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 and radiocollared 48 neonate white-tailed deer (*Odocoileus virginianus*) fawns (26 male, 20 female, 2 unknown sex). Thirteen of 17 (76%) vaginal implant transmitter searches resulted in the location of 18 live fawns. Ten adult female and 7 neonate fawn mortalities occurred this quarter. We collected 6,662 adult female GPS and radiolocations and radio-monitored fawns for daily survival. We captured 12 wolves (4 male, 8 female), 3 coyotes (2 male, 1 female), 1 bobcat (male), and 5 black bears (3 male, 2 female). We conducted investigations at 230 carnivore cluster sites to identify carnivore prey sources. We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimate abundance. We completed snowshoe hare (*Lepus americanus*) pellet surveys at 455 random locations stratified within 6 land covers to estimate hare density. We deployed hair snares at 49 sites to estimate black bear abundance. We gave 11 presentations and hosted a field techniques seminar for 25 undergraduate students. We updated the project website and project Facebook page with information and results obtained this quarter. We trained 8 technicians to assist with ongoing field activities.
Summary

- We observed 10 dead radio-collared adult female white-tailed deer (*Odocoileus virginianus*) which were attributed to 2 starvations, 7 wolf predations, and 1 unknown causes.

- We captured and radio-collared 48 neonate fawns, including 26 males, 20 females, and 2 unknown sex.

- Thirteen of 17 (76%) vaginal implant transmitter searches resulted in the location of 18 live fawns.

- We obtained 6,662 adult female deer GPS radiolocations and monitored VITs and fawn collars daily via VHF telemetry.

- We observed 7 radio-collared neonate fawn mortalities attributed to 2 coyote predations, 2 bear predations, 1 wolf predation, 1 unidentified predation, and 1 non-predation natural causes (pending lab necropsy).

- We captured 12 wolves (4 male, 8 female), 3 coyotes (2 male, 1 female), 1 bobcat (male), and 5 black bears (3 male, 2 female). Each were fitted each with a GPS collar.

- We conducted investigations at 230 carnivore cluster sites to identify carnivore prey sources.

- We conducted 5 ruffed grouse (*Bonasa umbellus*) drumming surveys to estimated grouse abundance. Probability of detection was 50.6% resulting in an estimated density of 2.86 grouse/km².

- We completed snowshoe hare (*Lepus americanus*) pellet count surveys at 455 random locations stratified within 6 different land cover types to estimate hare densities with respect to available land cover. Across land cover types estimated hare density was 23.12 hare/km².

- We deployed hair snares at 49 sites throughout the study area to estimate black bear abundance.

- We hosted 25 undergraduate students from Purdue University to demonstrate detection dog work, carnivore capture and immobilization, radio-telemetry, and fawn capture.

- We gave 11 presentations to local school classes.

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

Fawn Capture

Beginning in June, we captured and radio-collared white-tailed deer fawns. Forty-eight neonate fawns were captured and fitted with expandable radio-collars (model 4210, Advanced Telemetry Systems, Inc., Isanti, MN) during 29 May – 22 June, consisting of 26 males, 20 females, and 2 unknown sex. We attached an individually numbered plastic ear tag to fawns and collected fawn morphometrics, hair, and vitals as we were able to while restricting handling time to 15 minutes. We also recorded bed site and surrounding habitat, presence of dam, additional deer sighted, and handling time as available. No stillborn fawns were found at collared doe parturition sites. Parturition of collared does began on 31 May and 1 doe had not given birth as of 22 June.

Twenty-three adult female deer fitted with vaginal implant transmitters (VITs) during Jan-Mar 2019 survived through 1 Jun 2019. Three VITs failed or were expelled prior to parturition with no evidence of a birth site nearby, so we could not conduct a fawn search. An additional two VITs were expelled in open areas during sunny periods such that we did not detect parturition until >2 days later. We conducted fawn searches at these sites but fawns were likely not in the area anymore. One VIT was not yet expelled as of 22 June. We successfully detected parturition and conducted searches at the birth site in the effort to find fawns of 17 implanted pregnant adult females. Thirteen of 17 (76%) VIT
searches resulted in the location of ≥1 live or dead fawn (18 live fawns and 0 stillbirths). An additional 5 parturition events were identified through GPS movements of deer without VITs, at which 3 live fawns were located. Twenty-seven fawns were captured through opportunistic encounters within the study area. Fawn capture efforts are still ongoing as of 22 June 2019.

Deer Mortality

We recorded 10 adult female mortalities during 15 Mar – 22 Jun 2019. Seven mortalities were attributed to wolf predation. Two mortalities were attributed to starvation. We were unable to diagnose cause of mortality for 1 adult female.

We recorded 3 juvenile deer mortalities on individuals born during 2018 consisting of 3 wolf predations.

We recorded 7 neonatal deer mortalities of fawns born during 2019, including 1 from unidentified non-predation natural causes (lab necropsy pending), 2 coyote predations, 1 wolf predation, 2 bear predations, and 1 predation in which the predator species could not be identified based on field evidence. Additionally, 1 fawn which slipped its collar and 1 fawn which lost collar signal were censored from survival analyses.

All mortality causes are preliminary until results from carcass DNA swabs and lab necropsies are obtained.

Deer Telemetry

We obtained 6,662 GPS locations of radiocollared adult females between 15 March and 22 June 2019. Beginning 15 May, we conducted daily truck-based telemetry and tri-weekly aerial telemetry to monitor VIT status of does and survival of VHF collared fawns.

Carnivore Capture

During 13 May–15 June, we captured 12 wolves (4 male, 8 female), 3 coyotes (1 female, 2 male), and 1 bobcat (male) using foothold traps. Five black bears (2 female, 3 male) were captured in barrel traps or modified Aldrich foot snares. We immobilized captured individuals and recorded gender, weight, and affixed uniquely numbered ear tags (Table 1). We recorded morphometric measurements and collected blood and hair from each immobilized carnivore. We estimated body condition scores for each carnivore and estimated body condition of black bears using bioelectrical impedance analysis. We removed a vestigial premolar for age estimation in black bears. We fitted all captured wolves with Lotek 7000SU or LiteTrack (Lotek Engineering, Newmarket, ON, Canada) global positioning system (GPS) radiocollars.

We programmed all GPS radiocollars to obtain a location every 15 minutes from 1 May–31 September and then every 35 hours thereafter.

Carnivore Cluster Investigation

During 15 May–22 June, we used clusters of carnivore locations obtained from GPS radiocollars to identify potential kill sites and estimate the number and species of prey killed. Currently, we have investigated 230 GPS location clusters identified using ArcGIS and the statistical software program R (R Development Core Team, Vienna, Austria). We defined a cluster spatially as ≥5 locations within 50 m of each other within a 24-hour period. Of the 230 clusters, 101 were black bear, 20 coyote and 109 wolf. Analysis of cluster data is ongoing.
Ruffed Grouse Drumming Survey
We conducted ruffed grouse (*Bonasa umbellus*) drumming surveys during 05 May – 10 May. We conducted surveys from one half hour before sunrise to 5 hours after sunrise. Each survey contained 5 routes with 10-15 sites per route for a total of 64 sites (Figure 4). Observers listened for 5 minutes at each site for drumming grouse and recorded number and bearing of each drumming grouse. We used site occupancy to estimate male grouse density. Probability of detection was 50.6% resulting in an estimated density of 2.86 grouse/km$^2$.

Snowshoe Hare Pellet Counts
We conducted snowshoe hare (*Lepus americanus*) pellet counts during 05 May – 14 May. We counted number of hare pellets within a 1 m$^2$ rectangle at 455 random sites (Figure 3). We separated pellet counts into 6 main land cover types (aspen [*Populus tremuloides*]), deciduous (excluding aspen), coniferous, mixed forest, woody wetland, and open herbaceous). We related hare pellet densities to hare abundance using a linear regression developed by McCann et al. (2008). Across land cover types estimated hare density was 23.12 hare/km$^2$.

Black Bear Abundance Estimation
On 20 May we began the pre-bait period for a hair snare survey to estimate black bear abundance. Hair snares (*n* = 49; Figure 5) consist of a single strand of 4-pronged barbed wire placed around three or four trees to create an enclosure about 50 cm above ground. We baited snares by placing 0.5 L of fish oil on a pile of dead wood in the center of each enclosure and spraying anise or raspberry oil on close proximity trees. We also placed a remote trail camera at each site to document site visitation. Project personnel check snares, add lure, and collect hair samples every ten days. We will check each snare five times; the survey will continue through 18 July. We will send hair samples to the MDNR lab for DNA extraction and subsequent individual identification. We have 223 samples collected after 3 of 5 checks.

Public Outreach
We hosted 25 undergraduate students from Purdue University on 31 May for demonstrations of detection dogs, carnivore immobilizations, fawn capture, vegetation surveys, and deer telemetry. We also gave presentations to 11 classes at local public schools, reaching 263 students. We updated our Facebook page (https://www.facebook.com/campfirewildlife/) to provide the public with project results.

Presentations:


Seminars and Workshops:


Technician Selection and Hiring

We retained our 8 seasonal technicians (5 hired in early May and 3 that were originally hired as technicians for 2018-2019 winter season) to assist with field work from May through 31 August 2019. Additionally, we contracted work with Find It Detection Dogs for the use of 3 conservation detection dogs and 2 handlers to aid in the search for predation events at carnivore cluster sites.
Work to be completed (16 June 2019 – 30 September 2019)

Carnivore Monitoring
We will continue monitoring carnivores twice weekly via aerial telemetry. We will download location data from carnivore GPS collars through 31 August for predation site investigation.

Predation Site Investigation
We will continue investigations of carnivore predation site locations (clusters) through 31 August to assess their role in predation on white-tailed deer.

Deer Telemetry
Collared adult female deer will transmit location and survival status at 13-hr intervals via satellite. Through post-parturition we will continue to observe radio-collared deer daily to monitor the remaining VIT tag expulsion and capture fawns. We will monitor fawn survival via truck-based telemetry daily through August and investigate mortalities as soon as practical (generally <5 hours) after detecting a mortality signal to determine cause of death.

Black Bear Abundance Estimation
We will check each hair snare for a total of five checks; the survey will continue through 18 July. We will continue to send hair samples to the MDNR lab for DNA extraction and subsequent individual identification.

Fawn Capture and Radio-collaring
We will continue efforts to capture fawns opportunistically and using VIT signals, then fit each fawn with an expandable VHF collars. At each capture, we will collect morphometric indicators of health. We will check mortality status of radio-collared fawns daily through 90 days post-parturition, and monitor weekly thereafter.

Coyote Abundance Estimation
On 12 July we will begin conducting howl surveys at 40 sites to estimate coyote abundance. We will conduct surveys every ten days and will continue through approximately 4 October for a total of eight surveys. We will estimate coyote abundance using an occupancy modeling approach (Royle and Nichols 2003).

Deer Abundance Estimation
We will begin pre-baiting 50 sites with 7.5 L of whole kernel corn on 12 August, and will rebait each site at 3-day intervals. Beginning 22 August we will place remote infrared cameras at each site. We will continue re-baiting each site every three days during the ten day survey. On 1 September we will start retrieving cameras. From camera images, we will estimate deer abundance/density for the sampling area using an occupancy modeling approach (Duquette et al. 2014).

In order to estimate deer abundance using a non-baited survey, we will place remote infrared cameras at 52 sites along secondary roads and trails within the study area from 15 July – 5 September. Non-baited camera sites will be placed a minimum of 500 m from the nearest baited camera site in order to avoid changes in deer movement associated with baited camera sites. Results from the non-baited survey will likely be analyzed using an occupancy modeling approach and compared with results from the baited survey.
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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Cody Norton, Graduate Student (Phase 2), Northern Michigan University
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Brendan Popp  Braiden Quinlan  Rebekah Lumkes  Jesse Ritter
Courtney Dotterweich  Steve Gurney  Sarah Trujillo  Angela Clarke
Emily Monfort  Kristina Kennedy  Forrest Rosenbower  Amanda Yaw
Morgan Oberly  Megan Petersohn  Elaine Gallengerg  Zarina Shiekh
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Literature Cited

relationships: a review of recent North American studies with emphasis on mule and black–


occupancy modeling and radiotelemetry to estimate ungulate population dynamics. Population

198.


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Figure 1. Location of phases 1-3 study areas and Michigan Department of Natural Resources Deer Management Units, Upper Peninsula of Michigan.
Figure 2. Location of phase 3 study area and counties, Upper Peninsula of Michigan, USA.
Figure 3. Locations of pellet plot locations to estimate snowshoe hare abundance, Upper Peninsula of Michigan, USA, 2019.
Figure 4. Locations of 64 grouse drumming survey sites with 550 m audible buffer, Upper Peninsula of Michigan, USA, 2017
Figure 5. Locations of 49 black bear hair snare sites to estimate black bear abundance, Upper Peninsula of Michigan, USA, 2019.