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 72 (55 female, 17 male) white-tailed deer (*Odocoileus virginianus*) in Clover traps including 47 adults, 4 yearlings, and 21 fawns. Thirty-eight pregnant females were radio-collared and received vaginal implant transmitters. Ten fawns were radio-collared. We investigated 7 adult female radio-collared deer mortalities (2 wolf predations, 1 unidentified canid predation, and 4 censors). We investigated 9 fawn radio-collared deer mortalities (4 coyote predations, 1 wolf predation, 1 unknown canid, 1 starvation, and 2 unknown mortalities). We immobilized 9 adult black bear (*Ursus americanus*; 2 male, 7 female) and 7 yearlings (3 male, 4 female) in their dens and observed 6 cubs (4 male, 2 female) from 2 females. We captured 6 bobcats (*Lynx rufus*) and fitted 5 with global positioning system (GPS) collars. We captured one female coyote and fitted her with a GPS collar. We deployed hair snares and remote cameras at 64 sites to estimate bobcat abundance and obtained 297 hair samples and >490,000 images. We gave presentations of project results to the Michigan Department of Natural Resources Crystal Falls Field Office, Purdue University Chapter of The Wildlife Society, and U.P. Bear Houndsman Association. We hosted observers from the Michigan Department of Natural Resources, various universities, and local land owners to provide information on ongoing research. We updated the project website and Facebook page with information and results obtained this quarter. We began selecting applicants for 12 technician positions to begin work 1 May 2015.
Summary

- We captured 72 (55 female, 17 male) individual white-tailed deer (*Odocoileus virginianus*), including 47 adults, 2 yearlings, and 21 fawns.

- We radio-collared 38 pregnant females, each of which received a vaginal implant transmitter. We also collared 10 fawns (7 male, 3 female) in order to increase winter fawn survival sample size.

- We investigated 7 adult female deer mortalities attributed to wolf (*Canis lupus*) predation (*n* = 2), unidentified canid predation (*n* = 1), and 4 predation mortalities that were censored due to occurrence within 10 days of the capture date.

- We investigated 9 fawn deer mortalities attributed to coyote (*Canis latrans*) predation (*n* = 4), unidentified canid predation (*n* = 1), wolf predation (*n* = 1), starvation (*n* = 1), and 2 mortalities that did not have sufficient evidence to discern predations from scavenging.

- We immobilized 9 adult black bear (*Ursus americanus*; 2 male, 7 female) and 7 yearlings (3 male, 4 female) in their dens and observed 6 cubs (4 male, 2 female) from 2 females.

- We captured 4 female and 2 male bobcat (*Lynx rufus*) in cage traps at previously baited bobcat hair snares sites and fitted 5 with global positioning system collars.

- We deployed hair snares and remote cameras at 64 sites to estimate bobcat abundance. We obtained 297 hair samples >490,000 images.

- We gave presentations to the Michigan Department of Natural Resources Crystal Falls Field Office, Purdue University Chapter of The Wildlife Society, and U.P. Bear Houndsman Association.

- We hosted observers representing the Michigan Department of Natural Resources, Northern Michigan University, Purdue University, and local landowners. We also hosted TV personnel from Michigan Out-Of-Doors and Discovering, who took photographs and video footage of project staff performing field duties.

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

Management of wildlife is based on an understanding, and in some cases, manipulation of factors that limit wildlife populations. Wildlife managers sometimes manipulate the effect of a limiting factor to allow a wildlife population to increase or decrease. White-tailed deer (*Odocoileus virginianus*) are an important wildlife species in North America providing many ecological, social, and economic values. Most generally, factors that can limit deer numbers include food supply, winter cover, disease, predation, weather, and hunter harvest. Deer numbers change with changes in these limiting factors.

White-tailed deer provide food, sport, income, and viewing opportunities to millions of Americans throughout the United States and are among the most visible and ecologically–important wildlife species in North America. They occur throughout Michigan at various densities, based on geographical region and habitat type. Michigan spans about 600 km from north to south. The importance of factors that limit deer populations vary along this latitudinal gradient. For example, winter severity and winter food availability have less impact on deer numbers in Lower Michigan than in Upper Michigan.

Quantifying the relative role of factors potentially limiting white-tailed deer recruitment and how the importance of these factors varies across this latitudinal gradient is critical for understanding deer demography and ensuring effective management strategies. Considerable research has demonstrated the effects of winter severity on white-tailed deer condition and survival (Ozoga and Gysel 1972, Moen 1976, DelGiudice et al. 2002). In addition, the importance of food supply and cover, particularly during winter, has been documented (Moen 1976, Taillon et al. 2006). Finally, the role of predation on white-tailed deer survival has received considerable attention (e.g., Ballard et al. 2001). However, few studies have simultaneously addressed the roles of limiting factors on white-tailed deer.

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 Upper Michigan study area but applicable to other study areas with varying predator suites.

Objectives

1. Estimate survival and cause-specific mortality of white-tailed deer fawns and does.

2. Estimate proportion of fawn mortality attributable to black bear (*Ursus americanus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), and wolf (*Canis spp.*).

3. Estimate number and age of fawns killed by a bear, coyote, bobcat, or wolf during summer.
4. Provide updated information on white-tailed deer pregnancy and fecundity rates.

5. Estimate annual and seasonal resource use (e.g., habitat) and home range of white-tailed deer.

6. Estimate if familiarity of an area to each predator species affects the likelihood of fawn predation.

7. Assess if estimated composite bear, coyote, bobcat, and wolf use of an area influences fawn predation rates.

8. Describe association between fawn birth site habitat characteristics and black bear, coyote, bobcat, or wolf habitat use.

9. Estimate seasonal resource use (e.g., habitat, prey) and home range size of black bear, coyote, bobcat and wolf.

**Study Area**

The second phase of this study comprises about 1,000 km² (386 mi²) within Deer Management Unit 036 in Iron County (Figure 1). The general study area boundaries follow State Highway M-95 on the east, US Highway 41/28 on the north, US Highway 141 on the west, and State Highway M-69 on the south. The core study area, where most capture efforts and population surveys will occur, is north of the Michigamme Reservoir and includes state forest, commercial forest association, and private lands. The final study area will comprise a minimum convex polygon that will include the composite locations of all telemetered animals. We selected this study area because it occurs within the mid-snowfall range, receiving about 180 cm of snowfall annually (about 53 cm more snowfall annually than the phase 1 study area near Escanaba). Deer in this area migrate longer distances and exhibit yarding behavior during most winters as compared to Escanaba where deer migrate only short distances or are non-migratory (Beyer et al. 2010) and yard less frequently.

**Accomplishments**

**Deer Trapping**

From 11 January 2015 to 15 March 2015 we captured white-tailed deer in Clover traps (Figure 2) to place radio-collars on pregnant females. We captured 72 unique deer (55 females, 17 males), with an additional 47 recaptures. Individuals captured included 43 adult females, 4 adult males, 2 yearling females, 2 yearling males, 10 female fawns, and 11 male fawns. The fawn:adult female ratio for winter captures in 2014–2015 was 0.49:1. For comparison, the fawn:adult female ratio was 1:1 for winter 2012–2013 captures and 0.27:1 for winter 2013–2014 captures. We collected body condition scores (BCS) by palpation of fat deposits (scale: 1 [moribund]–5 [obese]) by two independent observers and attached ear tags (females = blue, males = yellow) to each deer. We also assessed pregnancy of yearling and adult females using ultrasonography.

Females (n = 55) and males (n = 17) had mean (± SD) body condition scores of 2.46 ± 0.52 and 2.39 ± 0.54, respectively. Two deer (one adult female, one male fawn) were euthanized due to spinal injuries sustained from the trap, and a third deer (adult female) died as a result of apparent cardiac arrest during the immobilization (necropsy pending).
We immobilized 42 females and fitted 38 with radio-collars (model 2610B, Advanced Telemetry Systems Inc., Isanti, MN). We fitted 38 pregnant females with a vaginal implant transmitter (VIT; model 3930, Advanced Telemetry Systems Inc., Isanti, MN). We monitored temperature, respiration, and heart rate as soon as practical after immobilization and at about 10-minute intervals thereafter until we administered a reversal drug. We estimated and recorded deer morphometrics and mid-rump fat depths (Table 1) when practical. We detected pregnancy with ultrasound in 98% of adults (n = 42) and 0% of yearlings (n = 2). In order to increase sample sizes for fawn winter survival and cause-specific mortality, we also fitted 10 fawns (7 Male, 3 Female) with expandable radio-collars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) through the mesh walls of the trap, without immobilization.

In addition to the 38 adult females and 10 fawns radio-collared this winter, we continued to monitor 25 does captured during January–March 2013 and 2014 and 8 fawns captured during May–June 2014.

Deer Mortality
Sixteen radio-collared deer mortalities occurred, consisting of 7 adult females and 9 fawns (6 male, 3 female). We censored four adult female mortalities from analyses that occurred within 10 days of capture to avoid possible bias from capture effects. We attributed the remaining three adult female mortalities as 2 wolf predations and 1 unidentified canine predation. We attributed 4 fawn mortalities as coyote predation, 1 as wolf predation, 1 as unidentifiable canid predation, 1 as starvation, and 2 as unknown causes, as sufficient evidence was not found to distinguish predation from scavenging. Additionally, one collar appeared to have fallen off a male fawn.

Deer Telemetry
We monitored radio-collared deer weekly for movement and survival using aerial- and vehicle-based telemetry. We are currently monitoring 57 individuals.

Black Bear Den Checks
During 15 January 2015–2 March 2015 we immobilized 9 adult black bears (2 male, 7 female) and 7 yearlings (3 male, 4 female). We weighed, recorded morphometric measurements, and drew blood from each immobilized bear. We replaced VHF radio-collars or GPS collars with new GPS collars on 9 previously collared adult black bears. We programmed GPS collars to obtain a location every 35 h until 1 May and then every 15 min until we remove the collar in the den. We handled 6 cubs (4 male, 2 female) from 2 adult females; mean litter size was 3 (SD = 1.41; Table 2).

Bobcat Capture
We set cage traps (n = 17) for a total of 200 unadjusted traps nights to capture bobcats at previously baited bobcat hair snare sites during 27 February–15 March. We captured 4 adult females, 2 adult males, and 1 kitten that we released without being immobilized (3.5% capture efficiency). Once immobilized, we weighed, sexed, and collected morphometric measurements from bobcats. We collared 2 male (15.9, 11.8 kg) and 3 female (9.5, 12.7, 12.8 kg) bobcats with a GPS collar that we programed to record 35 h locations until 1 May and then every 15 min until 31 August. We were unable to collar one female bobcat due to her low weight (7.3 kg).
Coyote Cable Neck Restraints
We baited 6 locations with vehicle-killed deer carcasses to attract coyotes for capture. We set 13 relaxing-lock cable neck restraints at 4 sites beginning 10 February. We immobilized 1 adult female coyote on 21 February (13.6 kg) and fit a GPS collar programed to record 35 h locations until 1 May and then every 15 min until 31 August. We removed all coyote cable neck restraints by 12 March due to unfavorable snow conditions.

Bobcat Hair Snares
We began baiting 64 bobcat hair snares sites (Figure 3) on 15 December 2014. After a two-week pre-bait period, we set 4–5 hair snares at each site beginning 2 January 2015. We also deployed a trail camera at each site, directed at the bait, to obtain images of all animals visiting the site.

We visited each bait site every 7 days to collect hair samples, reset snares, perform trail camera maintenance, and add bait as necessary. The eight-week survey was completed and we pulled snares during 27 February–6 March 2015.

We collected 297 hair samples (of both target and non-target species) and will send them to the MDNR Wildlife Disease Laboratory in Lansing for DNA extraction. We also obtained >490,000 camera images. Data entry and analysis is ongoing.

Public Outreach
During black bear den checks and white-tailed deer trapping we hosted individuals from Michigan Department of Natural Resources (MDNR), Northern Michigan University, Purdue University, Michigan Out-of-Doors, 906 Outdoors (Discovering), and other interested members of the public.

We participated in two forthcoming TV shows who obtained images and video footage of project staff performing various field duties and will provide this media to Safari Club International Foundation to promote the project.

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

Presentations:


Technician Hiring
We posted an advertisement and have begun reviewing applicants to assist with summer field work. We received 45 applications and intend to hire 12 technicians to begin field work 1 May 2015.

Work to be completed (16 March–15 June 2015)

Snowshoe Hare Pellet Survey
Following winter snowmelt and before spring green-up, we will conduct snowshoe hare (*Lepus americanus*) pellet counts along transects within each habitat type to assess hare density within our study area.

Ruffed Grouse Drumming Survey
We will conduct ruffed grouse (*Bonasa umbellus*) drumming surveys beginning in mid–April to estimate occupancy of grouse at survey sites. We will use grouse occupancy to estimate male densities with respect to habitat within our study area.

Carnivore Trapping and Radio-collaring
We will begin trapping black bear, bobcat, coyote, and wolves during late April or early May. We will use #3 Victor soft-catch (Oneida Victor Inc., Cleveland, Ohio) foothold traps for bobcats and coyotes; MB 750 (Minnesota Trapline Products Inc., Pennock, Minnesota) foothold traps to capture wolves; and barrel traps and foot-snares to capture black bears. We will fit captured carnivores with a GPS collar, affix ear tags, record morphometric measurements, determine sex and body condition, and evaluate for injury. We will collect blood, hair, and extract a vestigial premolar from black bear and an incisor from coyotes to estimate age.

Black Bear Hair Snares
During April–May, we will conduct repairs on black bear hair snares (*n* = 64; Figure 3), which were established during 2012. From late May–July we will collect black bear hair samples from snares to estimate abundance throughout the study area.

Predation Site Investigation
We will begin investigations of carnivore predation site locations (clusters) in early May with the use of trained dogs to assess white-tailed deer predation rates by each carnivore species.

Carnivore Scat Collection
We will begin collecting scat of black bear, bobcat, coyote, and wolves opportunistically throughout the study area 1 May for diet analysis. We will record date, GPS location, if tracks are present, scat diameter, and species for each collected scat.

Technician Hiring
We will conduct interviews of applicants and make final hiring decisions. We will hire 12 technicians to begin work 1 May 2015.

Public Outreach
We will continue to update our project Facebook page (http://www.facebook.com/MIpredprey) and web site (http://fwrc.msstate.edu/carnivore/predatorprey/) with project results.
Equipment Organization, Inventory, and Storage
We will inventory, organize, repair, and store all deer trapping and immobilization equipment and bobcat hair snare equipment. We will also repair and store all project snowmobiles.

Radiotelemetry
We will continue to monitor all radio-collared deer ≥1 time weekly. Beginning mid-May through 90 days post-parturition, we will locate radio-collared deer up to 4 times daily to monitor VIT tag expulsion (as available) and obtain locations. We will investigate mortalities as soon as practical after detecting a mortality signal to determine cause of death.

Fawn Capture and Radio-collaring
We will capture fawns opportunistically and using VIT signals through late May and early June. We will locate radio-collared fawns up to 4 times daily through 90 days post-parturition. We will investigate mortalities as soon as practical after detecting a mortality signal to determine cause of death. In addition, we will use our observations of immobile fawns to estimate how long the fawning period lasts. To estimate the twinning rate for the population, we will record observations of multiple young/adolescent female and will monitor and occasionally flush collared fawns to observe whether a sibling is present.

Vegetation Surveys
Beginning mid-May, we will collect vegetation data at random locations within the vegetation classes present in our study area. At each point, we will estimate horizontal cover following Ordiz et al. (2009). We will also estimate available forage by collecting current year’s growth of preferred deer food species, drying the samples, and comparing the resulting dry weights across vegetation classes.

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Participating Upper Peninsula landowners
Jared Duquette, Graduate Research Assistant (Phase 1), Mississippi State University
Nathan Svoboda, Graduate Research Assistant (Phase 1), Mississippi State University
Phase 2 – Project Technicians:
- Cody Norton
- Chloe Wright
- Todd Kautz
- Olivia Montgomery
- Matthew Peterson
- Tanya Wolf
- Jessie Roughgarden
- Daniel Tomasetti
- Evan Shields
- Ben Matykiewicz
- Anne Patterson
- Phillip Lyons
- Abbi Hirschy
- Sara Wendt
- Chris Boyce
- Jake Boone
- Jen Grauer
- Kyle Smith
- Tom Lacerda
- Monique Picon

Participating Upper Peninsula landowners
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Nathan Svoboda, Graduate Research Assistant (Phase 1), Mississippi State University
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Dr. Pat Lederle, MDNR
Brian Roell, MDNR
Monica Joseph, MDNR
Dave Painter, MDNR
Dave Dragon, MDNR
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Kurt Hogue, MDNR
Jason Peterson, MDNR
Marvin Gerlach, MDNR
Jason Neimi, MDNR
Vernon Richardson, MDNR
Dusty Arsnoe, MDNR
Mark Mylchrest, MDNR
Literature Cited


Table 1. Mean (\(\bar{x}\)) and standard deviation (SD) of 41 captured adult (\(n = 39\)) and yearling (\(n = 2\)) female white-tailed deer morphometrics and body condition estimates, Upper Peninsula of Michigan, USA, January–March 2015.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Adults</th>
<th>Yearlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>61.6</td>
<td>38.6</td>
</tr>
<tr>
<td>Hind foot (cm)</td>
<td>48.4</td>
<td>46.5</td>
</tr>
<tr>
<td>BCS(^1)</td>
<td>2.5</td>
<td>2.25</td>
</tr>
<tr>
<td>MIDF(^2) (cm)</td>
<td>0.62</td>
<td>0.14</td>
</tr>
</tbody>
</table>

\(^1\) Body Condition Score (BCS) for does derived from palpation following Cook et al. (2010).

\(^2\) Middle rump fat (MIDF) estimate measured at mid-point between ilium and ischial tuberosity on right hip (Cook et al. 2007).
Table 2. Den check data for 22 black bears, Upper Peninsula of Michigan, USA, 15 December 2015–02 March 2015.

<table>
<thead>
<tr>
<th>ID</th>
<th>Den check date</th>
<th>Age</th>
<th>Sex</th>
<th>Body weight (kg)</th>
<th>Right ear tag</th>
<th>Left ear tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB146</td>
<td>15-Jan</td>
<td>Adult</td>
<td>M</td>
<td>90.7</td>
<td>407</td>
<td>302</td>
</tr>
<tr>
<td>BB142</td>
<td>16-Jan</td>
<td>Adult</td>
<td>M</td>
<td>115.7</td>
<td>269</td>
<td>279</td>
</tr>
<tr>
<td>BB120</td>
<td>23-Feb</td>
<td>Adult</td>
<td>M</td>
<td>50.3</td>
<td>229</td>
<td>228</td>
</tr>
<tr>
<td>BB120</td>
<td>23-Feb</td>
<td>Yearling of BB120</td>
<td>F</td>
<td>12.2</td>
<td>424</td>
<td>425</td>
</tr>
<tr>
<td>BB120</td>
<td>23-Feb</td>
<td>Yearling of BB120</td>
<td>M</td>
<td>16.3</td>
<td>423</td>
<td>422</td>
</tr>
<tr>
<td>BB163</td>
<td>24-Feb</td>
<td>Adult</td>
<td>F</td>
<td>56.7</td>
<td>309</td>
<td>308</td>
</tr>
<tr>
<td>BB163</td>
<td>24-Feb</td>
<td>Yearling of BB163</td>
<td>F</td>
<td>16.3</td>
<td>480</td>
<td>481</td>
</tr>
<tr>
<td>BB103</td>
<td>25-Feb</td>
<td>Adult</td>
<td>F</td>
<td>56.7</td>
<td>213</td>
<td>214</td>
</tr>
<tr>
<td>BB103</td>
<td>25-Feb</td>
<td>Yearling of BB103</td>
<td>F</td>
<td>18.6</td>
<td>413</td>
<td>414</td>
</tr>
<tr>
<td>BB116</td>
<td>27-Feb</td>
<td>Adult</td>
<td>F</td>
<td>65.8</td>
<td>239</td>
<td>238</td>
</tr>
<tr>
<td>BB116</td>
<td>27-Feb</td>
<td>Yearling of BB116</td>
<td>F</td>
<td>14.8</td>
<td>482</td>
<td>486</td>
</tr>
<tr>
<td>BB112</td>
<td>28-Feb</td>
<td>Adult</td>
<td>F</td>
<td>77.1</td>
<td>220</td>
<td>219</td>
</tr>
<tr>
<td>BB112</td>
<td>28-Feb</td>
<td>Cub of BB112</td>
<td>M</td>
<td>2.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>BB112</td>
<td>28-Feb</td>
<td>Cub of BB112</td>
<td>M</td>
<td>1.8</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>BB144</td>
<td>1-Mar</td>
<td>Adult</td>
<td>F</td>
<td>63.6</td>
<td>268</td>
<td>272</td>
</tr>
<tr>
<td>BB144</td>
<td>1-Mar</td>
<td>Yearling of BB144</td>
<td>M</td>
<td>15.7</td>
<td>353</td>
<td>354</td>
</tr>
<tr>
<td>BB144</td>
<td>1-Mar</td>
<td>Yearling of BB144</td>
<td>M</td>
<td>15.5</td>
<td>352</td>
<td>351</td>
</tr>
<tr>
<td>BB162</td>
<td>2-Mar</td>
<td>Adult</td>
<td>F</td>
<td>NA(^1)</td>
<td>305</td>
<td>306</td>
</tr>
<tr>
<td>BB162</td>
<td>2-Mar</td>
<td>Cub of BB162</td>
<td>F</td>
<td>1.1</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>BB162</td>
<td>2-Mar</td>
<td>Cub of BB162</td>
<td>F</td>
<td>1.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>BB162</td>
<td>2-Mar</td>
<td>Cub of BB162</td>
<td>M</td>
<td>0.9</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>BB162</td>
<td>2-Mar</td>
<td>Cub of BB162</td>
<td>M</td>
<td>1.2</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

\(^1\)Unable to remove bear from den due to den entrance size.
Figure 1. Location of phase 1 and 2 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, USA, 2015.
Figure 2. Locations of Clover traps for deer capture, Upper Peninsula of Michigan, USA, 11 January–15 March 2015.
Figure 3. Location of black bear hair snare sites \((n = 64)\) and bobcat hair snare sites \((n = 64)\) within a 2.5 km\(^2\) grid, Upper Peninsula of Michigan, USA.