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
Nathan Svoboda – Graduate Research Assistant
Jared Duquette – Graduate Research Assistant

Graduate Advisor:
Dr. Jerrold Belant – Assistant Professor

Report Contributors:
Heather Stricker – Mississippi State University
Chris Ayers – Mississippi State University
Tyler Petroelje – Northern Michigan University

Mississippi State UNIVERSITY

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

Abstract –Seventy-seven individual white-tailed deer (*Odocoileus virginianus*) were caught during February-March 2009, of which 36 pregnant does received radiocollars and vaginal implant transmitters (VIT). From 26 May–1 July 2009 forty-eight fawns were captured and radiocollared including 8 fawns from 23 VIT searches. Twenty-four fawn mortalities occurred from 29 May–30 September 2009. Sixteen black bears (*Ursus americanus*), 3 bobcats (*Lynx rufus*), 9 coyotes (*Canis latrans*), and 2 wolves (*Canis lupus*) were captured from 1 May–30 September and fitted with GPS or VHF radiocollars. Two-hundred sixty carnivore cluster locations and 77 non-cluster locations were investigated with vegetation measurements and alternative prey information collected. Three hundred fifty carnivore scats were collected to investigate diet. Forty-five black bear hair snares were constructed and maintained with 267 hair samples collected and sent to a genetics laboratory for genotyping. Fifty-five howl survey locations were established within the study area; 1 coyote howl survey and one wolf howl survey was conducted at each location. Coyote howl survey yielded a response rate of 31% to the coyote group-yip howl with no response from wolves; a 45% response rate from coyotes was obtained during the wolf survey using a lone wolf howl. One site received a response from a wolf pack during the wolf survey, and no lone wolves were detected. Responses from multiple individual coyotes or multiple groups of coyotes were detected at 4% and 7% of sites during the coyote and wolf surveys, respectively. Vegetation surveys were conducted at 17 fawn predation sites, 23 VIT drop sites, 260 predator cluster and non-cluster locations and 77 random locations. Small mammal track tubes (*n* = 396) were placed in 9 landcover types throughout the study area to index small mammal relative abundance. Project graduate students have met with their respective committees and developed draft research proposals. The project website was completed and 4 media sources have covered research 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 been conducted demonstrating 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 southern 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 lupus*).

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:

This study is centered on a ~900 km^2 (~350 mi^2) area within Deer Management Unit (DMU) 055 in Menominee County. The general study area is bordered on the east by the shoreline of Lake Michigan, on the north by US Highway 2, on the west by US Highway 41, and the south by the town of Stephenson. The core study area includes a mix of forested and agricultural lands and is where capture efforts occur. The overall study area consists of a minimum convex polygon that includes the composite locations of telemetered animals. This study area was selected because of the relatively low snowfall and generally low winter severity. Deer in this area are generally migrate only short distances or are non-migratory, making direct comparisons to southern Michigan (i.e., Pusateri Burroughs et al. 2006) easier.

Accomplishments:

<u>Winter Deer Capture</u>

From 16 February–22 March 2009 project staff captured white-tailed deer to place radiocollars on pregnant females. Seventy-seven individual deer (61 females and 16 males) were captured on 98 occasions. There were 21 recaptures; 14 were recaptured 2 times, 2 recaptured 3 times, and 1 recaptured 4 times. Individuals consisted of 33 adults, 10 yearlings, and 34 fawns. There were 42 does (≥1.5 years old) and 1 adult (≥1.5 years old) buck captured, while the female: male fawn ratio was 1:1.3. All captured deer were given round uniquely-numbered ear tags with colors specific to sex (females = blue, males = yellow; *Figure 1*), and collection of hair, fecal, saliva sample(s), and body condition scores (BCS) were attempted from each individual.

Thirty-six pregnant females were caught, immobilized, radiocollared, and received vaginal implant transmitters (VIT) tagged from 17 February–22 March 2009 (*Table 1*). Pregnancy was detected in 7 of 10 yearlings (70%) and 29 of 32 adult females (91%) using ultrasonography. Pregnant female temperature, respiration, and heart rate were monitored as soon as practical after immobilization and about 10-min intervals thereafter until reversal drug was administered. Personnel measured and recorded pregnant female morphometrics, BCS, pregnancy, and maximum (MAXF) and mid-rump (MIDF) fat depths when practical. Collection of an incisor tooth, blood, and urine were also attempted from each captured pregnant female.

Principal components analysis of 12 morphometric and BCS scores suggested female body weight described the greatest amount of variation in morphometric and BCS score data (*Figure 2*). Body weight estimates were closely related to body length, head length, and chest girth. Also, MAXF and MIDF, total length, and neck circumference estimates described moderate variation in morphometric and BCS score data. Mean MAXF estimates were greater ($P = 0.03$, $n = 31$; 1-tailed *t*-test) in adult ($\bar{x} = 1.50$ cm) than yearling ($\bar{x} = 0.60$ cm) pregnant females. However, mean MIDF estimates were similar ($P = 0.07$, $n = 31$, 1-tailed *t*-test) between adults ($\bar{x} = 0.92$ cm) and yearling ($\bar{x} = 0.47$ cm) pregnant females. Pregnant female BCS (range = 1[poor]–5 [excellent]) were greater ($P < 0.01$, $n = 36$, 1-tailed *t-test*) for adults ($\bar{x} =$ 3.00 BCS) than yearlings ($\bar{x} = 2.71$ BCS). Body condition was associated modestly with MAXF ($R^2 = 0.41$) and poorly with mean MIDF ($R_2 = 0.16$) estimates. Fecal and saliva samples (to assess cortisol levels), blood characteristics, urine profiles, and age (estimated from extracted incisor teeth) data will be evaluated later this year after analyses at independent laboratories.

Nine radiocollared female (5 adults, 4 yearlings) mortalities occurred post capture. Of these, 3 were predated (2 coyote, 1 wolf), 3 were unknown, 1 from a vehicle collision, 1 drowned, and 1 was radiocollar related. Although causes of 3 mortalities were unknown, these likely resulted from a coyote predation, early parturition complications, and physiological stress during handling. The radiocollar related mortality resulted from a front hoof being stuck in the collar while trying to cross a river. In addition, 5 female (4 adults, 1 yearling) mortalities occurred in traps before handling, in which deer broke necks attempting to escape the trap. Several measures have been discussed to reduce capture mortality and will be implemented during future capture operations. Radio contact with 2 collared does has been lost presumably due to radiocollar failure. There are 23 radiocollared does being monitored as of 30 September 2009.

<u>Fawn Capture</u>

Vaginal implant transmitter searches were conducted to find fawns of 23 implanted pregnant females from 17 May–13 July 2009. One adult female has not expelled the VIT as of 30 September 2009, which could have resulted from numerous factors. For example, doe malnutrition can result in inability to support fetal growth consequently leading to reabsorption of the fetus(es). Eight of 23 (35%) VIT searches resulted in the location of at least 1 fawn, of which seven were radiocollared, including 1 set of twins. Although percentage of fawn capture from VIT searches was lower than similar research using this technology (e.g., 66%; Carstensen et al. 2009), our search efforts were hindered by comparatively small search crews and dense vegetation at presumed birth sites. One fawn was found still born and 1 was predated before our arrival at independent VIT sites.

Beginning in late May, project staff began capturing, radiocollaring, and radiolocating white-tailed deer fawns. Forty-eight fawns (22 females, 25 males, and 1 unknown) were captured and radiocollared from 26 May–1 July 2009 (*Figures 3*). Personnel attempted to collect fawn morphometrics (*Table 2*), saliva, blood, hair samples, and identify sex from all fawns detected regardless if they were radiocollared or not. Personnel monitored fawn respiration rate and rectal temperature during handling. Bedsite and surrounding habitat, flush distance, presence of dam, other deer, and handling time were also recorded when practical.

Estimation of fawning and twinning rates were hampered by difficulty in detecting and capturing fawns during VIT searches. However, field personnel attempted to observe the number of fawns with radiocollared does and also radiocollared fawns with siblings which were not radiocollared. From these observations 10 of 48 (21%) radiocollared fawns had at least one sibling. In addition, 2 radiocollared does were observed to have at least 1 fawn which were not radiocollared during VIT searches. Observations of radiocollared and non-radiocollared fawns with VIT tagged does resulted in a 44% fawning rate (i.e., ≥1 fawn/doe). It should be noted that these are minimum estimates because fawn mortalities could have occurred prior to observations or siblings were not detected, therefore biasing fawning and twinning rates low.

<u>Fawn Mortality</u>

Twenty-four radiocollared fawn (12 females, 11 males, 1 unknown) mortalities have occurred through 30 September (*Figure 4*); this represents 50% of the 48 radiocollared fawns. The majority of fawn mortalities occurred during 2 periods, from late-May through mid-June and from late-July through mid-August. Nineteen (77%; 7 females, 11 males, 1 unknown) mortalities were from predation (*Figure 3*). Predation sources included 7 coyote, 5 bobcat, 3 unknown predator, 2 black bear, 1 bald eagle, 1 unknown canid. Remaining mortality sources included: 1 vehicle collision and 4 potential abandonments. Incidents of fawn abandonment were likely not caused by researcher handling, as personnel strived to minimize human scent transfer and time handling fawns. However, a set of twins presumed to be abandoned were handled on two consecutive days due to a dropped radiocollar. In addition, 2 fawns were not detected within a month post capture, likely due to radiocollar failure. There are 22 fawns being monitored as of 30 September 2009.

<u>Adult and Fawn Telemetry</u>

Mortality of collared adult females and fawns was monitored 1-4 times weekly using aerial or ground telemetry. Currently, all does (n = 23) and fawns (n = 24) alive have ≥40 locations. Radiocollared fawns were located ≥3 times/week through August and currently are located ≥1 time week. Collared fawns were monitored and occasionally flushed to observe whether a sibling was present to estimate twinning rates. Mortalities are investigated upon receiving a mortality signal to estimate survival and cause-specific mortality agents.

<u>Deer Abundance Estimation: Camera Survey</u>

Fifty-five remote infrared cameras were deployed from 5–26 September 2009 (34 from 5–15 September, 21 from 16 September–26 September) to estimate deer and potentially black bear abundance in the study area (*Figure 5*). The study area consisted of one contiguous polygon encompassing all telemetry locations of collared does through 24 July 2009. Cameras were distributed using random stratification methods based on a hexagonal (hexagon = 1.58 km^2) grid. Sites were pre-baited for 10 days and rebaited with shelled corn every 2 days throughout the 10-day sampling period. Imagery data from cameras is currently being entered for subsequent abundance estimates. Deer abundance estimates will be based on antler characteristics of male deer and also tagged and non-tagged deer. Specifically, marked deer (tagged and antlered) can be used as a subsample population in which to estimate the total deer population in the study area using estimates of buck:doe ratio, fawns observed, and survival of these animals. Survey images may also allow an abundance estimate for black bears depending on the number of bears images captured.

Carnivore Trapping and Monitoring

From 2 May–9 August 2009, 16 black bears (*Ursus americanus*; 8 female, 8 male), 3 bobcats (*Lynx rufus*; 3 male), 9 coyotes (*Canis latrans*; 7 females, 2 males), and 2 wolves (*C. lupus*; 1 female, 1 male) were captured, immobilized, and radiocollared. An additional female bobcat was captured but was too small (6.6 kg) to be collared. Black bears, bobcats and coyotes were given uniquely numbered blue ear tags and wolves were given uniquely numbered red ear tags (*Figure 6*). All captured animals were weighed, sexed, and evaluated for injury. Various morphometric measurements were taken along with blood, hair, fecal, and saliva sample(s). For each carnivore, body condition index (BCI) scores were estimated; black bears also received a bioelectric impedance assessment (BIA) to estimate body condition. Bobcat, coyotes and wolves had either a lower premolar or an upper lateral incisor removed for age estimation and black bears had a vestigial premolar removed for age estimation.

Twelve black bears were fitted with Lotek 7000MU GPS collars (Lotek Engineering, Newmarket, ON, Canada) and 3 black bears were fitted with Advance Telemetry System M2500 VHF collars (Advanced Telemetry Systems Inc., Isanti, MN). One GPS collar was deployed 12 days before falling off the animal. This collar was deployed on another black bear, totaling 13 black bears receiving GPS collars. All bobcats, coyotes, and wolves were fitted with Lotek 7000SU GPS collars. Bobcat and coyote collars were programmed to obtain a GPS location every 8 hours until 22 May, every 15 min from 22 May-28 August and every 8 hr until the collars are removed. Wolf collars were programmed to obtain a GPS location every 8 hr until 22 May, every 15 min from 22 May-1 August, and every 8 hr until the collars are removed. Black bear GPS collars were programmed to obtain a location every 15 min from the time of deployment until the collars are removed. All 7000SU GPS collars include a drop-off mechanism to release collars 30 weeks after deployment. All GPS location data can be downloaded remotely on demand (*Figure 7*). To date, 27 flights have occurred to download GPS locations (*Tables 3, 4*). One male bobcat (BC03) and 1 female coyote (C03) have not been located since 16 June and 22 June, respectively, despite multiple aerial searches.

Carnivore Cluster Investigations

Using clusters of carnivore locations obtained from GPS collars to identify predation sites provides a more efficient way to estimate the number and species of prey killed by different predators. Since large prey items (e.g., deer) take time to consume, a GPS collar programmed at an appropriate fix interval will provide multiple location fixes at locations where prey are handled (i.e., cluster). These clusters of fix locations provide an efficient means to investigate potential predation events. From 26 May-14 August we visited 260 GPS location clusters (*Figure 8*) identified manually using ArcGIS and 77 non-cluster locations selected opportunistically. A cluster was defined as ≥8 locations within 50 m of each other. Of the 260 clusters, 85 were black bear (mean clusters/black bear = 7, SD = 4), 57 bobcat (mean clusters/bobcat = 19, SD = 3), 90 coyote (mean clusters/coyote = 10, SD = 5), and 28 wolf (mean clusters/wolf = 14, SD = 7). Of the 77 non-cluster locations, 28 were black bear (mean non-clusters/bear = 2, SD = 2), 13 bobcat (mean non-clusters/bobcat = 4, SD = 1), 22 coyote (mean non-clusters/coyote = 2, SD = 2) and 14 wolf (mean non-clusters/wolf = 7, SD = 4). No clusters were obtained from VHF collared black bears (n = 3). To prevent disturbing animal behavior, handheld telemetry is performed prior to investigating a cluster to verify the animal is no longer in the area. Preliminary results include black bears foraging on skunk cabbage (*Lysichiton camtschatcense*), jack-in-the-pulpit (*Arisaema triphyllum*), wild raspberries (*Rubus ideaus*), wild strawberries (*Fragaria vesca*), and various colonial insects (i.e., ants, termites). One fawn predation was identified at a black bear cluster location. It is important to note that most black bears were collared during June-July after peak fawning occurred. Seven fawn and 3 adult deer predation sites were identified at bobcat cluster locations as well as 1 raven (*Corvus corax*), 1 skunk (*Mephitis mephitis*), 1 porcupine (*Hystrix cristata*), 2 songbirds (species not yet identified), and 1 grouse (*Bonasa umbellus*). Two fawn kills and 2 turkey (*Meleagris gallopavo*) kills were identified at coyote cluster locations. Investigation of wolf clusters identified scavenging activity at a livestock carcass dump. Cluster locations of male wolf W02 have been located near (<50m) a potential denning area preventing investigation of most cluster locations.

Carnivore Scat Collection

Carnivore scat samples were collected opportunistically throughout the study area; labeled by date, species, and UTM coordinates; and frozen. Three hundred fifty samples consisting of 102 bear scats, 11 bobcat scats, 137 coyote scats, 55 wolf scats, and 45 unknown scats were collected. Preliminary examination identified plant seeds, fawn hooves and hair, unknown feathers and bones, ruffed grouse feathers and feet, snails, and adult deer hair. Samples were sent to Mississippi State University, Carnivore Ecology Laboratory and are currently being cleaned and sorted. Scats will be analyzed for presence of prey species (e.g., deer fawn) hair and other dietary items (e.g., berries and corn).

Carnivore Mortality

As of 1 October, 5 collared black bears have been harvested (3 female, 2 male) during the black bear hunting season (*Table 3*). One additional black bear (BB02) removed its GPS collar on 2 July and is no longer being monitored. No mortalities have occurred on any other collared predators.

Bear Abundance Estimation: Hair Snares

Recent advancements in molecular genetics combined with noninvasive sampling techniques (i.e., hair snares) provide a means to non-invasively estimate population size using genotyping data and mark-recapture methods. Genotype data collected throughout this study will be used to estimate the number of black bears in the study area. Beginning 9 June 2009 hair snares were constructed to estimate black bear abundance throughout the study area. One snare was constructed in each cell of a 3 km^2 grid, resulting in 45 snares (*Figure 9*). Each snare consisted of a strand of 4-pronged barbed wire attached to the outside of 3 trees in a triangle shape 50cm above ground. Snares were baited by pouring 0.5 L of fish oil over a small pile of dead wood on the ground in the center of the triangle and spraying blackberry oil on the inside bark of the trees about 2 m above ground. Snares were allocated into 5 groups of 9 and checked and relured at 10-day intervals. Each snare was checked 5 times in 2009 and not relured on the final check. We collected 267 black bear hair samples which were sent to a genetics lab for genotyping.

We are also investigating the relationship between individual resource use and biological outcome. For Michigan black bears we are measuring the body fat content of each captured bear, tracking their movements with GPS collars, and remeasuring body fat content in the den. This information will be compared with similar data on bears from Alaska and Mississippi.

Bobcat Abundance Estimation

We are investigating and developing 3 methods to estimate bobcat abundance: winter track surveys, hair snares for individual identification using DNA, and radio-collaring and telemetry for home range spatial overlap analysis.

Winter track surveys for bobcats will occur simultaneously with track surveys for wolves and coyotes. We will record instances of bobcat, wolf, coyote, and select alternative prey species encountered. Protocols and data sheets for winter track surveys have been developed and are currently are being finalized.

Hair will be collected for DNA analysis using a modified "break-away" body snare (DePue and Ben-David 2007) to prevent cross-contamination by >1 individual (*Figure 10*). A prototype using this design is currently being developed. Density will be estimated using a hierarchical spatial capture-recapture model derived from individual bobcat capture probabilities. The model will adopt a Bayesian analysis approach outlined by Royle and Young (2008) and Gardner et al (in press). Statistical modeling approaches are currently being investigated and evaluated for relevance to this work.

Data from 3 bobcats fitted with GPS collars in spring 2009 have been collected and plotted using geographic information systems (GIS; ESRI, Redlands, CA.). Analysis of spatial overlap has not yet begun.

Coyote and Wolf Abundance Estimation

During August-September 2009, coyote and wolf howl surveys (HS) were conducted by attempting a 3-week rotation with a coyote survey in week 1, a wolf survey in week 2, and no survey during week 3. The study area was divided into four sections, allowing a survey to be completed in four consecutive nights from dusk-0300 h, weather permitting. Vocalizations were elicited using a FoxPro game caller with a group-yip howl to call coyotes, and a lone wolf howl for wolves. At each of the 55 HS sites, data collected included humidity, temperature, moon phase, wind speed and direction, species responding, response time and direction, number of individuals responding, type of response (e.g., lone howl, group howl), and recordings of responses.

Responses were recorded to estimate the number of individuals by differentiating their fundamental harmonic frequencies with sonographic analysis (*Figure 11*). Recorded estimates of individuals per group will be compared to estimates made by the observer in the field, providing an indication of the effectiveness of humans to detect fundamental frequencies, and can be applied to group responses that were heard but not recorded due to distance, wind, or traffic noise. Abundance will be estimated using the mean number of individuals per survey site, and that value will be applied to the entire study area.

The coyote survey (28 August-5 September) yielded a response rate of 31% to the coyote group-yip howl with no responses from wolves (*Figure 12*). A response rate (45%) from coyotes was obtained during the wolf survey (9-20 September) using a lone wolf howl (*Figure 13*). One site received a response from a wolf pack during the wolf survey, and no lone wolves were observed elsewhere. Responses from multiple individual coyotes or multiple groups of coyotes were detected at 4% and 7% of sites during the coyote and wolf surveys, respectively. Analysis of howl survey data is continuing.

Vegetation Surveys

Surveys quantifying vegetation structure, composition, and density were conducted at fawn predation sites (n = 17), VIT tag sites (n = 23), predator cluster and non-cluster locations (n = 260) as well as random locations (n = 77). Vegetation data will be used to estimate if event locations (e.g., birth sites, predation sites) differ in structural vegetation characteristics. For example, fawn birth site locations may occur in areas with increased vegetation structure to provide greater cover and reduce predation risk. Conversely, fawn predation sites may occur in areas with reduced vegetation structure that increases predation risk. Vegetation survey data has been compiled and is currently being analyzed.

Small Mammal Survey

From 22 July–9 October, 396 small mammal track tubes were placed in 9 landcover types throughout the study area to provide an index of small mammal relative abundance (*Figure 14*). Small mammals serve as an alternative food sources for focal predators, thus, we will attempt to estimate the relative abundance of alternative food sources (i.e., small mammals) within each landcover type comprising the study area. Landcover types include agriculture (n = 37 track tubes), upland mixed forest (n = 101), upland deciduous (n = 39), upland coniferous (n = 38), lowland deciduous (n = 44), lowland coniferous (n = 40), lowland mixed forest (n = 35), non-forested wetlands (n = 31) and open/barren areas (n = 31). Track tubes were constructed of 5.8 cm diameter (4.7 cm inside diameter) PVC pipe cut into 76 cm lengths. Each track tube consisted of a tracking medium (i.e., printer toner), tracking paper (i.e., double-sided carpet tape) and bait (peanut butter and bird seed; *Figure 15*). Track tubes were placed 20-30 m from roadways and removed after 4 days. Track tube data has not been compiled or analyzed.

Alternative Prey, Carnivore and Deer Observations

Alternative prey, carnivore and deer observations were recorded (i.e., species, location, time) daily by project personnel to provide an index of relative abundance within the study area. Daily start and end times were also recorded by each crew to determine daily time afield. As of 30 September, 2,745 observations were recorded. The 3 most observed alternate prey species were turkey (*Meleagris gallopava*), ruffed grouse, and squirrel (*Sciurus* spp.; *Table 5*). The 3 most observed carnivores were coyote, black bear, and wolf. Project personnel recorded 3,624 deer in 1,848 observations.

Public Outreach

Numerous outreach efforts were conducted for the project including:

- Project meetings with area sportsmen groups:
    - U.P. Whitetails Association
    - U.P. Bear Houndsmen Association
    - Michigan Bear Hunters Association
    - U.P. Sportsman's Alliance
    - U.P. Trappers Association
- Presentations and mass media:
    - 5 project-related posters were presented at the 2009 annual meeting of the Mississippi chapter of The Wildlife Society in Jackson, Mississippi on 2 October, 2009.
        1. "White-tailed deer survival, reproduction, and condition in the Upper Peninsula of Michigan" – Jared Duquette
        2. "Resource selection by carnivores and white-tailed deer in Michigan's Upper Peninsula" – Nathan Svoboda

3. “Linking individual resource use to biological outcomes and population management” – Chris Ayers
4. “Estimating population size of bobcats in Michigan’s Upper Peninsula” – Heather Stricker
5. “Estimating Coyote and Gray Wolf Abundance Using Howl Surveys in Michigan's Upper Peninsula” – Tyler Petroelje

- 2 Newspaper articles: Daily Press (Escanaba, MI)
- 1 Newspaper article: Mining Journal (Marquette, MI)
- Associated Press article: numerous newspapers and webpages
- Television program “Discovering” with Buck Lavasseur
- “Trails & Tails Outdoors Radio Show” with Tim Kobasic
- Research study website launched: http://fwrc.msstate.edu/carnivore/predatorprey/
- Presentation to the AuSable Institute of Environmental Science
- Production and distribution of 400 project brochures describing research goals and objectives

To improve our outreach efforts we are developing a communication strategy with the assistance of Dr. James Cantrill, Department Head, Communication and Performance Studies, Northern Michigan University. In order to improve communication and the transparency of our research results, Dr. Cantrill and his students will hold focus group meetings with a number of stakeholder groups to acquire feedback as to how we can most effectively communicate the results and management implications of this research to a broader public. The information will also be used to guide our future outreach efforts, as well as encourage further public cooperation with the project.

Protocols, Manuals, and Datasheets

The following protocols have been created:

- Fawn capture and radiocollaring
- Immobilization and handling
- Ultrasound and necropsy
- Vegetation/habitat data collection
- Vaginal implant transmitter monitoring and searching
- Weather station data collection
- Conduct/expectation manual for seasonal staff
- Winter track survey
- Carnivore trapping and radiocollaring
- Population surveys (i.e., hair snares, camera, tracking, and howl surveys)
- Telemetry (ground and aerial)
- Cluster investigation

The following datasheets have been created:

- Deer fawn capture
- Adult deer capture
- Vegetation survey
- Carnivore cluster analysis
- Necropsy/mortality

- Carnivore capture
- Deer radiotelemetry
- Trapline (deer and carnivore)
- Winter track survey

<u>Project Crew Selection and Hires</u>

One research associate was hired for the project. Project graduate students selected and hired 4 seasonal wildlife technicians and 3 volunteers for spring and summer field research activities. Several members of the public have also participated in various research activities.

Work to be completed (October-December 2009):

<u>Deer Trapping</u>

Modifications to improve our Clover trap design to reduce trap-induced deer injury are currently being implemented. Specifically, we will be tightening the netting and improving the door slide mechanism on traps. We will begin the second season of deer trapping efforts the third week of January 2010. Two additional volunteers will be recruited for winter trapping to increase our trapping efficiency and decrease time deer are in traps.

<u>Bobcat Capture and GPS Collaring</u>

Attempts at capturing bobcats will be made beginning in November and will continue through February. We will use Tomahawk box traps and California cage traps, baited with road-kill deer and beaver carcasses collected opportunistically from trappers. Bobcats captured will be fitted with a GPS collar and ear tags; hair, morphometric measurements, and sex data will also be recorded.

<u>Bobcat Hair Snares</u>

Design and assembly of bobcat hair snares will begin in October. Approximately 50 snares will be constructed and 2-3 snares will be set out early (before snowfall) to test field efficacy. Hair snares will be deployed during winter for 6 weeks on known bobcat trails and predetermined bait sites, likely beginning in December, with hair removed at weekly intervals. Bait will consist of road-killed deer carcasses or beaver carcasses collected from private trappers. Hair samples will be sent to a genetics laboratory for analysis. We will develop hair snare survey protocols and datasheets to begin use this winter.

<u>Winter Track Surveys</u>

Winter track surveys for all species of interest (bobcat, wolf, coyote) will begin at first snowfall, likely in late November or early December, and will continue throughout favorable snow conditions. Track surveys will be completed via truck, snowmobile, or ATV and will be conducted 24-48 hours after snowfall to allow for animal movement. Once identified, carnivore tracks will be followed a distance to identify individuals to estimate minimum abundance and possibly identify kill sites. Squirrel and other alternative prey tracks will also be recorded to estimate relative abundance within the study area. Track detections of bobcats, wolves, and coyotes will be used to derive rates of track deposition and minimum abundance. Two additional volunteers will be recruited in November for winter track surveys.

Carnivore Scat Collection

Project staff will continue to collect scat samples of focal carnivore species opportunistically throughout the study area. Staff will record date, GPS location, and species for each scat collected for analysis. Samples will be evaluated to estimate diet of each carnivore species throughout the year.

Alternative Prey and Deer Data

Project personnel will continue to record their daily start and end times in the field, as well as coordinates and time for each deer and alternative prey species observed. These data will provide an index of relative abundance of alternative prey and deer across the study area.

Public Outreach

The project brochure will be updated with preliminary results, printed, and distributed. Additionally, we will continue to work with Dr. James Cantrill, Department Head, Communications and Performance Studies, Northern Michigan University to develop a communication strategy to improve our outreach efforts.

Protocols and Manuals

- Cluster selection protocols
- Bobcat hair snare protocol
- All project protocols and manuals will be finalized, printed, and laminated for future use and reference

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.

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.

Depue, J.E. and M. Ben-David. 2007. Hair Sampling Techniques for River Otters. Journal of Wildlife Management 71: 671-674.

Gardner, B., J.A. Royle, M.T. Wegan. Spatial Models for Estimating Population Size from DNA Mark-Recapture Studies. *Submitted.*

Hiller, T. L. 2007. Land-use patterns and population characteristics of white-tailed deer in an agro-forest ecosystem in south central Michigan. Thesis, Michigan State University, East Lansing, USA.

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

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

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 K. V. Young. 2008. A Hierarchical Model for Spatial Capture-Recapture Data. Ecology 89:2281-2289.

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

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Table 1. Mean ($\bar{x}$) and standard deviation (SD) of morphometrics from 36 captured pregnant adult (*n* = 29) and yearling (*n* = 7) white-tailed deer, Upper Peninsula of Michigan, February–March 2009.

Age Class	Body weight (kg)	Body Length (cm)	Total Length (cm)
$\bar{x}$ Adult	56.10	147.31	173.05
SD	5.58	7.04	7.30
$\bar{x}$ Yearling	44.15	141.01	164.20
SD	3.77	5.55	6.59
$\bar{x}$ All Classes	54.10	146.08	171.33
SD	6.98	7.16	7.92
	Tail Length (cm)	**Head Length (cm)**	**Right Ear (cm)**
$\bar{x}$ Adult	25.75	32.02	15.60
SD	2.88	1.61	0.83
$\bar{x}$ Yearling	23.19	30.39	34.70
SD	4.48	0.76	50.85
$\bar{x}$ All Classes	25.25	31.70	19.31
SD	3.34	1.61	22.42
	Neck Circ (cm)	**Right Hind Foot (cm)**	**Chest Girth (cm)**
$\bar{x}$ Adult	34.19	47.88	91.79
SD	2.03	1.39	6.03
$\bar{x}$ Yearling	33.06	46.16	85.40
SD	3.33	1.24	5.80
$\bar{x}$ All Classes	33.97	47.54	90.54
SD	2.32	1.51	6.44
	BCI [1]	**Max-fat [2] (cm)**	**Mid-fat [3] (cm)**
$\bar{x}$ Adult	3.00	1.50	0.92
SD	0.31	2.16	1.37
$\bar{x}$ Yearling	2.71	0.60	0.47
SD	0.17	0.48	0.27
$\bar{x}$ All Classes	2.94	1.30	0.82
SD	0.31	1.94	1.22

[1] Body Condition Index (BCI) score for deer derived from palpating the scapula, spinal column, rump, and rib cage.
[2] Maximum rump fat estimate measured above pin bone of right hind hip.
[3] Middle rump fat estimate measured at mid-point between Ilium and pin bone on right hip.

Table 2. Mean ($\bar{x}$) and standard deviation (SD) of morphometrics from 50 white-tailed deer fawns (26 males, 22 females, 2 unknowns), Upper Peninsula of Michigan, 26 May–1 July 2009.

Sex	Body weight (kg)	Body Length (cm)	Total Length (cm)
$\bar{x}$ Male	2.17	62.33	73.45
SD	0.64	7.30	8.10
$\bar{x}$ Female	1.96	61.36	72.29
SD	0.54	5.34	6.12
$\bar{x}$ Both	2.07	61.90	72.93
SD	0.60	6.21	7.11
	Tail Length (cm)	**Right Shoulder (cm)**	**Right Ear (cm)**
$\bar{x}$ Male	11.11	43.60	8.62
SD	1.92	5.03	0.68
$\bar{x}$ Female	10.92	43.87	8.69
SD	2.45	3.56	0.98
$\bar{x}$ Both	11.03	43.73	8.65
SD	2.15	4.36	0.81
	Mean NHG [1]	**Right Hind Foot (cm)**	**Chest Girth (cm)**
$\bar{x}$ Male	3.15	26.71	36.69
SD	1.03	2.18	4.72
$\bar{x}$ Female	3.11	26.50	35.88
SD	0.99	1.66	3.37
$\bar{x}$ Both	3.13	26.62	36.32
SD	0.97	2.06	4.06

[1] Mean new hoof growth (NHG) calculated as mean new hoof growth of inside and outside toe of right front hoof.

Table 3. Capture and monitoring data for 31 radiocollared carnivores, Upper Peninsula of Michigan, 2 May–7 October, 2009

Species	*ID*	*Capture Date*	*Age*	*Sex*	*Weight (kg)*	*Ear Tag #'s*	*Days Monitored*	*Locations[1,2,3]*	*Collar Status/Interval*
Black bear	BB01	9-Jun-09	Adult	M	145.5	75/76	121	11418	Active/15 min
Black bear	BB02	21-Jun-09	Adult	M	NA	63/NA	12	994	Slipped Collar; 2 Jul 09
Black bear	BB03	21-Jun-09	Juvenile	F	23.0	55/56	93	8609	Harvested; 21 Sep 09
Black bear	BB04	23-Jun-09	Adult	M	140.9	57/NA	44	3475	Unable to locate
Black bear	BB05	29-Jun-09	Adult	M	79.5	59/60	84	7808	Harvested; 20 Sep 09
Black bear	BB06	30-Jun-09	Adult	F	88.6	61/62	81	7410	Harvested; 18 Sep 09
Black bear	BB07	1-Jul-09	Adult	M	208.7	64/65	99	9037	Active/15 min
Black bear	BB08	11-Jul-09	Adult	F	83.9	11/12	89	8321	Active/15 min
Black bear	BB09	12-Jul-09	Adult	M	93.0	66/67	88	8031	Active/15 min
Black bear	BB10	12-Jul-09	Juvenile	F	72.3	68/69	88	8249	Active/15 min
Black bear	BB11	19-Jul-09	Juvenile	F	74.8	70/71	71	6485	Harvested; 27 Sep 09
Black bear	BB12	21-Jul-09	Adult	F	99.8	72/73	79	6968	Active/15 min
Black bear	BB13	23-Jul-09	Adult	M	131.5	77/78	7	7	Harvested; 8 Aug 09
Black bear	BB14	4-Aug-09	Adult	F	68.0	79/80	65	6039	Active/15 min
Black bear	BB15	8-Aug-09	Adult	M	104.3	81/82	7	7	Active/VHF
Black bear	BB16	9-Aug-09	Adult	F	79.4	83/84	7	7	Active/VHF
Bobcat	BC01	4-May-09	Adult	M	12.7	47/48	156	6973	Active/8 hr
Bobcat	BC02	5-May-09	Juvenile	F	6.6	38/39	NA	NA	NA
Bobcat[1]	BC03	9-May-09	Adult	M	NA	1/2	39	2469	Unable to locate
Bobcat	BC04	16-May-09	Adult	M	10.9	26/27	144	9280	Active/8 hr
Coyote	C01	4-May-09	Adult	F	14.5	45/46	156	6903	Active/8 hr
Coyote	C02	5-May-09	Adult	F	10.9	13/14	155	6916	Active/8 hr
Coyote[2]	C03	8-May-09	Adult	F	12.3	40/41	29	1037	Unable to locate
Coyote	C04	20-May-09	Adult	M	14.3	51/52	140	9303	Active/8 hr
Coyote	C05	21-May-09	Adult	F	11.4	53/54	139	9370	Active/8 hr
Coyote	C06	22-May-09	Adult	F	11.8	30/31	138	9304	Active/8 hr
Coyote	C07	23-May-09	Adult	M	12.5	21/33	137	9180	Active/8 hr
Coyote	C08	31-May-09	Adult	F	10.7	3/4	94	8596	Maintenance mode[4]
Coyote	C09	5-Jun-09	Adult	F	NA	NA/NA	124	7405	Active/8 hr
Wolf	W01	2-May-09	Adult	F	30.5	553/554	158	6610	Active/8 hr
Wolf	W02	4-May-09	Adult	M	42.3	555/556	156	6779	Active/8 hr

[1] Bobcat BC03 has not been located since last downloaded on 16 June

[2] C03 locations were last downloaded on 5 June; GPS battery is no longer working

[3] BB13, BB15, BB16 received VHF collars only

[4] C08 locations were last downloaded 1 September; collar is in maintenance mode and is no longer capable of sending GPS locations remotely

Table 4. Monitoring data for 26 radiocollared carnivores, Upper Peninsula of Michigan, 2 May–7 October 2009.

		Number of days monitored			Number of locations		
Species	**n**	**mean**	**SD**	**range**	**mean**	**SD**	**range**
Black bear[1]	12	84	19	44-121	7654	1905	3475-11418
Bobcat[2]	3	113	64	39-156	6241	3464	2469-9280
Coyote[3,4]	9	124	40	29-156	7557	2657	1037-9370
Wolf	2	157	1	156-158	6695	120	6610-6779

[1] Data does not include 3 bears with VHF collars or bear (BB02) that slipped GPS collar after 12 days

[2] Bobcat BC03 has not been located since last downloaded on 16 Jun

[3] Coyote CO3 locations were last downloaded on 5 June: GPS battery is no longer working

[4] C08 locations were last downloaded 1 Sep 09; collar is no longer sending GPS locations remotely

Table 5. Alternative prey and carnivore observations, Upper Peninsula of Michigan, 1 May–5 October, 2009.

Alternative Prey Observations		
Species	Observations	No. Observed
Turkey	237	618
Grouse	158	223
Squirrel	113	120
Pheasant	79	91
Unk. Game Bird	75	75
Rabbit/Hare	59	64
Porcupine	56	58
Woodcock	49	54
Small Mammals	10	10
Woodchuck	6	6
Skunk	5	5
Raccoon	3	4

Carnivore Observations		
Species	Observations	No. Observed
Coyote	13	28
Bear	13	13
Wolf	8	15
Red Fox	4	4
Skunk	5	5
Raccoon	3	4
Bobcat	3	3
Unk. Canid	3	3
Gray Fox	2	2
Feral Cat	2	2
Badger	1	1
Marten	1	1

Figure 1. Ear tag of female (blue) and male (yellow) white-tailed deer, Upper Peninsula of Michigan, 2009.

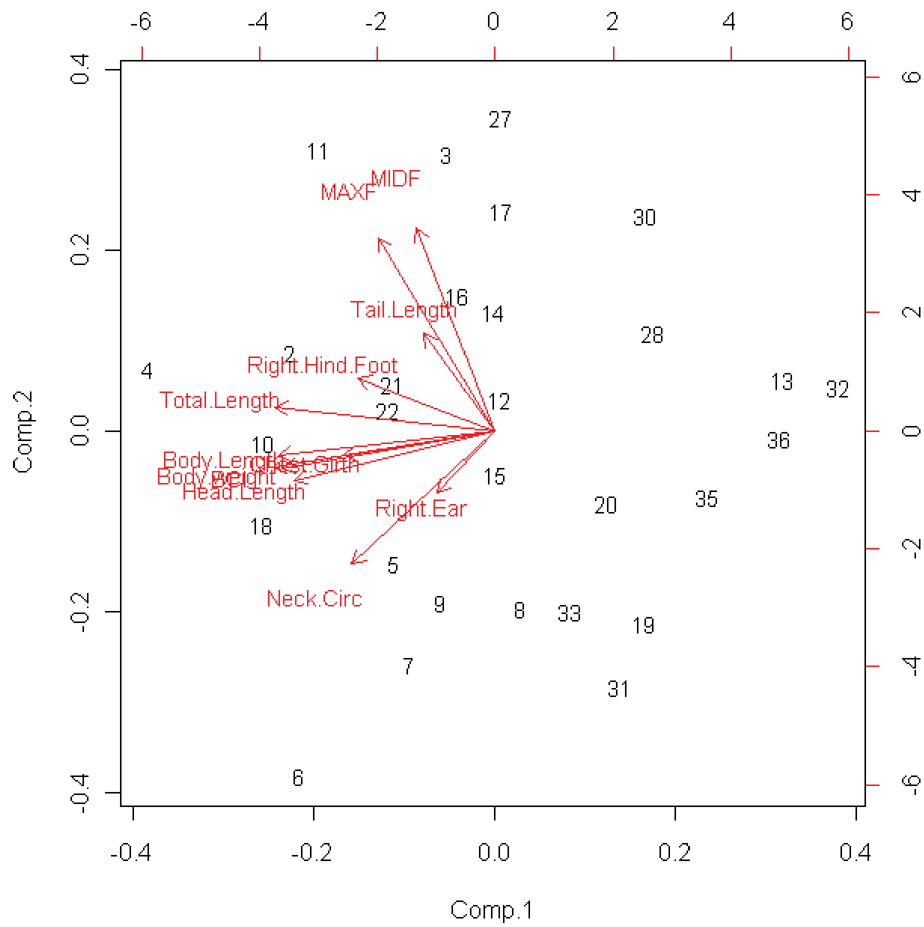

Figure 2. Principal component biplot for morphometric and physical condition estimates of 36 pregnant female white-tailed deer, Upper Peninsula of Michigan, February–March 2009. Components (e.g., MAXF) with longer arrows explain a greater amount of variation in cumulative estimates. Components approximating a similar plane (e.g., Right.Ear and Neck.Circ) explain similar variation in cumulative estimates.

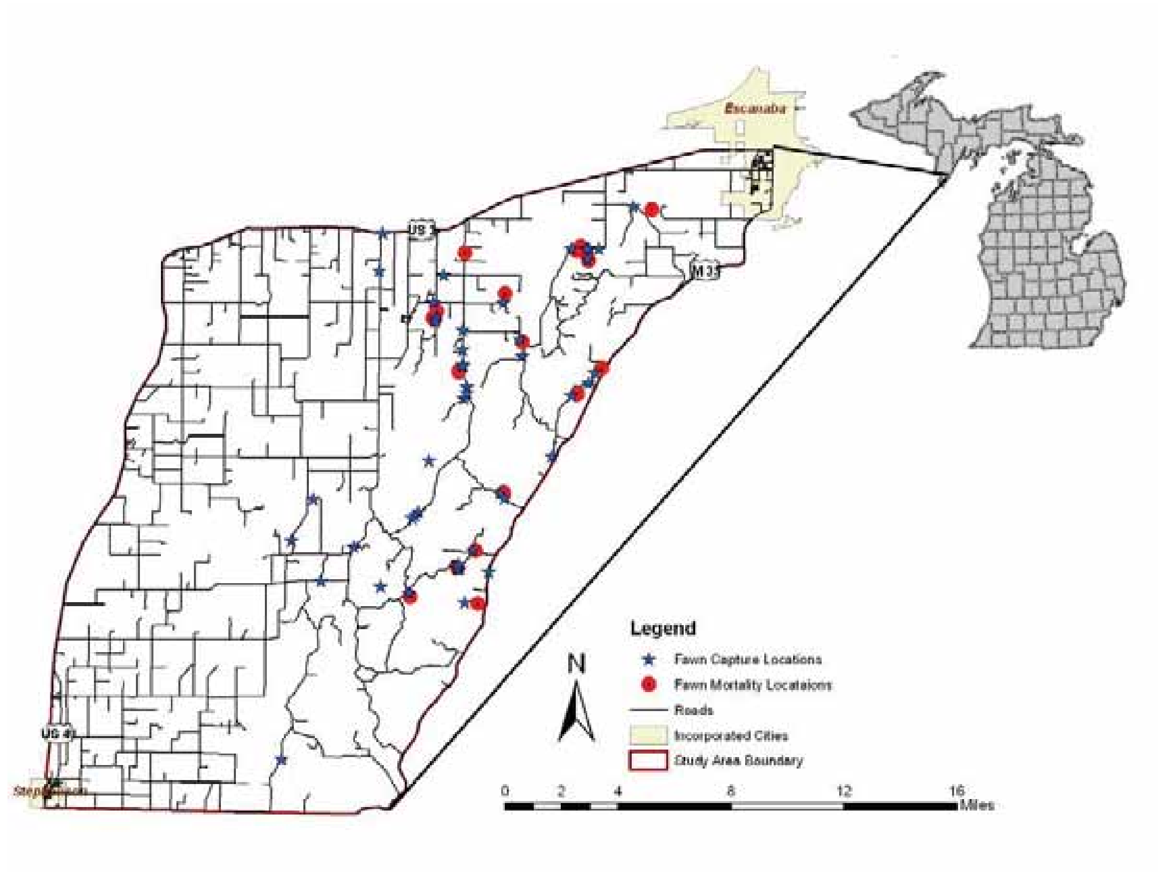

Figure 3. White-tailed deer fawn capture locations (n = 48) and predation sites (n = 19) predation sites, Upper Peninsula of Michigan, 26 May-30 September 2009.

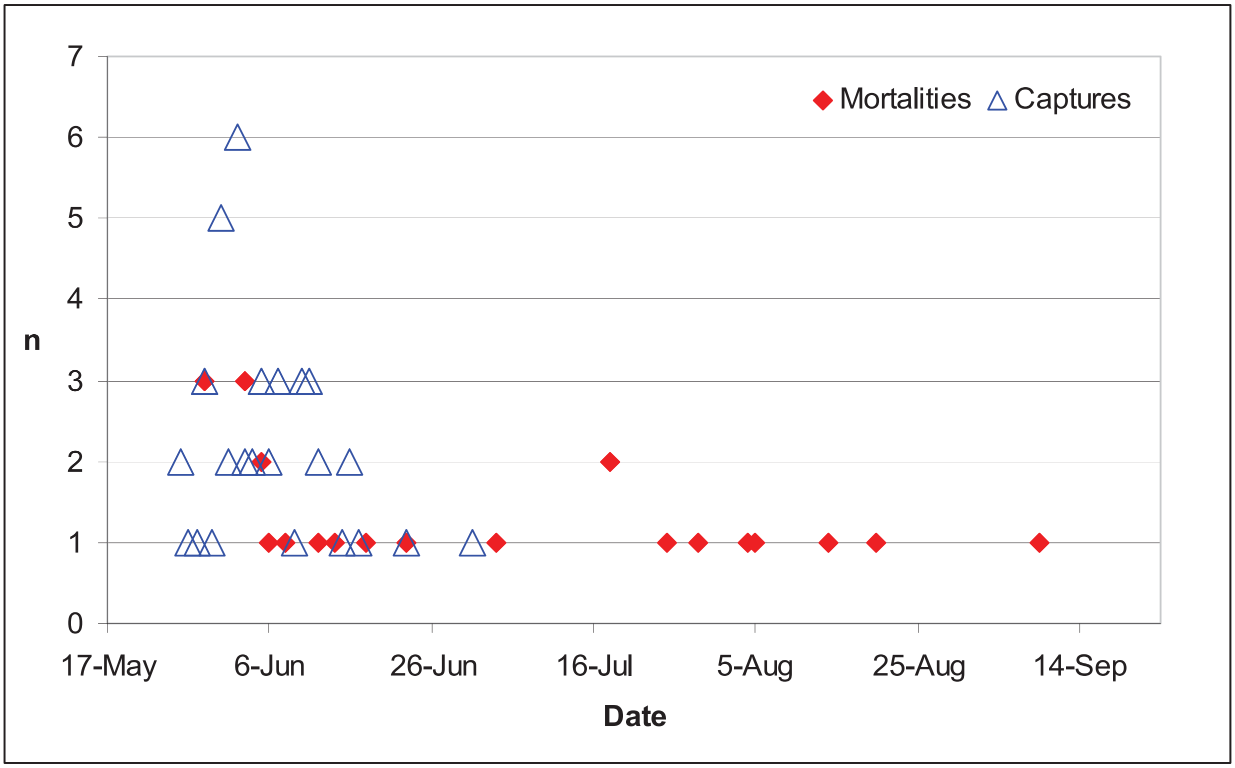

Figure 4. Capture (n = 48) and mortality dates (n = 24) of white-tailed deer fawns affixed with expandable radiocollars, Upper Peninsula of Michigan, 26 May–30 September 2009.

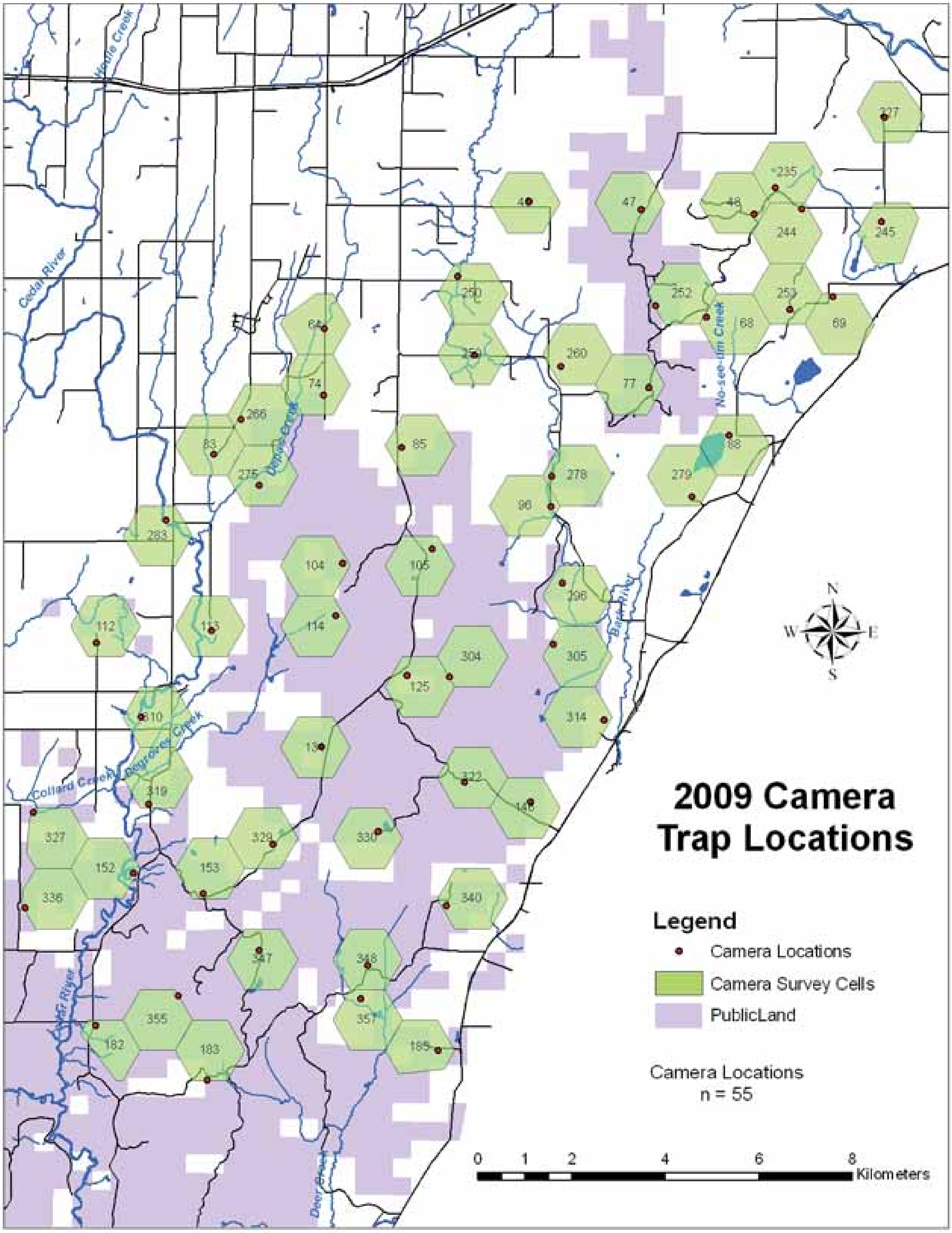

Figure 5. Locations and survey cells for 55 cameras used to estimate white-tailed deer abundance, Upper Peninsula of Michigan, 5-26 September 2009.

Figure 6. Ear tagged black bear, bobcat, coyote, and wolf, Upper Peninsula of Michigan, 2009.

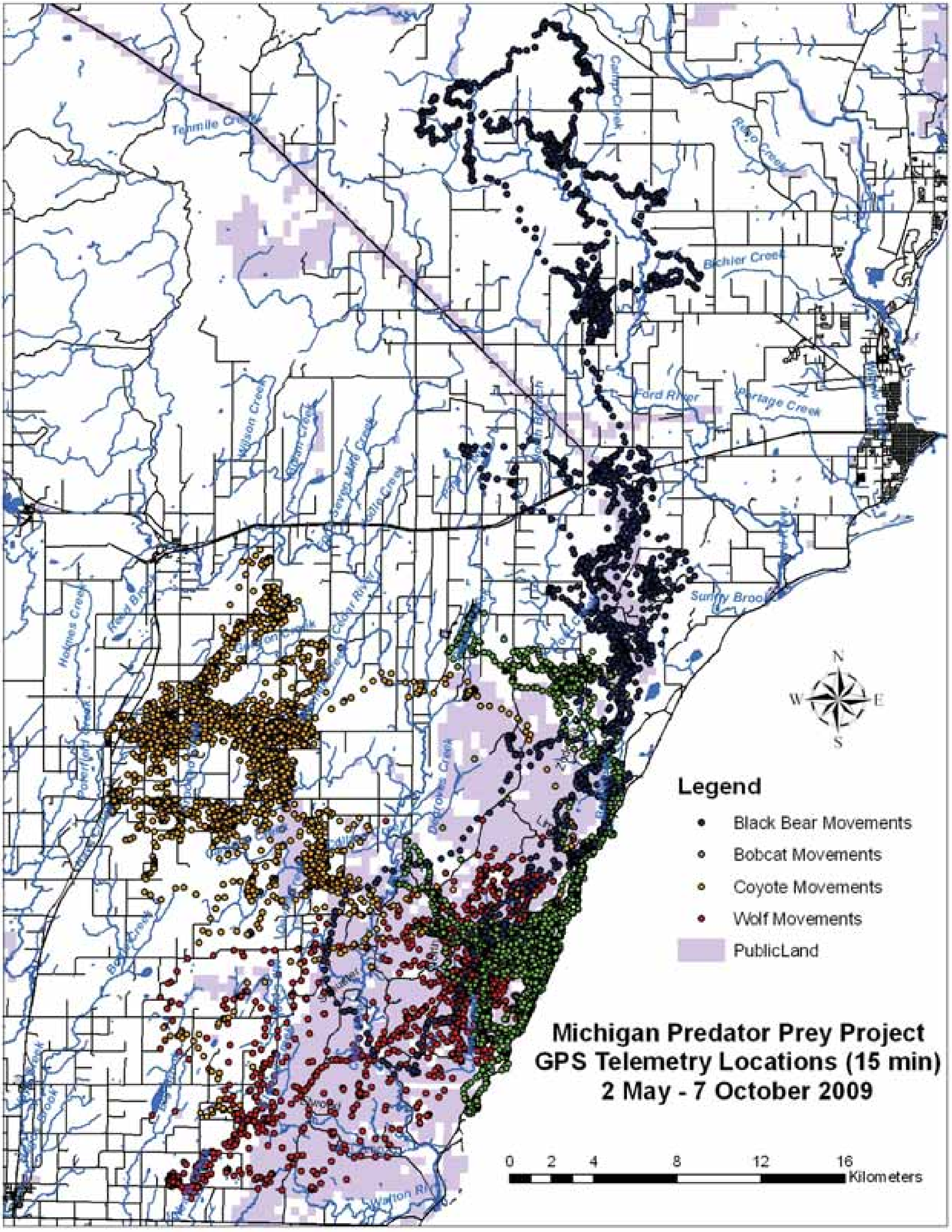

Figure 7. GPS telemetry locations for 1 black bear, 1 bobcat, 1 coyote and 1 wolf, Upper Peninsula of Michigan, 2 May–7 October, 2009

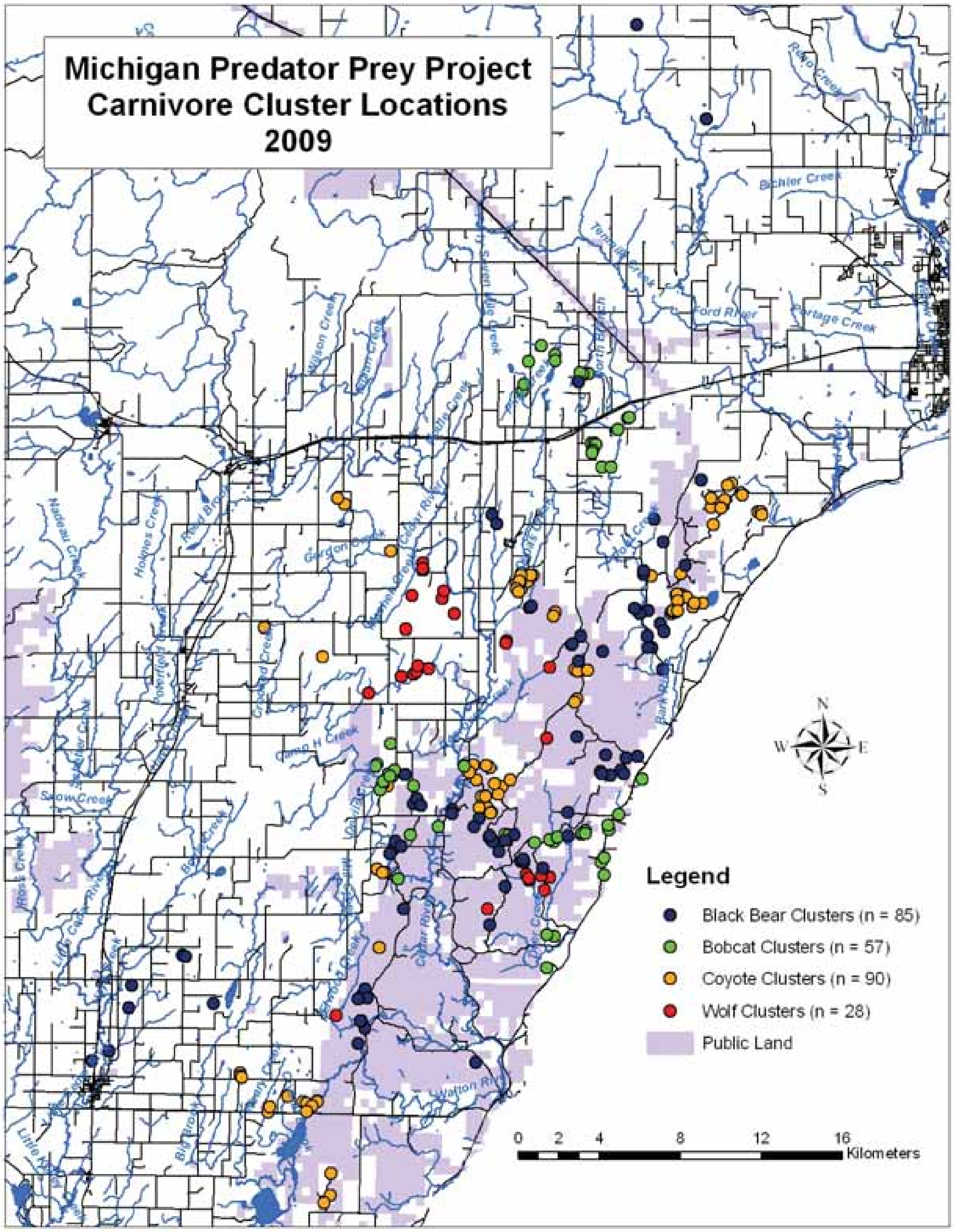

Figure 8. Cluster locations ($n = 260$) for 13 black bears, 3 bobcats, 9 coyotes, and 2 wolves, Upper Peninsula of Michigan, 26 May–30 Sep, 2009

Figure 9. Black bear hair snare locations (n = 45), Upper Peninsula of Michigan, 2009.

Figure 10. Modified body-snare for hair sample collection. From DePue and Ben-David (2007).

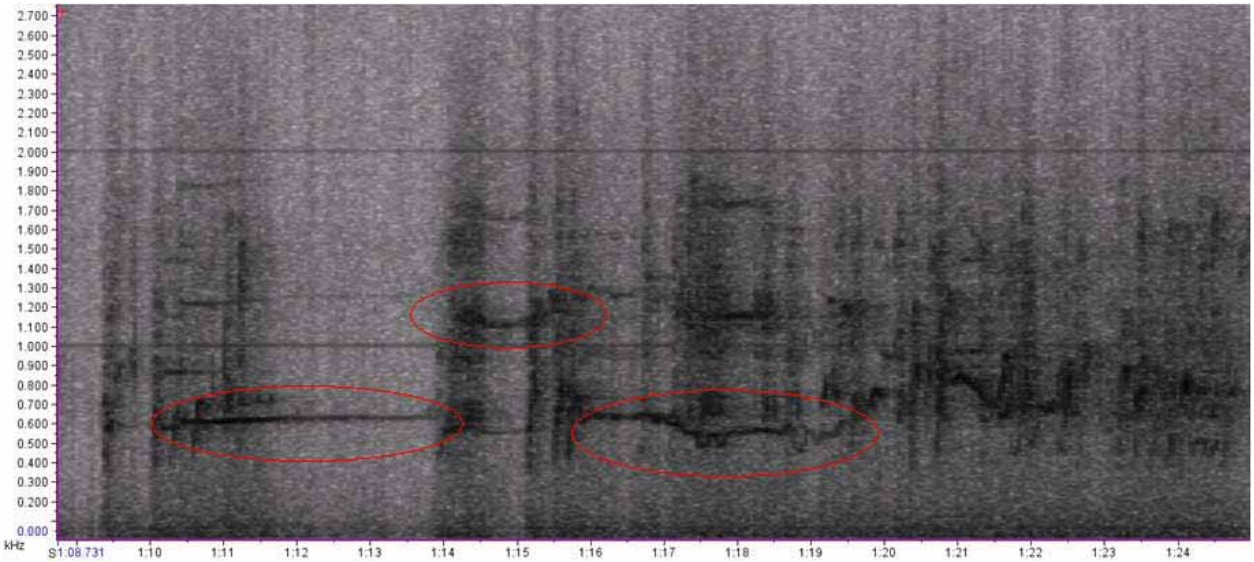

Figure. 11. Sonogram of coyote pack including radio-collared male and female approximately 1.0 km away, Upper Peninsula of Michigan, 2009.

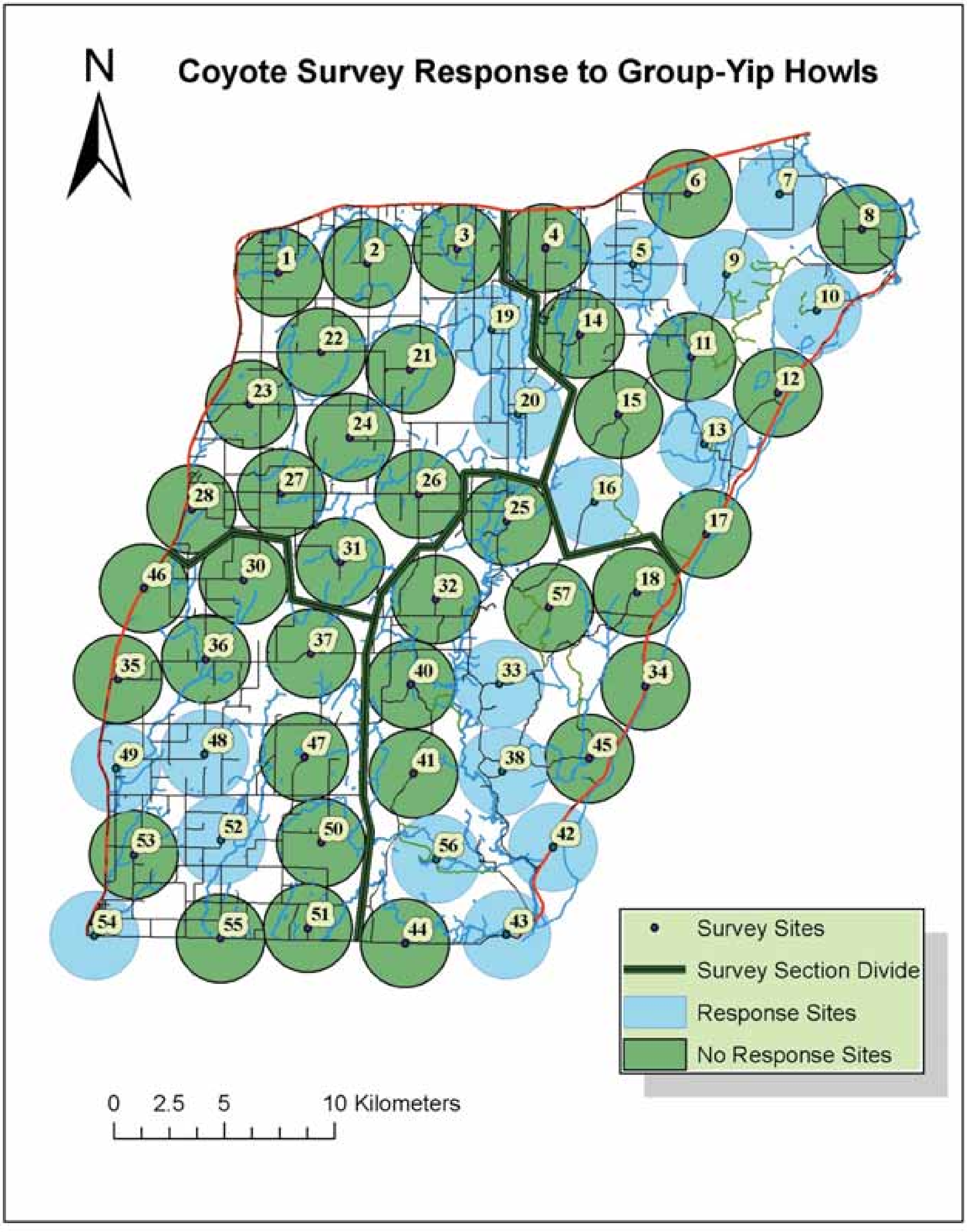

Figure 12. Howl survey sites where coyote responses were elicited during coyote survey, Upper Peninsula of Michigan, 28 August-5 September 2009.

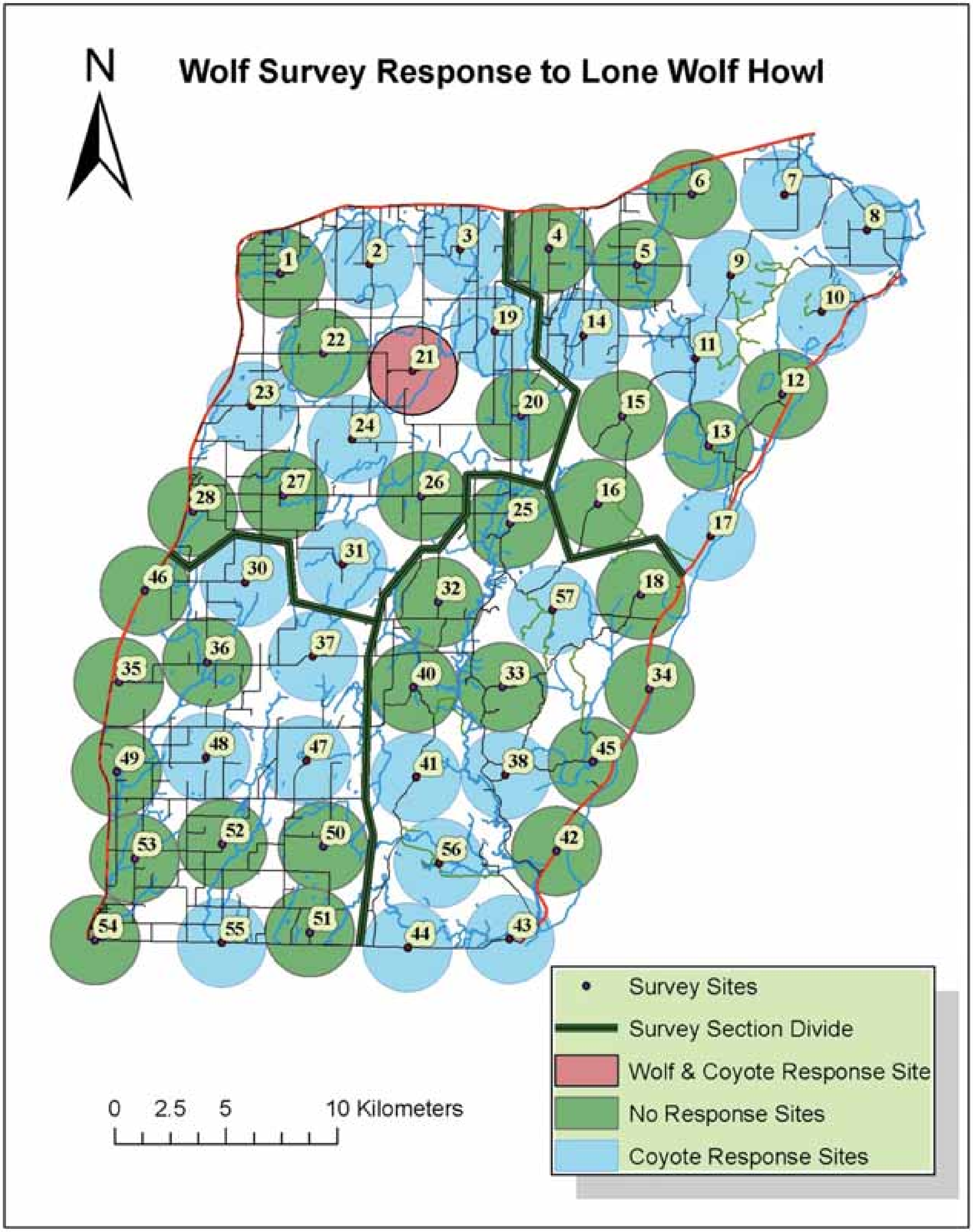

Figure 13. Howl survey sites where responses were elicited during wolf survey, Upper Peninsula of Michigan, 9-20 September 2009.

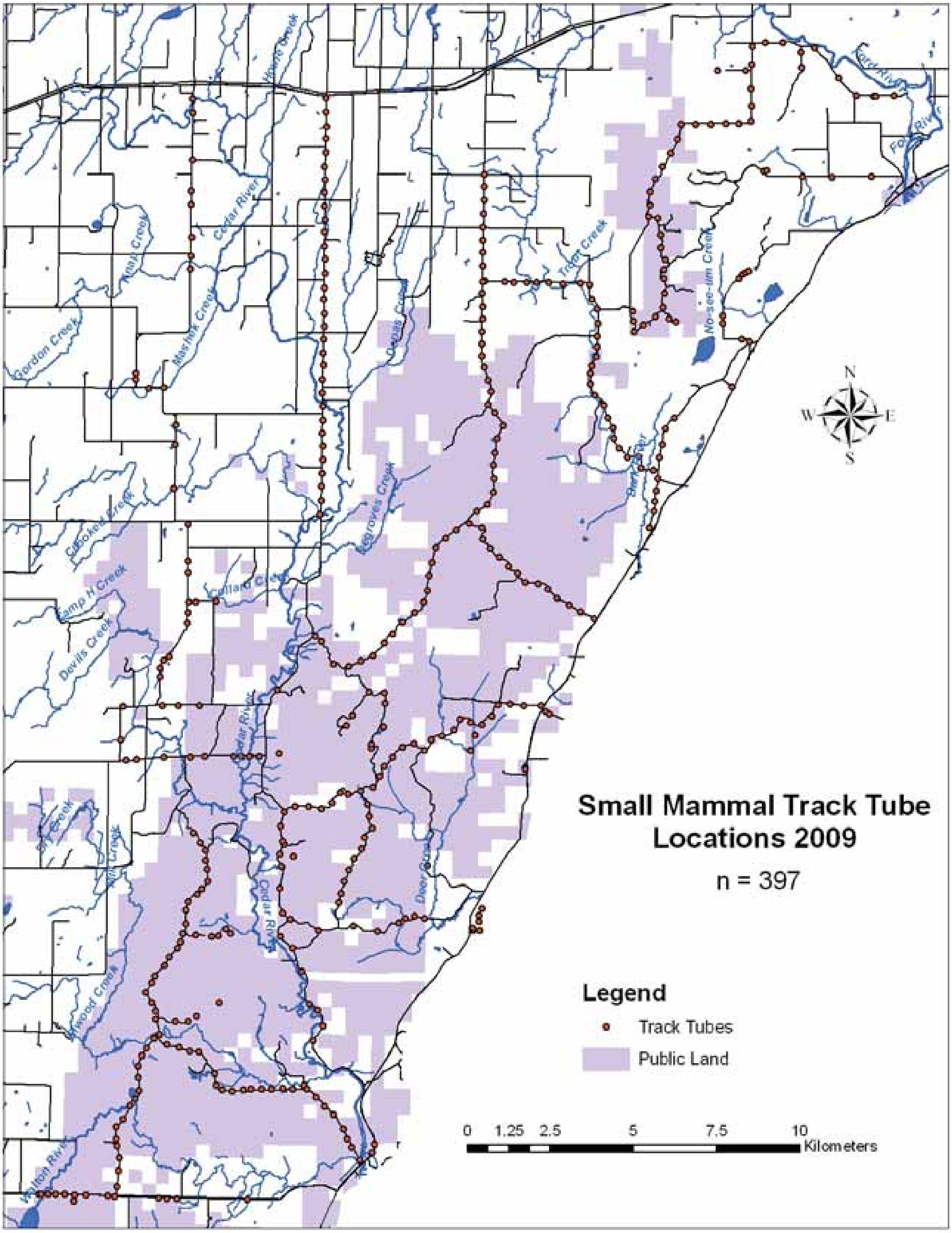

Figure 14. Locations of 397 small mammal track tubes, Upper Peninsula of Michigan, 2009.

Figure 15. Small mammal track tube.