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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Abstract—We captured 96 white-tailed deer (57 females, 39 males) with Clover traps during January–February. We captured, radiocollared, and implanted vaginal implant transmitters (VIT) in 35 pregnant females. We detected pregnancy with ultrasound in 100% of females ≥1.5 years old, but no fawns. We captured 49 neonate fawns (21 females, 28 males) and fitted each with an expandable radiocollar during May–June. Captures included ≥1 fawn at 10 of 17 (59%) VIT searches, including 3 sets of twins. Twenty mortalities of fawns radiocollared in 2011 occurred (15 predations) through 31 August 2011; representing 41% of radiocollared fawns. Six females ≥1.5 years old radiocollared in 2010 died (3 predations), representing in a 78% annual survival rate for this cohort. We immobilized 7 adult black bears (4 female, 3 male) in their dens and fitted them with GPS collars. We captured and immobilized 6 black bears (2 females, 4 males), 1 bobcat (male), 8 coyotes (3 females, 5 males), and 3 female wolves from 17 December 2010–31August 2011and fitted them with GPS collars. We investigated 661 carnivore cluster locations and 272 non-cluster locations and measured vegetation structure and collected alternative prey information at each location. We collected 289 hair samples at bobcat hair snares and 1,165 hair samples at bear hair snares. We detected 45 sets of wolf tracks with ≥1 individual (32 included >1 individual), 193 sets of coyote tracks, and 8 sets of bobcat tracks during 12 winter track surveys traversing 523.5 km. During howling surveys, we recorded average coyote response rates of 28.6% and 26.1% using the coyote group-yip howl and lone wolf howl, respectively. The greatest aurally estimated number of coyotes responding during a coyote and wolf survey was 42 and 39, respectively. We collected 214 scats in 2011 and 269 samples collected during 2009–2010 have been cleaned, sorted and analyzed. We conducted vegetation surveys at 23 deer mortality sites, 21 VIT tag/birth sites, 933 predator cluster and non-cluster locations and 115 random locations. We placed small mammal track tubes (*n* = 396) in 9 landcover types throughout the study area to index small mammal relative abundance. Project personnel gave 8 presentations and held 5 workshops during 2011.

Summary

- We captured 96 white-tailed deer (57 females, 39 males) with Clover traps during January–February.
- We radiocollared and VIT tagged 35 pregnant females.
- We detected pregnancy with ultrasound in 100% of adult (n = 32) and yearling (n = 3) females; 0 of 3 female fawns were pregnant.
- Mean age for 2011 radiocollared does was 7 years (range = 1–15; n = 36), with 13 does estimated at 10 years or older.
- We captured 49 fawns (21 females, 28 males) and fitted them with expandable radiocollars during May–June.
- We radiocollared ≥1 fawn at 10 of 17 (59%) VIT searches, including 3 sets of twins, compared to 60% and 35% successful searches in 2010 and 2009, respectively.
- Six females (≥1.5 years old) radiocollared in 2010 died (3 predations), resulting in a 78% annual survival rate for this cohort.
- As of 31 August 2011, 7 females (≥1.5 years old) radiocollared in 2011 died; 3 were predations.
- Seventeen fawns radiocollared in 2010 died (12 predations), resulting in a 61% annual survival rate for this cohort.
- As of 31 August 2011, 20 of 49 (41%) fawns radiocollared in 2011 died (15 predations).
- We immobilized 7 adult black bears (4 females, 3 males) and 6 yearlings (1 male, 1 female, 4 unknown) in their dens and fitted adults with GPS radiocollars.
- We captured, immobilized, and fitted GPS radiocollars on 13 black bears (6 females, 7 males), 1 bobcat (1 male), 9 coyotes (3 females, 6 males), and 3 wolves (3 females).
- We investigated 661 cluster (217 black bear, 67 bobcat, 258 coyote, 119 wolf) and 272 non-cluster (96 black bear, 24 bobcat, 101 coyote, 51 wolf) locations to determine potential predation locations.
- We collected 1,165 hair samples at bear hair snares.
- We collected 148,932 telemetry locations (65,239 black bear, 9,447 bobcat, 45,059 coyote, 29,187 wolf) in 2011.
- We collected 115 hair samples at bobcat hair snares.

- We conducted 12 winter wolf track surveys traversing 523.5 km. We observed a minimum of 6 individuals in the 7 Mile Marsh Pack (7 observed in 2010) and a minimum of 5 individuals in the Hayward Lake Pack (4 observed in 2010).

- We completed 3 coyote and wolf howl surveys (mean coyote response rate of 28.6% to a group-yip howl and 26.1% response rate to a lone wolf howl).

- We collected 214 scats (87 black bear, 24 bobcat, 79 coyote, 22 wolf, and 2 unknown).

- We conducted vegetation surveys at 23 deer mortality sites, 54 VIT tag/birth sites, 933 predator cluster and non-cluster locations, and 115 random locations.

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

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 Peninsula of 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>

We captured white-tailed deer (*Odocoileus virginianus*) to place radiocollars on pregnant females from 17 December 2010–27 February 2011 (Figure 1). We captured 96 individual deer (57 females, 39 males) in Clover traps, with an additional 49 recaptures including 4 fawns radiocollared in 2010. Individual captures included 49 adults, 10 yearlings, and 37 fawns; 7 and 14 were yearling and adult males, respectively. The female:male fawn ratio was 1:0.95. We attempted to collect hair, saliva, body condition scores (BCS), and attach ear tags (females = yellow, males = blue; Figure 2) to each deer.

Eight capture related mortalities occurred; 2 from vertebrae fractures from Clover traps, 1 from a broken tibia in the trap, 1 from a trap collapsing on the animal, and 2 were likely related to physiological stress from capture. Improved Clover trap design (e.g., tightened netting) appeared to alleviate trap related injuries in 2011 (n = 4), but losses were higher than in 2010 (n = 1). An additional deer mortality occurred during release (fawn collided with tree) and 1 deer capture myopathy occurred post-release, although the deer appeared malnourished at capture. Number of deer captured this winter was greater than 2010 and similar to 2009, likely due to increased snow levels and more timber cuts in 2011.

We immobilized 35 pregnant females and fitted them with a radiocollar (model 2610B, Advanced Telemetry Systems Inc., Isanti, MN), and vaginal implant transmitter (VIT; model 3930, Advanced Telemetry Systems Inc., Isanti, MN), including 4 does originally captured in 2009 or 2010. We monitored temperature, respiration, and heart rate as soon as practical after immobilization and at about 10–min intervals thereafter until an antagonist drug was administered. We estimated and recorded deer morphometrics, BCS, pregnancy, and maximum- (MXF) and mid-rump (MDF) fat depths (Table 1) when practical. We also attempted to collect a lower canine, blood, and urine from each pregnant female. We detected pregnancy with ultrasound in 100% of adult (n = 32) and yearling (n = 3) females, but no fawns (n = 3).

Mean adult doe weight from 2011 (Table 1) was similar to 2009 (n = 32; 73.10 ± 7.90) and 2010 (n = 22; 78.80 ± 7.50 kg). Overall mean doe weight was 66.3 ± 13.9 kg (n = 101). Mean BCS for adult does from 2011 was similar to 2009 (n = 33; 2.9 ± 0.3) but greater than 2010 (n = 26; 2.5 ± 0.4). Mean MDF and MXF depth for pregnant females was less or similar to 2009 and 2010 estimates. For comparison, MDF and MXF values for 2009 were 0.83 ± 1.16 and 1.30 ± 1.85, respectively (n = 34); values for 2010 were 0.73 ± 0.37 and 1.04 ± 0.43 cm (n = 27), respectively.

<u>2011 Fawn Capture</u>

Beginning mid-May, we began capturing, radiocollaring, and radiolocating neonatal white-tailed deer fawns. We captured and fitted 49 fawns with expandable radiocollars (model 4210, Advanced Telemetry Systems Inc., Isanti, MN) from 23 May–13 June 2011 (Figure 3), including 21 females, 28 males. We captured 13 fawns during vaginal implant transmitter (VIT) searches. Personnel attached 2 individually numbered (#51–100) rectangular white flexible plastic ear tags to fawns (Figures 2, 3) and attempted to collect fawn body weight and length, chest girth, and front shoulder length; saliva, blood, and hair samples; vitals; and identify sex (Table 2). We attempted to record bed site and surrounding habitat, flush distance, presence of dam, additional deer, dam behavior, and handling time. Our mean fawn handling time was 16 min, compared to mean handing times of 25 and 24 min in 2009 and 2010, respectively. Based on VIT searches and adjusted new hoof growth, peak parturition occurred around 1 June 2011, similar to 2010 and 2009 (Figure 4, Table 3).

We conducted 17 Vaginal Implant Transmitter (VIT) searches to find fawns of implanted pregnant adult females from 11 May–12 June 2011. Five VITs presumably failed as their signals were never detected from May–July and 1 additional VIT failed due to mechanical failure of transmitter assembly and was recovered. We found and radiocollared ≥1 fawn, including 3 sets of twins, at 10 of 17 VIT searches. Also, we found a still born fawn at 2 VIT sites and a predated fawn at a third VIT site (sibling was captured and radiocollared).

Deer Mortality

Adult females—Five radiocollared female (≥1.5 years) predations occurred each year in 2009 and 2010 (Table 4). Accounting for all sources of mortality, we observed annual survival rates of 78% for the 2009 and 2010 adult female cohorts. Seven predations of 2011 radiocollared females (n = 31) have occurred as of 31 August 2011, representing 77% survival. The estimates of survival do not include capture related deaths or animals censored due to unknown status (e.g., radiocollar failure). We attributed coyotes (*Canis latrans*) as the leading cause of predation (Table 4).

Fawns—Twenty mortalities of 2011 radiocollared neonatal fawns (n = 49) occurred as of 31 August 2011, representing 59% survival; 1 radiocollar was dropped in early June. Predation accounted for 91% of 2011 fawn mortalities. Seventeen and 31 radiocollared 2010 and 2009 neonate fawn predations occurred (Table 5). Accounting for all sources of mortality, we observed annual survival rates of 37% and 61% for the 2009 and 2010 fawn cohorts, respectively. Survival estimates do not include fawns censored due to unknown status (e.g., radiocollar failure). Known predations accounted for 71% of both 2010 and 2009 mortalities (Figure 5). However, 13 and 5 radiocollars of 2010 and 2009 fawns either failed or dropped off the animals before a full year of monitoring.

Deer Telemetry

Adults—We monitored locations and mortality of radiocollared females 1–7 times/week using aerial or ground telemetry. We were monitoring 34 radiocollared adult females from 2009–2011 captures as of 26 August 2011 to meet study requirements (e.g., deer camera survey). Individual adult females (2009–2011) had 1–186 radiolocations depending on capture and censor dates.

2009 Fawns—We monitored locations and mortality of fawns radiocollared in 2009 using aerial telemetry ≥1 time/week. We recorded 1,472 locations (range = 1–88 locations/fawn) for all 2009 radiocollared fawns. All 2009 fawn radiocollars have dropped or failed (expected fawn radiocollar battery life is 12 months).

2010 Fawns—We monitored locations and mortality of fawns radiocollared in 2010 using aerial or ground telemetry 4 times/week from capture through early August 2010 and monitored ≥1 time/week thereafter. We recorded 1,877 locations (range = 1–49 locations/fawn) for all 2010 radiocollared fawns. All 2010 fawn radiocollars have dropped or failed as of June 2011.

2011 Fawns—We monitored locations and mortality of fawns using aerial or ground telemetry ≥4 times/week from capture through early August 2011 and monitored ≥1 time/week thereafter. We have recorded 893 locations (range = 1–39 locations/fawn) for all 2011 radiocollared fawns and were monitoring 26 fawns as of 26 August 2011.

Deer Characteristics

Estimated ages of females captured in 2011 were similar ($\bar{x}$ = 7 yrs; range = 1–15; n = 36) to 2009 ($\bar{x}$ = 6 yrs; range = 1–13; n = 38) and 2010 ($\bar{x}$ = 6 yrs; range = 1–15; n = 27) captures.

We received blood (*n* = 101) and urine (*n* = 88) analyses results from the Michigan State University, Diagnostic Center for Population and Animal Health (DCPAH). We will compare results to previously published data to assess nutritional status of yearling and adult females captured in 2009–2011.

Deer Abundance Camera Survey

We obtained 6,749 images of deer from 55 remote infrared cameras captured from 1 September–8 October 2010 to estimate deer abundance in the study area. We estimated deer abundance and density for the 256.2 km^2 sampling area using 3 methods (Table 6; Jacobson et al. 1997, Demarais et al. 2000, Rowcliffe et al. 2008) based on male antler characteristics, deer demography, and movement rates.

Black Bear Den Checks

We immobilized 7 adult black bears (4 females, 3 males) and 6 yearlings (1 male, 1 female, 4 unknown) in their dens. Of these, 7 adult bears had their Global Positioning System (GPS) radiocollars removed and replaced with new GPS radiocollars. We programmed GPS radiocollars to obtain a location every 35 hours until 1 May and every 15 minutes thereafter. We handled 6 cubs (4 females, 2 males) during den work. Mean litter size was 3.0 cubs (SD = 1.41; Table 7). We weighed, recorded morphometric measurements, and implanted a Passive Integrated Transponder (PIT) for each bear. We placed all bears back into their respective dens for recovery. We were unable to immobilize 2 male black bears during den checks and did not replace GPS radiocollars. We found 1 yearling male bear (BB26) dead outside of a den and sent it to Michigan State University DCPAH for necropsy; cause of death was attributed to aspiration pneumonia (Scott Fitzgerald, DCPAH Pathologist, Necropsy Report No. 11079).

Carnivore Trapping and Monitoring

From 5 March–7 June 2011, we captured and immobilized 7 black bears (2 females, 5 males), 1 bobcat (*Lynx rufus*; male), 9 coyotes (3 females, 6 males), and 3 wolves (3 females). We fitted 6 black bears (2 females, 4 males) with Lotek 7000MU GPS radiocollars (Lotek Engineering, Newmarket, ON, Canada). We released 1 male black bear at capture site because of radiocollar limitations. We replaced the radiocollar on one recaptured male black bear originally radiocollared in 2010. We monitored 13 GPS radiocollared black bears (6 females, 7 males) in 2011, which included 8 individuals (4 females, 4 males) originally radiocollared in 2010. We fitted all captured bobcats, wolves, and 8 coyotes (3 females, 5 males) with Lotek 7000SU GPS radiocollars. One male coyote sustained a broken leg during capture and was not radiocollared. We gave black bears, bobcats and coyotes uniquely numbered blue ear tags and wolves uniquely numbered red ear tags (Figure 6). We weighed, sexed, and evaluated all captured animals for injury. We took morphometric measurements and collected blood, hair, fecal, and saliva samples. We estimated BCS scores for each carnivore and estimated body condition of black bears using bioelectrical impedance analysis (BIA). We removed a lower premolar or upper incisor for age estimation in bobcats and coyotes, and a vestigial premolar for age estimation in black bears.

We programmed bobcat, coyote, and wolf radiocollars 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 radiocollars were scheduled to drop off. We programmed black bear GPS radiocollars to obtain a location every 15 minutes from the time of deployment. We fitted all non-bear 7000SU GPS radiocollars with a drop-off mechanism to release collars 30 weeks after deployment. We downloaded GPS location data remotely (Figure 7). We conducted 46 flights to download GPS locations (Tables 8, 9). One male coyote (C17) GPS radiocollar from 2010 failed to release and was monitored thru May 2011.

GPS radiocollared black bears currently being monitored have carried collars for 97–269 consecutive days ($\bar{x}$ = 137, SD = 63; Table 9) resulting in 1,364–10,488 locations per individual ($\bar{x}$ = 6,524, SD = 3,215). As of 31 August 2011, one bobcat (BC08) had carried an active radiocollar for 125 consecutive days resulting in 9,447 locations. Coyotes have carried active radiocollars for 115–186 consecutive days ($\bar{x}$ = 145, SD = 34) resulting in 6,633–10,227 locations per individual ($\bar{x}$ = 9,008, SD = 1,475). Wolves have carried active radiocollars for 115–130 consecutive days ($\bar{x}$ = 125, SD = 9) resulting in 7,995–11,207 locations per individual ($\bar{x}$ = 9,729, SD = 1,621).

<u>Carnivore Cluster Investigations</u>

We used clusters of carnivore locations obtained from GPS radiocollars to identify kill sites and estimate the number and species of prey killed. In 2011, we investigated 661 GPS location clusters identified using ArcGIS and the statistical software program R (R Development Core Team, Vienna, Austria) and 272 non-cluster locations selected opportunistically. We defined a cluster spatially as ≥8 locations within 50 m of each other within a 24–hour period. Of the 661 clusters, 217 were black bear (mean clusters/black bear = 19.7, SD = 12.1), 67 bobcat, 258 coyote (mean clusters/coyote = 43.0, SD = 19.8), and 119 wolf (mean clusters/wolf = 39.7, SD = 17.6). Of the 272 non-cluster locations, 96 were black bear (mean non-clusters/bear = 12.0, SD = 5.4), 24 bobcat, 101 coyote (mean non-clusters/coyote = 20.2, SD = 9.2), and 51 wolf (mean non-clusters/wolf = 17.0, SD = 5.0).

We are currently analyzing cluster location investigations. Preliminary results include black bears foraging on wild raspberries (*Rubus ideaus*), wild strawberries (*Fragaria vesca*), various colonial insects (e.g., ants), and vegetation (e.g., jack-in-the-pulpit [*Arisaema triphyllum*]). We located numerous black bear bedding sites as well as 3 fawn predations. We identified 2 ruffed grouse (*Bonasa umbellus*), 1 ring-necked pheasant (*Phasianus colchicus*), 2 bluejays (*Cyanocitta cristata*), 7 fawns, 2 adult deer, 1 muskrat (*Ondatra zibethicus*), 2 raccoons (*Procyon lotor*), 1 eastern cottontail (*Sylvilagus floridanus*) and 2 unknown bird predations at bobcat cluster locations. We identified 5 adult deer, 3 fawns, 7 grouse, and 2 eastern cottontail predations at coyote cluster locations as well as foraging on turkey (*Meleagris gallopavo*) eggs. We identified predations of 5 adult deer, 5 fawns, 4 turkeys, and 2 grouse at wolf clusters.

<u>Bobcat Hair Snares</u>

We deployed hair snares for bobcats for 8 weeks starting 17 January 2011. We deployed snares on a 2.5 km^2 grid cell system, with one bait site in each of 44 cells. We moved 12 bait sites from 2010 locations within respective cells to reduce domestic dog visitation and increase bobcat visitation (Figure 8). We combined grid cells truncated by >50% due to the Lake Michigan shoreline with adjacent cells. We deployed 3–6 snares at each site (181 total snares), based on the number of trails that developed during the 2–week pre-baiting period. We collected hair samples (Figure 9) and reset snares as necessary every 7 days. We collected 289 hair samples (target and non-target species) and sent them to the MDNR Wildlife Disease Laboratory in East Lansing, MI for genetic analysis.

Wolf Track Surveys and Abundance Estimations

In 2011 we conducted 12 wolf track surveys from 16 January–28 February 2011, traversing 523.5 km. We also recorded wolf and other carnivore tracks opportunistically while performing other field duties. We detected wolf tracks on 45 occasions (32 observations included >1 individual). We also observed 193 sets of coyote tracks and 8 sets of bobcat tracks during track surveys. Low snowfall during late January and February prevented more surveys from being completed. We used track surveys for wolves to estimate the number of packs in the study area and the minimum number of individuals within each pack.

Based on 2009–2011 summer GPS data, we estimated at least 2 packs occurred in the study area (7 Mile Marsh Pack and Hayward Lake Pack; Figure 10). We identified a minimum of 6 individuals in the 7 Mile Marsh Pack (7 observed in 2010) and a minimum of 5 individuals in the Hayward Lake Pack (4 observed in 2010). During track surveys we observed raised leg urinations along several roads within the study area, suggesting territorial marking. We also observed estrous blood in both pack areas suggesting that breeding may have occurred within both packs.

Bobcat Harvest Data

We compiled unpublished MDNR data from December 2009–February 2010 and used these data to assess bobcat distribution in the study area. We plotted bobcat harvest locations by section using a Geographic Information System (GIS; Figure 11). Harvested bobcats (n = 14) included 6 females and 8 males. Two of these bobcats were radiocollared previously by project personnel.

Carnivore Scat Collection

We collected carnivore scats opportunistically throughout the study area; we labeled each by date, species, presence of tracks, and Universal Transverse Mercator (UTM) coordinates; and frozen. This year we collected 214 scats (87 black bear, 24 bobcat, 79 coyote, 22 wolf, and 2 unknown).

From 2009 to 2011, we collected 1,108 scats consisting of 421 black bear, 63 bobcat, 367 coyote, 155 wolf, and 102 unknown. From 2009–2011, we cleaned and sorted 348 samples of which 269 (94 bear, 3 bobcat, 120 coyote, 52 wolf) were analyzed. We found adult deer hair in 48% and 34% of coyote and wolf scats, respectively. We found fawn deer hair in 15% and 32% of coyote and wolf scats, respectively. Analysis of scats is ongoing.

Black Bear Abundance Estimation: Hair Snares

Beginning 5 June 2011, we reset hair snares to estimate black bear abundance in a portion of the study area. We initially set snares in summer 2009 in each of 45 contiguous 3 km^2 grid cells Each snare consisted of a strand of barbed wire attached to the outside of three trees in a triangle shape 50 cm above ground. We lured snares 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 bark of trees 2 m above ground. We divided the 45 snares into 4 groups of 10-12 for convenience of checking and reluring. We checked and relured each group every 10 days. We checked each snare 5 times in 2011 and removed snares after the final check. We collected 1,045 black bear hair samples (1165 total samples) and sent all to the MDNR Wildlife Disease Laboratory in Lansing, MI for genetic analysis. We will use these data to estimate the number of bears in this part of the study area.

<u>Coyote and Wolf Howl Surveys</u>

We conducted coyote and wolf howl surveys (HS) June–August 2011 attempting a 4-week rotation with a coyote survey in week 1, a wolf survey in week 2, and no surveys during weeks 3 and 4. We divided the study area into 4 sections, allowing a survey to be completed in 4 consecutive nights from dusk–0300 h, weather permitting. We elicited vocalizations using a FoxPro game caller (FoxPro Inc., Lewistown, PA) using a group-yip howl to call coyotes, and a lone wolf howl for wolves. At each of the 55 HS sites, we recorded humidity, temperature, percent of moon illuminated, wind speed and direction, atmospheric trend, species responding, response time and direction, number of individuals responding, type of response (e.g., lone howl, group howl), and recordings of responses.

We recorded responses to estimate the number of individuals by differentiating their fundamental harmonic frequencies with sonographic analysis (Figure 12). We will compare number of individuals estimated by sonograms to those made by the observer in the field. This will provide an estimate of the effectiveness of humans to discriminate number of individuals responding. We will apply this correction factor to group responses that were heard but not recorded due to distance, wind, or traffic noise. We will estimate abundance using occupancy modeling.

During 2011, we observed average coyote response rates of 28.6% and 26.1% using the coyote group-yip howl and lone wolf howl, respectively. The greatest aurally estimated number of coyotes responding during a coyote and wolf survey was 42 and 39, respectively. We elicited no wolf responses during surveys. We will complete one additional coyote and wolf survey in September.

<u>Vegetation Surveys</u>

We characterized vegetation structure, composition, and density at deer mortality sites (*n* = 23), VIT tag/birth sites (*n* = 21), predator cluster and non-cluster locations (*n* = 933) as well as random locations (*n* = 115). We will use vegetation data to estimate if 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. We have entered and compiled vegetation survey data into a database.

<u>Small Mammal Survey</u>

Small mammals serve as an alternative food source for focal carnivores, thus, from 1 August–6 September, we placed 396 small mammal track tubes in 9 landcovers throughout the study area to provide an index of small mammal relative abundance (Figure 13). 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). We constructed track tubes from 5.8 cm diameter (4.7 cm inside diameter) PVC pipe cut into 76-cm lengths. We prepared each track tube using a tracking medium (i.e., printer toner), tracking paper (i.e., double-sided carpet tape) and bait (peanut butter and bird seed; Figure 14). We placed track tubes 20-30 m from roadways and removed them after 4 days. We are currently compiling and analyzing track tube data.

Alternate Prey, Carnivore, and Deer Data

We recorded alternative prey, carnivore, and deer observations (i.e., species, location, time) to provide an index of relative abundance. We also recorded daily start and end times to estimate daily time afield. During 2011, we recorded 1,238 alternative prey observations. We recorded 5,603 total observations from 2009–2011. The 3 most frequently observed alternate prey species were turkey, ruffed grouse, and squirrel (*Glaucomys sabrinus*, *Sciurus carolinensis, Tamiasciurus hudsonicus*; Figure 15). The 3 most frequently observed carnivores were black bear, coyote, and wolf.

Public Outreach

Presentations:

Beyer, D. E., and J. L. Belant. 2011. *Challenges of maintaining long-term research: identifying obstacles and developing strategies.* 71st Midwest Fish and Wildlife Conference, Minneapolis, Minnesota (Presented by Pat Lederle).

Duquette, J. F. 16 May 2011. *The Wildlife Experience*. St. Charles Community High School, St. Charles, MI. 120 attendees.

Duquette, J. F., J. L. Belant, D. E. Beyer, Jr., and N. J. Svoboda. 2011. *Effect of body condition on ketamine-xylazine immobilization of female white-tailed deer.* Southeastern Natural Resources Graduate Student Symposium, Mississippi State, Mississippi.

Svoboda, N. J., J. F. Duquette, T. Petroelje, J. L. Belant, and D. E. Beyer. 6 Aug 2011. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Timber Wolf Alliance, Weekend with Wolves, Manitowash Waters, WI. 18 attendees.

Svoboda, N. J., J. F. Duquette, J. L. Belant, D. E. Beyer, T. Petroelje, and J. Fosdick. 16 April 2011. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Safari Club International Michigan Involvement Committee Banquet, Gladstone, MI. 86 attendees.

Svoboda, N. J., J. F. Duquette, J. L. Belant, D. E. Beyer, T. Petroelje, and J. Fosdick. 18 May 2011. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Wildlife Unlimited Annual Banquet, Gladstone, MI. 52 attendees.

Svoboda, N. J., T. Petroelje, J. F. Duquette, J. L. Belant, D. E. Beyer, and J. Fosdick. 8 Mar 2011. *Role of predators, winter weather, and habitat on white-tailed deer fawn survival in Michigan.* Menominee Rotary Club, Menominee, MI. 36 attendees.

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Beyer, D. E., J. L. Belant, N. J. Svoboda, J. F. 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.

Duquette, J. D., and J. S. Fosdick. 8–9 October 2010. *Wildlife techniques and animal capture workshop*. Michigan Technological University, Student Chapter of the Wildlife Society, Escanaba, MI. 12 students.

Svoboda, N. J, and T. R. Petroelje. 2011. *Wildlife capture and animal handling workshop*. Northern Michigan University, 22 January 2011, Escanaba, Michigan, USA. 9 biology students.

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Svoboda, N. J, T. R. Petroelje, and J. S. Fosdick. 2011. *Wildlife capture and animal handling workshop*. Michigan Technological University, Student Chapter of the Wildlife Society, 25–26 February 2011, Escanaba, Michigan, USA. 7 students.

Project Field Personnel Hiring

We posted an announcement for seasonal wildlife technicians on the Texas A&M job board. We received and evaluated 47 applications and hired 10 individuals for the summer field season:

Alec Nelson
Cody Norton
Jasmine Reppen
Kelsy Payne
Eric Maringer
Eric Ness
Marie Tosa
Stephanie Raiman
Chris Waas
Marian Wahl

We hired 3 individuals for the fall field season and are hosting a master's student from Germany:

Chloe Wright
Kristin Wockanick
Jasmine Reppen
Milena Stillfried (master's student)

Publications

Duquette, J. F., J. L. Belant, D. E., Beyer, N. J. Svoboda, and C. A. Albright. 2011. Bald Eagle predation of a white-tailed deer fawn. Northeastern Naturalist 18:87-94.

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Duquette, J. F., J. L. Belant, D. E. Beyer, and N. J. Svoboda. Interaction of serum leptin and body condition in female white-tailed deer. Journal of Wildlife Diseases. *In Review*.

Duquette, J. F., J. L. Belant, D. E. Beyer, and N. J. Svoboda. Comparison of pregnancy detection methods in live white-tailed deer. Wildlife Society Bulletin. *In Review*.

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Svoboda, N. S., J. L. Belant, D. E., Beyer, J. F. Duquette, H. K. Stricker, and C. A. Albright. 2011. American black bear predation of an adult white-tailed deer. Ursus 22:91-94.

Svoboda, N. S., J. L. Belant, D. E., Beyer, J. F. Duquette, and J. A. Martin. 2011. Identifying bobcat kill sites using a Global Positioning System (GPS). *In Preparation*.

Work to be completed (September–December 2011)

Radiotelemetry

We will locate and monitor mortality of adult females and fawns radiocollared in 2010–2011 using ground and aerial telemetry ≥1 time/week. We will investigate deer mortalities upon detecting a radiocollar mortality signal.

Deer Abundance Camera Survey

We will estimate deer abundance using remote infrared cameras beginning 1 September. The study area will consist of one contiguous polygon as used in 2009 and 2010 surveys. Half of the cameras (~26) will be placed in high use areas within radiocollared doe home range areas and remaining cameras will be randomly distributed throughout the study area based on a 3 strata overlying square grid scheme. We will pre-bait sites with shelled corn before each 10-day survey period. We will conduct abundance estimates on yearling and adult male deer, which will serve as marked deer based on unique antler characteristics. We will also incorporate tagged (i.e., radiocollared and ear tagged) and untagged deer to supplement abundance estimates, using the number of tagged versus untagged deer observed in images. We will derive a deer density estimate based on camera detection zone, number of camera images, and radiocollared doe movement rates following Rowcliffe et al. (2008).

Howl Surveys

We will complete one wolf and one coyote howl survey in September.

Alternative Prey and Deer Data

We will continue to record daily start and end times in the field, as well as coordinates and time observed for each deer and alternative prey species.

Black Bear Den Checks

We will conduct black bear den checks in mid-December to remove GPS radiocollars.

Carnivore Scat Collection

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

GPS Radiocollar Recovery

Beginning 4 October, GPS radiocollars with drop off mechanisms will begin detaching from radiocollared animals. We will recover dropped radiocollars and download location and activity data. Radiocollars will be cleared of data, dismantled, cleaned, and stored.

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Wildlife Unlimited of Delta County
Participating Upper Peninsula landowners
Heather Stricker – Mississippi State University
Joshua Fosdick – Mississippi State University
Past Project Staff:

Orrin Duvuvei	Erin High	Mike Jones
Lisa Fouladbash	Clay Wilton	Rebekah Karsch
Justin Edge	Heather Stricker	Lacey Kreiensieck
Kevin Smith	Chad Corroy	Jarrod Hammerly
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Meghan Harrigan	Tim Swearingen	Emily Bouckart

Craig Albright – Michigan Department of Natural Resources
Dr. Glenn DelGiudice – Minnesota Department of Natural Resources
Gordy Zuehlke (Air 3) – Michigan Department of Natural Resources
Neil Harri (Air 1) – Michigan Department of Natural Resources
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Table 1. Mean ($\bar{x}$) and standard deviation (SD) of 39 captured adult (n = 35), yearling (n = 3), and fawn (n = 1) female white-tailed deer morphometric and body condition estimates, Upper Peninsula of Michigan, USA, December 2010–February 2011.

	Age Class		
	Adults	Yearlings	Fawn
Estimate (unit)	$\bar{x}$ ± SD	$\bar{x}$ ± SD	
Body weight (kg)	79.3 ± 12	51.0 ± 5.2	45.0
Body length (cm)	149.8 ± 9.9	125.8 ± 3.8	128.8
Total length (cm)	173.3 ± 9.1	152.2 ± 6.2	149.2
Chest girth (cm)	91.8 ± 8.1	81.0 ± 3.9	80.3
Neck circumference (cm)	38.3 ± 3.1	33.9 ± 3.1	32.1
Hind foot (cm)	47.4 ± 2.0	45.4 ± 2.2	43.8
Tail length (cm)	23.8 ± 5.2	26.4 ± 3.5	20.4
Head length (cm)	32.5 ± 1.4	27.5 ± 1.4	27.6
Ear length (cm)	15.5 ± 0.8	14.6 ± 0.5	15.3
BCS [a]	3.1 ± 0.4	3.0 ± 0.3	3.0
MDF [b] (cm)	0.6 ± 0.4	0.4 ± 0.2	0.5
MXF [c] (cm)	1.1 ± 0.4	0.6 ± 0.2	1.0

[a] Body condition score for does derived from palpating the scapula, spinal column, rump, and rib cage.
[b] Maximum rump fat estimate measured dorsal of the ishial tuberosity of right hip.
[c] Middle rump fat estimate measured at mid-point between ilium and ishial tuberosity on right hip.

Table 2. Mean ($\bar{x}$) and standard deviation (SD) of 49 captured female (*n* = 21) and male (*n* = 28) neonatal white-tailed deer morphometrics, Upper Peninsula of Michigan, USA, May–June 2011.

	Sex	
	Females	Males
Estimate (unit)	$\bar{x} \pm$ SD	$\bar{x} \pm$ SD
Body weight (kg)	4.4 ± 1.0	4.4 ± 1.4
Body length (cm)	62.2 ± 3.6	59.9 ± 6.1
Chest girth (cm)	35.9 ± 2.9	35.8 ± 3.0
Shoulder height (cm)	44.1 ± 5.7	43.7 ± 5.2
New hoof growth (mm)	2.6 ± 1.1	2.6 ± 1.2
Birth mass [a] (kg)	4.2 ± 0.7	4.0 ± 1.0

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

Table 3. Mean ($\bar{x}$) and standard deviation (SD) of captured neonatal white-tailed deer (*n* = 143) estimated birth mass and median date of parturition by year, Upper Peninsula of Michigan, USA, May–June 2009–2011.

Year	Fawn birth mass[a] $\bar{x}$ ± SD	Median date of parturition (*n*)
2009	2.37 ± 0.82	02 Jun (50)
2010	4.19 ± 1.57	02 Jun (44)
2011	4.10 ± 0.91	01 Jun (49)

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

Table 4. Radiocollared (2009–2011) female white-tailed deer (≥1.5 year old) predation sources (n = 13) during annual monitoring periods, Upper Peninsula of Michigan, USA, February 2009–August 2011.

Predating Species	2009	2010	2011[a]	Combined
Coyote	3	2	2	7
Coyote (probable)	-	1	-	1
Wolf	1	2	-	3
Bobcat	-	-	1	1
Black bear	1	-	-	1

[a] From capture to 31 August 2011.

Table 5. Radiocollared (2009–2011) white-tailed deer neonatal fawn predations (n = 52) during annual monitoring periods, Upper Peninsula of Michigan, USA, May 2009–August 2011.

Predating Species[a]	2009	2010	2011[b]	Combined
Coyote	9	4	9	22
Coyote (probable)	-	1	2	3
Bobcat	6	3	3	12
Black bear	2	-	2	4
Wolf	-	3	1	4
Wolf (probable)	-	-	1	1
Unknown predator	3	-	-	3
Unknown canid	1	1	-	2
Bald eagle	1	-	-	1

[a] Unknown predations were sent to the Michigan Department of Natural Resources Wildlife Diseases Laboratory for predator-specific determination.
[b] From capture to 31 August 2011.

Table 6. White-tailed deer demographics and abundance in 256 km^2 study area estimated using 54 remote infrared cameras, Upper Peninsula of Michigan, USA, September 2009 and September–October 2010.

	2009		2010		
Estimated parameter	Demarais[a]	Jacobson[b]	Demarais	Jacobson	Rowcliffe[c]
Males (≥1.4 years)	103	118	71	99	-
Females (≥1.4 years)	323	276	257	356	-
Female:Male	3.1:1	2.3:1	3.6:1	3.6:1	-
Fawns	48	41	87	121	-
Female:Fawn	6.7:1	6.7:1	3.0:1	2.9:1	-
Total deer	474	435	415	576	-
Deer/km^2	6.1	5.7	16.2	22.5	8.6
Deer abundance	1588	1460	4155	5759	2204

[a] Demarais et al. 2000.
[b] Jacobson et al. 1997.
[c] Rowcliffe et al. 2008.

Table 7. Capture data for 19 black bears at dens, Upper Peninsula of Michigan, USA, 17 December 2010–18 February 2011.

Species	ID	Capture date	Age[a,b]	Sex	Body weight (kg)	Right ear tag	Left ear tag
Black bear	BB44	17-Dec-10	4	M	145.1	143	144
Black bear	BB28	15-Jan-11	Adult	M	140.6	1110	100
Black bear	BB33	21-Jan-11	Adult	M	99.8	98	NA
Black bear	BB16	10-Feb-11	7	F	NA	84	83
Black bear	BB25	10-Feb-11	1	F	20.4	91	150
Black bear	BB26	10-Feb-11	1	M	NA	NA	NA
Black bear	BB27	10-Feb-11	1	U	NA	141	135
Black bear	BB14	11-Feb-11	5	F	79.4	79	80
Black bear	BB22	11-Feb-11	1	U	24.9	146	95
Black bear	BB23	11-Feb-11	1	U	20.4	97	147
Black bear	BB24	11-Feb-11	1	U	20.4	148	149
Black bear	BB32	17-Feb-11	3	F	70.3	10	6
Black bear	BB47	17-Feb-11	0	M	1.4	NA	NA
Black bear	BB48	17-Feb-11	0	F	1.4	NA	NA
Black bear	BB08	18-Feb-11	10	F	149.7	180	NA
Black bear	BB49	18-Feb-11	0	M	2.0	NA	NA
Black bear	BB50	18-Feb-11	0	F	1.8	NA	NA
Black bear	BB51	18-Feb-11	0	F	1.1	NA	NA
Black bear	BB52	18-Feb-11	0	F	1.4	NA	NA

[a]Ages were estimated using tooth analyses by the Michigan Department of Natural Resources.

[b]Ages reported as 0 are cubs of the year.

Table 8. Capture and monitoring data for 27 radiocollared carnivores, Upper Peninsula of Michigan, USA, 17 December 2010–31 August 2011.

Species	ID	Capture date[a]	Age[b]	Sex	Weight (kg)[c]	Ear tag no. right/left	Days monitored	Locations	Radiocollar status/interval[d]
Black bear	BB44	17-Dec-10	4	M	145.1	143/144	269	10488	Active/15 min
Black bear	BB28	15-Jan-11	Adult	M	140.6	1110/100	240	10094	Active/15 min
Black bear	BB33	21-Jan-11	Adult	M	99.8	98/NA	1	1	
Black bear	BB16	10-Feb-11	7	F	NA	84/83	101	1364	Collar Malfunction; 22 May 11
Black bear	BB14	11-Feb-11	5	F	79.4	79/80	1	1	Radiocollar Malfunction
Black bear	BB32	17-Feb-11	3	F	70.3	10/6	1	1	Radiocollar Malfunction
Black bear	BB08	18-Feb-11	10	F	149.7	180/NA	132	2644	Slipped; 30 Jun 11
Black bear	BB53	25-May-11	Adult	M	111.1	198/197	110	7424	Active/15 min
Black bear	BB43	28-May-11	3	M	111.1	137/212	107	7062	Active/15 min
Black bear	BB54	29-May-11	Adult	F	63.5	202/201	106	8757	Active/15 min
Black bear	BB55	29-May-11	Adult	M	88.5	42/151	106	7592	Active/15 min
Black bear	BB56	29-May-11	Adult	M	97.5	204/211	106	2624	Active/15 min
Black bear	BB57	7-Jun-11	Adult	M	108.9	205/206	1	1	Did not radiocollar
Black bear	BB58	7-Jun-11	Adult	F	77.1	208/207	97	7186	Active/15 min
Bobcat	BC08	10-May-11	1	M	9.5	184/183	125	9447	Active/15 min
Coyote	C21	5-Mar-11	Adult	M	15.0	94/93	1	1	Harvested
Coyote	C22	8-Mar-11	Adult	F	12.7	199/200	1	1	Harvested
Coyote	C23	10-Mar-11	Adult	M	13.2	189/188	186	10083	Active/15 min
Coyote	C24	14-Mar-11	Adult	F	15.0	140/136	59	16	Radiocollar Malfunction
Coyote	C25	18-Mar-11	Adult	M	15.4	96/194	178	10227	Active/15 min
Coyote	C26	9-May-11	Adult	F	10.9	181/182	126	9503	Active/15 min
Coyote	C27	16-May-11	Adult	M	12.7	190/191	119	8594	Active/15 min
Coyote	C28	16-May-11	Adult	M	NA	193/192	1	1	Did not radiocollar
Coyote	C29	20-May-11	Adult	M	14.5	196/195	115	6633	Active/15 min

Table 8 (continued). Capture and monitoring data for 27 radiocollared carnivores, Upper Peninsula of Michigan, USA, 17 December 2010–31 August 2011.

Species	ID	Capture date[a]	Age[b]	Sex	Weight (kg)[c]	Ear tag no. right/left	Days monitored	Locations	Radiocollar status/interval[d]
Wolf	W08	5-May-11	Adult	F	29.0	1118/1119	130	9985	Active/15 min
Wolf	W09	5-May-11	Adult	F	NA	1121/1120	130	11207	Active/15 min
Wolf	W10	21-May-11	Adult	F	27.2	1122/1123	114	7995	Active/15 min

[a] BB08, BB14, BB16 were captured in 2009 and collars were replaced during 2009-10 and 2010-11 den checks. BB28, BB32, BB33, BB43, BB44 were captured in 2010 and radiocollars were replaced during 2010-11 den checks.

[b] Ages were estimated using cementum annuli techniques by Michigan Department of Natural Resources Diagnostics Laboratory, Lansing, MI.

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

[d] C21, and C22 were shot shortly after being radiocollared; C28 sustained a broken leg during capture and was not radiocollared.

Table 9. Monitoring data for 27 GPS-radiocollared carnivores, Upper Peninsula of Michigan, USA, 17 December 2010–31 August 2011.

		Number of days monitored[a,b]			Number of locations[a,b]		
Species	n	mean	SD	range	mean	SD	range
Black bear	14	137	63	97-269	6524	3215	1364-10488
Bobcat	1	125	NA	NA	9447	NA	NA
Coyote	9	145	34	115-186	9008	1475	6633-10227
Wolf	3	125	9	115-130	9729	1621	7995-11207

[a] Data does not include non-collared bear (BB57) or collars that malfunctioned (BB14, BB32, BB33).

[b] Data does not include harvested coyotes (C21, C22), uncollared coyote (C28), or collar that malfunctioned (C24).

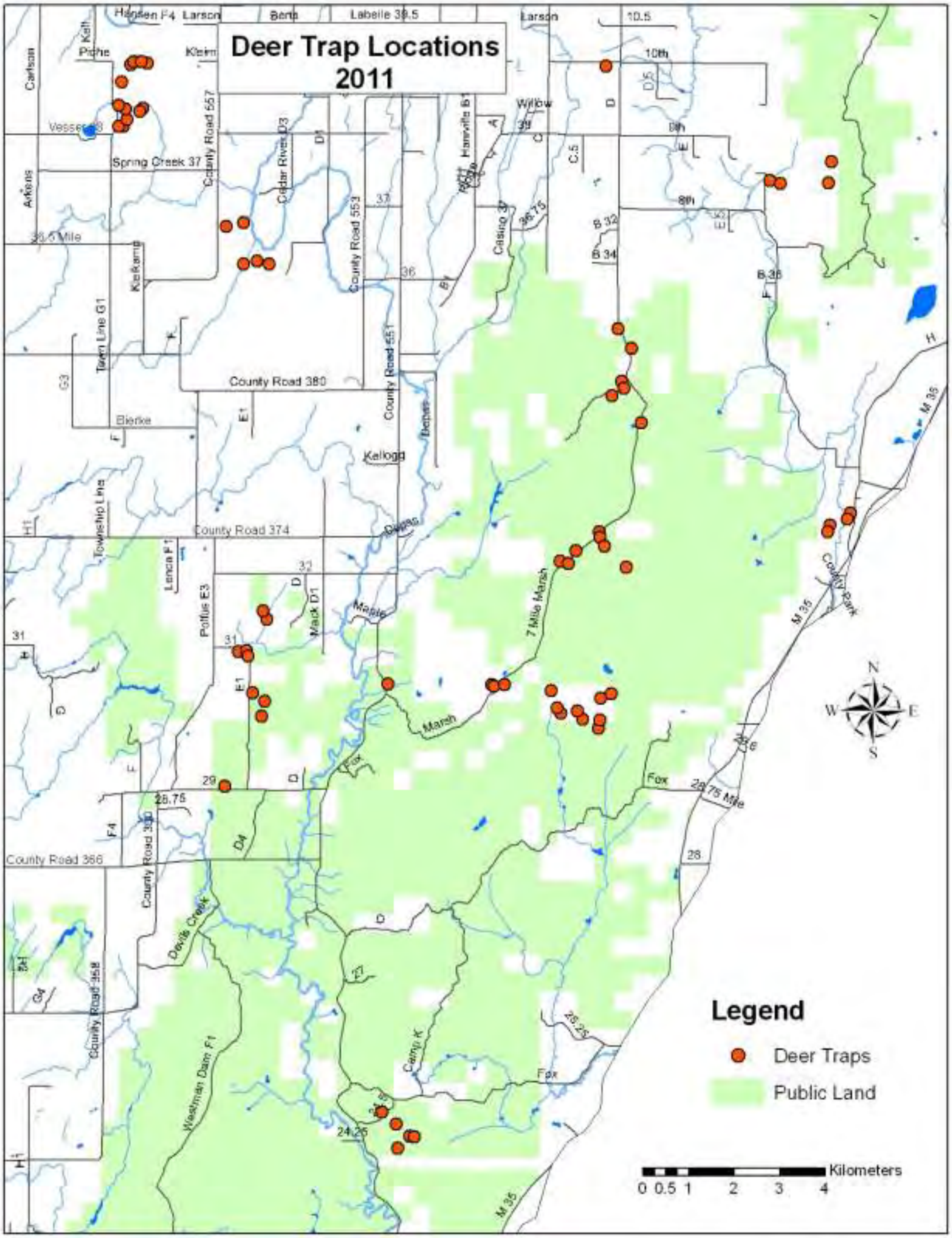

Figure 1. White-tailed deer Clover trap locations, Upper Peninsula of Michigan, USA, 17 December 2010–27 February 2011.

Figure 2. Neonate (white), female (blue), and male (yellow) white-tailed deer ear tags, Upper Peninsula of Michigan, USA, 2011.

Figure 3. Ear tag (white) and expandable radiocollar (above) and neonate white-tailed deer fitted with ear tags and radiocollar (below), Upper Peninsula of Michigan, 2011.

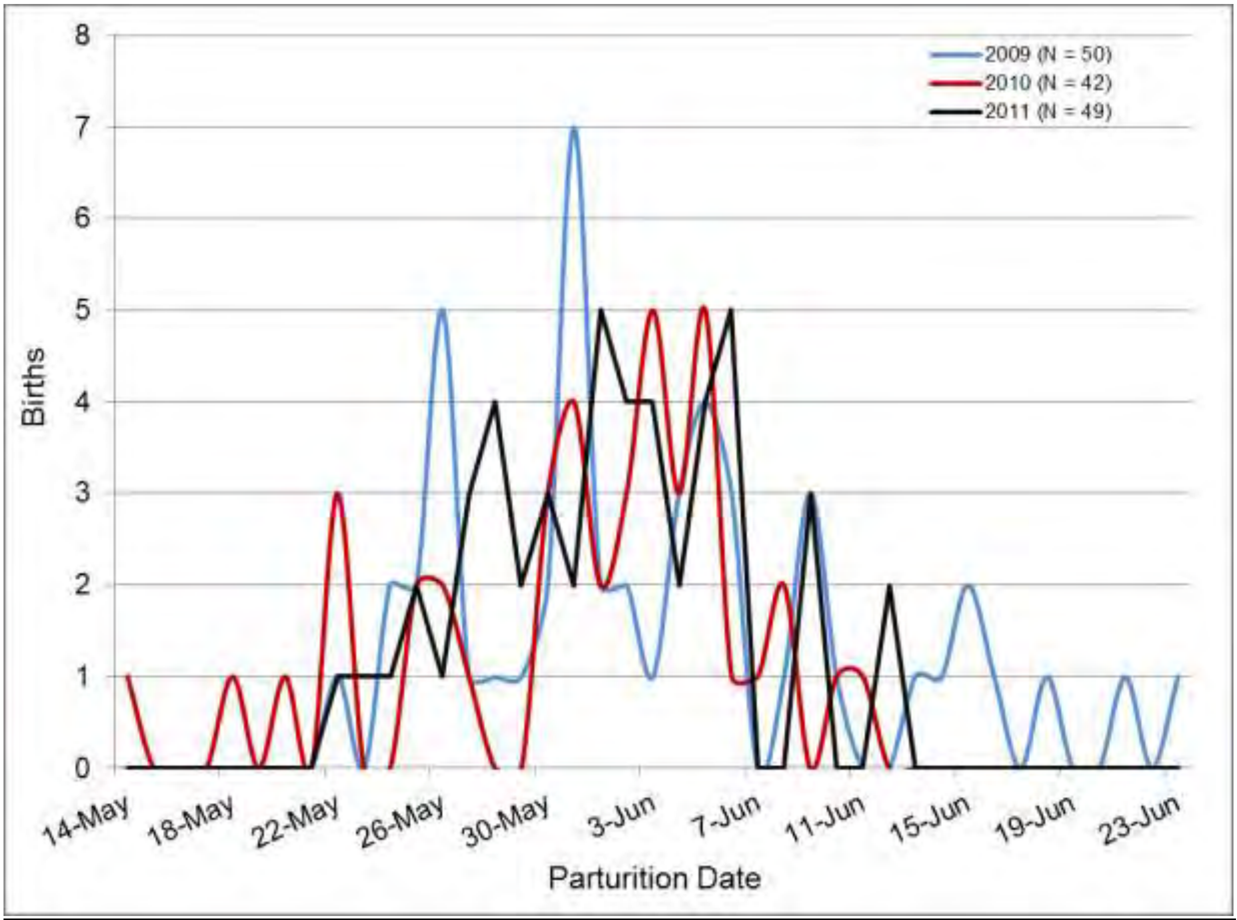

Figure 4. Estimated parturition dates of neonate white-tailed deer in 2009 (*n* = 50), 2010 (*n* = 42) and 2011 (*n* = 49), Upper Peninsula of Michigan, USA.

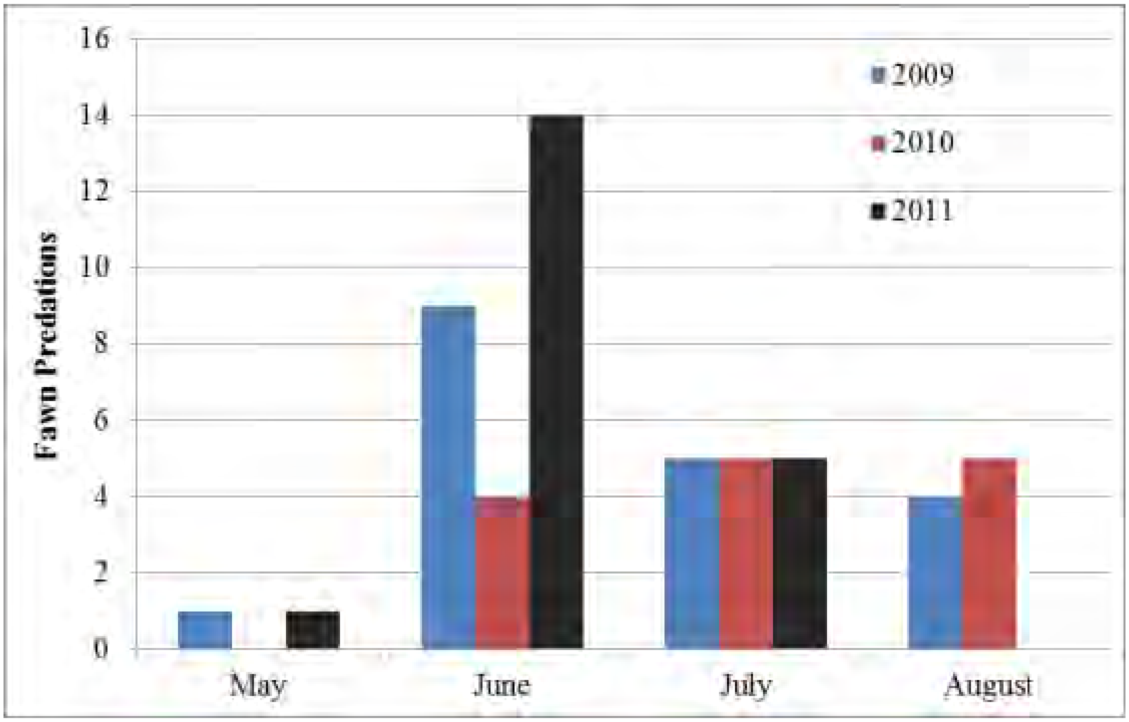

Figure 5. Number of radiocollared white-tailed deer fawn predations by month, Upper Peninsula of Michigan, USA, May–August 2009–2011.

Figure 6. Ear tagged black bear, bobcat, coyote, and wolf, Upper Peninsula of Michigan, USA, 2010.

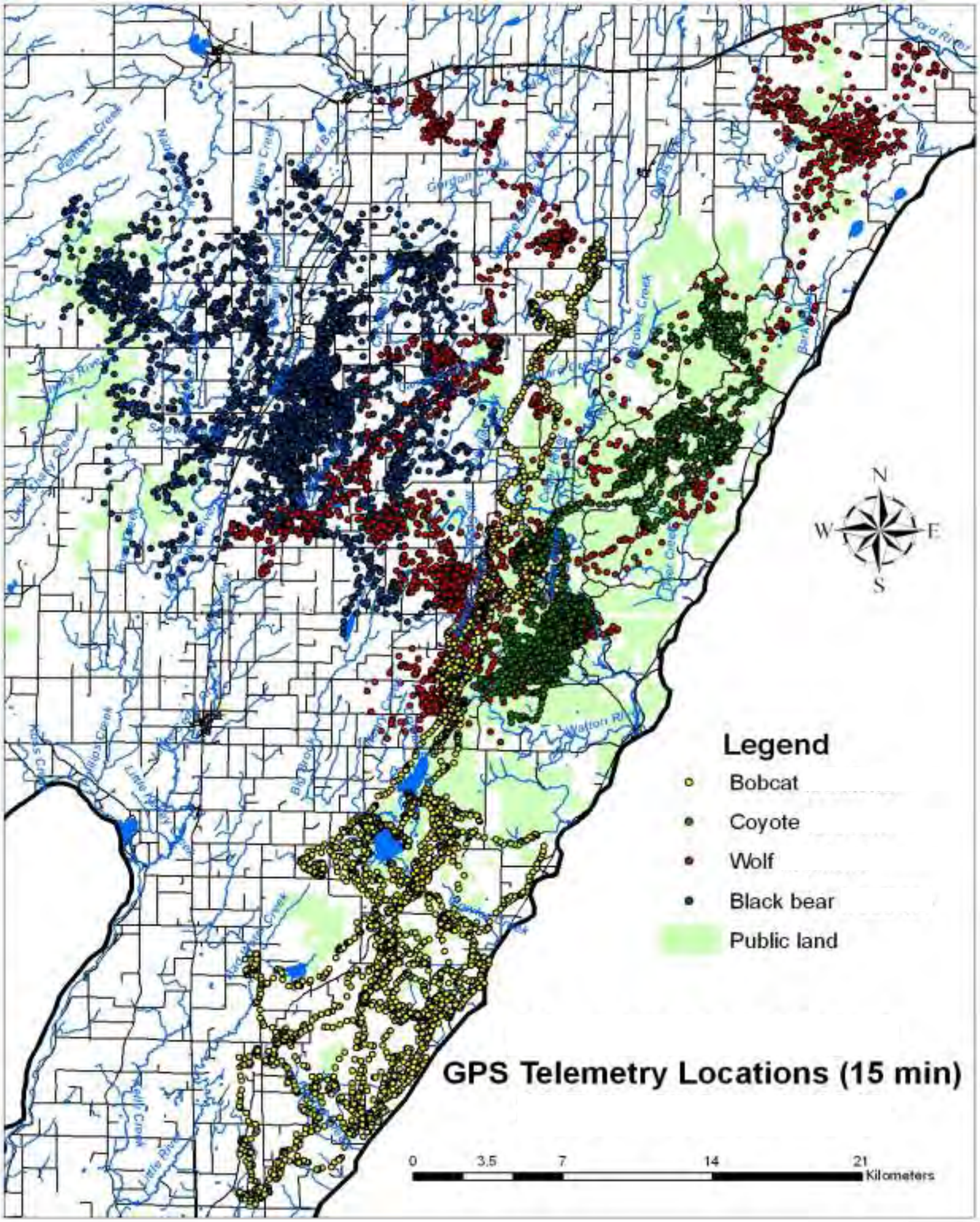

Figure 7. GPS telemetry locations for 1 black bear, 1 bobcat, 1 coyote and 1 wolf, Upper Peninsula of Michigan, USA, 24 February–25 August 2011.

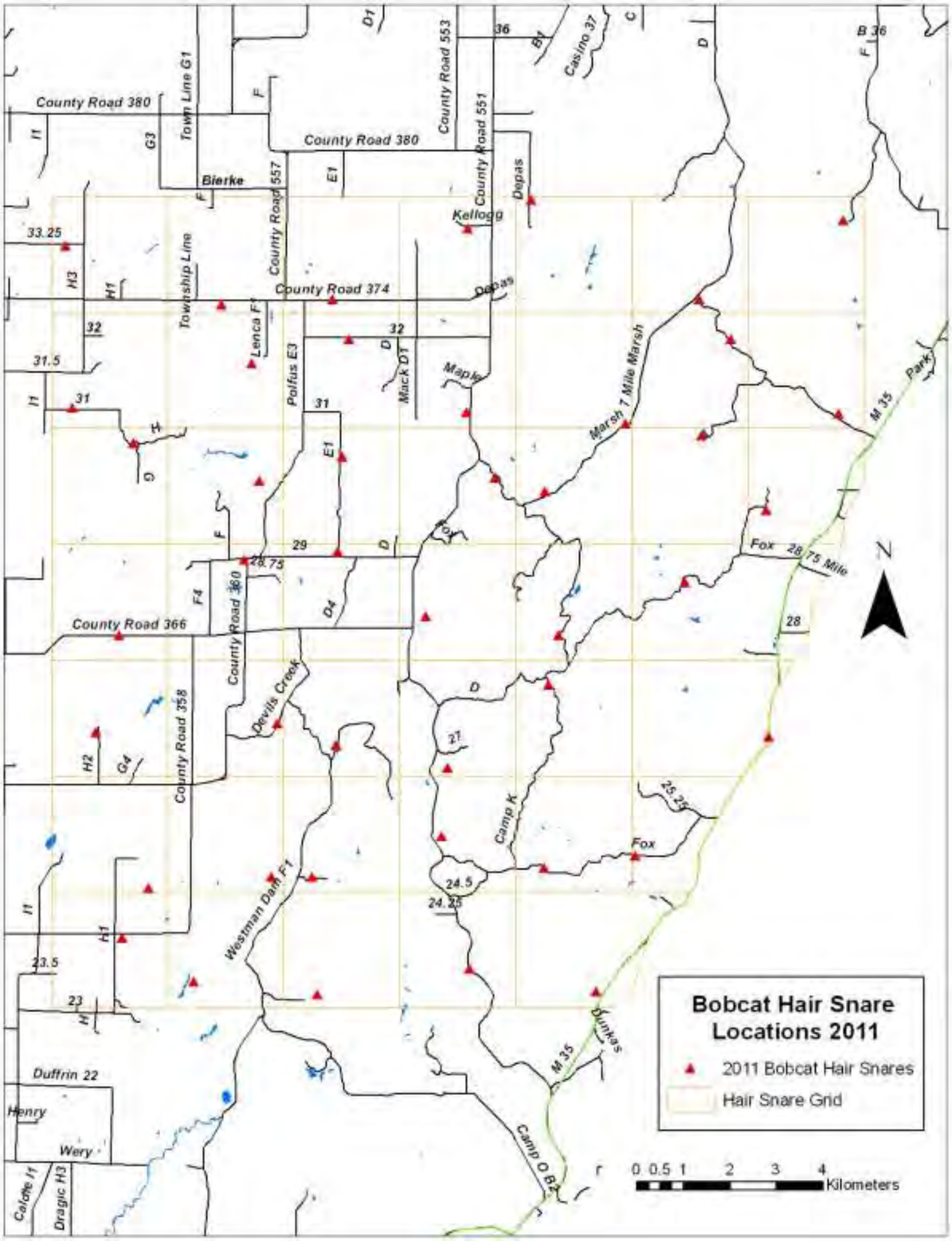

Figure 8. Bobcat hair snare sites (n = 44) within a 2.5 km^2 grid, Menominee County, Upper Peninsula of Michigan, USA, January–March 2011.

Figure 9. Baited snare site (top) and hair sample obtained (bottom) using a modified body snare, Upper Peninsula of Michigan, USA, January–March 2011.

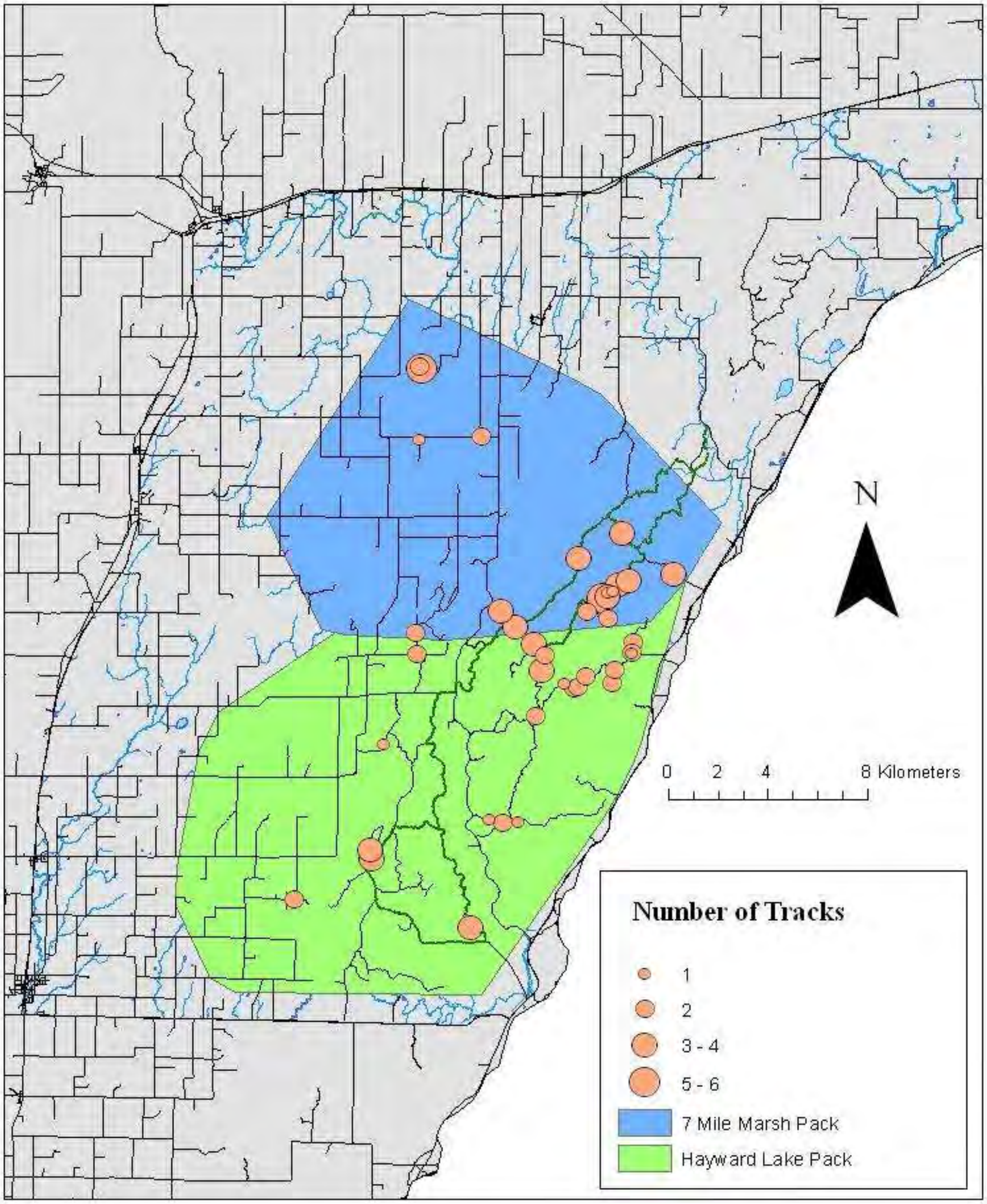

Figure 10. Estimated summer 2009–2010 wolf pack areas based on GPS data from 5 collared individuals. Track locations from January–February 2011 surveys, Upper Peninsula of Michigan, USA.

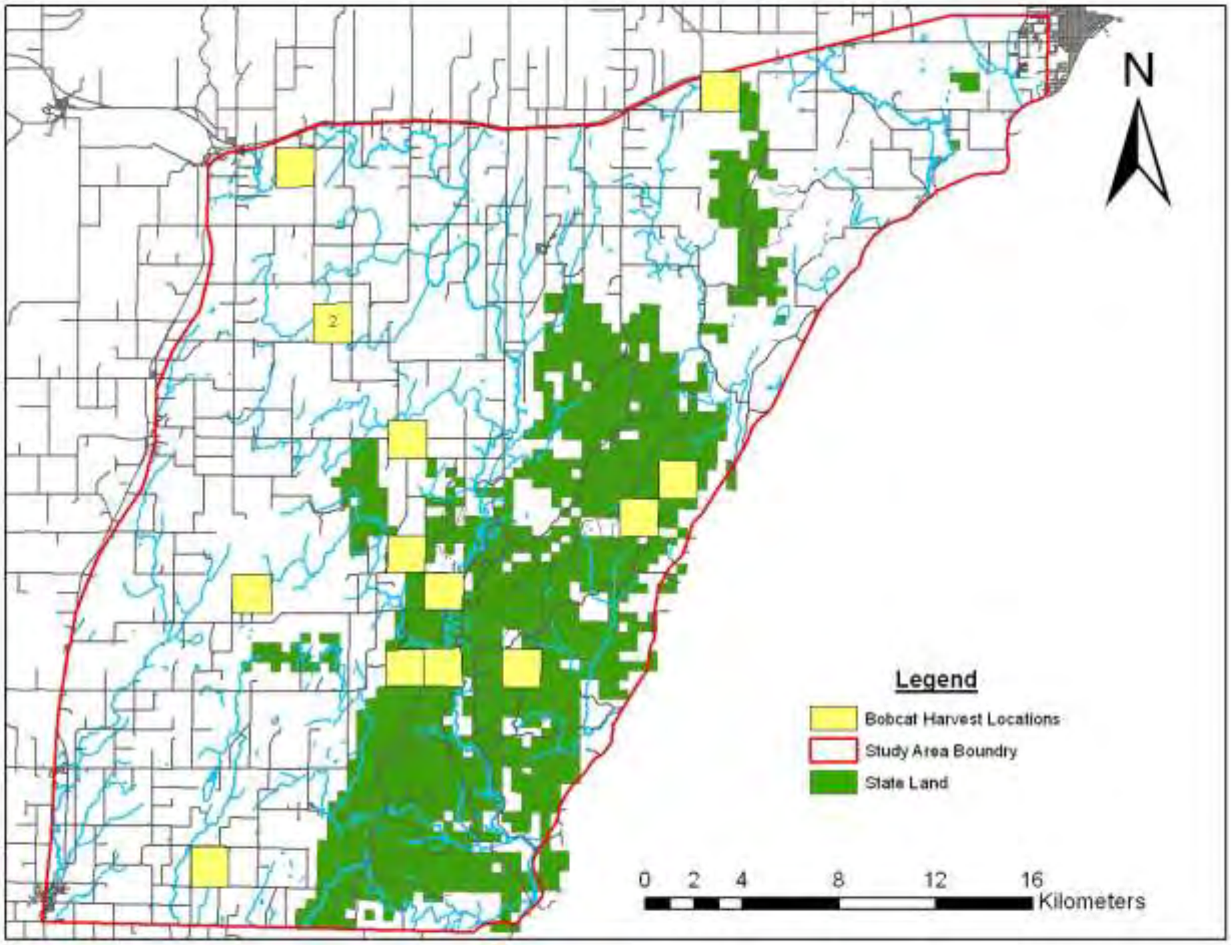

Figure 11. Bobcat hunting and trapping harvest (*n* = 14) by section (Michigan Department of Natural Resources unpublished data), Upper Peninsula of Michigan, USA, 1 December 2010–1 March 2011.

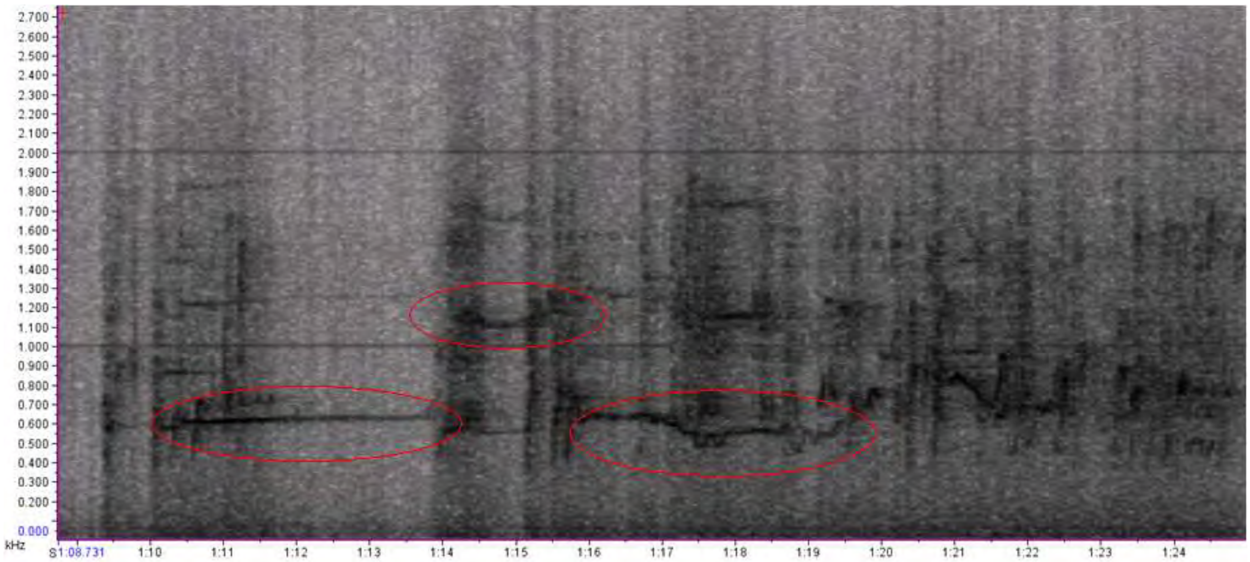

Figure 12. Sonogram of coyote pack including radio-collared male and female about 1.0 km away, Upper Peninsula of Michigan, USA, 2009.

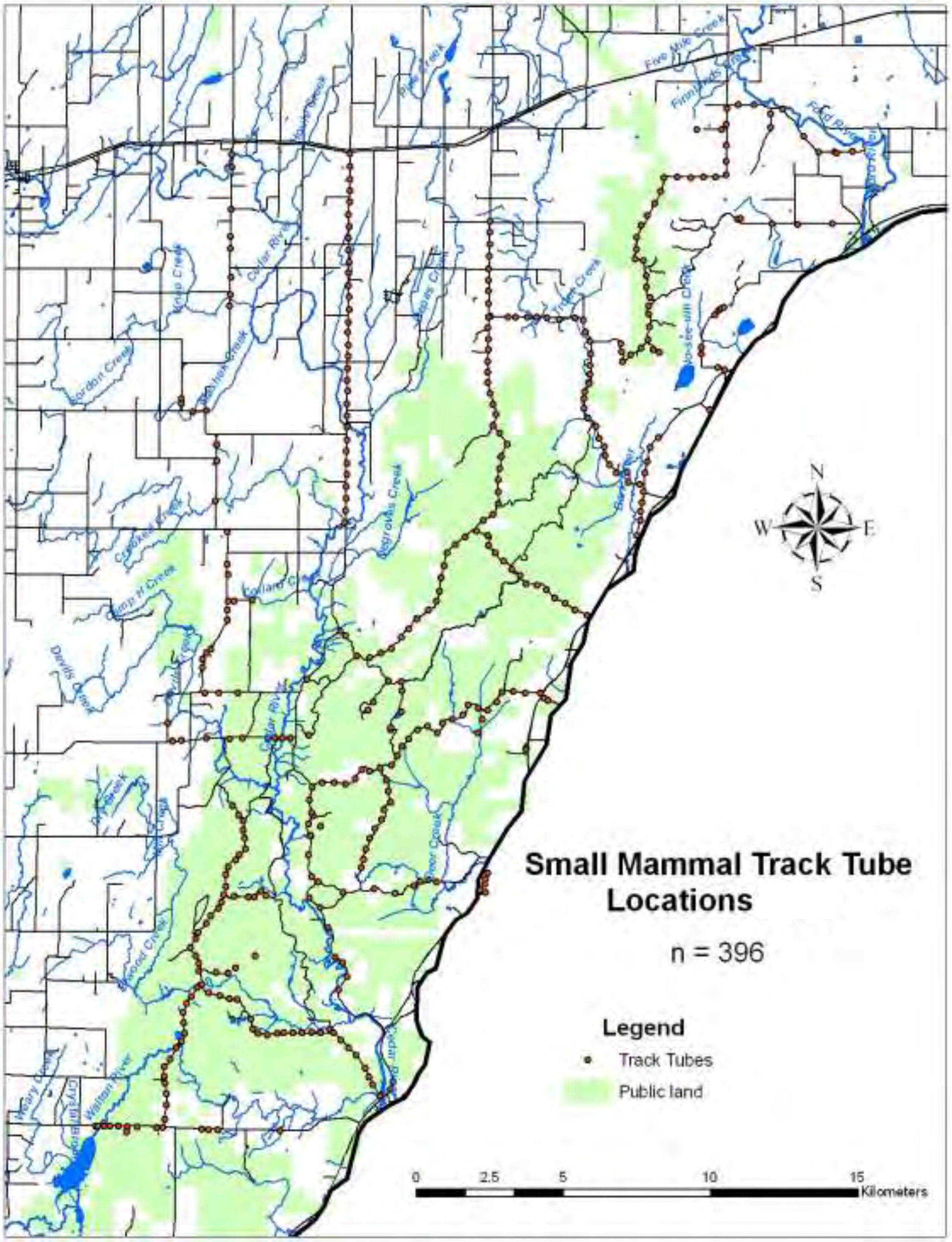

Figure 13. Locations of 396 small mammal track tubes, Upper Peninsula of Michigan, USA, August–September 2011.

Figure 14**.** Track tube used to obtain small mammal abundance estimates, Upper Peninsula of Michigan, USA.

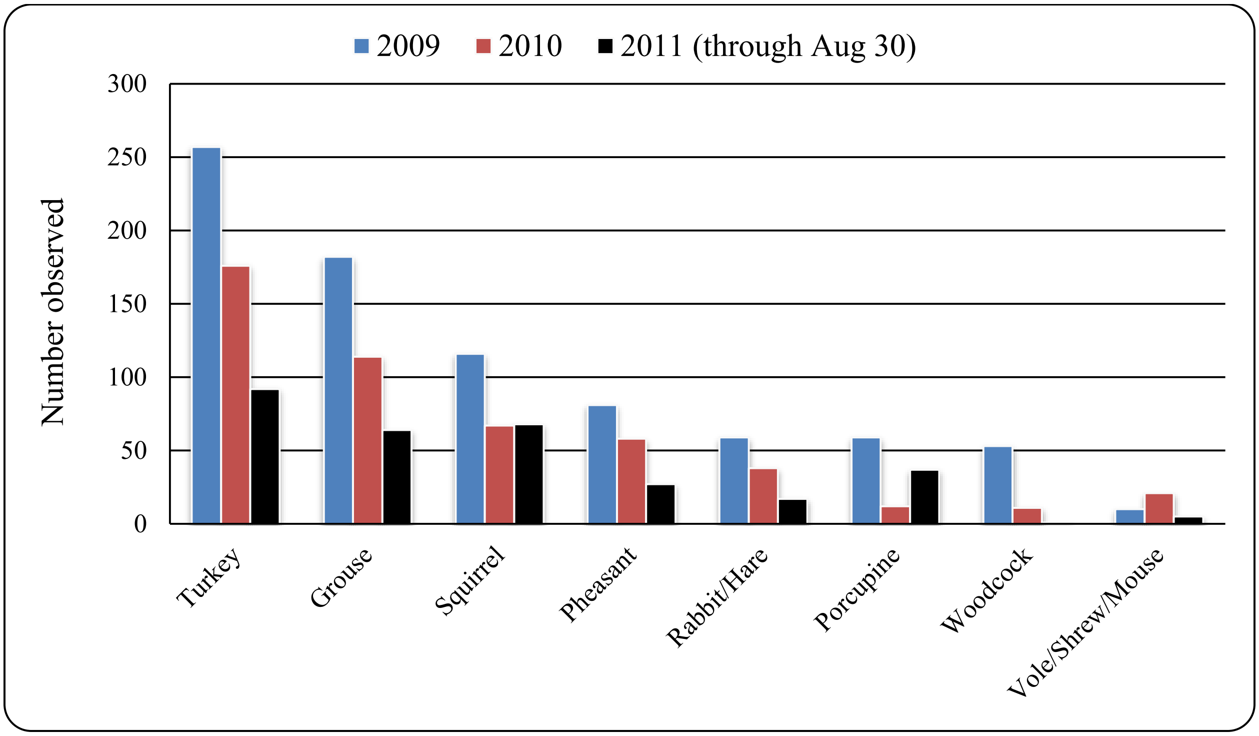

Figure 15. Observations of alternative prey species, Upper Peninsula of Michigan, USA, 2009–2011.