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 74 (17 male, 57 female) individual white-tailed deer (*Odocoileus virginianus*), including 48 adults, 5 yearlings, and 21 fawns. We radio-collared and VIT tagged 41 female deer. We detected pregnancy with ultrasound in 93% of adult ($n = 41$) and 33% of yearling ($n = 3$) females. We captured and radio-collared 32 neonate fawns (19 male, 13 female). Thirteen of 19 (68%) vaginal implant transmitter searches resulted in the location of 16 live fawns. We obtained 5,771 adult female and neonate fawn radiolocations, and captured or continued to monitor a total of 144 individual deer. We observed 20 radio-collared adult female white-tailed deer mortalities, 16 mortalities of radio-collared fawns born during 2015, and 14 mortalities of radio-collared fawns born during 2014. To estimate deer abundance, we placed 64 remote infrared cameras throughout the study area at baited sites and obtained 28,650 images including 6,494 observations of deer (4,994 adult females, 298 adult males, 1,052 fawns, and 150 unidentified deer). To estimate horizontal cover and deer forage with respect to available land cover, we completed vegetation surveys at 329 random locations stratified within 5 different land cover types. We immobilized 10 adult black bear (*Ursus americanus*; 2 male, 8 female) and 7 yearlings (3 male, 4 female) in their dens and observed 6 cubs (4 male, 2 female) from 2 females. From February to June we captured and immobilized 8 coyotes (*Canis latrans*; 2 male, 6 female), 6 bobcats (*Lynx rufus*; 3 male, 3 female), and 4 wolves (*C. spp.*; 1 male, 3 female) and either fitted them with GPS collars or released them due to their small size. During May–June we captured 4 adult black bears (3 male, 1 female) and fitted each with a GPS collar. We collected 297 hair samples and > 490,000 images from bobcat hair snares and remote cameras, respectively. We collected 2170 hair samples and 34,431 images from black bear hair snares and remote cameras, respectively. During howl surveys we recorded an average coyote response rate (RR) of 29% and wolf RR of 0.2%. We conducted investigations at 715 carnivore cluster sites to identify carnivore prey sources and opportunistically collected 642 scats from black bear, bobcat, coyote, and wolf. We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimate grouse abundance and had a 50% average detection rate across surveys. We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 485 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 36 inactive lodges, 53 active lodges with a cache present, and 8 caches with no sign of a lodge. We published 6 refereed manuscripts in the journals PLOS One, Population Ecology, The Wildlife Society Bulletin, Behavioural Processes, and Human-Wildlife Interactions. Throughout the year, we hosted many volunteers from various organizations and two photographers/videographers, gave 46 presentations, hosted 2 workshops, and kept our Facebook page (www.Facebook.com/MIpredprey) current with project results.

Summary

➢ We captured 74 deer (17 male, 57 female) individual white-tailed deer (*Odocoileus virginianus*), including 48 adults, 5 yearlings, and 21 fawns.

➢ We fitted 41 pregnant female deer with a radio-collar and a VIT.

➢ We detected pregnancy with ultrasound in 93% of adult (*n* = 41) and 33% of yearling (*n* = 3) females.

➢ We captured and radio-collared 32 neonate fawns (19 male, 13 female).

➢ Thirteen of 19 (68%) vaginal implant transmitter searches resulted in the location of 16 live fawns.

➢ We obtained 5,776 radiolocations of adult female and neonate fawn white-tailed deer.

➢ We observed 20 dead radio-collared adult female white-tailed deer. We attributed 11 mortalities to predation; 7 wolf, 1 coyote, and 3 unidentified canid (either coyote [*Canis latrans*] of wolf [*Canis* spp.]). We censored five mortalities, in which predation was the apparent proximate cause, from the study sample because they occurred within 10 days of capture. We observed 2 mortalities from illegal harvest, and two mortalities in which the cause of death could not be determined from evidence at the carcass site.

➢ Of the 32 neonate fawns collared during 2015, sixteen fawns died as of 20 September. We attributed 15 mortalities to predation: 5 black bear, 3 bobcat, 2 coyote, and 5 unidentified predations. We observed 1 mortality due to a vehicle collision. Additionally, we censored three fawns from the study sample after their radio-collars appeared to have fallen off.

➢ We placed 64 remote infrared cameras throughout the study area to estimate deer abundance and obtained 28,650 images including 6,494 observations of deer (4,994 adult females, 298 adult males, 1,052 fawns, and 150 unidentified deer).

➢ We completed vegetation surveys at 329 random locations stratified within 5 different land cover types to estimate horizontal cover and deer forage with respect to available land cover.

➢ We immobilized 10 adult black bear (*Ursus americanus*; 2 male, 8 female) and 7 yearlings (3 male, 4 female) in their dens and observed 6 cubs (4 male, 2 female) from 2 females.

➢ We set 12 cage traps to capture bobcats (*Lynx rufus*). We captured 6 bobcats and were able to collar 5 with GPS collars. We did not collar one of the bobcats because it weighed < 7.3 kg.

➢ We captured and immobilized 4 adult black bear (3 male, 1 female) using foot snares and barrel traps as capture techniques. We fitted 1 bear with a GPS camera collar and the remaining 3 bears with GPS radio-collars.

➢ We set padded foothold traps and non-powered cable neck restraints (coyotes only) along roadways and in frozen marshes to capture bobcats, coyotes, and wolves. We captured 8 coyotes and 4 wolves and fitted each with a GPS or VHF radio-collar.

➢ We deployed hair snares and remote cameras at 64 sites throughout the study area to estimate bobcat abundance. We obtained 297 hair samples and > 490,000 images.

➢ We deployed hair snares and remote infrared cameras at 64 sites throughout the study area to estimate black bear abundance and obtained 2170 samples of black bear hair.

➢ We obtained a coyote response rate (RR) of 29% and wolf RR of 0.2% to broadcasted recordings of coyote group-yip-howls during howl surveys.

➢ We conducted investigations at 715 carnivore cluster sites to identify carnivore prey.

➢ We opportunistically collected 642 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 50% across surveys.

➢ We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 485 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 558 km of river and lakeshore and detected 53 active beaver caches.

➢ We hosted individuals from Michigan Department of Natural Resources, Northern Michigan University, Purdue University, and members of the Safari Club International Michigan Involvement Committee. 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 two television specials.

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

➢ We hosted students from Purdue University for demonstrations of detection dogs, carnivore immobilizations, fawn searches, and black bear den checks.

➢ We gave presentations to 46 different groups or organizations (including school groups) about ongoing project activities and findings.

➢ During January–March 2015 and May–August 2015 we hired and employed 6 and 13 technicians, respectively. We hired one technician to assist with fall project activities.

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 second phase of this study spans about 1,000 km^2 (386 mi^2) within Deer Management Unit 036 in Iron County (Figure 1). The general study area boundaries follow State Highway M-95 on the east, US Highway 41/28 on the north, US Highway 141 on the west, and State Highway M-69 on the south. The core study area, where we conducted most capture efforts and population surveys, is north of the Michigamme Reservoir and includes state forest, commercial forest association, and private lands. The final study area will comprise a minimum convex polygon that will include the composite locations of all telemetered animals. We selected this study area because it occurs within the mid-snowfall range, receiving about 180 cm of snowfall annually (about 53 cm more snowfall annually than the phase 1 study area near Escanaba). Deer in this area migrate longer distances and exhibit yarding behavior during most winters as compared to deer near Escanaba that migrate only short distances or are non-migratory (Beyer et al. 2010) and yard less frequently.

Accomplishments

Deer Trapping

From 11 January 2015 to 15 March 2015 we captured white-tailed deer in Clover traps (Figure 2) to place radio-collars on pregnant females. We captured 74 unique deer (57 females, 17 males), with an additional 47 recaptures. Individuals captured included 44 adult females, 4 adult males, 3 yearling females, 2 yearling males, 10 female fawns, and 11 male fawns. The fawn:adult female ratio for winter captures in 2014–2015 was 0.48:1. For comparison, the fawn:adult female ratio was 1:1 for winter 2012–2013 captures and 0.27:1 for winter 2013–2014 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.

Females ($n = 55$) and males ($n = 17$) had mean (± SD) body condition scores of 2.46 ± 0.52 and 2.39 ± 0.54, respectively. Two deer (one adult female, one male fawn) were euthanized due to spinal injuries sustained from the trap, and a third deer (adult female) died as a result of apparent cardiac arrest during the immobilization (necropsy pending).

We immobilized 44 females and fitted 41 with radio-collars (model 2610B, Advanced Telemetry Systems Inc., Isanti, MN). We fitted 41 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 recorded deer morphometrics and mid-rump fat depths (Table 1) when practical.

We detected pregnancy with ultrasound in 98% of adults ($n = 41$) and 33% of yearlings ($n = 3$). Two adult females identified as pregnant using ultrasound during winter capture did not have a parturition event during the summer, and so were either not pregnant or had an early termination of pregnancy. Estimated age of captured does using cementum annuli ranged from 1.7-15.7 years old, with a mean estimated age of 5.77 years.

In order to increase sample sizes for fawn winter survival and cause-specific mortality, we also fitted 10 fawns (7 Male, 3 Female) with expandable radio-collars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) during January deer capture, without immobilization.

In addition to the 41 adult females and 10 fawns radio-collared this winter, we continued to monitor 27 does captured during January–March 2013 or 2014, and 14 fawns captured during May–June 2014.

Fawn Capture

Beginning mid-May we captured, radio-collared, and obtained radio-locations for white-tailed deer fawns. We captured 32 neonate fawns (19 male, 13 female) and fitted them with expandable radio-collars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) during May–July. 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 were 24 May–4 July, with a median parturition date of 8 June (Figure 3). Average estimated birth mass of fawns in 2014 was similar to average birth mass of fawns born in 2013 (3.6 ± 1.3 kg and 3.1 ± 1.1 kg, respectively). Mean estimated fawn age at capture was 2.25 days.

We conducted vaginal implant transmitter (VIT) searches to find fawns of 19 implanted pregnant adult females. Thirteen of nineteen (68%) VIT searches resulted in the location of 16 live fawns.

Deer Telemetry

We used bi-weekly aerial telemetry, 24-hour ground telemetry, and 5 GPS collars to obtain 5,776 locations of radio-collared adult females and fawns during 15 September 2014 to 15 September 2015. We monitored deer collars every two weeks for survival status. We monitored a total of 121 deer via radio-collar during 15 September 2014–15 September 2015 (Table 3).

Deer Mortality

From 15 September 2014–15 September 2015, we recorded 20 adult female mortalities. We attributed 11 mortalities to predation (7 wolf, 1 coyote, and 3 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 five mortalities, in which predation was the apparent proximate cause, from the study sample because they occurred within 10 days of capture. We observed 2 mortalities from illegal harvest, and two mortalities in which the cause of death could not be determined from evidence at the carcass site.

We recorded 14 mortalities and 7 censors of fawns born in May–June 2014. We attributed causes of mortality to 5 wolf predations, 4 coyote predations, 2 unidentifiable predations, 1 winter

starvation, and 2 unknown causes in which we could not distinguish predation from scavenging. Censors were due to dropped collars and radio failure.

We recorded 16 mortalities of neonate fawns born in May–July 2015, including 5 black bear predations, 3 bobcat predations, 2 coyote predations, and 5 unidentified predations. We censored three fawn collars that appeared to have fallen off the animal. Excluding censors, 2015 fawn apparent survival from birth to 1 September was 44%.

Deer Camera Survey

We pre-baited sixty-four sites throughout the study area (Figure 4) 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 28,650 images including 6,494 observations of deer (4,994 adult females, 298 adult males, 1,052 fawns, and 150 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).

Deer Forage and Vegetation Survey

From 12 May to 13 August we conducted vegetation surveys at 329 random locations within 6 main land cover types (deciduous [$n = 51$], coniferous [$n = 60$], mixed forest [$n = 38$], woody wetland [$n = 46$], herbaceous wetland [$n = 92$], and herbaceous grassland [$n = 40$]; Table 4). At each random location we established 5 plots. Within each plot, we estimated horizontal cover and counted number of tree, shrub, and percent of herbaceous plants selected for by white-tailed deer (McCaffery et al. 1974, Stormer and Bauer 1980). We also collected vegetation samples, which we dried for 24 hours in a forced air oven and then subsequently weighed. We will use vegetation data to estimate forage availability within each of our land cover types.

Black Bear Den Checks

During 16 January 2015–2 March 2015 we immobilized 10 adult black bears (2 male, 8 female) and 7 yearlings (3 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 10 previously collared adult black bears. We programmed the GPS collars to obtain a location every 35 h until 1 May and then every 15 min until we remove the collar in the den. We handled 6 cubs (4 male, 2 female) from 2 adult females; mean litter size was 3 (SD = 1.41; Table 5).

Bobcat Capture

We set cage traps ($n = 17$) to capture bobcats at previously baited bobcat hair snare sites during 6–15 March. We captured 3 female (7.3, 9.5, 12.7 kg) and 3 male (11.8, 12.8, 15.9 kg) bobcat. Once immobilized, we weighed, sexed, and collected morphometric measurements from bobcats. We collared every bobcat > 7.3 kg with a GPS collar that we programed to record 35 h locations until 1 May and then every 15 min until 31 August. We were unable to collar one female bobcat due to her light weight (7.3 kg).

Coyote Cable Neck Restraints

We baited 6 locations with vehicle-killed deer carcasses to attract coyotes for capture. We set 13 relaxing-lock cable neck restraints at 4 sites starting on 10 February. We immobilized 1 adult female coyote on 21 February (13.6 kg) and fit a GPS collar programed to record 35 h locations until 1 May

and then every 15 min until 31 August.   We removed all coyote cable neck restraints by 12 March due to continuing unfavorable snow conditions.

Spring/Summer Carnivore Capture

During 22 May–15 June, we captured 3 male black bears, 8 coyotes (2 male, 6 female), and 4 wolves (1 male, 3 female) using foothold traps. We immobilized captured individuals and recorded gender, weight, and affixed uniquely numbered ear tags (Figure 5; Table 6). 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 lower premolar or upper incisor for age estimation in coyotes, and 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 4 captured bears, we fitted 3 male bears with GPS radio-collars, and fitted one female bear with a Lotek 7000MU GPS camera collar that we programmed to record video every half hour for 30 seconds during 0500–1000 hours and 1800–2100 hours.

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 the 7000MU GPS camera collar and 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 2 bobcat, 3 coyote, and 3 wolf GPS radio-collars after the drop-off mechanisms activated during September–December 2014 and 2 additional wolf and 1 black bear GPS radio-collars in September 2015. We sent three damaged GPS radio-collars to the manufacturer for refurbishment. We observed six harvested black bear and recovered their collars, during the Michigan and Wisconsin 2014 black bear hunting seasons. We sent a premolar from each black bear to the Michigan Department of Natural Resources Disease Laboratory for age estimation.

We were unable to locate or recover GPS collars from 1 wolf, 2 bobcats, and 1 coyote. From 25 September to 15 December 2014, we located 9 black bears 5 times to follow their movements and confirm denning location. We located 9 bear dens (2 male, 7 female) during 1–12 December.

Bobcat Hair Snares

We began baiting 64 bobcat hair snare sites (Figure 4) on 15 December 2014. After a two-week pre-bait period, we set 4–5 hair snares at each site beginning 2 January 2015. 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 27 February–6 March 2015.

We collected 297 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 >490,000 camera images, including 11,050 observations of bobcat.

Black Bear Abundance Estimation: Hair Snares

During 27 May – 11 July we conducted a hair snare survey to estimate black bear abundance. Hair snares (n = 64; Figure 4), erected during 2012, 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 2170 hair samples. We sent these hair samples to the MDNR lab for DNA extraction and subsequent individual identification. We removed all hair snares, cameras, and signage following the survey as this was the final year for this survey in this study area.

Coyote Howl Surveys

We completed 5 howl surveys at 40 sites (Figure 6) beginning on 13 July. Surveys are on a 10 day rotation with each survey completed in 4 days, weather permitting. 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.

Through the end of the survey we obtained coyote and wolf response rates of 29% and 0.2%, respectively. We will estimate coyote abundance using an occupancy modeling approach (Petroelje et al. 2014).

Wolf Track Surveys

The Michigan Department of Natural Resources (DNR) conducted wolf track surveys for the 2015 population estimate during 9–27 February within our study area to identify the number of wolf packs in the study area and the minimum number of individuals within each pack. We also used information from 3 GPS collared individuals to estimate territorial boundaries for 2 packs within the study area; Deer Lake and Mitchigan. Michigan DNR personnel identified a minimum of 25 individuals consisting of four packs with their entire territories occurring within the study area: Deer Lake (minimum 6 individuals); Mitchigan (minimum 7 individuals); Shank Lake (minimum 7 individuals); and Republic (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 2015, we investigated 715 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 715 clusters investigated this year, 239 were black bear (mean clusters/black bear = 23.9), 160 bobcat (mean clusters/bobcat = 23.3), 189 coyote (mean clusters/coyote = 32.2), and 127 wolf (mean clusters/wolf = 23.9).

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 black bear clusters where foraging and bedding sites co-occurred. We identified ruffed grouse (*Bonasa umbellus*), porcupine (*Erithizon dorsatum*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), 1 Sandhill crane (*Grus canadensis*), and fawn predations at bobcat clusters sites. We identified predations of snowshoe hare (*Lepus americanus*), frog (*Rana* spp.), turkey (*Meleagris gallopavo*), 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 642 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 have begun washing and drying scats. We packaged 611 scats (174 black bear, 18 bobcat, 216 coyote, and 203 wolf) and sent them 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 23 April–1 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 65 sites (Figure 7). 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 50% of the sites on average.

Snowshoe Hare Pellet Counts

We conducted snowshoe hare (*Lepus americanus*) pellet counts during 24 April–26 May. We counted number of hare pellets within a 1 m^2 rectangle at 485 random sites (Figure 8). 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) and observed a decreasing trend in the hare population during 2013–2015 (Figure 9). Snowshoe hare densities were greatest within mixed aspen/evergreen and woody wetland land covers.

Aerial Beaver Cache Survey

To provide an index of beaver abundance, we flew 558 km of river and lakeshore on 5–6 November to identify active beaver caches. We conducted flights at an altitude of 550–650 m. We detected 36 inactive lodges, 53 active lodges with a cache present, and 8 caches with no sign of a lodge (equates to one active cache for every 9.1 km flown; Figure 10).

Public Outreach

During black bear den checks and white-tailed deer trapping we hosted individuals from Michigan Department of Natural Resources (MDNR), Northern Michigan University, Purdue University, Michigan Out-of-Doors, 906 Outdoors (Discovering), and other interested members of the public. We hosted two TV shows who obtained images and video footage of project staff performing various field duties and provided this media to Safari Club International Foundation to promote the project. We hosted 5 observers from Northern Michigan University on several occasions and gave presentations for Northern Michigan University Wildlife Society's "Wolf Week". We attended several MDNR 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 31 undergraduate students from Purdue University on 4–5 June for demonstrations of detection dogs, carnivore immobilizations, fawn capture, vegetation surveys, and deer telemetry. We presented at a local community center in Iron River, MI on 9 May to inform members of the public about ongoing

research in the area. We also gave presentations to 25 classes at local public schools, reaching over 400 students. We updated our Facebook page (www.Facebook.com/MIpredprey) to provide the public with project results.

Presentations to hunting groups and service organizations:

Fowler, N.L., T.R. Petroelje, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 17 September 2014. Update on Michigan Predator-Prey Project. Sagola Sportsman's Coalition Meeting, Sagola, MI. 12 attendees.

Fowler, N.L., D.C. Norton, Petroelje T.R., T.M. Kautz, J.L. Belant, and D.E. Beyer, Jr. 16 October 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Northern Michigan University's Wildlife Society Wolf Week, Marquette, MI. 20 attendees.

Fowler, N.L., D.C. Norton, T.R. Petroelje, T.M. Kautz, J.L. Belant, and D.E. Beyer, Jr. 28 October 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Water Works Group Conference. Harris, MI. 50 attendees.

Fowler, N.L., D.C. Norton, T.R. Petroelje, T.M. Kautz, J.L. Belant, and D.E. Beyer, Jr. 17 November 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. North Lakeland Discovery Center. Manitowish Waters, WI. 25 attendees.

Fowler, N.L., T.R. Petroelje, T.M. Kautz, J.L. Belant, and D.E. Beyer, Jr. 2 December 2014. Update on Michigan Predator Prey Project. Sagola Sportman's Coalition Meeting. Sagola, MI. 22 attendees.

Kautz, T. M., T.R. Petroelje, N.L. Fowler, J.L. Belant, and D.E. Beyer, Jr. 24 November 2014. Michigan Predator Prey Project Overview. Watkins Glen High School, Watkins Glen, NY. 70 attendees.

Kautz, T., T.R. Petroelje, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 13 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Watkins Glen High School, Watkins Glen, NY. 60 attendees.

Kautz, T., T.R. Petroelje, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 14 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Cornell University Student Chapter of The Wildlife Society, Ithaca, NY. 20 attendees.

Lutto, A.L., N. Fowler, T.R. Petroelje, T. Kautz, J.L. Belant, and D.E. Beyer, Jr. 27 March 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. West Iron County Public School, Iron River, MI. 15 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 30 March 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Iron Mountain Public Schools North Elementary, Iron Mountain, MI. 20 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 31 March 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Forest Park Elementary School Pre-Kindergarten, Crystal Falls, MI. 12 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 31 March 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Forest Park Elementary School Pre-Kindergarten, Crystal Falls, MI. 7 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 31 March 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park High School, Crystal Falls, MI. 48 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 1 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Forest Park Elementary School Second Grade, Crystal Falls, MI. 30 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 1 April 2015. Michigan Predator-Prey Project. Forest Park Elementary School Fifth Grade, Crystal Falls, MI. 22 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 1 April 2015. Michigan Predator-Prey Project. Forest Park Elementary School Third Grade, Crystal Falls, MI. 25 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 1 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Forest Park Elementary School First and Second Grade, Crystal Falls, MI. 16 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 2 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Forest Park Elementary School First Grade, Crystal Falls, MI. 26 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 2 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Forest Park Elementary Kindergarten, Crystal Falls, MI. 16 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 21 April 2015. Michigan Predator-Prey Project. Iron Mountain East Elementary Sixth Grade, Iron Mountain, MI. 18 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 21 April 2015. Michigan Predator-Prey Project. Iron Mountain East Elementary Sixth Grade, Iron Mountain, MI. 20 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 21 April 2015. Michigan Predator-Prey Project. Iron Mountain East Elementary Fourth Grade, Iron Mountain, MI. 16 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 21 April 2015. Michigan Predator-Prey Project. Iron Mountain East Elementary Fouth Grade, Iron Mountain, MI. 18 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 21 April 2015. Michigan Predator-Prey Project. Iron Mountain North Elementary Third Grade, Iron Mountain, MI. 40 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 21 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Iron Mountain High School, Iron Mountain, MI. 45 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Iron Mountain Middle School, Iron Mountain, MI. 48 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Iron Mountain Middle School, Iron Mountain, MI. 49 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Stambaugh Elementary School Kindergarten, Iron River, MI. 16 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Stambaugh Elementary School Kindergarten, Iron River, MI. 17 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Stambaugh Elementary School Kindergarten, Iron River, MI. 13 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 28 April 2015. Michigan Predator-Prey Project and Upper Peninsula Wildlife. Stambaugh Elementary School First Grade, Iron River, MI. 19 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Middle School Seventh Grade, Crystal Falls, MI. 19 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Middle School Eighth Grade, Crystal Falls, MI. 24 attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, D.E. Beyer Jr. 12 February 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Michigan Department of Natural Resources Crystal Falls Field Office. Crystal Falls, MI. 20 Attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, D.E. Beyer Jr. 22 February 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Purdue University. Crystal Falls, MI. 11 Attendees.

Petroelje, T.R., D.C. Norton, T. Kautz, N. Fowler, J.L. Belant, D.E. Beyer Jr. 7 March 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. U.P. Bear Houndsman Banquet. Escanaba, MI. 75 Attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 11 April 2015. Michigan Predator-Prey Project: Deer Survival in Michigan's Upper Peninsula. Grayling, MI. 40 attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 April 2015. Michigan Predator-Prey: Deer Survival Update 2015. Upper Peninsula Sportsman Alliance, Iron Mountain, MI. 70 attendees.

Petroelje, T.R., N. Fowler, T.M. Kautz, N.S. Svoboda, J.F. Duquette J.L. Belant, and D.E. Beyer, Jr. 23 April 2015. Michigan Predator-Prey Project: Wolf-Deer Relationships in Michigan's Upper Peninsula. Midwest Wolf Stewards Conference. Ashland, WI. 150 attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 9 May 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Windsor Center, Iron River, MI. 70 attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 8 June 2015. Update on Michigan Predator Prey Project. Sagola Sportman's Coalition Meeting, Sagola, MI. 15 attendees.

Petroelje, T.R., T. Kautz, D.E. Beyer, Jr., N. Fowler, and J.L. Belant. 8 September 2015. Phase 1 Summary and Update on Michigan Predator Prey Project. Michigan Department of Natural Resources Wildlife Division Annual Conference, Ralph A. MacMullan Conference Center, Grayling, MI. 75 attendees

Petroelje, T.R., T. Kautz, D.E. Beyer, Jr., N. Fowler, and J.L. Belant. 8 September 2015. Update on Michigan Predator Prey Project. Ottawa Sportman's Coalition Meeting, Baraga, MI. 5 attendees

Petroelje, T.R., T. Kautz, D.E. Beyer, Jr., N. Fowler, and J.L. Belant. 8 September 2015. Update on Michigan Predator Prey Project. Ontonagon Valley Sportman's Coalition Meeting, Bergland, MI. 12 attendees

Seminars and Workshops:

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 24-25 May 2015. Field techniques for wildlife capture and predation investigation. Purdue Wildlife Ecology Field Class, Crystal Falls, MI. 40 attendees.

Popular Media:

Michigan Out-of-Doors TV. April 2015. "Michigan Predator Prey Project".
https://www.michiganoutofdoorstv.com/shows.cfm?VideoID=345

906 Outdoors. March 2015. "Predator Prey Study".
http://www.906outdoors.com/906outdoors/videos/S135.html

Safari Club International Foundation. November 2014. "Weekly Update: Michigan Predator-Prey Project". SCI Foundation's First for Wildlife blog,
https://firstforwildlife.wordpress.com/2014/11/20/weekly-update-michigan-predator-prey-project-2/

Technician Hiring

During January–March 2015 and May–August 2015 we hired and employed 7 and 13 technicians, respectively. We hired one technician from 72 applicants to assist during fall 2015.

Publications

Duquette, J.F., J.L. Belant, D.E. Beyer, Jr., N.J. Svoboda, and P.E. Lederle. 2014. Effects of Maternal Nutrition, Resource Use and Multi- Predator Risk on Neonatal White-Tailed Deer Survival. Plos One 9:1-10.

Duquette, J.F., J.L. Belant, N.J. Svoboda, D.E. Beyer, Jr., and C. A. Albright. 2014. Comparison of occupancy modeling and radio-telemetry to estimate ungulate population dynamics. Population Ecology 56:481-492.

Wegan, M.T., D.R. Etter, J.L. Belant, D.E. Beyer, Jr., N.J. Svoboda, T.R. Petroelje. 2014. A Cable Neck-restraint to Live-capture Coyotes. Wildlife Society Bulletin 38:160–164.

Bowman, B, J.L. Belant, D.E. Beyer, Jr, and D. Martell. 2015. Characterizing non-target species use at bait sites for white-tailed deer. Human-Wildlife Interactions: 9:110-118.

Stillfried M., J.L. Belant, N. Svoboda, D.E. Beyer, H. Hofer, S. Kramer-Schadt. 2015. When top predators become prey: Large carnivores alter movement behavior in response to perceived mortality risk. Behavioural Processes 120:30-39.

Duquette, J.F., J.L. Belant, N.J. Svoboda, D.E. Beyer, Jr., and P.E. Lederle. (Accepted). Scale dependence of female ungulate reproductive success in relation to nutritional condition, resource selection and multi-predator avoidance. Plos One 0:000-000.

Work to be completed (September–December 2015)

White-tailed Deer Monitoring

We will use radio-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. Additionally, we will move all project equipment to Baraga in preparation for the 3rd phase of the project.

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

Cody Norton, Graduate Student (Phase 2), Northern Michigan University

Dr. Dwayne Etter, MDNR
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Jason Peterson, MDNR
Marvin Gerlach, MDNR
Jason Neimi, MDNR
Vernon Richardson, MDNR
Dusty Arsnoe, MDNR
Mark Mylchrest, MDNR

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Ballard, W. B., D. Lutz, T. W. Keegan, L. H. Carpenter, and J. C. deVos, Jr. 2001. Deer–
    predator relationships: a review of recent North American studies with emphasis on mule
    and black–tailed deer. Wildlife Society Bulletin 29:99–115.

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Carstensen, M., G. D. DelGiudice, B. A. Sampson, and D. W. Kuehn. 2009. Survival, birth
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    Wildlife Management 73:175–183.

Cook, R. C., T. R. Stephenson, W. L. Myers, J. G. Cook, and L. A. Shipley. 2007. Validating
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Cook, R. S., J. G. Cook, T. R. Stephenson, W. L. Myers, S. M. McCorquodale, D. J. Vales, L. L.
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    Wildlife Management 74:880–896.
DelGiudice, G. D., M. R. Riggs, P. Joly, and W. Pan. 2002. Winter severity, survival, and cause–
    specific mortality of female white–tailed deer in north–central Minnesota. Journal of
    Wildlife Management 66:698–717.

Duquette, J. F., J. L. Belant, N. J. Svoboda, D. E. Beyer, Jr., C. A. Albright. 2014. Comparison
    of occupancy modeling and radiotelemetry to estimate ungulate population dynamics.
    Population Ecology 56:481–492.

Jin, S, Yang, L, Danielson, P, Homer, C, Fry, J, and Xian, G. 2013. A comprehensive change detection method for updating the National Land Cover Database to circa 2011. Remote Sensing of Environment 132:159–175.

McCaffery, K. R., J. Tranetzki, and J. Piechura Jr. 1974. Summer foods of deer in northern Wisconsin. Journal of Wildlife Management 38:215–219.

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Petroelje, T. P., J. L. Belant, D. E. Beyer, Jr., G. Wang, and B. D. Leopold. 2014. Population-level response of coyotes to a pulsed resource event. Population Ecology 56:349–358.

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Stormer, F. A. and W. A. Bauer. 1980. Summer forage use by tame deer in northern Michigan. Journal of Wildlife Management 44:98–106.

Taillon, J., D. G. Sauve, and S. D. Cote. 2006. The effects of decreasing winter diet quality on foraging behavior and life–history traits of white-tailed deer fawns. Journal of Wildlife Management 70:1445–1454.

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Table 1. Mean ($\bar{x}$) and standard deviation (SD) of 43 captured adult ($n = 41$) and yearling ($n = 3$) female white-tailed deer morphometrics and body condition estimates, Upper Peninsula of Michigan, USA, January–March 2015.

Metric	Adults		Yearlings
	$\bar{x}$	SD	$\bar{x}$
Body weight (kg)	61.6	6.6	44.32
Hind foot (cm)	48.4	1.3	46.1
BCS[1]	2.5	0.6	2.13
MIDF[2] (cm)	0.62	0.6	0.16

[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 32 captured female ($n = 13$) and male ($n = 19$) neonate fawn morphometrics, Upper Peninsula of Michigan, USA, 24 May–4 July 2015.

	Sex	
	Female	Male
Estimate	$\bar{x} \pm$ SD	$\bar{x} \pm$ SD
Body Weight (kg)	4.5 ± 1.9	4.4 ± 1.2
Body Length (cm)	61.0 ± 4.8	60.0 ± 2.3
Chest Girth (cm)	35.6 ± 3.4	34.9 ± 2.3
Hind Foot (cm)	26.7 ± 2.0	26.1 ± 1.1
Shoulder Height (cm)	51.5.7 ± 7.3	48.6 ± 3.3
New Hoof Growth (mm)	2.2 ± 1.1	3.0 ± 1.1
Birth Mass (kg)[1]	4.2 ± 1.7	3.8 ± 1.0

[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. Sample sizes of radio-collared and/or ear-tagged white-tailed deer captured or monitored via telemetry, Upper Peninsula of Michigan, USA, 15 September 2014–15 September 2015.

	Adult (>1 year)		Fawn, born 2014		Fawn, born 2015		All Deer
	Female	Male	Female	Male	Female	Male	
Radio-collared	65	0	9	15	13	19	121
Ear-tagged, not collared	5	6	6	5	0	0	22
Total Marked Sample	70	6	15	20	13	19	143

Table 4. Land cover designations as defined in the national land cover database (Jin et al. 2013). Iron County, Upper Peninsula of Michigan, 2011.

Land cover class	Definition of designation
Deciduous forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Woody wetland	Areas where forest or shrub land vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Mixed forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Evergreen forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Emergent herbaceous wetland	Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Table 5. Den check data for 22 black bears, Upper Peninsula of Michigan, USA, 15 December 2015–02 March 2015.

ID	Den check date	Age	Sex	Body weight (kg)	Right ear tag	Left ear tag
BB146	15-Jan	Adult	M	90.7	407	302
BB142	16-Jan	Adult	M	115.7	269	279
BB120	23-Feb	Adult	F	50.3	229	228
BB156	23-Feb	Yearling of BB120	F	12.2	424	425
BB157	23-Feb	Yearling of BB120	M	16.3	423	422
BB163	24-Feb	Adult	F	56.7	309	308
BB179	24-Feb	Yearling of BB163	F	16.3	480	481
BB103	25-Feb	Adult	F	56.7	213	214
BB149	25-Feb	Yearling of BB103	F	18.6	413	414
BB116	27-Feb	Adult	F	65.8	239	238
BB152	27-Feb	Yearling of BB116	F	14.8	482	486
BB112	28-Feb	Adult	F	77.1	220	219
BB169	28-Feb	Cub of BB112	M	2	NA	NA
BB170	28-Feb	Cub of BB112	M	1.8	NA	NA
BB144	1-Mar	Adult	F	63.5	268	272
BB154	1-Mar	Yearling of BB144	M	15.7	353	354
BB155	1-Mar	Yearling of BB144	M	15.5	352	351
BB162	2-Mar	Adult	F	NA*	305	306
BB171	2-Mar	Cub of BB162	F	1.1	NA	NA
BB172	2-Mar	Cub of BB162	F	1.0	NA	NA
BB173	2-Mar	Cub of BB162	M	0.9	NA	NA
BB174	2-Mar	Cub of BB162	M	1.2	NA	NA

*Unable to weigh bear due to den dimensions

Table 6. 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
Bear	BB175	09-May-15	M	40.8	337	336
Bear	BB176	11-May-15	M	67.1	334	335
Bear	BB177	16-May-15	M	40.8	349	350
Bear	BB178	16-Jun-15	F	60.3	346	345
Bear	BB117	28-Jun-15	F	73.0	173	161
Bobcat	BC111	7-Mar-15	F	9.5	412	411
Bobcat	BC112	7-Mar-15	F	12.7	404	410
Bobcat	BC113	9-Mar-15	M	11.8	408	409
Bobcat	BC114	10-Mar-15	F	7.3	405	406
Bobcat	BC106	10-Mar-15	M	12.8	250	249
Bobcat	BC115	11-Mar-15	M	15.9	403	420
Coyote	CO113	21-Feb-15	F	13.6	402	401
Coyote	CO114	6-May-15	F	10.7	418	416
Coyote	CO115	16-May-15	M	12.5	347	348
Coyote	CO116	18-May-15	F	11.0	339	338
Coyote	CO117	25-May-15	F	13.0	NA	NA*
Coyote	CO118	2-Jun-15	M	10.0	110	109
Coyote	CO119	5-Jun-15	F	12.3	114	113
Wolf	WO110	4-May-15	F	28.1	1110	1109
Wolf	WO111	15-May-15	F	33.0	1238	1239
Wolf	WO102	18-May-15	M	32.0	1104	1103
Wolf	WO112	29-May-15	F	25.4	1117	1241

*Animal euthanized due to long bone fracture
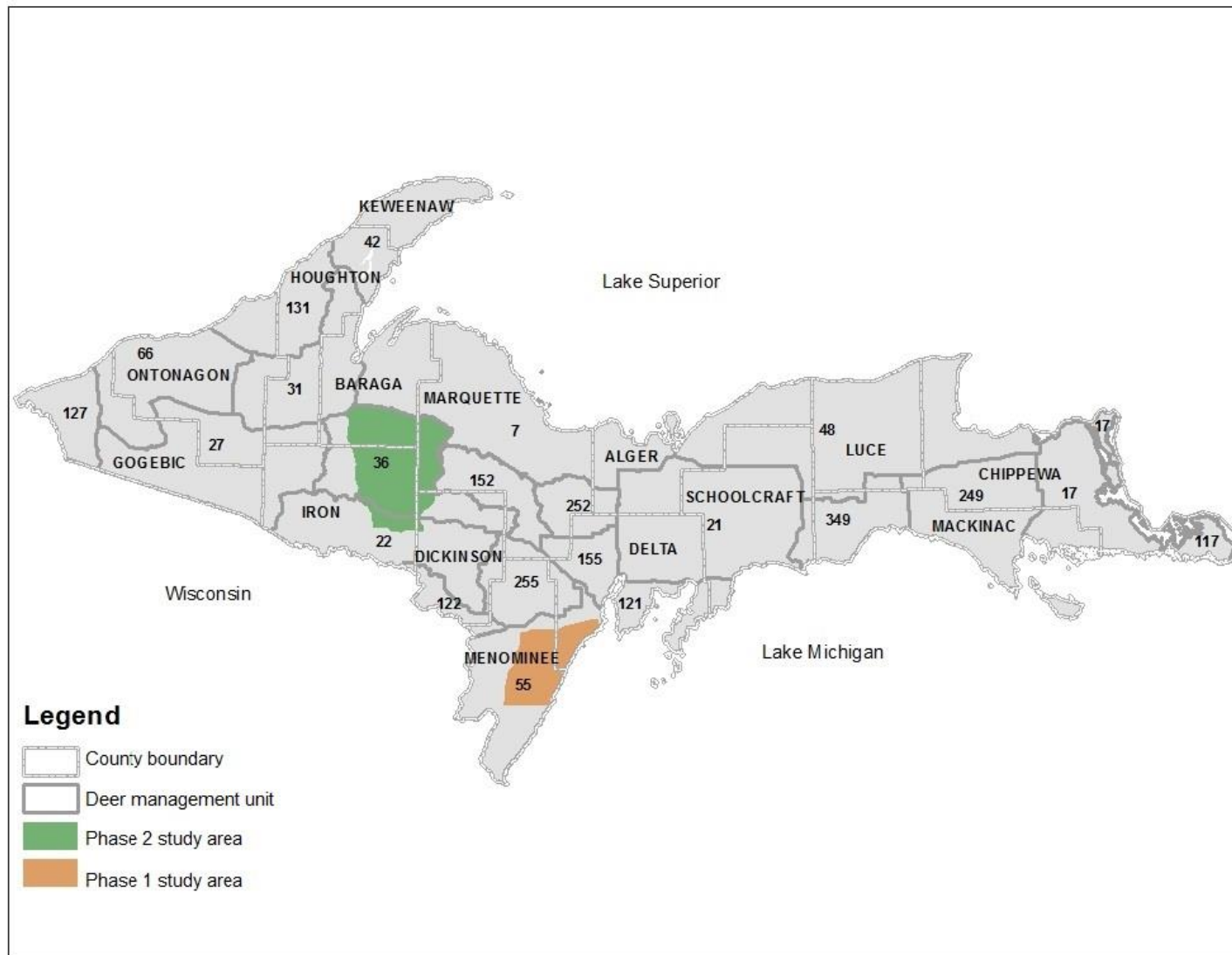
Figure 1. Location of phase 1 and 2 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, 2008–2015.
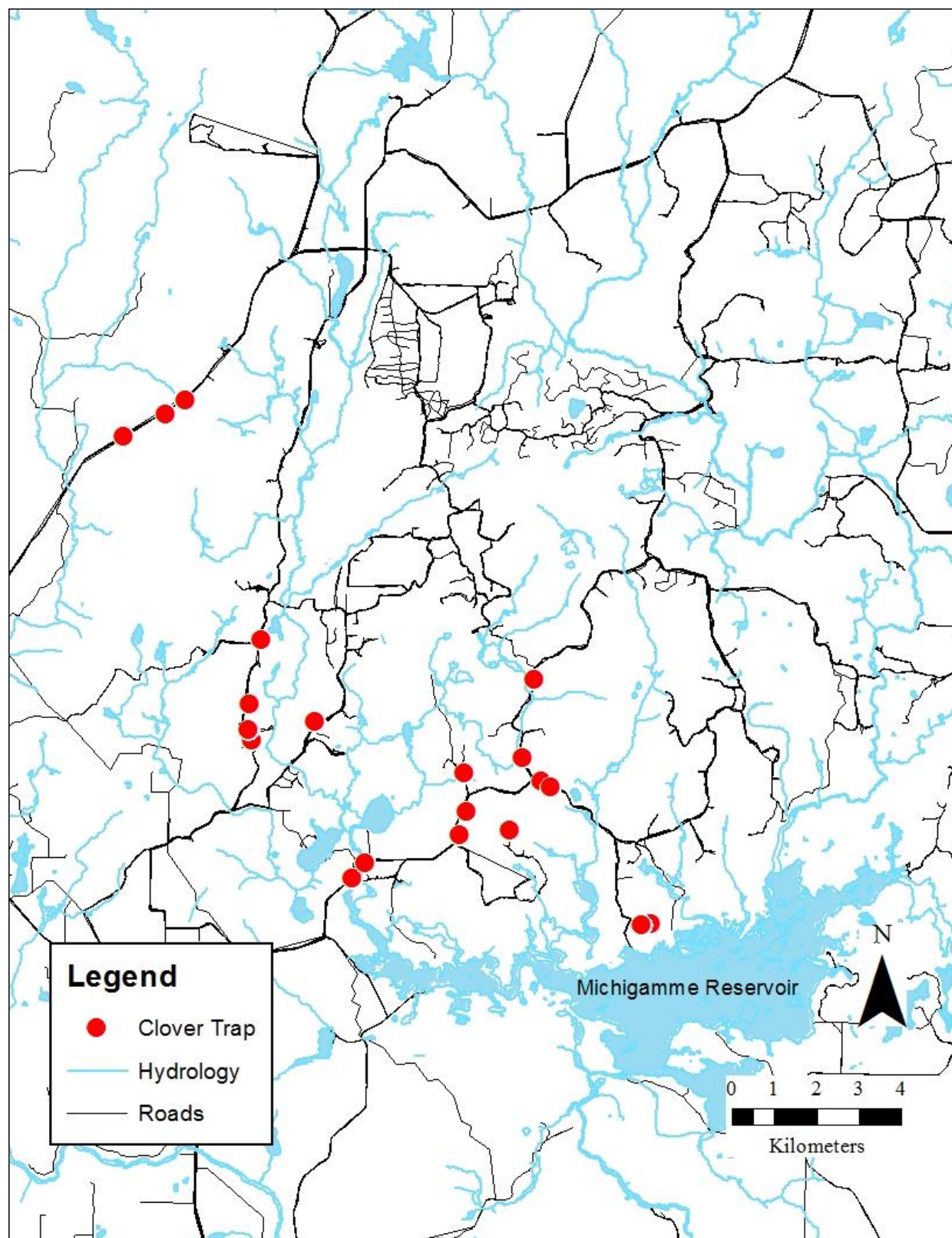
Figure 2. Locations of Clover traps for deer capture, Upper Peninsula of Michigan, USA, 11 January–26 March 2015.
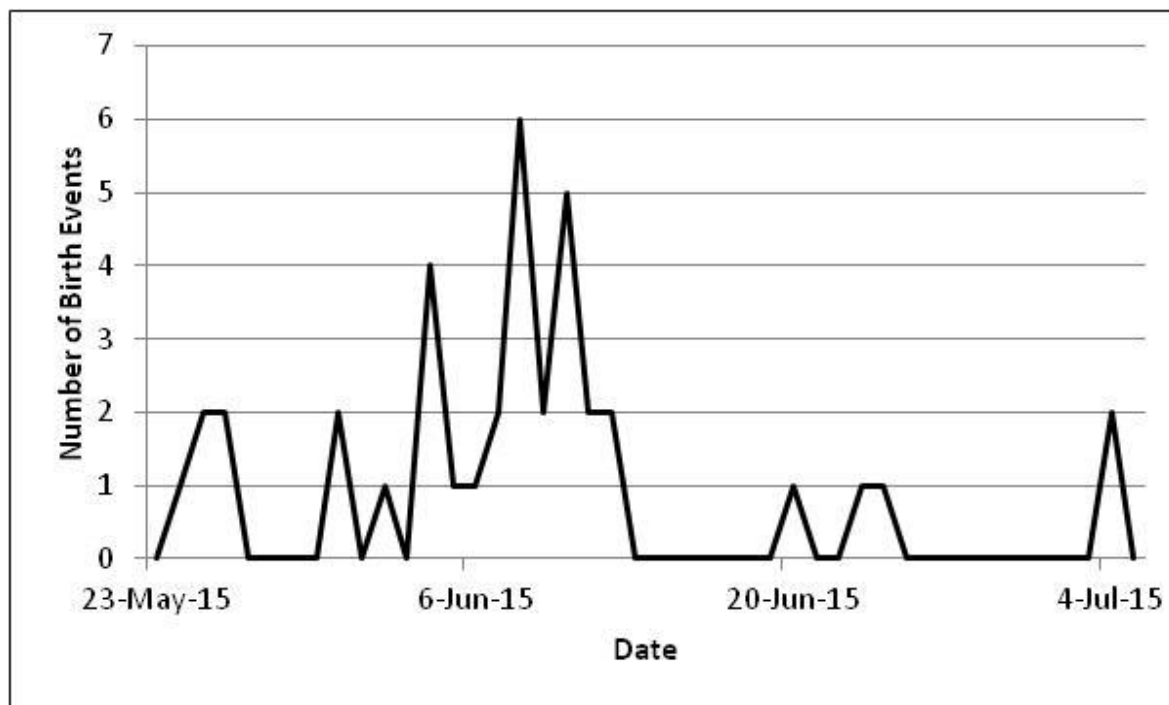
Figure 3. Estimated parturition dates of 32 free-ranging white-tailed deer fawns and 5 Vaginal Implant Transmitter drop sites where a fawn was not found but a birth site was evident, Upper Peninsula of Michigan, USA, 2015.
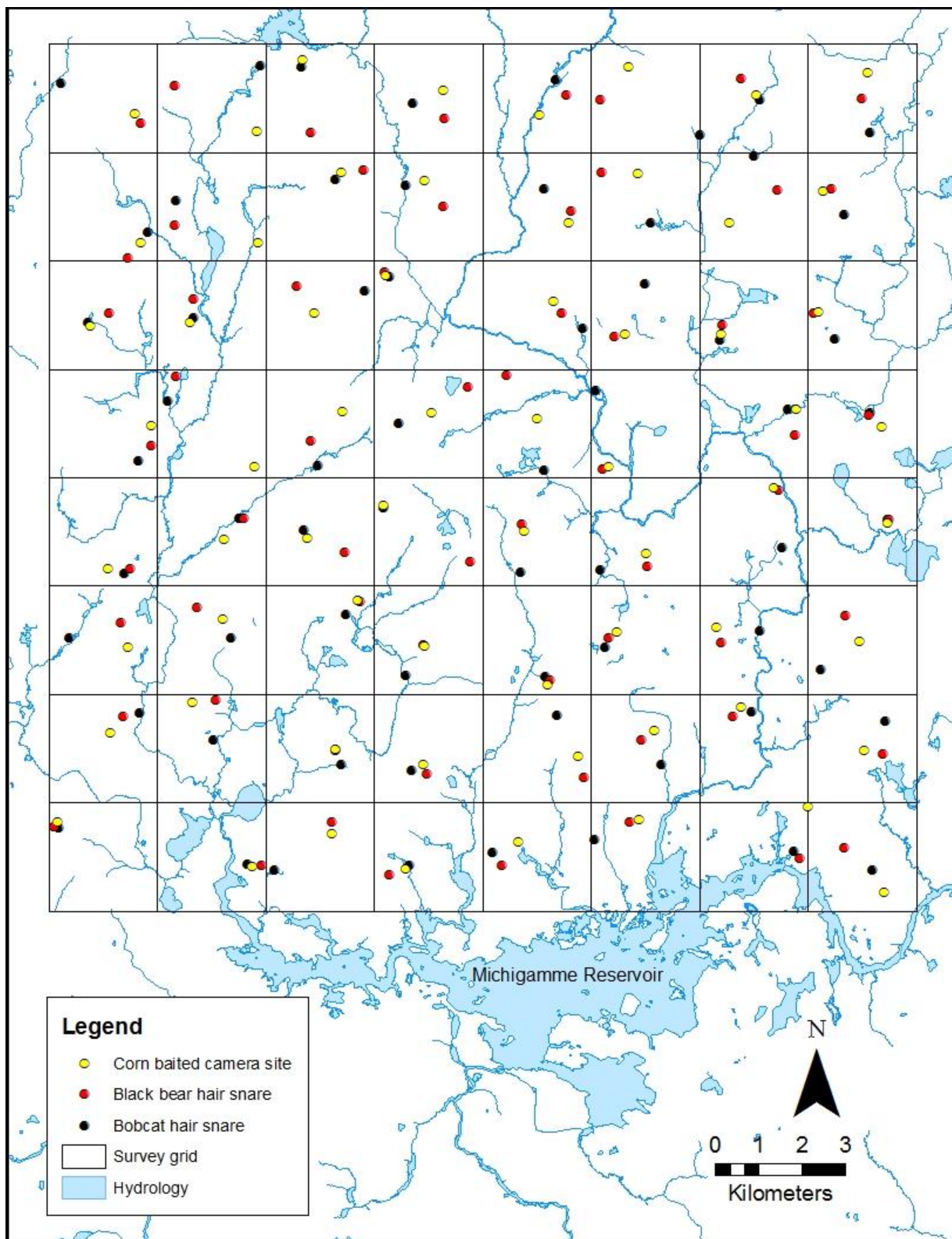
Figure 4. Locations of 64 bobcat hair snares, black bear hair snares, and corn baited camera sites to estimate bobcat, black bear, and white-tailed deer abundance, respectively; Upper Peninsula of Michigan, 2015.

Figure 5. Ear tagged black bear, bobcat, coyote, and wolf, Upper Peninsula of Michigan, USA, 2009.
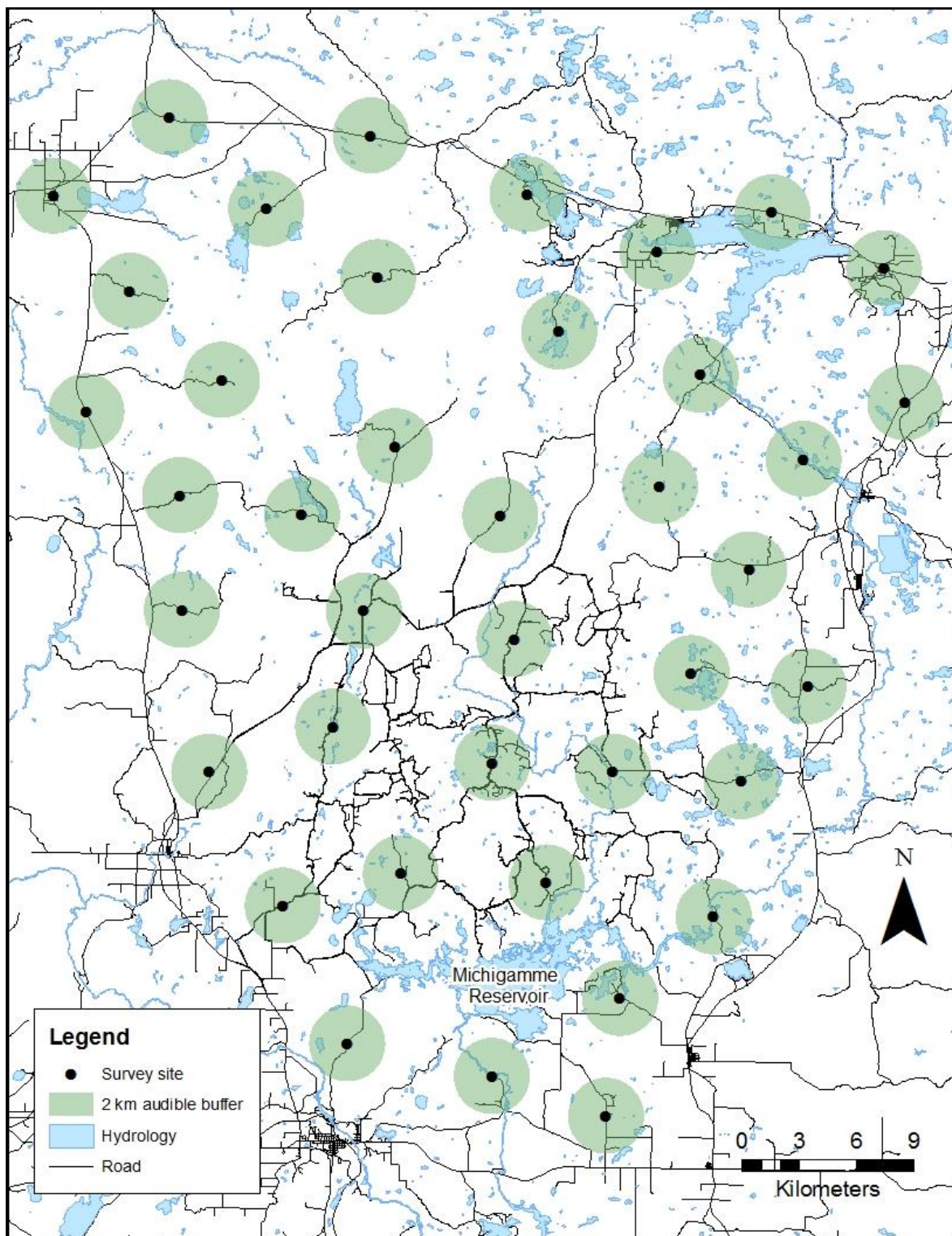
Figure 6. Locations of 40 howl survey sites to estimate coyote abundance, Upper Peninsula of Michigan, 2015.
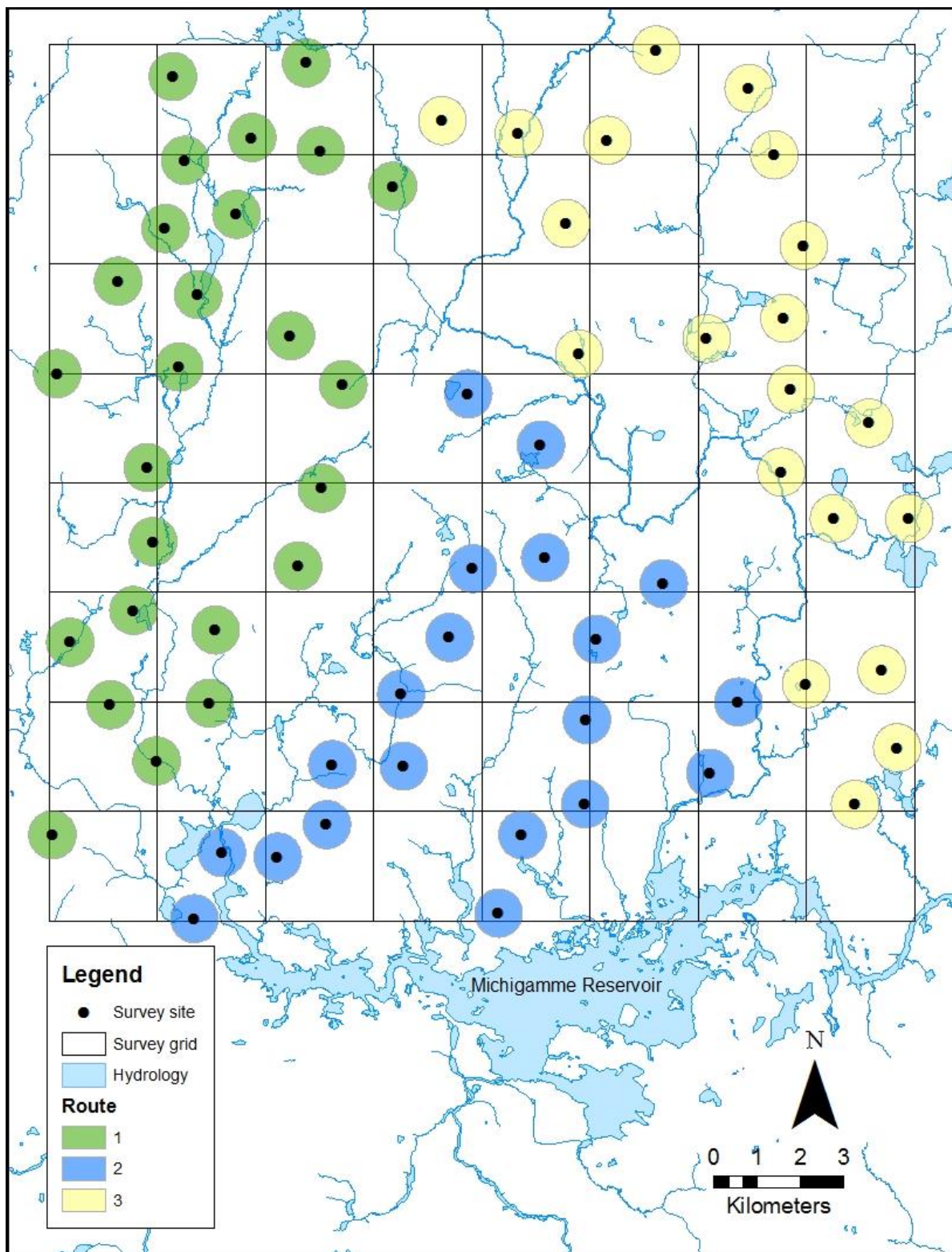
Figure 7. Locations of 65 grouse drumming survey sites with 550 m audible buffer along 3 routes to estimate abundance, Upper Peninsula of Michigan, USA, 2015.
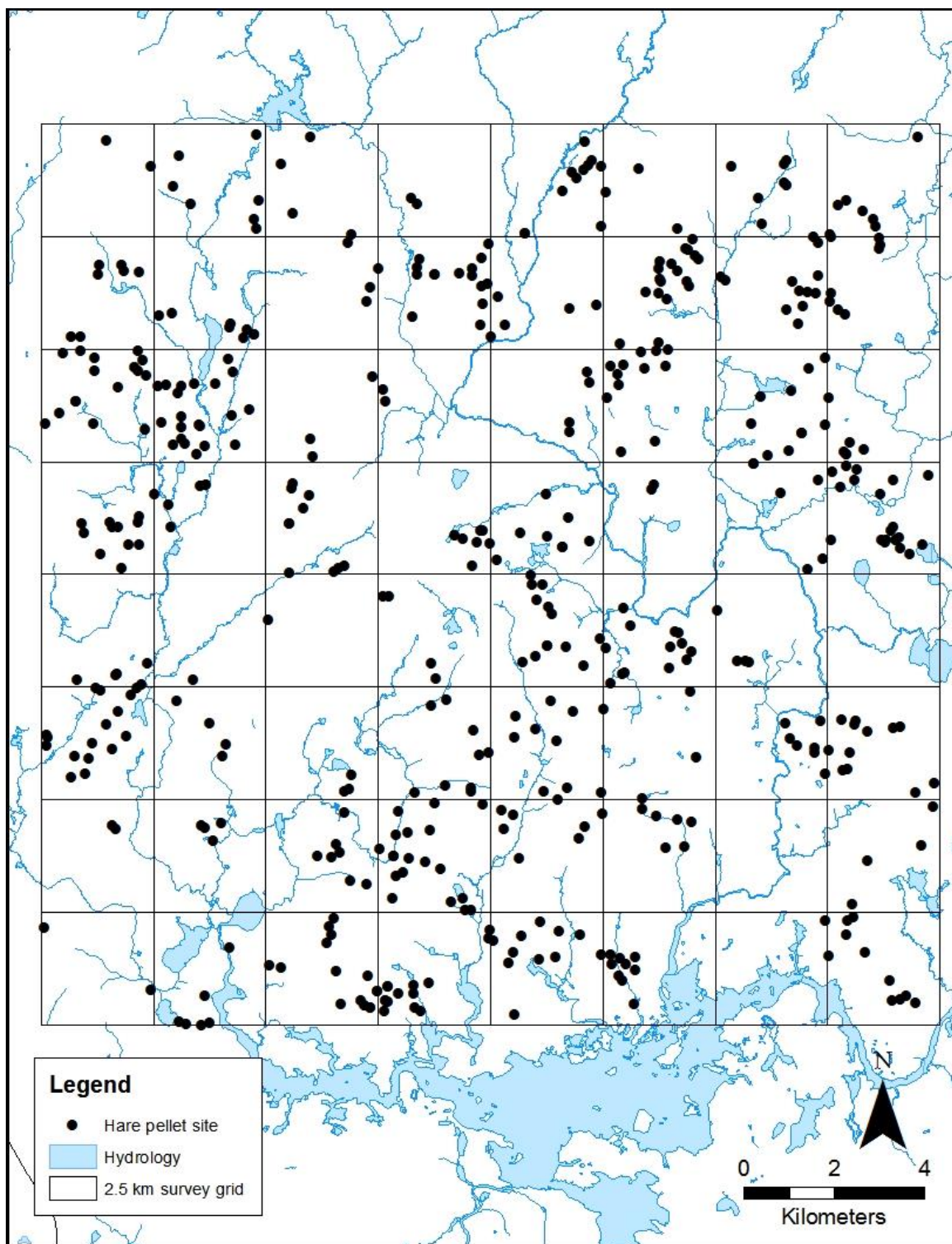
Figure 8. Locations of 448 hare pellet plot survey sites used to estimate snowshoe hare abundance, Upper Peninsula of Michigan, USA, 2015.
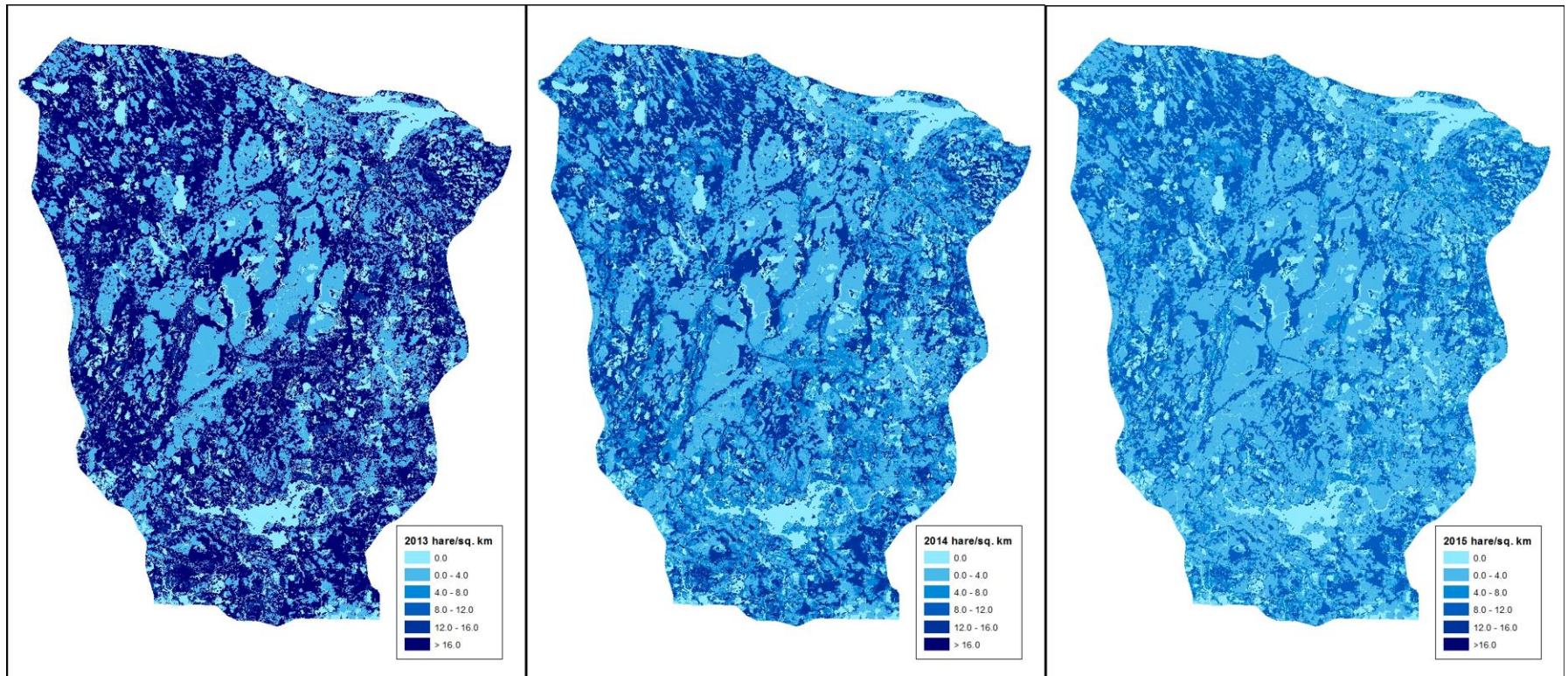
Figure 9. Snowshoe hare (*Lepus americanus*) densities by land cover type, Phase 2 study area, Upper Peninsula of Michigan, USA, 2013–2015.
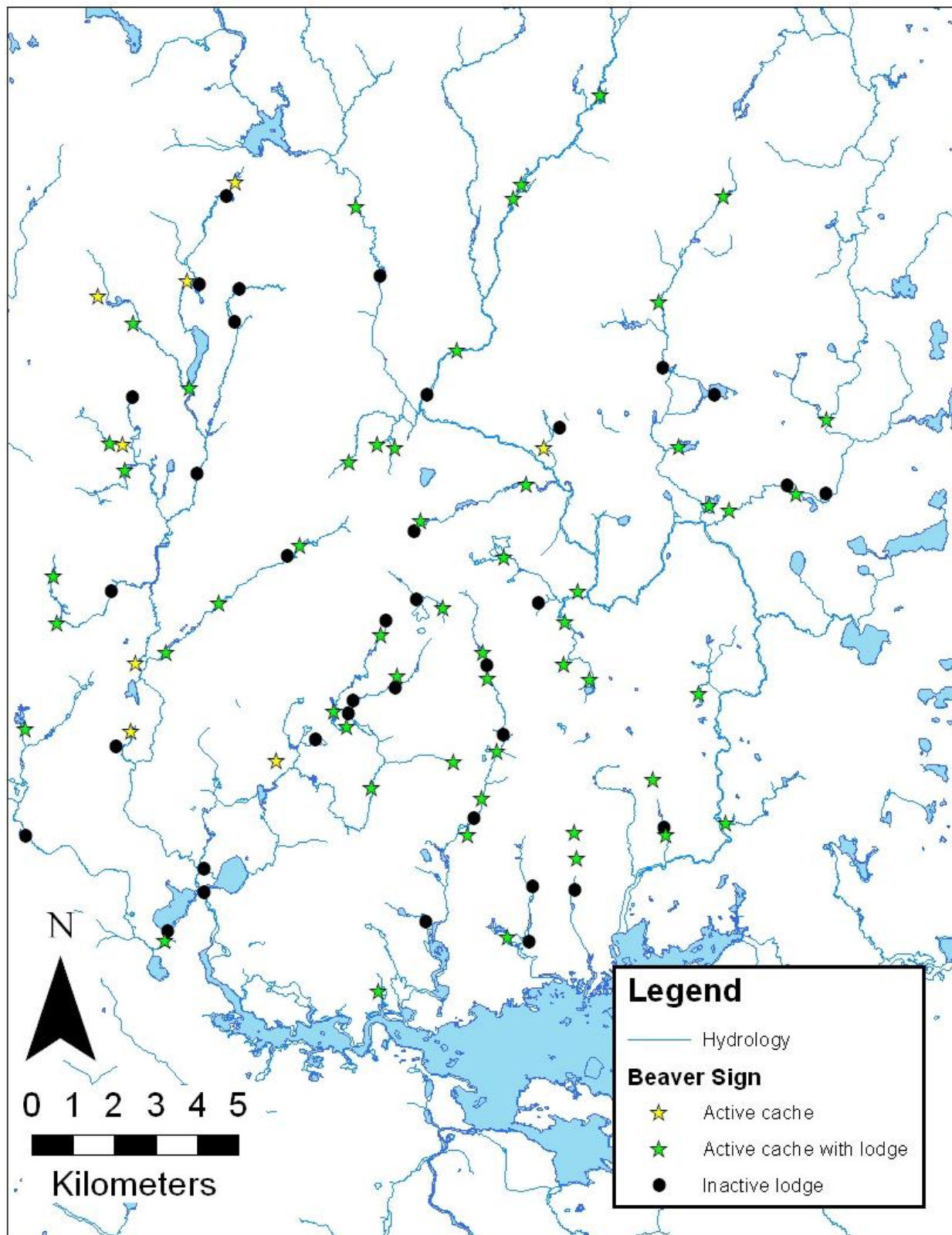
Figure 10. Locations of beaver caches and lodges detected aerially during 5–6 November, Upper Peninsula of Michigan, USA, 2014.