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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Prepared by:
Mississippi State University – College of Forest Resources
Tyler Petroelje – Graduate Research Assistant
Todd Kautz – Graduate Research Assistant
Nick Fowler – Research Associate

Graduate Advisor:
Dr. Jerrold Belant – Associate Professor

Website: http://www.fwrc.msstate.edu/carnivore/predatorprey/index.asp
Facebook page: https://www.facebook.com/MIpredprey

MISSISSIPPI STATE UNIVERSITY
CARNIVORE ECOLOGY LABORATORY

Carnivore Ecology Laboratory
Forest and Wildlife Research Center
Mississippi State University
P.O. Box 9690
Mississippi State, MS 39762

Abstract We captured 73 (15 male, 58 female) individual white-tailed deer (*Odocoileus virginianus*), including 50 adults, 11 yearlings, and 12 fawns. We radio-collared 44 female deer, of which 43 pregnant females were also VIT tagged. We detected pregnancy with ultrasound in 100% of adult (*n* = 44) and 67% of yearling (*n* = 6) females. We captured and radiocollared 25 neonate fawns (12 male, 13 female). Seven of 9 (78%) vaginal implant transmitter searches resulted in the location of 8 live and 1 dead fawns. We obtained 3,434 adult female and neonate fawn radiolocations. We observed 46 radiocollared adult female white-tailed deer mortalities, and we attributed 25 to predation (11 wolf, 7 coyote, 1 bobcat, and 6 unknown), 11 due to natural causes, and 10 other circumstances. Eight of the radiocollared fawns died as of 25 August including 7 predations (4 black bear, 1 coyote, 1 bobcat, and 1 unknown) and one mortality in which the cause of death could not be determined in the field. To estimate deer abundance, we placed 64 remote infrared cameras throughout the study area at baited sites and obtained 9,764 images. To estimate horizontal cover and deer forage with respect to available land cover, we completed vegetation surveys at 306 random locations stratified within 5 different land cover types. We immobilized 14 adult black bear (*Ursus americanus*; 6 male, 8 female) and 4 yearlings (32 male, 1 female) in their dens and observed 12 cubs (10 male, 2 female) from 5 females. From January to July we captured and immobilized 5 coyotes (*Canis latrans*; 1 male, 5 female), 7 bobcats (*Lynx rufus*; 1 male, 5 female, 1 unknown gender), and 5 wolves (*C*. spp.; 3 male, 1 female) and either fitted them with GPS collars or released them due to their small size. During May–July we captured 8 adult black bears (5 male, 3 female) and fitted each with a GPS or VHF collar. We collected 179 hair samples and > 620,000 images from bobcat hair snares and remote cameras, respectively. We collected 966 hair samples and 22,448 images from black bear hair snares and remote cameras, respectively. During howl surveys we recorded an average coyote response rate (RR) of 34% and wolf RR of 0.5%. We conducted investigations at 568 carnivore cluster sites to identify carnivore prey sources and opportunistically collected 391 scats from black bear, bobcat, coyote, and wolf. We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimated grouse abundance and had a 41% average detection rate across surveys. We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 440 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 24 inactive lodges, 32 active lodges with a cache present, and 4 caches with no sign of a lodge. We published 4 refereed manuscripts in the journals PLOS One, Population Ecology, and The Wildlife Society Bulletin. Throughout the year, we hosted many volunteers from various organizations and two photographers/videographers, gave 15 presentations, hosted 2 workshops, and kept our Facebook page (www.Facebook.com/MIpredprey) up to date with project results.

Summary

- We captured 73 deer (15 male, 58 female) individual white-tailed deer (*Odocoileus virginianus*), including 50 adults, 11 yearlings, and 12 fawns.

- We fitted 44 pregnant female deer with a radio-collar and a VIT.

- We detected pregnancy with ultrasound in 100% of adult (*n* = 44) and 67% of yearling (*n* = 6) females.

- We captured and radiocollared 25 neonate fawns (12 male, 13 female).

- Seven of nine (78%) vaginal implant transmitter searches resulted in the location of 8 live and 1 dead fawns.

- We obtained 3,434 adult female and neonate fawn radiolocations.

- We observed 46 dead radiocollared adult female white-tailed deer. We attributed 26 mortalities to predation; 11 wolf, 7 to coyote, 1 bobcat, 6 unidentified. Eleven mortalities resulted from natural causes, all showing signs of malnutrition. We also observed one mortality each from drowning after falling through the ice, unknown trauma, illegal harvest, and capture-related stress.

- Eight of the radiocollared fawns died as of 25 August. We attributed 7 mortalities to predation: 4 black bear, 1 bobcat, 1 coyote, and 1 unknown predation. We observed one mortality in which we could not determine cause of death in the field. We observed 1 stillborn fawn at a birth site.

- We placed 64 remote infrared cameras throughout the study area to estimate deer abundance and obtained 9,760 images.

- We completed vegetation surveys at 306 random locations stratified within 5 different land cover types to estimate horizontal cover and deer forage with respect to available land cover.

- We immobilized 14 adult black bear (*Ursus americanus*; 6 male, 8 female) and 4 yearlings (3 male, 1 female) in their dens and observed 12 cubs (10 male, 2 female) from 5 females.

- We set 12 cage traps to capture bobcats (*Lynx rufus*). We captured 7 bobcats and were able to collar 4 with GPS collars. Three of the bobcats were not collared because they were too small.

- We captured and immobilized 8 adult black bear (5 male, 3 female) using foot snares and barrel traps as capture techniques. We fitted 1 bear with a GPS camera collar, 1 bear with a GPS radiocollar, and the remaining 6 bears with VHF radiocollars.

- We set padded foothold traps along roadways to capture bobcats, coyotes, and wolves (*Canis* spp.). We captured 5 coyotes and 5 wolves and fitted each with a GPS or VHF radiocollar.

- We deployed hair snares and remote cameras at 64 sites throughout the study area to estimate bobcat abundance. We obtained 179 hair samples and > 620,000 images.

- We deployed hair snares and remote infrared cameras at 64 sites throughout the study area to estimate black bear abundance and obtained 966 samples of black bear hair.

- We obtained a coyote response rate (RR) of 34% and wolf RR of 0.5% to broadcasted recordings of coyote group-yip-howls during howl surveys.

- We conducted investigations at 568 carnivore cluster sites to identify carnivore prey.

- We opportunistically collected 391 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 41% across surveys.

- We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 440 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 or river and lakeshore and detected 36 active beaver caches.

- We hosted individuals from Michigan Department of Natural Resources, Northern Michigan University, Michigan Technological University, and Iron County Sherriff's Department. We hosted Rick Westphal of Westphal Productions who took photos and video footage of project staff performing field duties.

- 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, and deer mortality investigations. We conducted a trapping demonstration for undergraduate students at The Wildlife Society Midwest Student Conclave. We set up an informational booth at the National Trappers Convention in Escanaba, MI to provide the public with videos, interactive displays, and updates of ongoing project activities.

- We gave presentations to 13 different groups or organizations about ongoing project activities and findings.

- During January–March 2014 and May–August 2014 we hired and employed 6 and 11 technicians, respectively. We hired three technicians 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 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 deer near Escanaba that migrate only short distances or are non-migratory (Beyer et al. 2010) and yard less frequently.

Accomplishments

Winter Deer Capture

From 4 January 2014 to 22 March 2014 we captured white-tailed deer in Clover traps (Figure 3) to place radio-collars on pregnant females. We captured 73 deer (15 male, 58 female), with an additional 36 recaptures. Individuals captured included 45 adult females, 5 adult males, 7 yearling females, 4 yearling males, 6 female fawns, and 6 male fawns. One adult female mortality occurred as a result of trap-related injuries. The adult female:fawn ratio for winter captures in 2014 was 3.8:1. When compared to the winter 2013 adult female:fawn ratio of 0.9:1, this suggests fewer fawns per adult doe during winter 2014. We attempted to collect body condition scores (BCS) by palpation of fat deposits by two independent observers and attach ear tags (females = blue, males = yellow) to each deer. We also assessed pregnancy of yearling and adult females using ultrasonography. Females ($n = 52$) and males ($n = 33$) had mean (± SD) body condition scores (scale: 1 [moribund]–5 [obese]) of 2.7 ± 0.6 and 3.0 ± 0.3, respectively.

We immobilized 49 females and fitted 44 with radio-collars (model 2610B, Advanced Telemetry Systems Inc., Isanti, MN). We fitted 43 pregnant females with a vaginal implant transmitter (VIT; model 3930, Advanced Telemetry Systems Inc., Isanti, MN). We monitored temperature, respiration, and heart rate as soon as practical after immobilization and at about 10 minute intervals thereafter until we administered a reversal drug. We estimated and recorded deer morphometrics and maximum and mid-rump fat depths when practical. We detected pregnancy with ultrasound in 100% of adults (n = 44) and 67% of yearlings (n = 6). Preliminary data indicates a declining trend in maximum rump fat of immobilized does as winter progressed.

In addition to the 43 individuals radiocollared this winter, we continued to monitor 30 does captured during January–March 2013.

Fawn Capture

Beginning mid-May we captured, radiocollared, and obtained radio-locations for white-tailed deer fawns. We captured 25 neonate fawns (12 male, 13 female) and fitted them with expandable radiocollars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) during May and June. We attached 2 individually numbered plastic ear tags to fawns and attempted to collect fawn morphometrics (Table 4), 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 26 May–25 June, with a median parturition date of 10 June (Figure 6). 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).

We conducted vaginal implant transmitter (VIT) searches to find fawns of 9 implanted pregnant adult females. Seven of nine (78%) VIT searches resulted in the location of ≥ 1 live or dead fawn, including 8 live fawns and 1 stillbirth.

Deer Telemetry

We used bi-weekly aerial telemetry and 24-hour ground telemetry to obtain 3,434 locations of radiocollared adult females and fawns from 15 September 2013 to 25 August 2014.

Deer Mortality

From 15 September 2013 to 25 August 2014, we recorded 46 adult female mortalities. We attributed twenty mortalities to predation (11 wolf, 7 coyote, 1 bobcat, and 6 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. Eleven mortalities resulted from natural causes, all showing signs of malnutrition. We attributed one mortality each to drowning, illegal hunting harvest, unknown trauma, and capture-related stress. We were unable to determine the cause of mortality for 4 females.

We recorded 6 mortalities and 3 censors of fawns born in May–June 2013. We attributed causes of mortality to 2 coyote predations, 2 unidentifiable predations, and 2 cases of winter starvation/exposure. Censors were due to dropped collars and radio failure.

We recorded 8 mortalities of neonate fawns born in May–June 2014, including 4 bear predations, 1 coyote predation, 1 bobcat predation, 1 unidentified predation, and 1 intact carcass that we will submit to the Michigan DNR Diagnostic Laboratory for necropsy. We also observed 1 stillborn fawn at a VIT search site. We censored two fawn collars due to one radio failure and another that fell off the animal. Excluding censors, 2014 fawn apparent survival from birth to 1 Sep was 65%. For comparison, 2013 fawn apparent survival from birth to 1 Sep was 27%.

Deer Camera Survey

We pre-baited sixty-four sites throughout the study area (Figure 5) 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 used ten days of camera data as the sampling period. We obtained 9,760 images. From camera images, we will estimate deer abundance/density for the 298.1 km^2 sampling area using an occupancy modeling approach (Duquette et al. 2014).

Deer Forage and Vegetation Survey

From 13 May to 10 August we conducted vegetation surveys at 302 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 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 December 2013–12 March 2014 we immobilized 14 adult black bears (6 male, 8 female) and 4 yearlings (3 male, 1 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 11 previously collared adult black bears. Additionally, we removed collars from 3 adult black bear that had left the study area earlier in the year to den. 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 12 cubs (10 male, 2 female) from 5 adult females; mean litter size was 2.4 (SD = 0.55; Table 1).

Bobcat Capture

We set cage traps (n = 12) to capture bobcats during 6–25 March. We captured 5 female and 1 male bobcats. We captured one kitten that was too small to collar and we released it at the capture site without being immobilized. Once immobilized, we weighed, sexed, and collected morphometric measurements from bobcats. We collared one male (14.7 kg) and three female (8.7, 10.0, and 12.1 kg) bobcats 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 two female bobcats due to their light weight (4.5 and 6.6 kg [Table 2]).

Coyote Cable Neck Restraints

We baited 9 locations with vehicle-killed deer carcasses, starting in late January, to attract coyotes for capture. We set 10 relaxing-lock cable neck restraints at 3 sites starting on 10 February. Likely due to deep snow conditions and frozen bait from cold temperatures, coyotes failed to visit snares sites with carcasses. We removed all coyote cable neck restraints by 7 March due to continuing unfavorable snow conditions.

Spring/Summer Carnivore Capture

During 22 May–1 July, we captured 8 adult black bears (5 male, 3 female) with barrel traps, and captured 5 female coyotes, and 5 wolves (3 male, 2 female) using foothold traps. We immobilized captured individuals and recorded gender, weight, and affixed uniquely numbered ear tags (Table 2). 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) radiocollars (Lotek Engineering, Newmarket, ON, Canada). Of the 8 captured bears, we fitted 6 (3 males, 3 females) bears with very high frequency (VHF) radiocollars, one male bear with a GPS radiocollar, and 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, 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 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 in case bears disperse and we cannot relocate them.

<u>Carnivore Monitoring</u>

One GPS radiocollared black bear (BB122) and one wolf (WO108) slipped their collars on 25 April and 15 July, respectfully. This year, GPS radiocollared black bears have carried collars for 70–257 consecutive days ($\bar{x}$ = 178, SD = 58), resulting in 91–11,805 locations per individual ($\bar{x}$ = 10,559, SD = 4,094). Bobcats have carried GPS radiocollars for 36–173 consecutive days ($\bar{x}$ = 137, SD =67), resulting in 25–11,747 locations per individual ($\bar{x}$ = 8,815, SD = 5,860). Coyotes have carried GPS radiocollars for 64–98 consecutive days ($\bar{x}$ = 83, SD = 14), resulting in 6,144–9,408 locations per individual ($\bar{x}$ = 7,930, SD = 1,387). Wolves have carried GPS radio collars for 25–113 consecutive days ($\bar{x}$ = 82, SD = 40), resulting in 2,400–10,848 locations per individual ($\bar{x}$ = 7,848, SD = 3,817).

We observed one female bobcat mortality (15 April), likely due to starvation, and one female coyote mortality (21 July), cause unknown. We sent remains to the Michigan Department of Natural Resources Wildlife Disease Laboratory for necropsy. Five black bear (4 male, 1 female), previously radio-collared in the summers of 2012 and 2013, were harvested during the 2013 Michigan black bear hunting season (10 September–26 October). We sent a premolar from each black bear to the Michigan Department of Natural Resources Disease Laboratory for age estimation.

<u>Bobcat Hair Snares</u>

We began baiting 64 bobcat hair snare sites (Figure 5) on 15 December 2013. After a two-week pre-bait period, we set 4–5 hair snares at each site beginning 2 January 2014. We also deployed a remote infrared camera at each site, directed at the bait, to obtain images of bobcats visiting the site.

We visited each bait site every 7 days to collect hair samples, reset snares, perform remote camera maintenance, and add bait as necessary. We pulled snares during 1–6 March 2014 once the eight-week survey was completed.

We collected 179 hair samples of bobcat and non-target species and sent them to the DNR Wildlife Disease Laboratory in Lansing for DNA extraction. We obtained > 620,000 camera images. Analysis of hair samples and images is ongoing.

<u>Black Bear Abundance Estimation: Hair Snares</u>

During 12 June–4 August we conducted a hair snare survey to estimate black bear abundance. Hair snares (*n* = 64; Figure 5), 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 966 hair samples. We sent these hair samples to the MDNR lab for DNA extraction and subsequent individual identification.

Coyote Howl Surveys

We completed 5 howl surveys at 40 sites (Figure 9) beginning on 16 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 2 September we have obtained coyote and wolf response rates of 34% and 0.5%, respectively. Collection of howl survey data is ongoing, with 3 more surveys planned. 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 during 3–14 March 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 4 GPS collared individuals to estimate territorial boundaries for 3 packs within the study area; Deer Lake, Mitchigan, and Shank Lake (Figure 4). Michigan DNR personnel identified a minimum of 24 individuals consisting of four packs with territories occurring within the study area: Deer Lake (minimum 5 individuals); Mitchigan (minimum 7 individuals); Shank Lake (minimum 8 individuals); and Republic (minimum 4 individuals).

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 2014, we investigated 568 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 568 clusters investigated this year, 155 were black bear (mean clusters/black bear = 14.09), 111 bobcat (mean clusters/bobcat = 37.00), 154 coyote (mean clusters/coyote = 51.33), and 148 wolf (mean clusters/wolf = 37).

Preliminary results from cluster investigations include black bears foraging on chokecherries (*Prunus virginiana*), 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. We identified ruffed grouse (*Bonasa umbellus*), porcupine (*Erithizon dorsatum*), muskrat (*Ondatra zibethicus*), 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 ruffed grouse, and fawn and adult deer at wolf clusters. Analysis of cluster findings is ongoing.

Carnivore Scat Collection

We opportunistically collected 391 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 396 scats (211 black bear, 14 bobcat, 86 coyote, and 85 wolf) and sent them to Mississippi State University's Carnivore Ecology Laboratory for identification of prey remains.

Ruffed Grouse Drumming Surveys

We conducted ruffed grouse (*Bonasa umbellus*) drumming surveys during 6–23 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 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 drumming grouse response was 41% on average.

Snowshoe Hare Pellet Counts

We conducted snowshoe hare (*Lepus americanus*) pellet counts from 1 May to 28 May. We counted number of hare pellets within a 1 m^2 rectangle at 440 random sites (Figure 8). We separated pellet counts into 5 main land covers (aspen [*Populus tremuloides*], deciduous [excluding aspen], coniferous, mixed forest, and woody wetland) identified by criteria used in Jin et al. (2013 [Table 5]). We will relate hare pellet densities to hare abundance using a linear regression developed by McCann et al. (2008).

Aerial Beaver Cache Survey

To provide an index of beaver (*Castor canadensis*) abundance, we flew 558 km of river and lakeshore on 29 October and 6 November to identify active beaver caches. We conducted flights at an altitude of 550–650 m. We detected 24 inactive lodges, 32 active lodges with a cache present, and 4 caches with no sign of a lodge (equates to one active cache for every 15.5 km flown; Figure 2).

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, Michigan Technological University, and Iron County Sherriff's Department. During 19–27 February we hosted Rick Westphal of Westphal Productions who obtained images and video footage of project staff performing various field duties and will provide this media to Safari Club International Foundation to promote the project.

We hosted 34 undergraduate students from Purdue University during 29–30 May 2014 for demonstrations of detection dogs, carnivore immobilizations, and deer mortality investigations. We also conducted a trapping demonstration for undergraduate students at Northern Michigan University on 12 April 2014. We set up an informational booth at the National Trappers Convention in Escanaba, MI during 23–26 July 2014 to provide the public with videos, interactive displays, and updates of ongoing project activities.

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

Presentations:

Petroelje, T.R., D.C. Norton, N.L. Libal, D. Martell, J.L. Belant, D.E. Beyer Jr. 18 October 2013. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Northern Michigan Wildlife Society. Marquette, MI. 35 Attendees.

Petroelje, T.R., D.C. Norton, N.L. Libal, D. Martell, J.L. Belant, D.E. Beyer Jr. 29 October 2013. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Public Works Water Operators Banquet. Escanaba, MI. 30 Attendees.

Petroelje, T. R., T. Kautz, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 9 March 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan's Upper Peninsula. Red Buck Eagle Scouts, Escanaba, MI. 40 attendees.

Petroelje, T.R., T. Kautz, J.L. Belant, and D.E. Beyer, Jr. 22 March 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Michigan Bear Hunter's Association Annual Meeting, Gaylord, MI. 100 attendees.

Petroelje, T.R., T. Kautz, D. Martell, J.L. Belant, and D.E. Beyer, Jr. 24 March 2014. 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.

Kautz, T., T.R. Petroelje, J.L. Belant, and D.E. Beyer, Jr. 12 April 2014. An update on 2013-14 adult and fawn deer survival in Michigan's Upper Peninsula, USA. The Upper Peninsula Sportsman's Alliance, United Sportsman's Club, Iron Mountain, MI.

Petroelje, T.R., T. Kautz, J.L. Belant, and D.E. Beyer, Jr. 12 April 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. The Wildlife Society Midwest Student Conclave, Big Bay, MI. 75 attendees.

Belant, J.L, D.E. Beyer, Jr., T.R. Petroelje, N.J. Svoboda, and J.F. Duquette. 7 May 2014. Coyote-deer relationships in Upper Peninsula, Michigan. North American furbearer joint workshop, East Cambridge, OH. 60 attendees.

Duquette, J.F. 22 May 2014. White-tailed deer population dynamics in a multi-predator landscape. Dissertation defense, Mississippi State University, Starkville, MS. 40 attendees.

Kautz, T., T.R. Petroelje, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 28 May 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Middle School, Crystal Falls, MI. 60 attendees.

Petroelje, T.R., T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 19 June 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Ottawa National Forest Visitor Center, Watersmeet, MI. 35 attendees.

Petroelje, T.R., T. Kautz, J.L. Belant, and D.E. Beyer, Jr. 20 June 2014. Observations of winter weather and the influence on deer survival and recruitment. Michigan's Upper Peninsula deer winter range working group, Marquette, MI. 12 attendees.

Kautz, T., T.R. Petroelje, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 9 July 2014. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Crystal Falls Methodist Men's Breakfast, Crystal Falls, MI. 20 attendees.

Summers, S.M., F. Blend, D. Martell, T.R. Petroelje, D.E. Beyer Jr., J.L. Belant. 9 June 2014. Scale Dependent Resource Selection in Bobcats (*Lynx rufus*). American Society of Mammalogist Annual Conference, Oklahoma City, OK. 40 attendees.

Belant, J.L., ,D.E. Beyer, Jr., J.F. Duquette, N.J. Svoboda, T.R. Petroelje, and T.R. Kautz. 18 August 2014. Predator-prey project update. Michigan Department of Natural Resources, Wildlife Division, Roscommon, MI. 50 attendees.

Seminars and Workshops:

Beyer, D.E., Jr., B. Roell, T.R. Petroelje and D.C. Norton. 12 April 2014. Field Techniques for Wildlife Capture and Immobilization. The Wildlife Society Midwest Student Conclave, Big Bay, MI. 64 students.

Petroelje, T.R., T. Kautz, J.L. Belant, and D.E. Beyer, Jr. 29–30 May 2014. Field Techniques for Wildlife Capture, Immobilization, and Predation Investigation. Purdue Wildlife Ecology Field Class, Crystal Falls, MI. 34 students.

Popular Media:

Safari Club International Foundation. March 2014. "Weekly Update: Michigan Predator-Prey Project". SCI Foundation's First for Wildlife blog, http://firstforwildlife.wordpress.com/2014/03/06/weekly-update-michigan-predator-prey-project/

Technician Hiring

During January–March 2014 and May–August 2014 we hired and employed 6 and 11 technicians, respectively. We hired three technicians from 48 applicants to assist during fall 2014.

Publications

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.

Duquette, J.F., J.L. Belant, N.J. Svoboda, D.E. Beyer, Jr., P.E. Lederle. 2014. Effects of maternal nutrition, resource use and multi-predator risk on neonatal white-tailed deer survival. PLoS ONE 9:e100841.

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

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.

Work to be completed (September–December 2014)

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.

Carnivore Monitoring and GPS Radiocollar 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 radiocollars 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.

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 2015.

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.

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.

Technician Hiring

We will post an advertisement for available positions in early October and 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.

<u>Public Outreach</u>

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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Phase 2 – Project Technicians:

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Matthew Peterson
Tanya Wolf
Elizabeth Robbe
Missy Stallard
Brian Kidder
Caleb Eckloff
Polly Chen
Mac Nichols
Annie Washakowski
Ty Frank
Jessie Roughgarden
Daniel Tomasetti
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Literature Cited

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.

Beyer, D., B. Rudolph, K. Kintigh, C. Albright, K. Swanson, L. Smith, D. Begalle, and R. Doepker. 2010. Habitat and behavior of wintering deer in northern Michigan: a glossary of terms and associated background information. Michigan Department of Natural Resources and Environment, Wildlife Division Report 3520, Marquette, Michigan, USA.

Carstensen, M., G. D. DelGiudice, B. A. Sampson, and D. W. Kuehn. 2009. Survival, birth characteristics, and cause-specific mortality of white-tailed deer neonates. Journal of Wildlife Management 73:175–183.

Cook, R. C., T. R. Stephenson, W. L. Myers, J. G. Cook, and L. A. Shipley. 2007. Validating predictive models of nutritional condition in mule deer. Journal of Wildlife Management 71:1934–1943.

Cook, R. S., J. G. Cook, T. R. Stephenson, W. L. Myers, S. M. McCorquodale, D. J. Vales, L. L. Irwin, P. B. Hall, R. D. Spencer, S. L. Murphie, K. A. Schoenecker, and P. J. Miller. 2010. Revisions of rump fat and body scoring indices for deer, elk, and moose. Journal of 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.

Moen, A. N. 1976. Energy conservation by white–tailed deer in the winter. Ecology 57:192–198.

Ordiz, A., O. G. Støen, L. G. Langebro, S. Brunberg, and J. E. Swenson. 2009. A practical method for measuring horizontal cover. Ursus 20:109–113.

Ozoga, J. and L. Gysel. 1972. Response of white–tailed deer to winter weather. Journal of Wildlife Management 36:892–896.

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.

Pusateri Burroughs, J., H. Campa, III, S. R. Winterstein, B. A. Rudolph, and W. E. Moritz. 2006. Cause–specific mortality and survival of white–tailed deer fawns in southwestern Lower Michigan. Journal of Wildlife Management 70:743–751.

Royle, J. A. and J. D. Nichols. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777–790.

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.

Verme, L. J., and D. E. Ullrey. 1984. Physiology and nutrition. Pages 91–118 *in* L. K. Halls, editor. White-tailed deer ecology and management. Stackpole Books, Harrisonburg, Pennsylvania, USA.

Table 1. Den check data for 30 black bears, Upper Peninsula of Michigan, USA, 16 December–12 March 2014.

ID	Capture date	Sex	Body weight (kg)	Right ear tag	Left ear tag	Ear tag color	Age
BB145	16-Dec-13	M	103.4	286	285	Blue	Adult
BB148	17-Dec-13	M	111.1	303	307	Light Blue	Adult
BB112	18-Dec-13	F	70.3	220	219	Blue	Adult
BB123	18-Dec-13	M	28.1	316	315	Light Blue	Yearling
BB124	18-Dec-13	M	25.9	313	314	Light Blue	Yearling
BB125	18-Dec-13	M	25.4	318	317	Light Blue	Yearling
BB117	19-Dec-13	F	121.6	173	161	Blue	Adult
BB143	4-Feb-14	M	79.4	266	280	Blue	Adult
BB126	23-Feb-14	F	NA	287	288	Blue	Adult
BB127	23-Feb-14	F	18.6	218	242	Blue	Yearling
BB103	24-Feb-14	F	70.3	213	214	Blue	Adult
BB149	24-Feb-14	M	1.5	NA	NA	NA	Newborn
BB150	24-Feb-14	M	1.3	NA	NA	NA	Newborn
BB151	24-Feb-14	M	1.3	NA	NA	NA	Newborn
BB116	25-Feb-14	F	70.3	239	238	Blue	Adult
BB152	25-Feb-14	F	1.4	NA	NA	NA	Newborn
BB153	25-Feb-14	M	1.6	NA	NA	NA	Newborn
BB144	26-Feb-14	F	66.2	268	272	Blue	Adult
BB154	26-Feb-14	M	1.8	NA	NA	NA	Newborn
BB155	26-Feb-14	M	1.9	NA	NA	NA	Newborn
BB142	3-Mar-14	M	81.6	269	279	Blue	Adult
BB120	3-Mar-14	F	59.9	229	228	Blue	Adult
BB156	3-Mar-14	M	1.2	NA	NA	NA	Newborn
BB157	3-Mar-14	M	1.2	NA	NA	NA	Newborn
BB158	3-Mar-14	M	1.3	NA	NA	NA	Newborn
BB141	4-Mar-14	F	68.0	290	289	Blue	Adult
BB159	4-Mar-14	M	2.3	NA	NA	NA	Newborn
BB160	4-Mar-14	F	2.3	NA	NA	NA	Newborn
BB146	4-Mar-14	M	74.8	209	302	Blue	Adult
BB139	12-Mar-14	M	65.8	295	296	Blue	Adult

Table 2. Carnivore capture data, Upper Peninsula of Michigan, USA, 7 March–28 June 2014.

Species	ID	Capture date	Sex	Body weight (kg)	Right ear tag	Left ear tag
Black bear	BB161	30-May-14	M	77.1	257	253
Black bear	BB162	5-Jun-14	F	68.0	305	305
Black bear	BB163	6-Jun-14	F	47.6	309	308
Black bear	BB164	10-Jun-14	M	58.1	320	319
Black bear	BB166	22-Jun-14	M	65.8	266	280
Black bear	BB165	22-Jun-14	M	NA	312	310
Black bear	BB167	29-Jun-14	F	47.2	485	484
Black bear	BB168	1-Jul-14	M	68.0	488	487
Bobcat	BC105	7-Mar-14	F	4.5	255	256
Bobcat	BC106	10-Mar-14	M	14.7	250	249
Bobcat	BC107	11-Mar-14	F	8.7	252	251
Bobcat	BC108	18-Mar-14	F	12.1	230	231
Bobcat	BC109	20-Mar-14	F	10.0	160	172
Bobcat	BC110	30-Mar-14	F	6.6	267	210
Coyote	CO108	25-May-14	F	10.0	246	245
Coyote	CO109	29-May-14	F	8.9	260	259
Coyote	CO110	31-May-14	F	10.4	243	244
Coyote	CO111	4-Jun-14	F	11.1	248	247
Coyote	CO112	21-Jun-14	F	12.8	321	322
Wolf	WO105	10-May-14	F	21.3	1124	1125
Wolf	WO106	18-May-14	M	32.7	1102	1101
Wolf	WO107	8-Jun-14	F	21.8	577	576
Wolf	WO108	20-Jun-14	M	29.5	1006	1005
Wolf	WO109	28-Jun-14	M	34.0	575	574

Table 3. Mean ($\bar{x}$) and standard deviation (SD) of 46 captured adult (*n* = 40) and yearling (*n* = 6) female white-tailed deer morphometrics and body condition estimates, Upper Peninsula of Michigan, USA, January–March 2014.

	Age Class			
	Adults		Yearlings	
Metric	$\bar{x}$	SD	$\bar{x}$	SD
Body weight (kg)	65.0	6.4	49.0	5.4
Hind foot (cm)	48.5	1.9	47.6	2.3
BCS[1]	2.8	0.6	2.7	0.3
MIDF[2] (cm)	0.4	0.4	0.4	0.3
MAXF[3] (cm)	0.6	0.5	0.7	0.4

[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).

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

Table 4. Mean ($\bar{x}$) and standard deviation (SD) of 25 captured female (*n* = 13) and male (*n* = 12) neonate fawn morphometrics, Upper Peninsula of Michigan, USA, 27 May–15 June 2014.

	Sex	
	Female	Male
Estimate	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Body Weight (kg)	4.1 ± 1.7	4.3 ± 1.6
Body Length (cm)	62.0 ± 6.6	59.0 ± 5.7
Chest Girth (cm)	33.6 ± 4.2	34.8 ± 4.4
Hind Foot (cm)	24.5 ± 3.0	26.0 ± 1.8
Shoulder Height (cm)	42.7 ± 3.3	43.25 ± 6.0
New Hoof Growth (mm)	2.3 ± 1.2	2.7 ± 1.2
Birth Mass (kg)[1]	3.6 ± 1.3	3.7 ± 1.4

[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 5. 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.

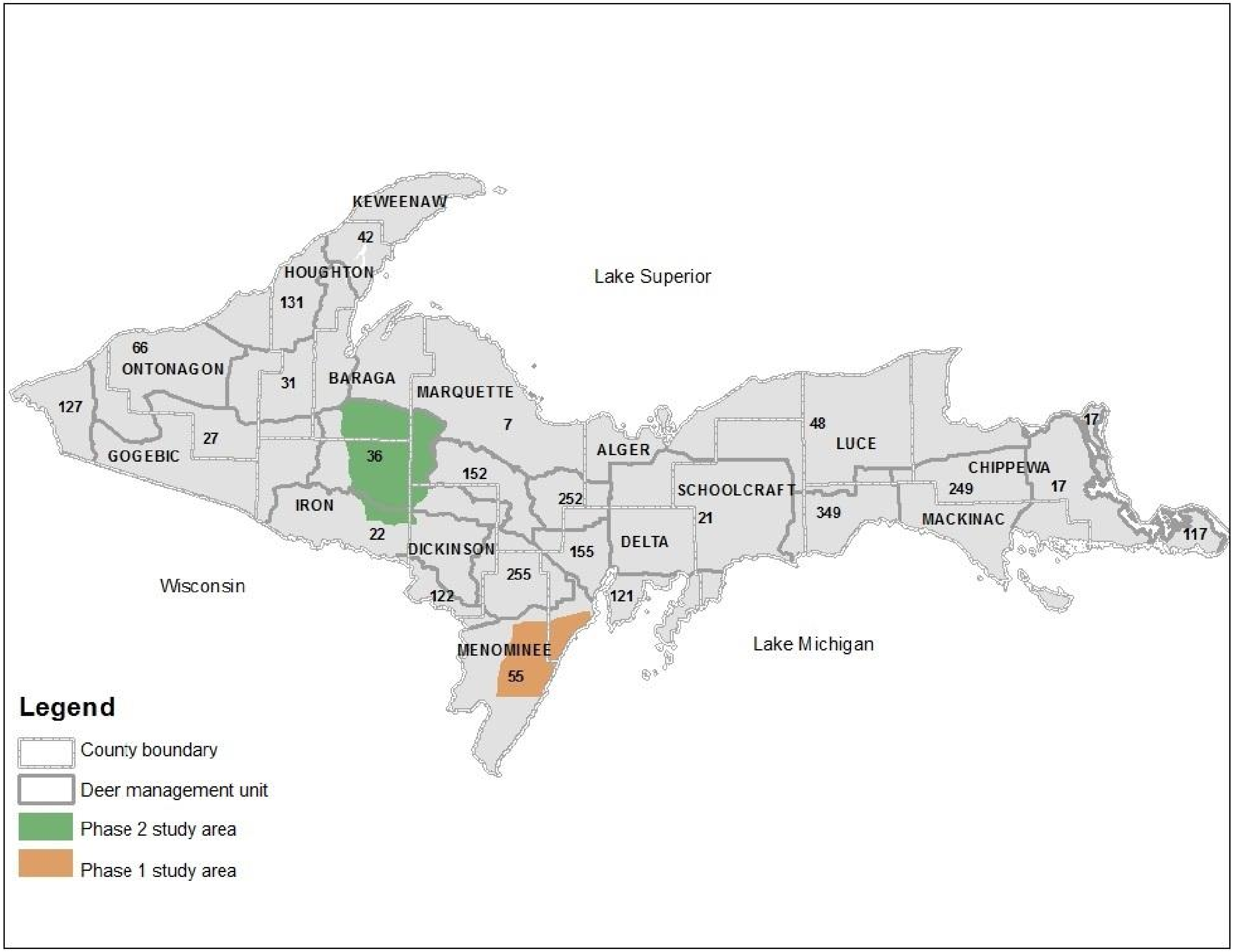

Figure 1. Location of phase 1 and 2 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, 2013.

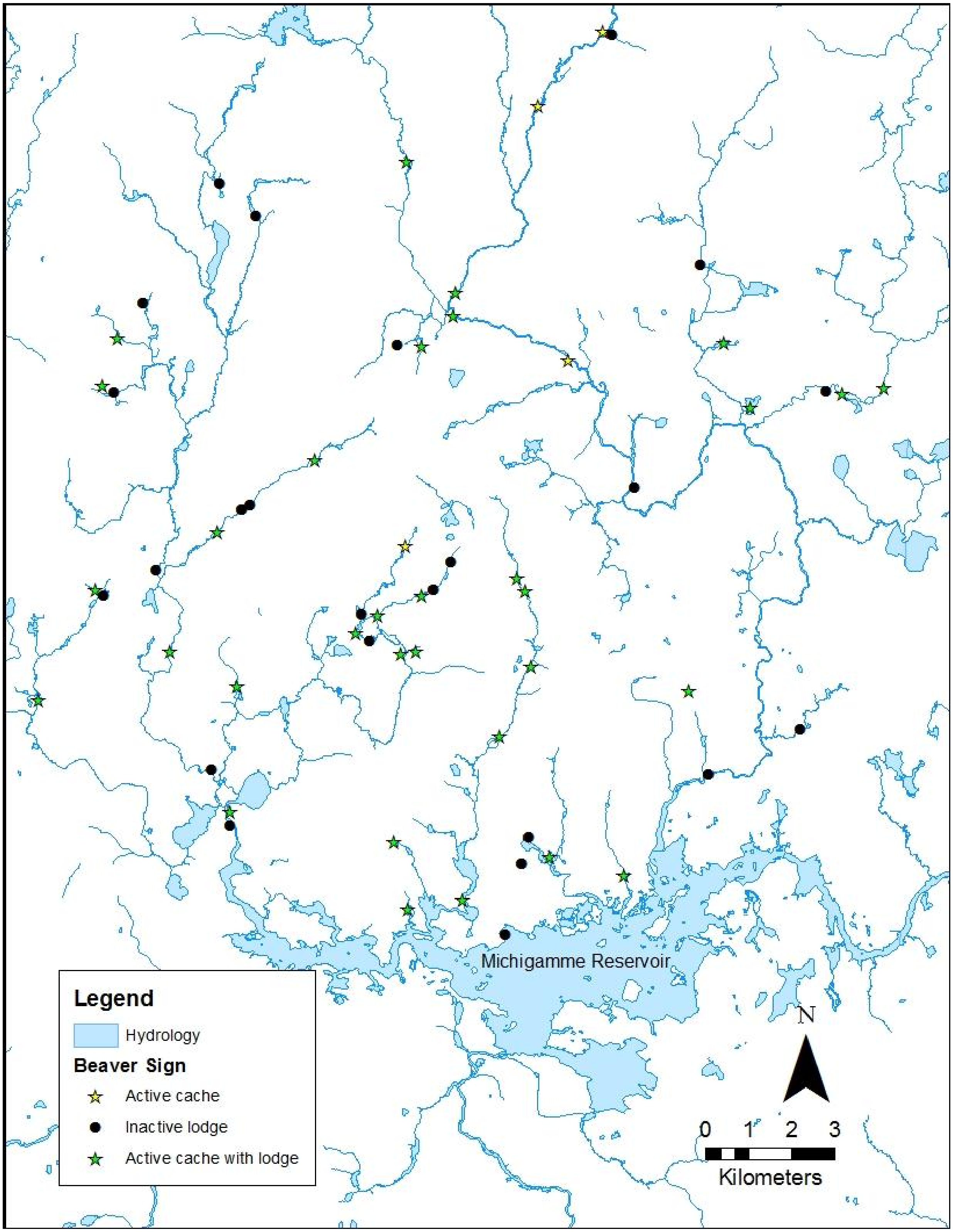

Figure 2. Locations of beaver caches and lodges detected aerially during 29 October and 6 November, Upper Peninsula of Michigan, USA, 2013.

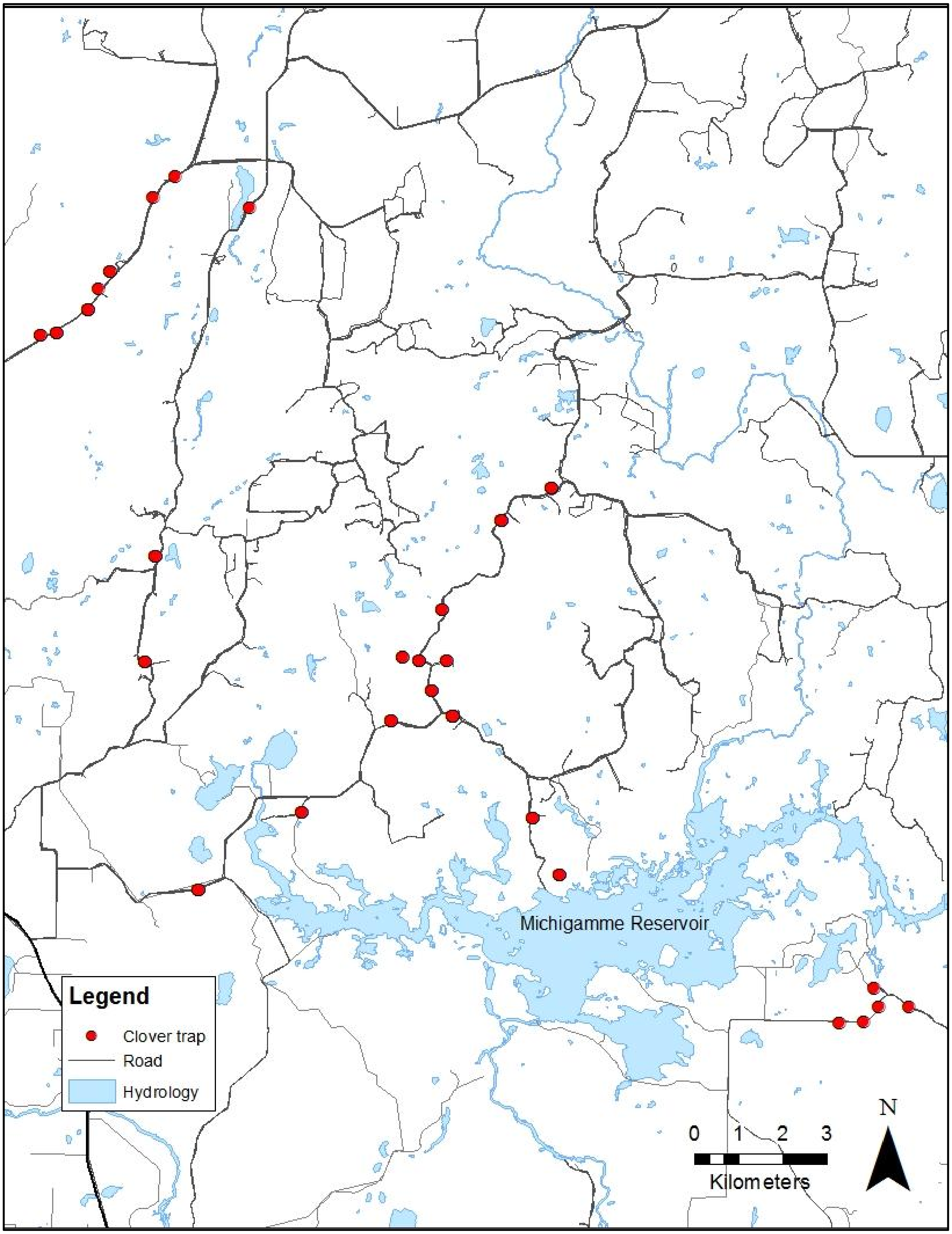

Figure 3. Locations of Clover traps for deer capture, Upper Peninsula of Michigan, USA, 4 January–15 March 2014.

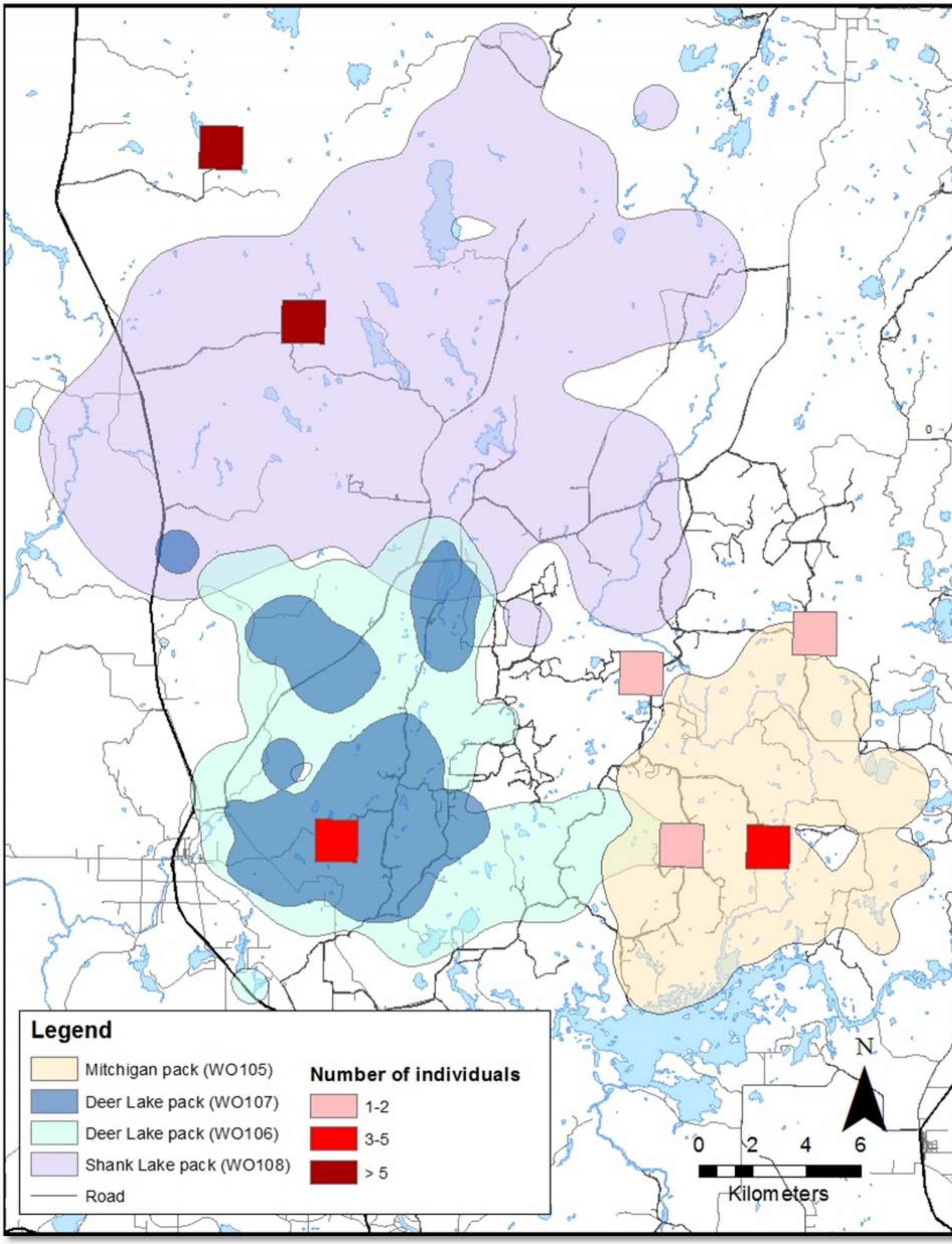

Figure 4. Estimated wolf pack territories (shaded polygons) from GPS radiocollar locations of four individuals, May–August 2014. Section locations and estimated number of wolves (red squares) derived from track surveys, Upper Peninsula of Michigan, USA, March 2014.

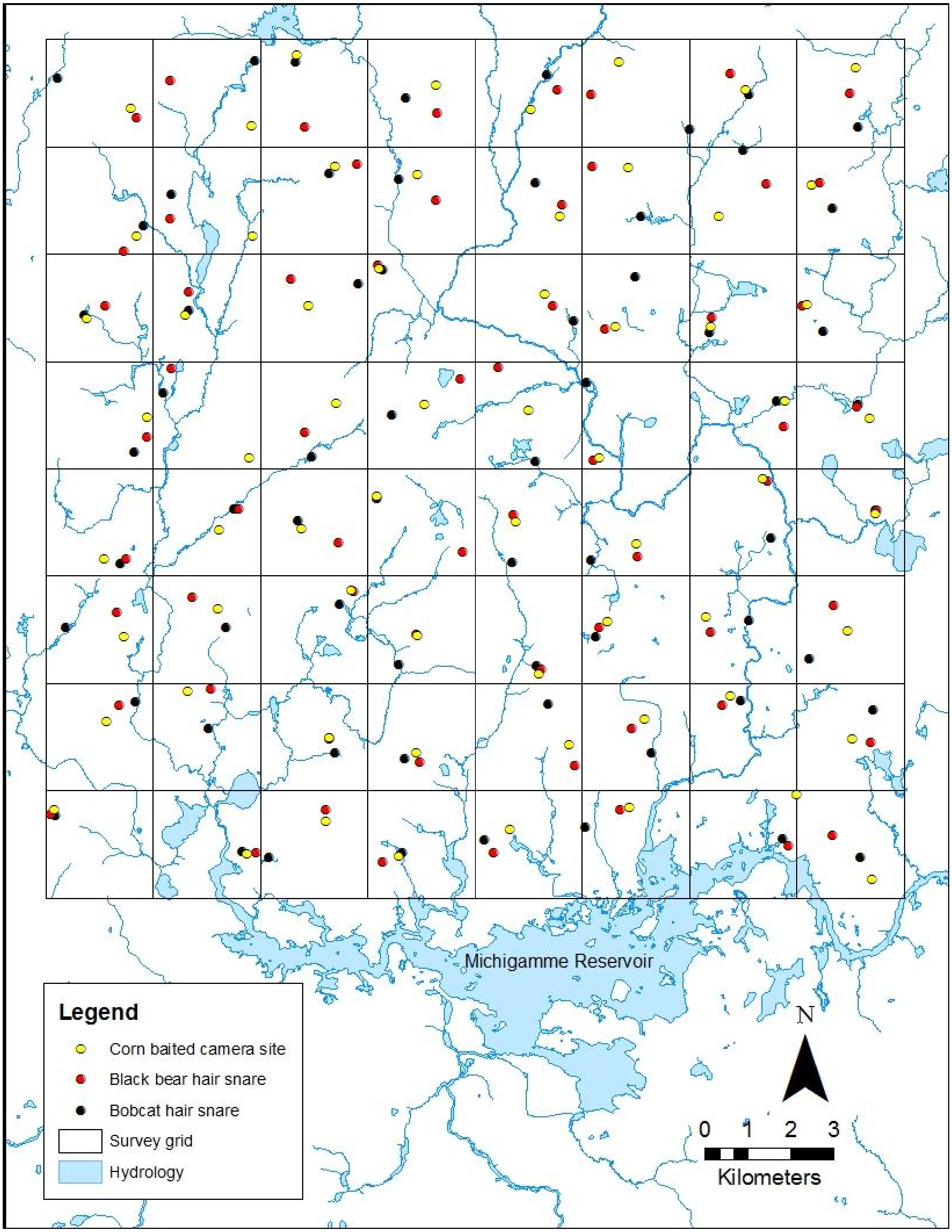

Figure 5. Locations of 64 bobcat hair snares, black bear hair snares, and corn baited camera sites to estimate bobcat, black bear, and white-tailed deer abundance, respectively; Upper Peninsula of Michigan, 2014.

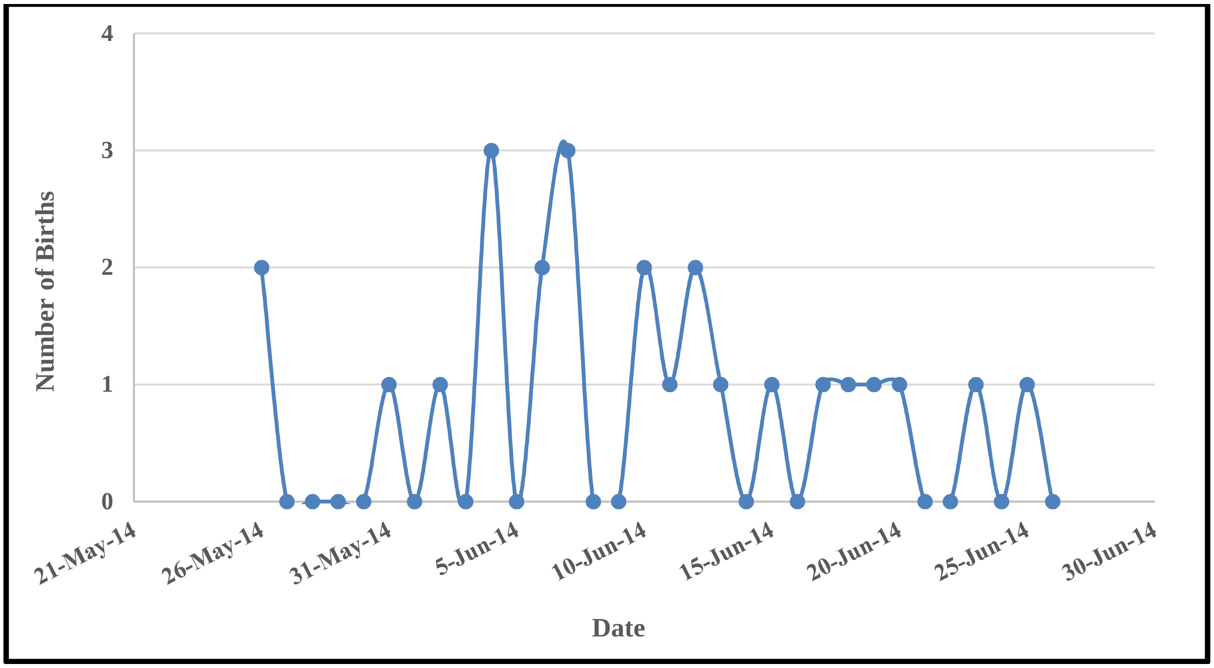

Figure 6. Estimated parturition dates of 25 free-ranging white-tailed deer fawns, Upper Peninsula of Michigan, USA, 2014.

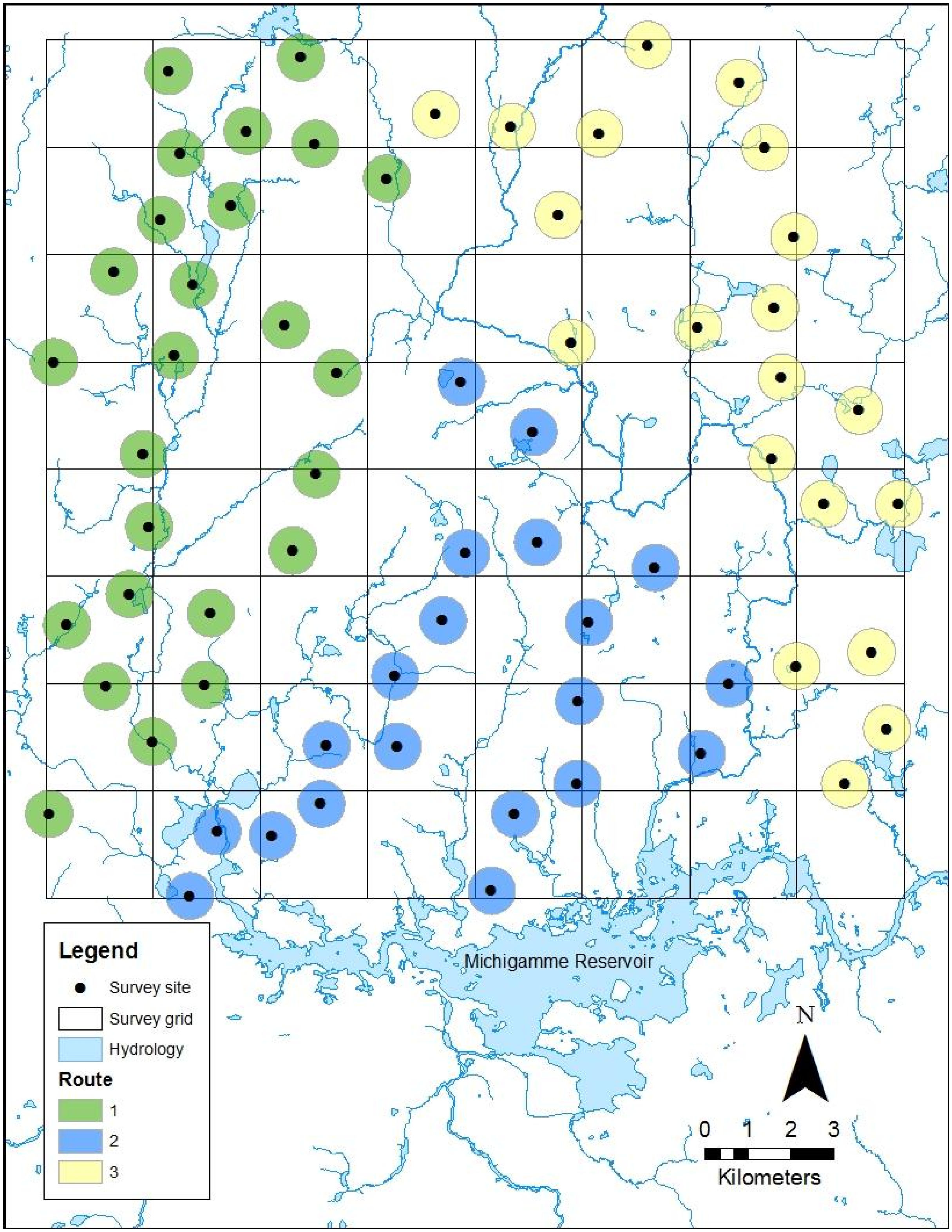

Figure 7. Locations of 65 grouse drumming survey sites with 550 m audible buffer along 3 routes to estimate abundance, Upper Peninsula of Michigan, USA, 2014.

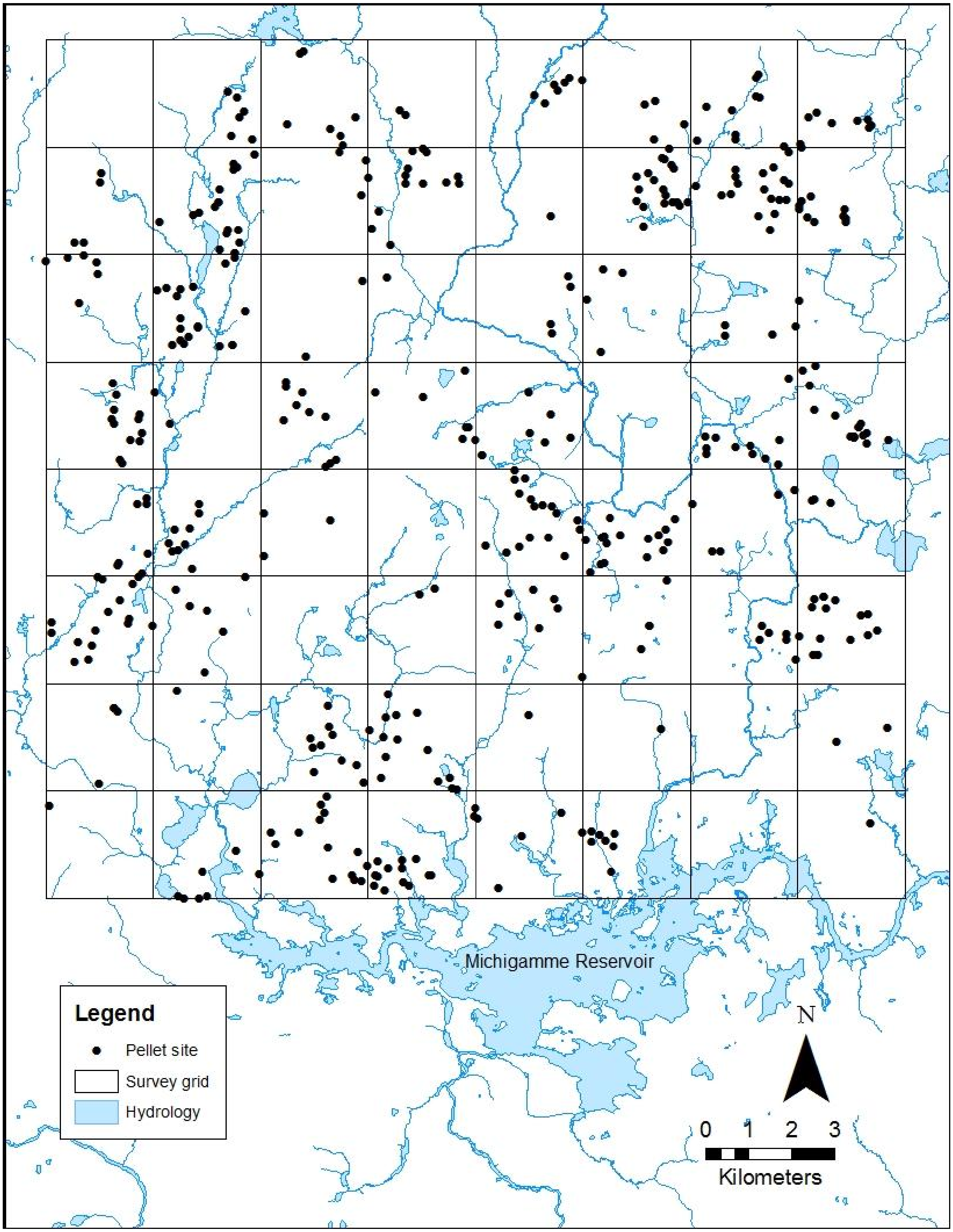

Figure 8. Locations of 440 hare pellet plot survey sites used to estimate snowshoe hare abundance, Upper Peninsula of Michigan, USA, 2014.

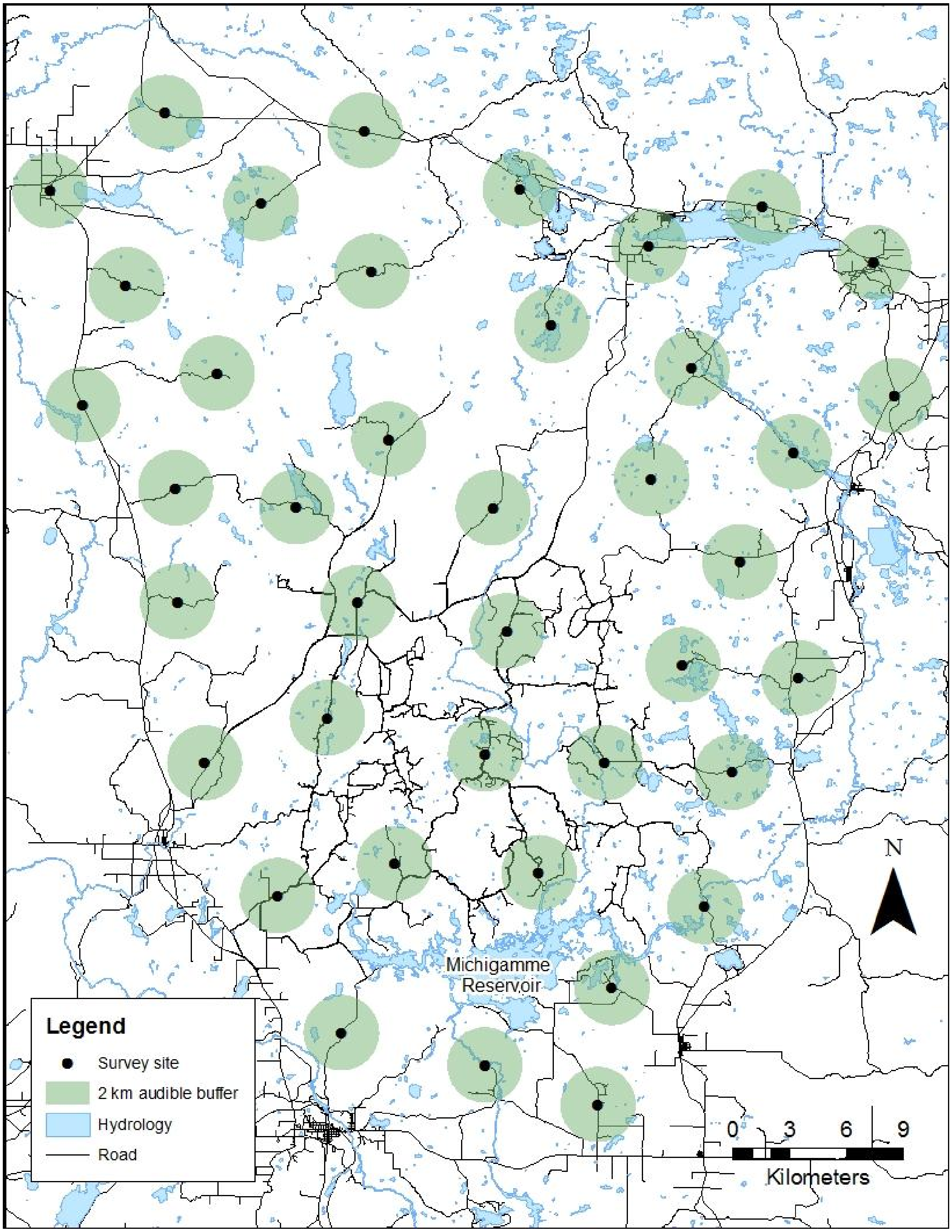

Figure 9. Locations of 40 howl survey sites to estimate coyote abundance, Upper Peninsula of Michigan, 2014.