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

Progress Report – 1 October 2009 – 31 August 2010
Date Issued:14 September 2010

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

Prepared by:
Mississippi State University – College of Forest Resources
Jared Duquette – Graduate Research Assistant
Nathan Svoboda – Graduate Research Assistant
Tyler Petroelje – Graduate Research Assistant
Christopher Ayers – Graduate Research Assistant

Graduate Advisor:
Dr. Jerrold Belant – Assistant Professor

Website: http://www.fwrc.msstate.edu/carnivore/predatorprey/index.asp

Mississippi State UNIVERSITY

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

Abstract– Fifty-seven white-tailed deer were captured (43 female, 14 male) with Clover traps and cannon nets. Twenty-seven pregnant females were captured, radiocollared, and VIT tagged. Pregnancy was detected with ultrasound in 100% of adult and yearling females, but no fawns. Forty-four fawns were captured and fitted with expandable radiocollars, including 20 females, 23 males, and 1 unknown. Twelve of 20 (60%) VIT searches resulted in the location of ≥1 fawn, including 1 set of twins, compared to 35% of searches in 2009. Eight radiocollared 2009 adult female mortalities occurred (5 predations), representing 78% annual survival. Thirty one radiocollared 2009 fawn mortalities occurred (22 predations), representing 37% annual survival. Fourteen radiocollared 2010 fawn mortalities occurred (11 predations) through 31 August 2010; representing 31% of the 44 radiocollared fawns. Eight adult black bears (5 female, 3 male) and 2 yearlings (1 female, 1 male) were immobilized in their dens and fitted with GPS or VHF collars. Fifteen black bears (5 females, 10 males), 3 bobcats (1 female, 2 males), 11 coyotes (6 females, 5 males), and 3 wolves (2 female, 1 male) were captured and immobilized during spring and summer and fitted with GPS or VHF collars. Five hundred fifty five carnivore cluster locations and 408 non-cluster locations were investigated with vegetation measurements and alternative prey information collected at each. Seven hundred twelve km of rivers and streams were aerially searched and 13 beaver caches were identified. Two hundred thirty hair samples were collected at bobcat and coyote hair snares. Two hundred sixty seven hair samples were collected at bear hair snares. We detected 36 sets of wolf tracks with at least 1 individual (28 included >1 individual), 44 sets of coyote tracks with ≥1 individual, 2 sets each of bobcat, marten, and fisher tracks during 17 winter track surveys traversing 319.5 km. Coyote surveys yielded an average coyote response rate of 24.8% to the coyote group-yip howl with 1 response from a wolf pack (n ~ 5) during the June survey. A 24.5% response rate from coyotes and 1 response from a lone wolf in August were obtained during the wolf surveys using a lone wolf howl. The aurally estimated number of coyotes responding during the coyote and wolf surveys was 36 and 41, respectively. A total of 528 scats were collected in 2010 and 179 samples from 2009 have been cleaned and sorted. Vegetation surveys were conducted at 22 deer mortality sites, 23 VIT tag sites, 963 predator cluster and non-cluster locations and 65 random locations. Small mammal track tubes (n = 396) were placed in 9 landcover types throughout the study area to index small mammal abundance. Five posters were created and 10 presentations given during 2010.

Summary

- Fifty-seven white-tailed deer were captured (43 females, 14 males) with Clover traps and cannon nets.
- Twenty-seven pregnant females were captured, radiocollared, and VIT tagged.
- Pregnancy was detected with ultrasound in 100% of adult (*n* = 27) and yearling (*n* = 3) females, but no fawns (*n* = 4).
- Mean age for 2009 radiocollared does (*n* = 38) was 6 ± 4 years, with 11 does estimated at 10 yrs or older.
- Forty-four fawns were captured and fitted with expandable radiocollars, including 20 females, 23 males, and 1 unknown.
- Twelve of 20 (60%) VIT searches resulted in the location of ≥1 fawn, including 1 set of twins, compared to 35% successful searches in 2009.
- Eight radiocollared 2009 female mortalities occurred (5 predations), representing 78% annual survival; 2 additional mortalities occurred after the annual period.
- As of 31 August 2010, 6 radiocollared 2010 female mortalities occurred, all were predations.
- Thirty-one radiocollared 2009 fawn (14 females, 15 males, 2 unknowns) mortalities occurred (22 predations), representing 37% annual survival.
- As of 31 August 2010, 14 radiocollared 2010 fawn (4 females, 10 males) mortalities occurred, 11 were predations.
- Eight adult black bears (5 females, 3 males) and 2 yearlings (1 female, 1 male) were immobilized in their dens and fitted with GPS or VHF collars.
- Fifteen black bears (5 females, 10 males), 3 bobcats (1 female, 2 males), 11 coyotes (6 females, 5 males), and 3 wolves (2 female, 1 male) were captured and immobilized during spring and summer and fitted with GPS or VHF collars.
- Five hundred fifty five cluster (203 black bear, 121 bobcat, 136 coyote, 95 wolf) and 408 non-cluster (128 black bear, 77 bobcat, 120 coyote, 83 wolf) locations were investigated to determine potential predation locations.
- In 2010, 198,151 telemetry locations (86,680 black bear, 25,383 bobcat, 56,489 coyote, 29,599 wolf) were collected.

- Seven hundred twelve km of rivers and streams were aerially searched and 13 beaver caches were identified.

- Two hundred thirty hair samples were collected at bobcat and coyote hair snares.

- Two hundred sixty seven hair samples were collected at bear hair snares.

- We detected 36 sets of wolf tracks with at least 1 individual (28 included >1 individual); 44 sets of coyote tracks with ≥1 individual; and 2 sets each of bobcat, marten, and fisher tracks during 17 winter track surveys traversing 319.5 km.

- Three coyote and wolf howl surveys were completed (coyote response rate to group-yip call was 24.8% and to lone wolf howl was 24.5%).

- Five hundred and twenty eight scat samples were collected (240 bear, 36 bobcat, 164 coyote, and 88 wolf).

- Vegetation surveys were conducted at 22 deer mortality sites, 23 VIT tag sites, 963 predator cluster and non-cluster locations, and 65 random locations.

- Small mammal track tubes (*n* = 396) were placed in 9 landcover types throughout the study area to index small mammal abundance.

- Five posters were created and 10 project presentations were given during 2010.

- One GPS collared female coyote was shot and killed by a farmer.

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:

Winter Deer Capture

From 18 January–21 April 2010 project staff captured white-tailed deer to place radiocollars on pregnant females. Fifty-seven individual deer (43 females, 14 males) were captured in Clover traps (*n* = 44) and cannon-nets (*n* = 13), with an additional 18 recaptures including 2 radiocollared fawns (F008 and F030; Figure 1). Individual captures included 27 adults, 3 yearlings, and 27 fawns; no adult or yearling males were captured. The female:male fawn ratio was 1:0.93. Personnel attempted to collect hair, saliva, body condition scores (BCS), estimate pregnancy of females and rump fat depths with ultrasonography, and attach ear tags (females = yellow, males = blue; Figure 2) to each deer. Females and males had mean BCS (scale: 1 [moribund]–5 [obese]) of 2.3 ± 0.4 and 2.4 ± 0.4, respectively. Two capture related mortalities occurred, 1 resulted from a vertebrae fracture from the Clover trap prior to researcher trap check and another was likely related to physiological stress from cannon-net capture. Improved Clover trap design (e.g., tightened netting) appeared to alleviate trap related injuries in 2010 (*n* = 1) compared to 2009 (*n* = 5). Compared to 2009 during which 77 unique deer were captured, 2010 captures were hindered by limited timber harvesting and low depth and early loss of snow. Deer did not concentrate in trapping areas used in 2009 likely due to warmer temperatures and increased available food in nearby agricultural areas.

Twenty-seven pregnant adult females were immobilized, radiocollared (model 2610B, Advanced Telemetry Systems Inc., Isanti, MN), and VIT tagged (model 3930, Advanced Telemetry Systems Inc., Isanti, MN), including 2 does (D055 and D037) originally captured in 2009. Deer temperature, respiration, and heart rate were monitored as soon as practical after immobilization and about 10 minutes intervals thereafter until a reversal drug was administered. Personnel estimated and recorded deer morphometrics, body condition score (BCS), pregnancy, and maximum (MAXF) and mid-rump (MIDF) fat depths (Table 1) when practical. Collection of an incisor tooth, blood, and urine were also attempted from each pregnant female. Pregnancy was detected with ultrasound in 100% of adult (*n* = 26) and yearling (*n* = 3) females, but no fawns (*n* = 4). Two fetuses were detected in 11 does, though multiple fetuses may have been present in remaining does, detection of twins was often limited by fetal development and deer handling precautions (e.g., hastened release due to low temperature) taken by personnel. Protein specific pregnancy–B estimates from doe blood samples (*n* = 69) were 94% concordant with ultrasound pregnancy estimates. In addition, pregnancy was detected in 3 females (2 adults, 1 yearling) collected opportunistically from vehicle collisions in the study area, with both adults having twin fetuses and the yearling having a single fetus.

Mean age for 2009 radiocollared does (*n* = 38) was 6 ± 4 years, with 11 does estimated at 10 yrs or older. Teeth from 2010 doe captures are currently be analyzed for age. Mean adult doe weight from 2009 (*n* = 32) was 73.10 ± 7.90 and 2010 (*n* = 22) was 78.80 ± 7.50 kg, while mean BCS for adult does from 2009 (*n* = 33) was 2.9 ± 0.3 and 2010 (*n* = 26) was 2.5 ± 0.4. Mean MIDF and MAXF depth for adult and yearling does in 2009 (*n* = 34) was 0.83 ± 1.16 and 1.30 ± 1.85, and in 2010 (*n* = 27) was 0.73 ± 0.37 and 1.04 ± 0.43 cm, respectively.

<u>2010 Fawn Capture</u>

Beginning mid-May, project staff began capturing, radiocollaring, and radiolocating white-tailed deer fawns. Forty-four fawns were captured and fitted with expandable radiocollars (model 4210, Advanced Telemetry Systems Inc., Isanti, MN) from 14 May–17 June 2010 (Figure 3), including 20 females, 23 males, and 1 unknown. Personnel attached 1 or 2 individually numbered (#51–100) rectangular white flexible plastic ear tags to fawns (*n* = 31; Figure 2) and attempted to collect fawn morphometrics (Table 2); saliva, blood, and hair samples; and monitor temperature and respiration. Bed site and surrounding habitat, flush distance, presence of dam, additional deer, dam behavior, and handling time were also recorded as available. Mean fawn handling time was 23 minutes, similar to the mean of 25 minutes in 2009. Temporal range of fawn parturition appeared to be similar to 2009, peaking around 1 June (Figure 4). Estimated mean fawn birth mass (kg) was greater (t_{85} = 6.83, P <0.01) in 2010 ($\bar{x}$ = 4.2, range = 1.2–7.8) than in 2009 ($\bar{x}$ = 2.4, range = 0.5–4.0).

Vaginal Implant Transmitter (VIT) searches were conducted to find fawns of 23 implanted pregnant adult females from 8 May–8 June 2010. One adult female has not expelled the VIT as of 1 July and radio detection of 2 VITs was lost after 4 June and could not be detected with repeated attempts. Additionally, 1 VIT search could not be completed due to denial of private land access. Twelve of 20 (60%) VIT searches resulted in the location of ≥1 fawn, including 1 set of twins, compared to 35% successful searches in 2009. Fawn search crews were evaluated for efficacy of finding fawns around VIT sites using mock fawns (Figure 5) in varying habitats and distances from the mock VIT drop site. Search crews were 80% successful in detecting ≥1 mock fawn during 10 searches of single or twin mock fawns, but found ≤1 mock fawn at 38% of twin sites; mean search time was 73 minutes. Also, a mock VIT drop experiment was conducted to detect whether VITs would change pulse rate (VITs have temperature sensitive pulse switches) depending on sunlight and reflectance. Eighteen VITs were divided into groups of 6 and each group was either placed in direct sun, direct sun with aluminum foil wrapping, or complete shade; all were on drop pulse (80 bpm) before testing and ambient temperature was 23° C. Aluminum foil wrapping was used to evaluate whether a reflective coating could be used to decrease heat that triggers VIT pulse switch. All VITs in direct sun and with aluminum foil switched back to implant pulse (40 bpm) ≤5 minutes after placement, whereas complete shade VITs remained on drop pulse for the 120 minute test period. Results suggested location of VIT drop (e.g., direct sun) can influence time lapse between detection of actual fawn parturition and crew searches, thus potentially decreasing ability of crews to find fawns shortly after parturition.

<u>Deer Mortality</u>

Eight mortalities of ≥1-year-old females radiocollared in 2009 occurred (5 predations), representing 78% annual survival; 2 additional mortalities occurred after the annual period. As of 31 August 2010, 6 females ≥1 year old radiocollared in 2010 died from predation.

Thirty-one mortalities of fawns (14 females, 15 males, 2 unknowns) radiocollared in 2009 occurred (22 predations), representing 37% annual survival. Additionally, radiocollars wore off and were retrieved from 3 fawns, 1 slipped its radiocollar, and 6 radiocollars likely failed and could not be located (fawn collars battery life expectancy is 12 months).

Fourteen mortalities of fawns (4 females, 10 males) radiocollared in 2010 occurred through 27 August; representing 31% of the 44 radiocollared fawns (Table 4). The unknown mortality was sent to the MDNRE Wildlife Disease Laboratory for necropsy. Predations accounted for 79% of 2010 mortalities, equivalent to the same period in 2009; although predations were observed earlier in 2009 (Figure 6). Two fawns were not detected within a week after capture, likely due to radiocollar failure.

Deer Telemetry

Locations and mortality of radiocollared adult females was monitored 1–7 times/week using aerial or ground telemetry. Priority females (those with radiocollared fawns) were monitored simultaneously with their fawn(s) and with greater frequency. There were 40 females being monitored as of 27 August and females have a median of 57 locations (range = 25–118). Three thousand one hundred and ninety-one locations (median = 41; range = 1–118) have been recorded for all radiocollared females.

Locations and mortality of fawns radiocollared in 2009 was monitored ≥1 time/week using aerial or ground telemetry. One thousand four hundred and thirty-one locations (median = 23; range = 1–69) have been recorded for all radiocollared fawns. There were 8 animals being monitored as of 27 August and fawns have a median of 25 locations (range = 55–69).

Locations and mortality of fawns radiocollared in 2010 was monitored ≥4 times/week through early August and currently are located ≥1 time/week. There were 28 fawns being monitored as of 27 August and fawns have a median of 25 locations (range = 5–58). One thousand forty-seven locations (median = 25; range = 1–58) have been recorded for all radiocollared fawns. Radiocollared fawns were monitored and occasionally flushed to observe whether a sibling was present to estimate twinning rates. Mortalities were investigated upon receiving a mortality signal to estimate survival and cause-specific mortality agents.

Deer Abundance Camera Survey

Fifty-four remote infrared cameras captured 8,159 images of deer throughout September 2009 to estimate deer abundance in the study area. Deer abundance and density/km^2 was estimated for the 256.2 km^2 sampling area using 2 methods (Table 5; Jacobson et al. 1997, Demarais et al. 2000) based on male antler characteristics and deer demography.

Black Bear Den Checks

Eight adult black bears (*Ursus americanus*; 5 female, 3 male) and 2 yearlings (1 female, 1 male) were immobilized in their dens. Of these, 5 adult bears had their Global Positioning System (GPS) collars removed and replaced with new GPS collars. Two adult black bears (1 female, 1 male) previously captured by MDNRE personnel were immobilized, had their VHF collars removed, and were fitted with GPS collars. Previously collared female black bear (BB08) and her 2 yearlings slipped their collars during December and were re–immobilized in their den and re–collared. GPS collars were programmed to obtain a location every 35 hours until 1 May and then every 15 minutes. A male bear shot and wounded on 15 September 2009 had his GPS collar removed and replaced with a VHF collar. We handled 10 cubs (1 female, 9 male) during den work. Mean litter size was 2.5 cubs (SD = 0.58; Table 6). Black bears were weighed, had morphometric measurements recorded, and implanted with a Passive Integrated Transponder tag (PIT). All bears were placed back into their respective dens for recovery.

Carnivore Trapping and Monitoring

From 25 April–31 August 2010, 15 black bears (5 females, 10 males), 3 bobcats (*Lynx rufus*; 1 female, 2 males), 11 coyotes (*Canis latrans*; 6 females, 5 males), and 3 wolves (*C. lupus*; 2 female, 1 male) were captured and immobilized. Eight black bears (8 males) were fitted with Lotek 7000MU GPS collars (Lotek Engineering, Newmarket, ON, Canada) and 5 black bears (4 female, 1 male) were fitted with Advanced Telemetry System M2500 VHF collars (Advanced Telemetry Systems Inc., Isanti, MN). Two black bears (1 female, 1 male) died during immobilization and are currently awaiting necropsy by MDNRE Wildlife Disease Laboratory. Preliminary examination of the female bear suggests a preexisting liver and spleen condition unrelated to capture event (Tom Cooley, MDNRE Pathologist, personal communication). Two male black bears slipped their GPS collars shortly after being released. Five GPS collared black bears (3 female, 2 male) and 2 VHF collared black bears (1 female, 1 male) radiocollared in 2009 are being monitored in 2010, resulting in 11 GPS collared black bears (3 females, 8 males) and 7 VHF collared black bears (5 females, 2 males) currently being monitored. All captured bobcats, wolves, and 8 coyotes (3 females, 5 males) were fitted with Lotek 7000SU GPS collars. Three captured coyotes (3 females) were not collared and 1 collared female coyote was shot and killed by a landowner 13 days after capture. Black bears, bobcats and coyotes were given uniquely numbered blue ear tags and wolves were given uniquely numbered red ear tags (Figure 7). All captured animals were weighed, sexed, and evaluated for injury. Morphometric measurements were taken along with blood, hair, fecal, and saliva samples. For each carnivore, body condition index (BCS) 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 incisor removed for age estimation and black bears had a vestigial premolar removed for age estimation.

Bobcat, coyote, and wolf collars were programmed to obtain a GPS location every 35 hours until 1 May, every 15 minutes from 1 May–30 September and then every 35 hours until the collars are removed. Black bear GPS collars were programmed to obtain a location every 15 minutes 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 8). To date, 27 flights have occurred to download GPS locations (Tables 7, 8). One male coyote (C07) GPS collared in 2009 failed to drop off and is still being monitored using VHF telemetry. One male coyote (C18) GPS collared in 2010 is no longer collecting GPS locations but continues to be monitored using VHF telemetry.

GPS collared black bears currently being monitored have worn collars from 64–190 consecutive days ($\bar{x}$ = 125, SD = 59; Table 7) resulting in 2170–11,176 locations per individual ($\bar{x}$ = 7506, SD = 2,973). In 2010, bobcats have worn active collars from 46–129 consecutive days ($\bar{x}$ = 94, SD = 43) resulting in 4,169–11,516 locations per individual ($\bar{x}$ = 8461, SD = 3827). Coyotes have worn active collars from 87–125 consecutive days ($\bar{x}$ = 107, SD = 17) resulting in 7,618–11,370 locations per individual ($\bar{x}$ = 9413, SD = 1,452). Wolves have worn active collars from 110–121 consecutive days ($\bar{x}$ = 117, SD = 6) resulting in 9,372–10,189 locations per individual ($\bar{x}$ = 9866, SD = 435).

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. In 2010, we have investigated 555 GPS location clusters identified using ArcGIS and the statistical software program R (R Development Core Team, Vienna, Austria) and 408 non-cluster locations selected opportunistically (Figure 9). A cluster was defined spatially as ≥8 locations within 50 m of each other within a 24–hour period. Of the 555 clusters, 203 were black bear ($\bar{x}$ clusters/black bear = 16, SD = 13; Figure 9), 121 bobcat ($\bar{x}$ clusters/bobcat = 40, SD = 17), 136 coyote ($\bar{x}$ clusters/coyote = 19, SD = 10), and 95 wolf (mean clusters/wolf = 32, SD = 15). Of the 408 non-cluster locations, 128 were black bear ($\bar{x}$ non-clusters/bear = 10, SD = 9; Figure 10), 77 bobcat ($\bar{x}$ = 26, SD = 13; Figure 10), 120 coyote ($\bar{x}$ = 17, SD = 11), and 83 wolf ($\bar{x}$ = 28, SD = 4). To prevent disturbing animals, handheld telemetry is performed before investigating a cluster to verify the animal is no longer in the area.

Cluster location investigations are currently being analyzed. Preliminary results include black bears foraging on wild raspberries (*Rubus ideaus*), wild strawberries (*Fragaria vesca*), and various colonial insects (e.g., ants). Black bears have also been detected scavenging at a livestock carcass dump. Numerous black bear bedding sites have been located as well as 2 scratching/rubbing posts. Two grouse (*Bonasa umbellus*), 1 goose (*Branta canadensis*), 6 fawn, and 1 unknown bird predation site were identified at bobcat cluster locations. Bobcats were also identified scavenging on 3 adult deer carcasses. Three fawn predations were identified at coyote cluster locations as well as scavenging activity on 5 adult deer carcasses and one fawn scavenging site. Investigation of wolf clusters identified scavenging activity at a livestock carcass dump. One unknown bird predation and multiple bed sites were also identified at wolf clusters. It is important to note that many wolf clusters were located on inaccessible private land preventing the investigation of many cluster locations. In addition, a male and female wolf have spent considerable time near (<50 m) a potential denning area preventing investigation of many clusters.

Beaver Survey

To provide an index of beaver abundance, on 5 and 12 November 2009, aerial flights were conducted throughout the study area to detect fresh beaver caches. Flights were conducted at an altitude of about 150–300 m. A total of 712 km of rivers and streams were aerially searched. Thirteen active beaver caches were located.

Bobcat and Coyote Hair Snares

Hair snares for bobcats and coyotes were deployed for 8 weeks from 12 January–13 March 2010. Snares were deployed on a 2.5 km^2 grid cell system, with one bait site per cell (Figure 11). Grid cells truncated by >50% due to the Lake Michigan shoreline were combined with adjacent cells. We deployed 2–6 snares at each site (161 total snares) based on the number of trails that developed during the 3–week pre-baiting period. Hair samples were collected (Figure 12) and snares reset as necessary every 7 days; 230 hair samples (of target and non-target species) were collected and sent to the MDNRE Wildlife Disease Laboratory in Lansing, MI for genetic analysis.

Carnivore Track Surveys

We conducted 17 track surveys on 12 days from 11 January–3 March 2010, traversing 319.5 km. Additional track observations were made opportunistically while performing other field duties. We detected wolf tracks on 36 occasions with $\geq$1 individual (28 included $\geq$2 individuals), 44 sets of coyote tracks with $\geq$1 individual; and 2 sets each of bobcat, marten, and fisher tracks. Poor snow conditions during much of the winter prevented more surveys from being completed, therefore near the end of winter (late February through March) many track surveys focused on detecting wolves. For wolves and coyotes, the number of individuals traveling together (Figure 13) was used to estimate minimum pack sizes and a minimum abundance estimate for the area.

Wolf Abundance Estimations

Based on summer GPS data, 2 packs occurred in the study area (7 Mile Marsh Pack and Hayward Lake Pack; Figure 14). We identified a minimum of 7 individuals in the 7 Mile Marsh Pack. Raised leg urinations were observed suggesting territorial marking, although no estrous blood was detected. Surveys during winter 2010 identified $\geq$4 individuals in the Hayward Lake Pack. Track surveys in this pack's home range also revealed several raised–leg urinations and squatted urinations with estrous blood, suggesting territorial marking and breeding.

One male wolf was found captured outside of the study area in an illegal neck snare and reported to MDNRE Law Enforcement personnel and was subsequently fitted with a VHF collar. This individual belongs to the Carney Pack, residing primarily west of the study area boundary. This pack may, however, make occasional forays into the study area; locations of this individual are being monitored (Figure 14).

Bobcat Harvest Data

Unpublished MDNRE data for 2008–2009 and 2009–2010 harvest seasons were compiled and used to assess bobcat distribution and sex ratio in the study area. Distribution was assessed by plotting bobcat harvest locations by section in a GIS (Figure 15). Harvested bobcats from the study area (n = 20) included 6 females, 13 males, and 1 unknown.

Carnivore Scat Collection

Carnivore scat samples were collected opportunistically throughout the study area; labeled by date, species, and UTM coordinates; and frozen. Scats are analyzed for presence of prey species (e.g., deer fawn) hair and other dietary items (e.g., berries and corn). Five-hundred and twenty-eight samples consisting of 240 bear scats, 36 bobcat scats, 164 coyote scats, and 88 wolf scats were collected from October 2009-September 2010 (Table 9); 12.3% of scats had tracks associated with them. 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 where 179, from 2009, have been cleaned and sorted.

Black Bear Abundance Estimation: Hair Snares

Beginning on 7 June 2010 hair snares (*n* = 45) were set to estimate black bear abundance throughout the study area (Figure 16). Snares were previously placed in each cell of a 3 km^2 grid in summer 2009 and needed minor repairs for use in summer 2010. Each snare consists of a strand of barbed wire attached to the outside of three trees in a triangle shape 50 cm above ground. The snare is lured 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 trees about 2 m above ground. The 45 snares were broken into 4 groups of 10–12 for convenience of checking and reluring. Each group was checked and relured every 10 days for 5 occassions. Two hundred eleven of 267 hair samples collected were identified as black bear. All samples were sent to MDNRE Wildlife Disease Laboratory in Lansing, MI for identification of individual bears. These data will be used to estimate the number of bears in the study area.

Coyote and Wolf Howl Surveys

During June-September 2010, coyote and wolf howl surveys (HS) were conducted by attempting a 4-week rotation with a coyote survey in week 1, a wolf survey in week 2, and no survey during weeks 3 and 4. The study area was divided into 4 sections, allowing a survey to be completed in 4 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 17). 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 an occupancy modeling approach.

Surveys yielded an average coyote response rate of 24.8% to the coyote group-yip howl with 1 response from a wolf pack (*n* ~ 5) during the June survey (Figure 18). A 24.5% response rate from coyotes and 1 response from a lone wolf in August were obtained (Figure 19). The aurally estimated average number of coyotes responding during the coyote and wolf surveys was 36 and 41, respectively. Analysis of howl survey data is continuing.

Vegetation Surveys

Surveys quantifying vegetation structure, composition, and density were conducted at deer mortality sites (*n* = 22), VIT tag sites (*n* = 23), predator cluster and non-cluster locations (*n* = 963) as well as random locations (*n* = 65). Vegetation data will be used to estimate if event locations (e.g., birth sites, predation sites) differ in vegetation structure. 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 have been compiled and are currently being analyzed.

Small Mammal Survey

Small mammals serve as an alternative food source for focal predators, thus, from 8 July–9 August, 396 small mammal track tubes were placed in 9 landcover types throughout the study area to provide an index of small mammal abundance (Figure 20). Landcover types included 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 (n = 35), non-forested wetlands (n = 31) and open/barren areas (n = 31). Track tubes were constructed from 5.8 cm diameter (4.7 cm inside diameter) PVC pipe cut into 76 cm lengths. Each track tube included a tracking medium (i.e., printer toner), tracking paper (i.e., double-sided carpet tape) and bait (peanut butter and bird seed; Figure 21). Track tubes were placed 20-30 m from roadways and removed after 4 days. Track tube data are currently being compiled and analyzed.

Alternate Prey, Carnivore, and Deer Data

Alternative prey, carnivore, and deer observations were recorded (i.e., species, location, and 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 August 2010, 4,365 total observations were recorded, including 1,620 observations in 2010. The 3 most observed alternate prey species were turkey (*Meleagris gallopava*), ruffed grouse, and squirrel (*Sciurus* spp.; Table 10). The 3 most observed carnivores were coyote, wolf, and bobcat. Project personnel recorded 1,844 deer in 1,036 observations from 6 October 2009–31 August 2010.

Public Outreach

Numerous outreach efforts were conducted by project personnel this year:

1) 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.
    a) "White-tailed deer survival, reproduction, and condition in the Upper Peninsula of Michigan" – Jared Duquette
    b) "Resource selection by carnivores and white-tailed deer in Michigan's Upper Peninsula" – Nathan Svoboda
    c) "Linking individual resource use to biological outcomes and population management" – Chris Ayers
    d) "Estimating population size of bobcats in Michigan's Upper Peninsula" – Heather Stricker
    e) "Estimating Coyote and Gray Wolf Abundance Using Howl Surveys in Michigan's Upper Peninsula" – Tyler Petroelje
2) Beyer, D., J. Belant, N. Svoboda, J. Duquette, and C. Albright. 10 Nov 2010. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Wildlife Management Course BI 442, Northern Michigan University, Marquette, MI. 20 students.
3) Svoboda, N., J. Duquette, J. Belant, and D. Beyer. 4 Dec 2009. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Wildlife Unlimited, Quarterly Meeting, Escanaba, MI. 18 attendees.

4) Duquette, J., N. Svoboda, J. Belant, D. Beyer, and D. Beyer. 1 Feb 2010. *White-tailed deer fawn survival in the southwestern U.P.* Escanaba Lions Club, Escanaba, MI. 25 attendees.
5) Duquette, J., N. Svoboda, J. Belant, and D. Beyer. 1 Feb 2010. *White-tailed deer fawn survival in the southwestern U.P.* Wildlife Unlimited of Delta County, Escanaba, MI. 72 attendees.
6) Duquette, J., N. Svoboda, J. Belant, D. Beyer, and C. Albright. 6 Feb 2010. *White-tailed deer fawn survival in the southwestern U.P.* U.P. Trappers Association, Powers, MI. 110 attendees.
7) Duquette, J. N. Svoboda, J. Belant, D. Beyer, and C. Albright. 12 Feb 2010. *Upper Peninsula predator-prey study research update.* North Menominee County Sportsmans Club (NORMENCO), Wilson, MI. 15 attendees.
8) Beyer, D., J. Belant, N. Svoboda, J. Duquette, and C. Albright. 10 Mar 2010. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Population Ecology Course BI 517, Northern Michigan University, Marquette, MI. 25 students.
9) Svoboda, N., J. Duquette, J. Belant, and D. Beyer. 5 Apr 2010. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Wildlife Techniques Course WF 4243, Mississippi State University, Starkville, MS. 28 students.
10) Svoboda, N., J. Duquette, J. Belant, and D. Beyer. 17 Jul 2010. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* U.P. Trappers Association, Annual Convention, Escanaba, MI. 36 attendees.
11) Beyer, D., J. Belant, N. Svoboda, J. Duquette, and C. Albright. 26 Aug 2010. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* United States Forest Service, Science Cafe, Munising, MI. 10 attendees.

Popular Articles:

1) Gaylord Herald Times. 11 June 2010. “Predators & prey: Fawn survival in Northern Michigan.” *Contributing Writer*: George Rowe.
2) Michigan Outdoor News. 14 June 2010. “Early results in from U.P. fawn study.” *Contributing Writer*: Richard P. Smith.

Project assistance forms were distributed to Escanaba High School, Bark River-Harris River High School, Gladstone High School, and Hannahville Indian School to promote knowledge of wildlife research to interested high school students. Two high school students assisted with black bear immobilizations and vegetation surveys during June 2010.

On 2 occasions in May 2010, project personnel demonstrated wildlife capture and handling techniques to students from a Northern Michigan University Wildlife Techniques class, including a black bear immobilization and handling procedure.

On 7 June 10, Upper Peninsula Sports Writers group participated in a coyote immobilization and other field activities with project staff in an effort to promote communication and update the public on the progress of the research.

Approximately six hundred project brochures describing research goals and activities have been distributed. The project website is (http://fwrc.msstate.edu/carnivore/predatorprey/) has been updated with current photos and results.

Project Crew Selection and Hires

Thirteen technicians were hired in 2010.

1) Rebekah Karsch - winter/spring/summer
2) Chad Corroy - winter
3) Lacey Kreiensieck - winter
4) Kevin Smith - winter
5) Josh Fosdick - spring/summer
6) Jarrod Hammerly - spring/summer
7) Rhonda Houk - spring/summer
8) Julie Jarvey - spring/summer
9) Karina Lamy - spring/summer
10) Caitlin Ott-Conn - spring/summer
11) Christina Rasanen - spring/summer
12) Nick Vinciguerra - spring/summer
13) Tanya Wolf - spring/summer

Publications

Duquette, J.F., J.L. Belant, D.E., Beyer, N.J. Svoboda, and C.A. Albright. 2010. Bald Eagle predation of a white-tailed deer fawn. Northeastern Naturalist, *In Press*.

Work to be completed (October–December 2010)

Radiotelemetry

Radiocollared females and fawns radiocollared in 2009 (i.e., yearlings) and 2010 will continue to be located ≥1 weekly and fawns captured in 2010 will be located ≥2 weekly.

Deer Abundance Camera Survey

Deer abundance will be estimated across the study area using remote infrared cameras. The sampling area will consist of the same area (256.2 km^2) used in 2009. One camera will be placed within the home range of each radiocollared doe in the sampling area (n = 28) and an equal number of locations randomly distributed throughout the study area. Locations will be pre-baited with bait replenished during the survey using shelled corn. Abundance estimates will be based on antler characteristics of male deer and also tagged and non-tagged deer. Survey photos may also allow a supplemental abundance estimate for black bear in the area.

Deer Trapping

We will begin the last season of deer trapping efforts the second week of December 2010. Deer will be captured using Clover traps and air-powered cannon nets. Two additional volunteers will be recruited for winter trapping to increase our trapping efficiency and decrease time deer are in traps.

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.

Black Bear Den Checks

Black bear den checks will be conducted on male black bears in mid-December to replace batteries on GPS radiocollars.

Carnivore Scat Collection

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

Bobcat Hair Snares

Design and assembly of bobcat hair snares will begin in October. Hair snares will be deployed during winter for 8 weeks at predetermined bait sites beginning in January, 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.

Winter Track Surveys

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. Wolf tracks will be followed to identify the number of individuals to estimate minimum abundance. Two seasonal technicians will be recruited in December for winter track surveys.

Public Outreach

Project brochure will be updated with preliminary results, printed, and distributed.

Acknowledgements:

We thank the following for their support:
Michigan Department of Natural Resources and Environment
Safari Club International Foundation
Safari Club International – Michigan Involvement Committee
Safari Club International – Northwoods Chapter
Karen Brasher – Mississippi State University, Publications Editor/Web Designer
Mississippi State University – College of Forest Resources
U.P. Whitetails Association, Inc., Menominee County Chapter
Wildlife Unlimited of Delta County
Participating Upper Peninsula landowners
Mr. Tom Olsen for allowing us to establish a weather station on his property
Heather Stricker – Research Associate – Mississippi State University
Alban Guillaumet – Post-doctoral Research Associate – Mississippi State University
Cole Brazil – Mississippi State University

Rebekah Karsch – Wildlife Technician
Project Seasonal Technicians:
Tanya Wolf
Nick Vinciguerra
Rhonda Houk
Jarrod Hammerly
Julie Jarvey
Christina Rasanen
Karina Lamy
Caitlin Ott-Conn
Josh Fosdick
Dr. Glenn DelGiudice – University of Minnesota
Barry Sampson – Minnesota Department of Natural Resources
Justin Edge – Michigan Department of Natural Resources and Environment
Gordy Zuehlke (Air 3) – Michigan Department of Natural Resources and Environment
Neil Harri (Air 1) – Michigan Department of Natural Resources and Environment
Dr. Dan O'Brian – Michigan Department of Natural Resources and Environment
Dr. Dwayne Etter – Michigan Department of Natural Resources and Environment
Dr. Pat Lederle – Michigan Department of Natural Resources and Environment
Brian Roell – Michigan Department of Natural Resources and Environment
Bob Doepker – Michigan Department of Natural Resources and Environment
Kurt Hogue – Michigan Department of Natural Resources and Environment
Bill Rollo – Michigan Department of Natural Resources and Environment
Jason Peterson – Michigan Department of Natural Resources and Environment
Jessica Avery – Michigan Department of Natural Resources and Environment
Marvin Gerlach – Michigan Department of Natural Resources and Environment
Jason Neimi – Michigan Department of Natural Resources and Environment
Cole Brazil – Mississippi State University
Ingrid Kobler – Mississippi State University
Kamen Campbell – Mississippi State University
Dr. James Cantrill – Northern Michigan University
Whitney Morgan Oppenhuizen – Northern Michigan University
Forest Preserve District of DuPage County
Doug Wagner – Michigan Department of Natural Resources and Environment
Gil Grinsteiner – Menominee County Journal
Richard Wetthuhn
Hannahville Indian Community
Scott Sandahl
John Kralovetz and family
Nancy and Joe Hudson
Bob Steinmetz
Dan Kirschner
Kevin Swille and family
Marvin Parrett
Butch Kwarciany and family
Randy and Tammy Bajanen

Viau's Market, Escanaba, MI.
Michigan Meat Processors, Inc.
Elmer's Market, Escanaba, MI.

Literature Cited:

Ballard, W. B., D. Lutz, T. W. Keegan, L. H. Carpenter, and J. C. deVos, Jr. 2001. Deer–predatorrelationships: a review of recent North American studies with emphasis on mule and black–tailed deer. Wildlife Society Bulletin 29:99-115.

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

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.

Demarais, S., W. McKinley, and H. Jacobson. 2000. Using infrared-triggered cameras to survey white-tailed deer in Mississippi. Research Advances 5. Mississippi State University, Forest and Wildlife Research Center, Mississippi State, Mississippi, USA.

Jacobson, H. A., J. C. Kroll, R. W. Browning, B. H. Koerth, and M. H. Conway. 1997. Infrared-Triggered Cameras for Censusing White-Tailed Deer. Wildlife Society Bulletin 25: 547–556.

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.

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

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

Table 1. Mean ($\bar{x}$) and standard deviation (SD) of 35 captured female adult (*n* = 16), yearling (*n* = 3), and male and female fawn (*n* = 16) white-tailed deer morphometrics and body condition estimates, January-April 2010, Upper Peninsula of Michigan, USA.

	Age Class		
	Adults	Yearlings	Fawns
Metric (unit)	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Body Weight (kg)	78.8 ± 7.6	70.1 ± 8.6	47.0 ± 10.6
Body Length (cm)	144.3 ± 6.15	132.3	125.0 ± 1.4
Total Length (cm)	169.4 ± 5.9	158.5	149.8 ± 2.9
Chest Girth (cm)	91.2 ± 3.9	83.0 ± 3.9	76.2 ± 4.0
Neck Circumference (cm)	38.8 ± 3.1	36.5 ± 4.1	35.4 ± 4.8
Hind Foot (cm)	47.8 ± 1.3	46.5	43.9 ± 2.6
Shoulder Height (cm)	95.2 ± 3.8	94.3 ± 4.0	85.5 ± 0.2
Tail Length (cm)	25.1 ± 2.3	26.2	25.3 ± 2.0
Head Length (cm)	31.4 ± 3.6	32.4 ± 1.8	27.4 ± 0.6
Ear Length (cm)	15.2 ± 0.9	14.2 ± 0.9	14.1
BCS [1]	2.5 ± 0.4	2.2 ± 0.2	2.3 ± 0.3
MIDF [2] (cm)	0.8 ± 0.4	0.4 ± 0.4	0.7 ± 0.2
MAXF [3] (cm)	1.1 ± 0.4	0.8 ± 0.5	0.8 ± 0.2

[1] Body Condition Score (BCS) derived from palpating fat deposits along the scapula, spinal column, rump, and rib cage.

[2] Maximum rump fat estimate measured above ichial tuberosity of right hind hip.

[3] Middle rump fat estimate measured at mid-point between ilium and ichial tuberosity on right hip.

Table 2. Mean ($\bar{x}$) and standard deviation (SD) of 44 captured female (*n* = 20), male (*n* = 23), and unknown sex (*n* = 1) neonate fawn white-tailed deer morphometrics, May–June 2010, Upper Peninsula of Michigan, USA.

	Sex		
	Female	Male	Unknown
Estimate (unit)	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Body Weight (kg)	4.4 ± 1.8	4.7 ± 1.6	6.8
Body Length (cm)	62.4 ± 6.3	60.4 ± 11.0	na
Total Length (cm)	77.8 ± 4.9	67.3 ± 11.5	na
Chest Girth (cm)	38.1 ± 8.4	37.0 ± 4.0	40.5
Hind Foot (cm)	27.9 ± 1.1	45.7 ± 5.5	na
Shoulder Height (cm)	44.1 ± 5.1	24.7 ± 3.4	na
New Hoof Growth (mm)	3.6 ± 1.4	3.0 ± 1.1	4
Birth Mass (kg) [1]	3.9 ± 1.8	4.5 ± 1.4	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 3. Radiocollared adult and yearling female white-tailed deer (*n* = 16) mortality sources from 2009 and 2010 releases through 31 August 2010, Upper Peninsula of Michigan, USA.

Mortality Source	2009	2010	Combined
Coyote	3	3	6
Wolf	1	2	3
Drowned	2	na	2
Black bear	2	na	2
Birthing Complications	1	na	1
Vehicle	1	na	1
Unknown Predator	na	1	1

Table 4. Radiocollared white-tailed deer neonate fawns (*n* = 44) mortality sources from 2009 and 2010 releases through 31 August 2010, Upper Peninsula of Michigan, USA.

Mortality Source	2009	2010	Combined
Coyote	8	5	13
Bobcat	6	3	9
Unknown predator	5	na	5
Abandonment	4	na	4
Unknown agent	1	2	3
Black bear	2	na	2
Vehicle	2	na	2
Wolf	na	2	2
Bald Eagle	1	na	1
Pleuritis; Pneumonia	na	1	1
Harvest (Illegal)	1	na	1
Unknown canid	na	1	1

Table 5. White-tailed deer abundance in 256 km^2 study area estimated using 54 remote infrared cameras, Upper Peninsula of Michigan, USA, September 2009.

	Demarais et al. Method	Jacobson et al. Method
Bucks surveyed	103	118
Does surveyed	323	276
Fawns surveyed	48	41
#Deer surveyed	474	435
#Deer/km^2	6.2	5.7
#Deer/study area	1588	1460

Table 6. Capture data for 20 black bears at dens, Upper Peninsula of Michigan, USA, 1 October 2009–31 August 2010.

Species	ID	Capture date	Age[a]	Sex	Body weight (kg)	Right ear tag	Left ear tag
Black bear	BB12	22-Feb-10	12	F	113.4	72	73
Black bear	BB20	22-Feb-10	Cub from BB12	M	N/A	N/A	N/A
Black bear	BB21	22-Feb-10	Cub from BB12	F	N/A	N/A	N/A
Black bear	BB15	22-Feb-10	3	M	127.0	82	81
Black bear	BB14	23-Feb-10	3	F	83.9	79	80
Black bear	BB22	23-Feb-10	Cub from BB14	M	1.8	N/A	N/A
Black bear	BB23	23-Feb-10	Cub from BB14	M	1.8	N/A	N/A
Black bear	BB24	23-Feb-10	Cub from BB14	M	1.6	N/A	N/A
Black bear	BB16	24-Feb-10	5	F	90.7	84	83
Black bear	BB25	24-Feb-10	Cub from BB16	M	2.3	N/A	N/A
Black bear	BB26	24-Feb-10	Cub from BB16	M	2.3	N/A	N/A
Black bear	BB27	24-Feb-10	Cub from BB16	M	2.3	N/A	N/A
Black bear	BB28	24-Feb-10	Adult	M	113.4	1110	28
Black bear	BB09	25-Feb-10	Adult	M	68.0	99	67
Black bear	BB29	25-Feb-10	Adult	F	133.8	5	45
Black bear	BB30	25-Feb-10	Cub from BB29	M	2.3	N/A	N/A
Black bear	BB31	25-Feb-10	Cub from BB29	M	2.3	N/A	N/A
Black bear	BB08	8-Mar-09	8	F	NA	N/A	11
Black bear	BB17	8-Mar-09	Yearling	F	29.5	35	34
Black bear	BB18	8-Mar-09	Yearling	M	40.8	24	25

[a]Ages of independent bears were estimated using cementum annuli counts by the Michigan Department of Natural Resources and Environment

Table 7. Capture and monitoring data for 38 radiocollared carnivores, Upper Peninsula of Michigan, USA, 12 December 2009–31 August 2010.

Species	ID	Capture date[a]	Age[b]	Sex	Weight (kg)[c]	Ear tag no. right/left	Days monitored	Locations	Collar status/interval[d]
Black bear	BB04	12-Dec-09	Adult	M	185.1	57/58	170	2774	Slipped Collar; 30 May 10
Black bear	BB08	8-Mar-10	Adult	F	129.3	na/11	176	11,023	Active/15 min
Black bear	BB09	25-Feb-10	8	M	86.6	66/67	16	16	Active/VHF
Black bear	BB12	22-Feb-10	12	F	113.4	72/73	1	1	Slipped Collar; 22 Feb 10
Black bear	BB14	23-Feb-10	3	F	83.9	79/80	189	9021	Active/15 min
Black bear	BB15	22-Feb-10	3	M	127.0	82/81	190	9028	Active/15 min
Black bear	BB16	24-Feb-10	5	F	90.7	84/83	188	11,176	Active/15 min
Black bear	BB17	8-Mar-10	Yearling	F	29.5	35/34	16	16	Active/VHF
Black bear	BB18	14-Dec-09	Yearling	M	40.8	24/25	2	2	Slipped Collar; 8 Feb 10
Black bear	BB28	24-Feb-10	Adult	M	113.4	1110/28	188	10,908	Active/15 min
Black bear	BB29	25-Feb-10	Adult	F	133.8	05/45	1	1	Slipped collar; 28 Feb 10
Black bear	BB32	1-May-10	Adult	F	43.0	10/9	6	6	Active/VHF
Black bear	BB33	21-May-10	Adult	M	60.8	na/na	6	6	Active/VHF
Black bear	BB34	1-Jun-10	Juvenile	M	37.2	na/na	92	6530	Active/15 min
Black bear	BB36	2-Jun-10	Adult	M	102.1	126/127	15	1202	Slipped; 16 Jun 10
Black bear	BB37	3-Jun-10	Adult	M	97.5	185/186	1	78	Slipped; 3 Jun 10
Black bear	BB38	17-Jun-10	Adult	M	92.1	133/131	76	6442	Active/15 min
Black bear	BB39	20-Jun-10	Adult	M	104.3	179/178	72	6724	Active/15 min
Black bear	BB41	21-Jun-10	Juvenile	M	44.5	145/134	71	4430	Active/15 min
Black bear	BB42	23-Jun-10	Adult	F	54.9	139/138	6	6	Active/VHF
Black bear	BB43	27-Jun-10	Adult	M	70.8	179/178	66	5112	Active/15 min
Black bear	BB44	29-Jun-10	Adult	M	102.5	143/144	64	2170	Active/15 min
Black bear	BB45	10-Jul-10	Juvenile	F	33.1	142/122	5	5	Active/VHF
Black bear	BB46	27-Jul-10	Adult	F	77.6	123/132	3	3	Active/VHF

Table 7. (continued). Capture and monitoring data for 38 radiocollared carnivores, Upper Peninsula of Michigan, USA, 12 December 2009–31 August 2010.

Species	ID	Capture date[a]	Age[b]	Sex	Weight (kg)[c]	Ear tag no. right/left	Days monitored	Locations	Collar status/interval[d]
Bobcat	BC05	25-Apr-10	Adult	M	15.4	86/87	129	11,516	Active/15 min
Bobcat	BC06	6-May-10	Juvenile	F	6.4	42/32	46	4169	Slipped; 21 Jun 10
Bobcat	BC07	18-May-10	Adult	M	14.1	22/23	106	9698	Active/15 min
Coyote	C10	29-Apr-10	Adult	M	13.2	85/74	125	10,319	Active/15 min
Coyote	C11	30-Apr-10	Juvenile	M	13.2	36/37	124	11,370	Active/15 min
Coyote	C12	1-May-10	Adult	F	17.5	43/44	4	10	Shot; 14 May 10
Coyote	C15	11-May-10	Juvenile	F	9.3	NA/NA	112	9991	Active/15 min
Coyote	C16	18-May-10	Adult	M	13.2	20/19	105	9290	Active/15 min
Coyote	C17	3-Jun-10	Adult	F	10.0	125/124	89	7888	Active/15 min
Coyote	C18	3-Jun-10	Adult	M	12.7	176/177	3	3	Active/VHF[e]
Coyote	C20	5-Jun-10	Adult	M	15.0	129/128	87	7618	Active/15 min
Wolf	W05	2-May-10	Adult	F	70.8	15/16	121	10,038	Active/15 min
Wolf	W06	4-May-10	Adult	M	46.3	557/558	119	10,189	Active/15 min
Wolf	W07	13-May-10	Adult	F	34.9	17/18	110	9372	Active/15 min

[a] BB04, BB08, BB09, BB12, BB14, BB15, BB16 were captured in 2009 and collars were replaced during 2009-10 den checks.

[b] Ages were estimated after 2009 capture by Michigan Department of Natural Resources and Environment Diagnostics Laboratory, Lansing, MI.

[c] Weights are for most recent capture or den check of animal.

[d] BB09 was wounded by rifle hunter on 15 September

[e] GPS collar is in maintenance mode; collar is being monitored using VHF

Table 8. Monitoring data for 23 GPS-radiocollared carnivores, Upper Peninsula of Michigan, USA, 12 December 2009–31 August 2010.

		Number of days monitored			Number of locations		
Species	n	mean	SD	range	mean	SD	range
Black bear	11	125	59	64-190	7506	2973	2170-11,176
Bobcat	3	94	43	46-129	8461	3827	4169-11,516
Coyote[a]	6	107	17	87-125	9413	1452	7618-11,370
Wolf	3	117	6	110-121	9866	435	9372-10,189

[a] Excludes coyote that was shot (C12) and coyote with collar that malfunctioned (C18).

Table 9. Percent frequency of occurrence of prey species identified in black bear (*n* = 62), bobcat (*n* = 1), coyote (*n* = 23), and wolf (*n* = 5) scat, Upper Peninsula of Michigan, USA, 5 June–13 August 2009.

	Black bear		Bobcat		Coyote		Wolf	
Prey item	No. Scats	%	No. Scats	%	No. Scats	%	No. Scats	%
White-tailed deer, adult (*O. virginianus)*	4	6.5	0	0.0	13	56.5	1	20.0
White-tailed deer, fawn	2	3.2	0	0.0	4	17.4	2	40.0
Rabbit/hare (*S. floridanus; L. americanus*)	0	0.0	0	0.0	2	8.7	0	0.0
Porcupine (*E. dorsatum*)	1	1.6	0	0.0	0	0.0	0	0.0
Raccoon (*P. lotor*)	0	0.0	0	0.0	1	4.3	0	0.0
Unknown hair	3	4.8	0	0.0	0	0.0	0	0.0
Unknown bones	4	6.5	0	0.0	19	82.6	4	80.0
Unknown plant material	53	85.5	1	100.0	14	60.9	3	60.0
Corn (*Z. mays*)	7	11.3	0	0.0	0	0.0	0	0.0
Sunflower seeds (*H. annuus*)	2	3.2	0	0.0	0	0.0	0	0.0
Unknown seeds	13	21.0	0	0.0	0	0.0	0	0.0
Unknown insects	5	8.1	0	0.0	1	4.3	0	0.0
Beetle (*Coleoptera spp.*)	6	9.7	0	0.0	2	8.7	0	0.0
Bee (*Apidae spp.*)	1	1.6	0	0.0	0	0.0	0	0.0
Ants	39	62.9	1	100.0	0	0.0	0	0.0
Snails	1	1.6	0	0.0	0	0.0	0	0.0
Ticks	0	0.0	0	0.0	2	8.7	0	0.0
Unknown feathers	1	1.6	0	0.0	0	0.0	0	0.0
Hair of focal species	4	6.5	0	0.0	3	13.0	2	40.0

Table 10. Alternative prey and carnivore observations, Upper Peninsula of Michigan, USA, 6 October 2009–31 August 2010.

Alternative Prey Observations			Carnivore Observations		
Species	Observations	No. Observed	Species	Observations	No. Observed
Turkey	175	620	Coyote	38	57
Grouse	106	155	Wolf	20	24
Squirrel	63	67	Bobcat	13	13
Pheasant	56	77	Skunk	12	12
Rabbit/Hare	37	43	Gray Fox	10	10
Sm. Mammal	21	22	Black bear	4	7
Porcupine	12	12	Red Fox	4	4
Woodcock	10	15	Otter	1	2
Other	6	9	Badger	1	1

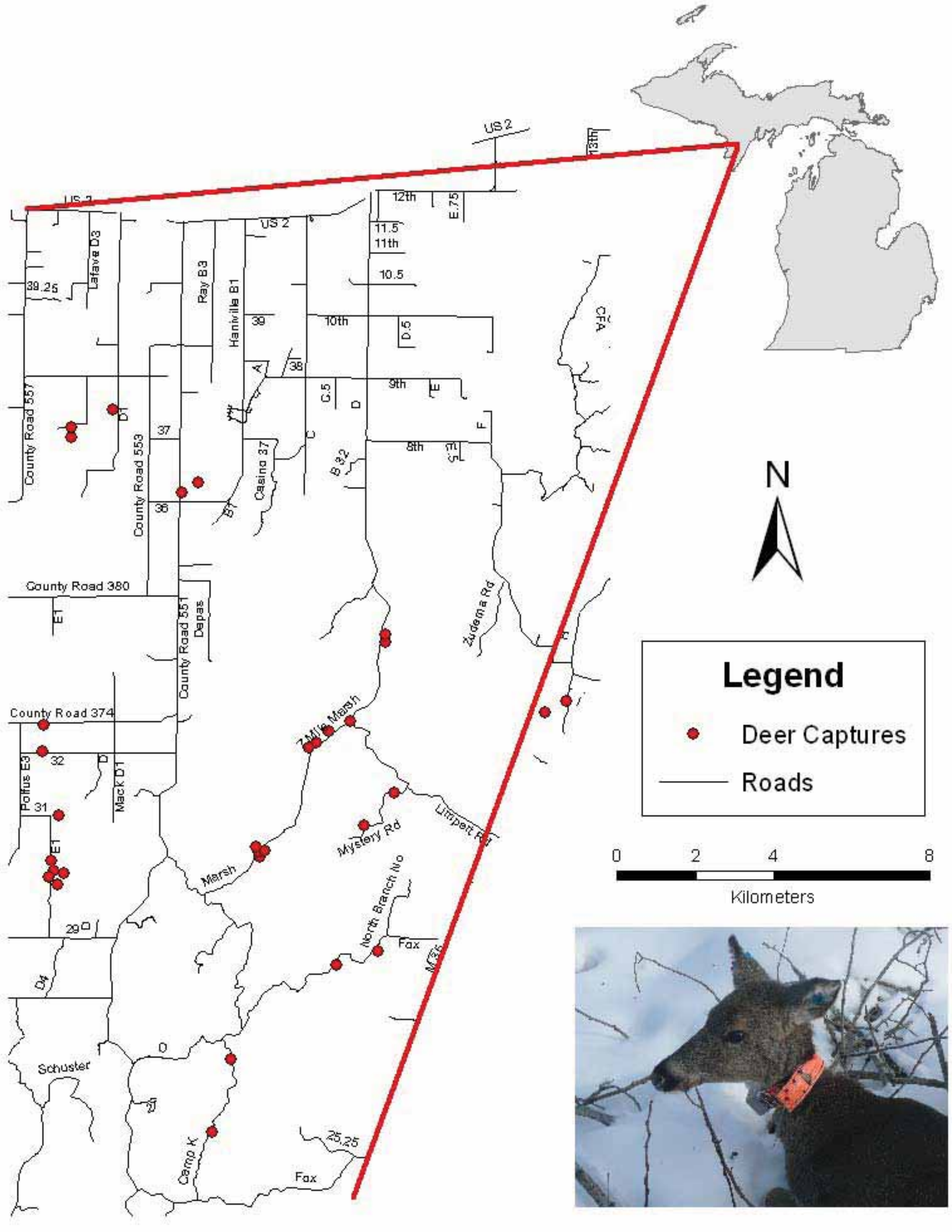

Figure 1. Capture locations of 57 white-tailed deer, Upper Peninsula of Michigan, USA, 18 January–21 April 2010.

Figure 2. Female (blue), male (yellow), and neonate (white) fawn white-tailed deer ear tags, Upper Peninsula of Michigan, USA, 2010.

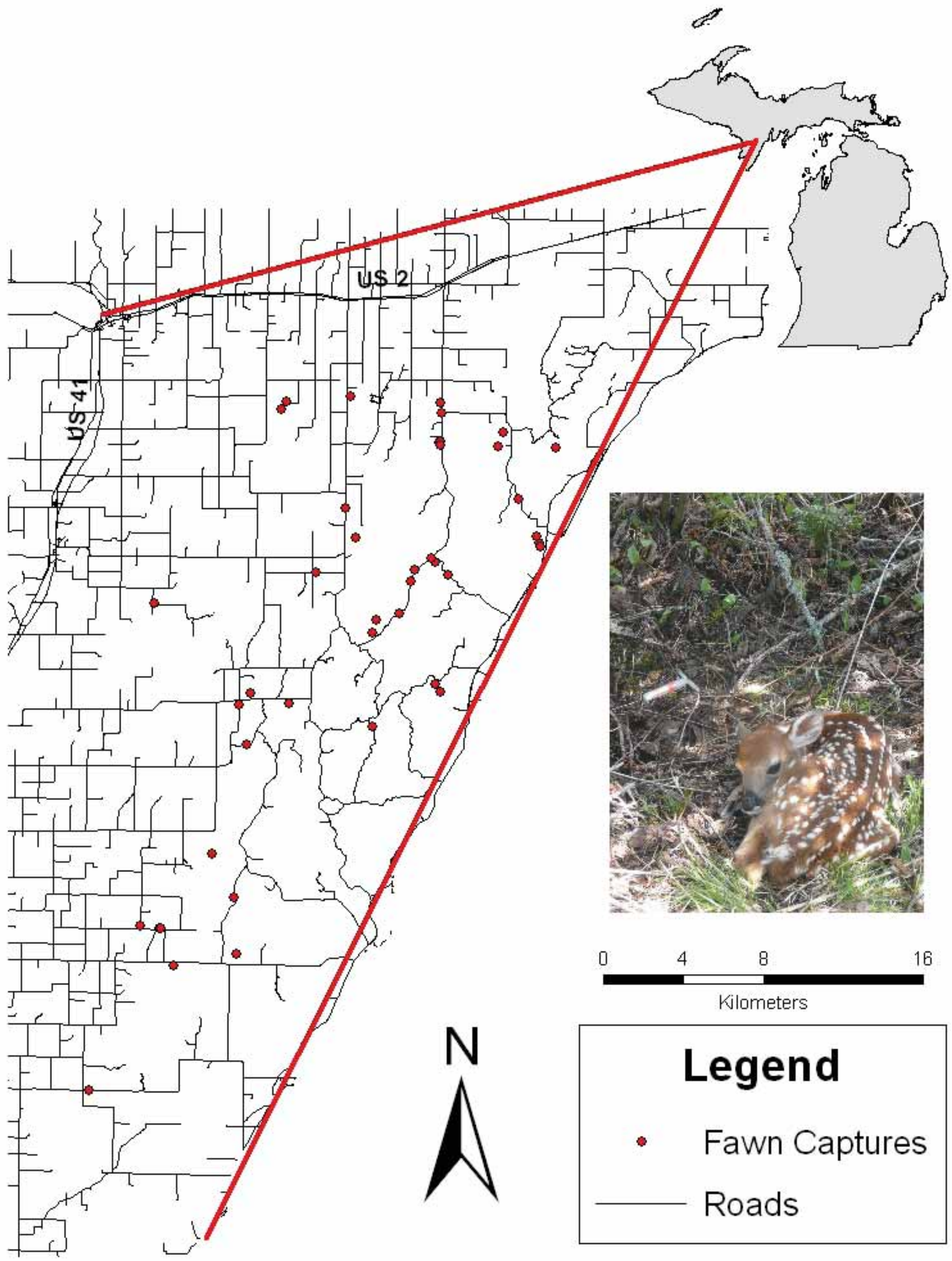

Figure 3. Capture locations of 44 white-tailed deer fawns, Upper Peninsula of Michigan, USA, 14 May–17 June 2010.

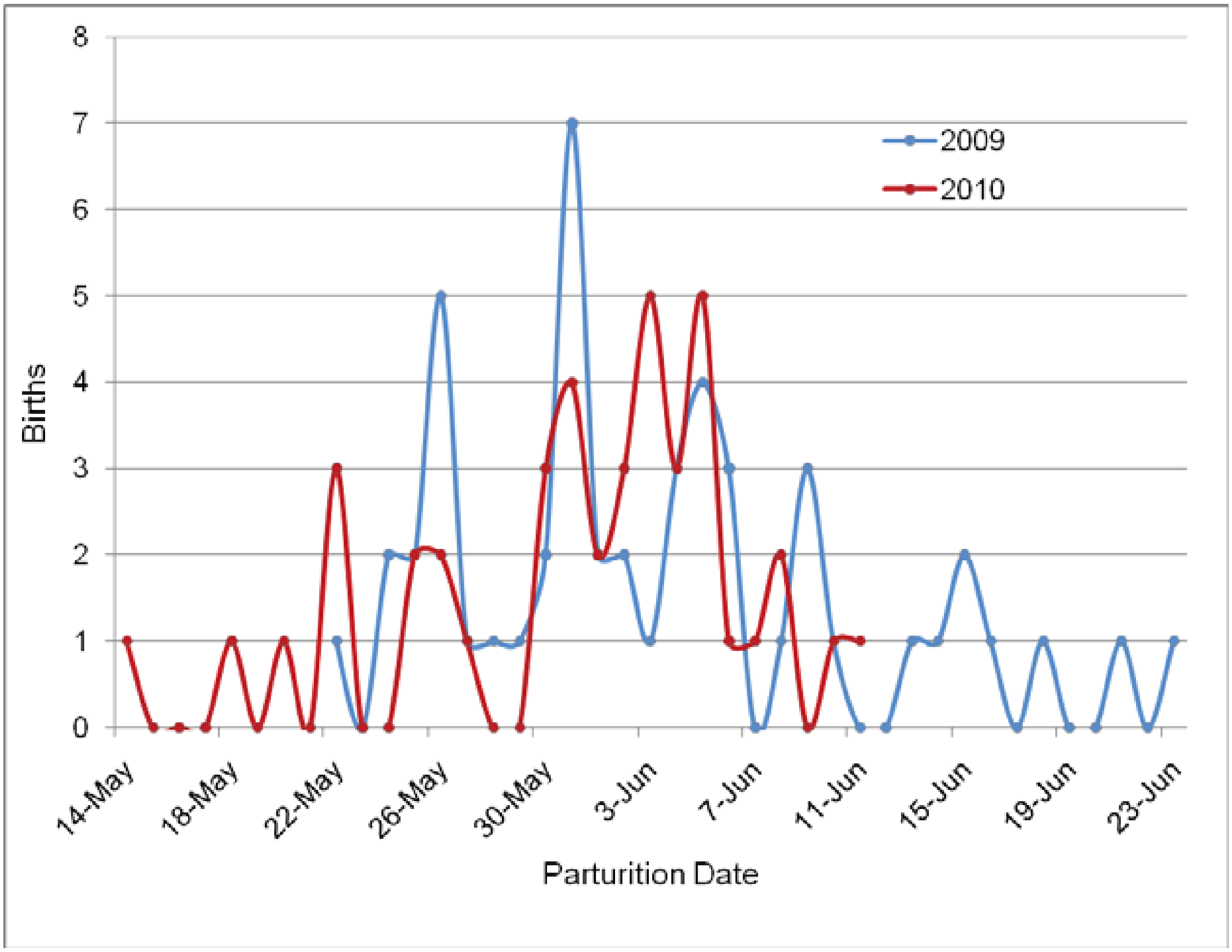

Figure 4. Estimated parturition dates of fawns in 2009 (*n* = 50) and 2010 (*n* = 41), Upper Peninsula of Michigan, USA.

Figure 5. Mock fawn used to estimate neonate fawn search efficacy at vaginal implant transmitter expulsion sites, Upper Peninsula of Michigan, USA.

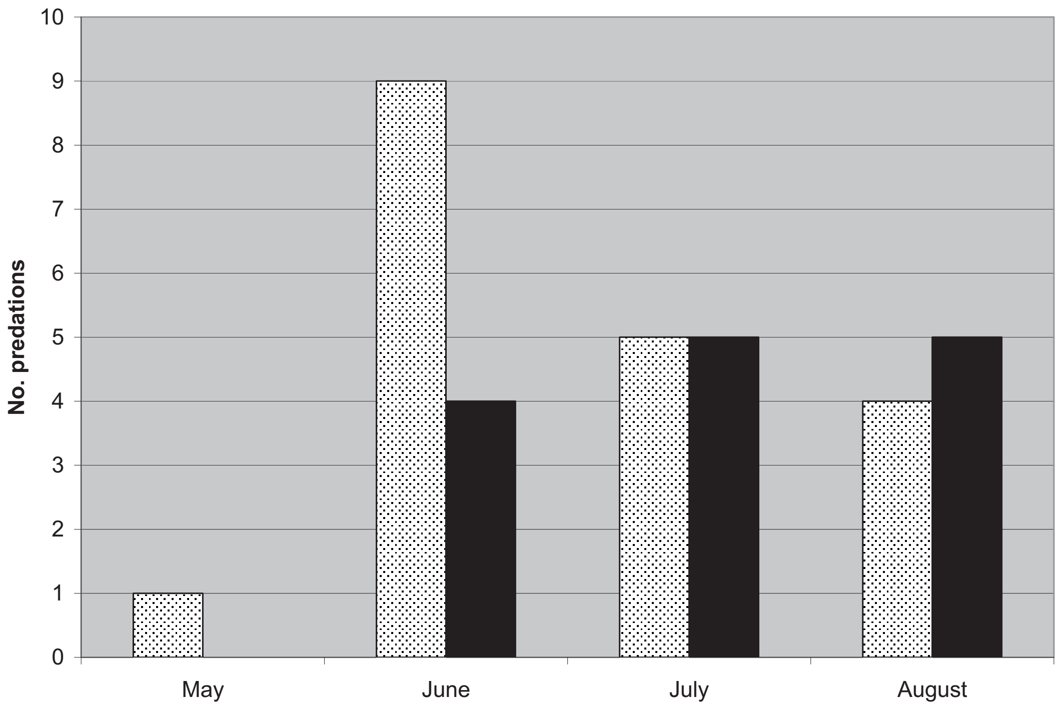

Figure 6. Radiocollared fawn predations, May-August 2009 (n = 19; stippled bars) and 2010 (n = 14; solid bars), Upper Peninsula of Michigan, USA.

Figure 7. Ear tagged black bear, bobcat, coyote, and wolf, Upper Peninsula of Michigan, USA, 2009.

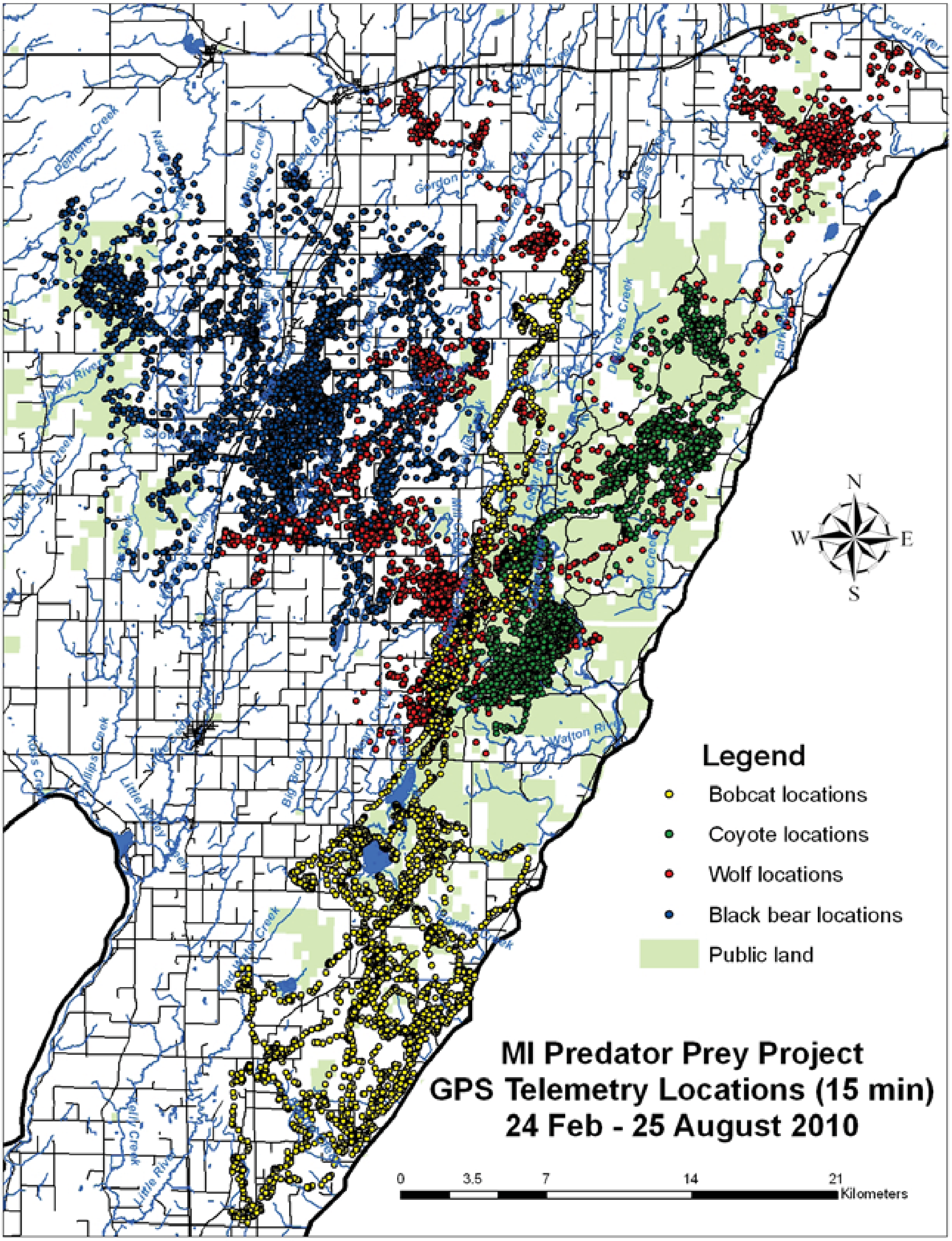

Figure 8. GPS telemetry locations for 1 black bear, 1 bobcat, 1 coyote and 1 wolf, Upper Peninsula of Michigan, USA, 24 February–25 August 2010.

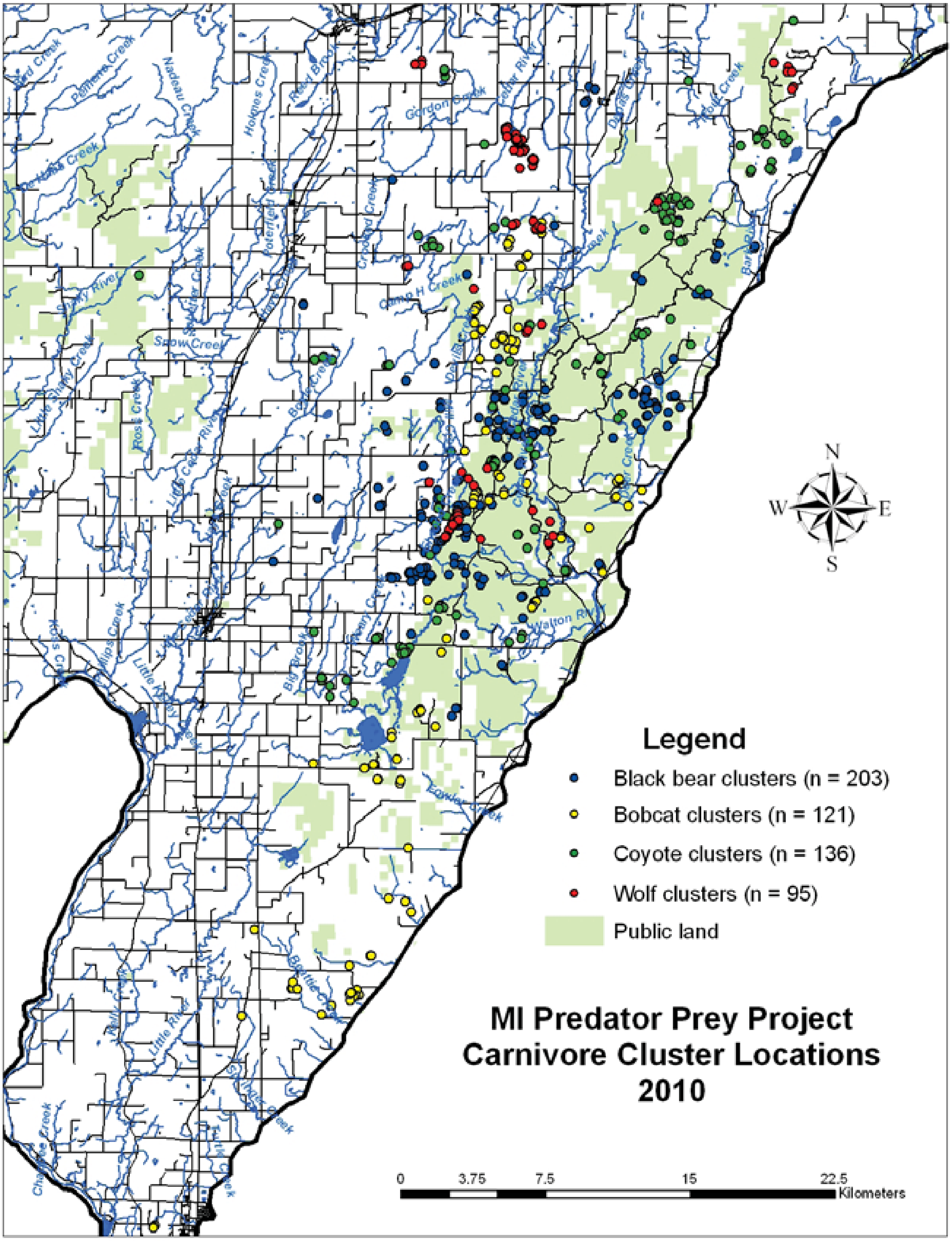

Figure 9. Cluster locations (n = 555) for 13 black bears, 3 bobcats, 7 coyotes, and 3 wolves, Upper Peninsula of Michigan, USA, 4 May–31 August 2010.

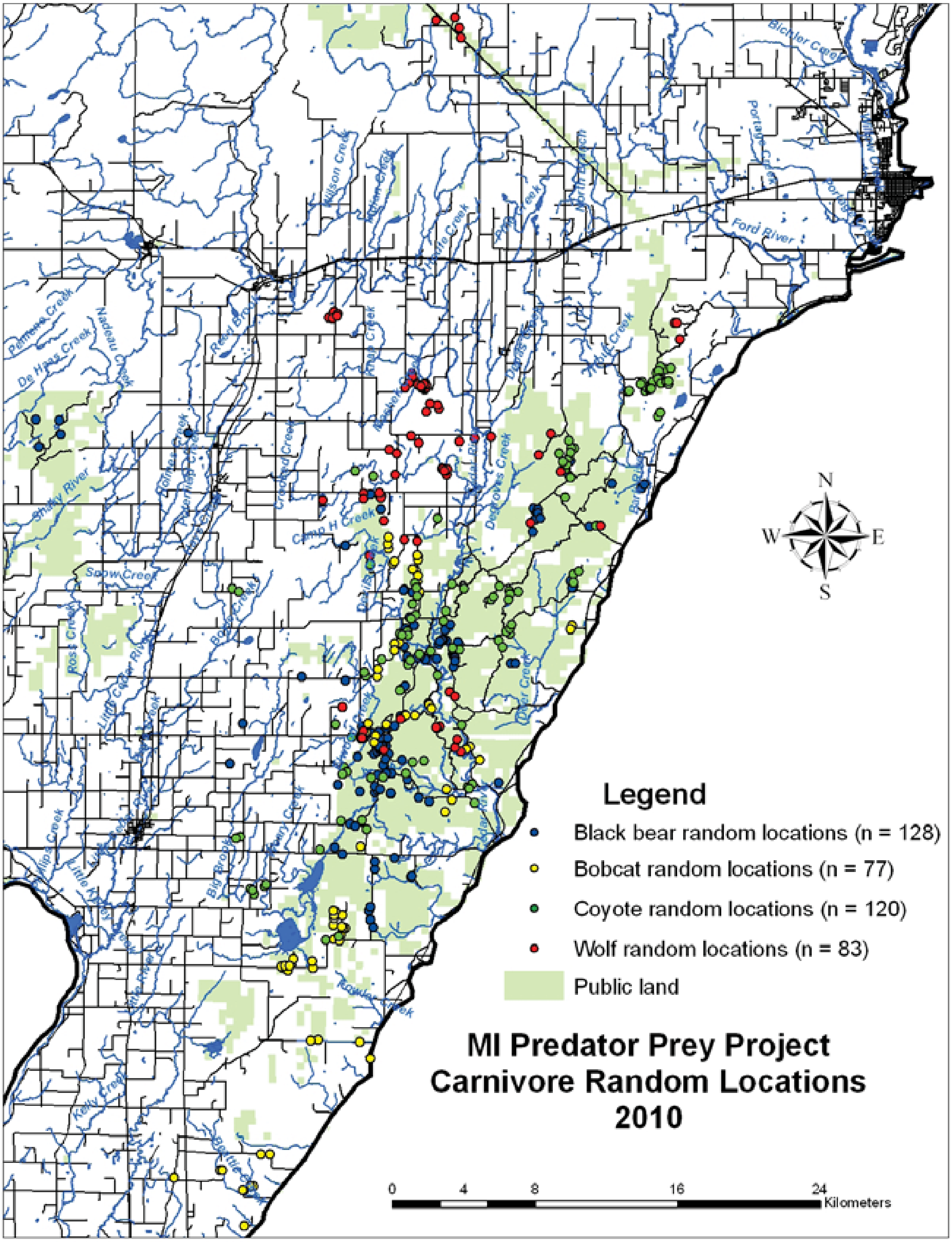

Figure 10. Non-cluster locations (n = 408) selected opportunistically for 13 black bears, 3 bobcats, 7 coyotes, and 3 wolves, Upper Peninsula of Michigan, USA, 4 May–31 August 2010.

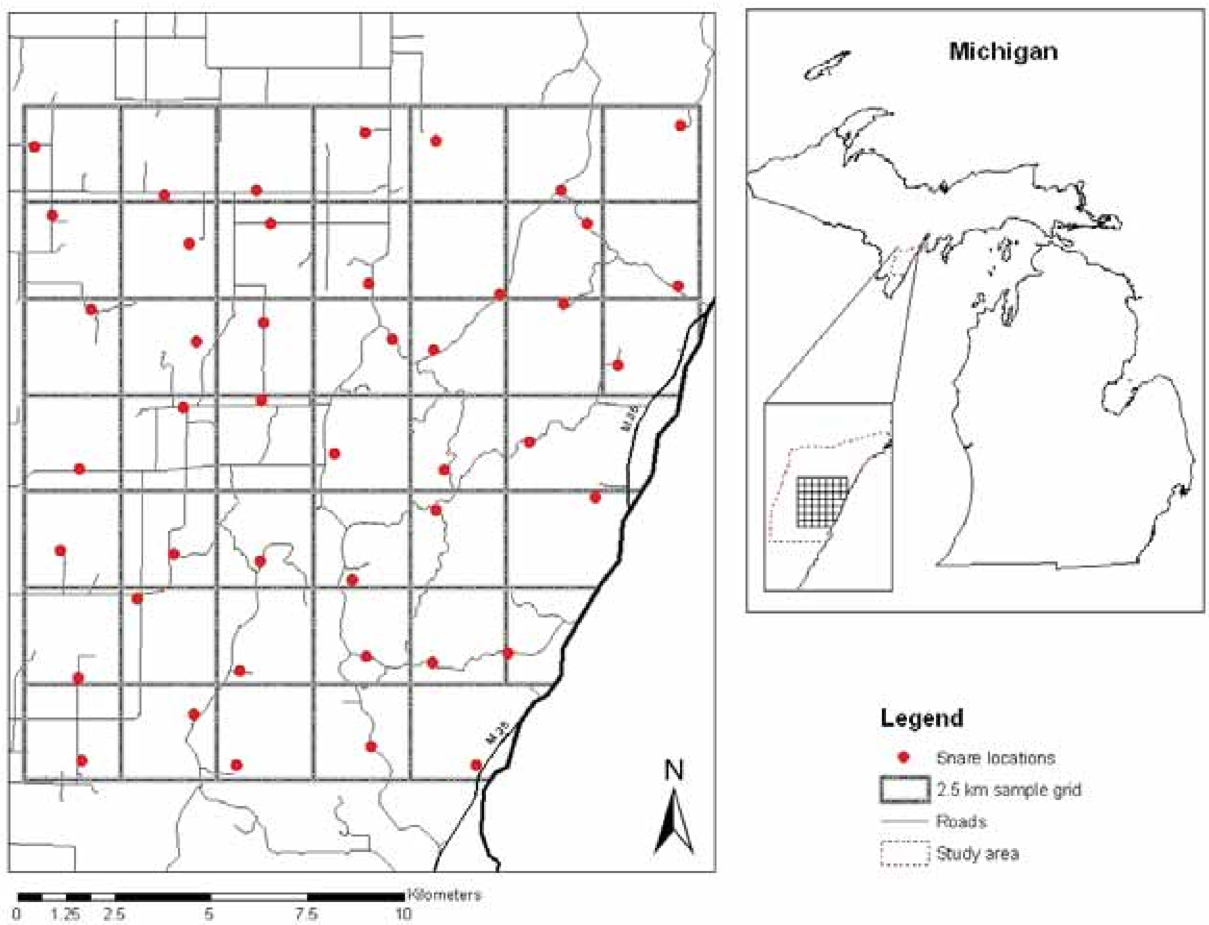

Figure 11. Bobcat and coyote hair snare sites (n = 44) within 2.5 km^2 grid cells, Upper Peninsula of Michigan, USA, January–March 2010.

Figure 12. Baited snare site (top) and hair sample captured (bottom) using a modified body snare, Upper Peninsula of Michigan, USA, January–March 2010.

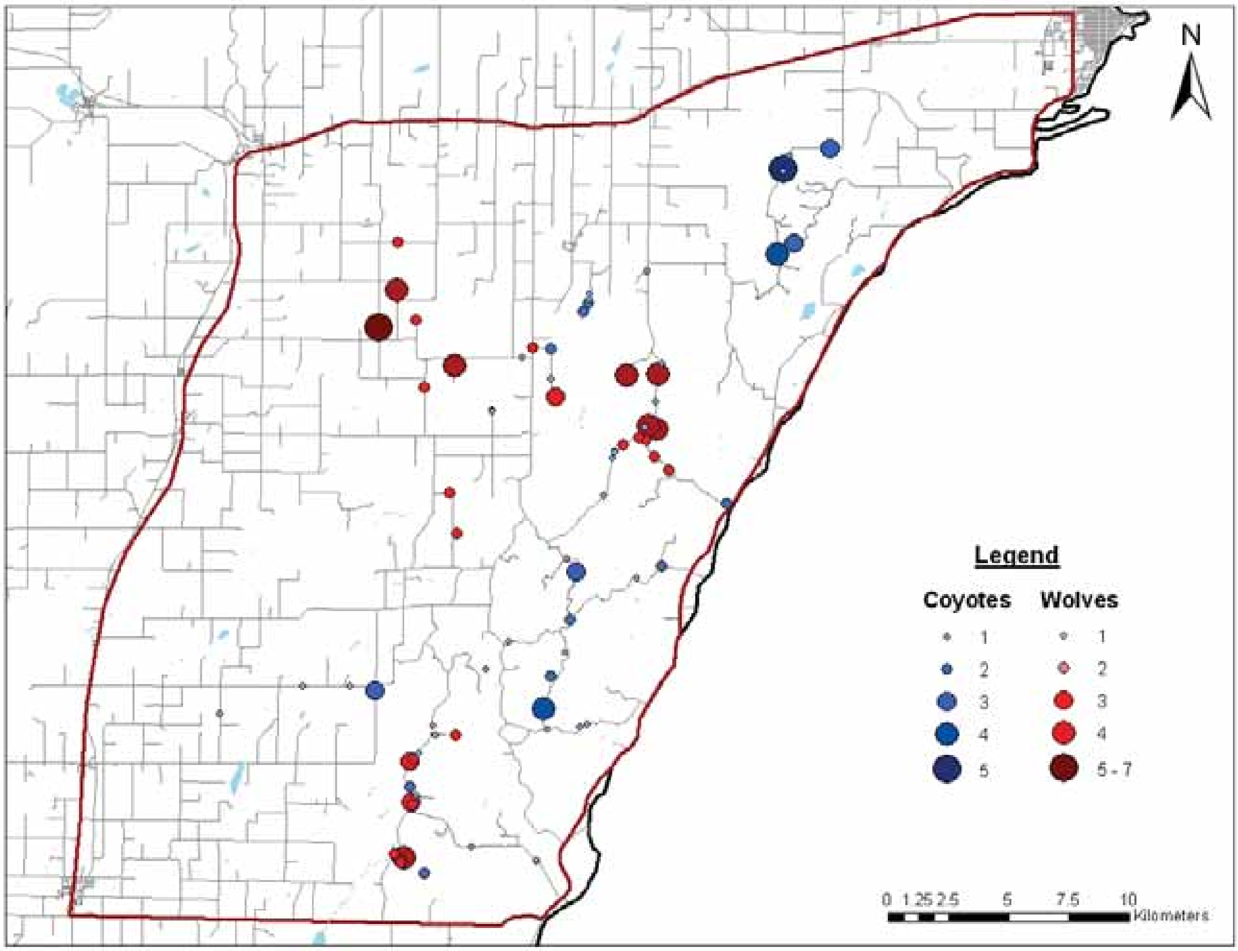

Figure 13. Winter track survey observations for wolves and coyotes, Upper Peninsula of Michigan, USA, January–March, 2010. Observations are displayed based on number of animals traveling together.

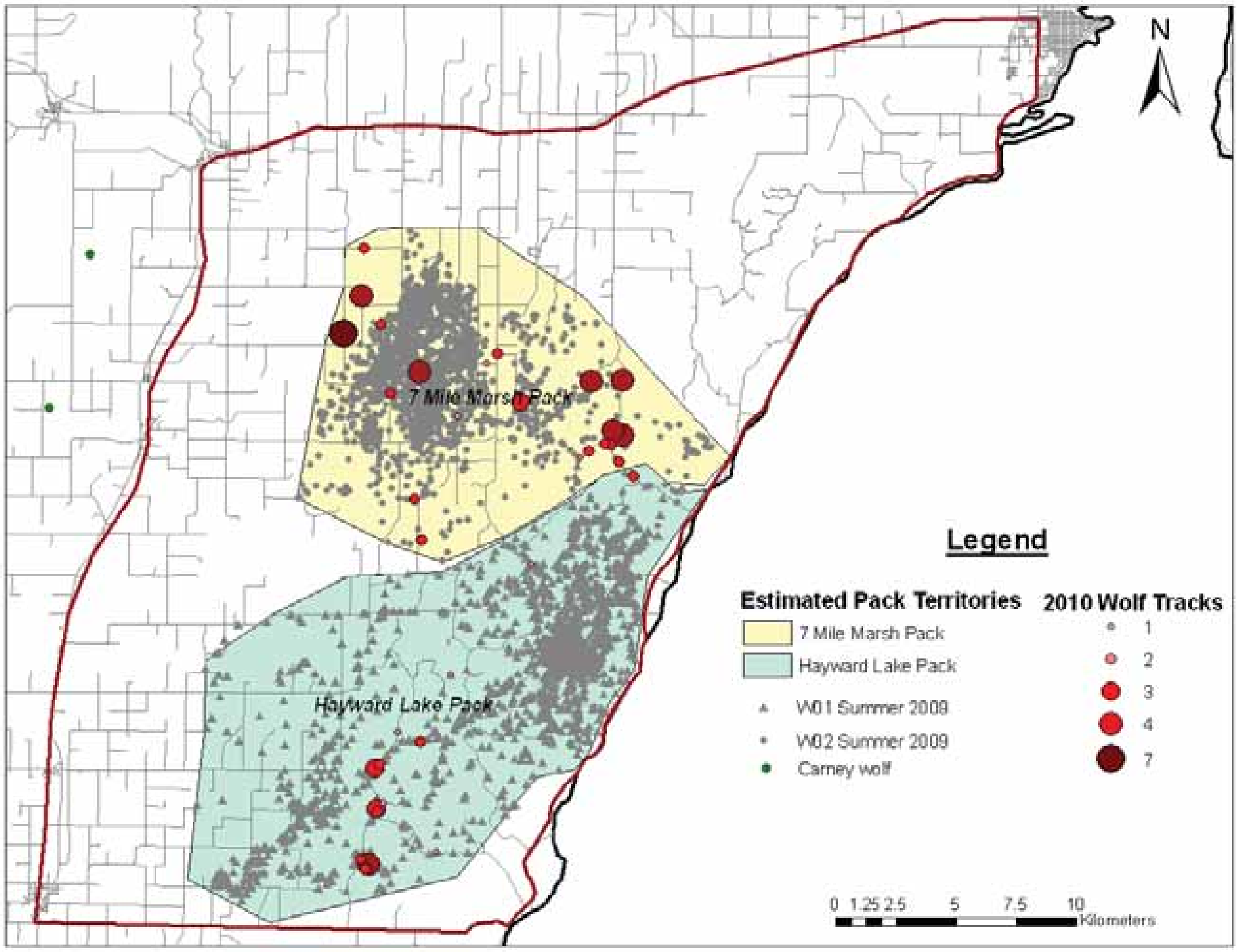

Figure 14. Approximate wolf pack territories based on summer 2009 wolf GPS data and winter 2010 track survey observations, Upper Peninsula of Michigan, USA. Also shown are telemetry relocations of a radio-collared wolf in the Carney Pack.

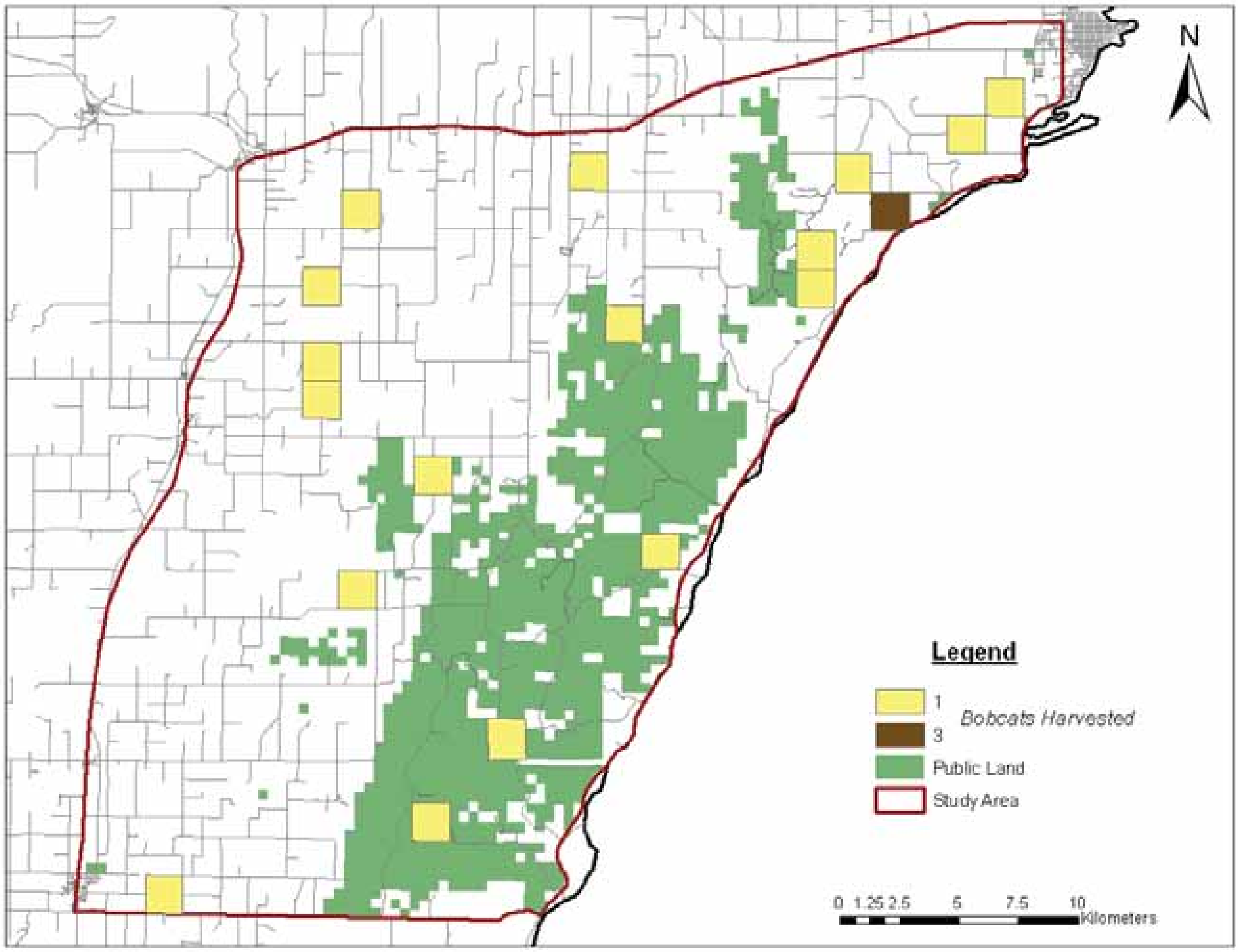

Figure 15. Bobcat harvest data (n = 20) by section (2008 and 2009 MDNRE unpublished data), Upper Peninsula of Michigan, USA.

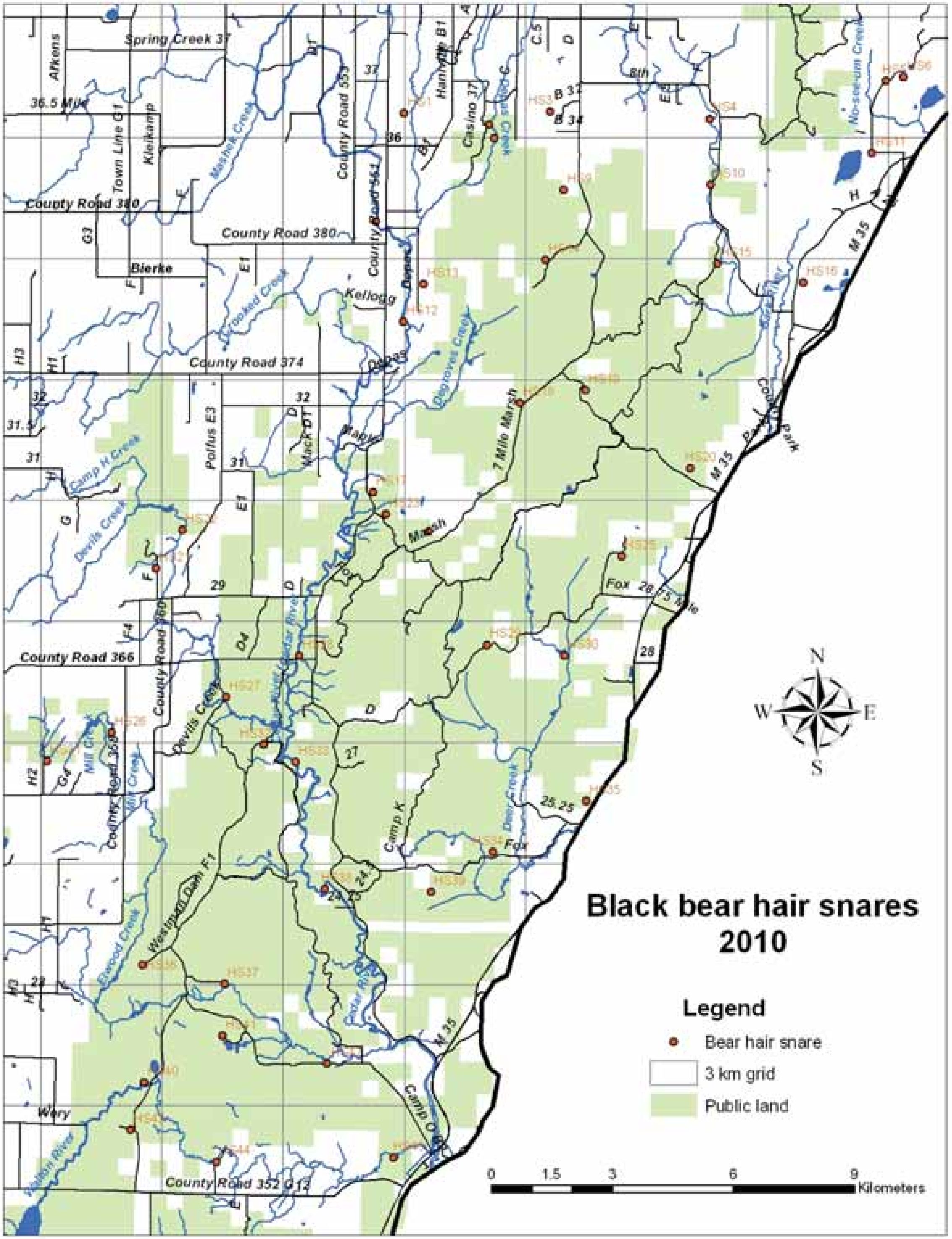

Figure 16. Black bear hair snare locations ($n = 45$), Upper Peninsula of Michigan, USA, 2010.

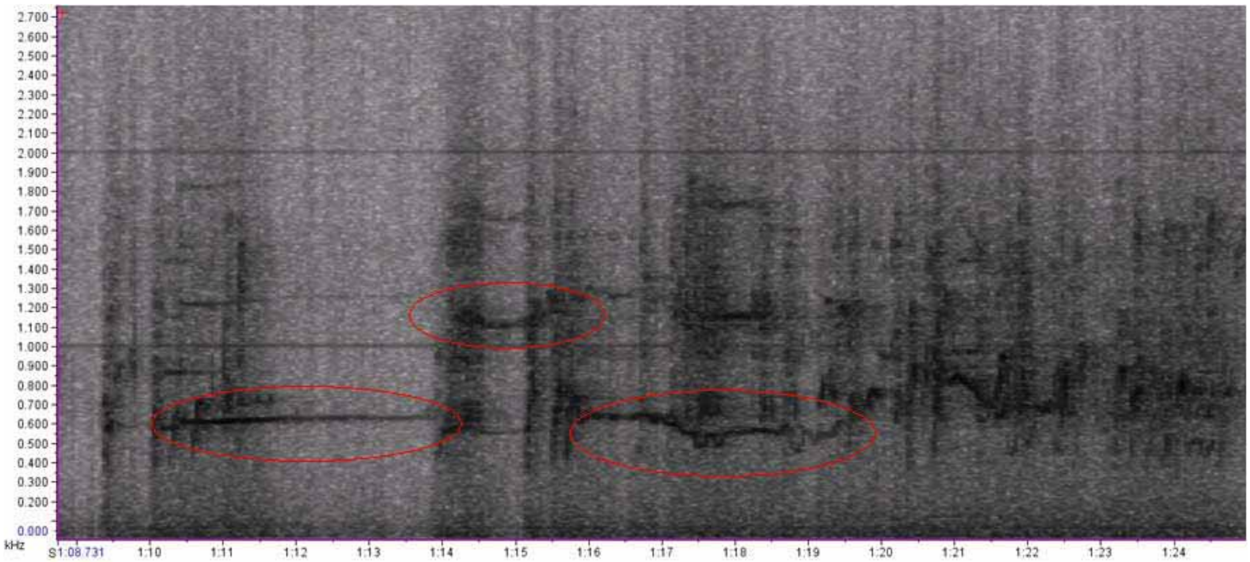

Figure 17. Sonogram of coyote pack including radio-collared male and female approximately 1.0 km away, Upper Peninsula of Michigan, USA, 2009.

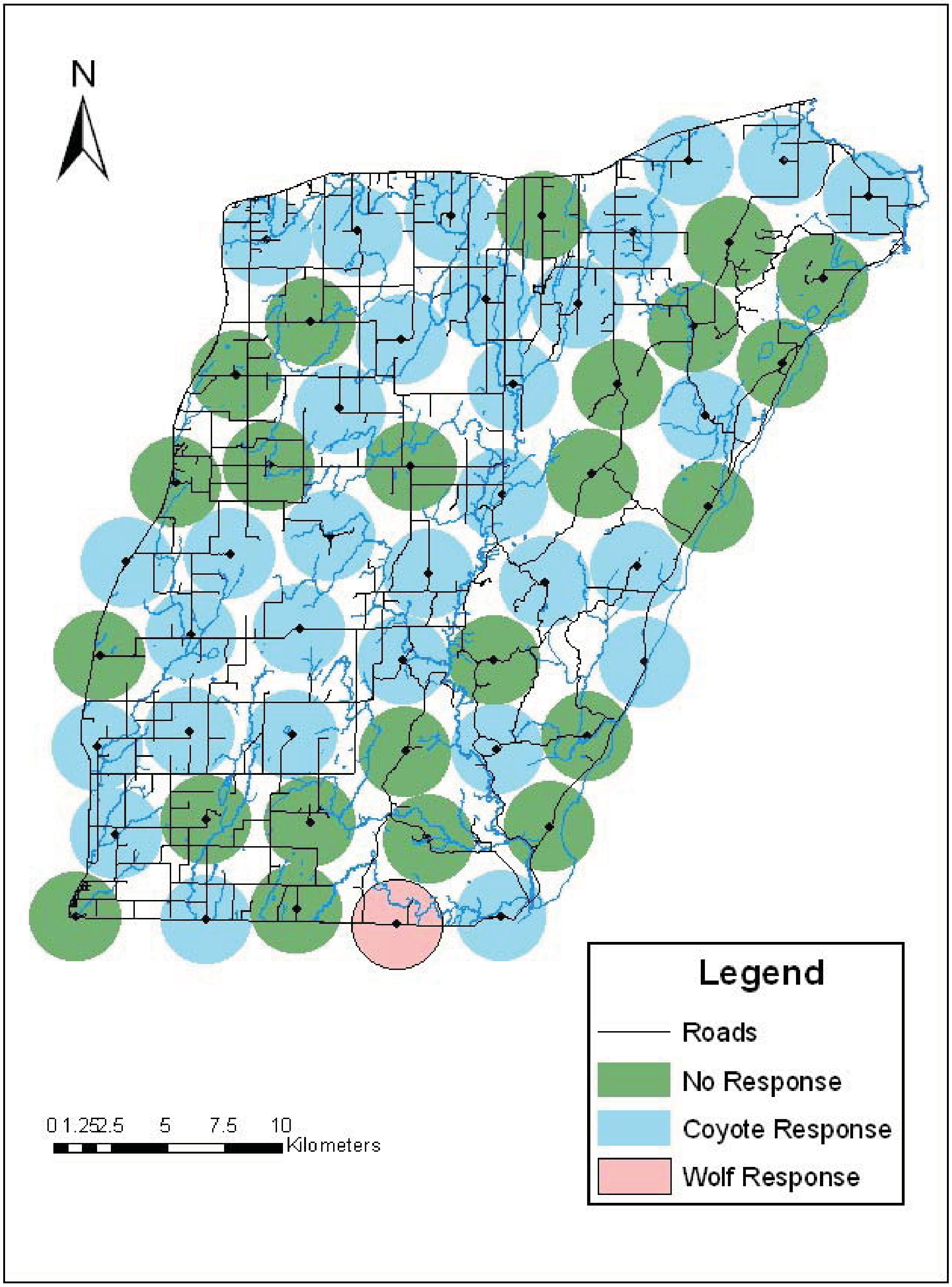

Figure 18. Howl survey sites where coyote and wolf responses were elicited during coyote group-yip broadcasts, Upper Peninsula of Michigan, USA, June-August 2010.

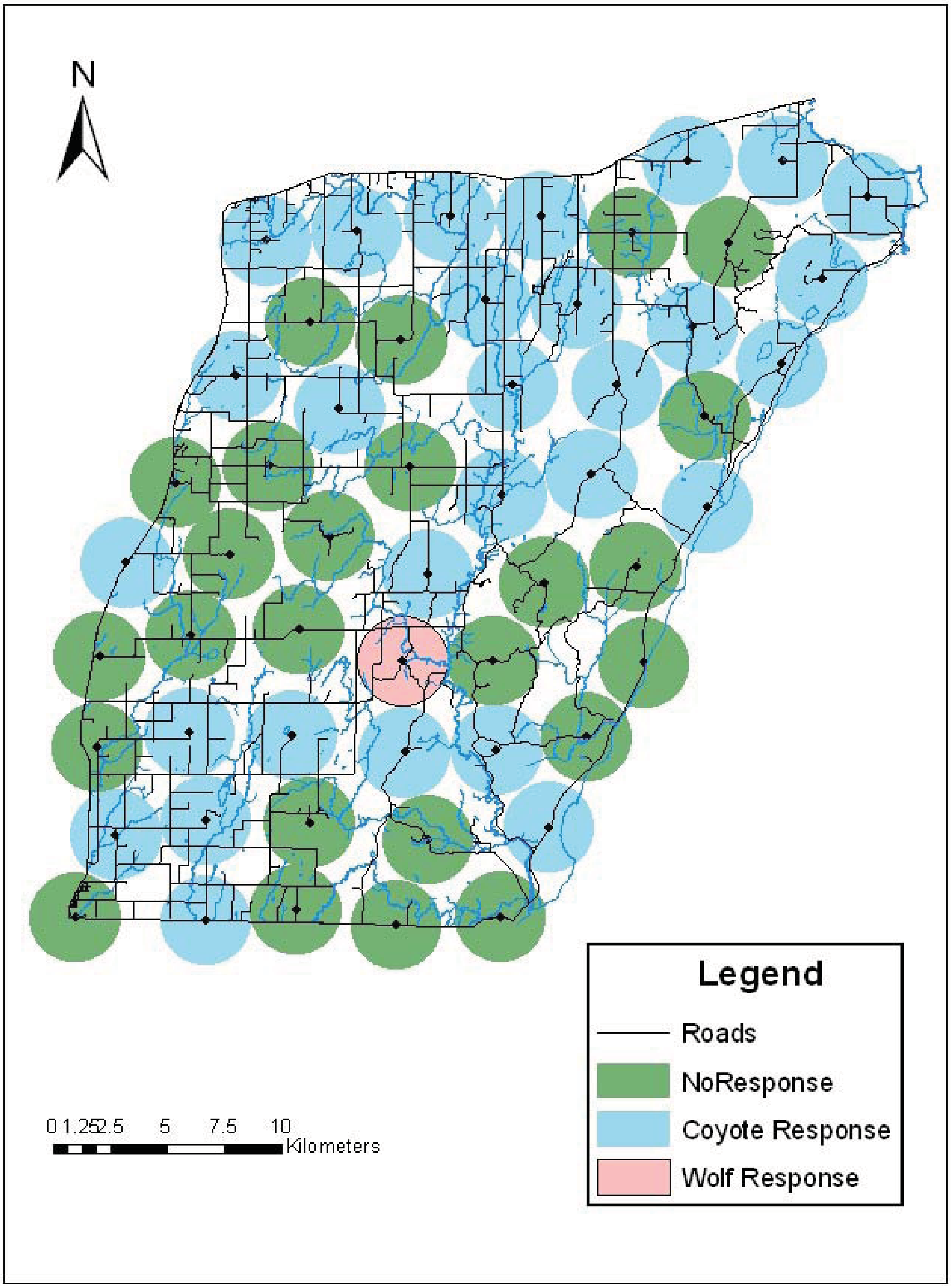

Figure 19. Howl survey sites where coyote and wolf responses were elicited during wolf lone howl broadcasts, Upper Peninsula of Michigan, USA, June-August 2010.

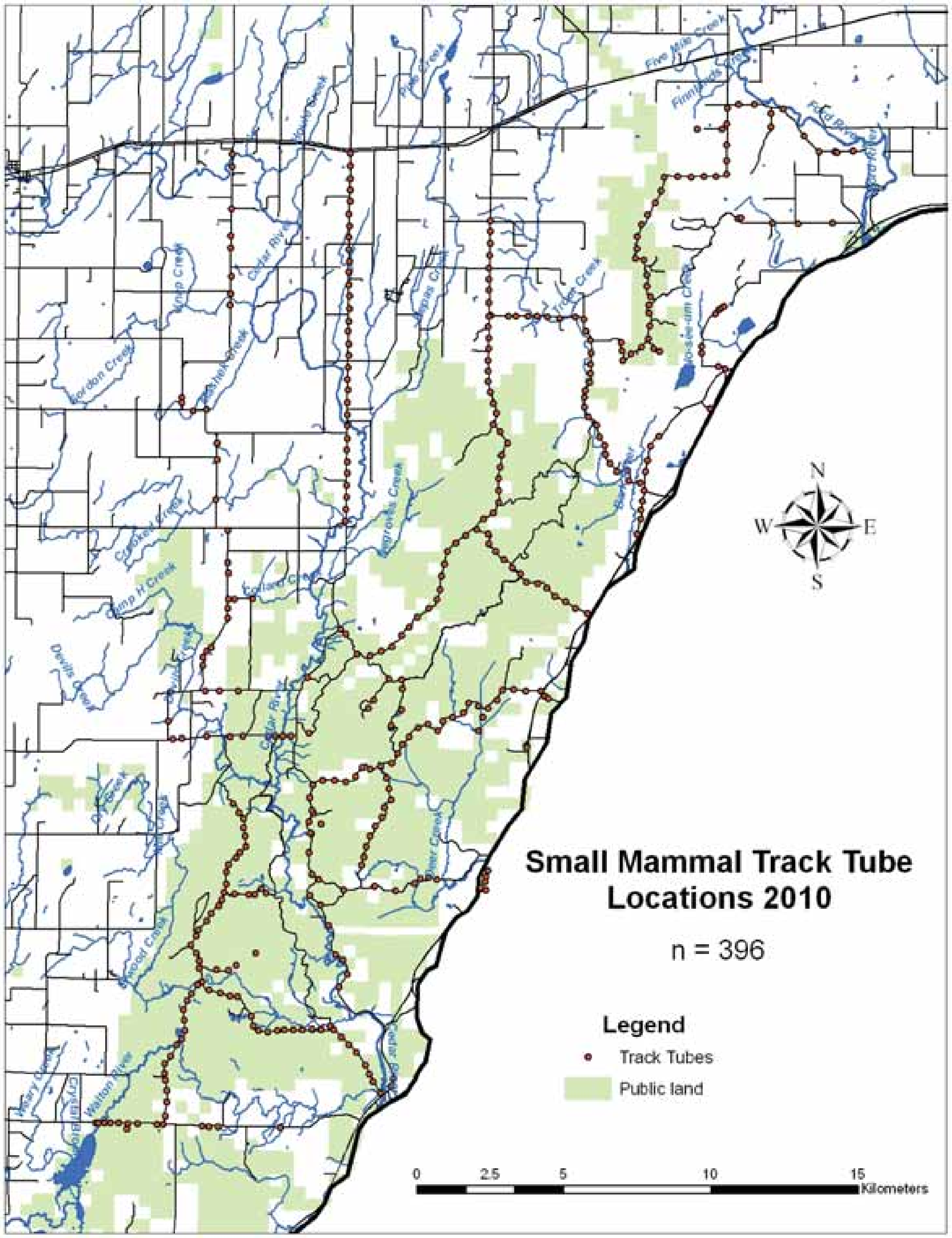

Figure 20. Locations of 396 small mammal track tubes, Upper Peninsula of Michigan, USA, 2010.

Figure 21**.** Track tube used to obtain small mammal abundance estimates, Upper Peninsula of Michigan, USA.