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


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Abstract  We captured 110 (69 female, 41 male) white-tailed deer (*Odocoileus virginianus*) in Clover traps. Thirty-three adult females were fitted with global positioning system (GPS) collars and thirty-three received vaginal implant transmitters. We investigated 13 radio-collared deer mortalities which were attributed to capture myopathy (*n* = 2), wolf predation (*n* = 3), coyote predation (*n* = 1), bobcat predation (*n* = 2), unidentified predation (*n* = 3), legal hunter harvest (*n* = 1) and unknown natural causes (*n* = 1). We collected 6,571 locations from GPS collared deer. We immobilized 8 adult black bears (*Ursus americanus*: 4 male, 4 female) in their dens and observed 3 cubs (2 male, 1 female) from 1 female and 6 yearlings (3 male, 3 female) from 3 females. We deployed hair snares and remote cameras at 52 sites to estimate bobcat abundance and obtained 316 hair samples and 118,459 images. We hosted observers from the Michigan Department of Natural Resources (MDNR), Keweenaw Bay Indian Community Natural Resources Department (KBNRD), Michigan State University, Grand Valley State University, various media outlets, and local land owners to provide project information. We updated the project website and project Facebook page with information and results obtained this quarter.
Summary

- We captured 110 (69 female, 41 male) individual white-tailed deer (*Odocoileus virginianus*), including 57 adults, and 53 fawns.

- We placed GPS collars on 33 adult female deer, 33 of which received a vaginal implant transmitter. We assisted the Upper Peninsula Deer Movement Study by placing GPS collars on 12 adult males, 4 juvenile males, and 1 juvenile female.

- We investigated 7 collared adult female deer mortalities, with the causes of mortality determined as capture related (*n* = 2), wolf predation (*n* = 2), unknown non-predation natural causes (*n* = 1), legal hunter harvest (*n* = 1), and bobcat predation (*n* = 1).

- We investigated 6 collared fawn mortalities, with the causes of mortality determined as wolf predation (*n* = 1), bobcat predation (*n* = 1), coyote predation (*n* = 1), and unidentified predation (*n* = 3).

- We collected 6,571 locations from deer with GPS collars and monitored survival of 118 collared deer.

- We immobilized 8 adult black bears (*Ursus americanus*: 4 male, 4 female) in their dens and observed 3 cubs (2 male, 1 female) from 1 female and 6 yearlings (3 male, 3 female) from 3 females.

- We deployed hair snares and remote cameras at 52 sites to estimate bobcat abundance. We obtained 316 hair samples and 118,459 images.

- We hosted observers representing the Michigan Department of Natural Resources (MDNR), Keweenaw Bay Indian Community Natural Resources Department (KBNRD), Michigan State University, Grand Valley State University, and local landowners. We also hosted television personnel from Michigan Out-of-Doors, who took photographs and video footage of project staff performing field duties.


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.

Our overall goal 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 Upper 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 have now completed field work within a low snow depth study site and are currently collecting data within a second study site with moderate snow depth. The following objectives are specific to the Upper Michigan study areas but are also 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 third phase of this study spans about 1,550 km² (598 mi²) within Deer Management Unit 031 in Baraga, Houghton and Ontonagon Counties (Figure 1). The general study area boundaries follow US Highway 41/141 on the east, State Highway M-38 on the north, US Highway 45/State Highway M-26 on the west, and State Highway M-28 on the south. Dominant land cover classes are deciduous (35%), evergreen (23%), and mixed forests (21%). Road density is low across the study area at 0.62 km/km² but higher densities do occur around few small towns on the periphery. The core study area, where we conducted most capture efforts and population surveys, is centered on National Forest Rd 16 and almost exclusively within Ottawa National Forest. The final study area will comprise a minimum convex polygon that will include the composite locations of all telemetered animals. We selected this study area because it occurs within the high-snowfall range, receiving over 250 cm of snowfall annually (about 70 cm more snowfall annually than the Phase 2 study area near Crystal Falls, Figures 1 and 2).

**Accomplishments**

**Deer Trapping**

From 14 January to 1 March we captured white-tailed deer in Clover traps to place radio-collars on pregnant females. We captured 110 individual deer (69 female, 41 male), with an additional 109 recaptures. We captured 36 adult and 6 yearling females, 15 adult or yearling males, 27 female fawns, and 26 male fawns. The fawn:adult female ratio for winter captures was 1.48:1.

We immobilized 39 females and fitted 33 with GPS collars (model vertex survey 1D, Vectronic Aerospace, Berlin, Germany) set to record location information at 13-hour intervals. 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 morphometric data and mid-rump fat depths (Table 1) when practical. We detected pregnancy with ultrasound in 97% of adult females and 33% of yearling females. 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 fitted 33 pregnant females with a vaginal implant transmitter (VIT; model 3930, Advanced Telemetry Systems Inc., Isanti, MN). Five immobilized females (1 adult, 4 yearling) were not pregnant and did not receive a VIT. We assisted the project “Quantifying Upper Peninsula Deer Movements and Abundance: Preparing for CWD Management”, by capturing and attaching expandable GPS collars (model LifeCycle 330, Lotek Wireless Inc., Newmarket, Ontario, Canada) to 12 adult males, 4 male fawns, and 1 female fawn.
Deer Mortality
Thirteen radio-collared deer mortalities occurred (7 adult females, 6 fawns). Two adult female mortalities occurred within 14 days of capture and will be censored from analyses to avoid possible bias from capture effects. The remaining adult female mortalities were attributed to 1 legal hunter harvest, 1 unidentified causes non-predation mortality, 1 bobcat predation and 2 wolf predations. Fawn mortalities were attributed to 1 coyote predation, 1 bobcat predation, 1 wolf predations, and 3 predations where we were unable to determine likely predator species.

Deer Telemetry
During 1 January–8 March, we collected 6,571 GPS locations from 87 adult female deer. We monitored 14 VHF-collared fawns using weekly aerial telemetry. As of 15 March, we were monitoring GPS or VHF collars on 80 adult females, 14 adult males, and 11 fawns.

Black Bear Den Checks
During 28 January–1 February we immobilized 2 adult black bears (2 male). From 28 February–12 March we immobilized 6 adult (2 male, 4 female) and 4 yearling (2 male, 2 female) black bears. Two yearling (1 male, 1 female) black bears were observed in the den without immobilization. We weighed, recorded morphometric measurements, and drew blood from each immobilized bear. We replaced batteries on GPS collars. Three collars were removed and not replaced due to the bear moving outside of the study area. We programmed the GPS collars to obtain a location every 35 h until 1 May and then every 15 min thereafter until we remove the collar. We handled 3 cubs (3 male, 1 female) from 1 adult female (Table 2).

Bobcat Capture
We set cage traps (n = 3) to capture bobcats at previously baited bobcat hair snare during 14 January–22 February. We captured 1 adult female and 1 kitten; we released the kitten without immobilization. Once immobilized, we weighed (9.5 kg), sexed, and collected morphometric measurements from the adult bobcat. We also attached a GPS collar that we programed to record 35 h locations until 1 May and then every 15 min until 31 August. Trapping efforts have continued with cage traps (n = 2) set 6 March at locations of observed bobcat sign.

Coyote Cable Neck Restraints
We baited 2 locations with vehicle-killed deer carcasses to attract coyotes for capture. Due to cold temperatures and deep snow levels, we did not set cable neck restraints.

Bobcat Hair Snare
We began baiting 52 bobcat hair snare sites (Figure 3) on 10 December 2018 and set 4 hair snares at each site beginning 5 January 2019. We also deployed a trail camera at each site, directed at the bait, to obtain images of animals visiting the site. We visited each bait site every 7 days for 6 weeks to collect hair samples, reset snares, perform trail camera maintenance, and add bait as necessary. Due to extreme winter conditions, the survey was limited to 6 weeks as opposed to 8 weeks as in previous seasons.
We collected 316 hair samples of target and non-target species and will send samples to the MDNR Wildlife Disease Laboratory in Lansing for DNA extraction. We also obtained 118,459 camera images. Data entry and analysis is ongoing.
Public Outreach

During black bear den checks and white-tailed deer trapping we hosted individuals from the Michigan Department of Natural Resources (MDNR), Keweenaw Bay Indian Community Natural Resources Department (KBNRD), Michigan State University, Michigan Out-of-Doors, and other interested members of the public.

We participated in one television show 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 Facebook page (https://www.facebook.com/campfirewildlife/) and website (https://campfirewildlife.com/projects/predator-prey/) to provide the public with current project activities.

Presentations to hunting groups and service organizations:
None to report during this period

Outdoor shows:
Michigan Out-of-Doors – Episode #1911
https://www.youtube.com/watch?time_continue=670&v=mu5oBuW10Tw

Field Assistants

We recruited 5 seasonal technicians to assist with field work May-August 2019. Three technicians recruited for the winter field season will continue through the summer.

Work to be completed (16 March 2019 – 15 June 2019)

Snowshoe Hare Pellet Survey
Following snowmelt and before spring green-up, we will conduct snowshoe hare (Lepus americanus) pellet counts. We will count the number of snowshoe hare pellets in 10 cm x 10 m plots. We will set up plots with the bottom left portion of the plot starting at the site coordinates and oriented northward. We will generate 80 random plots in deciduous, evergreen, mixed forest, and woody wetland land cover classes. Additionally, thirty randomly generated plot locations will be generated in grassland/herbaceous, emergent herbaceous wetland, and shrub/scrub land cover types to confirm absence. No effect of road proximity was found in the Phase II study area and all plot locations will be within 1 km of roads to increase efficiency. Hare pellet density will be related to hare abundance using a linear regression technique developed by McCann et al. (2008).

Ruffed Grouse Drumming Survey
We will conduct ruffed grouse (Bonasa umbellus) drumming surveys beginning in late–April to estimate occupancy of grouse at survey sites. We will periodically visit survey sites during late-April to gauge peak drumming to begin the survey. Surveys will be conducted from one half hour before sunrise to 5 hours after sunrise. Sixty-four survey sites a minimum of 550 m apart will be visited 5 times each over the course of the survey (Figure 4). We will listen for 5 minutes at each site and record number and bearing of each drumming grouse. We will use site occupancy to estimate male grouse density and relate this to land cover post hoc in model structure for extrapolation.
Carnivore Trapping and Radio-collaring
We will begin trapping black bear, bobcat, coyote, and wolves during early May. We will use #3 Victor soft-catch foothold traps (Oneida Victor Inc., Cleveland, Ohio) for bobcat and coyote; MB 750 foothold traps (Minnesota Trapline Products Inc., Pennock, Minnesota) to capture wolves; and barrel traps and foot-snares to capture black bears. We will fit captured carnivores with a GPS collar, attach ear tags, record morphometric measurements, determine sex and body condition, and evaluate for injuries. We will collect blood, hair, and extract a vestigial premolar from black bear.

Black Bear Hair Snares
During April–May, we will conduct repairs on black bear hair snares \((n = 52; \text{Figure 5})\), established during 2016. 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) mid-May using trained dogs to assess white-tailed deer predation rates by each carnivore species.

Radio Telemetry
Collared adult female deer will transmit location and survival status year-round at 13-hr intervals via satellite. From mid-May through post-parturition, we will observe VIT-tagged deer up to 2 times daily to monitor fawn birth events and capture fawns. After capture, we will monitor fawn survival from birth to 31 August daily via radio-telemetry using expandable VHF collars. After 31 August, we will monitor fawn survival twice per week using VHF telemetry. 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 through opportunistic encounters during routine work and using VIT signals, then fit each with an expandable VHF collar. At each capture, we will collect blood and morphometric indicators of health. We will check mortality status of radio-collared fawns 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 VIT expulsions and age estimates of opportunistically captured fawns to estimate the distribution of fawn birthing dates. We will measure horizontal vegetative cover at each fawn birth, bedding, and mortality site. We will pair each of these measurements with a random point 100 meters distant to test for selection.

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.

Public Outreach
We will continue to update our Facebook page (https://www.facebook.com/campfirewildlife/) and website (https://campfirewildlife.com/projects/predator-prey/) to provide the public with current project activities.
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Nathan Svoboda, Graduate Student (Phase 1), Mississippi State University
Cody Norton, Graduate Student (Phase 2), Northern Michigan University
Tyler Petroelje, Graduate Student (Phase 1 & 2), Mississippi State University

Phase 3 – Project Technicians:

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Courtney Dotterweich   Steve Gurney   Sarah Trujillo    Angela Clarke
Emily Monfort          Kristina Kennedy Forrest Rosenbower Amanda Yaw
Morgan Oberly          Megan Petersohn  Elaine Gallengerg  Zarina Shiekh
Sara Harrington        DJ Steakley    Abigail Thiemkey  Emily Masterton
Mark Jackson           Ben Murley     Victoria Frailey  Alec Rutherford
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Gordy Zuehlke (Air 3), MDNR
Neil Harri (Air 1), MDNR
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Literature Cited


Table 1. Mean ($\bar{x}$) and standard deviation (SD) of adult ($n = 33$) and yearling ($n = 6$) female white-tailed deer morphometrics and body condition estimates, Upper Peninsula of Michigan, USA, January–March 2019.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Adults</th>
<th>Yearlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>65.2</td>
<td>52.6</td>
</tr>
<tr>
<td>BCS$^1$</td>
<td>2.61</td>
<td>2.38</td>
</tr>
<tr>
<td>MIDF$^2$ (cm)</td>
<td>0.45</td>
<td>0.24</td>
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</table>

$^1$ Body condition score (BCS) 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. Data for black bears handled during den checks, Upper Peninsula of Michigan, USA, 28 Jan–12 March 2019.

<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>
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<tbody>
<tr>
<td>BB358</td>
<td>28-Jan-19</td>
<td>Adult</td>
<td>M</td>
<td>67.7</td>
<td>619</td>
<td>617</td>
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<tr>
<td>BB359</td>
<td>1-Feb-19</td>
<td>Adult</td>
<td>M</td>
<td>47.5</td>
<td>638</td>
<td>637</td>
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<tr>
<td>BB335</td>
<td>28-Feb-19</td>
<td>Adult</td>
<td>F</td>
<td>78.5</td>
<td>429</td>
<td>428</td>
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<tr>
<td>BB349</td>
<td>28-Feb-19</td>
<td>Yearling of BB335</td>
<td>M</td>
<td>NA(^2)</td>
<td>NA(^2)</td>
<td>NA(^2)</td>
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<tr>
<td>BB350</td>
<td>28-Feb-19</td>
<td>Yearling of BB335</td>
<td>F</td>
<td>NA(^3)</td>
<td>NA(^3)</td>
<td>NA(^3)</td>
</tr>
<tr>
<td>BB339</td>
<td>2-Mar-19</td>
<td>Adult</td>
<td>F</td>
<td>59.9</td>
<td>438</td>
<td>439</td>
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<tr>
<td>Yearling 1</td>
<td>2-Mar-19</td>
<td>Yearling of BB339</td>
<td>M</td>
<td>18.2</td>
<td>630</td>
<td>628</td>
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<tr>
<td>Yearling 2</td>
<td>2-Mar-19</td>
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<td>F</td>
<td>18.5</td>
<td>632</td>
<td>626</td>
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<tr>
<td>BB303</td>
<td>3-Mar-19</td>
<td>Adult</td>
<td>M</td>
<td>NA(^1)</td>
<td>663</td>
<td>601</td>
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<td>BB338</td>
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<td>144.8</td>
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<td>BB351</td>
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<td>73.5</td>
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<td>BB361</td>
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<td>BB362</td>
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<td>BB343</td>
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<td>22.1</td>
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<td>698</td>
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</table>

\(^1\)Unable to weigh bear due to den location.
\(^2\), \(^3\)Yearlings were not immobilized.
Figure 1. Location of phase 1, 2, and 3 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan, 2008–2017.
Figure 2. Location of phase 3 study area and counties, Upper Peninsula of Michigan, USA.
Figure 3. Locations of 52 bobcat hair snare sites to estimate bobcat abundance, Upper Peninsula of Michigan, USA, 2019
Figure 4. Locations of 64 grouse drumming survey sites with 550 m audible buffer along 3 routes to estimate abundance, Upper Peninsula of Michigan, USA, 2019.
Figure 5. Locations of 52 black bear hair snare sites to estimate black bear abundance, Upper Peninsula of Michigan, USA, 2019.