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 immobilized 10 adult black bear (*Ursus americanus*; 2 male, 8 female) and 1 female yearling in their dens and observed 11 cubs (9 male, 2 female) from 4 females. From January–July we captured and immobilized 6 coyotes (*Canis latrans*; 1 male, 5 female), 4 bobcats (*Lynx rufus*; 1 male, 3 female), and 4 wolves (*C.* spp.; 3 male, 1 female) and fitted them with GPS collars, and 11 adult black bears (8 male, 3 female) which were fitted with either GPS or VHF collars. We captured 119 (82 female, 37 male) individual white-tailed deer (*Odocoileus virginianus*), including 54 adults, 16 yearlings, and 49 fawns. We radio-collared forty-eight female deer, of which 46 pregnant females were also VIT tagged. We detected pregnancy with ultrasound in 100% of adult (n = 42) and 89% of yearling (n = 9) females. We captured and radiocollared 43 neonate fawns, including 26 males, 16 females, and 1 unknown. Sixteen of 29 (55%) vaginal implant transmitter searches resulted in the location of 12 live and 7 dead fawns. We obtained 2,861 adult female and 921 neonate fawn radiolocations. We observed 16 dead radiocollared adult female white-tailed deer (7 coyote predations, 3 wolf predations, 1 bobcat predation, 1 due to drowning after falling through the ice, 1 due to disease, 1 due to birthing complications/malnutrition, 1 due to illegal harvest, and 1 unknown). Twenty-six of the radiocollared fawns died as of 15 September including 19 predations (6 coyote, 2 black bear, 3 wolf, 2 bobcat, 1 fox, 1 unknown canid, and 4 unknown), one vehicle collision, and 6 mortalities in which the cause of death could not be determined in the field. We conducted 23 wolf track surveys from 1 January–15 March and identified a minimum of 30 individuals in six packs in the study area. We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimated grouse abundance and detected an average of 38 grouse per survey. We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 345 random locations stratified within 5 different land cover types to estimate hare densities with respect to available land cover. We collected 160 hair samples and 508,617 images from bobcat hair snare sites and 1,627 hair samples and 37,879 images from black bear hair snare sites. To estimate deer abundance, we placed 64 remote infrared cameras throughout the study area and obtained 8,848 images. We conducted investigations at 868 carnivore cluster sites and 328 non-cluster sites to identify carnivore prey sources and opportunistically collected 522 scats from black bear, bobcat, coyote, and wolf. During howl surveys we recorded an average coyote response rate (RR) of 26.3% and wolf RR of 2.1%. To estimate horizontal cover and deer forage with respect to available land cover, we completed vegetation surveys at 311 random locations stratified within 5 different land cover types. We placed remote cameras at 51 random locations along roadways to estimate vehicle traffic volumes. Throughout the year, we hosted many volunteers from various organizations and two photographers/videographers, gave multiple presentations, and kept our Facebook page (www.Facebook.com/MIpredprey) up to date with project results.

Summary

- We immobilized 10 adult black bear (*Ursus americanus*; 2 male, 8 female) and 1 female yearling in their dens and we observed 11 cubs (9 male, 2 female) from 4 females.

- We set 24 cable neck restraints at 4 baited sites to capture coyotes (*Canis latrans*). We captured 3 coyotes and fitted 2 with a GPS radiocollar.

- On 16 occasions we ran bobcats (*Lynx rufus*) with dogs, and captured bobcats on 3 occasions. One female bobcat was able to be collared; 2 captured bobcats were too small to collar.

- We captured 119 (82 female, 37 male) individual white-tailed deer (*Odocoileus virginianus*), including 54 adults, 16 yearlings, and 49 fawns.

- We radio-collared forty-eight female deer, of which 46 pregnant females were also VIT tagged.

- We detected pregnancy with ultrasound in 100% of adult (n = 42) and 89% of yearling (n = 9) females.

- We conducted 23 wolf track surveys and identified a minimum of six packs with territories occurring at least partly within the study area: Deer Lake (minimum 4 individuals); Mitchigan (minimum 7 individuals); Drummond Lake (minimum 2 individuals); Shank Lake (minimum 9 individuals); Michigamme (minimum 4 individuals); and Republic (minimum 4 individuals).

- We deployed hair snares and remote cameras at 64 sites throughout the study area to estimate bobcat abundance. We obtained 160 hair samples and 508,617 images.

- We captured and radiocollared 43 neonate fawns, including 26 males, 16 females, and 1 unknown.

- Sixteen of 29 (55%) vaginal implant transmitter searches resulted in the location of 12 live and 7 dead fawns.

- We obtained 2,861 adult female and 921 neonate fawn radiolocations.

- We observed 16 dead radiocollared adult female white-tailed deer. We attributed 7 to coyote predation, 3 to wolf predation, 1 to bobcat predation, 1 to drowning after falling through the ice, 1 to disease, 1 to birthing complications/malnutrition, 1 to illegal harvest, and 1 unknown.

- Twenty-six of the radiocollared fawns died as of 15 September 2013. We attributed 19 mortalities to predation: 6 coyote, 2 black bear, 3 wolf, 2 bobcat, 1 fox, 1 unknown canid, and 4 unknown predations. We also attributed one to a vehicle collision and observed 6 mortalities in which the cause of death could not be determined in the field.

- Seven fawns were found dead at the birth sites of radio collared does; 2 were stillborn, 2 were black bear predations, 1 was a coyote predation, 1 was an unknown predation, and 1 was due to poor birth health.

- We captured and immobilized 11 adult black bear (8 male, 3 female) using foot snares and barrel traps as capture techniques. We fitted 1 bear with a GPS camera collar, 2 bears with GPS radiocollars, and the remaining 8 bears with VHF radiocollars.

- We set padded foothold traps along roadways to capture bobcats, coyotes, and wolves (*Canis* spp.). We captured 1 bobcat, 4 coyotes, and 4 wolves and fitted each with a GPS radiocollar.

- We conducted investigations at 868 carnivore cluster sites and 328 non-cluster sites to identify carnivore prey.

- We opportunistically collected 522 scats from black bear, bobcat, coyote, and wolf.

- We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimated grouse abundance. On average we detected 38 grouse per survey.

- We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 345 random locations stratified within 5 land covers to estimate hare densities.

- We deployed hair snares at 64 sites throughout the study area to estimate black bear abundance and obtained 1,627 samples of black bear hair.

- We completed vegetation surveys at 311 random locations stratified within 5 different land cover types to estimate horizontal cover and deer forage with respect to available land cover.

- We placed remote cameras at 51 random locations along roadways to estimate vehicle traffic volumes.

- We placed 64 remote infrared cameras throughout the study area to estimate deer abundance and obtained 8,848 images.

- We obtained a coyote response rate (RR) of 26.3% and wolf RR of 2.1% to broadcasted recordings of coyote group-yip-howls during howl surveys.

- We hosted multiple volunteers/observers representing the Michigan Department of Natural Resources (MDNR), Northern Michigan University, Safari Club International, Michigan Technological University, MI Hound Hunters, and friends and relatives of current project staff. We also hosted Dave Kenyon, MDNR photographer, and photographer/videographer Rick Westphal, who took photos and video footage of project staff performing field duties.

- We attended the Iron-Dickinson Sportsman Coalition meeting hosted by the MDNR to discuss the project with representatives from several local stakeholder groups.

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

- We gave presentations to the Northern Michigan University chapter of The Wildlife Society, a local church group, students of Forest Park School’s biology classes and West Iron County School’s conservation class, and a local chapter of The Audubon Society.

- We hired 6 technicians for January–March, 16 for May–August, and 2 for September–December.

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 most capture efforts and population surveys will occur, 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 Escanaba where deer migrate only short distances or are non-migratory (Beyer et al. 2010) and yard less frequently.

Accomplishments

Black Bear Den Checks

During 23 January–23 February we immobilized 10 adult black bears (2 male, 8 female) and 1 female yearling. We weighed, recorded morphometric measurements, and drew blood from each immobilized bear. We replaced very high frequency (VHF) radiocollars with Global Positioning System (GPS) radiocollars on all previously collared adult black bears. We programmed these collars to obtain a location every 35 h until 1 May and then every 15 min until the collar is removed in the den. We handled 11 cubs (9 male, 2 female) from 4 adult females; mean litter size was 2.75 (SD = 0.96; Table 1).

Coyote Cable Neck Restraints

We baited 6 locations with vehicle-killed deer carcasses to attract coyotes for capture during 16 February–19 March. We set 24 relaxing-lock cable neck restraints at 4 sites and successfully captured 3 female coyotes. One coyote escaped the cable neck restraint before we arrived to immobilize the individual. One coyote mortality occurred from thermal shock likely due to severe mange. We immobilized 2 coyotes, fit them with GPS radiocollars, and affixed ear tags (Table 2). We also drew blood, collected a hair sample, and recorded morphological measurements.

Bobcat Capture

We used dogs (*n* = 1–3) to run bobcats on 16 occasions during 6–25 March. We successfully captured 2 female bobcats using a dart gun once the bobcats were treed or cornered on the ground, and captured 1 female bobcat in a box trap. Once immobilized, we weighed, sexed, and collected morphometric measurements from bobcats. We affixed a GPS radiocollar on 1 of the bobcats that we programmed to record locations every 15 minutes from 1 May until 31 August. We were unable to collar the other 2 bobcats due to their low weight (5.9 and 5.6 kg [Table 2]).

Winter Deer Capture

From 5 January 2012–10 March 2013 we captured white-tailed deer in Clover traps to place radiocollars on pregnant females (Figure 2). We captured 119 deer (82 females, 37 males), with an additional 74 recaptures. Individual captures included 46 adult females, 8 adult males, 9 yearling females, 7 yearling males, 27 female fawns, and 22 male fawns. The female:male fawn ratio was 1:0.81. We attempted to collect body condition scores (BCS) and attach ear tags (females = blue, males = yellow) to each deer. We also assessed pregnancy of yearling and adult females using ultrasonography.

Females (*n* = 75) and males (*n* = 36) had mean (± SD) BCS (scale: 1 [moribund]–5 [obese]) of 2.8 ± 0.5 and 2.8 ± 0.4, respectively. Eight capture related mortalities occurred; 5 resulted from a vertebral fracture from striking the Clover trap, 1 from a broken tibia in the trap, and 2 were likely related to physiological stress from the capture event.

We immobilized 48 females and fitted them with a radiocollar (model 2610B, Advanced Telemetry Systems Inc., Isanti, MN), and also fitted 46 of the 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 a reversal drug was administered. We estimated and recorded deer morphometrics and maximum (MAXF) and mid-rump (MIDF) fat depths (Table 3) when practical. We detected pregnancy with ultrasound in 100% of adults (*n*= 42) and 89% of yearlings (*n*= 9).

Wolf Abundance Estimation: Track Surveys

We conducted 23 wolf track surveys between 1 January and 15 March. We also recorded wolf tracks, scat, urine, and sightings opportunistically while performing other field duties.

We used track surveys 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 four GPS collared individuals to estimate territorial boundaries and home range sizes for three packs in the study area; the Deer Lake, Republic, and Mitchigan packs (Figure 3). Based on this information and data gathered in previous years, we identified a minimum of six packs with territories occurring at least partly within the study area: Deer Lake (minimum 4 individuals); Mitchigan (minimum 7 individuals); Drummond Lake (minimum 2 individuals); Shank Lake (minimum 9 individuals); Michigamme (minimum 4 individuals); and Republic (minimum 4 individuals).

Bobcat Abundance Estimation: Hair Snares

We began baiting 64 bobcat hair snare sites (Figure 7) on 18 December 2012. After a two-week pre-baiting period, we set 4–5 hair snares at each site beginning 2 January 2013. We also deployed a trail camera at each site, directed at the bait, to capture 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–5 March 2013.

We collected 160 hair samples of target and non-target species and sent samples to the MDNR Wildlife Disease Laboratory in Lansing for DNA extraction. We also obtained 508,617 camera images containing at least 34 species of birds and mammals. Data entry and analysis is ongoing.

Fawn Capture

Beginning 27 May, we captured, radiocollared, and obtained radio-locations for white-tailed deer fawns. Forty-three neonate fawns were captured and fitted with expandable radiocollars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN, USA) from May to June, consisting of 26 males, 16 females, and 1 unknown. We attached 2 individually numbered plastic ear tags to fawns and attempted to collect fawn morphometrics (Table 4), blood, hair, vitals, and identify sex. We also recorded bed site and surrounding habitat, flush distance, presence of dam, additional deer sighted, and handling time as available. Mean fawn handling time was 18 minutes. Temporal range of fawn parturition was between 20 May and 26 June, peaking around 9 June (Figure 5).

We conducted vaginal implant transmitter (VIT) searches to find fawns of 29 implanted pregnant adult females. Two adult females have not expelled the VIT as of 15 September. Sixteen of 29 (55%) VIT searches resulted in the location of ≥1 live or dead fawn. We recorded 12 live fawns, 2 stillborns, one “weak fawn syndrome” mortality, 2 black bear predations, 1 coyote predation, and 1 unknown predation during VIT searches.

Deer Telemetry

We used aerial telemetry and ground triangulation to locate radiocollared adult females and neonate fawns. We obtained 2,861 adult female and 921 neonate fawn locations. Repeated relocation attempts of 1 fawn have been unsuccessful, presumably due to radiocollar malfunction.

Deer Mortality

We recorded 16 mortalities of radiocollared does. Eleven of these mortalities were attributed to predation (7 coyote, 3 wolf, and 1 bobcat). Additionally, 1 mortality appeared related to birthing complications and malnutrition, 1 yearling appeared to have drowned after falling through the ice, 1 died of disease, and 1 was attributed to illegal harvest. We were unable to determine cause of death for 1 doe.

Of the 43 collared fawns, 26 died as of 5 September 2013. Predation was the largest source of mortality, accounting for 19 fawns. We identified 6 coyote, 2 black bear, 3 wolf, 2 bobcat, 1 fox, 1 unknown canid, and 4 unknown predations. In addition to predation, 1 fawn was killed by a vehicle collision, and 6 mortalities in which the cause of death could not be determined in the field are being evaluated at the Michigan Department of Natural Resources Diagnostics Laboratory. We also observed seven additional fawns which were dead at the birth sites of radio collared does; 2 were stillborn, 2 were black bear predations, 1 was a coyote predation, 1 was an unknown predation, and 1 was due to poor birth health. Additionally, we observed 1 black bear predation while opportunistically searching for the fawn.

Spring/Summer Carnivore Capture

During 22 May–2 July we captured 11 adult black bears (8 male, 3 female) with foot snares and barrel traps, and captured 1 male bobcat, 4 coyotes (1 male, 3 female), and 4 wolves (3 male, 1 female) using padded foothold traps. We immobilized captured individuals and recorded gender, weight, and affixed uniquely numbered ear tags (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 GPS radiocollars (Lotek Engineering, Newmarket, ON, Canada). Of the 11 captured bears, we fitted 8 (6 males, 2 females) with VHF radiocollars and 2 (1 male, 1 female) with Lotek 7000MU GPS radiocollars. We also fitted one male 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 radiocollars 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 radiocollars 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 radiocollars with a drop-off mechanism to release collars 25–35 weeks after deployment. We fit all radiocollars on black bears with a leather breakaway device, as a safety measure, in case bears disperse and cannot be relocated.

Carnivore Monitoring

One GPS (BB122) and one VHF (BB142) radiocollared black bear slipped their collars on 19 May and 16 July, respectfully. One GPS collared female coyote, CO103, was hit and killed by a vehicle on 28 July. This year, GPS radiocollared black bears have carried collars for 60–219 consecutive days ($\bar{x}$ = 160, SD = 59), resulting in 5,760–11,779 locations per individual ($\bar{x}$ = 9,912, SD = 3,250). Bobcats have carried GPS radiocollars for 98–166 consecutive days ($\bar{x}$ = 132, SD =48), resulting in 9,408–11,742 locations per individual ($\bar{x}$ = 10,575, SD = 1651). Coyotes have carried GPS radiocollars for 82–189 consecutive days ($\bar{x}$ = 125, SD = 44), resulting in 7,872–11,758 locations per individual ($\bar{x}$ = 9,483, SD = 1484). Wolves have carried GPS radio collars for 85–99 consecutive days ($\bar{x}$ = 91, SD = 6), resulting in 8,160–9,504 locations per individual ($\bar{x}$ = 8,760, SD = 556).

Carnivore Cluster Investigation

We used clusters of carnivore locations obtained from GPS radiocollars to identify potential kill sites and estimate the number of prey species killed. In 2013, we investigated 868 GPS location clusters and 328 non-cluster locations identified using ArcGIS and the statistical program R (R Development Core Team, Vienna, Austria). We defined a cluster as >8 locations within 50 m of each other within a 24-hour period. Of the 868 clusters investigated this year, 318 were black bear (mean clusters/black bear = 30.0, SD = 20.5), 107 bobcat (mean clusters/bobcat = 53.5, SD = 7.8), 214 coyote (mean clusters/coyote = 42.8, SD = 27.9), and 229 wolf (mean clusters/wolf = 57.3, SD = 17.2). Of the 328 non-clusters, 115 were black bear (mean non-clusters/black bear = 9.8, SD = 5.3), 54 bobcat (mean non-clusters/bobcat = 27.0, SD = 9.9), 73 coyote (mean non-clusters/coyote = 14.6, SD = 10.5), and 86 wolf (mean non-clusters/wolf = 21.5, SD = 8.1).

Preliminary results from cluster investigations include black bears foraging on chokecherries (*Prunus virginiana*), black cherries (*P. serotina*), raspberries (*Rubus ideaus*), blueberries (*Vaccinium* spp.), and various colonial insects (e.g., ants). We identified black bear clusters where foraging and bedding sites co-occurred including 5 fawn predations found at black bear clusters. We identified 1 unknown bird species, 1 ruffed grouse (*Bonasa umbellus*), 1 porcupine (*Erithizon dorsatum*), 1 short-tailed weasel (*Mustela erminea*), 4 fawns, and 2 yearling deer predations at bobcat clusters sites. We identified predations of 1 American robin (*Turdus migratorius*), 1 blue jay (*Cyanocitta cristata*), 2 snowshoe hare (*Lepus americanus*), 4 ruffed grouse, 3 fawn, and 1 yearling deer at coyote clusters. We identified predations of 1 turkey polt (*Meleagris gallopavo*), 1 ruffed grouse, 7 adult deer, and 9 fawns at wolf clusters. Analysis of cluster findings is ongoing.

Carnivore Scat Collection

We opportunistically collected 522 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 washed and packaged 508 scats (211 black bear, 14 bobcat, 86 coyote, and 85 wolf) to be sent to Mississippi State University's Carnivore Ecology Laboratory for identification of prey remains.

Ruffed Grouse Drumming Surveys

We conducted ruffed grouse drumming surveys during 4–18 May. We conducted surveys from one half hour before sunrise until 5 hours after sunrise. Each survey contained 3 routes with 20–25 sites in each route for a total of 65 sites (Figure 5). Observers listened for 5 minutes at each site for drumming grouse and recorded number and bearing of each drumming grouse. We detected drumming grouse at 42 sites and on average counted 38 grouse each survey. We will use site occupancy to estimate male grouse density.

Snowshoe Hare Pellet Counts

We conducted snowshoe hare pellet counts from 2 May to 11 June. We counted number of hare pellets within a 1 m^2 rectangle at 345 random sites (Figure 6). We separated pellet counts into 5 main land covers (deciduous, coniferous, mixed forest, woody wetland, and open herbaceous). We will relate hare pellet densities to hare abundance using a linear regression developed by McCann et al. (2008).

Black Bear Abundance Estimation: Hair Snares

During 21 May–15 July we conducted a hair snare survey to estimate black bear abundance. Hair snares (n = 64; Figure 7), 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 1,627 samples of black bear hair. We sent these hair samples to the MDNR lab for DNA extraction and subsequent individual identification.

Vegetation Survey

From 7 May–12 August we conducted vegetation surveys at 311 random locations within 5 main land cover types (deciduous, coniferous, mixed forest, woody wetland, and herbaceous wetland). At each random location we established 5 plots. Within each plot, we estimated horizontal cover and % cover of tree, shrub, and herbaceous plants selected for by white-tailed deer (McCaffery et al. 1974, Stormer and Bauer 1980). We also collected vegetation samples, which are currently being dried and weighed. We will use vegetation data to estimate forage availability within each of our land cover types.

Traffic Survey

Limited mobility period: From 3 June–23 June we placed trail cameras at 15 random locations along primary roads and 17 random locations along secondary roads to estimate vehicle traffic. At each location, we recorded traffic for 7 days and used these data to estimate vehicles/hour. Traffic volumes were low and highly variable for primary and secondary roads (Table 5).

Social mobility period: From 28 July–19 August we placed trail cameras at 11 random locations along primary roads and 14 random locations along secondary roads. We are currently summarizing traffic volume data from this period.

Deer Abundance Estimation: Camera Survey

We pre-baited sixty-four sites throughout the study area (Figure 7) with 7.5 *l* of whole kernel corn beginning 12 August and re-baited sites at 3-day intervals. We placed remote infrared cameras at each of the pre-baited sites beginning 22 August and retrieved cameras by 3 September; at each site we will use a total of ten days of camera data. We obtained 8,848 images. From camera images, we will estimate deer abundance/density for the 298.1 km^2 sampling area using an occupancy modeling approach (Royle and Nichols 2003).

Coyote Abundance Estimation: Howl Surveys

We completed 6 howl surveys at 40 sites (Figure 8) beginning on 20 July, starting on the 1st, 10th, and 20th of every month and spanning 4 days per survey, weather permitting. We elicited vocalizations using a FoxPro game caller (FoxPro Inc., Lewistown, PA) using a group-yip howl to call coyotes. 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 15 September 2013 we have obtained a coyote response rate (RR) of 26.3% and obtained five wolf responses (2.1% RR). Collection of howl survey data is ongoing, with 2 more surveys planned beginning on 20 September and 1 October. We will estimate coyote abundance using an occupancy modeling approach (Petroelje et al. 2013).

Public Outreach

During winter black bear den checks we hosted individuals from Michigan Department of Natural Resources (MDNR), Northern Michigan University, Safari Club International (SCI), Michigan Technological University, Michigan Hound Hunters Association, and friends and relatives of project staff.

On 14 January 2013, we attended the Iron-Dickinson Sportsman Coalition meeting hosted by the MDNR, where we discussed the project with representatives from several local stakeholder groups.

From 25–28 February 2013 we hosted Dave Kenyon, MDNR photographer. Kenyon took images and video footage of project staff performing various field duties and will provide this media to SCI to promote the project. We hosted 3 volunteers/observers representing the Michigan Department of Natural Resources (MDNR) during June 2013. We also hosted a professional videographer, Rick Westphal of Westphal Productions, during May, June, and August 2013. Rick took photographs and video footage of project staff performing various field duties and provided this media to Safari Club International Foundation to promote the project.

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

Presentations:

Libal, N.S., T.R. Petroelje, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 18 October 2012. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Northern Michigan University Student Chapter, The Wildlife Society, Marquette, MI. 40 attendees.

Libal, N.S., T.R. Petroelje, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 13 February 2013. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan*. Crystal Falls Methodist Men's Breakfast Group, Crystal Falls, MI. 20 attendees.

Libal, N.S., T.R. Petroelje, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 11 April 2013. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan*. Forest Park Middle School, Crystal Falls, MI. 35 attendees.

Libal, N.S., T.R. Petroelje, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 18 April 2013. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan*. West Iron County Public School, Iron River, MI. 25 attendees.

Libal, N.S., T.R. Petroelje, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 12 August 2013. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Lee LeBlanc Chapter, the Audubon Society, Iron River, MI. 30 attendees.

Popular Media:

Iron County Reporter, Autumn in the Woods 2013. August 2013. "Predator-prey study taking place in Crystal Falls area". *Contributing writer:* Nicole Mitchell.

Libal, N.S., J.L Belant, and D.E. Beyer, Jr. September 2013. "Estimating White-Tailed Deer Fawn Survival in Michigan". SCI Foundation's First For Wildlife Blog, www.firstforwildlife.wordpress.com.

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Technician Hiring

During January–March 2013 and May–August 2013 we employed 6 and 16 technicians, respectively. We currently have two technicians to assist with fall projects.

Publications

Duquette, J.F., J.L. Belant, D.E. Beyer, Jr., and N.J. Svoboda. 2013. Body condition and dosage effects on ketamine-xylazine immobilization of female white-tailed deer. Wildlife Society Bulletin 36:In press.

Petroelje, T.P., J.L. Belant, and D.E., Beyer, Jr. 2013. Factors affecting the elicitation of vocal responses from coyotes. Wildlife Biology 19:41–47.

Svoboda, N.J., J.L. Belant, D.E. Beyer, Jr., J.F. Duquette, and J.A. Martin. 2013. Identifying bobcat kill sites using a global positioning system. Wildlife Biology 19:79–86.

Work to be completed (September–December 2013)

Carnivore Monitoring and GPS Radiocollar Recovery

We will continue to monitor collared carnivores twice monthly until drop-off mechanisms detach beginning 21 September for bobcats, coyotes, and wolves. We will recover the dropped radiocollars and download location and activity data. We will then clear 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 conduct black bear den checks beginning in mid-December to change GPS collar batteries on collared black bear.

White-tailed Deer Monitoring

We will use radiotelemetry 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.

Deer Forage Availability Estimation

We will continue drying and weighing vegetation samples obtained during the summer. We will then compare the dry weights across the five vegetation classes to estimate forage available to white-tailed deer within different land covers.

Bobcat Hair Snares

We will repair and replace bobcat hair snares as necessary and prepare deployment sites in September–October. We will also collect and freeze bait, either road-killed deer carcasses, deer from local game processors, or beaver carcasses collected from private trappers. We will pre-bait snare sites in mid-December in preparation for the survey beginning in January 2014.

Wolf Track Surveys

We will begin winter track surveys for wolves at first snowfall, likely in late November or early December, and will continue until we identify the number of packs and individuals/pack within the study area. We will conduct track surveys via truck, snowmobile, or ATV 24–48 hours after snowfall to allow for animal movement. Once identified, we will follow wolf tracks until we confirm number of individuals traveling together. We will use the number of independent tracks in each group and the distribution of groups to estimate minimum abundance.

Technician Hiring

We will post an advertisement for available positions in early October, conduct interviews, and make final selections by November. We plan to hire 5 or 6 technicians for January–March to assist with winter field work.

Equipment Organization, Inventory, and Storage

We will inventory, organize, repair, and store all summer field equipment. We will also replace netting and trigger mechanisms on Clover traps in preparation for the winter deer-trapping season, and repair and store all project ATVs.

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.

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Nathan Svoboda, Graduate Student (Phase 1), Mississippi State University
Todd Kautz, Graduate Student (Phase 2), Mississippi State University
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Missy Stallard	Jessie Roughgarden	Alyssa Roddy
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Table 1. Den check data for 22 black bears, Upper Peninsula of Michigan, USA, 23 January–23 February 2013.

ID	Capture date	Age	Sex	Body weight (kg)	Right ear tag	Left ear tag
BB115	23 Jan	Adult	Male	60.8	235	234
BB104	5 Feb	Adult	Male	115.7	156	155
BB112	16 Feb	Adult	Female	70.3	220	219
BB123	16 Feb	Cub from BB112	Male	0.8	NA	NA
BB124	16 Feb	Cub from BB112	Male	0.9	NA	NA
BB125	16 Feb	Cub from BB112	Male	0.8	NA	NA
BB102	17 Feb	Adult	Female	50.4	154	153
BB126	18 Feb	Adult	Female	82.6	287	288
BB127	18 Feb	Cub from BB126	Female	1.6	NA	NA
BB128	18 Feb	Cub from BB126	Male	1.81	NA	NA
BB103	19 Feb	Adult	Female	54.8	213	214
BB117	20 Feb	Adult	Female	89.8	173	161
BB129	20 Feb	Cub from BB117	Male	1.3	NA	NA
BB130	20 Feb	Cub from BB117	Male	1.8	NA	NA
BB116	21 Feb	Adult	Female	53.5	239	238
BB131	21 Feb	Yearling from BB116	Female	10.8	283	284
BB120	22 Feb	Adult	Female	78.4	229	228
BB122	23 Feb	Adult	Female	73.9	170	171
BB134	23 Feb	Cub from BB122	Male	0.9	NA	NA
BB135	23 Feb	Cub from BB122	Male	1.3	NA	NA
BB136	23 Feb	Cub from BB122	Male	0.9	NA	NA
BB137	23 Feb	Cub from BB122	Female	1.1	NA	NA

Table 2. Carnivore capture data, Upper Peninsula of Michigan, USA, 1 January–30 June 2013.

Species	ID	Capture date	Sex	Body weight (kg)	Right ear tag	Left ear tag
Black Bear	BB138	30-May	Male	NA	NA	NA
Black Bear	BB139	6-Jun	Male	59.9	295	296
Black Bear	BB140	7-Jun	Female	41.3	261	262
Black Bear	BB141	15-Jun	Female	52.2	290	289
Black Bear	BB142	22-Jun	Male	115.7	269	279
Black Bear	BB143	23-Jun	Male	56.7	266	280
Black Bear	BB144	24-Jun	Female	45.4	271	272
Black Bear	BB145	24-Jun	Male	27.7	286	285
Black Bear	BB146	28-Jun	Male	47.6	301	302
Black Bear	BB147	29-Jun	Male	54.4	324	325
Black Bear	BB148	2-Jul	Male	83.9	303	304
Bobcat	BC101	6-Mar	Female	5.9	281	282
Bobcat	BC102	12-Mar	Female	5.6	NA	NA
Bobcat	BC103	17-Mar	Female	10.4	NA	265
Bobcat	BC104	25-May	Male	13.4	NA	294
Coyote	CO101	21-Feb	Female	NA	NA	NA
Coyote	CO102	22-Feb	Female	12.4	291	292
Coyote	CO103	26-Feb	Female	10.4	275	276
Coyote	CO104	22-May	Female	10.4	298	297
Coyote	CO105	23-May	Female	10.9	299	300
Coyote	CO106	29-May	Female	NA	264	263
Coyote	CO107	10-Jun	Male	NA	273	274
Wolf	WO101	24-May	Male	32.7	1107	1108
Wolf	WO102	1-Jun	Male	36.3	1104	1103
Wolf	WO103	2-Jun	Female	32.2	1113	1114
Wolf	WO104	7-Jun	Male	34.0	1106	1101

Table 3. Mean ($\bar{x}$) and standard deviation (SD) of 51 captured adult (*n* = 42) and yearling (*n* = 9) female white-tailed deer morphometrics and body condition estimates, Upper Peninsula of Michigan, USA, January–March 2013.

	Age Class			
	Adults		Yearlings	
Metric	$\bar{x}$	SD	$\bar{x}$	SD
Body weight (kg)	63.4	6.0	52.5	5.1
Body length (cm)	153.8	6.3	146.3	10.0
Total length (cm)	177.8	6.7	170.1	9.0
Chest girth (cm)	95.3	5.0	89.0	4.3
Neck circumference (cm)	39.4	3.8	37.2	2.7
Shoulder length (cm)	96.8	3.5	92.9	3.1
Hind foot (cm)	48.0	1.6	47.4	1.6
Tail length (cm)	24.0	3.4	23.9	2.7
Head length (cm)	32.6	2.0	29.4	2.4
Ear length (cm)	15.6	0.8	15.2	0.4
Front teat length (mm)	15.8	4.2	8.8	2.8
Front teat width (mm)	9.1	3.0	4.8	0.9
Back teat length (mm)	16.6	4.2	9.1	3.3
Back teat width (mm)	9.3	3.5	4.6	1.6
BCS[1]	3.0	0.5	2.8	0.5
MIDF[2] (cm)	0.5	0.3	0.7	0.4
MAXF[3] (cm)	0.9	0.3	1.4	1.0

[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 ishial tuberosity on right hip (Cook et al. 2007).

[3] Maximum rump fat (MAXF) estimate measured above ishial tuberosity of right hip (Cook et al. 2007).

Table 4. Mean ($\bar{x}$) and standard deviation (SD) of 43 captured female (n = 16), male (n = 26), and unknown sex (n = 1) neonate fawn morphometrics, Upper Peninsula of Michigan, USA, May–June 2013.

	Sex		
	Female	**Male**	**Unknown**
Estimate	**$\bar{x}$ ± SD**	**$\bar{x}$ ± SD**	**$\bar{x}$**
Body weight (kg)	4.3 ± 1.6	3.6 ± 1.3	3.5
Body length (cm)	60.7 ± 7.4	57.3 ± 9.3	55.0
Chest girth (cm)	34.8 ± 5.3	32.3 ± 4.4	32.4
Hind foot (cm)	25.5 ± 2.1	24.8 ± 2.7	23.7
Shoulder height (cm)	41.3 ± 7.4	40.3 ± 5.6	34.1
New hoof growth (mm)	3.0 ± 1.3	2.8 ± 1.0	2.0
Birth mass (kg)[1]	3.5 ± 1.2	2.9 ± 1.0	3.3

[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 Ulrey 1984, Carstensen et al. 2009).

Table 5. Hourly mean vehicle traffic data for primary (n = 15) and secondary (n = 17) roads during fawns' limited mobility period, Upper Peninsula of Michigan, USA, June 2013.

Road Type	$\bar{x}$	**SD**	**Range**
Primary	0.32	0.43	0.01–1.7
Secondary	0.07	0.07	0.01–0.21

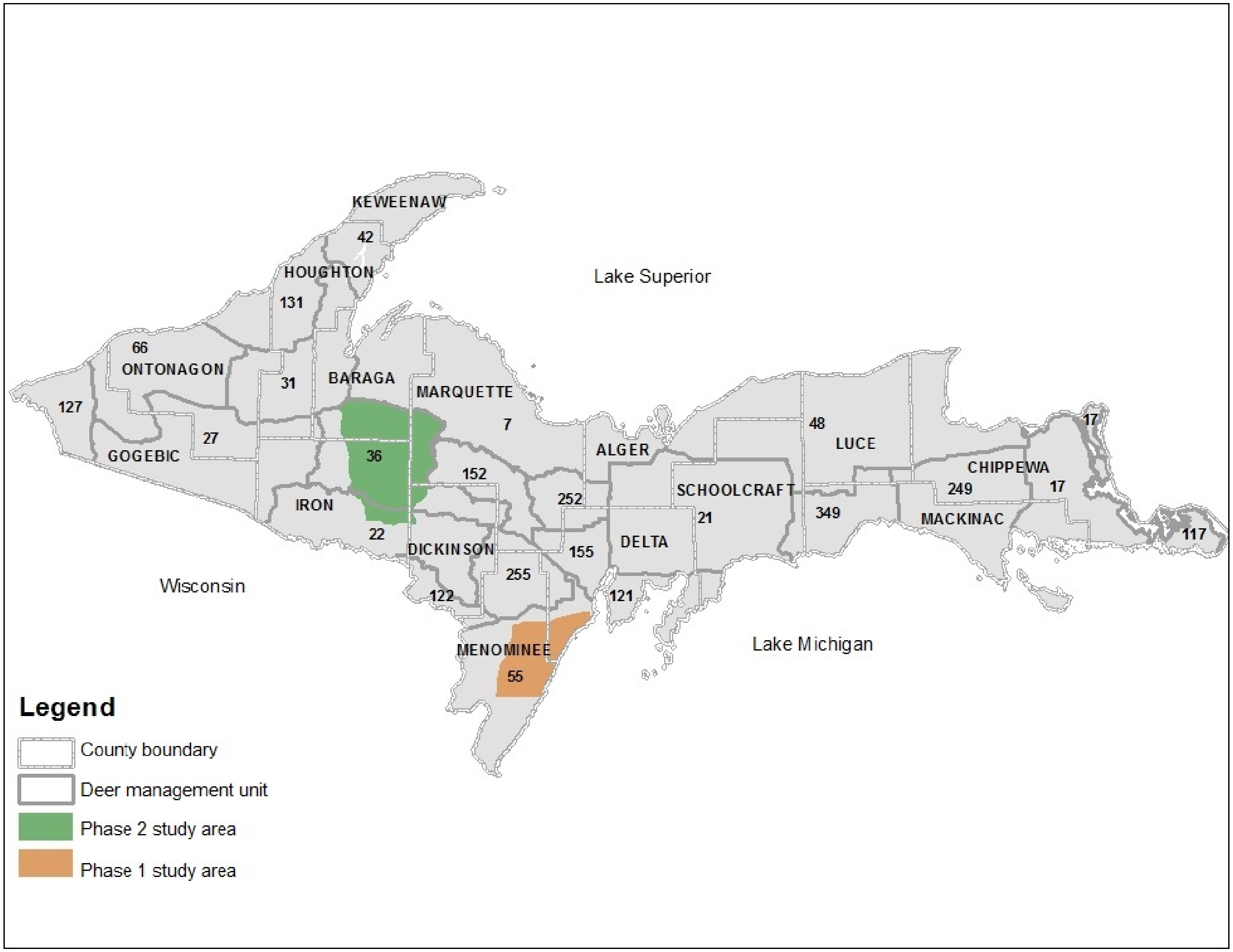

Figure 1. Location of phase 1 and 2 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, 2013.

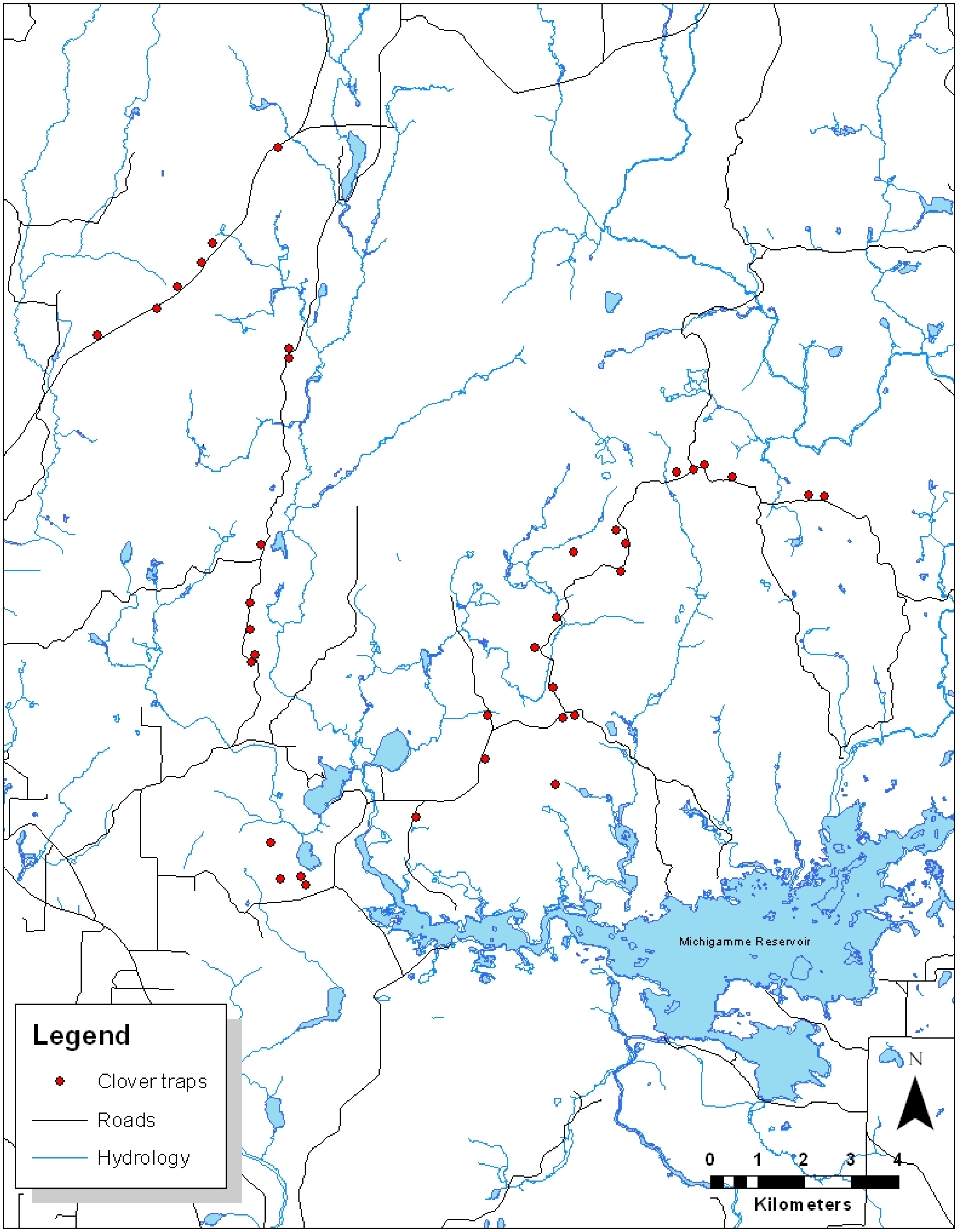

Figure 2. Locations of 45 Clover traps, Upper Peninsula of Michigan, USA, January–March 2013.

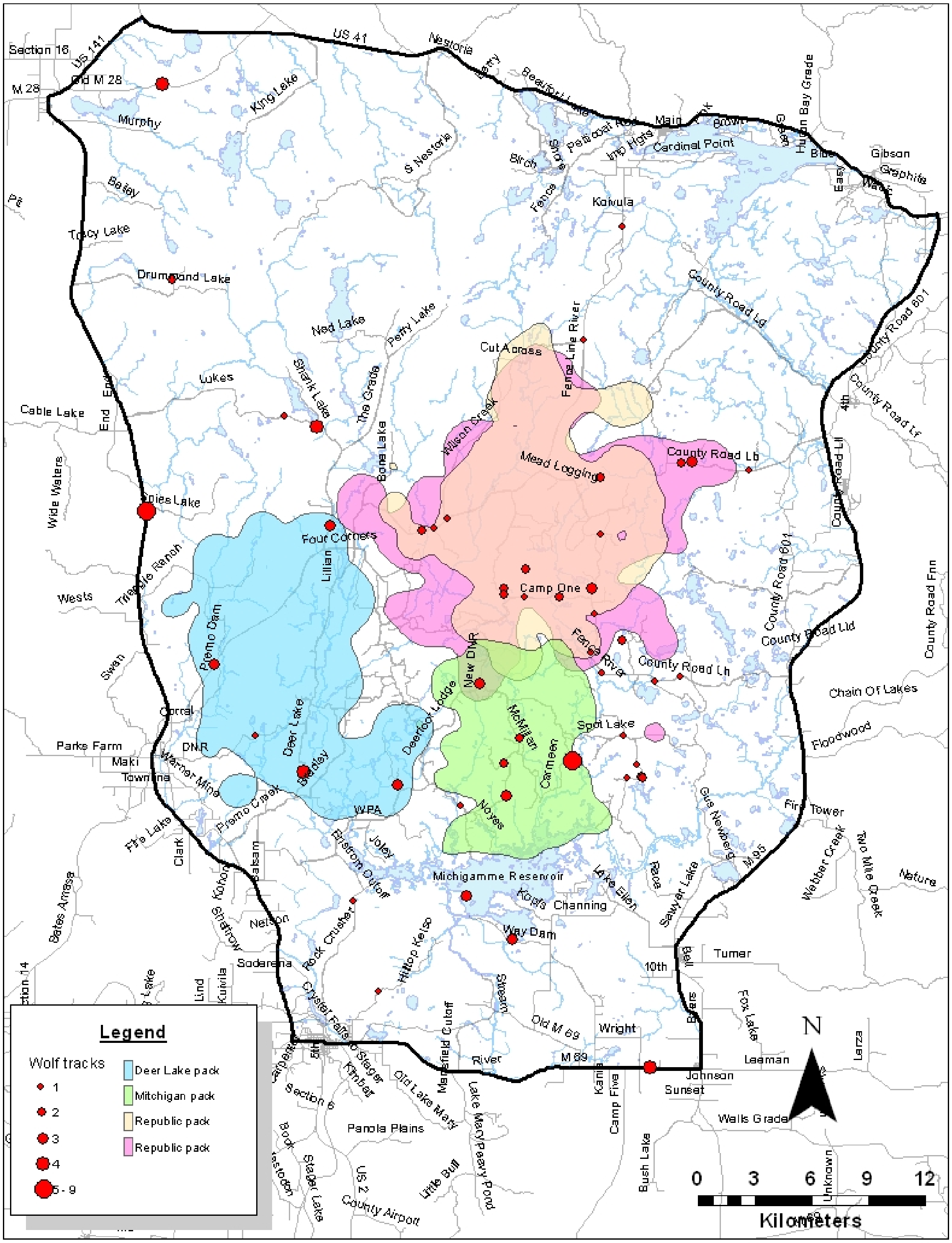

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Figure 3. Estimated wolf pack territories (shaded polygons) from GPS collar locations of 4 individuals, May 2013–September 2013. Locations and estimated number of wolves (red circles) derived from track surveys, Upper Peninsula of Michigan, USA, January–March 2013.

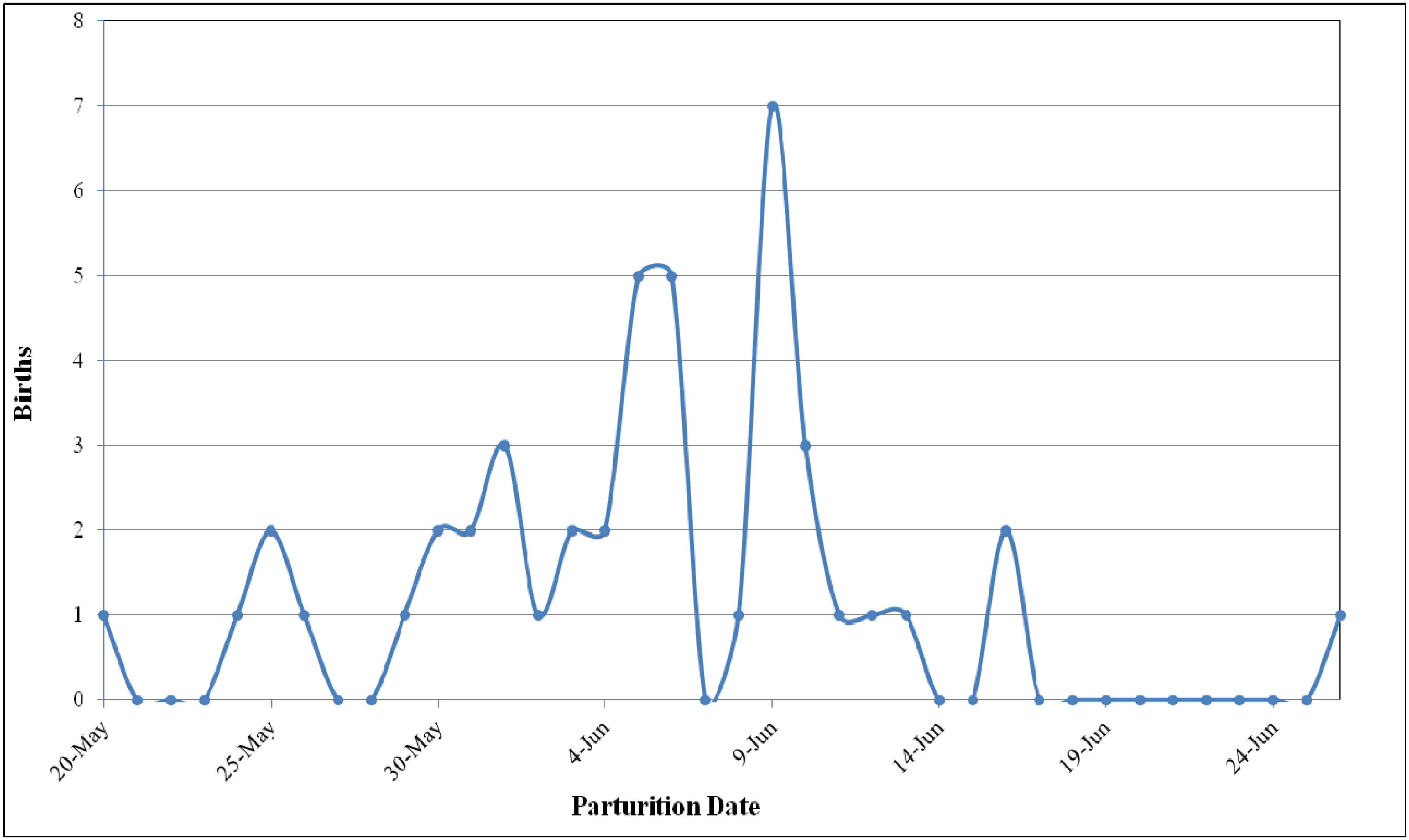

Figure 4. Estimated parturition dates of 43 free-ranging white-tailed deer fawns, Upper Peninsula of Michigan, USA, 2013.

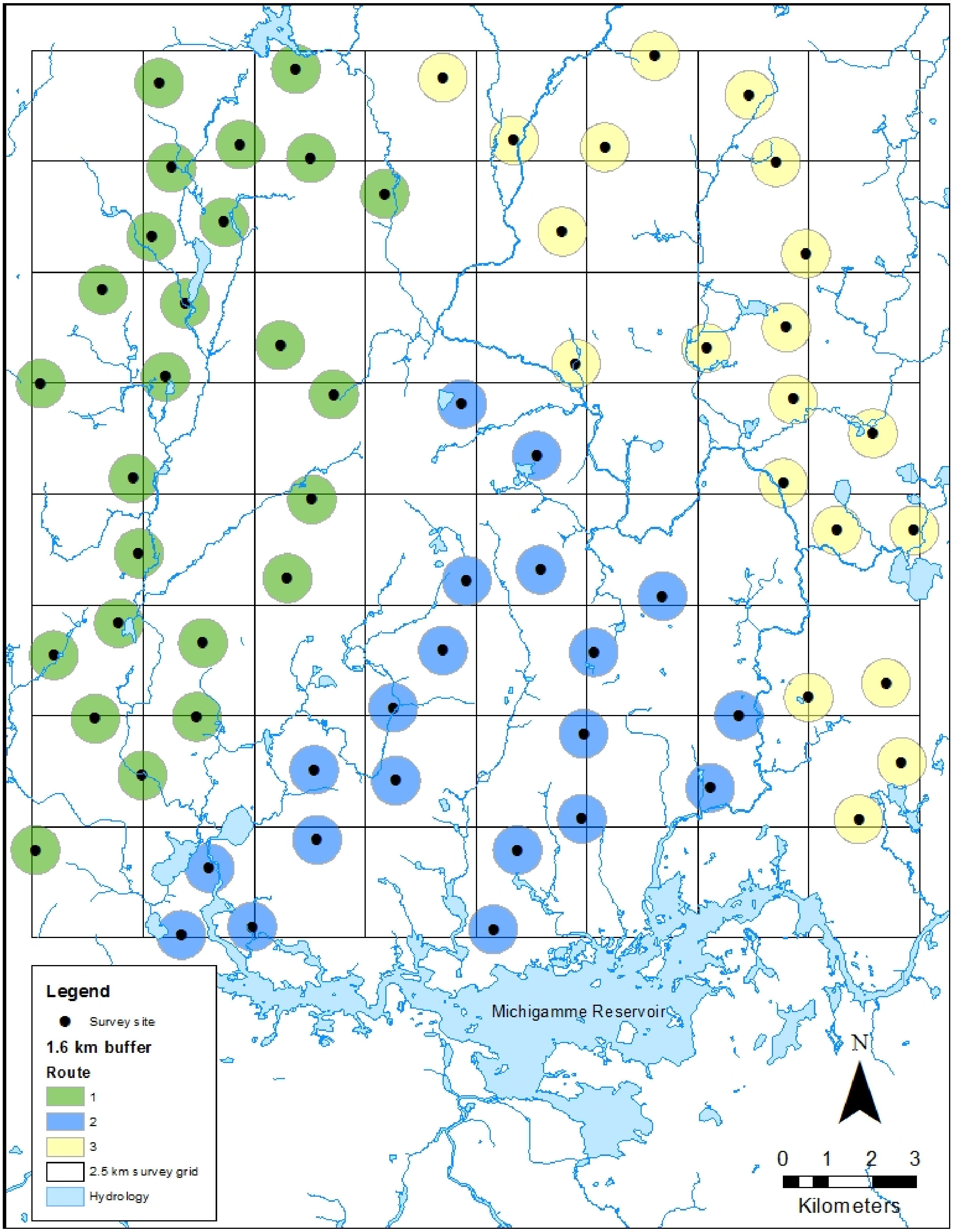

Figure 5. Locations of 65 grouse drumming survey sites by 3 route to estimate abundance, Upper Peninsula of Michigan, USA, 2013.

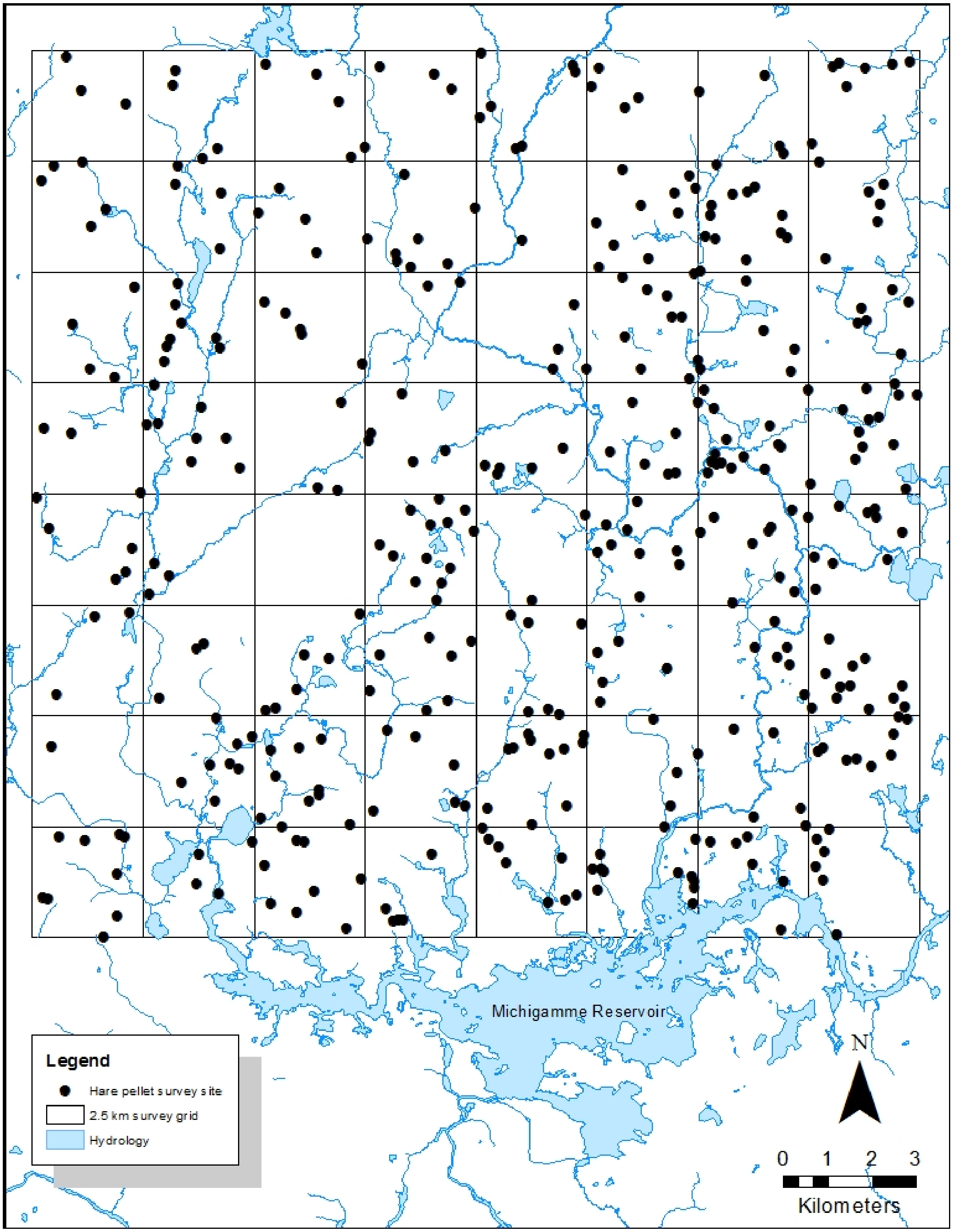

Figure 6. Locations of 345 snowshoe hare pellet survey sites used to estimate abundance, Upper Peninsula of Michigan, USA, 2013.

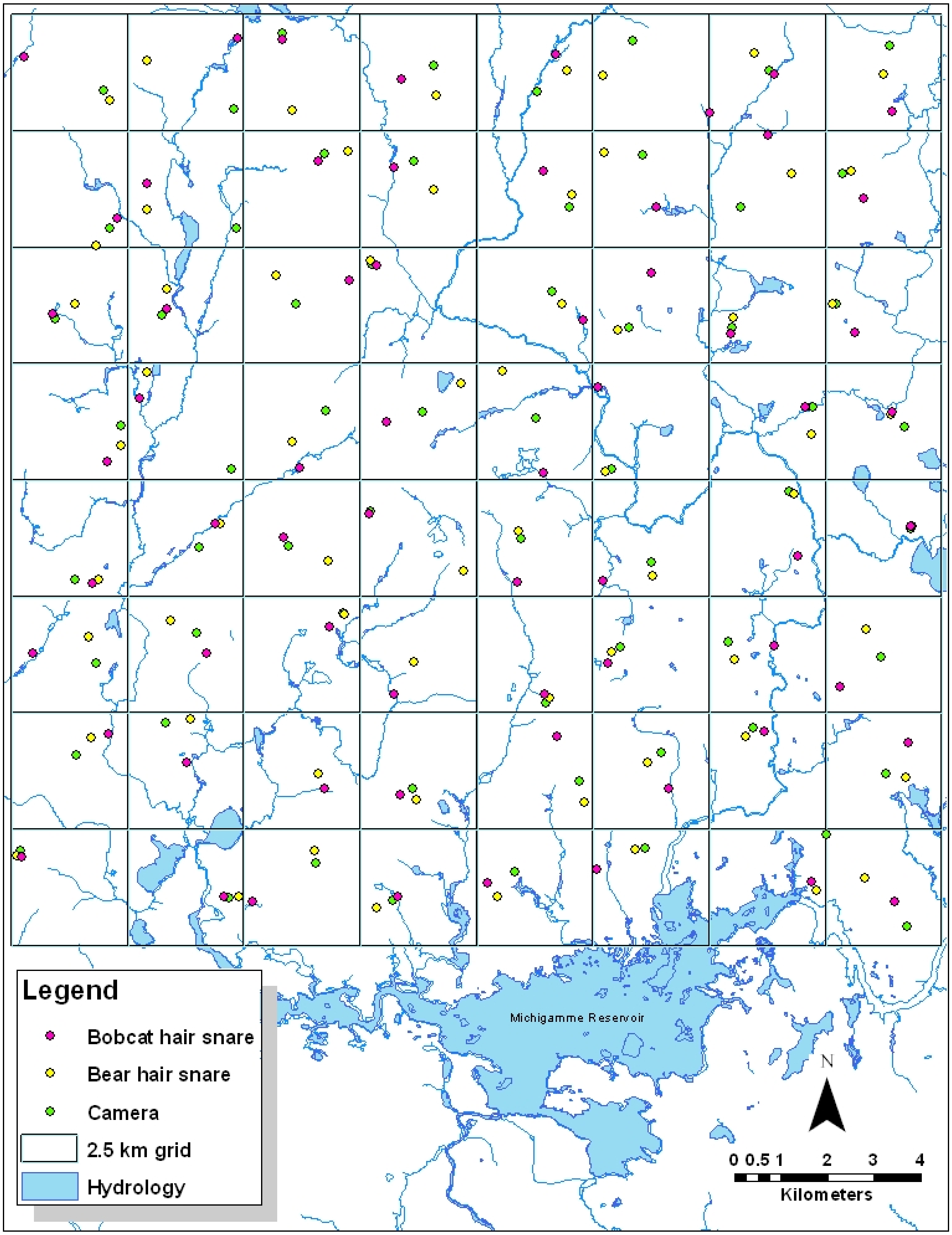

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Figure 7. Locations of 64 bobcat hair snares, black bear hair snares, and cameras to estimate bobcat, black bear, and white-tailed deer abundance, respectively; Upper Peninsula of Michigan, 2012–2013.

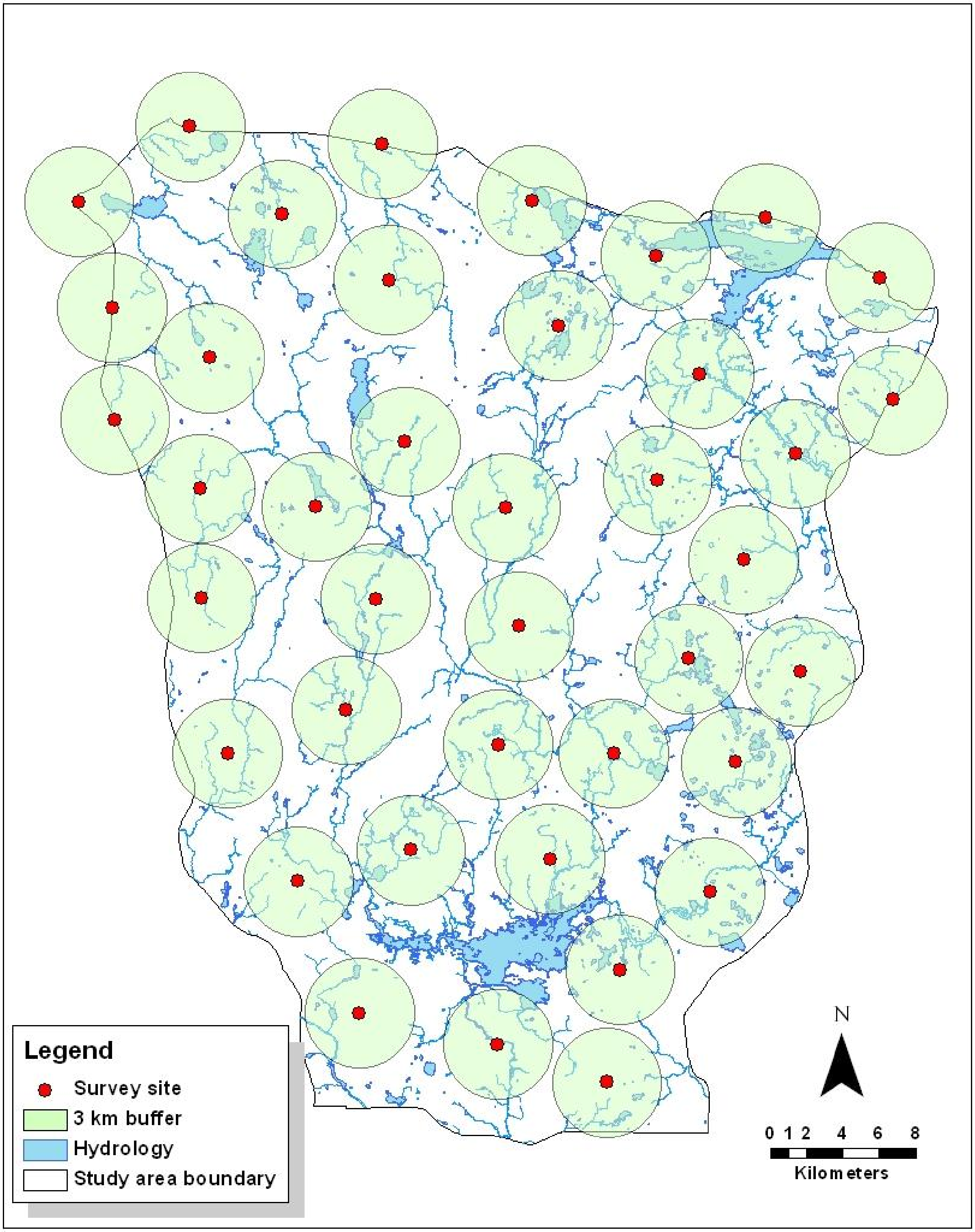

Figure 8. Locations of 40 howl survey sites to estimate coyote abundance, Upper Peninsula of Michigan, 2013.