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

Progress Report: 16 March 2014–15 June 2014

Date Issued:
30 June 2014

Submitted to:
Michigan Department of Natural Resources
Safari Club International Foundation
Safari Club International – Michigan Involvement Committee

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Abstract We captured and radiocollared 15 neonate white-tailed deer (*Odocoileus virginianus*) fawns (7 male, 8 female). Five of 7 (71%) vaginal implant transmitter searches resulted in the location of 6 live and 1 dead fawns. Thirty-five adult female and 3 neonate fawn mortalities occurred this quarter. We collected 1,166 adult female and neonate fawn radiolocations. We completed vegetation surveys at 139 random locations stratified within 5 land covers to estimate horizontal cover and deer forage. We captured 4 adult black bears (*Ursus americanus*; 3 male, 1 female) with barrel traps, three female bobcats (*Lynx rufus*; 2 large enough to collar) using cage traps, and 4 coyotes (*Canis latrans*; 1 male, 3 female) and 3 wolves (*C.* spp. 1 male, 2 female) with foothold traps. We investigated 136 carnivore cluster sites to identify prey remains. We opportunistically collected 134 scats from black bear, bobcat, coyote, and wolf. We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimate male grouse density and on average detected grouse at 41% of survey points. We completed snowshoe hare (*Lepus americanus*) pellet surveys at 440 random locations stratified within 6 land covers to estimate hare density. We deployed hair snares at 64 sites to estimate black bear abundance. We gave 7 presentations, conducted a trapping demonstration for undergraduates, and hosted 34 undergraduate students to provide a field techniques seminar. We updated the project website and project Facebook page with information and results obtained this quarter. We hired 11 technicians to assist with field activities.

Summary

- We observed 35 dead radiocollared adult female white-tailed deer (*Odocoileus virginianus*). We attributed 9 to wolf predation, 6 to coyote predation, 1 to bobcat predation, 4 to unidentified predations, 9 to natural causes, 1 to drowning, 1 to illegal harvest, and 4 to unknown causes.
- We captured and radiocollared 15 neonate fawns, including 7 males and 8 females
- Five of 7 (71%) vaginal implant transmitter searches resulted in the location of 6 live and 1 dead fawns.
- We obtained 1,166 adult female and neonate fawn radiolocations.
- We observed 3 dead neonate fawns attributed to 1 bear predation, 1 coyote predation, and 1 unknown cause.
- We completed vegetation surveys at 139 random locations stratified within 5 land covers to estimate horizontal cover and deer forage with respect to available land cover.
- We captured and immobilized 4 adult black bear (*Ursus americanus*; 3 male, 1 female) using barrel traps. We fitted 1 male bear with a GPS camera collar and remaining bears with VHF radiocollars.
- We set foothold traps along roadways to capture coyotes (*Canis latrans*) and wolves (*C.* spp.). We captured 4 coyotes (1 male, 3 female) and 3 wolves (1 male, 2 female) and fitted each with a GPS collar.
- We conducted investigations at 136 carnivore cluster sites to identify prey.
- We opportunistically collected 134 scats from black bear, bobcat, coyote, and wolf.
- We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimated male grouse density. We detected grouse on 41% of sampling points.
- We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 440 random locations stratified within 6 land covers to estimate hare densities.
- We deployed hair snares at 64 sites throughout the study area to estimate black bear abundance.
- We hosted 34 undergraduate students from Purdue University to demonstrate detection dog work, carnivore capture and immobilization, and deer mortality investigations.
- We gave presentations to local high school science classes, the Michigan Bear Hunter's Association, the American Society of Mammalogists, and the Upper Peninsula Sportsman's Alliance.

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

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.

Our overall goal 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 Upper 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 have now completed field work within a low snow depth study site and are currently collecting data within a second study site with moderate snow depth. The following objectives are specific to the Upper Michigan study areas but are also 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

Fawn Capture

Beginning mid-May we captured, radiocollared, and obtained radio-locations for white-tailed deer fawns. Fifteen neonate fawns were captured and fitted with expandable radiocollars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) during May and June, consisting of 7 males and 8 females. We attached 2 individually numbered plastic ear tags to fawns and attempted to collect fawn morphometrics (Table 1), blood, hair, and identify sex. We also recorded bed site and surrounding habitat, flush distance, presence of dam, additional deer sighted, and handling time as available. Estimated parturition dates of captured fawns was 26 May – 13 June (Figure 2), although some females had not given birth by the end of the reporting period. Average estimated birth mass of fawns was similar to average birth mass of fawns born in 2013 (3.2 ± 1.4 kg and 3.1 ± 1.1 kg, respectively).

As of 15 June, we conducted vaginal implant transmitter (VIT) searches to find fawns of 7 implanted pregnant adult females. Two adult females have not expelled the VIT as of 15 June. Five of seven (71%) VIT searches resulted in the location of ≥1 fawn, including 6 live fawns and 1 stillbirth.

Deer Mortality

We recorded 35 adult female mortalities. Twenty mortalities were attributed to predation (9 wolf, 6 coyote, 1 bobcat, and 4 unidentified). Unidentfied 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. Nine mortalities resulted from natural causes, all showing signs of malnutrition. One mortality was attributed to drowning, and another was attributed to illegal hunting harvest. We were unable to determine the cause of mortality for 4 females.

High adult female mortality rates during April and May were likely related to decreasing body condition as winter progressed. Maximum rump fat depth measured using ultrasonography suggested a trend of depleting rump fat by mid-March (Figure 3). Reduced rump fat may have increased deer susceptibility to starvation or exposure mortality, although surviving deer and deer succumbing to predation mortality had similar rump fat reserves (Figure 3).

We recorded 3 neonate fawn mortalities including 1 bear predation, 1 coyote predation, and 1 intact carcass that will be submitted to the Michigan DNR Diagnostic Laboratory for necropsy. We also observed 1 stillborn fawn at a VIT search site.

Deer Telemetry

We used bi-weekly aerial telemetry and 24-hour ground telemetry to obtain 1,166 locations of radiocollared adult females and neonate fawns between 1 May and 15 June 2014.

Vegetation Survey

From 13 May to 15 June we conducted vegetation surveys at 139 random locations within 5 main land cover types (deciduous, coniferous, mixed forest, woody wetland, and herbaceous wetland). At each location we established 5 plots. Within each plot, we estimated horizontal cover and counted number of trees, shrubs, and percentage of herbaceous plants selected for by white-tailed deer (McCaffery et al. 1974, Stormer and Bauer 1980). We also collected vegetation samples, which are being dried and weighed. We will use vegetation data to estimate forage availability within each land cover.

Carnivore Capture

During 22 May–15 June, we captured 4 adult black bears (3 male, 1 female) with barrel traps, and captured 4 coyotes (1 male, 3 female), and 3 wolves (1 male, 2 female) using padded foothold traps. We immobilized captured individuals and recorded sex, 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 4 captured bears, we fitted 3 (2 males, 1 females) with very high frequency (VHF) radiocollars and fitted one male bear with a Lotek 7000MU GPS camera collar 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 replace their collars at 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 to ensure collars release if bears disperse and cannot be relocated.

Carnivore Cluster Investigation

We used clusters of carnivore locations obtained from GPS radiocollars to identify potential kill sites and estimate the number and species of prey killed. We have investigated 136 GPS location clusters identified using ArcGIS and the statistical software program R (R Development Core Team, Vienna, Austria). We defined a cluster spatially as ≥5 locations within 50 m of each other within a 24-hour period. Of the 136 clusters, 46 were black bear, 34 bobcat, 23 coyote, and 33 wolf. Identification of prey items is ongoing.

Carnivore Scat Collection

We opportunistically collected 134 scats from black bear, bobcat, coyote, and wolf. We will wash, package, and send scat samples 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 4). 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. Mean drumming grouse response was 41%.

Snowshoe Hare Pellet Counts

We conducted snowshoe hare (*Lepus americanus*) pellet counts during 1–28 May. We counted number of hare pellets within a 1 m^2 rectangle at 440 random sites (Figure 5). We separated pellet counts into 6 main land covers (aspen (*Populus tremuloides*), deciduous (excluding aspen), 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

On 22 May we began the pre-bait period for a hair snare survey to estimate black bear abundance. Hair snares (n = 64; Figure 6) 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 also placed a remote trail camera at each site to document site visitation. Project personnel check snares, add lure, and collect hair samples every ten days. We will check each snare five times; the survey will continue through 1 August. We will send hair samples to the MDNR lab for DNA extraction and subsequent individual identification.

Public Outreach

We hosted 34 undergraduate students from Purdue University on 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 updated our website (http://fwrc.msstate.edu/carnivore/predatorprey/index.asp) and Facebook page (www.Facebook.com/MIpredprey) to provide the public with project results.

Presentations:

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, 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.

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.

Petroelje, T.R., T. Kautz, N. Fowler, 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.

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.

Petroelje, T.R., T. Kautz, 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.

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.

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 attendees.

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 attendees.

Publications:

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

Petroelje, T.R., 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:in press.

Technician Selection and Hiring

This quarter we hired 11 technicians to assist with field work from 1 May through 31 August, 2014.

Work to be completed (16 June 2014–30 September 2014)

Carnivore Monitoring

We will continue monitoring carnivores twice weekly via aerial telemetry. We will download location data from carnivore GPS collars through 31 August for predation site investigation.

Predation Site Investigation

We will continue investigations of carnivore predation site locations (clusters) through 31 August to assess their role in predation on white-tailed deer.

Carnivore Scat Collection

We will continue collecting scat of black bear, bobcat, coyote, and wolves opportunistically through 31 August for diet analysis. We will record date, GPS location, whether tracks are present, scat diameter, and species for each collected scat.

Deer Telemetry

We will continue to monitor all radio-collared deer up to 4 times daily through 31 August to monitor survival and obtain locations. We will investigate mortalities as soon as practical after detecting a mortality signal to determine cause of death.

Vegetation Surveys

We will continue to dry and weigh vegetation samples obtained during the last quarter. We will continue to collect vegetation data at random locations within the deciduous, evergreen, mixed forest, woody wetland, and herbaceous wetland vegetation classes. At each point, we will estimate horizontal cover following Ordiz et al. (2009). We will also estimate available forage by collecting current year's growth of species selected for by deer (McCaffery et al. 1974, Stormer and Bauer 1980), drying the samples, and comparing the resulting dry weights across vegetation classes.

Black Bear Abundance Estimation

We will check each hair snare two more times for a total of five checks; the survey will continue through 1 August. We will continue to send hair samples to the MDNR lab for DNA extraction and subsequent individual identification.

Coyote Abundance Estimation

On 20 July we will begin conducting howl surveys at 40 sites to estimate coyote abundance. We will conduct surveys every ten days and will continue through approximately 4 October for a total of eight surveys. We will estimate coyote abundance using an occupancy modeling approach (Royle and Nichols 2003).

Deer Abundance Estimation

We will begin pre-baiting 64 sites with 7.5 L of whole kernel corn on 12 August, and will re-bait each site at least every three days. Beginning 22 August we will place remote infrared cameras at each site. We will continue baiting at least every three days during the ten day survey. On 1 September we will start retrieving cameras. From camera images, we will estimate deer abundance/density for the 400 km^2 sampling area using an occupancy modeling approach (Royle and Nichols 2003).

Public Outreach

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

Acknowledgements

We thank the following for their support:
Michigan Department of Natural Resources (MDNR)
Safari Club International Foundation
Safari Club International, Michigan Involvement Committee
Mississippi State University; College of Forest Resources; Department of Wildlife, Fisheries, and Aquaculture; and Forest and Wildlife Research Center
Participating Upper Peninsula landowners
Dave and Nancy Young for allowing us to establish a weather station on their property
Jared Duquette, Graduate Student (Phase 1), Mississippi State University
Nathan Svoboda, Graduate Student (Phase 1), Mississippi State University
Project Technicians:

Cody Norton
Chloe Wright
Todd Kautz
Olivia Montgomery
Matthew Peterson
Tanya Wolf
Missy Stallard
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Caleb Eckloff
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Mac Nichols
Annie Washakowski
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Ty Frank
Jessie Roughgarden
Daniel Tomasetti
Evan Shields
Ben Matykiewicz
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Abbi Hirschy
Sara Harrington
Jen Graur
Chris Boyce
Sara Wendt
Jake Boone
Jackie Jeffries
Kyle Hines
Kyle Smith
Zack Farley
Savanna Summers
Pete Mumford

Pat Sommers – Sommers Sausage Shop
Dan Absilon
Art Villenue
Rob and Darren Peterson
Kim and Lee Nylund
The Bicigo family
Jerry Grailer
Chuck and Jim Satori
Rick Westphal

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Brian Roell, MDNR
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Bob Doepker, MDNR
Kurt Hogue, MDNR
Jason Peterson, MDNR
Marvin Gerlach, MDNR
Jason Neimi, MDNR
Vernon Richardson, MDNR

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Table 1. Mean ($\bar{x}$) and standard deviation (SD) of 15 captured female (n = 8) and male (n = 7) neonate fawn morphometrics, Upper Peninsula of Michigan, USA, 27 May–15 June 2014.

	Sex	
	Female	**Male**
Estimate	Female $\bar{x} \pm$ SD	Male $\bar{x} \pm$ SD
Body Weight (kg)	3.5 ± 1.7	3.6 ± 1.8
Body Length (cm)	60.1 ± 6.1	55.7 ± 4.8
Chest Girth (cm)	31.7 ± 3.5	32.8 ± 4.8
Hind Foot (cm)	24.3 ± 2.6	25.2 ± 2.0
Shoulder Height (cm)	42.3 ± 2.7	40.2 ± 5.7
New Hoof Growth (mm)	1.4 ± 09	2.5 ± 0.7
Birth Mass (kg)[1]	3.2 ± 1.6	3.3 ± 1.6

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

Table 2. Carnivore capture data, Upper Peninsula of Michigan, USA, 16 March–15 June 2014.

Species	ID	Capture date	Sex	Body weight (kg)	Right ear tag	Left ear tag
Black Bear	BB161	30-May	Male	77.1	257	253
Black Bear	BB162	5-June	Female	68.0	305	306
Black Bear	BB163	6-June	Female	47.6	309	308
Black Bear	BB164	10-June	Male	58.1	320	319
Bobcat	BC108	18-March	Female	12.1	230	231
Bobcat	BC109	20-March	Female	10.0	160	172
Bobcat	BC110	30-March	Female	6.6	267	210
Coyote	CO108	25-May	Female	10.0	246	245
Coyote	CO109	29-May	Female	8.8	260	259
Coyote	CO110	31-May	Female	10.4	243	244
Coyote	CO111	4-June	Female	11.1	248	247
Wolf	WO105	10-May	Female	21.3	1124	1125
Wolf	WO106	18-May	Male	32.7	1102	1101
Wolf	WO107	8-June	Female	21.8	0577	0576

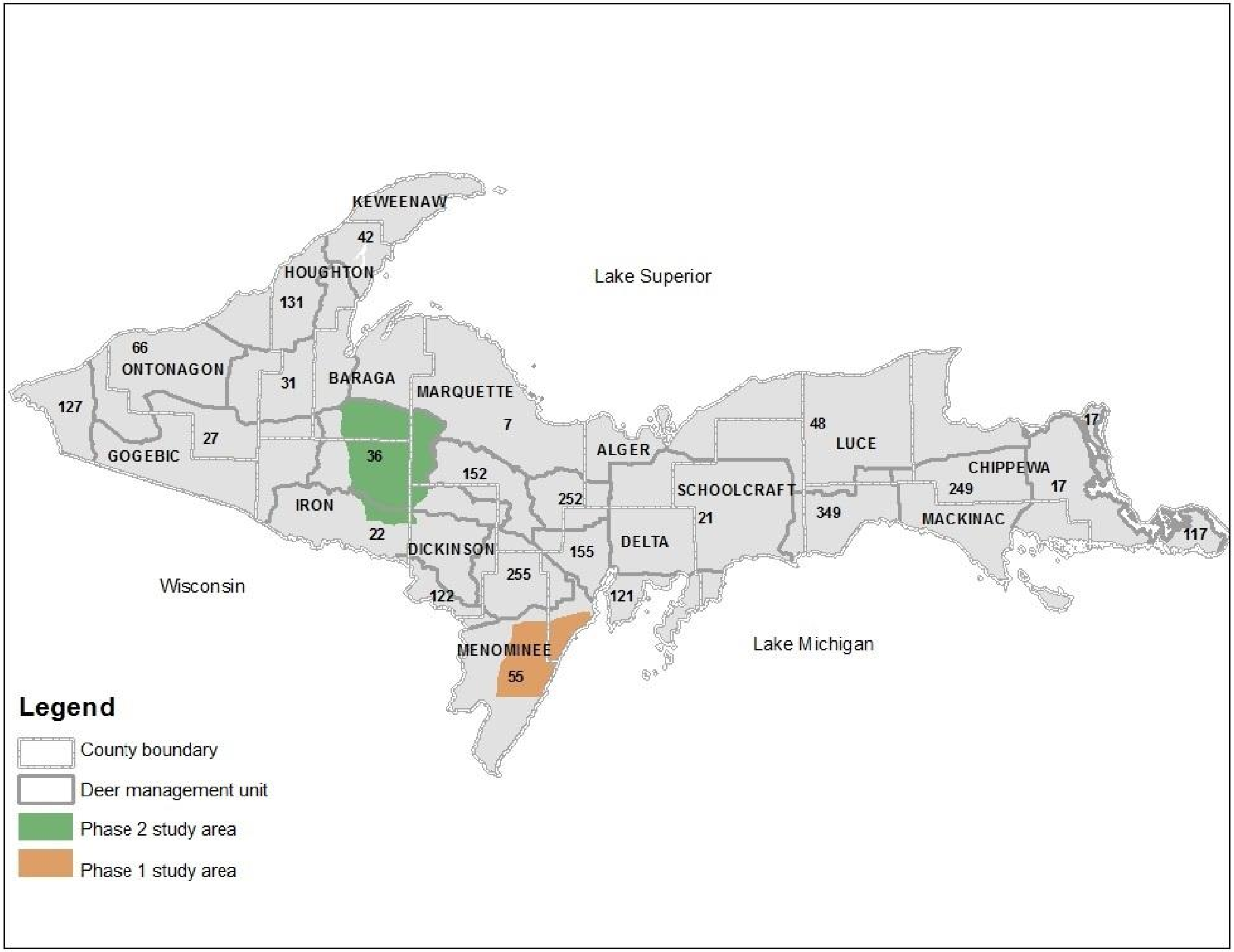

Figure 1. Location of phase 1 and 2 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, USA, 2013.

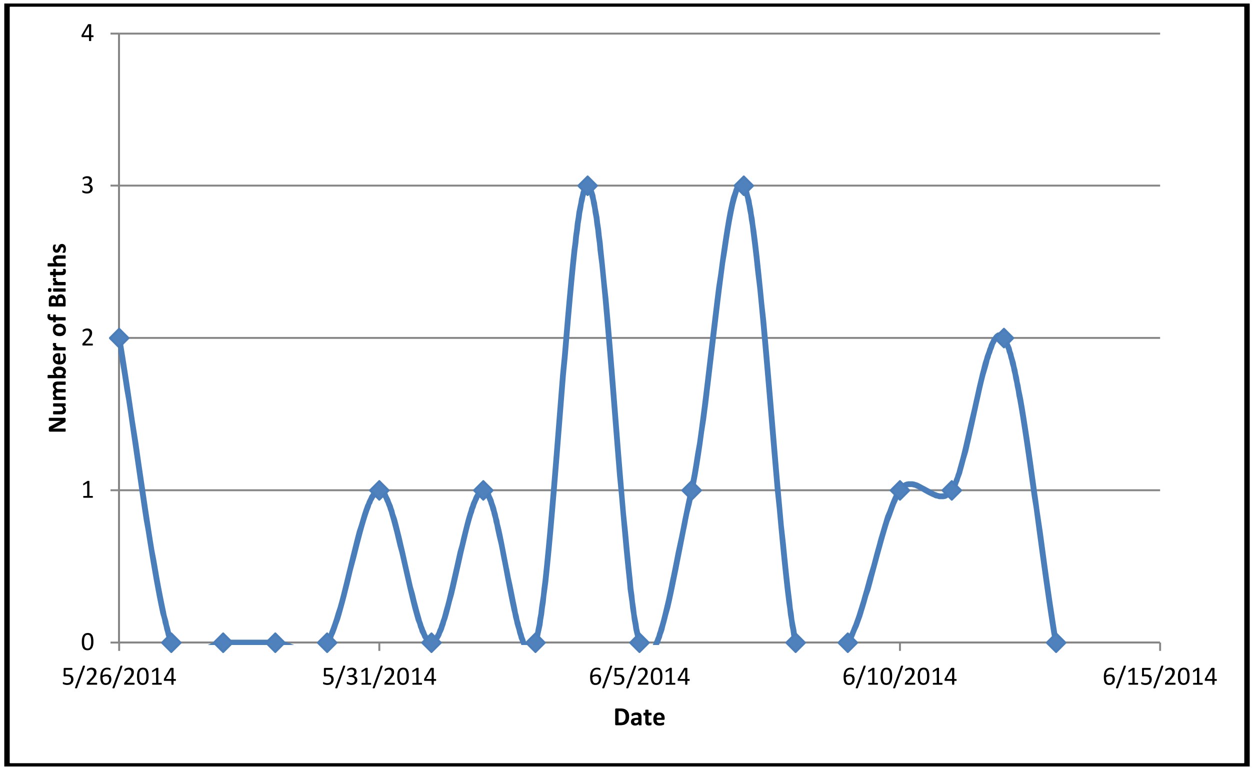

Figure 2. Estimated parturition dates of 15 free-ranging white-tailed deer fawns, Upper Peninsula of Michigan, USA, 2014.

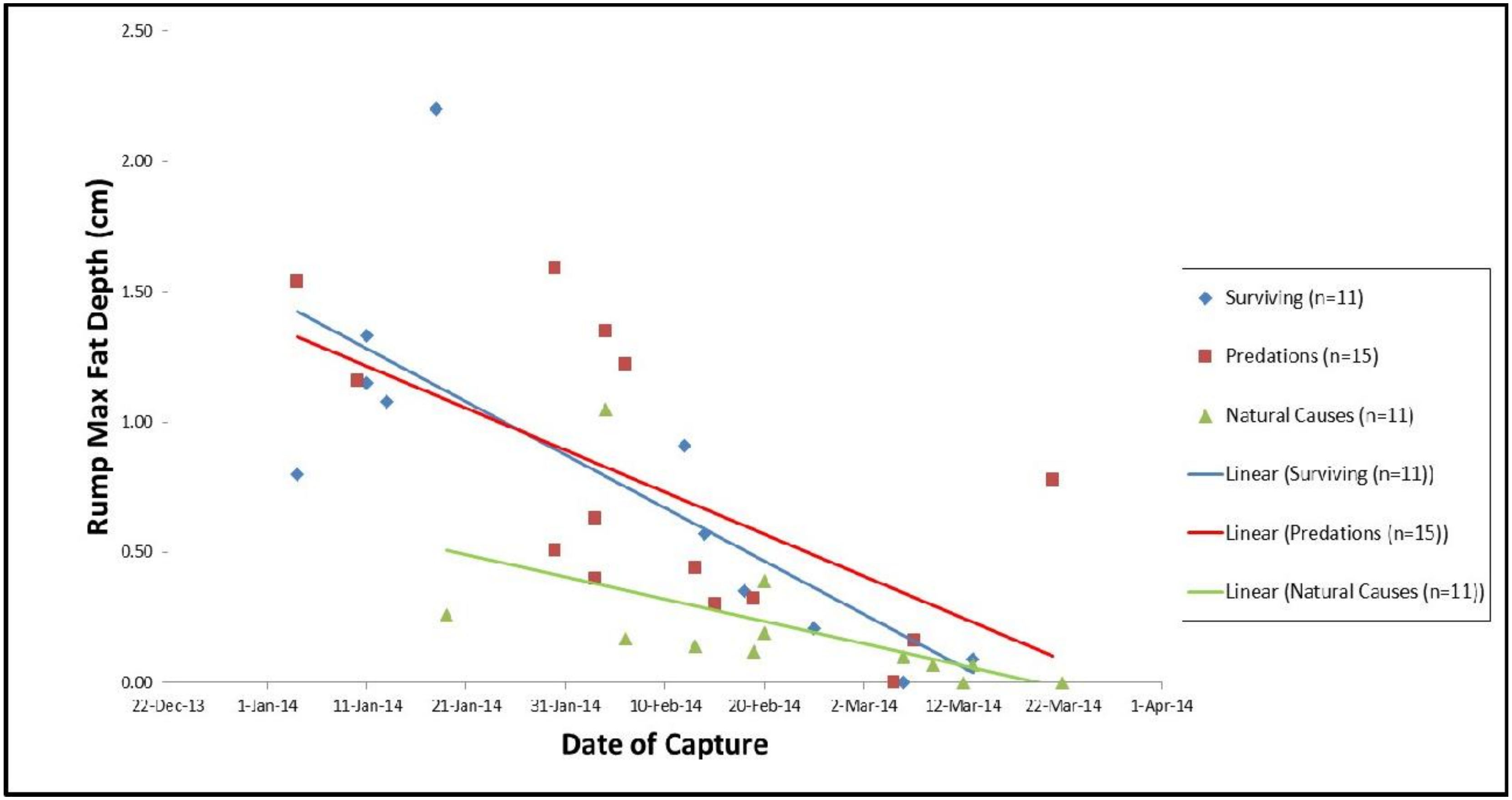

Figure 3. Maximum rump fat depth, capture date, and fates of 37 adult and yearling female deer, Upper Peninsula of Michigan, USA, Jan through March 2014. Regression lines reflect change in deer condition by capture date. Fates reflect deer survival from capture – 30 May 2014.

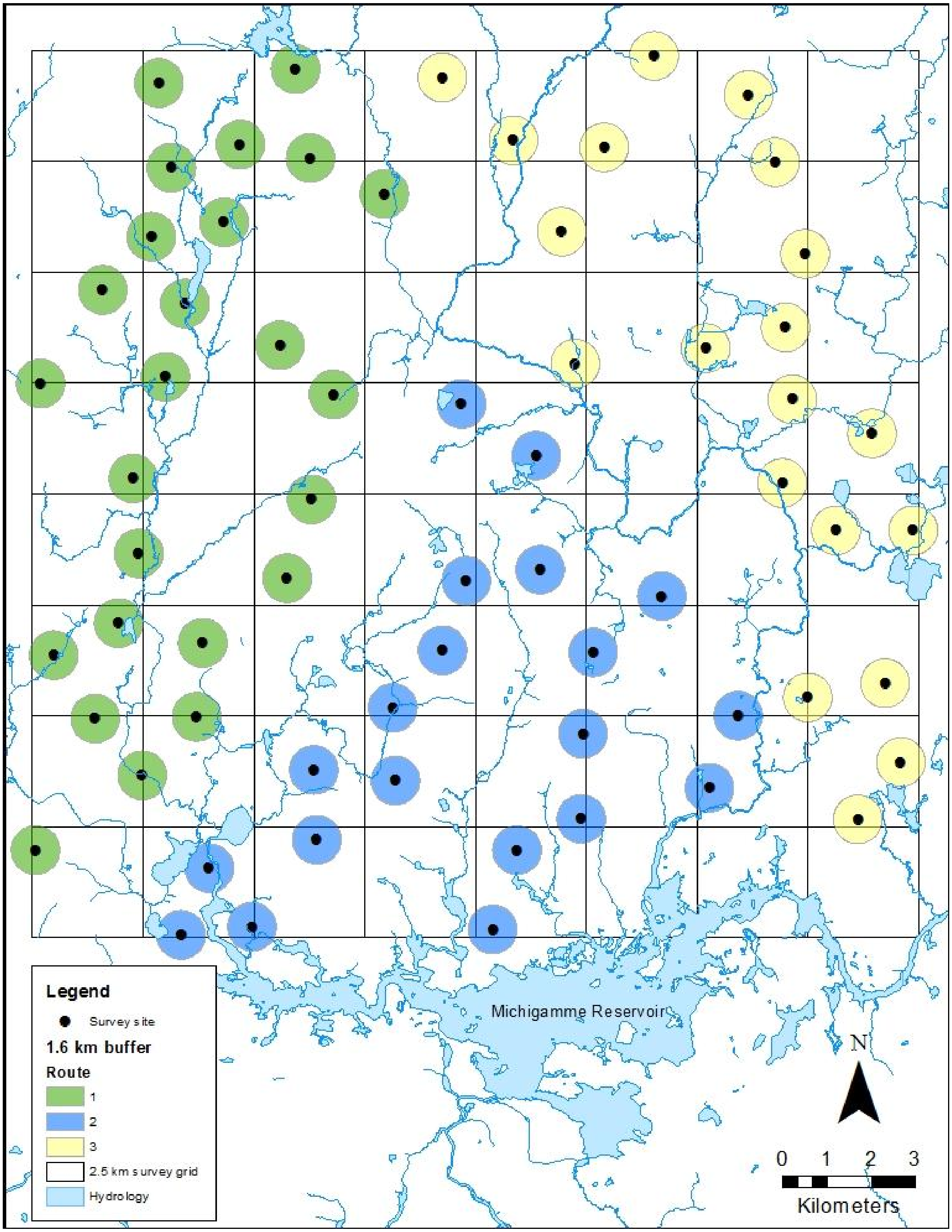

Figure 4. Locations of 65 grouse drumming survey sites with 3 routes shown to estimate ruffed grouse abundance, Upper Peninsula of Michigan, USA, 2013.

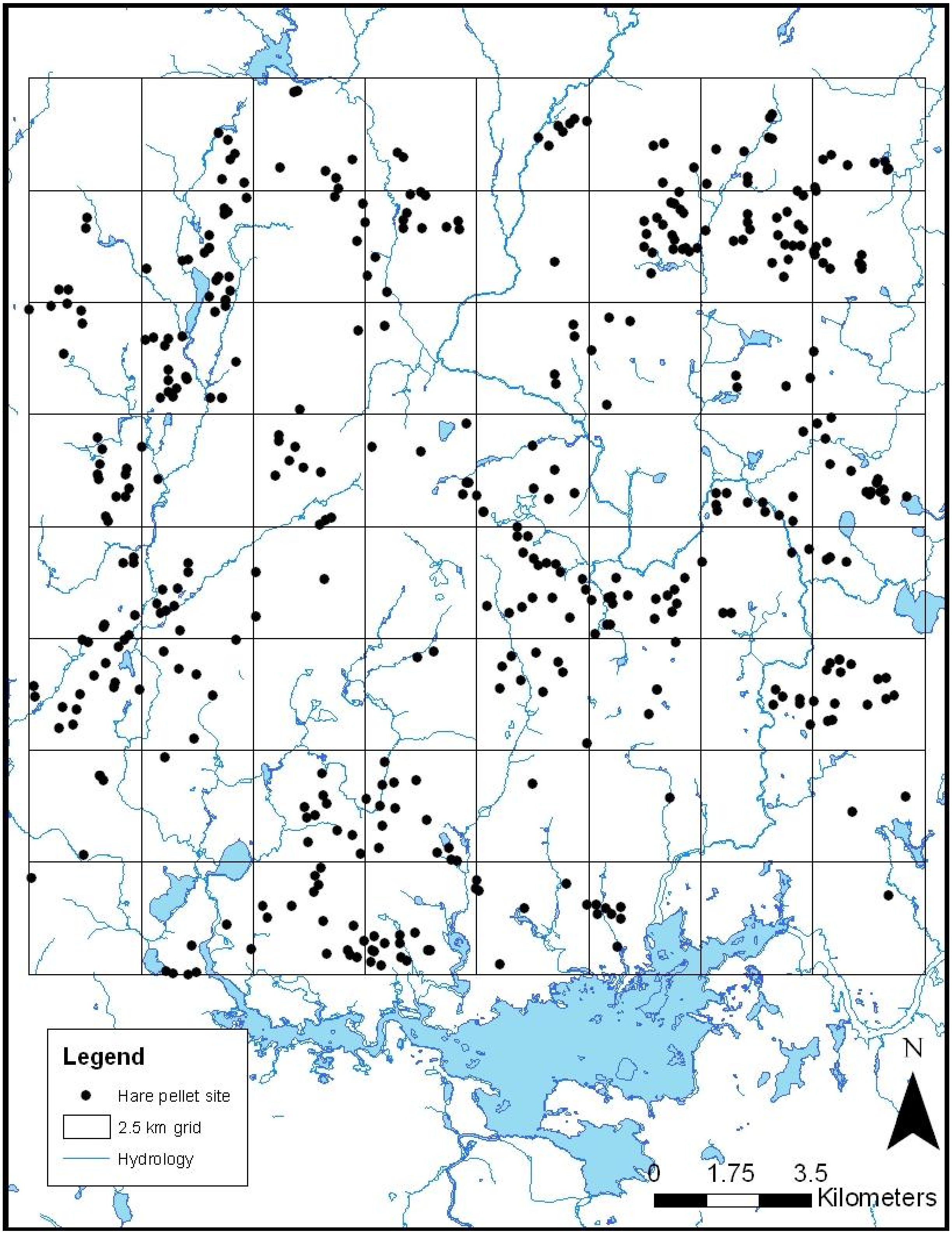

Figure 5. Locations of 440 completed hare pellet plot survey sites used to estimate snowshoe hare abundance, Upper Peninsula of Michigan, USA, 2014.

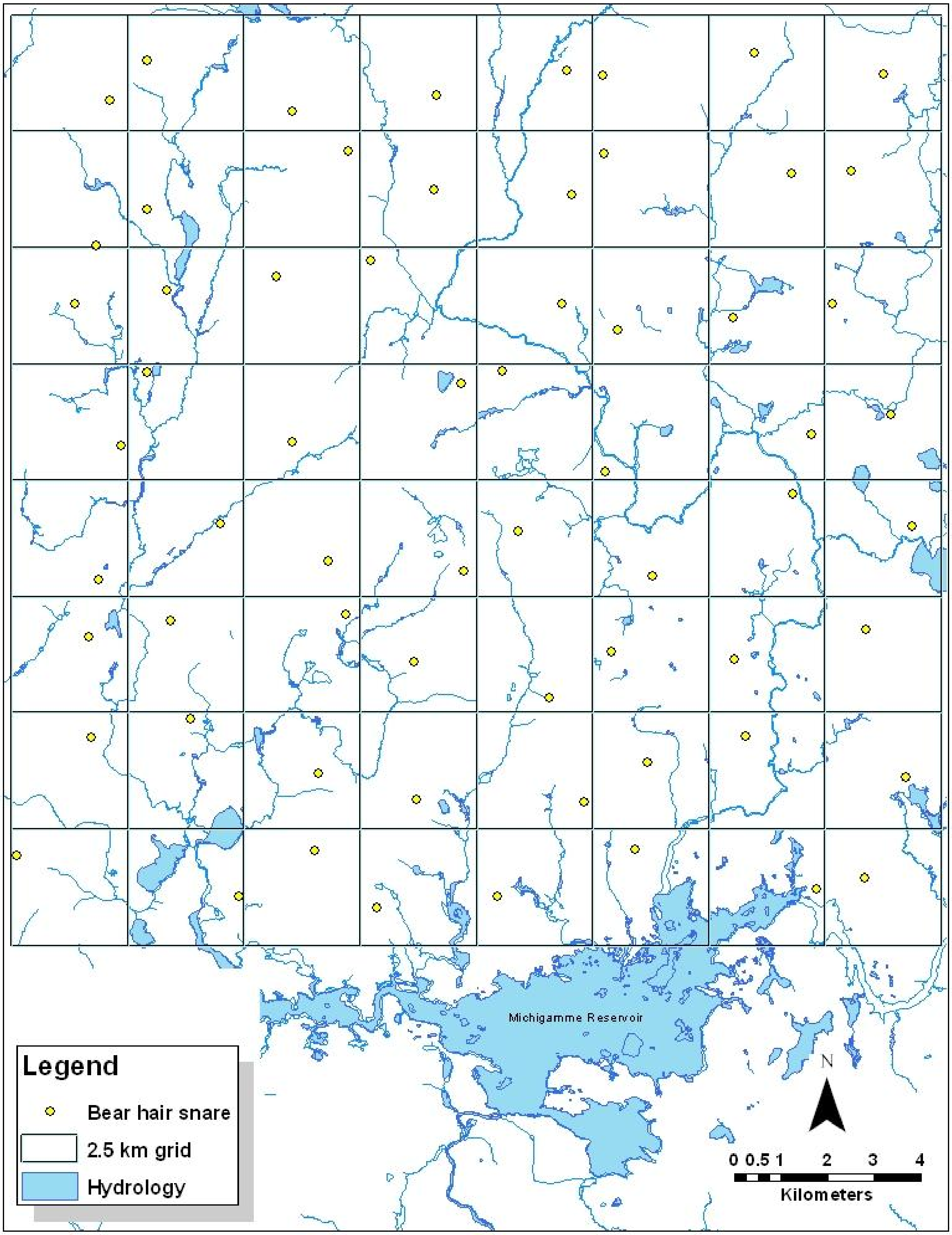

Figure 6. Locations of 64 black bear hair snares to estimate black bear abundance, Upper Peninsula of Michigan, USA, 2013.