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

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Abstract This report summaries work completed on both Phase 2 and 3; see details under the accomplishment section. We obtained 2,555 adult female and neonate fawn radiolocations in the Phase 2 study area. We observed 3 radio-collared adult female white-tailed deer mortalities, one mortality of a fawn radio-collared during June 2015, and we did not radio collar any fawns during 2016. To estimate deer abundance, we placed 52 remote infrared cameras throughout the Phase 3 study area at baited and unbaited sites and obtained >55,000 images. We immobilized 8 adult black bear (2 males, 6 females) and 5 yearlings (3 males, 2 females) and in dens and observed 10 cubs (7 males, 3 females) from 4 females in the Phase 2 study area. From May to July we captured and immobilized 24 adult black bears (18 male, 6 female) and fitted each with either a GPS or VHF collar in the Phase 3 study area. We completed howl surveys in the Phase 2 study area with response rates of coyotes and wolves of 28.7 and 1.7%, respectively. Howl surveys in the Phase 3 study area are ongoing with current coyote and wolf response rates of 11.25 and 1.25%, respectively. We opportunistically collected 147 scats from black bear, bobcat, coyote, and wolf in the Phase 3 study area. To provide an index of beaver abundance, we conducted aerial surveys and detected 37 inactive lodges, 60 active caches with a lodge present, and 16 active caches with no sign of a lodge in the Phase 2 study area. We published 2 refereed manuscripts in the journal PLoS One. Throughout the year, we hosted volunteers from various organizations and two photographers/videographers, gave 17 presentations, hosted 2 workshops, and kept our Facebook page (www.Facebook.com/MIpredprey) current with project results.

Summary

- We obtained 2,555 radiolocations of adult female and neonate fawn white-tailed deer in the Phase 2 study area.

- We observed 3 dead radio-collared adult female white-tailed deer. One mortality was attributed to bobcat predation, and two mortalities lacked sufficient evidence to determine cause.

- Of fawns radio-collared during summer 2015, we observed 1 mortality due to a vehicle collision. We censored 4 fawns after their radio-collars appeared to have fallen off.

- We placed 52 remote infrared cameras at non-baited sites throughout the Phase 3 study area to estimate deer abundance and obtained 36,385 images including 2,241 observations of deer (1366 adult female images, 115 adult male images, 598 fawn images, and 162 unidentified deer images).

- We placed 52 remote infrared cameras at baited sites throughout the Phase 3 study area to estimate deer abundance and obtained 19,187 images (Figure 1). Analysis of these images is ongoing.

- We immobilized 8 adult black bear (2 male, 6 female) and 5 yearlings (3 male, 2 female) and in dens and observed 10 cubs (7 male, 3 female) from 4 females in the Phase 2 study area.

- We set 1 cage trap to capture a bobcat (*Lynx rufus*) and removed its GPS collar in the Phase 2 study area.

- We captured and immobilized 24 adult black bear (18 male, 6 female) with barrel traps in the Phase 3 study area. We fitted 2 bear with a GPS collars and the remaining 22 bears with VHF radio-collars.

- We removed all 64 hair snare sites throughout the Phase 2 study area which were used to estimate black bear and bobcat abundance

- We built hair snares at 51 sites throughout the study area to estimate black bear and bobcat abundance (Figure 1).
- We completed 8 coyote (*Canis latrans*) howl surveys at 40 sites (Figure 2) in the Phase 2 study area from 13 July to 25 September 2015. Overall, we obtained coyote and wolf response rates of 28.7 and 1.7%, respectively.

- We established 40 sites for coyote howl surveys and subsequent abundance estimation (Figure 3). At present the coyote howl survey is in progress with 5 of 8 surveys completed. Currently response rates for coyotes and wolves are 11.25 and 1.25%, respectively.

- We opportunistically collected 147 scats from black bear, bobcat, coyote, and wolf.

- We conducted a beaver (*Castor canadensis*) cache survey to estimate beaver abundance within the Phase 2 study area. We flew 558 km of river and lakeshore and detected 76 active beaver caches (Figure 4).

- We are establishing a survey to estimate beaver abundance within the Phase 3 study area.

- We hosted individuals from Michigan Department of Natural Resources, Michigan Technological University, and Purdue University. We hosted a production crew of 906 Outdoors (Discovering) who took photos and video footage of project staff performing field duties featured in a television special.

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

- We gave presentations to 17 groups or organizations (including school groups) about project methods and results.

- During September–December 2015, May-August 2016 and September-December 2016 we hired and employed 2, 3, and 2 technicians, respectively.

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, to capture a gradient in winter conditions (Figure 5) and habitat. 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 comprised about 1,831 km^2 (706 mi^2) within Deer Management Unit 036 in Iron County (Figure 6). The general study area boundaries followed State Highway M-95 on the east, US Highway 41/28 on the north, US Highway 141 on the west, and State Highway M-69 on the south. The core study area, where we conducted most animal captures and population surveys, was north of the Michigamme Reservoir and included 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 occurred 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.

The third phase of this study spans about 1,550 km^2 (598 mi^2) within Deer Management Unit 031 in Baraga, Houghton, and Ontonagon counties (Figure 7). The general study area boundaries follow US Highway 41/141 on the east, State Highway M-38 on the north, US Highway 45/ State Highway M-26 on the west, and State Highway M-28 on the south. Dominant land cover classes are deciduous (35%), evergreen (23%), and mixed forests (21%). Road density is low across the study area (0.62 km/km^2) but higher densities occur around the few small towns on the periphery. The core study area, where we are conducting most capture efforts and population surveys, is centered on National Forest Road 16 and almost entirely within the Ottawa National Forest. 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 high-snowfall range, receiving over 250 cm of snowfall annually (about 70 cm more snowfall annually than the Phase 2 study area near Crystal Falls).

Accomplishments

Deer Telemetry (Phase 2)

We used bi-weekly aerial telemetry and GPS collars to monitor survival and obtained 2,555 locations of radio-collared adult females and fawns within the Phase 2 study area from 15 September 2015 to 15 September 2016. Monitoring of phase 2 deer was completed on 1 August 2016.

Deer Mortality (Phase 2)

From 16 September 2016 to 15 September 2016, we recorded 3 adult female mortalities. One mortality was attributed to bobcat predation, and for two mortalities the cause of death could not be determined.

We recorded 1 mortality and 4 censors of fawns born during May–June 2015. The mortality was attributed to a vehicle collision. Censors were due to dropped collars. Six fawns retained their collars and were monitored through 1 June 2016.

Deer Camera Survey (Phase 3)

From 3 July–3 August we placed 52 cameras at unbaited sites along secondary and tertiary trails throughout the study area to estimate deer abundance. We obtained 36,385 images including 2,241 observations of deer (1,366 adult female images, 115 adult male images, 598 fawn images, and 162 unidentified deer images). We will estimate deer abundance/density for the 261 km^2 sampling area using occupancy modeling (Duquette et al. 2014).

We also pre-baited 52 camera sites throughout the study area (Figure 1) with 7.5 *l* of whole kernel corn beginning 12 August and re-baited sites at 3-day intervals. The 10-day survey which included a 10-day pre-baiting period occurred from 12 August to 3 September. We obtained 19,187 images which we will estimate deer abundance/density for the 261 km^2 sampling area using occupancy modeling (Duquette et al. 2014) and will compare these results to the deer survey using unbaited cameras.

Black Bear Den Checks (Phase 2)

During 14 December 2015–28 February 2016 we immobilized 8 adult black bears (2 males, 6 females) and 5 yearlings (3 males, 2 females) in dens and observed 10 cubs (7 males, 3 females) from 4 adult females (Table 1). We weighed, recorded morphometric measurements, and collected blood samples from each immobilized bear. The yearlings did not receive collars and the collars on the adults were removed.

Bobcat Capture (Phase 2)

We set 1 cage trap to capture a previously collared bobcat at a private landowner's home. We captured the adult male on 22 February 2016. Once immobilized, we weighed, collected morphometric measurements, and removed the collar.

Spring/Summer Carnivore Capture (Phase 3)

During 20 May–20 July, we captured 24 black bears (18 males, 6 females) using barrel traps in the Phase 3 study area. We immobilized captured individuals and recorded gender, weight, and affixed uniquely-numbered ear tags (Figure 8; Table 2). We also recorded morphometric measurements, collected blood and hair samples, and estimated body condition

using physical attributes and bioelectrical impedance analysis. We removed a vestigial premolar for age estimation. All bears were fitted with VHF radio-collars except 2 females which were fitted with GPS collars, each with a leather breakaway device.

Carnivore Monitoring (Phase 2)

We recovered 2 bobcat, 3 coyote, and 3 wolf GPS radio-collars after the drop-off mechanisms activated during September–December 2015 in the Phase 2 study area. Including black bear collars retrieved from den checks we sent 17 GPS radio-collars to the manufacturer for refurbishment. We observed six harvested black bears and recovered their collars during the Michigan and Wisconsin 2015 black bear hunting seasons. We sent a premolar from each black bear to the Michigan Department of Natural Resources Disease Laboratory for age estimation. We located 9 bear dens (2 males, 7 females) during October–December 2015.

Black Bear and Bobcat Hair Snares (Phases 2 and 3)

We removed 64 black bear and bobcat hair snare sites from the Phase 2 study area from September–December 2015 and built 51 hair snare sites for each species? in the Phase 3 study area from May–September 2016. One black bear and bobcat hair snare site each remains to be constructed pending road access limitations.

Coyote Howl Surveys (Phases 2 and 3)

We completed 8 howl surveys at 40 sites (Figure 2) in the Phase 2 study area from 13 July to 25 September 2015. Overall, we obtained a coyote response rate of 28.7% and recorded five wolf responses (1.7% response rate). In the Phase 3 study area from 15 July to 10 September we have completed 5 of 8 howl surveys at 40 sites (Figure 3). Currently, coyote and wolf response rates are 11.25 and 1.25%, respectively. 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. At the end of the survey we will estimate coyote abundance in the Phase 3 study area using an occupancy modeling approach (Petroelje et al. 2014).

Wolf Track Surveys

We conducted wolf track surveys for the 2016 population estimate during 9–27 February within our study area to identify the number of wolf packs in the study area and the minimum number of individuals within each pack. We also used information from 3 GPS collared individuals to estimate territorial boundaries for 2 packs within the study area; Deer Lake and Mitchigan. We identified a minimum of 25 individuals consisting of four packs entire territories occurring within the study area: Deer Lake (minimum 6 individuals); Mitchigan (minimum 7 individuals); Shank Lake (minimum 7 individuals); and Republic (minimum 5 individuals).

Carnivore Scat Collection (Phase 3)

We opportunistically collected 147 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 are preparing scats for prey identification.

Aerial Beaver Cache Survey (Phases 2 and 3)

To provide an index of beaver abundance, we flew 558 km of river and lakeshore on 30th of October, 3rd and 10th November 2015 to identify active beaver caches in the Phase 2 study area. We conducted flights at an altitude of 200–250 m. We detected 37 inactive lodges, 60 active lodges with a cache present, and 16 caches with no sign of a lodge (equates to one active cache for every 7.3 km flown; Figure 2). We are currently designing the Phase 3 beaver survey which will occur during fall 2016.

Public Outreach (Phases 2 and 3)

During black bear den checks we hosted individuals from Michigan Department of Natural Resources (MDNR), Michigan Technological University, 906 Outdoors (Discovering), and other interested members of the public. We hosted a TV show who obtained images and video footage of project staff performing various field duties featured in a television special. We attended several Sportsman's Coalition Meetings where we discussed the project with members of the public to improve awareness of project goals and activities. We hosted 37 undergraduate students from Purdue University on 2–3 June for demonstrations of carnivore immobilizations, deer telemetry, trapping techniques, and non-invasive sampling methods. We presented at the Seney National Wildlife Refuge; Ottawa National Forest, Kenton Office; Ford Center in Alberta, MI; and Great Lakes Sports & Recreation Club in Escanaba, MI. We updated our Facebook page (www.Facebook.com/MIpredprey) to provide the public with project results.

Presentations to hunting groups and service organizations:

Fowler, N., C. Norton, T.M. Kautz, A.L. Lutto, Z. Farley, J.L. Belant, D.E. Beyer, Jr. 14 June 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Seney National Wildlife Refuge, Seney MI. 35 attendees.

Kautz, T.M., A.L. Lutto, N. Fowler, J.L. Belant, D.E. Beyer, Jr. 14 July 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Ottawa National Forest Kenton Office, Kenton, MI. 20 attendees.

Lutto, A.L., N. Fowler, Z. Farley, T.M. Kautz, J.L. Belant, D.E. Beyer, Jr. 10 August 2016. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Ford Center, Alberta, MI. 20 attendees.

Fowler, N., T.M. Kautz, T.R. Petroelje, A.L. Lutto, J.L. Belant, D.E. Beyer, Jr. 15 October 2015. Update on Michigan Predator-Prey Project. Sagola Sportsman's Coalition Meeting, Sagola, MI. 15 attendees.

Kautz, T.M., T.R. Petroelje, N.L. Fowler, A.L. Lutto, J.L. Belant, and D.E. Beyer, Jr. 4 November 2015. Michigan Predator Prey Project and the Role of Research in Natural Resource Management. Ithaca High School, Ithaca, NY. 130 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 17 November 2015. Michigan Predator-Prey Project. Forest Park Elementary School Second and Third Grade, Crystal Falls, MI. 30 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 17 November 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park High School, Crystal Falls, MI. 13 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 17 November 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park High School, Crystal Falls, MI. 17 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Michigan Predator-Prey Project. Forest Park Elementary School Second Grade, Crystal Falls, MI. 17 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Michigan Predator-Prey Project. Forest Park Elementary School Kindergarten, Crystal Falls, MI. 12 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Middle School Eighth Grade, Crystal Falls, MI. 17 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Middle School Sixth Grade, Crystal Falls, MI. 19 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan. Forest Park Middle School Seventh Grade, Crystal Falls, MI. 15 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Michigan Predator-Prey Project. Forest Park Elementary School Kindergarten, Crystal Falls, MI. 10 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 18 November 2015. Michigan Predator-Prey Project. Forest Park Elementary School Fourth Grade, Crystal Falls, MI. 20 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 24 November 2015. Michigan Predator-Prey Project. Forest Park Elementary School First Grade, Crystal Falls, MI. 16 attendees.

Lutto, A.L., T.R. Petroelje, T. Kautz, N. Fowler, J.L. Belant, and D.E. Beyer, Jr. 10 December 2015. Michigan Predator-Prey Project. Forest Park Elementary School Fifth Grade, Crystal Falls, MI. 17 attendees.

Seminars and Workshops:

Fowler, N., T. Kautz, A.L. Lutto, Z. Farley, J.L. Belant, and D.E. Beyer, Jr. 2-3 June 2016. Field techniques for wildlife capture and predation investigation. Purdue Wildlife Ecology Field Class, Silver Mountain, MI. 40 attendees.

Technician Hiring

During May-August and August-December 2016 we hired and employed 3 and 2 technicians, respectively.

Publications

Bled, F., S. Summers, D. Martell, T.R. Petroelje, D.E. Beyer, Jr., J.L. Belant. 2015. Effects of prey presence and scale on bobcat resource selection during winter. PLoS ONE 10:e0143347.

Duquette, J.F., J.L. Belant, N.J. Svoboda, D.E. Beyer, Jr., P.E. Lederle. 2015. Scale dependence of female ungulate reproductive success in relation to nutritional condition, resource selection and multi-predator avoidance. PLoS ONE 10:e0140433.

Work to be completed (September–December 2016)

Carnivore Monitoring and GPS Radio-collar Recovery

We will continue to monitor black bears until dens are located in early to mid-November.

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 hydrologic features to locate and record active beaver caches to index beaver abundance.

Equipment Organization, Inventory, and Storage

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

Public Outreach

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

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Table 1. Den check data for 23 black bears, Phase 2 Study Area, Upper Peninsula of Michigan, USA, 14 December 2015– 28 February 2016.

ID	Den check date	Age	Sex	Body weight (kg)	Right ear tag	Left ear tag
BB175	14-Dec-15	Adult	M	56.7	337	336
BB146	15-Dec-15	Adult	M	112.9	407	344
BB112	16-Dec-15	Adult	F	79.4	220	219
BB169	16-Dec-15	Yearling of BB112	M	24.9	343	342
BB162	17-Dec-15	Adult	F	90.7	305	306
BB171	17-Dec-15	Yearling of BB162	F	14.0	355	362
BB172	17-Dec-15	Yearling of BB162	F	7.0	358	356
BB173	17-Dec-15	Yearling of BB162	M	12.0	360	359
BB174	17-Dec-15	Yearling of BB162	M	19.0	357	361
BB117	25-Feb-16	Adult	F	93.0	173	161
BB180	25-Feb-16	Cub of BB117	M	1.5	NA	NA
BB181	25-Feb-16	Cub of BB117	F	2.0	NA	NA
BB182	25-Feb-16	Cub of BB117	M	2.0	NA	NA
BB120	26-Feb-16	Adult	F	72.6	229	228
BB183	26-Feb-16	Cub of BB120	F	1.5	NA	NA
BB184	26-Feb-16	Cub of BB120	F	1.5	NA	NA
BB185	26-Feb-16	Cub of BB120	M	2.0	NA	NA
BB116	27-Feb-16	Adult	F	70.3	239	238
BB186	27-Feb-16	Cub of BB116	M	1.0	NA	NA
BB187	27-Feb-16	Cub of BB116	M	1.5	NA	NA
BB188	27-Feb-16	Cub of BB116	M	1.5	NA	NA
BB178	28-Feb-16	Adult	F	79.4	346	345
BB189	28-Feb-16	Cub of BB178	M	1.5	NA	NA

Table 2. Capture data for 24 black bears, Phase 3 Study Area, Upper Peninsula of Michigan, USA, 24 May-20 July 2016.

ID	Capture date	Age	Sex	Body weight (kg)	Right ear tag	Left ear tag
BB300	24-May	Adult	M	52.2	341	340
BB301	8-Jun	Adult	M	63.0	327	326
BB302	9-Jun	Adult	F	74.8	328	329
BB303	15-Jun	Adult	M	56.7	333	332
BB304	18-Jun	Adult	M	NA*	NA**	NA**
BB305	18-Jun	Adult	M	47.6	330	417
BB306	19-Jun	Adult	M	124.7	378	377
BB307	22-Jun	Adult	F	61.2	399	400
BB308	23-Jun	Adult	M	55.6	389	390
BB309	24-Jun	Adult	M	61.0	387	331
BB310	26-Jun	Adult	M	40.3	392	391
BB311	27-Jun	Adult	M	127.0	379	380
BB312	27-Jun	Adult	M	43.6	394	393
BB320	5-Jul	Adult	M	123.7	470	471
BB313	27-Jun	Adult	F	38.9	381	382
BB314	28-Jun	Adult	M	89.7	384	385
BB315	29-Jun	Adult	M	48.9	451	452
BB316	29-Jun	Adult	M	42.2	474	475
BB317	3-Jul	Adult	F	44.9	383	398
BB318	4-Jul	Adult	F	62.6	396	395
BB319	5-Jul	Adult	M	59.8	473	472
BB321	7-Jul	Adult	M	69.1	463	464
BB322	12-Jul	Adult	M	84.8	465	466
BB323	20-Jul	Adult	F	49.3	467	468

*Unable to weigh bear due to shallow depth of immobilization

**Unable to ear tag bear due to shallow depth of immobilization

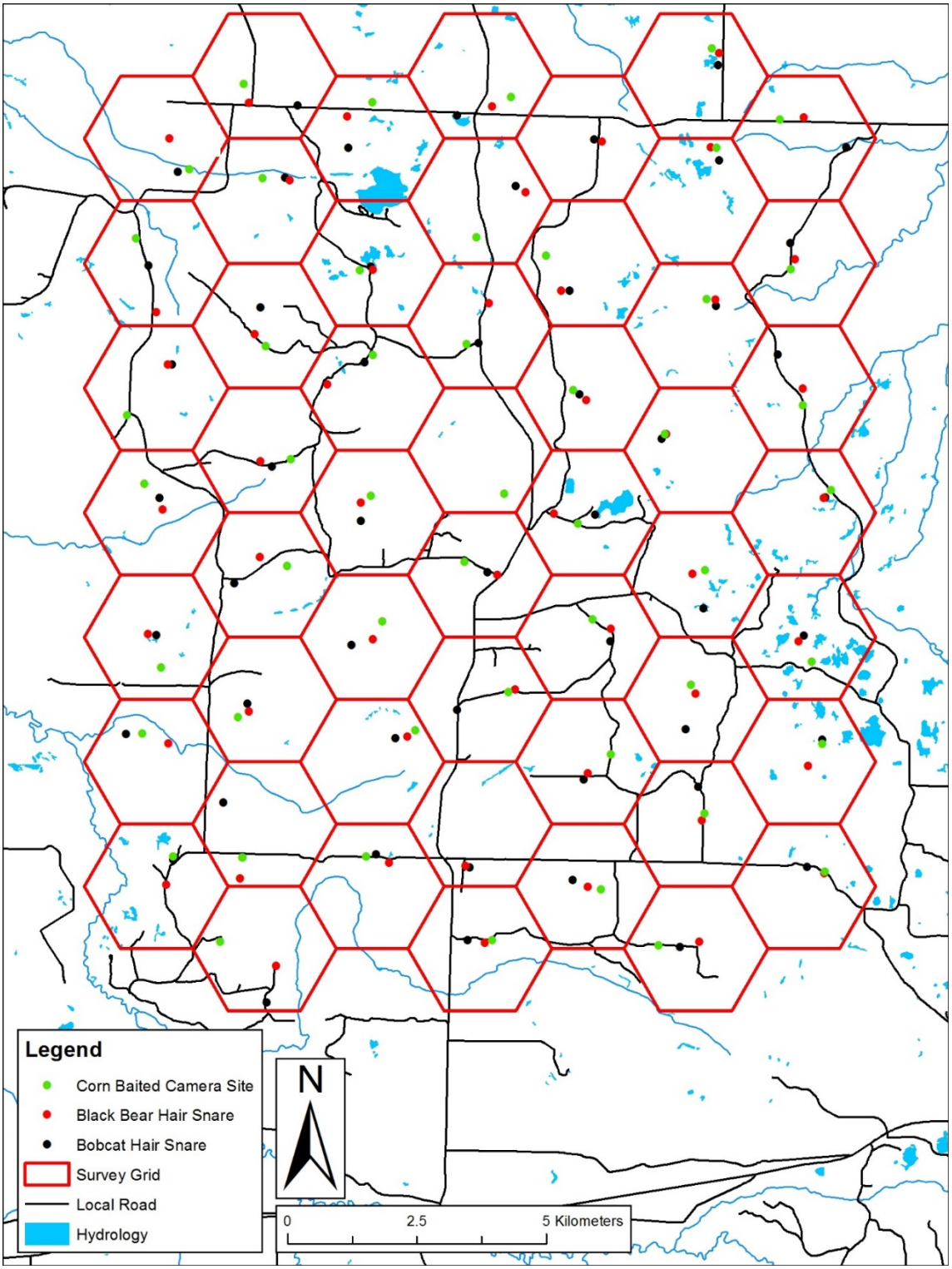

Figure 1. Locations of Phase 3 bobcat hair snares (51), black bear hair snares (51), and corn baited camera sites (52) to estimate bobcat, black bear, and white-tailed deer abundance, respectively; Upper Peninsula of Michigan, 2016. Remaining survey sites for bobcat and black bear is under construction.

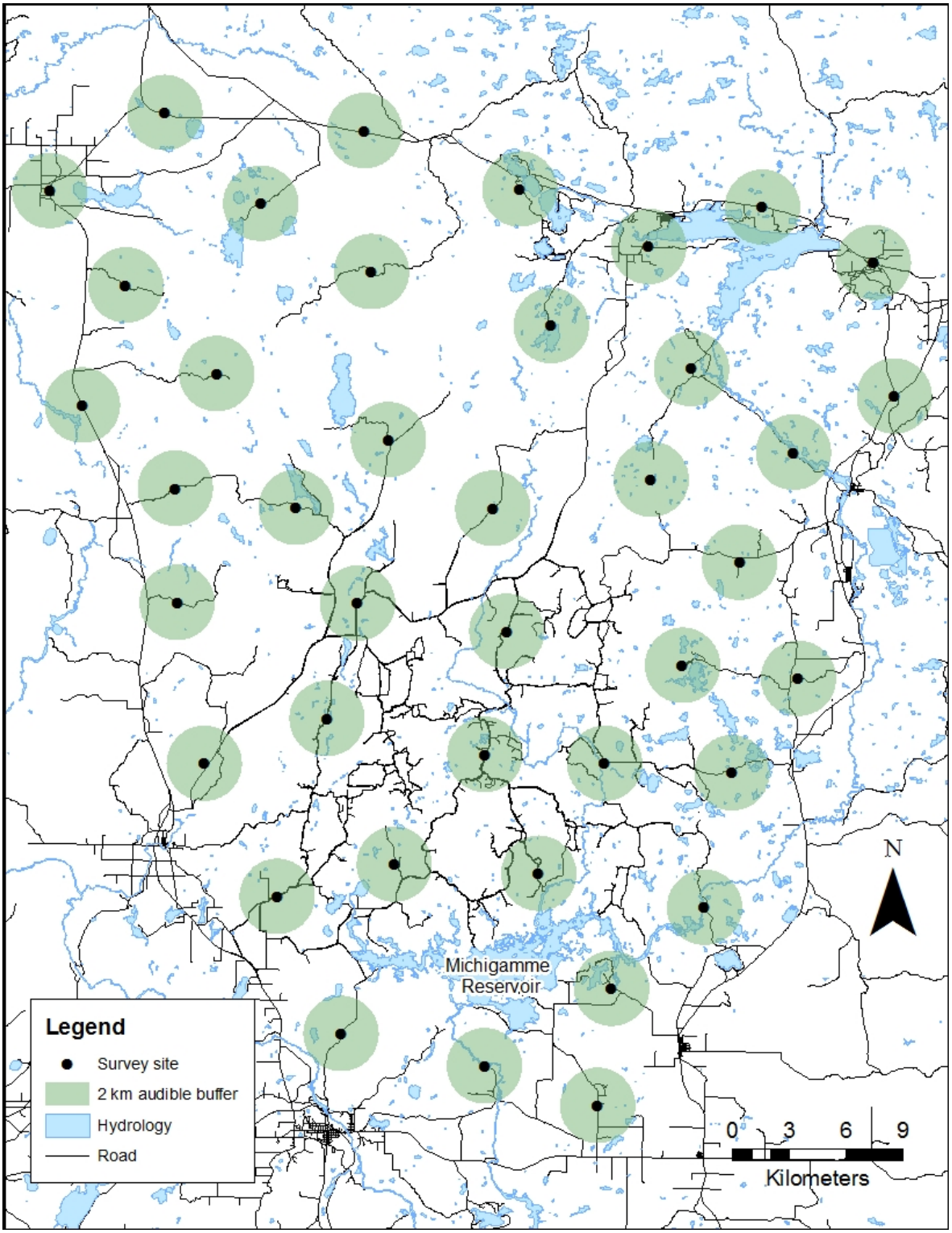

Figure 2. Phase 2 locations of 40 howl survey sites to estimate coyote abundance, Upper Peninsula of Michigan, 2015.

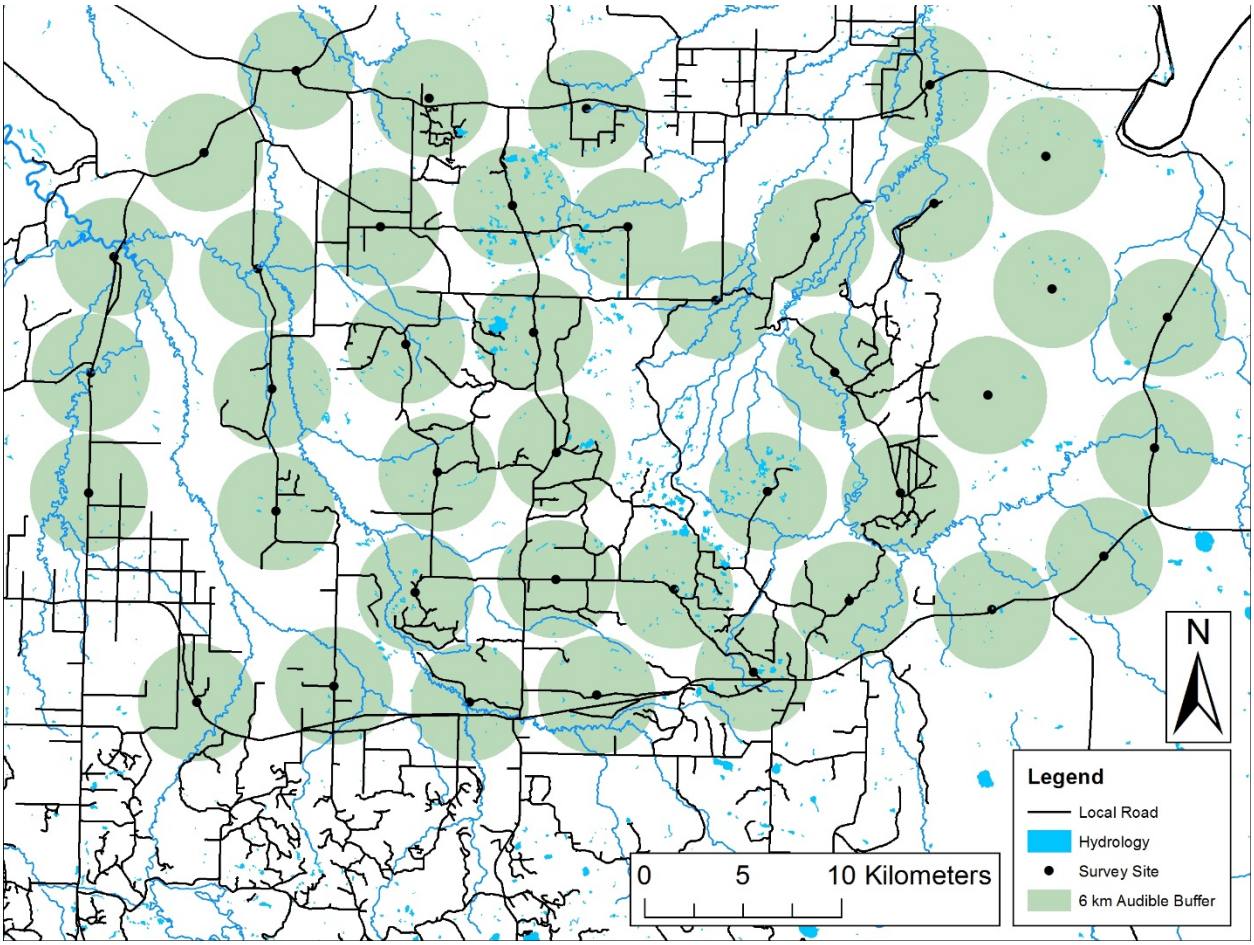

Figure 3. Phase 3 locations of 40 howl survey sites to estimate coyote abundance, Upper Peninsula of Michigan, 2016.

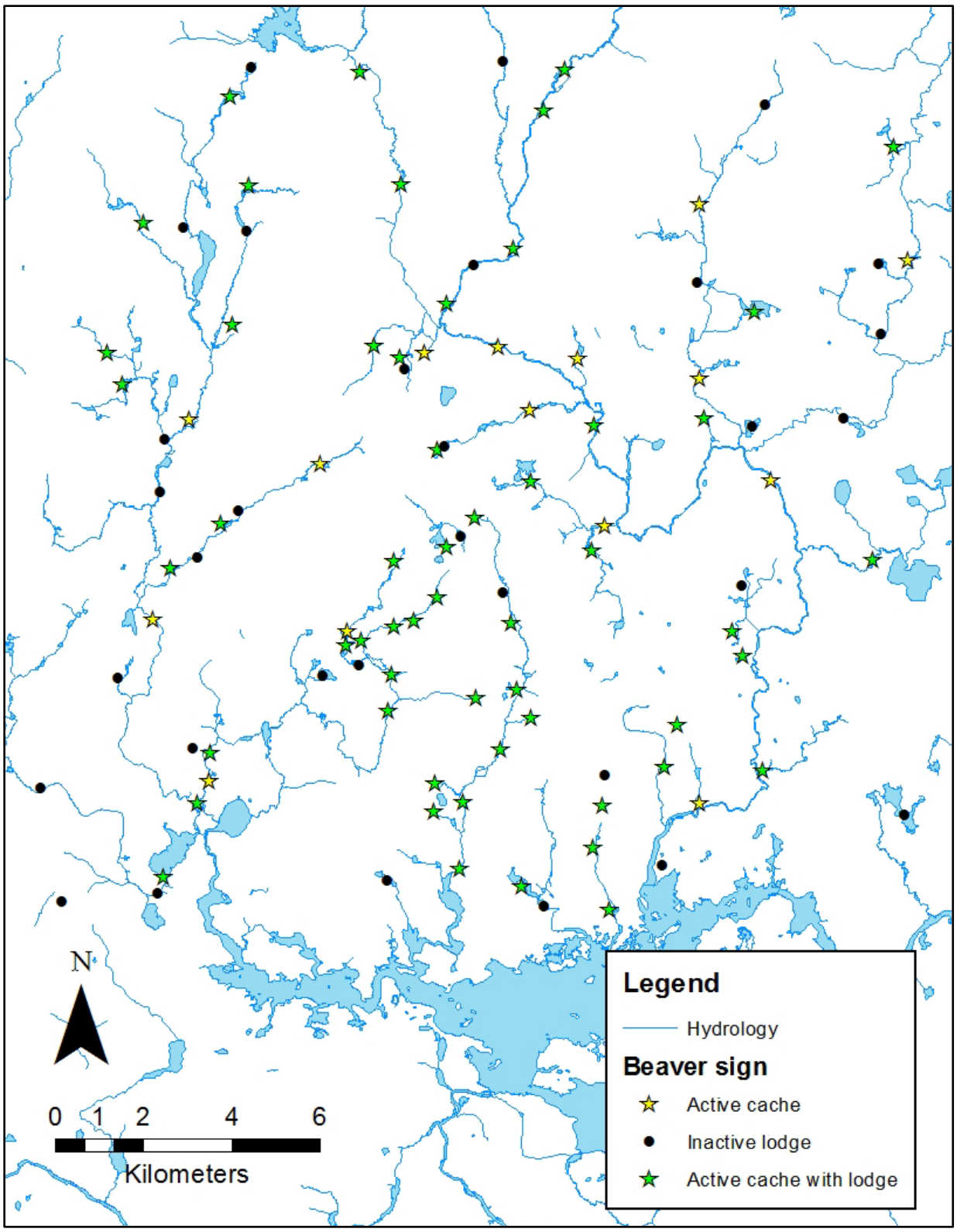

Figure 4. Locations of Phase 2 beaver caches and lodges detected aerially, Upper Peninsula of Michigan, USA, 30 October–03 November 2015.

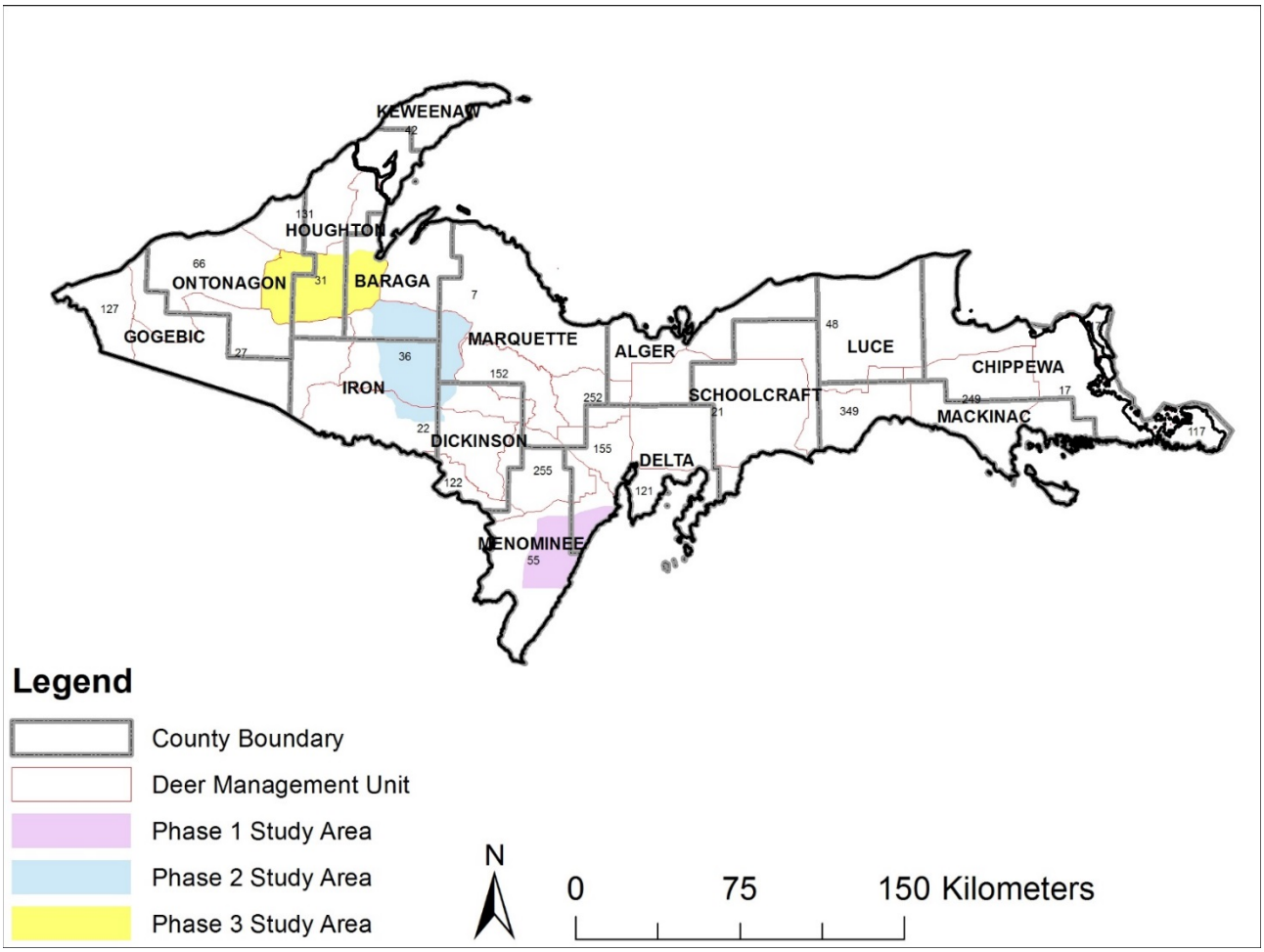

Figure 5. Location of phases 1, 2 and 3 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, 2008–2016.

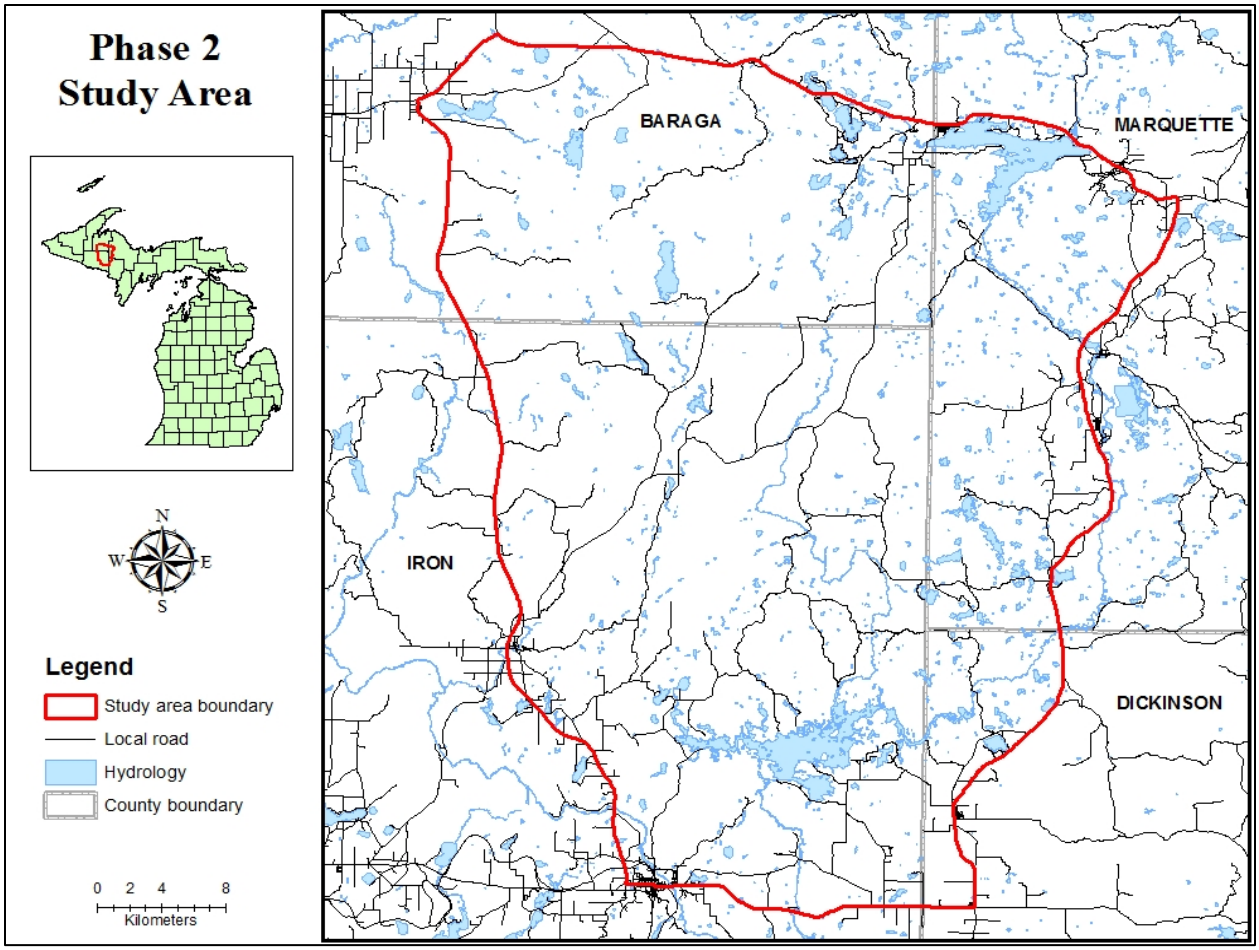

Figure 6. Phase 2 study area of Michigan Predator Prey Project, Upper Peninsula of Michigan, 2015.

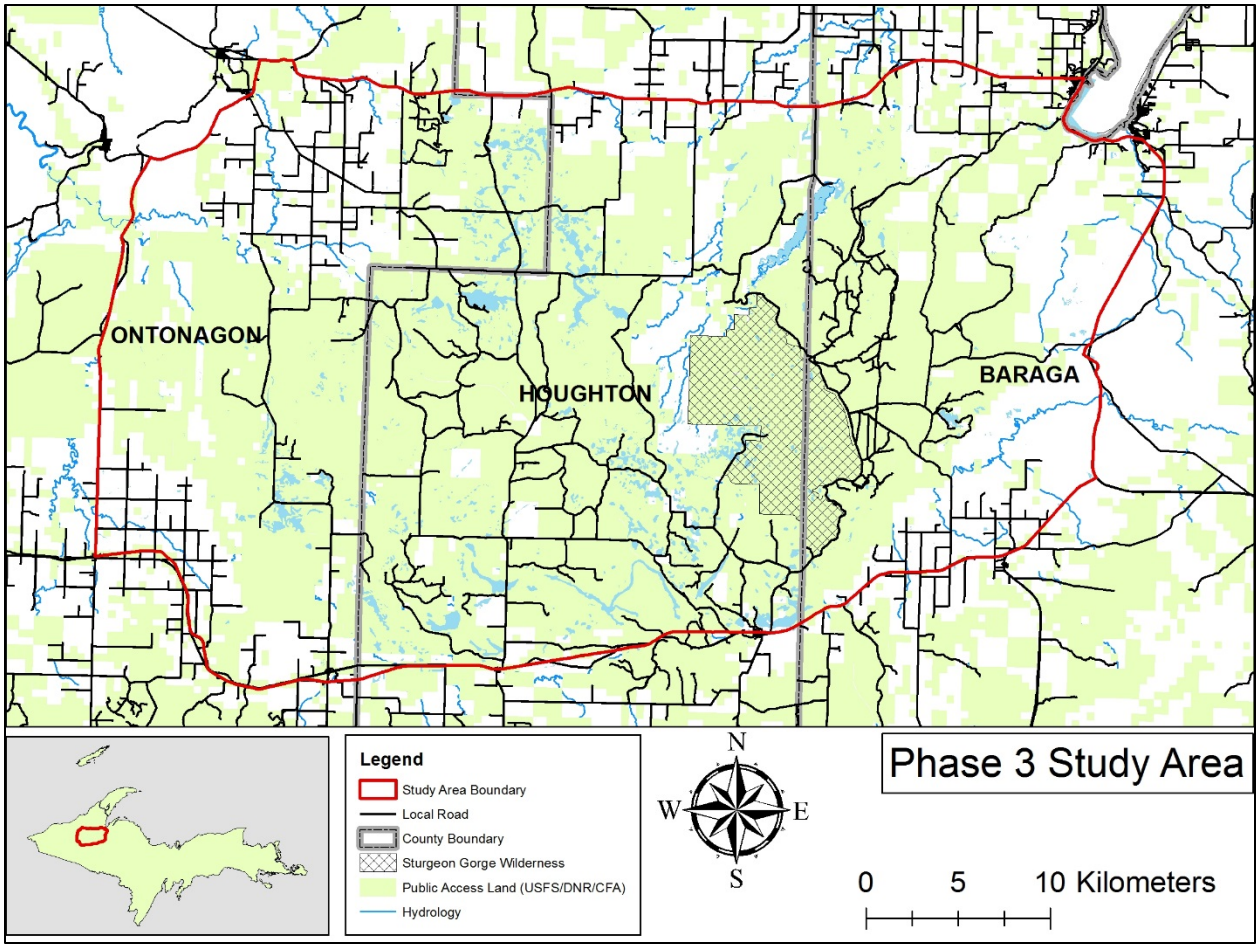

Figure 7. Phase 3 study area of Michigan Predator Prey Project, Upper Peninsula of Michigan, 2016.

Figure 8. Ear tagged black bear, bobcat, coyote, and wolf, Upper Peninsula of Michigan, USA, 2016.