Role of predators, winter weather, and habitat on white-tailed deer fawn survival in the south-central Upper Peninsula of Michigan

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Abstract We captured 125 (42 male, 83 female) individual white-tailed deer (*Odocoileus virginianus*), including 51 adults, 9 yearlings, and 65 fawns. We radio-collared 48 female deer and VIT tagged 47 female deer. We detected pregnancy with ultrasound in 98% of adult (n = 46) and 75% of yearling (n = 4) females. We captured and radio-collared 34 neonate fawns (18 male, 15 female, 1 unknown sex). Eighteen of 28 (64%) vaginal implant transmitter searches resulted in the location of 19 live and 3 stillborn fawns. We obtained 8,438 adult female deer GPS locations, and monitored fawn survival via VHF telemetry. We observed 10 radio-collared adult female white-tailed deer mortalities and 11 mortalities of radio-collared fawns born during 2017. To estimate deer abundance, we placed 52 remote infrared cameras throughout the study area at baited sites and obtained 13,225 images including 5,559 observations of deer (3,828 adult females, 614 adult males, 892 fawns, and 225 unidentified deer). We placed 52 remote infrared cameras at non-baited sites along trails throughout the study area to evaluate the effectiveness of a non-baited deer camera abundance estimate. We immobilized 9 adult black bears (*Ursus americanus*; 5 male, 4 female) in their dens and observed 7 cubs (4 male, 3 female) from 3 females. From May to July we captured and immobilized 17 black bears (*Ursus americanus;* 14 male, 3 female), 2 coyotes (*Canis latrans*; 1 male, 1 female), 2 bobcats (*Lynx rufus*; 1 male, 1 female), and 7 wolves (*C*. spp.; 6 male, 1 female) and either fitted them with GPS or VHF collars. We collected 466 hair samples and > 191,700 images from bobcat hair snares and remote cameras, respectively. We collected 802 hair samples and 2,927 images from black bear hair snares and remote cameras, respectively. During howl surveys we recorded an average coyote response rate (RR) of 13.3% and wolf RR of 2.0% through 6 of 8 total surveys. We conducted investigations at 513 carnivore cluster sites to identify carnivore prey sources and opportunistically collected 239 scats from black bear, bobcat, coyote, and wolf. We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimate grouse abundance and had a 43.6% average detection rate across surveys. We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 456 random locations stratified within 5 different land cover types to estimate hare densities with respect to available land cover. To provide an index of beaver (*Castor canadensis*) abundance, we conducted aerial surveys and detected 61 inactive lodges, 78 active lodges with a cache present, and 7 caches with no sign of a lodge. Project data was published in 2 refereed manuscripts in the Canadian Journal of Zoology and Thrombosis Research. Throughout the year, we hosted many volunteers from various organizations and two photographers/videographers, gave 35 presentations, hosted 3 workshops, and kept our Facebook page (www.Facebook.com/MIpredprey) and website current with project results.

Summary

- We captured 125 deer (83 female, 42 male) individual white-tailed deer (*Odocoileus virginianus*), including 51 adults, 9 yearlings, and 65 fawns.

- We fitted 48 pregnant female deer with a GPS collar and 47 with a VIT.

- We detected pregnancy with ultrasound in 98% of adult (*n* = 45) and 75% of yearling (*n* = 4) females.

- We captured and radio-collared 34 neonate fawns (18 male, 15 female, 1 unknown sex).

- 18 of 28 (64%) vaginal implant transmitter searches resulted in the location of 19 live and 3 stillborn fawns.

- We obtained 8,438 radiolocations of adult female white-tailed deer.

- We observed 10 dead radio-collared adult female white-tailed deer. We attributed 4 mortalities to wolf predation, 1 to unidentified predation, 1 to starvation, 1 to vehicle collision. We censored two mortalities from the study sample because they occurred within 14 days of capture. We observed one mortality in which the cause of death could not be determined from evidence at the carcass site, which is pending a lab necropsy.

- We observed 11 mortalities of fawns born during May-June, 2017. We attributed 6 mortalities to predation: 2 black bear, 2 coyote, 1 wolf and 1 unidentified predator. We observed 1 mortality due to neonatal orphaning as a result of a vehicle collision, and 4 unidentified cause mortalities which are pending lab necropsy. Additionally, we censored four fawns from the study sample after their radio-collars appeared to have fallen off.

- We placed 52 remote infrared cameras throughout the study area to estimate deer abundance and obtained. We obtained 13,225 images including 5,559 observations of deer (3,828 adult females, 614 adult males, 892 fawns, and 229 unidentified deer).

- We placed 52 remote infrared cameras at non-baited sites along trails throughout the study area as a trial method to estimate deer abundance. This survey is ongoing as of 15 September 2017.

- We immobilized 9 adult black bear (*Ursus americanus*; 5 male, 4 female) in their dens and observed 7 cubs (4 male, 3 female) from 3 females.

- We set 10 cage traps to capture bobcats (*Lynx rufus*). We captured 2 bobcats which we GPS collared.

- We captured and immobilized 17 adult black bear (14 male, 3 female) using barrel traps. We fitted 9 bears with a GPS collars and the remaining 8 bears with VHF radio-collars.

- We set padded foothold traps along roadways to capture coyotes and wolves. We captured 2 coyotes and 7 wolves and fitted each with a GPS collar.

- We deployed hair snares and remote cameras at 52 sites throughout the study area to estimate bobcat abundance. We obtained 466 hair samples and > 191,700 images.

- We deployed hair snares and remote infrared cameras at 52 sites throughout the study area to estimate black bear abundance and obtained 802 samples of black bear hair.

- We obtained a coyote response rate (RR) of 13% and wolf RR of 2% to broadcasted recordings of coyote group-yip-howls during after 6 of 8 surveys.

- We conducted investigations at 513 carnivore cluster sites to identify carnivore prey.

- We opportunistically collected 239 scats from black bear, bobcat, coyote, and wolf.

- We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimated grouse abundance. On average, grouse response rate was 43.6% across surveys.

- We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 456 random locations stratified within 5 land covers to estimate hare densities.

- We conducted a beaver (*Castor canadensis*) cache survey to estimate beaver abundance within the study area. We flew 578 km of river and lakeshore and detected 78 active beaver caches.

- We hosted individuals from Michigan Department of Natural Resources, Michigan State University, Michigan Technological University, Purdue University, and members of the Safari Club International Michigan Involvement Committee during black bear den checks. We hosted production crews of Discovering Michigan and Michigan Out-of-Doors who took photos and video footage of project staff performing field duties featured in three television specials.

- We updated our Facebook page (www.Facebook.com/MIpredprey) to provide the public with project results.

- We hosted students from Purdue University and Michigan Technological University for demonstrations of detection dogs, field techniques and presentations.

- We hosted educators from Michigan Department of Natural Resources' Academy of Natural Resources-North for demonstrations of detection dogs, field techniques and presentations.

- We gave presentations to 35 different groups or organizations (including school groups) about ongoing project activities and findings.

- During January–March 2017 we hired and employed 5 new technicians and 2 technicians from 2016 fall season stayed with the project. During May-August 2017 we hired and employed 7 new technicians. We hired 2 technicians to assist with fall project activities for September-December 2017.

Introduction

Management of wildlife is based on an understanding, and in some cases, manipulation of factors that limit wildlife populations. Wildlife managers sometimes manipulate the effect of a limiting factor to allow a wildlife population to increase or decrease. White-tailed deer (*Odocoileus virginianus*) are an important wildlife species in North America providing many ecological, social, and economic values. Most generally, factors that can limit deer numbers include food supply, winter cover, disease, predation, weather, and hunter harvest. Deer numbers change with changes in these limiting factors.

White-tailed deer provide food, sport, income, and viewing opportunities to millions of Americans throughout the United States and are among the most visible and ecologically–important wildlife species in North America. They occur throughout Michigan at various densities, based on geographical region and habitat type. Michigan spans about 600 km from north to south. The importance of factors that limit deer populations vary along this latitudinal gradient. For example, winter severity and winter food availability have less impact on deer numbers in Lower Michigan than in Upper Michigan.

Quantifying the relative role of factors potentially limiting white-tailed deer recruitment and how the importance of these factors varies across this latitudinal gradient is critical for understanding deer demography and ensuring effective management strategies. Considerable research has demonstrated the effects of winter severity on white-tailed deer condition and survival (Ozoga and Gysel 1972, Moen 1976, DelGiudice et al. 2002). In addition, the importance of food supply and cover, particularly during winter, has been documented (Moen 1976, Taillon et al. 2006). Finally, the role of predation on white-tailed deer survival has received considerable attention (e.g., Ballard et al. 2001). However, few studies have simultaneously addressed the roles of limiting factors on white-tailed deer.

The overall goal of this project is to assess baseline reproductive parameters and the magnitude of cause-specific mortality and survival of white-tailed deer fawns, particularly mortality due to predation, in relation to other possible limiting mortality agents along a latitudinal gradient in Michigan. We will simultaneously assess effects of predation and winter severity and indirectly evaluate the influence of habitat conditions on fawn recruitment. Considering results from Lower Michigan (Pusateri Burroughs et al. 2006, Hiller 2007) as the southern extent of this gradient, we propose three additional study sites from south to north across Upper Michigan. Because of logistical and financial constraints, we propose to conduct work sequentially across these study areas. The following objectives are specific to the Upper Michigan study area but applicable to other study areas with varying predator suites.

Objectives

1. Estimate survival and cause-specific mortality of white-tailed deer fawns and does.

2. Estimate proportion of fawn mortality attributable to black bear (*Ursus americanus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), and wolf (*Canis* spp.).

3. Estimate number and age of fawns killed by a bear, coyote, bobcat, or wolf during summer.

4. Provide updated information on white-tailed deer pregnancy and fecundity rates.

5. Estimate annual and seasonal resource use (e.g., habitat) and home range of white-tailed deer.

6. Estimate if familiarity of an area to each predator species affects the likelihood of fawn predation.

7. Assess if estimated composite bear, coyote, bobcat, and wolf use of an area influences fawn predation rates.

8. Describe association between fawn birth site habitat characteristics and black bear, coyote, bobcat, or wolf habitat use.

9. Estimate seasonal resource use (e.g., habitat, prey) and home range size of black bear, coyote, bobcat and wolf.

Study Area

The third phase of this study spans about 1,550 km^2 (598 mi^2) within Deer Management Unit 031 in Baraga, Houghton, and Ontonagon counties (Figure 1). The general study area boundaries follow US Highways 41/141 on the east, State Highway M-38 on the north, US Highway 45/ State Highway M-26 on the west, and State Highway M-28 on the south. Dominant land covers are deciduous (35%), evergreen (23%), and mixed forests (21%). Road density is 0.62 km/km^2 with greater densities around several small towns on the study area boundary. The core study area, where we conducted most capture efforts and population surveys, encompasses National Forest Rd 16 and is almost exclusively within the Ottawa National Forest. The final study area will comprise a minimum convex polygon that includes the composite locations of all telemetered animals. We selected this study area because it occurs within the high-snowfall range, receiving >250 cm of snowfall annually (about 70 cm more snowfall annually than the Phase 2 study area near Crystal Falls, Figures 1–2).

Accomplishments

<u>Deer Trapping</u>

From 07 January 2017 to 23 March 2017 we captured white-tailed deer in Clover traps (Figure 2) to place radio-collars on pregnant females. We captured 125 unique deer (82 females, 42 males), with an additional 75 recaptures. Individuals captured included 47 adult females, 4 adult males, 5 yearling females, 4 yearling males, 30 female fawns, and 35 male fawns. The fawn:adult female ratio for winter captures in 2014–2015 was 1.39:1. For comparison, the fawn:adult female ratio was 1:1 for winter 2012–2013 captures, 0.27:1 for winter 2013–2014 captures, and 0.48 for winter 2014–2015 captures. We collected body condition scores (BCS) by palpation of fat deposits (scale: 1 [moribund]–5 [obese]) by two independent observers and attached ear tags (females = blue, males = yellow) to each deer. We also assessed pregnancy of yearling and adult females using ultrasonography.

We immobilized 51 female deer and fitted 48 with radio-collars (model vertex survey 1D, Vectronic Aerospace, Berlin, Germany). We fitted 47 pregnant females with a vaginal implant transmitter (VIT; model 3930, Advanced Telemetry Systems Inc., Isanti, MN). We monitored temperature, respiration, and heart rate as soon as practical after immobilization and at about 10-minute intervals thereafter until we administered a reversal drug. We estimated and recorded deer morphometrics and mid-rump fat depths (Table 1) when practical.

We detected pregnancy with ultrasound in 98% of adult females (n = 46), 75% of yearling females (n = 4), and 0% of fawns (n = 1). Estimated age of captured does using cementum annuli ranged from 1.7-16.7 years old, with a mean estimated age of 8.5 years (Figure 3).

Fawn Capture

Beginning mid-May we captured, radio-collared, and obtained radio-locations for white-tailed deer fawns. We captured 34 neonate fawns (17 male, 14 female, 1 unknown sex) and fitted them with expandable radio-collars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) during May–June. We attached 2 individually numbered plastic ear tags to fawns and attempted to collect fawn morphometrics (Table 2), blood, hair, and identify sex. We also recorded bed site and surrounding habitat, flush distance, presence of dam, additional deer sighted, and handling time.

Estimated parturition dates of captured fawns and VIT tagged does were 18 May–28 June, with a median parturition date of 2 June (Figure 4). Thirty-eight adult female deer fitted with vaginal implant transmitters (VITs) during Jan-Mar 2017 survived through June 2017. Two VITs and lost signal prior to parturition. Four VITs were expelled early with no evidence of a fawn birth. Two VITs were expelled in areas continuously exposed to direct sunlight which prevented temperature drop, so we were not able to detect births within 5 days to conduct a fawn search. Two VITs were expelled on private property for which access could not be obtained to search for fawns. Six adult females have not expelled their VIT as of 15 June. We conducted searches in the effort to find fawns of 28 implanted pregnant adult females. 18 of 28 (64%) VIT searches resulted in the location of ≥1 live or dead fawns (19 live fawns and 3 stillbirths). We also characterized vegetation and horizontal cover at known fawn birth sites. 15 fawns were captured through opportunistic encounters within the study area.

Deer Telemetry

We recorded 8,438 locations of GPS-collared adult female deer during 15 September 2017 to 15 September 2015. Thirty-nine GPS collared deer survived through the spring migration period, of which 35 (90%) migrated >3 km to their summer ranges. Mean straight-line migration distance from summer to winter range was 39.8 km (Figure 5). We monitored VHF fawn collars for survival status using ground-based telemetry daily from capture–15 July, at 48 hour intervals from 16 July–1 September, and twice per week from 1 September–15 September. For fawns located in areas too remote to monitor signals from truck, aerial telemetry was used to monitor survival status as often as possible, generally 2-3 times per week.

Deer Mortality

From 15 September 2016–15 September 2017, we recorded 10 adult female mortalities. We attributed 5mortalities to predation (4 wolf, 1 unidentified). Unidentified predations showed signs of predation (e.g., puncture wounds, hemorrhaging, evidence of struggle), but lacked species-specific sign (e.g., canine spacing, tracks, scat) or showed sign of multiple predator species. We censored two mortalities from the study sample because they occurred within 10 days of capture. We observed one mortality from starvation, one from vehicle collision, and one case in which the cause of death could not be determined from evidence at the carcass site.

We recorded 11 mortalities of neonate fawns born in May–July 2017, including 2 bear predations, 2 coyote predations, 1 wolf predation, 1 unidentified predation, 1 fawn orphaned within a week after birth by a vehicle collision, and 4 unidentified cause mortalities which are pending lab necropsies by a veterinary pathologist. We censored four fawns in which the collar appeared to have fallen off the animal. Excluding censors, 2017 fawn apparent survival from birth to 15 September was 63%.

Deer Camera Survey

We pre-baited fifty-two sites throughout the study area (Figure 6) with 7.5 *l* of whole kernel corn beginning 12 August and re-baited sites at 3-day intervals. The 10-day survey period started at pre-baited sites beginning 22 August on and ended by 3 September. We obtained 13,225 images including 5,559 observations of deer (3,828 adult females, 614 adult males, 892 fawns, and 225 unidentified deer). From camera images, we will estimate deer abundance/density for the 298 km^2 sampling area using an occupancy modeling approach (Duquette et al. 2014).

Additionally, a non-baited camera survey trial of 52 sites was conducted during July – September 2017 (Figure 6). Non-baited sites were placed a minimum of 1.2 km apart for site independence, and at least 500 m from the nearest baited site to minimize interference in deer movement from baited survey sites. Data collection is ongoing for this survey. We will compare non-baited results with baited survey results and assess the viability of a non-baited approach to estimating deer abundance.

Black Bear Den Checks

During 19 February 2017–3 March 2017 we immobilized 9 adult black bears (5 male, 4 female). We weighed, recorded morphometric measurements, and drew blood from each immobilized bear. We replaced VHF radio-collars or Global Positioning System (GPS) collars with new GPS collars on 8 previously collared adult black bears. One collar was removed and not replaced due the bear moving outside of the study area. We programmed the GPS collars to obtain a location every 35 h until 1 May and then every 15 min until 31 August with 35 h relocations resuming until we remove the collar in the den. We handled 7 cubs (4 male, 3 female) from 3 adult females; mean litter size was 2.3 (SD = 1.41; Table 3).

Bobcat Capture

We set cage traps (n = 10) to capture bobcats at previously baited bobcat hair snare sites during 6–25 May. We captured 1 female (7.2 kg) and 1 male (14.1 kg) bobcat. Once immobilized, we weighed, sexed, and collected morphometric measurements from bobcats. We collared bobcats collar that we programed to record 35 h locations until 1 May and then every 15 min until 31 August.

Coyote Cable Neck Restraints

We baited 8 locations with vehicle-killed deer carcasses to attract coyotes for capture. Due to unfavorable weather conditions (i.e., warm temperatures and lack of snow), we were unable to set cable restraints.

Spring/Summer Carnivore Capture

During 10- May–25 July, we captured 17 black bears (14 male, 3 female), 2 coyotes (1 male, 1 female), and 7 wolves (6 male, 1 female) using barrel traps and foothold traps. We immobilized captured individuals and recorded gender, weight, and affixed uniquely numbered ear tags (Figure 5; Table 4). We recorded morphometric measurements and collected blood and hair from each immobilized carnivore. We estimated body condition scores for each carnivore and estimated body condition of black bears using bioelectrical impedance analysis. We removed a vestigial premolar for age estimation in black bears. We fitted all bobcats, coyotes, and wolves with Lotek 7000SU global positioning system (GPS) radio-collars (Lotek Engineering, Newmarket, ON, Canada). Of the 17 captured bears, we fitted X bears with GPS radio-collars, and fitted X bear with VHF collars.

We programmed all 7000SU GPS radio-collars for bobcats, coyotes, and wolves to obtain a location every 35 hours until 1 May, every 15 minutes from 1 May–31 September and then every 35 hours until the scheduled collar drop-off date. We programmed all 7000MU GPS radio-collars, fitted on black bear, to obtain a location every 35 hours until 1 May and then every 15 minutes until we change their collars out in their dens. We fitted all 7000SU GPS radio-collars with a drop-off mechanism to release collars 25–35 weeks after deployment. We fit all radio-collars on black bears with a leather breakaway device in case bears disperse and we cannot relocate them.

Carnivore Monitoring

We recovered five GPS radio-collars during May-July 2017 after black bears collared during May–June 2017 slipped their collars. We recovered three VHF radio-collars during July-September 2016 after black bears collared during May–June 2016 slipped their collars. Eleven black bears (1 female, 10 male), radio-collared during May–July 2016, and four ear-tagged black bears (2 female, 2 male), previously captured in the Phase II study area, were harvested during the 2016 Michigan and Wisconsin black bear hunting seasons.

From 20 October 2016 to 15 January 2017, we located 9 black bears 15 times to follow their movements and confirm denning location. We located 9 bear dens (5 male, 4 female) during 1–15 January 2017.

Bobcat Hair Snares

We began baiting 52 bobcat hair snare sites (Figure 7) on 09 December 2016. After a two-week pre-bait period, we set 4 hair snares at each site beginning 05 January 2017. We also deployed a trail camera at each site, directed at the bait, to obtain images of all animals visiting the site.

We visited each bait site every 7 days to collect hair samples, reset snares, perform trail camera maintenance, and add bait as necessary. The eight-week survey was completed and we pulled snares during 02–08 March 2017.

We collected 466 hair samples (of both target and non-target species) which were sent to the MDNR Wildlife Disease Laboratory in Lansing for DNA extraction. We also obtained >191,700 camera images, including 6 observations of bobcat.

Black Bear Abundance Estimation: Hair Snares

During 27 May–21 July 2017 we conducted a hair snare survey to estimate black bear abundance. Hair snares (n = 52; Figure 8), erected during 2016, consist of a single strand of 4-pronged barbed wire placed around three or four trees to create an enclosure about 50 cm above ground. We baited snares by placing 0.5 L of fish oil on a pile of dead wood in the center of each enclosure and spraying anise oil on each of the trees 2 m above ground. We checked snares, added lure, and collected hair samples every ten days, for a total of five checks. We collected 802 hair samples. We sent these hair samples to the MDNR lab for DNA extraction and subsequent individual identification.

Coyote Howl Surveys

We completed 5 howl surveys at 40 sites (Figure 9) from 13 July to 24 September 2016. Surveys are on a 10 day rotation with each survey completed in 4 days, weather permitting. Through the end of the survey we obtained coyote and wolf response rates of 10% and 1.7%, respectively. We have completed 6 of 8 howl surveys at 40 sites which began on 13 July 2017. Currently, coyote and wolf response rates are 13% and 2% respectively.

We elicited vocalizations using a FoxPro game caller (FoxPro Inc., Lewistown, PA) using a group-yip howl to elicit coyote vocal response. At each survey site we recorded moon phase, cloud cover, wind speed, species responding, response time and direction, number of individuals responding, type of response (e.g., bark-howl, lone howl), and recordings of responses. We will estimate coyote abundance using an occupancy modeling approach (Petroelje et al. 2014).

Wolf Track Surveys

The Michigan Department of Natural Resource (DNR) conducted wolf track surveys for the 2017 population estimate during 2–20 February within the study area to identify the number of wolf packs and minimum number of individuals within each pack. Track surveys were informed by locations of 4 previously GPS collared individuals. Michigan DNR personnel identified a minimum of 31 individuals consisting of 6 packs whose territories include the study area: Baraga Plains (minimum 5 individuals), Frost Junction (minimum 4 individuals), Sidnaw-Kenton (minimum 7 individuals), Trout Creek (minimum 6 individuals), Prickett Dam (minimum 4 individuals), Gardner Road (minimum 5 individuals).

Carnivore Cluster Investigation

We used clusters of carnivore locations obtained from GPS radio-collars to identify potential kill sites and estimate the number of prey species killed. In 2017, we investigated 513 GPS cluster locations identified using ArcGIS and the statistical program R (R Development Core Team, Vienna, Austria). We defined a cluster as > 4 locations within 50 m of each other within a 24-hour period. Of the 513 clusters investigated this year, 147 were black bear (mean clusters/black bear = 18.4), 124 bobcat (mean clusters/bobcat = 62.0), 98 coyote (mean clusters/coyote = 49.0), and 144 wolf (mean clusters/wolf = 24.0).

Preliminary results from cluster investigations include black bears foraging on chokecherries (*Prunus virginiana*), raspberries (*Rubus ideaus*), blueberries (*Vaccinium* spp.), fawns, and various colonial insects (e.g., ants). We identified ruffed grouse (*Bonasa umbellus*), porcupine (*Erithizon dorsatum*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), and fawn predations at bobcat clusters sites. We identified predations of snowshoe hare (*Lepus americanus*), frog (*Rana* spp.), ruffed grouse, and fawn and adult deer at coyote clusters. We identified predations of beaver, and fawn and adult deer at wolf clusters. Analysis of cluster findings is ongoing.

Carnivore Scat Collection

We opportunistically collected 239 scats from black bear, bobcat, coyote, and wolf. We labeled collected scats with date, species, presence of tracks, diameter, and Universal Transverse Mercator (UTM) coordinates. We packaged all scats from the 2016 summer season for washing and drying preparation and future shipment to Mississippi State University's Carnivore Ecology Laboratory for identification of prey remains.

Ruffed Grouse Drumming Survey

We conducted ruffed grouse (*Bonasa umbellus*) drumming surveys during 29 April– 08 May. We conducted surveys from one half hour before sunrise to 5 hours after sunrise. Each survey contained 3 routes with 20–25 sites in each route for a total of 64 sites (Figure 10). Observers listened for 5 minutes at each site for drumming grouse and recorded number and bearing of each drumming grouse. We will use site occupancy to estimate male grouse density. Throughout the survey we heard drumming grouse at 43.6% of the sites on average resulting in an estimated density of 3.09 grouse/km^2.

Snowshoe Hare Pellet Counts

We conducted snowshoe hare (*Lepus americanus*) pellet counts during 24 April–25 May. We counted number of hare pellets within a 1 m^2 rectangle at 456 random sites. We separated pellet counts into 6 main land cover types (aspen [*Populus tremuloides*]), deciduous (excluding aspen), coniferous, mixed forest, woody wetland, and open herbaceous). We related hare pellet densities to hare abundance using a linear regression developed by McCann et al. (2008). Across land cover types estimated hare density was 5.26 hare/km^2.

Aerial Beaver Cache Survey

To provide an index of beaver abundance, we flew 578 km of river and lakeshore on 02-04 November 2016 to identify active beaver caches. We conducted flights at an altitude of 200-250 m. We detected 61 inactive lodges, 78 active lodges with a cache present, and 8 caches with no sign of a lodge (equates to one active cache for every 6.7 km flown; Figure 11).

Public Outreach

During black bear den checks and white-tailed deer trapping we hosted individuals from Michigan Department of Natural Resources (MDNR), Michigan State University, Michigan Technological University, Michigan Out-of-Doors, 906 Outdoors (Discovering), Safari Club International Michigan Involvement Committee and other interested members of the public. We participated in three TV shows who obtained images and video footage of project staff performing various field duties and will provide this media to Safari Club International Foundation to promote the project.

We attended several Sportsman's Coalition Meetings where we discussed the project with interested members of the public and tried to improve regional awareness of project goals and activities. We hosted 28 and 25 undergraduate students from Purdue University and Michigan Technological University, respectfully, on 2 June and 27 July for demonstrations of detection dogs, carnivore immobilizations, fawn capture, vegetation surveys, and deer telemetry. We presented at two Michigan Department of Natural Resources Wildlife Through Forestry Forums to inform members of the public about ongoing research in the area. We also gave presentations to 22 classes at local public schools, reaching over 500 students. We hosted 21 educators from Michigan Department of Natural Resources' Academy of Natural Resources-North for demonstrations of detection dogs, carnivore capture and telemetry.

We updated our project website (fwrc.msstate.edu/carnivore/predatorprey/) and Facebook page (www.Facebook.com/MIpredprey) to provide the public with project results.

Peer-reviewed publications:

Duquette, J.F., J.L. Belant, C.M. Wilton, N. Fowler, B.W. Waller, D.E. Beyer, Jr., N.J. Svoboda, S.L. Simek, J. Beringer. 2017. Black bear functional resource selection relative to intraspecific competition and human risk. Canadian Journal of Zoology 95:203-212.

Friedrich, A. U., J. Kakuturu, P. J. Schnorr, D. E. Beyer Jr, J. A. Palesty, E. W. Dickson, G. Basadonna, and M. A. Cahan. 2017. Comparative coagulation studies in hibernating and summer-active black bears (Ursus americanus). Thrombosis Research 158:16.

Presentations to hunting groups and service organizations:

Fowler, N., T.M. Kautz, A.L. Lutto, Z. Farley, J.L. Belant, D.E. Beyer, Jr. 8 September 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Escanaba Sportsmen's Club, Escanaba, MI. 20 attendees.

Lutto, A.L., N. Fowler, Z. Farley, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 19 October 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Ontonagon Ranger District Forest Service Office, Ontonagon, MI. 15 attendees.

Lutto, A.L., N. Fowler, T.M. Kautz, Z. Farley, J.L. Belant, D.E. Beyer, Jr. 4 November 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Peter White Library, Marquette, MI. 8 attendees.

Fowler, N., Z. Farley, A.L. Lutto, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 14 November 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Kenton Ranger District Forest Service Office, Kenton, MI. 2 attendees.

Lutto, A.L., Z. Farley, N. Fowler, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 14 November 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Michigan Technological University, Houghton, MI. 20 attendees.

Kautz, T., N. Fowler, A.L. Lutto, Z. Farley, J.L. Belant, D.E. Beyer Jr. 8 March 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Michigan Department of Natural Resources Wildlife Through Forestry Forum. Ewen, MI. 30 Attendees.

Kautz, T., N. Fowler, A.L. Lutto, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 22 March 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Michigan Department of Natural Resources Research Division, Marquette, MI. 18 attendees.

Lutto, A.L, E. Largent, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 24 March 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. MooseWood Nature Center, Marquette, MI. 13 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 18 April 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Baraga Area Schools Sixth Grade, Baraga, MI. 23 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 18 April 2017. Michigan Predator-Prey Project. Baraga Area Schools Kindergarten, Baraga, MI. 17 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 19 April 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Schools Agricultural Sciences Class, Crystal Falls, MI. 19 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 19 April 2017. Michigan Predator-Prey Project. Forest Park Schools Second Grade, Crystal Falls, MI. 22 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 19 April 2017. Michigan Predator-Prey Project. Forest Park Schools Third and Fourth Grades, Crystal Falls, MI. 21 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 19 April 2017. Michigan Predator-Prey Project. Forest Park Schools Kindergartens, Crystal Falls, MI. 31 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 19 April 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Schools Biology Class, Crystal Falls, MI. 27 attendees.

Lutto, A.L., Z. Farley, N. Fowler, T. Kautz, J.L. Belant, and D.E. Beyer, Jr. 20 April 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Calumet-Keweenaw Sportsmens Club, Copper City, MI. 38 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 21 April 2017. Michigan Predator-Prey Project. Forest Park Schools First Grades, Crystal Falls, MI. 49 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 21 April 2017. Michigan Predator-Prey Project. Forest Park Schools Fourth Grade, Crystal Falls, MI. 21 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 21 April 2017. Michigan Predator-Prey Project. Forest Park Schools Third Grade, Crystal Falls, MI. 23 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 21 April 2017. Michigan Predator-Prey Project. Forest Park Schools Fifth Grade, Crystal Falls, MI. 1921 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 21 April 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Schools Seventh Grade, Crystal Falls, MI. 21 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 25 April 2017. Michigan Predator-Prey Project. West Iron County Schools Kindergarten, Iron River, MI. 16 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 25 April 2017. Michigan Predator-Prey Project. West Iron County Schools Kindergarten, Iron River, MI. 15 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 25 April 2017. Michigan Predator-Prey Project. West Iron County Schools Third Grade, Iron River, MI. 26 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 25 April 2017. Michigan Predator-Prey Project. West Iron County Schools Kindergarten, Iron River, MI. 18 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 25 April 2017. Michigan Predator-Prey Project. West Iron County Schools Fourth and Fifth Grades, Iron River, MI. 19 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 26 April 2017. Michigan Predator-Prey Project. West Iron County Schools Second Grade, Iron River, MI. 22 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 26 April 2017. Michigan Predator-Prey Project. West Iron County Schools First Grades, Iron River, MI. 48 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 26 April 2017. Michigan Predator-Prey Project. West Iron County Schools Second Grades, Iron River, MI. 47 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 26 April 2017. Michigan Predator-Prey Project. West Iron County Schools First Grade, Iron River, MI. 24 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 26 April 2017. Michigan Predator-Prey Project. West Iron County Schools Third Grade, Iron River, MI. 21 attendees.

Kautz, T., N. Fowler, A.L. Lutto, Z. Farley, J.L. Belant, D.E. Beyer Jr. 8 May 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Michigan Department of Natural Resources Wildlife Through Forestry Forum. Pelkie, MI. 42 Attendees.

Fowler, N., A.L. Lutto, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 2 June 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Purdue Wildlife Ecology Field Class, Silver Mountain, MI. 28 attendees.

Lutto, A.L, N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 27 July 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Michigan Technological University Field Class, Silver Mountain Field Station, MI. 25 attendees.

Lutto, A.L., Z. Farley, N. Fowler, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 10 August 2017. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Ford Center, Alberta, MI. 21 attendees.

Seminars and Workshops:

Lutto, A.L., N. Fowler, A.L. Lutto, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 2 June 2017. Field techniques for wildlife capture and predation investigation. Purdue Wildlife Ecology Field Class, Silver Mountain Field Station, Pelkie, MI. 28 attendees.

Lutto, A.L., N. Fowler, T. Kautz, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 27 July 2017. Field techniques for wildlife capture and predation investigation. Michigan Technological University Field Class, Silver Mountain Field Station, Pelkie, MI. 25 attendees.

Lutto, A.L., Z. Farley, N. Fowler, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 10 August 2017. Field techniques for Michigan Predator-Prey Project. Silver Mountain Field Station, Pelkie, MI. 21 attendees.

News Broadcast:

TV 6. March 2017. "First of four 'Wildlife through Forestry' forums held" http://www.uppermichiganssource.com/content/news/First-of-four-Wildlife-through-Forestry-forums-held--415818203.html

TV 6. March 2017. "DNR wildlife forum will look at Predator-Prey Project" http://www.uppermichiganssource.com/content/news/DNR-wildlife-forum-will-look-at-Predator-Prey-Project-415152823.html

Keweenaw Report. May 2017. Preliminary results of region's predator-prey study to be detailed http://www.keweenawreport.com/news/local-news/preliminary-results-regions-predator-prey-study-detailed/

Outdoor shows:

Michigan Out of Doors Television
Den Check
906 Outdoors Discovering
Part 1
Part 2

Popular Media:

Safari Club International Foundation – Conservation. Nov 2016. "The Michigan Predator-Prey Story" https://firstforwildlife.com/2016/11/08/the-michigan-predator-prey-story/

State of Michigan. Feb 2017. "DNR to offer first in 'Wildlife Through Forestry' forums in western UP https://www.michigan.gov/som/0,4669,7-192-26847-405628--,00.html

Technician Hiring

During January-March 2017 and May-August 2017 we hired and employed 7 technicians for each season. We hired and employed 2 technicians for September-December 2017. One technician from the summer will continue to work through the fall.

Work to be completed (September–December 2017)

White-tailed Deer Monitoring

We will use radio and aerial telemetry to locate collared does and fawns weekly. We will also investigate mortalities as soon as practical after detecting a mortality signal to determine cause of death.

Carnivore Monitoring and GPS Radio-collar Recovery

We will continue to monitor collared carnivores twice monthly until drop-off mechanisms detach for bobcats, coyotes, and wolves. We will recover the dropped radio-collars and download location and activity data. We will clear recovered collars of data, clean them, and store or send them back to the manufacturer for refurbishment. We will monitor black bears until dens are located in early to mid-November.

Black Bear Den Checks

We will locate and mark black bear dens in late-November before heavy snow fall and conduct black bear den checks beginning in mid-December to change GPS collar batteries on collared male black bear.

Aerial Beaver Cache Survey

Starting around 15 October, after leaf-off, we will conduct an annual aerial beaver cache survey. We will fly along rivers, streams, lakes, and other hydrology to locate and mark active beaver caches as an index to beaver abundance.

Equipment Organization, Inventory, and Storage

We will inventory, organize, repair, and store all summer field equipment and repair and store all project ATVs. We will prepare deer and bobcat traps for winter trapping, as well as bobcat hair snares. Additionally, we will begin washing and drying scat collected from the summer to send to Mississippi State University's Carnivore Ecology Laboratory for identification of prey remains.

Public Outreach

We will continue to update our project Facebook page (http://www.facebook.com/MIpredprey) and web site (http://fwrc.msstate.edu/carnivore/predatorprey/) with project results.

Acknowledgements

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Mississippi State University; College of Forest Resources; Department of Wildlife, Fisheries, and Aquaculture; and Forest and Wildlife Research Center
Plum Creek Timber Company

Ontonagon Sportsman Club
Jared Duquette, Graduate Student (Phase 1), Mississippi State University
Nathan Svoboda, Graduate Student (Phase 1), Mississippi State University
Cody Norton, Graduate Student (Phase 2), Northern Michigan University
Tyler Petroelje, Graduate Student (Phase 1 & 2), Mississippi State University

Phase 3 – Project Technicians:
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Sofia Ziemienski
Brendan Popp
Courtney Dotterweich
Emily Monfort
Morgan Oberly
Sara Harrington
Mark Jackson
Brandon Bernhardt
Gregory Robertson
Emma Doden
Jessica Beach
Braiden Quinlan
Steve Gurney
Kristina Kennedy
Megan Petersohn
DJ Steakley
Ben Murley
Kathryn Sliwa

Visiting Researcher from the United Kingdom: Lizzie Croose

Phase 2 – Project Technicians:
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Tanya Wolf
Elizabeth Robbe
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Brian Kidder
Caleb Eckloff
Polly Chen
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Annie Washakowski
Ty Frank
Jessie Roughgarden
Daniel Tomasetti
Evan Shields
Ben Matykiewicz
Anne Patterson
Phillip Lyons
David Rogers
Logan Thompson
Kelly Deweesee
Alyssa Roddy
Steffen Peterson
Kris Harmon
Peter Mumford
Greta Schmidt
Abbi Hirschy
Sara Wendt
Chris Boyce
Jake Boone
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Sara Harrington
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Garret Price
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Mark Mylchrest, MDNR
Caitlin Ott-Conn, MDNR
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Table 1. Mean ($\bar{x}$) and standard deviation (SD) of 51 captured adult (*n* = 46) and yearling (*n* = 5) female white-tailed deer morphometrics and body condition estimates, Upper Peninsula of Michigan, USA, January–March 2017.

	Age Class			
	Adults		Yearlings	
Metric	$\bar{x}$	SD	$\bar{x}$	SD
Body weight (kg)	68.7	5.6	54.9	2.5
BCS[1]	3.0	0.5	2.5	0.9
MIDF[2] (cm)	0.71	0.5	0.44	0.3

[1] Body Condition Score (BCS) for does derived from palpation following Cook et al. (2010).

[2] Middle rump fat (MIDF) estimate measured at mid-point between ilium and ischial tuberosity on right hip (Cook et al. 2007).

Table 2. Mean ($\bar{x}$) and standard deviation (SD) of 33 captured female (n = 15) and male (n = 18) neonate fawn morphometrics, Upper Peninsula of Michigan, USA, 24 May–28 June 2017.

	Sex	
	Female	Male
Estimate	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Body Weight (kg)	4.1 ± 1.5	4.8 ± 1.1
Body Length (cm)	61.1 ± 5.8	62.1 ± 4.7
Chest Girth (cm)	36.1 ± 3.8	36.7 ± 3.2
Hind Foot (cm)	26.1 ± 2.4	26.7 ± 1.3
Shoulder Height (cm)	45.7 ± 4.9	46.7 ± 3.7
New Hoof Growth (mm)	3.5 ± 0.8	3.3 ± 1.2
Birth Mass (kg)[1]	2.9 ± 0.9	3.9 ± 1.1

[1] Birth masses of fawns with unknown parturition dates estimated by assuming an average daily mass gain of 0.2 kg since birth (Verme and Ullrey 1984, Carstensen et al. 2009).

Table 3. Den Check data for 16 black bears, Upper Peninsula of Michigan, USA, 19 Feb- 03 March 2017.

ID	Den check date	Age	Sex	Body weight (kg)	Right ear tag	Left ear tag
BB321	19-Feb	Adult	M	85.7	443	464
BB303	21-Feb	Adult	M	87.0	450	332
BB309	22-Feb	Adult	M	85.0	387	331
BB316	24-Feb	Adult	M	56.8	474	475
BB313	26-Feb	Adult	F	49.5	381	382
BB317	27-Feb	Adult	F	67.0	383	398
BB324	27-Feb	Cub of BB317	M	2.7	NA	NA
BB302	28-Feb	Adult	F	95.9	328	329
BB325	28-Feb	Cub of BB302	M	1.5	NA	NA
BB326	28-Feb	Cub of BB302	M	1.4	NA	NA
BB327	28-Feb	Cub of BB302	F	1.7	NA	NA
BB307	1-Mar	Adult	F	87.2	399	400
BB328	1-Mar	Cub of BB307	F	1.4	NA	NA
BB329	1-Mar	Cub of BB307	F	1.6	NA	NA
BB330	1-Mar	Cub of BB3017	M	1.8	NA	NA
BB300	3-Mar	Adult	M	NA*	341	340

*Unable to weigh bear due to shallow depth of immobilization

Table 4. Carnivore capture data, Upper Peninsula of Michigan, USA, 7 March–28 June 2015.

Species	ID	Capture date	Sex	Body weight (kg)	Right ear tag	Left ear tag
Bobcat	BC300	10-May-17	M	14.1	374	373
Bobcat	BC301	10-May-17	F	7.2	NA*	375
Wolf	WO301	10-May-17	M	31.2	1215	1216
Wolf	WO302	11-May-17	M	NA**	1218	1217
Wolf	WO303	19-May-17	M	34.4	1221	NA*
Wolf	WO304	24-May-17	M	33.5	1207	1208
Wolf	WO305	25-May-17	M	21.1	1115	1206
Wolf	WO306	29-May-17	M	36.0	573	600
Wolf	WO307	2-Jun-17	F	21.5	1201	1202
Coyote	CO300	29-May-17	M	15.6	369	462
Coyote	CO301	5-Jun-17	F	11.7	364	363
Black Bear	BB310	6-Jul-17	M	87.0	392	442
Black Bear	BB321	29-Jun-17	M	80.0	443	464
Black Bear	BB331	8-Jun-17	M	147.9	431	371
Black Bear	BB332	13-Jun-17	M	134.8	426	NA*
Black Bear	BB333	20-Jun-17	M	47.5	365	367
Black Bear	BB334	20-Jun-17	M	47.0	448	397
Black Bear	BB335	20-Jun-17	F	73.7	429	428
Black Bear	BB336	20-Jun-17	M	131.7	430	432
Black Bear	BB337	25-Jun-17	M	40.1	446	447
Black Bear	BB338	25-Jun-17	M	113.6	445	444
Black Bear	BB339	29-Jun-17	F	54.3	438	439
Black Bear	BB340	3-Jul-17	M	38.8	437	436
Black Bear	BB341	7-Jul-17	M	49.8	433	461
Black Bear	BB342	9-Jul-17	M	60.1	366	427
Black Bear	BB343	15-Jul-17	F	54.0	454	455
Black Bear	BB344	17-Jul-17	M	158.3	434	323
Black Bear	BB345	20-Jul-17	M	61.3	459	460

NA*= Did not ear tag due to old ear injury unrelated to capture

NA**= Unable to weigh wolf to shallow depth of immobilization

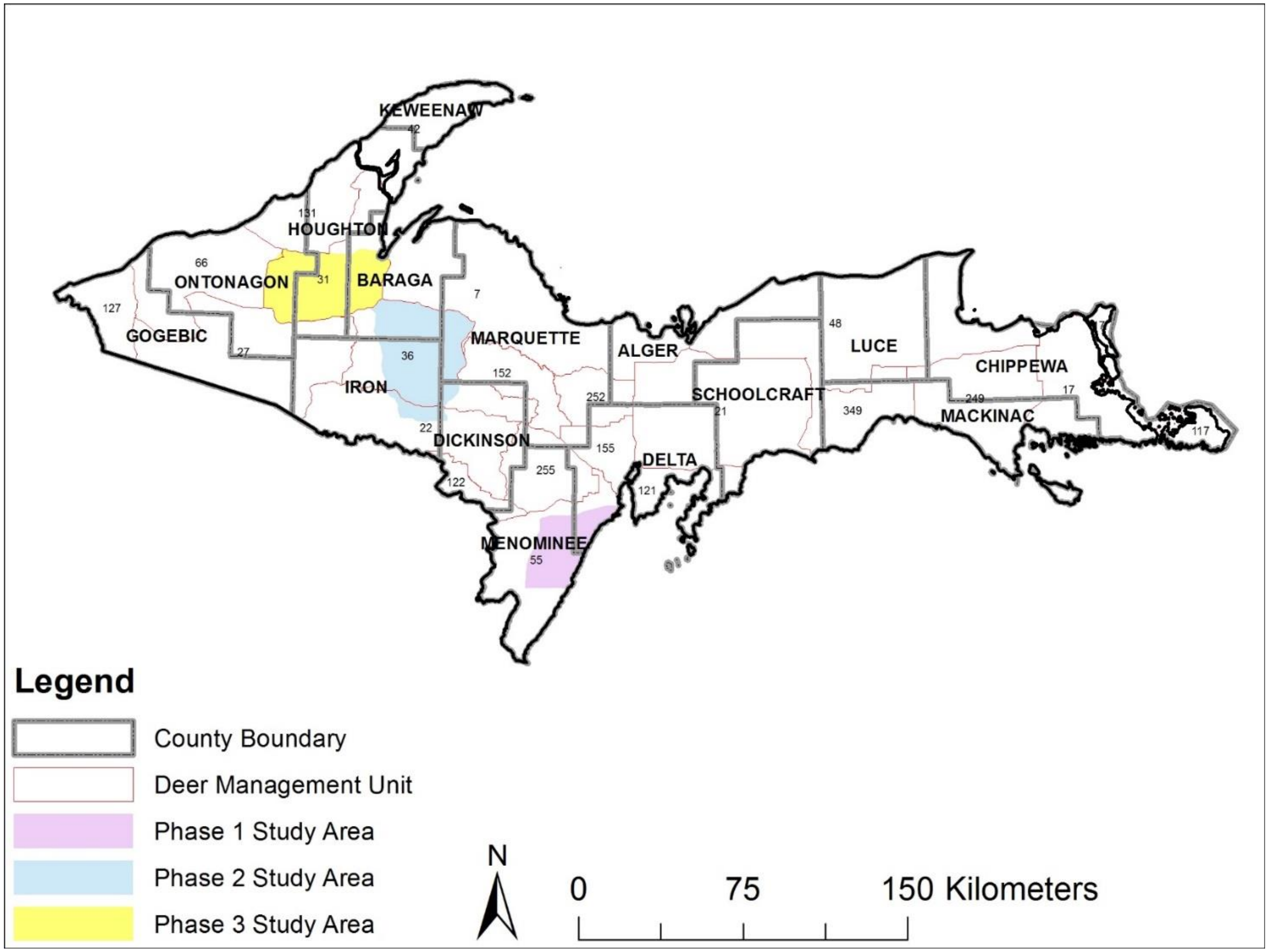

Figure 1. Location of phase 1, 2 and 3 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, 2008–2017.

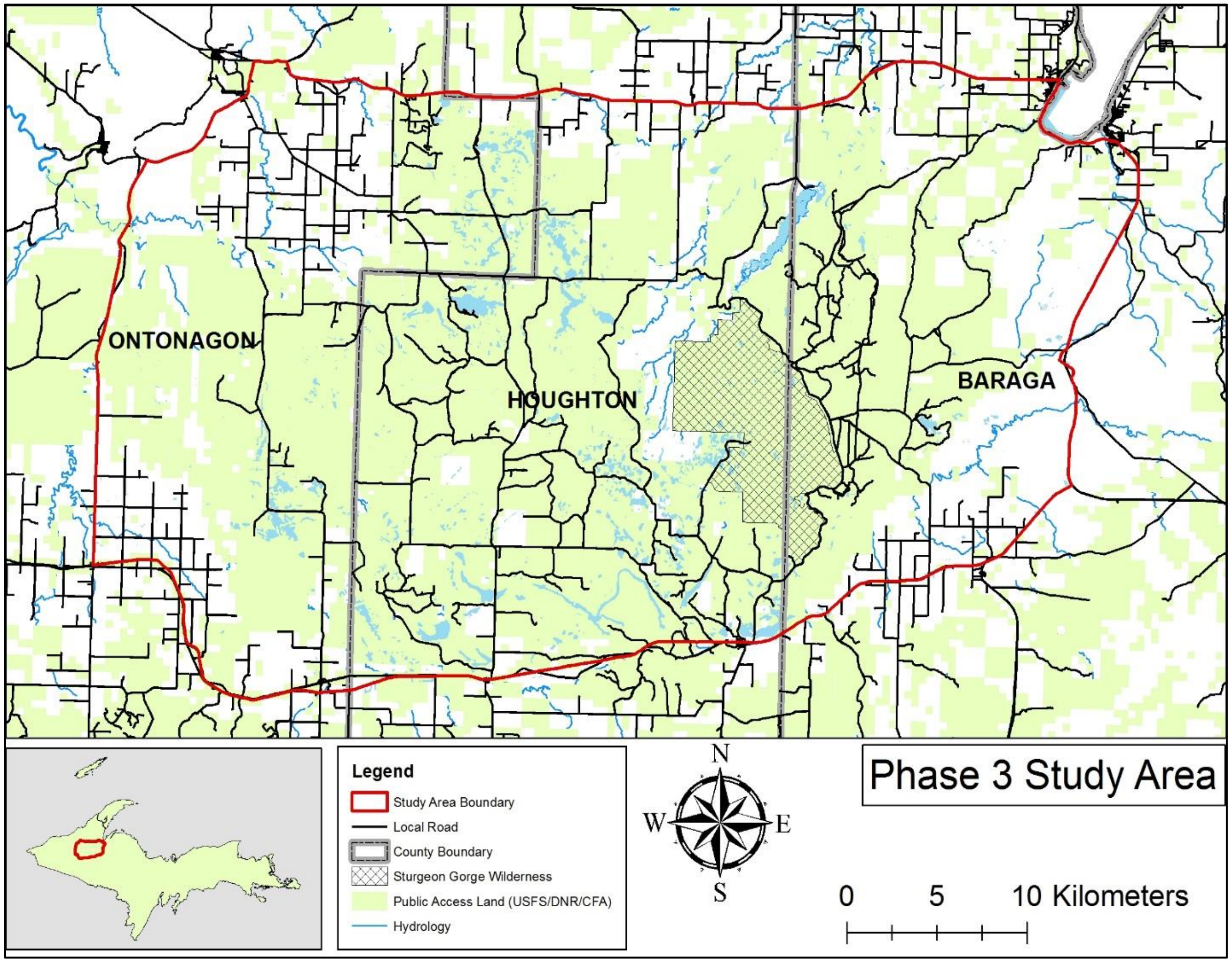

Figure 2. Location of phase 3 study area and counties, Upper Peninsula of Michigan, USA.

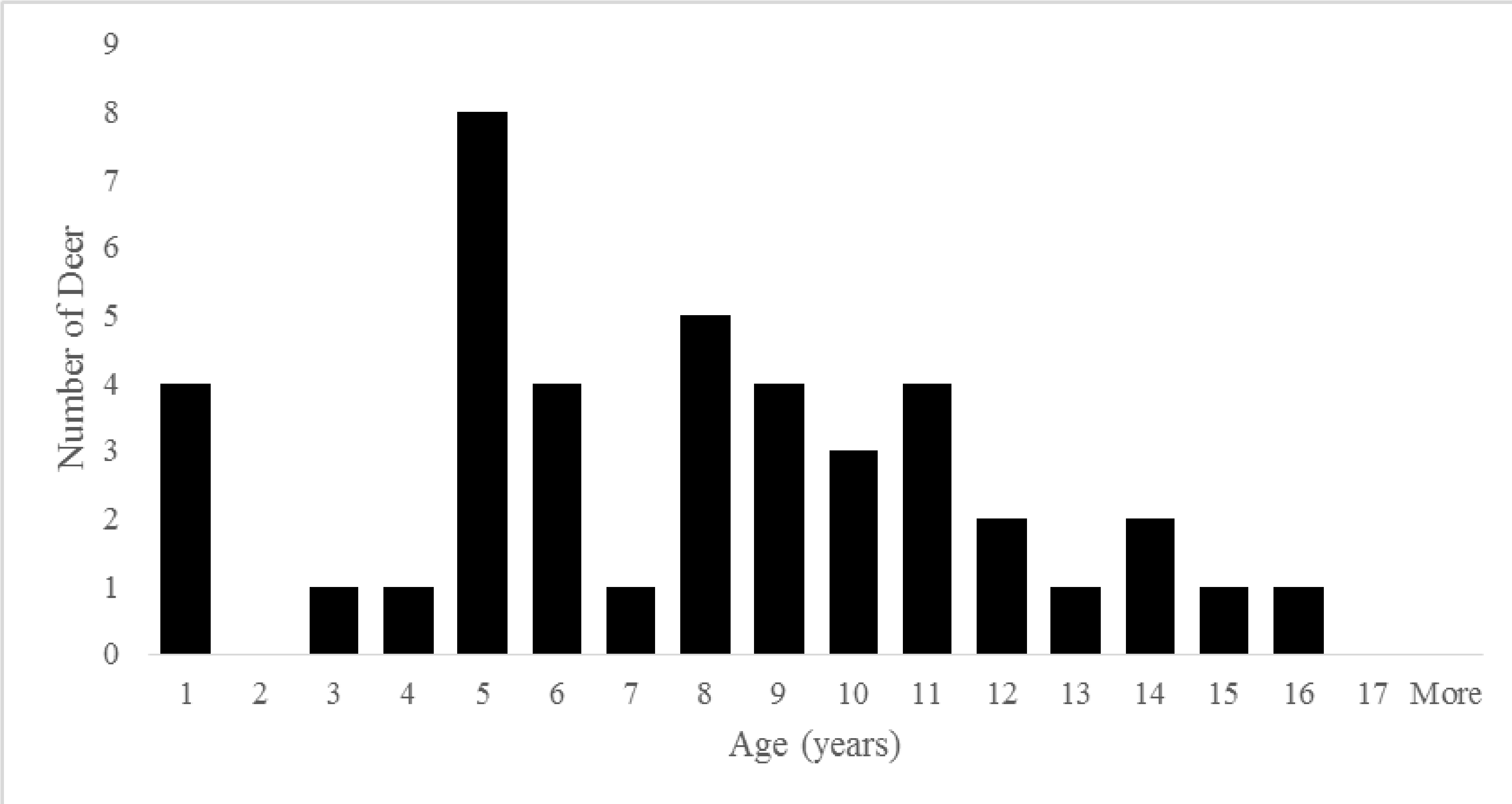

Figure 3. Cementum annuli estimated ages of chemically immobilized female white-tailed deer (n = 42) captured during January – March, 2017, Upper Peninsula of Michigan, USA.

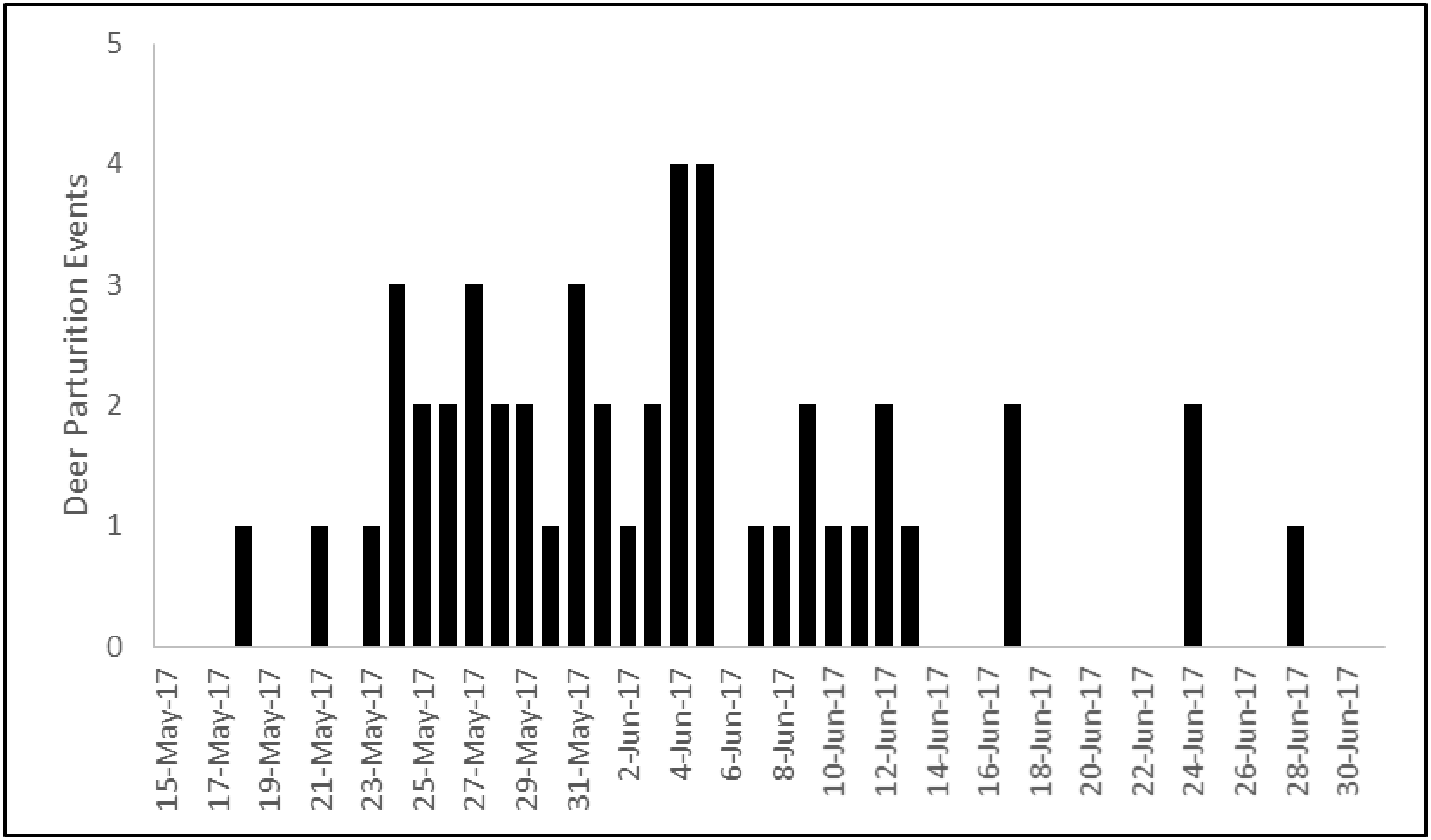

Figure 4. White-tailed deer parturition dates estimated from vaginal implant transmitters (n = 35) and opportunistically captured fawns (n= 13), Upper Peninsula of Michigan, USA, 2017.

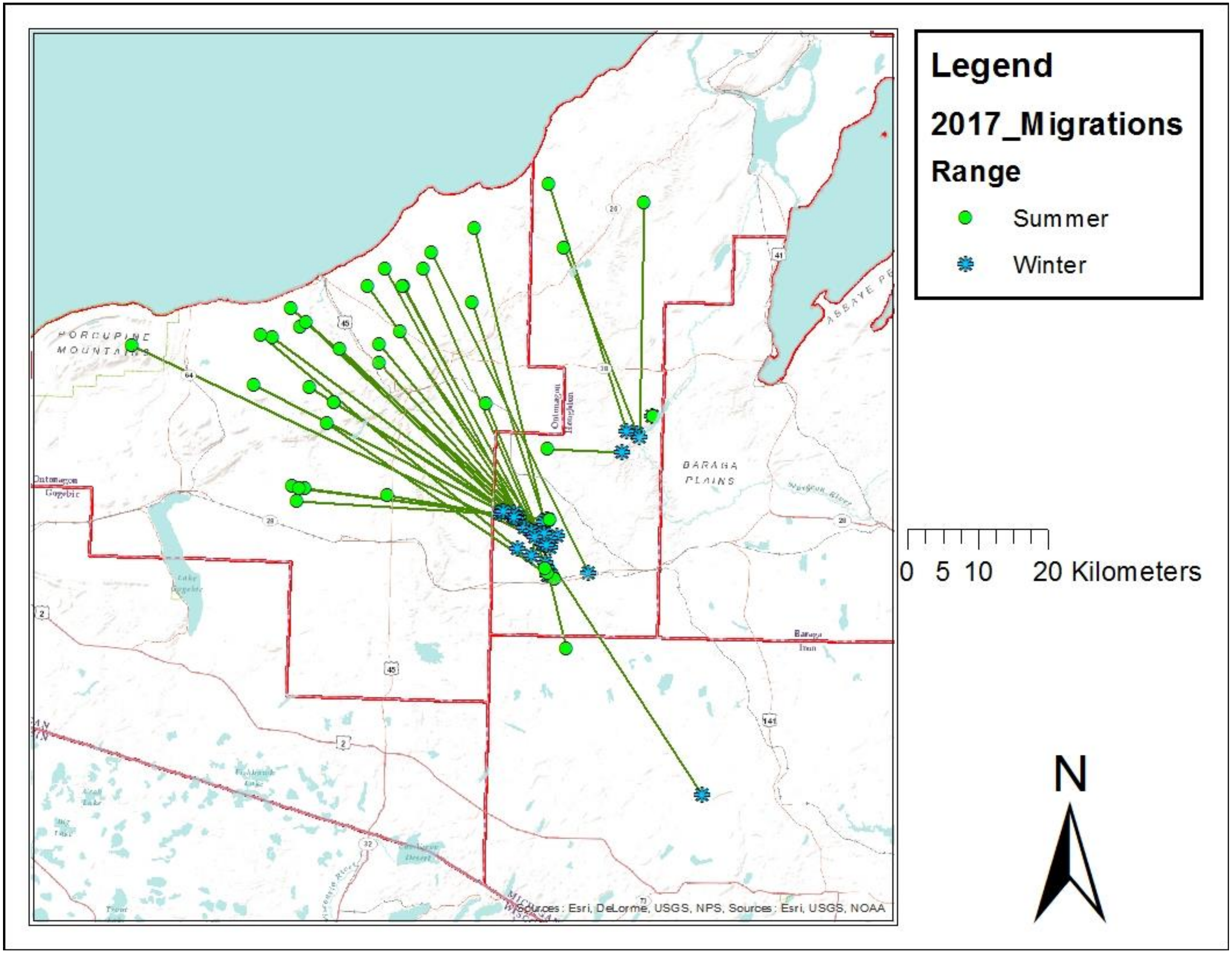

Figure 5. Spring migrations of 39 adult and yearling female white-tailed deer, Upper Peninsula of Michigan, USA, 2017.

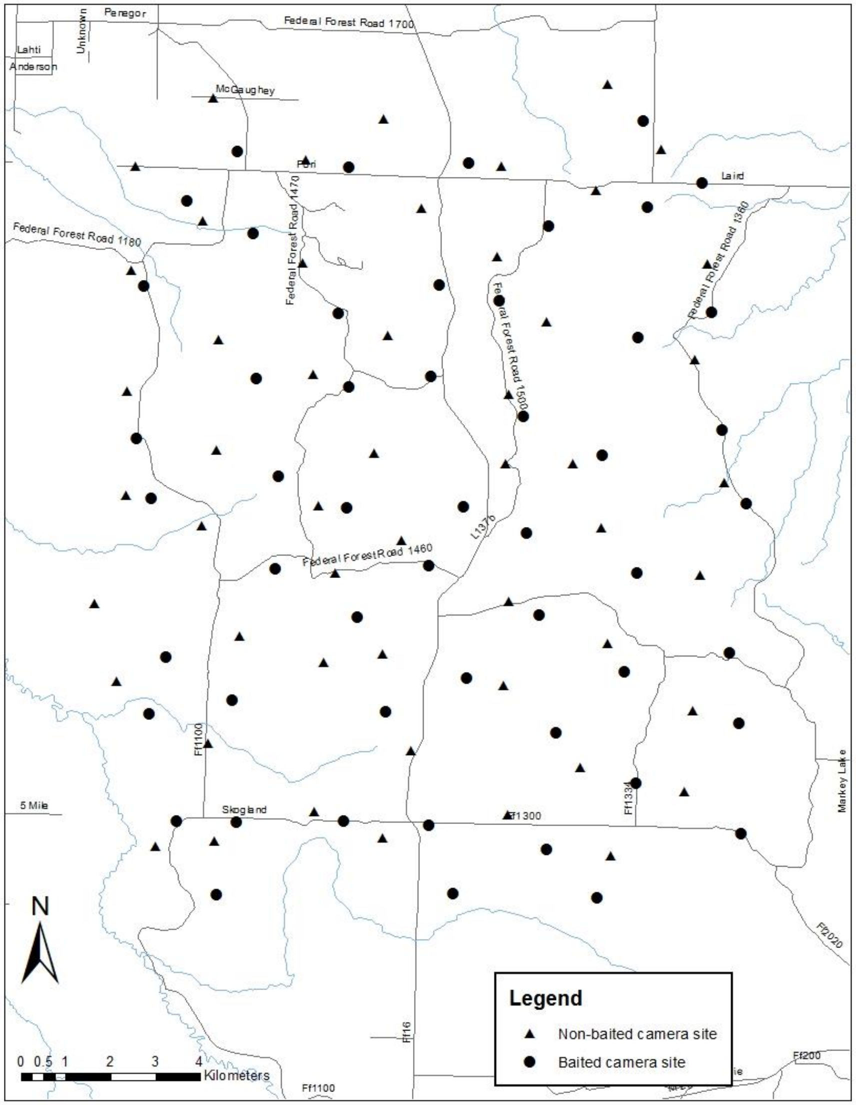

Figure 6. Locations of 52 baited and 52 non-baited remote camera sites to estimate deer abundance, Upper Peninsula of Michigan, USA, 2017.

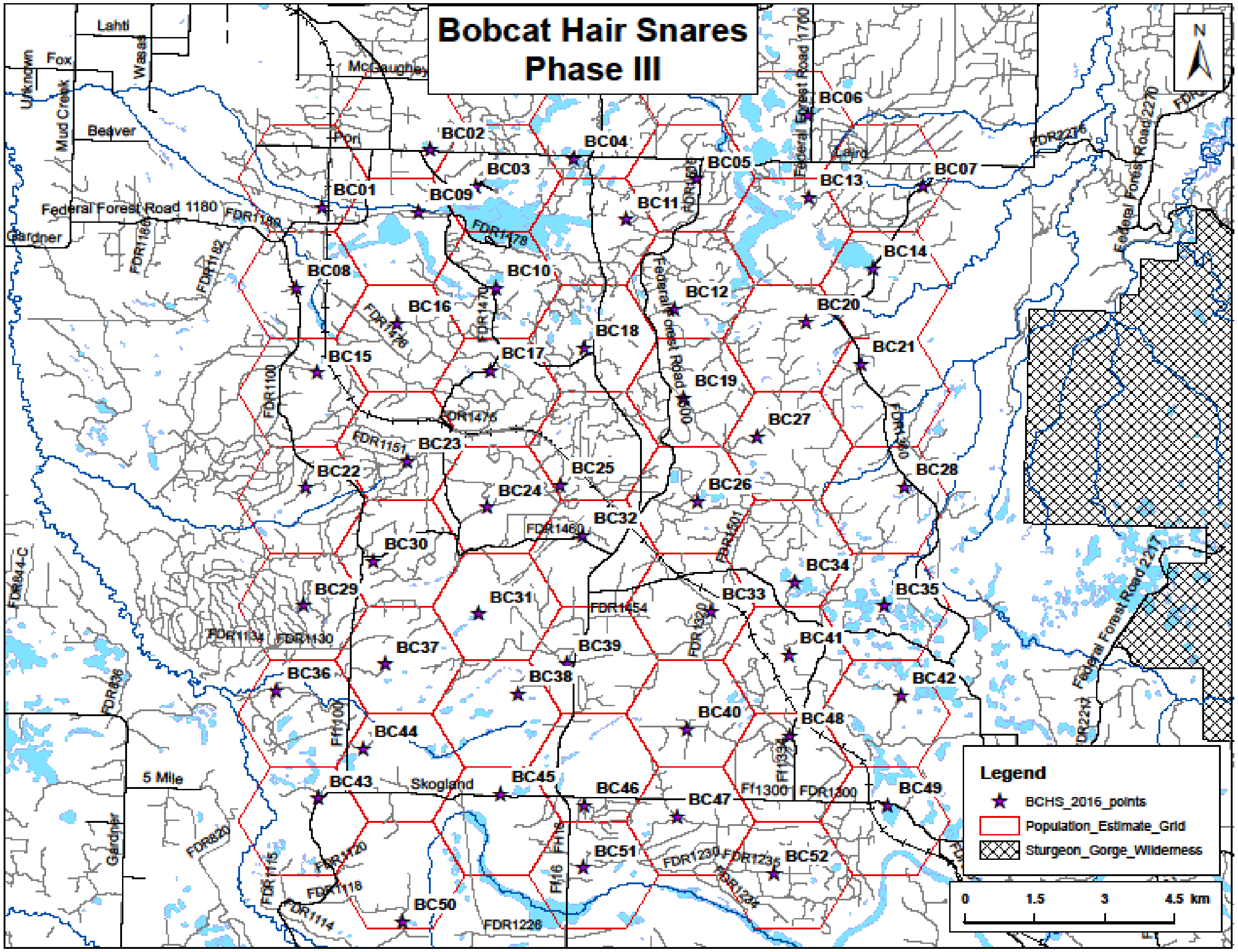

Figure 7. Locations of 52 bobcat hair snare sites to estimate bobcat abundance, Upper Peninsula of Michigan, USA, 2016

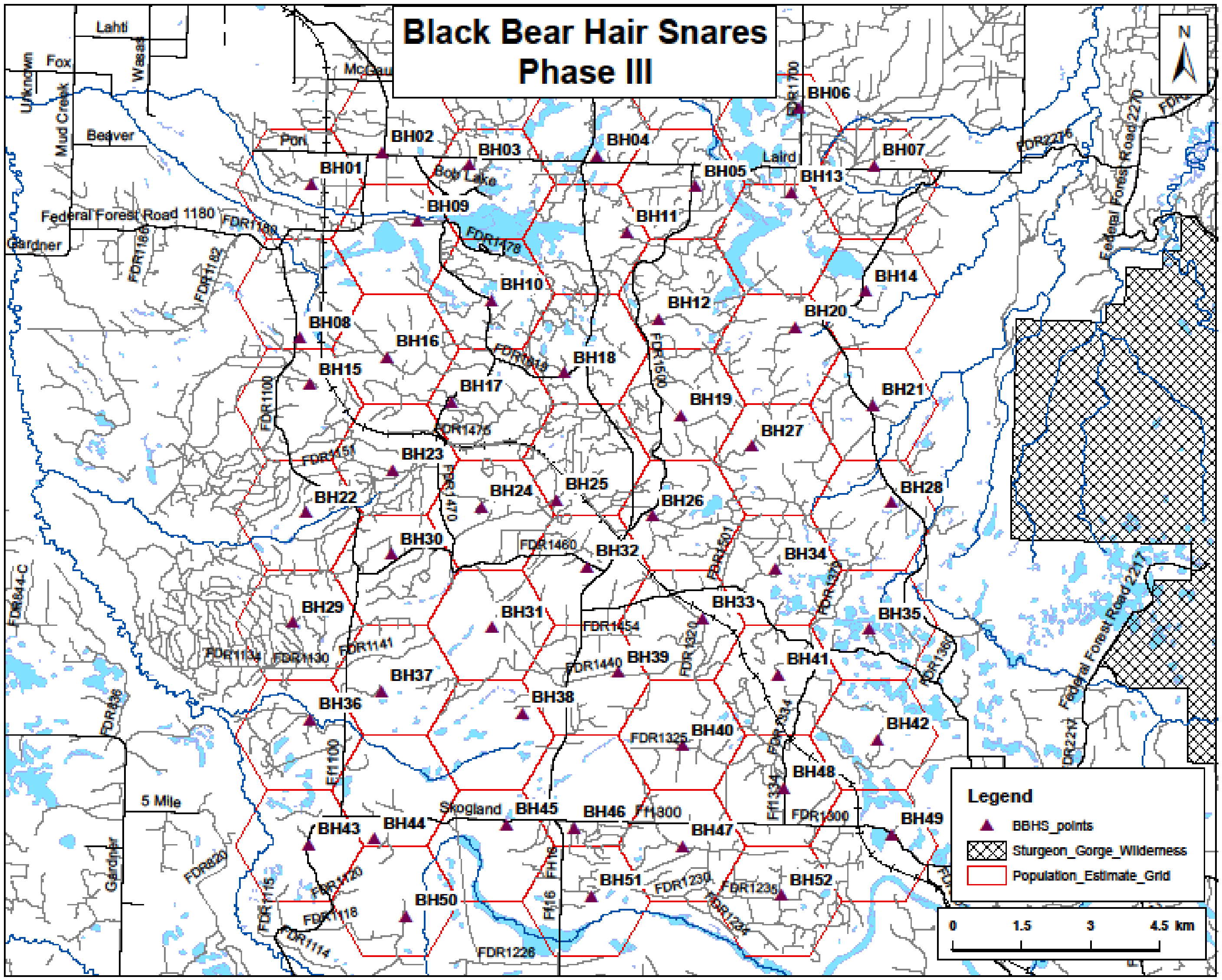

Figure 8. Locations of 52 black bear hair snare sites to estimate black bear abundance, Upper Peninsula of Michigan, USA, 2016.

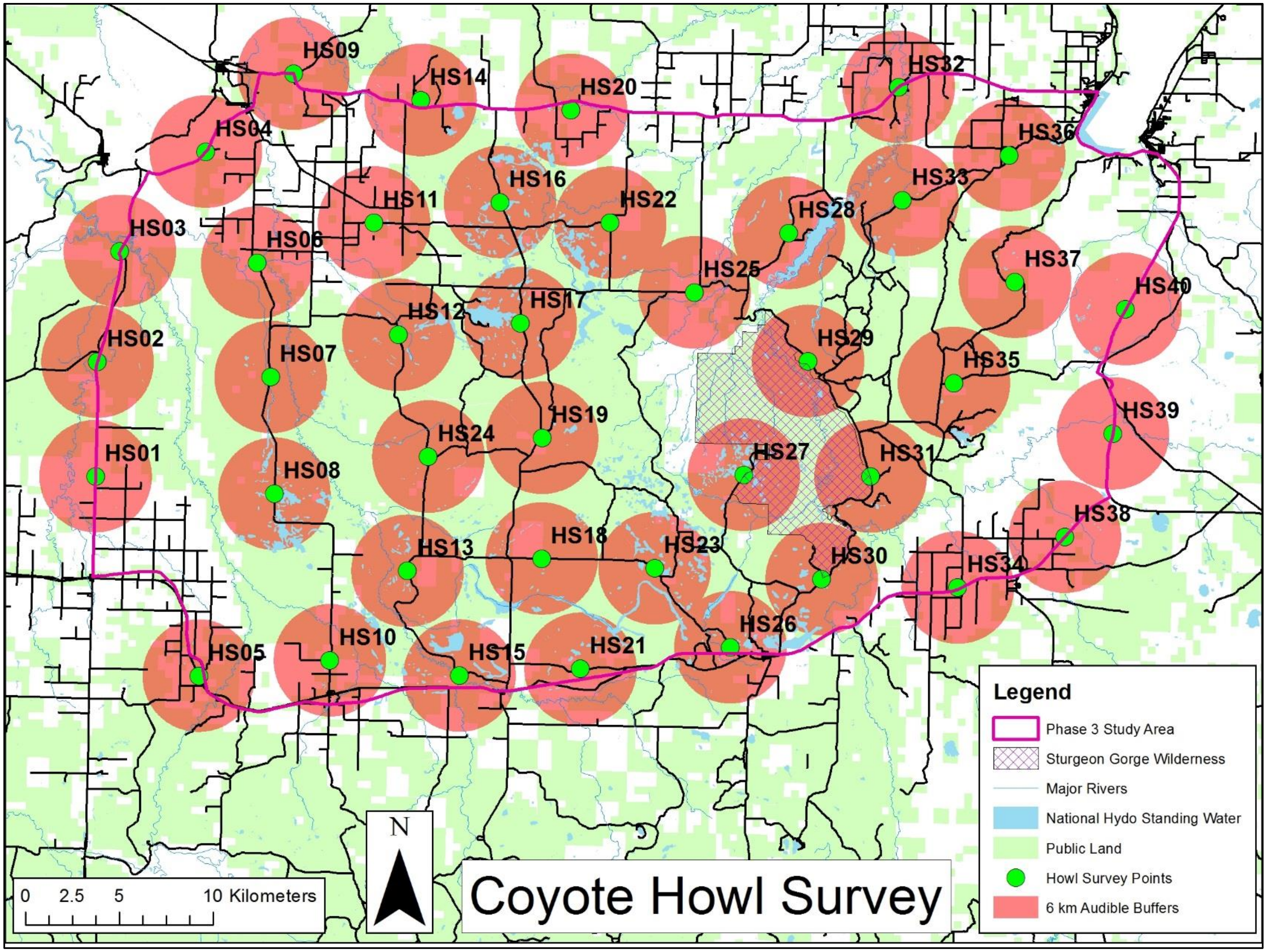

Figure 9. Locations of 40 howl survey sites to estimate coyote abundance, Upper Peninsula of Michigan, 2017.

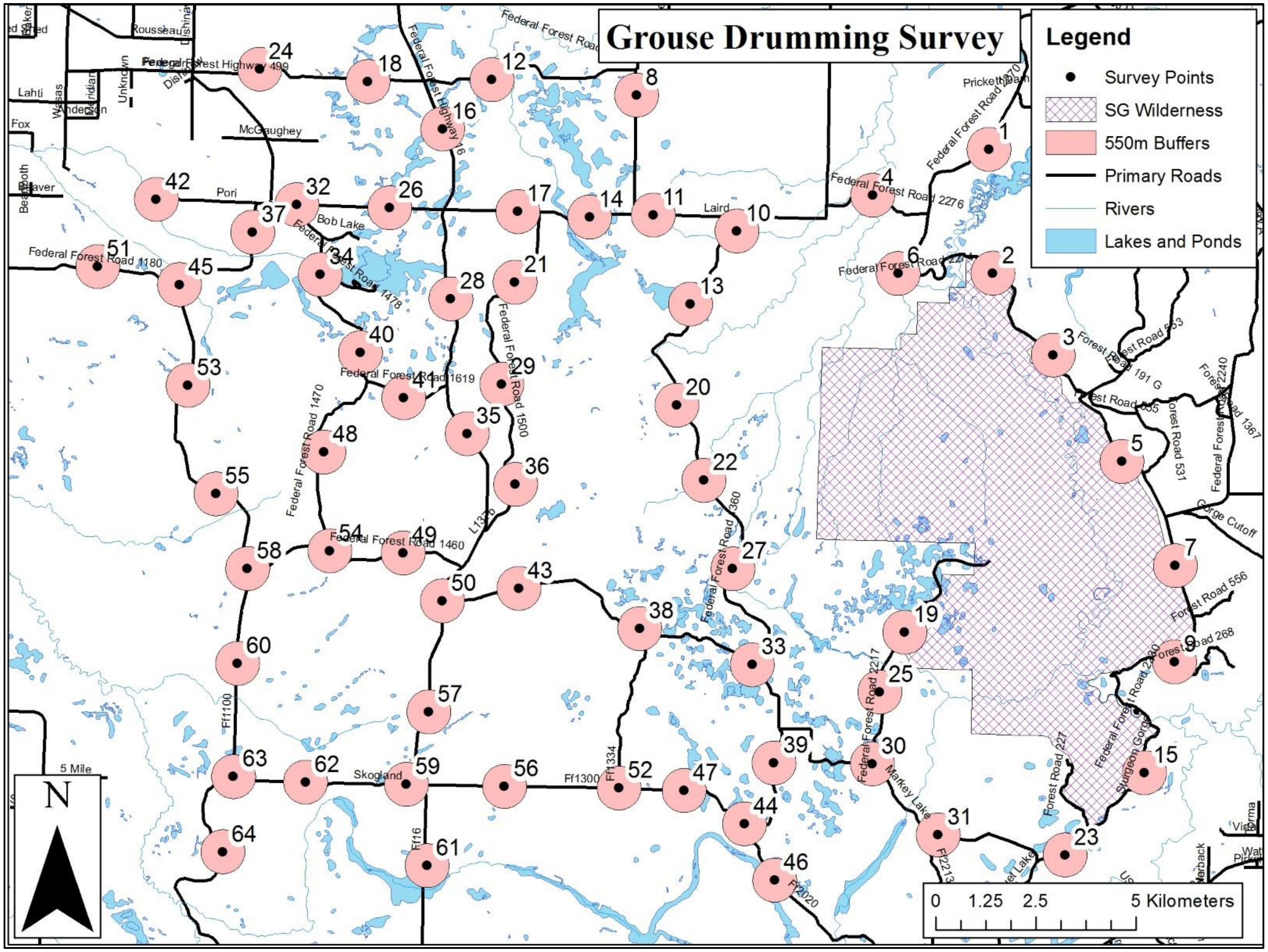

Figure 10. Locations of 64 grouse drumming survey sites with 550 m audible buffer along 3 routes to estimate abundance, Upper Peninsula of Michigan, USA, 2017.

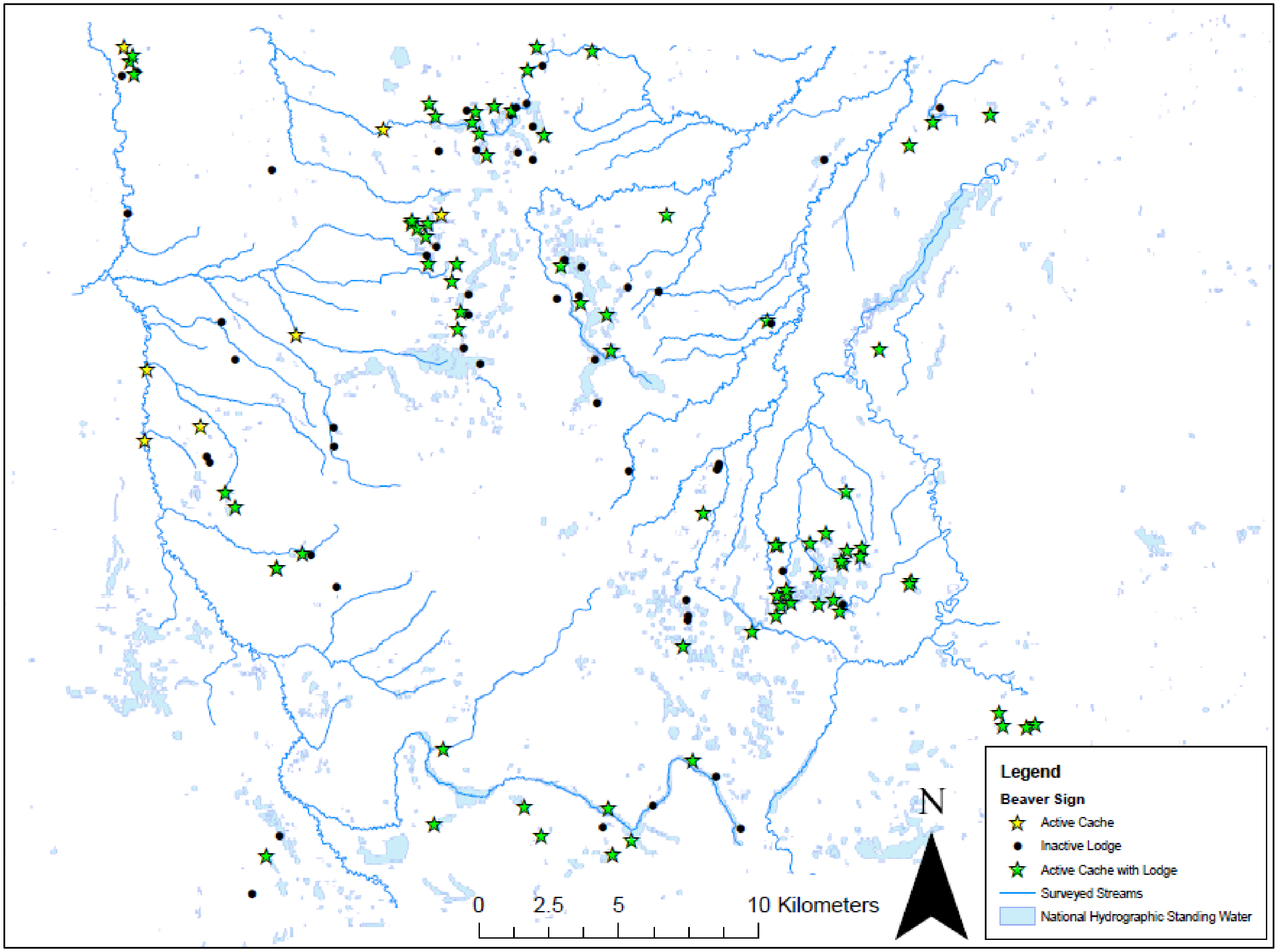

Figure 11. Locations of beaver caches and lodges detected aerially during 5–6 November, Upper Peninsula of Michigan, USA, 2016.