though uncommon, may serve as a source of disease to deer populations in central Minnesota. This information is of direct value to managers when planning additional surveillance and management activities beyond the currently delineated Southeast CWD Management Zone.

<u>Migratory movements</u>

We also observed 15% (n = 9/61) of females and 6% (n = 3/54) of males complete apparent seasonal migration between summer and winter ranges (Table 1), although there was no significant difference between these proportions ($\chi^2 = 1.70$, P = 0.19). The average one-way distance traveled for migratory females and males was 12.8 km (CI: 3.49-18.40) and 17.7 km (CI: 1.35-27.20), respectively (Table 1). Both sexes spent about 10 days on the migratory path to their seasonal range, although the median dispersal date varied from April 16 for females to May 20 for males (Table 1). The number of migratory animals was too small to detect general patterns, and it is not clear if these movements were driven by some evolutionary or proximate resource cause. However, we observed 5 deer that moved into northern Iowa (Howard, Floyd, and Mitchell counties), which is a cause for concern about potential CWD spread between Minnesota and Iowa. To our knowledge there has not been extensive CWD surveillance in those Iowa counties, which poses a risk for both of our states.

<u>Temporary movements</u>

Many animals in the study conducted temporary excursions from their home range, lasting hours to several days. It is not clear yet whether the timing of these excursions are clustered during particular seasons, but it is likely that these type of movements are important in the process of intragroup disease transmission at a local spatial scale. We are currently in the process of analyzing these movements to find any patterns that might emerge.

Pathways of movement

Of 52 deer that made natal dispersal or migratory movements, 43 had sufficient location data during the movement to evaluate habitat selection. We used step selection analysis to evaluate land cover use during movement. We used a case-control design, in which we paired each observed deer location with 15 'available' locations. Available locations were selected from a bivariate normal distribution of locations based on each observed step. We classified land cover data into row-crop agriculture, forest, open grasslands/shrubs, and riparian land cover. Riparian land cover was defined as land cover within 200 meters of a major river (Figure 6). We classified each observed and available location by cover type to evaluate differences in land cover use during travel.

For each animal, we used case-control conditional logistic regression to evaluate the relative strength of selection (RSS) for cover types, using agriculture as the reference class. We hypothesized that deer would use riparian corridors and forests as primary travel pathways within the study area. Relative selection strength is defined as the ratio of the probability of an event occurring (observed deer location) to the event occurring in a control group (a paired random location), and is calculated as the exponential of the beta coefficient for each covariate. We log-transformed RSS values for ease of interpretation because negative values indicate avoidance and positive values indicate selection for a given covariate (Avgar et al. 2017). We averaged lnRSS values for deer with significant lnRSS values to estimate population-level habitat selection.

Deer exhibited considerable heterogeneity in habitat selection and the strength of habitat selection; only 20 of 43 deer (46%) exhibited significant habitat selection over agriculture. Observed deer locations were an average of 1,316 m (± 1,337 m) away from a riparian corridor; only 19% percent of locations were within 200 meters of a forested river corridor. In contrast, deer were located an average of 269 m (± 328 m) away from the nearest forest patch, with 38% of locations being within 100 m (Figure 9). Of these, 18 deer (75%) selected forested cover over agriculture, 14 deer also selected open land cover, and 8 deer had a higher probability of use in riparian land cover compared to agriculture. Log-transformed RSS indicated that deer had a higher probability of use of forest (lnRSS = 1.30 ± 0.32 SE; CI: 0.67-1.93), open (lnRSS = 1.04 ± 0.30 SE; CI: 0.45-1.63), and riparian (lnRSS = 1.45 ± 0.39 SE; CI: 0.69-2.21) land covers relative to agriculture. Relative selection strength did not differ among these cover types. Deer appeared to avoid developed land cover; however, developed land was rare in the study area and beta coefficients were estimated using a very small sample size.

The variation in dispersal behavior that we observed in southeastern Minnesota reflects the transition in landscape features across the study area. Our study occurred in a region of southeastern Minnesota that transitions from the eastern forested bluff and ridge country along the Mississippi into the row-crop agriculture in the western part of the study area. In southwestern Minnesota, a significant proportion of deer perform seasonal migrations initiated by severe weather (Brinkman et al 2005), and we observed seasonal migrations for some animals in the southwestern part of our study area. These deer spent the summer months in northern Iowa and returned to Minnesota in winter. A study conducted in the 1980s around Whitewater Wildlife Management Area in southeastern Minnesota using radio telemetry showed that some deer migrated between Minnesota and Wisconsin (Simon 1986). We have not observed such interstate movements in our study to date and most deer have not exhibited seasonal migration patterns.

While male dispersal typically is regarded as the primary force driving potential disease spread (CWD) on the landscape (Grear et al 2006, Oyer et al. 2007), evidence suggests that high underlying deer density (Lutz et al. 2015) can drive females to disperse. Approximately one-third of all collared deer in the study dispersed from its natal range and several deer migrated seasonally. Given the relatively high rate and extent of these movements and high pre-fawn deer densities in the farmland-forest transition zone of our study area at around 42 deer/mi^2 (16 deer/km^2; E. Michel, pers. comm.), we hypothesize that density-induced dispersal and/or migration may be occurring in southeastern Minnesota. This highly productive landscape favors high deer survival and fecundity, given the extensive food resources, winter cover, and relatively mild winters. Additional study of deer representative of southeastern Minnesota will further inform our understanding of dispersal and movement activities as it relates to potential spread of CWD prions on the Minnesota landscape.

Table 1. The proportion of deer dispersing or migrating, average distance travelled, median calendar date of travel, and mean number of days traveled based on the sample of GPS-collared deer tracked in southeastern Minnesota in 2018 and 2019. Numbers within parentheses represent 95% confidence intervals, except for Median travel date, which shows the minimum and maximum calendar date of initiation of a movement.

	Natal dispersers		Seasonal Migrators	
	Male (n = 23)	Female (n = 16)	Male (n = 3)	Female (n = 9)
Percent (%) of collared deer	42.6 (29.5-56.7)	26.2 (16.2-39.3)	5.6 (1.4-16.3)	14.8 (7.4-26.7)
Movement distance (km)	22.8 (11.7-32.1)	20 (5.3-30.1)	17.7 (0-27.2)	12.8 (3.6-18.4)
Median travel date	May 29 (Mar. 21 - Oct. 26)	Jun. 1 (Mar. 12 - Dec. 7)	May 20 (Jan. 11 - Sept. 9)	Apr. 16 (Mar. 24 - Nov. 26)
Mean number of days	15.2 (0.2-24.3)	5.5 (1.6 - 8.3)	9.6 (4.8-13.7)	10.8 (0.2-19.0)

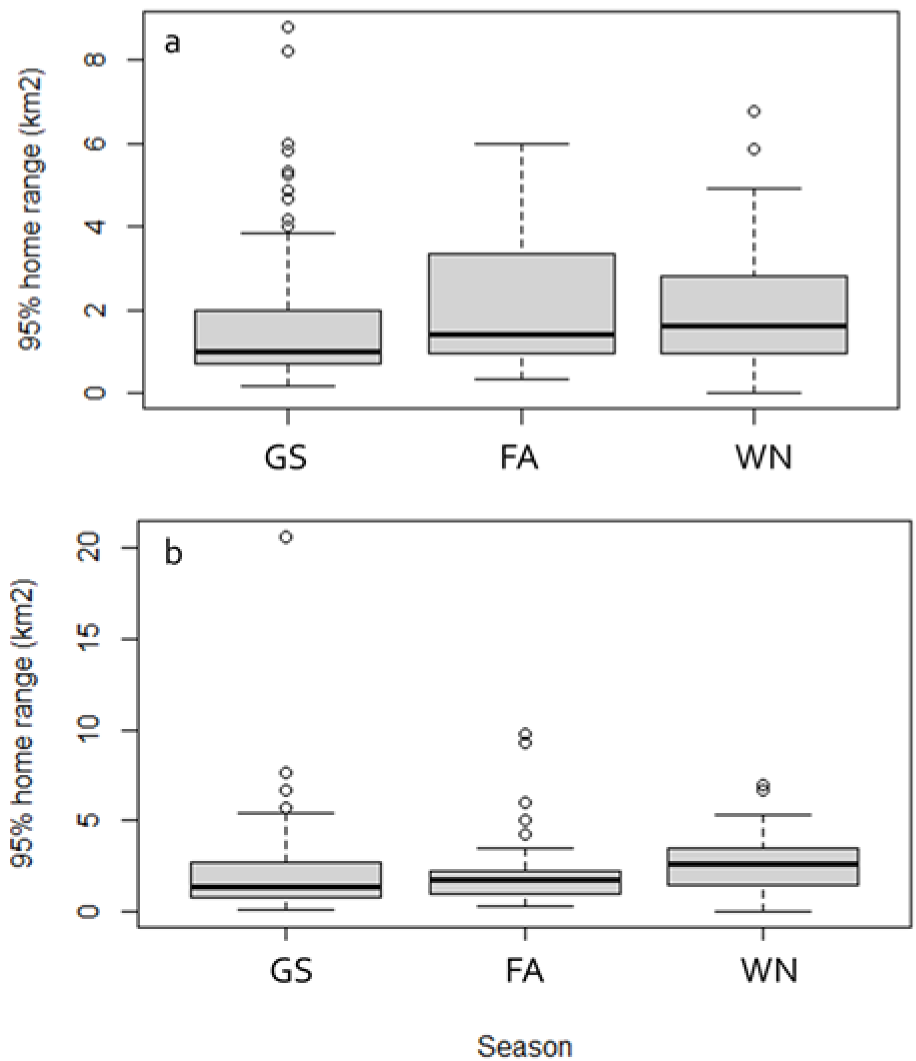


Figure 2. Distribution of 95% home range sizes (km^2) by season for female (a) and male (b) white-tailed deer collared and monitored in southeastern Minnesota, 2018-2020. Seasonal home ranges were defined as: Growing Season (GS); 01 May–31 Aug. of each year; FalL (FA)l; 01 Sept. – 15 Nov., and Winter(WN); 16 Nov.–30 Apr of each year. Season dates were set using first and last snowfall dates and frost-free dates.

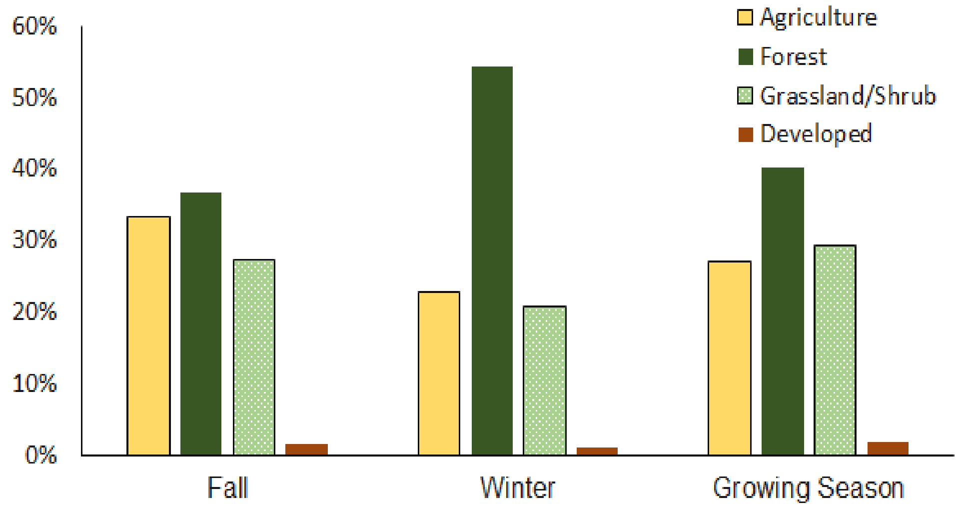


Figure 3. Average proportions of deer locations in each of four land cover types within seasonal home ranges for white-tailed deer (n = 127) collared and monitored in southeastern Minnesota, 2018-2020. Seasonal home ranges were defined as: Growing Season; 01 May–31 Aug. of each year; Fall; 01 Sept. – 15 Nov., and Winter; 16 Nov.–30 Apr of each year. Season dates were set using first and last snowfall dates and frost-free dates.

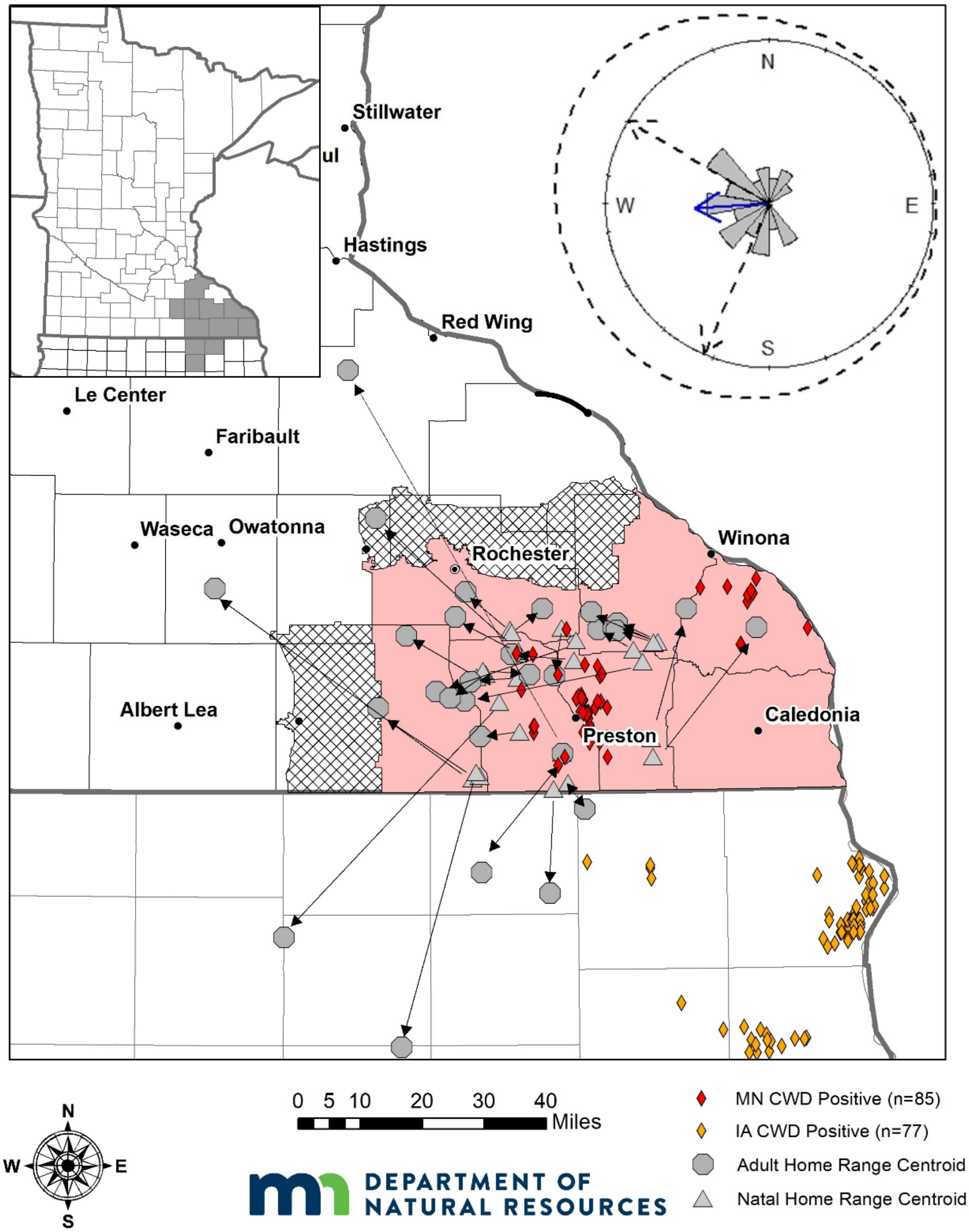


Figure 4. The movement trajectories of dispersing and migratory deer captured in 2018 and 2019 within the southeastern Minnesota study area. Only deer with dispersal (n=21) and migratory (n=7) distances greater than 10 km are displayed. Triangles represent the centroid of pre-movement home ranges and octagons represent the centroid of post-movement home ranges. In the case of dispersers, the post-movement home range is equivalent to the adult home range. The superimposed panel in the top right represents the best supported model of population movement trajectory, which shows deer tend to move westward. Pink areas represent the Southeast CWD Management Zone and hatched areas represent the CWD Control Zone.

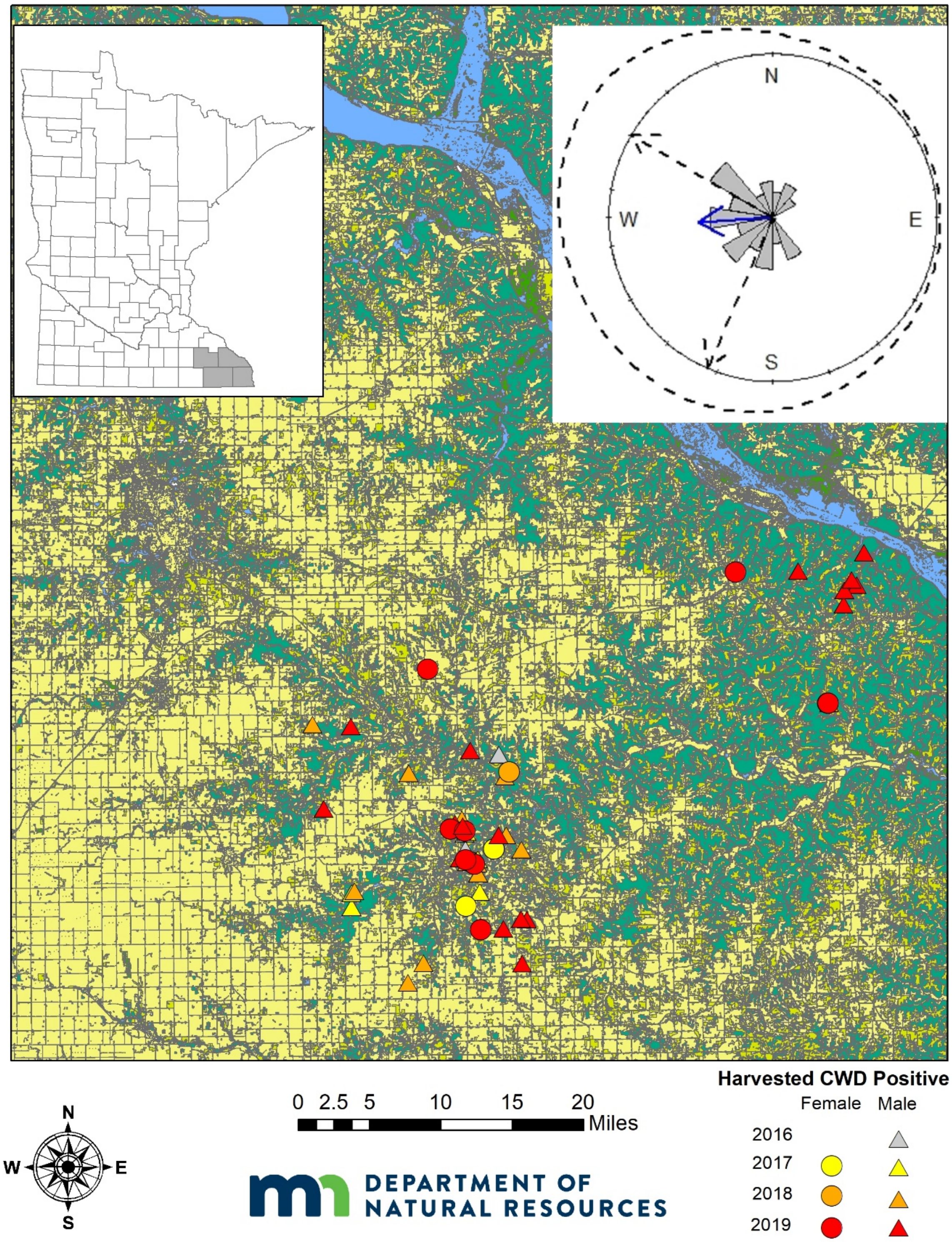
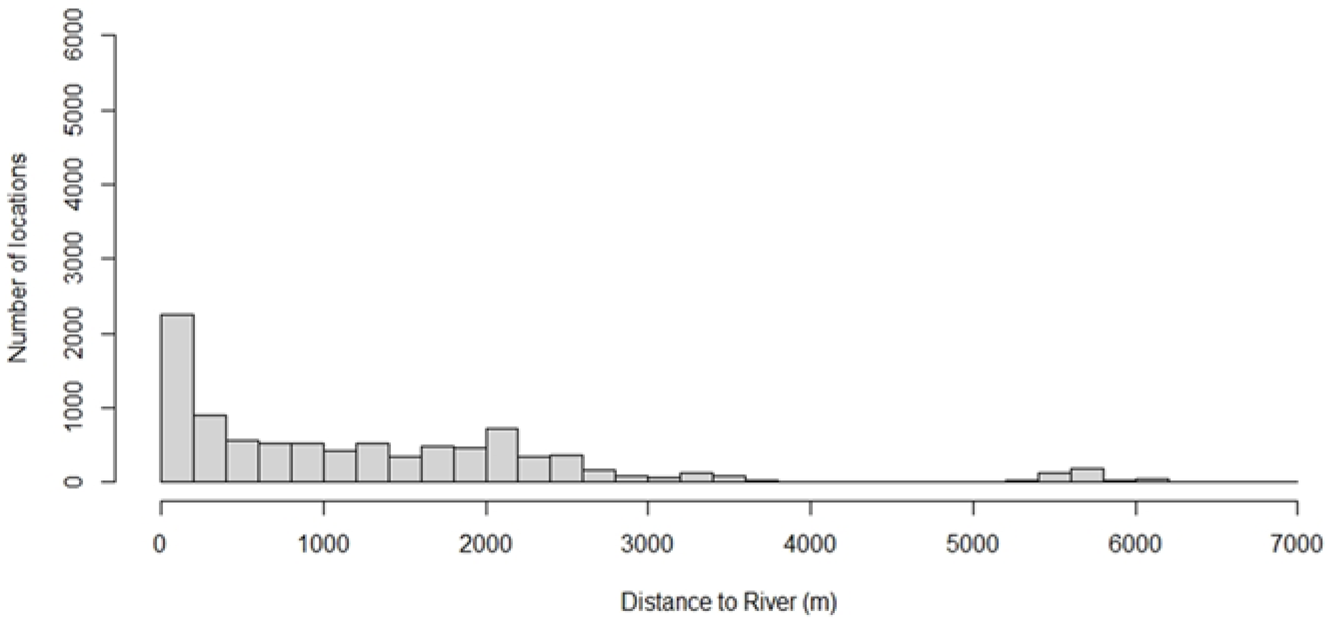


Figure 5. Distribution of CWD positive hunter-harvested deer (n=54) in southeastern Minnesota from 2016 through 2019. The trajectory of CWD positive deer over time, particularly males, suggests westward spread of CWD. The superimposed panel in the top right represents the best supported model of population movement trajectory, which shows deer tend to move westward.



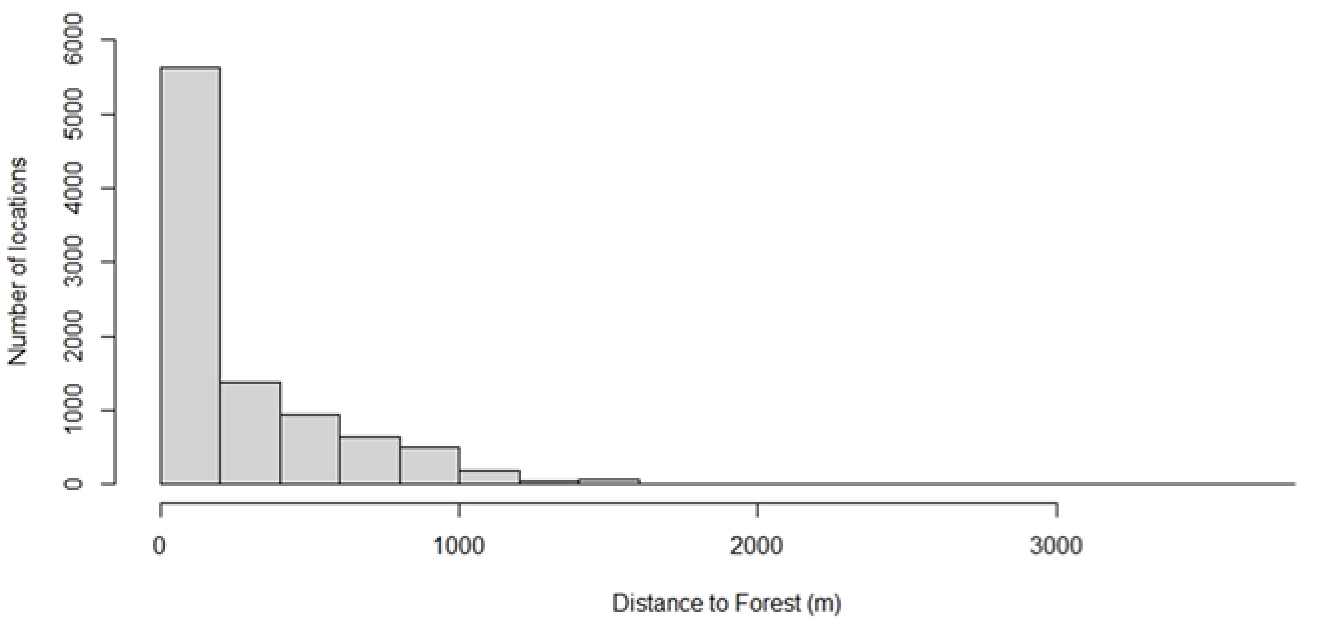


Figure 6. Frequency distributions of the straight-line distances between deer locations and the nearest forested river corridor (upper panel) and the nearest forest edge (lower panel) for 42 deer making either natal dispersal (n = 31) or seasonal migratory (n = 11) movements in southeastern Minnesota, 2018-2020.

ACTIVITY 3: Determination of cause-specific mortality

Description: The GPS collar technology will permit detection of likely mortalities, and we will estimate cause-specific mortality rates by generalized categories (e.g., harvested, vehicle collision, depredation) and incorporate those estimates into population models to improve accuracy and understanding of deer population dynamics in southeastern Minnesota. This work is being completed as part of MNDNR's in-kind services to be applied to the project with other funds, as listed in Section VI. B.

Summary Budget Information for Activity 3: | | |
|---|---|
| **ENRTF Budget:** | **$ 0** |
| **Amount Spent:** | **$ 0** |
| **Balance:** | **$ 0** |

Outcome	Completion Date
1. Estimate cause-specific mortality and describe factors related to mortality trends for year 1 data.	06/30/2019
2. Estimate cause-specific mortality and describe factors related to mortality trends for year 2 data.	06/30/2020
3. Report findings in research summaries and prepare peer-reviewed publications	10/31/2020

Activity 3 Status as of December 01, 2018: Of the original cohort of 109 deer released with GPS collars, 23 in the study have died thus far. Mortality sources include coyote predation (n=3), vehicle collision (n=3), disease (n=1), capture–related (5), and hunter harvest (n=11). Formalized cause-specific mortality estimates will be generated in early 2019.

Activity 3 Status as of May 1, 2019:

Of the 109 collared and released deer from the 2018 cohort, 34 that have died thus far and mortality sources include agency-culled (n=4), vehicle collision (n=4), capture-related and unknown (12), and hunter harvest (n=14).

Of the 64 collared and released deer from the 2019 cohort, six have died (five females and one male). Within about a month of capture, a male was able to kick its collar off. There is evidence that one female may have died due to capture myopathy.

Activity 3 Status as of October 15, 2019:

To date, there have been 46 known mortalities of GPS collared deer, which include 17 females and 29 males. The sources of mortality include hunter harvest (n=14), vehicle collision (n=6), agency-culled (n=4), poor health (n=6), unknown cause (n=4), and capture-related issues (12). A total of 81 collars have been deactivated because of hardware failure (either collar expansion or internal electronics failure). Due to these failures, we were (are) not able to document the fates of these animals, and our recorded mortalities likely underestimate the true number of collared deer that have died in the field.

Activity 3 Status as of April 15, 2020:

There have been 81 known mortalities of deer from this study including 57 males and 24 females. The sources of mortality we identified included hunter harvest (n=33), capture-related issues (n=14), unknown cause (n=12), vehicle collision (n=10), complications due to leg injury (n=5), agency culling (n=4), and likely predation (n=3). It is important to note that five of 12 deer ascribed to the unknown cause source wore GPS collars that failed after deployment, so we never received a mortality signal to follow up with carcass investigations. Instead, in these cases, either landowners or hunters happened upon carcasses in the field by chance and only skeletal remains were left preventing us from ascribing a source of mortality. Since the last update, we deactivated 12 additional collars (93 total) either because they reached the end of their battery life or experienced internal electronics failure.

Project Update: As of April 15 2020, we continue to monitor 29 animals (19 females and 10 males) collared in 2019. All animals collared in 2018 either have collars that are no longer transmitting data (n=46) or have died (n=49). To date, 81 study deer have died, with sources of mortality including hunter harvest (n=33), capture-related issues (n=14), unknown cause (n=12), vehicle collision (n=10), complications due to leg injury (n=5), and agency culling (n=4), and likely predation (n=3).

Final Report Summary:

As of July 30 2020, there have been 86 known collared deer mortalities from this study including 57 males and 29 females. The sources of mortality we identified included hunter-harvest (n = 36), capture-related issues (n = 14), vehicle collision (n = 13), indeterminate causes (n = 7), underlying health conditions (n = 6), agency culling (n = 4), trauma (n = 4), and predation/scavenging (n = 2) (Figure 7). Given we are actively monitoring 72 animals and we expect to capture an additional 45 in early 2021, these statistics will change in the future.

We estimated average survival by year and sex and grouped causes of mortality as hunter-harvest, vehicle collision, and other (except for capture-related causes) in order to estimate annual cumulative incidence curves (Figure 8). Average annual survival for females and males was 0.73 (CI: 0.62-0.86) and 0.54 (CI: 0.40-0.73), respectively, and the difference was marginally significant ($Z = 1.80$; $P = 0.07$). Average annual mortality due to hunter harvest was 18%, while that for other causes and vehicle collision were 11% and 6%, respectively. After adjusting for multiple comparisons using a Bonferroni correction, hunter harvest was significantly greater than vehicle collision ($Z = 2.37$; $P = 0.05$), but not other causes ($Z = 1.19$; $P = 0.71$). Other causes of mortality were not significantly different from vehicle collision ($Z = 1.28$; $P = 0.60$). The low survival estimates likely reflect liberalized harvest regulations within the study area in order to manage CWD, coupled with the fact that yearlings and young adults are the most vulnerable group to hunter harvest.

We captured deer when they were older fawns, at least 7-9 months old; therefore, our survival estimates are conditional on animals surviving through this age. Furthermore, our study only reflects two years of survival data, and the upper limit on age classes reflected is around 3.5 years. Deer typically experience the highest risk of mortality after birth through the first year of life (DelGiudice et. al. 2006), so our estimates do not capture the period when deer are most vulnerable. Several neonate studies in the upper Midwest have shown that fawn mortality during the first few months of life for white-tailed deer was driven by predators or natural causes (Brinkman et al. 2004, Carstensen et al. 2009, Grovenburg et al. 2011, Warbington et al. 2017). Research in Minnesota has shown that winter severity index and wolf predation can be significant sources of mortality for deer, particularly in the northern forest region (DelGiudice et al. 2006). However, in our study area, sources of mortality are more aligned with patterns observed in southwestern Minnesota and other parts of the Midwest, where hunter harvest and deer-vehicle collisions are the primary causes in adult deer (Brinkman et al. 2004, VerCauteren and Hygnstrom 2011, Krebs 2014).

Our survival estimates appear to be low and, taken at face value, would yield an average life expectancy of about 4.5 years and 2.5 years for females and males, respectively. However, these estimates potentially reflect several processes at work. Our sample purposely focuses on a narrow range of age classes, primarily yearling deer, because we sought to investigate dispersal patterns. It is well known that yearling and 2.5 year-old males are the most vulnerable age-sex class to hunter harvest (Roseberry and Klimstra 1974, McCullough 1979, Nixon et al. 1994). To facilitate CWD management efforts, in 2017 antler point restrictions (APR) were removed from Deer Permit Area (DPA) 603 and unlimited antlerless tags were available for a nominal fee, which represented a small subset of our study area. In 2019, MNDNR dissolved DPA 603 into a broader CWD Management Zone, and removed APR and liberalized harvest throughout our entire study area. The possible effect of this liberalized harvest regulation change may be reflected in lower male survival during 2019 compared with 2018 (Figure 12). Potentially adding to this effect, it is possible that hunters selectively harvested collared deer at a higher rate (Jacques et al. 2011), thus biasing our annual survival estimates low.

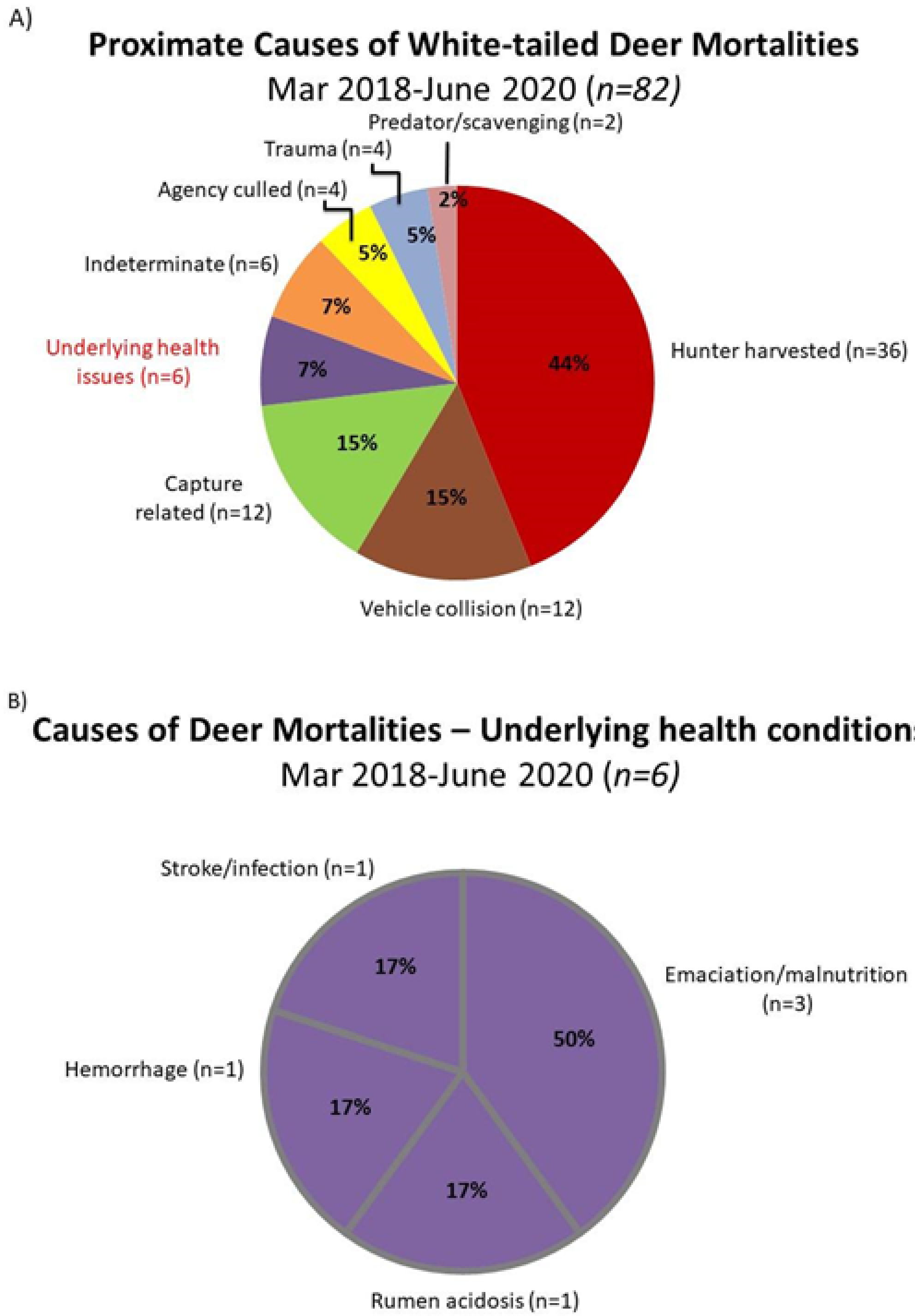


Figure 7. A) Causes of known mortality for 82 collared yearling and adult deer from March 2018 through June 2020 in southeastern Minnesota. Hunter harvest represents the primary source of mortality. B) Within the category of underlying health condition, we identified more detailed causes of mortality.

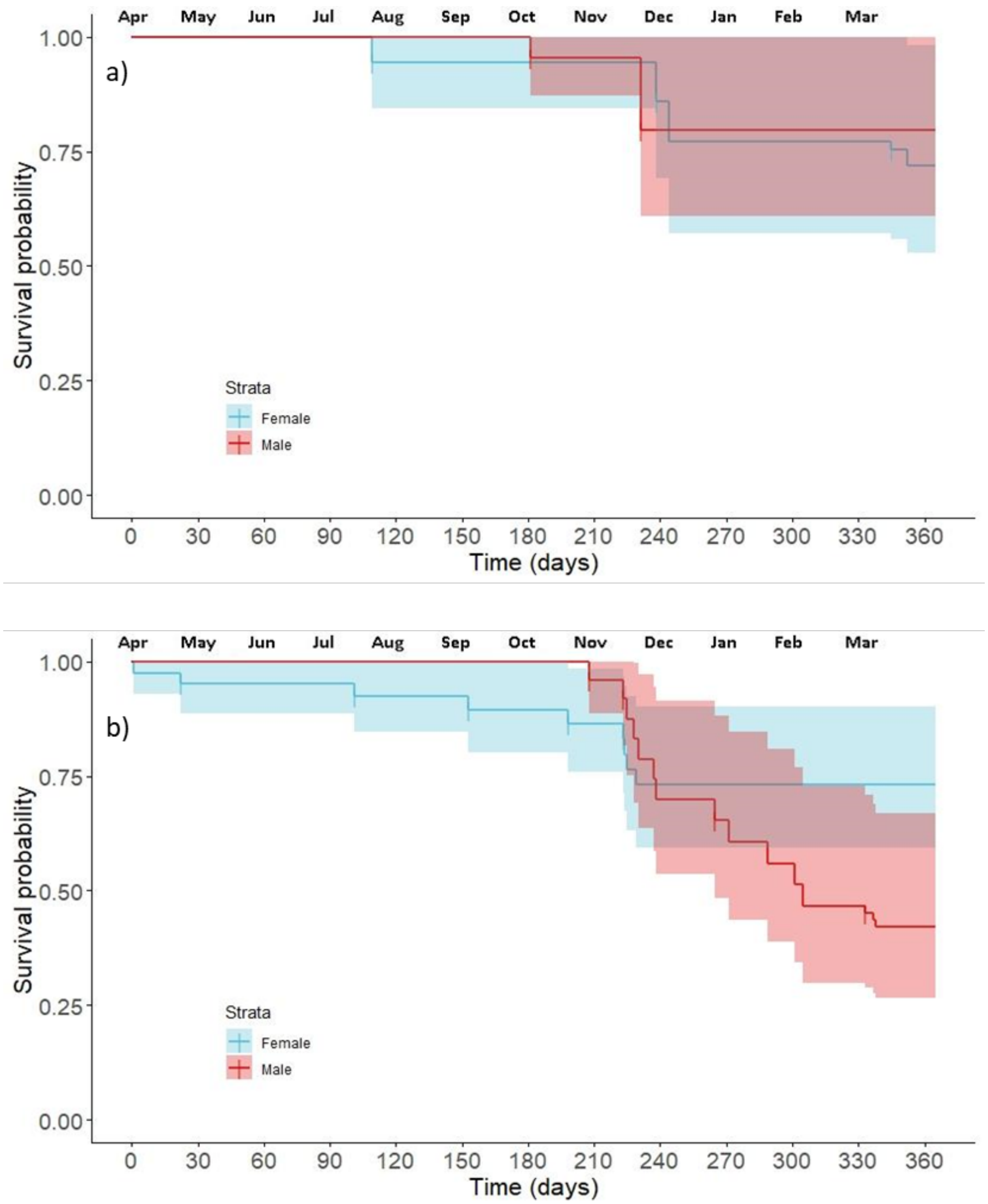


Figure 8. Estimated survival (and 95% CI) by sex for collared white-tailed deer in southeastern MN from 1 April 2018 through 31 March 2019 (upper panel; a), and from 1 April 2019 through 31 March 2020 (lower panel; b).

V. DISSEMINATION:

Description: The initial outlet for results from this project will likely be through an official MNDNR research summary that will be available on the DNR webpage after October 2018. The webpage to which the summary will be posted is: http://dnr.state.mn.us/publications/wildlife/index.html.

We will also prepare peer-reviewed manuscript(s) for publication based on this research. The scientific outlets may include Journal of Wildlife Management, Journal of Wildlife Diseases, Journal of Mammalogy, or PLoS One. Furthermore, there are likely to be press releases that report on the status of this project in popular media outlets.

Status as of April 15, 2018:

We have had considerable media coverage of this project thus far. A list of the various stories that have been published about this study include:

Newspaper Articles:

- Star Tribune – 10/17/2017 – *Minnesota to collar more than 100 wild deer with tracking devices to fine-tune its fight against CWD*
- Star Tribune – 12/12/2017 – *Minnesota DNR needs help to track deer movements in southeast area*
- Post Bulletin – 12/14/2017 – *DNR seeks landowners' help in deer study*
- Outdoor News – 02/12/2018 – *In Minnesota, southeast deer study set for kickoff*
- KBJR6 and WPTA21 – 03/12/2018 – *Minnesota DNR to start deer movement study to help against CWD*
- MNDNR Press Release – 03/12/2018 – *Deer movement study begins in southeastern Minnesota's CWD zone*
- Albert Lea Tribune – 03/12/2018 – *DNR begins deer movement study in Minnesota*
- 103.1 KFIL radio – 03/13/2018 – *Deer movement study begins in CWD zone of SE Minnesota*
- Austin Daily Herald – 03/14/2018 – *DNR will study area including Mower for CWD*
- Winona Post – 03/14/2018 – *Deer movement study begins in southeastern Minnesota's CWD zone*
- Post Bulletin – 03/14/2018 – *Outdoor notes: Deer study pushed back by at least one week*
- KWWL7 and KBJR6 News and WXOW – 03/18/2018 – *Helicopter aids in MN DNR movement study*
- Star Tribune – 03/21/2018 – *Helicopter crew netting deer in Fillmore County in state's fight against CWD*

TV Stories/Interviews:

- KIMT3 News – 03/14/2018 – DNR research project aims to study CWD
- WCCO4 News – 03/23/2018 – Helicopter capture aims to track CWD, protect Minnesota's white-tailed deer

Radio Interviews:

- KATE Radio (Albert Lea) – 03/16/2018 – 10-minute live segment on deer movement study
- The 4 Outdoorsmen on BOB 106 FM – 04/15/2018 – Interview on southeast deer movement study and other DNR initiatives

Status as of December 01, 2018: We completed an official MNDNR research summary of the project, which will be made available to the public on the DNR webpage. In addition, we built a dedicated webpage that outlines the deer movement study, provides periodic updates about our findings, and has links to movement maps that we created to show some of the interesting movements that some of our study deer have made. It can be viewed at: https://www.dnr.state.mn.us/cwd/deer-movement-study.html.

Without the support of private landowners in the study area to permit deer captures, this project would not be possible. We have been providing quarterly updates to the 200+ property owners that have graciously given us permission to capture deer for the study on their land. These quarterly updates include maps of movements from our study deer, highlights about novel information that we are gleaning, and upcoming plans for the study.

We have had considerable media coverage of this project thus far. A list of the various stories that have been published about this study since the last update in April 2018 include:

Newspaper/Online Articles:

- Rochester Post Bulletin – 07/26/2018 – Deer study yields stunning results
- Winona Post – 09/05/2018 – Growing threat: Chronic wasting disease in deer
- MPR – 08/16/2018 – Chronic wasting disease spread faster than expected
- Bluestem Prairie – 8/19/2018 – Will new research on deer movement prompt Minnesota legislature to act on CWD?

Status as of May 1, 2019:

We continue to update a dedicated webpage to the deer movement study located at https://www.dnr.state.mn.us/cwd/deer-movement-study.html. The page outlines the objectives of the study, provides statistics on movement parameters and updates about our findings, and has links to movement maps that we created to show some of the interesting movements that some of our study deer have made.

Without the support of private landowners in the study area to permit deer captures, this project would not be possible. We have been providing bi-annual updates to the 200+ property owners that have graciously given us permission to capture deer for the study on their land. We also provide updates to a large number of city, state, and federal colleagues that have provided support and are responsible for various resource management duties in the study area. These quarterly updates include maps of movements from our study deer, highlights about novel information that we are gleaning, and upcoming plans for the study.

We have had considerable media coverage of this project thus far. A list of the various stories that were published about this study and presentations since the last update in December 2018 include:

Newspaper/Online Articles:

- North American White-tail – 02/14/2019 – Tracking deer providing valuable CWD information
- Tri-County Record – 2/28/2019 – Rushford airport is home base for DNR deer study

Presentations:

- Minnesota Board of Animal Health Quarterly Board Meeting – 09/18/2018
- Minnesota Department of Natural Resources Round Table – 01/11/2019
- Midwest Association of Fish and Wildlife Agencies Health Committee – 4/24/2019

Status as of October 15, 2019:

We continue to update a dedicated webpage to the deer movement study located at https://www.dnr.state.mn.us/cwd/deer-movement-study.html. The page outlines the objectives of the study, provides statistics on movement parameters and updates about our findings, and has links to movement maps that we created to show some of the interesting movements that some of our study deer have made.

Without the support of private landowners in the study area to permit deer captures, this project would not be possible. We have been providing bi-annual updates to the 200+ property owners that have graciously given us permission to capture deer for the study on their land. We also provide updates to a large number of city, state, and federal colleagues that have provided support and are responsible for various resource management duties in the study area. These quarterly updates include maps of movements from our study deer, highlights about novel information that we are gleaning, and upcoming plans for the study.

Since our last update on May 1 2019, although we have had no additional media coverage to report regarding this project, we have had additional outreach opportunities to highlight this study. On May 5 2019, we gave an oral presentation on the deer movement study at a statewide DNR meeting to Division of Fish and Wildlife staff. We gave another oral presentation of the study ("Deer movement in Minnesota and the potential to spread chronic wasting disease") at the international Wildlife Disease Association conference in Tahoe City, CA on August 8, 2019. In addition, we advertised the study with a poster at both the Minnesota State Fair between August 27 and September 7, 2019 and a Bell Museum Spotlight Science event focused on chronic wasting disease on September 14, 2019.

Status as of April 15, 2020:

We continue to update a dedicated webpage to the deer movement study located at https://www.dnr.state.mn.us/cwd/deer-movement-study.html. Currently, we are working with DNR Communications staff to revamp the webpage to provide additional information on the study to the public. We expect to launch the new webpage by July 2020. The new webpage will include the rationale behind the research, educational vignettes about CWD and deer movement ecology, a project timeline, and results on dispersal, movement pathways, and causes of mortality. The goal is to ensure that the webpage will appeal to a diverse audience of hunters, landowners, citizens, and educators.

Without the support of private landowners in the study area to permit deer captures, this project would not be possible. We have been providing bi-annual updates to the 200+ property owners that have graciously given us permission to capture deer for the study on their land. In January, we sent participating landowners a Winter Newsletter to update them on the study. This newsletter provided recipients with maps of deer captures and movements, highlights about novel information gleaned from the study, and upcoming plans for the spring capture period. We also provide updates to a large number of city, state, and federal colleagues that have provided support and are responsible for various resource management duties in the study area. Currently, we are putting together our Spring Newsletter, which we will send to landowners, municipalities, and state and federal colleagues in May 2020.

Radio Interviews:

- KFAN 100.3 – 10/19/2019 – Discussed CWD in Minnesota and some details about the deer movement

Final Report Summary:

Over the course of this project, we have had 23 articles, interviews, or media reports pertaining to this study. MNDNR staff have given at least 14 professional presentations regarding this study to state, federal, and University audiences. We have also created a dedicated webpage devoted to providing background and updates to this study at https://www.dnr.state.mn.us/cwd/deer-movement-study.html. We have outreached to over 250 private landowners in southeastern Minnesota as part of the process of obtaining permission to access private property for deer capture and GPS-collaring efforts. We have provided regular updates and interactive maps to participating landowners, interested citizens, and hunters who have submitted harvested collared deer to us. We are in the process now of creating an interactive map of select study deer to go live on our webpage that will allow the public to better engage with the amazing movement data we have collected thus far. We have written three DNR agency reports of this project thus far, and are in the process of writing manuscripts for publication.

VI. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview:

***This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report.**

Budget Category	$ Amount	Overview Explanation
Professional/Technical/Service Contracts:	$ 157,500	1 contract with a wildlife helicopter capture company TBD through competitive bid for capturing and collaring deer; 1 contract with a GPS data collection and reporting service TBD through competitive bid – this may be combined as a package with a GPS collar vendor; 1 contract with a wildlife aerial survey company TBD through competitive bid to spot prospective deer herds for capture.
Equipment/Tools/Supplies:	$ 180,418	GPS collars to be placed on white-tailed deer
Capture crew_expenses in MN:	$ 6,538	Mileage, meals
Personnel (50% FTE):	$ 43,000	Cost represents 19 months of hire.
50% FTE expenses:	$ 23,518.50	Includes vehicle expense ($0.55/mile at 230 miles/week for 83.33 weeks), field supplies, and travel expenses
Other:	$ 13,462	Direct and necessary costs including Department support services (Human Resources, IT, Safety, Financial, Communications, and Planning)
TOTAL ENRTF BUDGET:	**$ 350,000**	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than $5,000: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 0.5 for year 1 and 0.25 for year 2.

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: N/A

Final ENRTF Budget Overview

Budget Category	$ Amount	Overview Explanation
Professional/Technical/Service Contracts:	$ 118,967	1 contract with a wildlife helicopter capture company through competitive bid for capturing and collaring deer; 1 contract with a GPS data collection and reporting service through competitive bid – this may be combined as a package with a GPS collar vendor (Lotek Wireless Inc.); 1 contract for a wildlife aerial survey (MNDNR) to spot prospective deer herds for capture (in year 1 only).
Equipment/Tools/Supplies:	$ 272,829	GPS collars to be placed on white-tailed deer
Capture crew expenses in MN:	$ 5,888	Mileage, meals
Personnel (50% FTE):	$ 31,163	Cost represents 19 months of hire.
50% FTE expenses:	$ 16,418	Includes vehicle expense ($0.55/mile at 230 miles/week for 83.33 weeks), field supplies, and travel expenses
Other:	$ 4,291	Direct and necessary costs including Department support services (Human Resources, IT, Safety, Financial, Communications, and Planning)
TOTAL ENRTF BUDGET:	**$ 449,556**	

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
In-kind services to be applied to project during project period			
Salary	$ 76,000	$ 220,175	MNDNR Wildlife Health Group and Farmland Populations and Research Group; multiple employees working on project management, field work, data analyses, reporting of results; 20% effort.
Mortality Diagnostics	$ 2,000	$ 2,750	Some mortalities retrieved with unknown or suspicious cause of death will be taken to the UMN Veterinary Diagnostic Lab for necropsy.
Disease Screening	$ 5,000	$ 0	Blood samples retrieved from study animals will be screened for a variety of infectious diseases.

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
MNDNR Funding*	$ 330,000	$ 115,531	These funds will be used to purchase additional GPS collars, pay for transmission fixes, staff salaries, supplies, and logistics.
TOTAL OTHER FUNDS:	**$ 4**13,000	$ 338,456	

*Additional funding being provided by MNDNR for continuation of the study.

VII. PROJECT STRATEGY:

A. Project Partners:

As of 03/24/2020, Dr. Joanne Crawford, a new member of the MNDNR Wildlife Health Program has been included as a co-Principal Investigator on this project. She brings a wealth of experience in wildlife movement ecology, as well as genetics expertise that complements the project perfectly.

Partners receiving ENRTF funding

Collaborator:

Kelsie LaSharr / Joanne Crawford – MNDNR (25% FTE for the project)

Partners NOT receiving ENRTF funding

- Collaborators:

  Michelle Carstensen – MNDNR

  Lou Cornicelli – MNDNR

  Ryan Tebo – MNDNR

  Tyler Obermoller – MNDNR

  Erik Hildebrand – MNDNR

  Margaret Dexter – MNDNR

  Todd Froberg – MNDNR

  Andrew Norton – South Dakota Game, Fish, and Parks

- Please make note that Dr. Andrew Norton is no longer a co-Principal Investigator on this project.

B. Project Impact and Long-term Strategy:

This study will provide critical information on deer movements, which directly relates to CWD prion transmission to new areas. These data will inform future surveillance and management strategies related to white-tailed deer; a $500,000,000 annual resource in Minnesota. In addition, we will collect survival information used to inform population models and guide management recommendations.

C. Funding History:

N/A

VIII. REPORTING REQUIREMENTS:

- **The project is for 2.75 years, will begin on 10/01/2017, and end on 06/30/2020.**
- **Periodic project status update reports will be submitted April 15 and October 15 of each year.**
- **A final report and associated products will be submitted on August 15 2020**.

IX. VISUAL COMPONENT or MAP(S): See attached maps below (Figures 1, 2, 3, 4, 5 and 6)

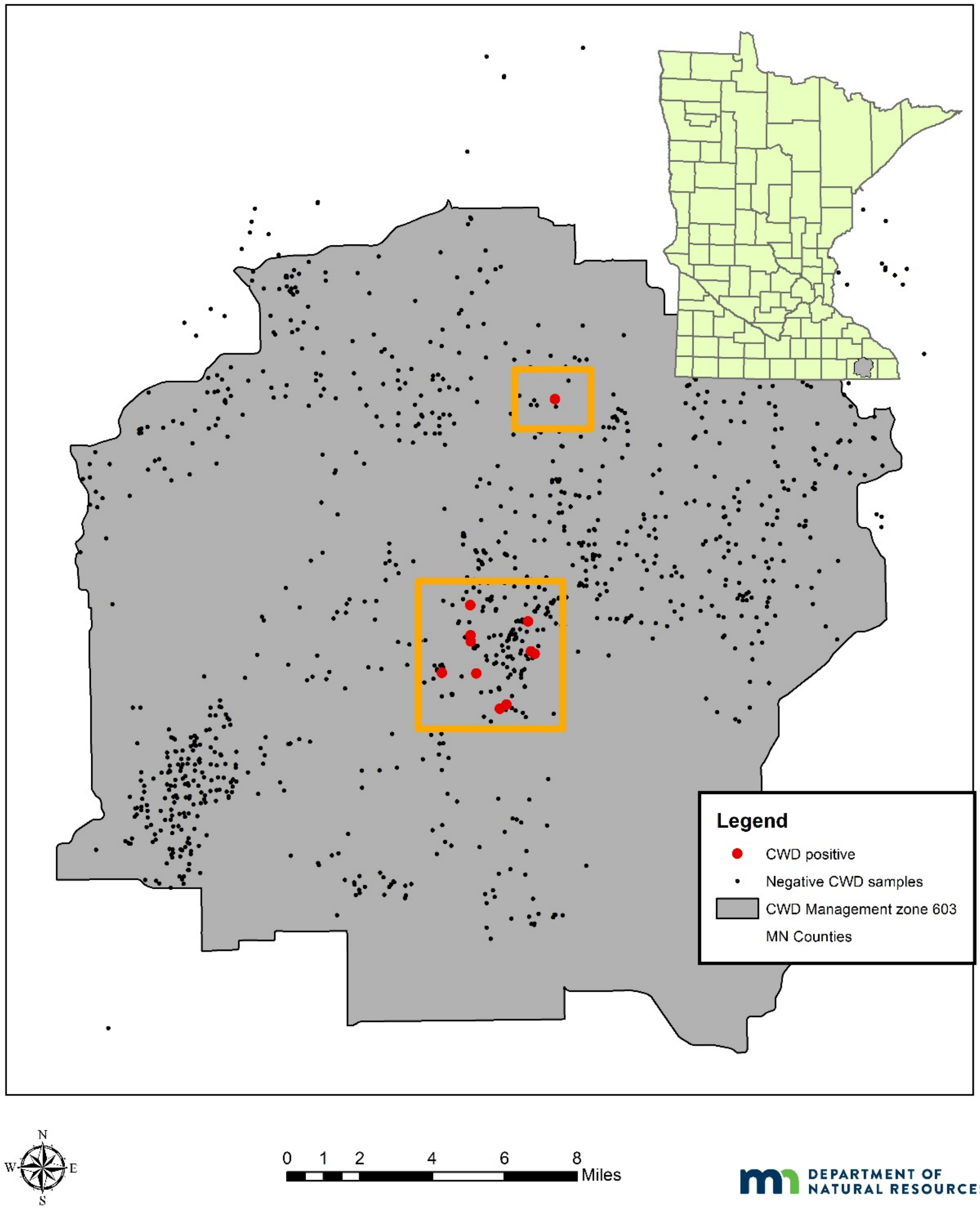


Figure 1. Chronic wasting disease management zone 603 established in fall 2016 in response to three CWD positive wild white-tailed deer detections. From September 2016 through March 2017 with additional efforts via a special hunt, landowner permits, and a USDA removal contract, a total of 11 CWD positive white-tailed deer were detected in zone 603.

Study Area

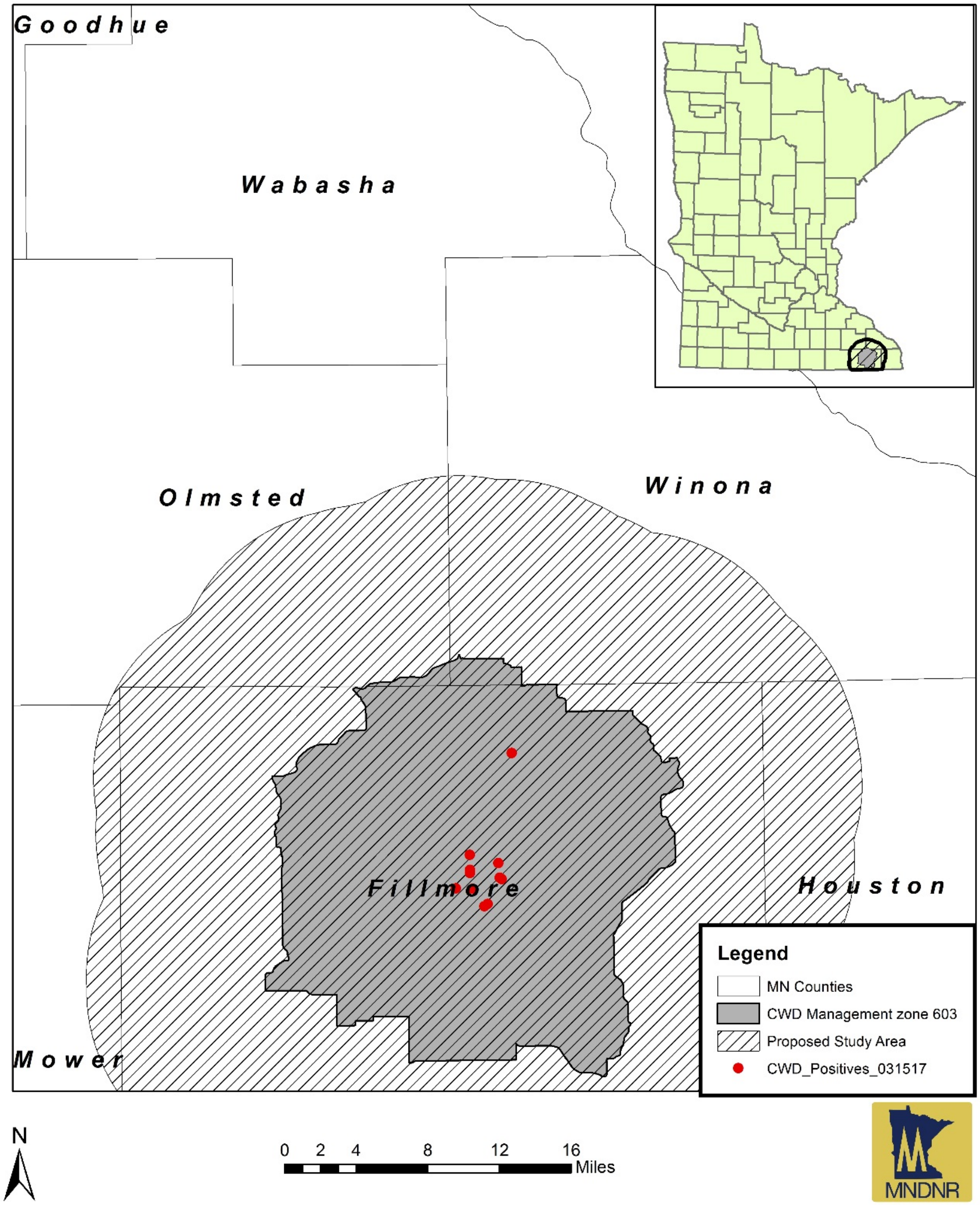


Figure 2. Proposed study area in and around the chronic wasting disease management zone (Deer Permit Area 603). This area is largely private land, so the final disposition of sampling locations for GPS collaring deer will depend on permissions we receive from cooperating landowners, weather patterns, and local scale landscape characteristics that facilitate helicopter capture of wild white-tailed deer.

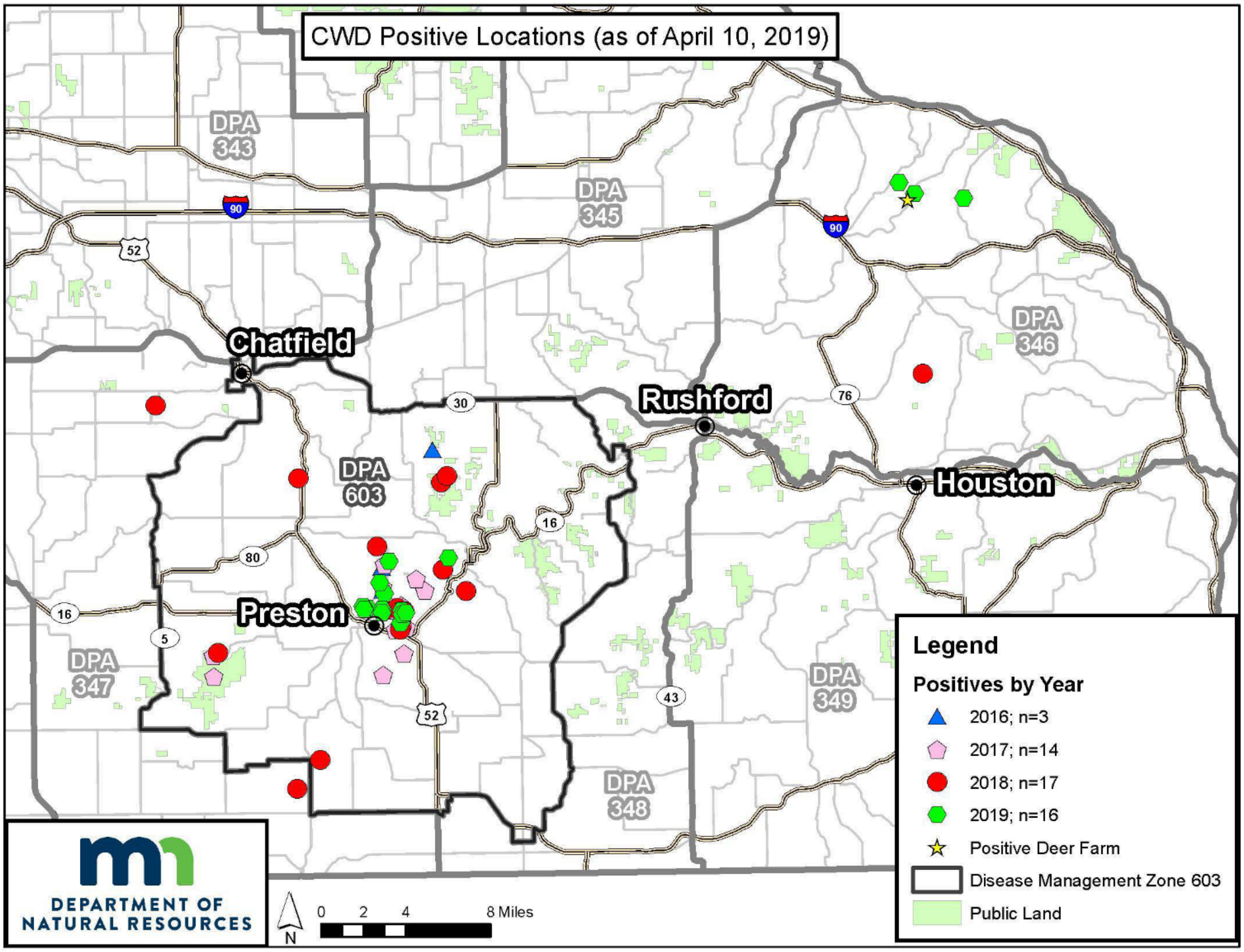


Figure 3. Spatial distribution of wild white-tailed deer confirmed with CWD infection in and around DPA 603 as of 04/10/19. Since 2016, there have been a total of 50 confirmed CWD-positive wild deer in southeastern Minnesota.

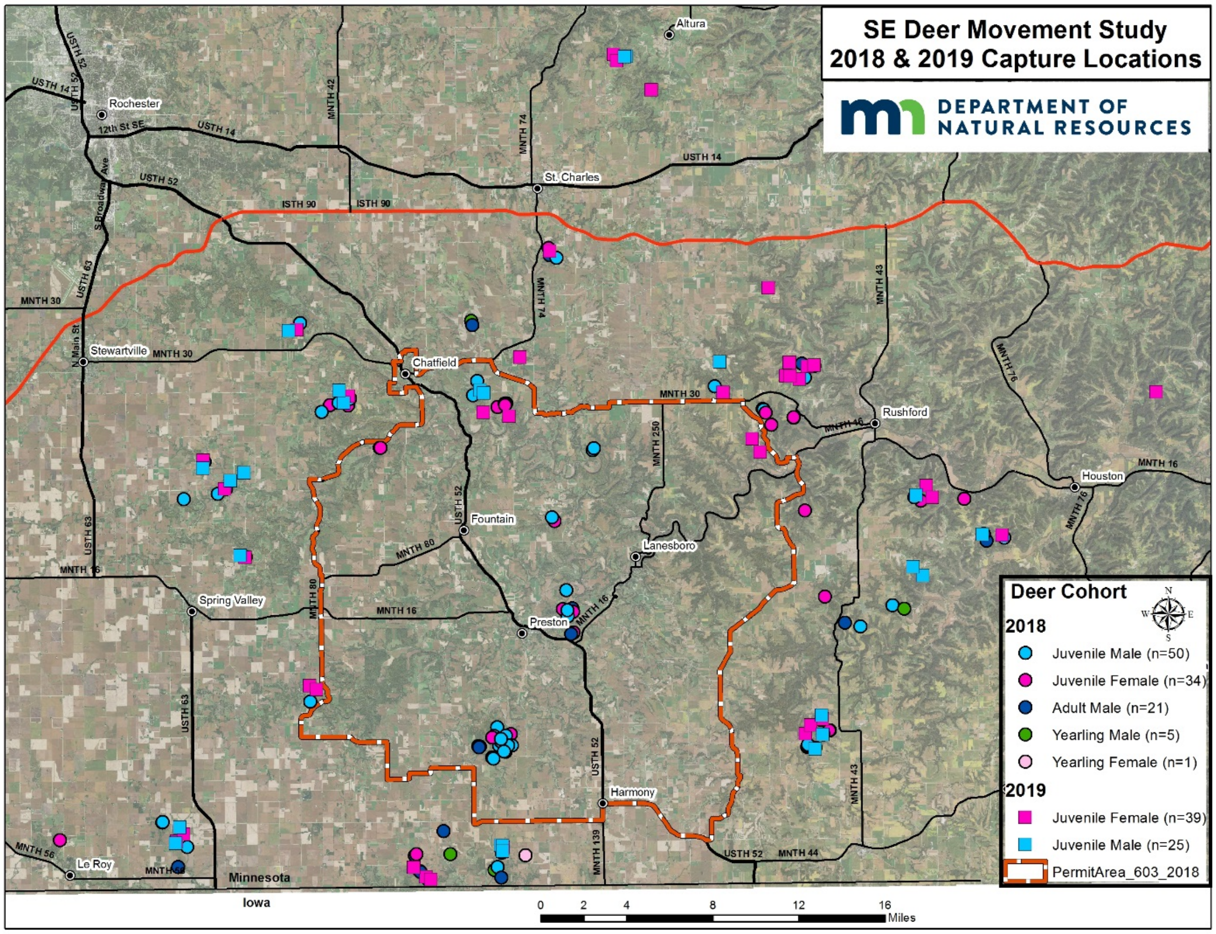


Figure 4. Spatial distribution of deer captured and collared during 2018 and 2019 in the study area. Points represent the locations where white-tailed deer were captured, collared with GPS units, and released in the study area centered on CWD management zone 603 in Fillmore County. Year one captures occurred from March 18-23, 2018 and year two captures occurred from February 18-21, 2019.

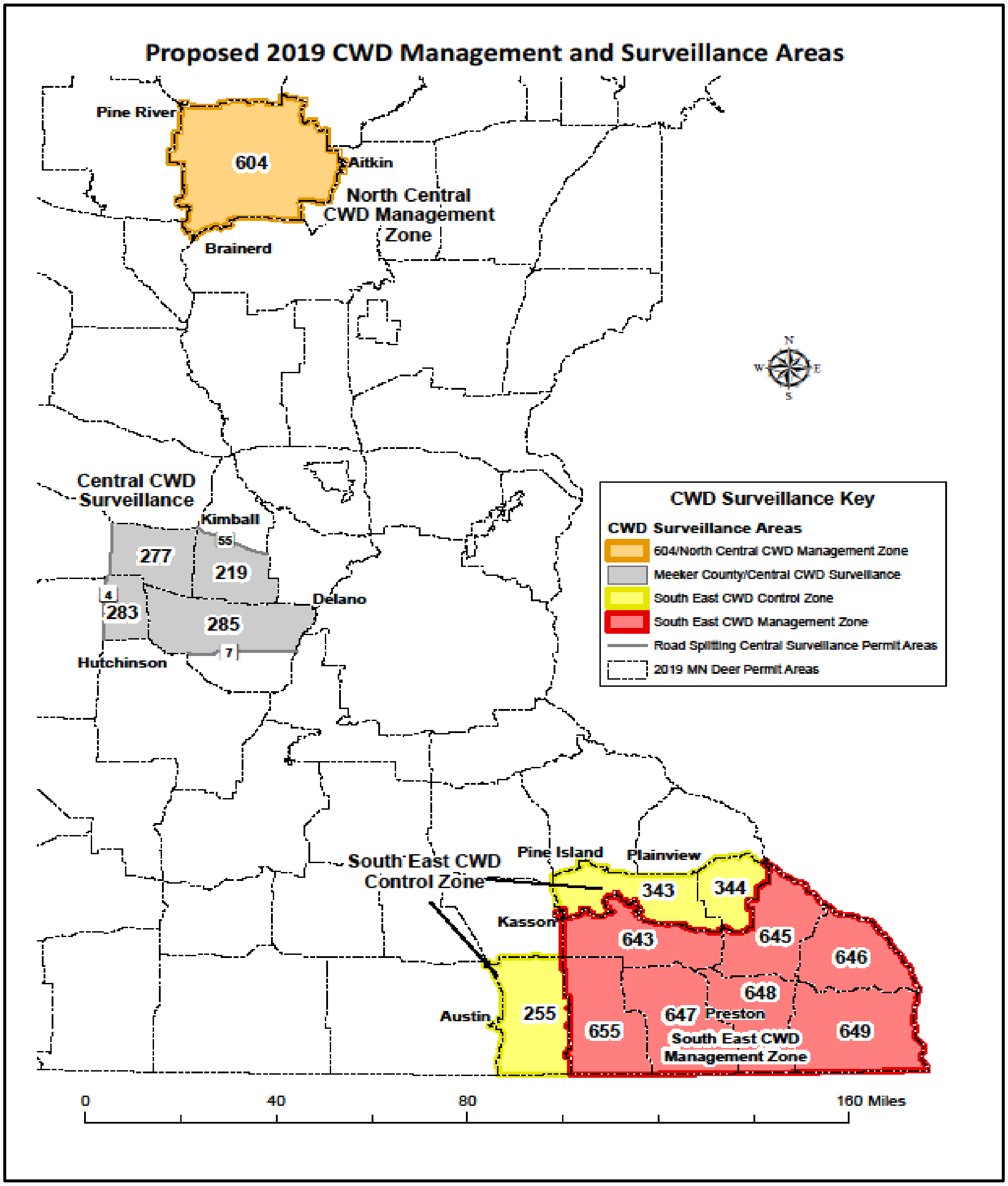


Figure 5. Changes to CWD Management and Surveillance areas for fall 2019. Deer Permit Area (DPA) 603 has been dissolved, and seven DPAs (643, 645, 646, 647, 648, 649, and 655) have been re-designated as the South East CWD Management Zone (red shaded area). Surrounding this management zone, there are three newly designated DPAs (255, 343, and 344) as the South East CWD Control Zone (yellow shaded area). These zones were established to liberalize harvest regulations and increase harvest of CWD positive deer, reduce overall deer density, and reduce the likelihood of disease spread across the landscape. In Meeker County centered on the captive cervid farm that was linked to the Crow Wing County CWD-positive captive cervid farm, is the Central CWD Surveillance Zone (DPAs 219, 277, 283, and 285). In Crow Wing County, the North Central CWD Management Zone was newly created surrounding the detection of a CWD-positive wild deer close to the location of the CWD-positive captive cervid farm.

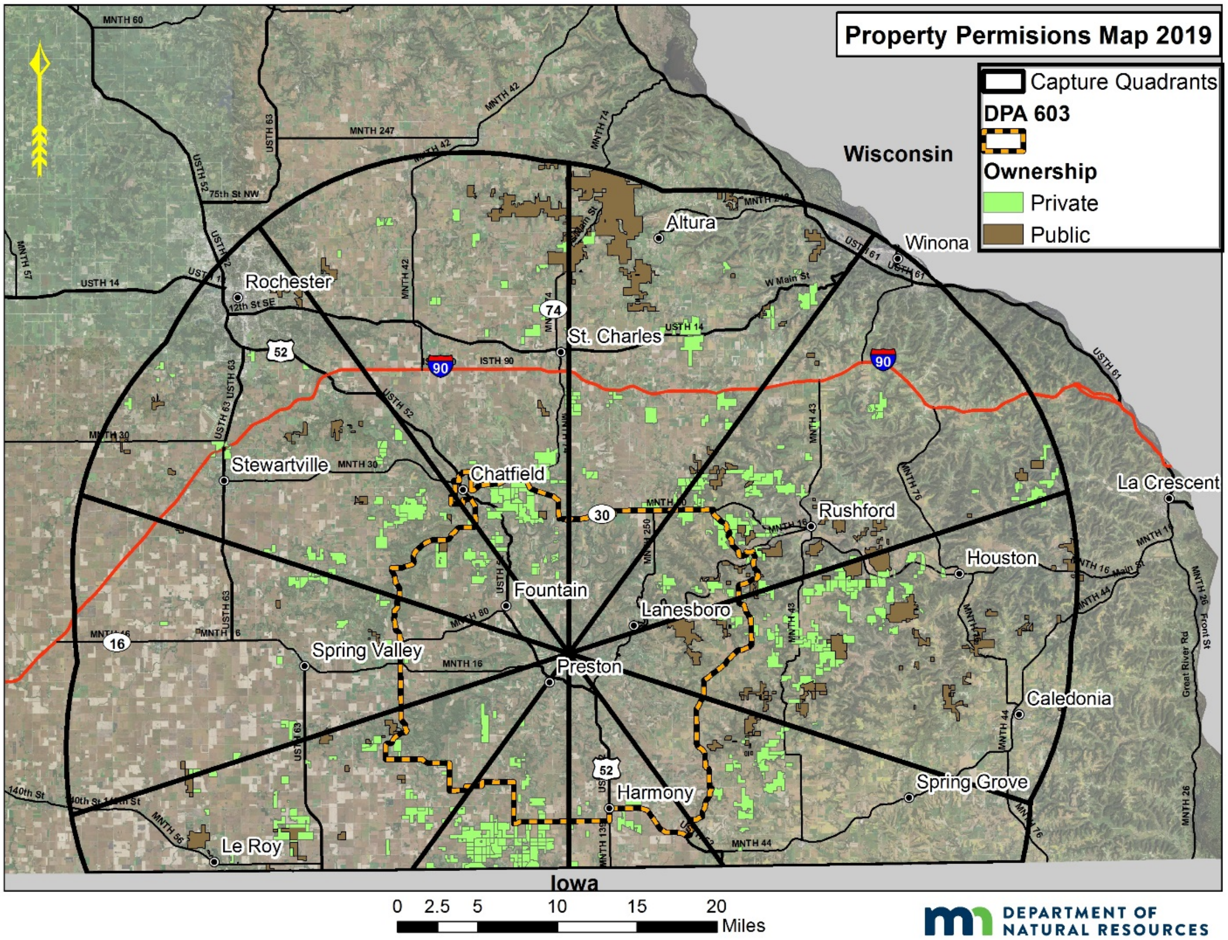


Figure 6. Spatial distribution of study area capture quadrants to be used as a basis for establishing the January/February 2020 deer capture goals in southeastern Minnesota. The target optimal capture distribution will be 4-5 female and 4-5 male white-tailed deer fawns captured per quadrant. We secured permissions to access 115,259 acres of property for 2019 captures, consisting of private (72,398 ac) and public (42,861ac) lands – over 180 mi^2 and plan to inquire with additional landowners to increase the available capture area.

X. RESEARCH ADDENDUM

Literature Cited

Avgar, T., R. Subhash, J. Lele, L. Keim, and M. S. Boyce. 2017. Relative selection strength: quantifying

Effect size in habitat- and step-selection inference. Ecology and Evolution 14: 5322–30.

https://doi.org/10.1002/ece3.3122.

Brinkman, T. J., J. A. Jenks, C. S. DePerno, B. S. Haroldson, and R. G. Osborn. 2004. Survival of white-tailed deer in an intensively farmed region of Minnesota. Wildlife Society Bulletin 32:726–731.

Brinkman, T. J., C. S. DePerno, J. A. Jenks, B. S. Haroldson, and R. G. Osborn. 2005. Movement of female white-tailed deer: Effects of climate and intensive row-crop agriculture. Journal of Wildlife Management 69:1099-1111.

DelGiudice, G. D., J. Fieberg, M. R. Riggs, M. Carstensen Powell, and W. Pan. 2006. A long-term age-specific survival analysis of female white-tailed deer. Journal of Wildlife Management 70:1556-1568.

Grear, D. A., M. D. Samuel, J. A. Langenberg, and D. Keane. 2006. Demographic patterns and harvest vulnerability of chronic wasting disease infected white-tailed deer in Wisconsin. Journal of Wildlife Management 70:546-553.

Grovenburg, T. W., C. N. Jacques, C. S. DePerno, R. W. Klaver, and J. A. Jenks. 2011. Female white-tailed deer survival across ecoregions in Minnesota and South Dakota. American Midland Naturalist 165:426-435.

Jacques, C. N., T. R. Van Deelen, W. H. Hall Jr., K. J. Martin, and K. C. VerCauteren. 2011. Evaluating how hunters see and react to telemetry collars on white-tailed deer. Journal of Wildlife Management 75: 221-231.

Kernohan, B. J., J. A. Jenks, and D. E. Naugle. 1994. Movement patterns of white-tailed deer at Sand Lake National Wildlife Refuge, South Dakota. Prairie Naturalist 26:293–300.

Krebs, N. New Wisconsin study reveals data on deer mortality. Outdoor Life. Accessed on 6/17/20.

https://www.outdoorlife.com/blogs/newshound/2014/01/new-wisconsin-study-reveals-data-deer-mortality/.

Lutz, C. L., D. R. Diefenbach, and C. S. Rosenberry. 2015. Population density influences dispersal in female white-tailed deer. Journal of Mammalogy 96:494-501.

Magle, S. B., L. H. Kardash, A Oyer Rothrock, J. C. Chamberlin, and N. E. Mathews. 2015. Movements and habitat interactions of white-tailed deer: implications for chronic wasting disease management. The American Midland Naturalist 173: 267–82. https://doi.org/10.1674/amid-173-02-267-282.1.

McCullough, D. R. 1979. The George Reserve Deer Herd: Population Ecology of a K Selected Species. Ann Arbor, MI: University of Michigan.

Nixon, C. M., L. P. Hansen, P. A. Brewer, J. E. Chelsvig, J. B. Sullivan, T. L. Esker, R. Korkenmeier, D. R. Etter, J. Cline, J. A. Thomas. 1994. Behavior, dispersal and survival of male white-tailed deer in Illinois. Illinois Natural History Survey Biological Notes 139.

Nixon, C. M., P. C. Mankin, D. R. Etter, L. P. Hansen, P. A. Brewer, J. E. Chelsvig, T. L. Esker, and J. B. Sullivan. 2007. White-tailed deer dispersal behavior in an agricultural environment. American Midland Naturalist 157: 212-220.

Oyer, A. M., N. E. Mathews, and L. H. Skuldt. 2007. Long distance movement of a white-tailed deer away form a chronic wasting disease area. Journal of Wildlife Management 71:1635-1638.

Roseberry, J. L., and W. D. Klimstra. 1974. Differential vulnerability during a controlled deer harvest. Journal of Wildlife Management 38: 499-507.

Simon, D. E. 1986. Density, migration, and mortality patterns of white-tailed deer using a sanctuary in southeastern Minnesota. M. S. thesis. University of Minnesota. 66 pages.

VerCauteren, K., and S. E. Hygnstrom. 2011. Managing white-tailed deer: Midwest North America. In Biology and Management of White-tailed Deer (ed. D. G. Hewitt). CRC Press, Boca Raton.

Walter, W. D., K. C. VerCauteren, H. Campa, III, W. R. Clark, J. W. Fischer, S. E. Hygnstrom, N. E. Mathews, C. K. Nielsen, E. M. Schauber, T. R. Van Deelen, and S. R. Winterstein. 2009. Regional assessment on influence of landscape configuration and connectivity on range size of white-tailed deer. Landscape Ecology 24: 1405−1420.

Walter, W. D., S. E. Tyler, D. Stainbrook, B. D. Wallingford, C. S. Rosenberry, and D. R. Diefenbach. 2018. Heterogeneity of a landscape influences size of home range in a North American cervid. Scientific Reports 8: 14667. https://doi.org/10.1038/s41598-018-32937-7.

Warbington, C. H., T. R. Van Deelen, A. S. Norton, J. L. Stenglein, D. J. Storm, and K. J. Martin. 2017. Cause-specific neonatal mortality of white-tailed deer in Wisconsin, USA. Journal of Wildlife Management 81:824-833.

Environment and Natural Resources Trust Fund
M.L. 2017 Final Project Budget

Project Title: Deer movement related to potential CWD prion transmission
Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 10 - Emerging Issues Account as extended M. L. 2017, Chap. 96, Sec. 2, Subd. 18 as extended M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 20 as extended by M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2,
Project Manager: Christopher S. Jennelle
Organization: Minnesota Department of Natural Resources
M.L. 2017 ENRTF Appropriation: $ 449,557
Project Length and Completion Date: 2.75 years, June 30, 2020
Date of Report: October 06, 2020

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget 08/15/2020	Amount Spent 08/15/2020	Balance 08/15/2020	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM				*CWD spatial pathways mapping*			*Determination of cause-specific mortality*				
Professional/Technical/Service Contracts											
Hells Canyon Helicopters Inc.: contract with a wildlife helicopter capture company for capturing and collaring deer. This includes hangar rental during capture operations.	$ 61,410	$ 61,410	$ -							$61,410	$0
MNDNR Law Enforcement: Hourly rate for DNR law enforcement fixed-wing craft and pilot to spot prospective deer herds for capture and ensure adherence to study design. This includes hangar rental during operations and periodic aerial surveys to monitor VHF signals from collared deer.	$ 7,963	$ 7,963	$ -							$7,963	$0
Lotek Wireless Inc.: contract with a GPS data collection and reporting service – this was combined as a package deal with a GPS collar vendor	$ 49,594	$ 49,594	$ 0.12							$49,594	$0.12
Equipment/Tools/Supplies											
GPS collars to be placed on white-tailed and any shipping costs associated with collars.	$ 272,829	$ 272,829	$ -							$272,829	$0
Capture crew travel expenses in Minnesota											
Mileage and meals for up to 3 staff members and 3 vehicles over the course of-deer capture periods.	$ 5,888	$ 5,888	$ -							$5,888	$0
Personnel											
50% FTE Natural Resource Specialist 1	$ 31,163	$ 31,163	$ -							$31,163	$0
Expenses (includes vehicle expense of $0.55/mile at 154.8 miles/week for 134.33 weeks), field supplies, food allowance ($36 once every 2.48 weeks), and lodging ($75/night for 1 night stay every 4.96 weeks)	$ 16,418	$ 16,418	$ -							$16,418	$0
Other											
Direct and necessary costs: HR Support (~$588), Safety Support (~$135), Financial Support (~$8), Communications Support (~$1,271), IT Support (~$1,217), and Planning Support (~$1,072) necessary to accomplish funded programs/projects	$ 4,291	$ 4,291	$ -							$4,291	$0
COLUMN TOTAL	**$ 449,556**	**$ 449,556**	**$ 0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$449,556**	**$0**