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Characterizing nontarget species use at bait sites for white-tailed deer

BRENT BOWMAN, Carnivore Ecology Laboratory, Forest and Wildlife Research Center, P. O. Box 9690, Mississippi State University, Mississippi State, MS 39762, USA bbowman@msstate.edu

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

DEAN E. BEYER JR., Michigan Department of Natural Resources, Wildlife Division, 1990 US Highway 41 S., Marquette, MI 49855, USA

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

Abstract: Baiting white-tailed deer (*Odocoileus virginianus*) has evolved into a controversial issue of wildlife management. During August–September 2012, we established a grid of 64 cameras in the Upper Peninsula of Michigan at sites baited with corn that simulated legal bait sites for white-tailed deer to characterize presence, diversity, and frequency of species use. We detected >20 species of wildlife that visited bait sites. We categorized 3,177 of 11,194 images as independent detections (i.e., species detected >1 hour apart). White-tailed deer had the greatest detection rate (47%), but overall detections of nontarget species was slightly greater (53%). Most frequent nontarget species detected were northern raccoons (*Procyon lotor*) and American black bears (*Ursus americanus*). Wildlife officials should consider the potential effects of baiting on species' ecology and the potential for disease transmission that high-use of bait sites by nontarget species present.

Key words: bait sites, camera trap, human–wildlife conflict, nontarget species, white-tailed deer

ANIMALS HAVE THE POTENTIAL for increased interactions and competition at seasonally abundant food sources or during pulsed-resource events (Polis and Strong 1995). For example, scavenging mesopredators and small vertebrates showed increased use of, and multi-species interactions at, carrion sites (DeVault and Rhodes 2002). Brown bears (*Ursus arctos*) formed aggregations to forage on concentrations of migrating salmon (*Oncorhynchus* spp.) in Alaskan streams (Egbert and Stokes 1974). White-tailed deer (*Odocoileus virginianus*) interactions increased in areas containing hard mast (e.g., acorns) during autumn (McShea and Schwede 1993).

Concentrations of anthropogenic foods, including garbage, agricultural crops, introduced fruit-bearing trees, and bait sites, similarly, can attract wildlife (McKinley et al. 2014, Dieter et al. 2014). American black bears (*Ursus americanus*) in an urban area had a greater probability of being seen when apple trees were bearing fruit (Merkle et al. 2013). They also congregated near residential areas and campgrounds to forage on anthropogenic foods (Rogers et al. 1976, Beckmann and Berger 2003a). Ring-necked pheasants (*Phasianus*

colchicus) aggregated to corn and sorghum to enhance their survival during winter (Bogenshutz et al. 1995). Also, white-tailed deer congregated to forage on agricultural crops, such as alfalfa (Palmer et al. 1982).

Baiting is a proven technique to attract animals to a specific location for hunting and wildlife research (Dunkley and Cattet 2003). Distribution of food sources can alter species ecology (Beckmann and Berger 2003b); for example, changing food availability can alter animals' use of space (Pickford and Reid 1943). Not only can localized abundance of species using the resource increase, but their predators also may increase (Lima 2002). For example, coyotes (*Canis latrans*) aggregated at resource patches where black-tailed jackrabbits (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*) were most common (Razo et al. 2012). Distribution of supplemental food resources also can change the extent of spatial overlap among individuals where clumped resources facilitate formation of local aggregations (Wehjte and Gompper 2011). Northern raccoons (*Procyon lotor*) had greater contact rates and a greater chance of disease transmission at clumped resources, such as piles of cracked

corn, than at resources scattered throughout an area (Wright and Gompper 2005). Parasite transmission, such as *Baylisascaris procyonis* from northern raccoons, also has potential to increase at high contact rates (Page et al. 1998). Numerous diseases can be transferred at bait sites and transmitted among individuals using them (Sorenson et al. 2014). Bovine tuberculosis has spread to white-tailed deer from domestic cattle due to clumped resources, such as baiting (Schmitt et al. 2006).

Baiting is commonly used by hunters to attract and harvest game and has become an important issue in wildlife management and conservation (Inslerman et al. 2006). It is allowed in most states within the U.S.A. (Wildlife Society 2007). Considerable controversy among wildlife officials, scientists, government officials, and the public exists regarding regulations on baiting of wildlife (Wildlife

Society 2007). Most research regarding wildlife use of bait has emphasized target species (Rudolph et al. 2006); however, only limited research has been conducted quantifying use of bait sites by nontarget species (Lambert and Demarias 2001, Campbell et al. 2013). We conducted a short-term study to estimate establishment patterns of use at a bait site by white-tailed deer and other wildlife species. Our objective was to characterize the presence, species richness, and frequency of nontarget species at bait sites for white-tailed deer. We predicted a greater number of detections of nontarget species than white-tailed deer. We also predicted that mammal detections would vary by time of day, based on species life history, and that bird detections would be greater during the day.

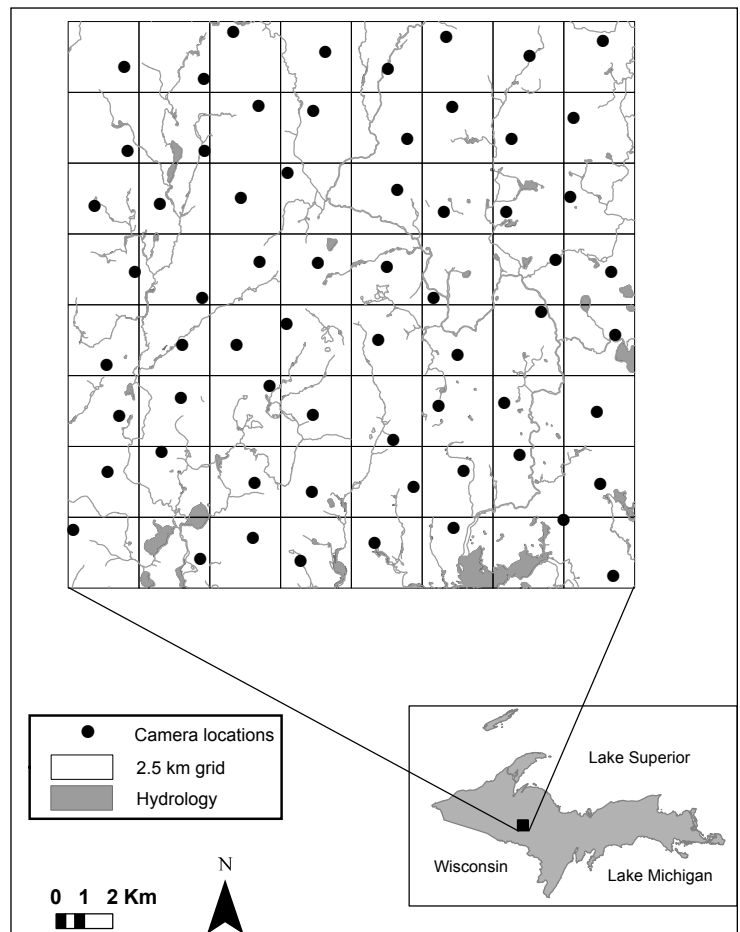


Figure 1. Locations of 64 remote infrared cameras to estimate wildlife use of bait sites for white-tailed deer, Upper Peninsula of Michigan, USA, August–September 2012.

Study area

We conducted this study north of the Michigamme Reservoir in Iron County, Upper Peninsula of Michigan. 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 (46°13'N, 88°14'W). Soils are predominantly podzolized sandy loams and loamy sands (U.S. Department of Agriculture 1997). Land covers include deciduous forests (38%), woody wetlands (29%), mixed forests (13%), conifer forests (6%), open water (4%), grassland and herbaceous (3%), developed (3%), and other (3%). Dominant tree species include sugar maple (*Acer saccharum*) and trembling aspen (*Populus tremuloides*) in upland deciduous forests, black spruce (*Picea mariana*)

Table 1. Camera trap detections of white-tailed deer and nontarget species at sites baited with corn, Iron County, Michigan, USA, August–September 2012. Total detections (column 2) are images taken throughout the study before the 1-hour time frame. Total independent detections (column 3) are detections >1 hour apart.

Species	Total detections	Total independent detections
White-tailed deer (<i>Odocoileus virginianus</i>)	5,597	1,497 (47.12%)
Northern raccoon (<i>Procyon lotor</i>)	2,024	758 (23.86%)
American black bear (<i>Ursus americanus</i>)	1,385	361 (11.36%)
Eastern chipmunk (<i>Tamias striatus</i>)	177	99 (3.12%)
Squirrel (<i>Sciurus</i> spp.)	124	88 (2.78%)
Snowshoe hare (<i>Lepus americanus</i>)	91	47 (1.48%)
Badger (<i>Taxidea taxus</i>)	5	5 (0.16%)
Coyote (<i>Canis latrans</i>)	6	5 (0.16%)
Skunk (<i>Mephitis mephitis</i>)	4	4 (0.13%)
Short-tailed weasel (<i>Mustela erminea</i>)	3	3 (0.09%)
Wolf (<i>Canis lupus</i>)	3	1 (0.03%)
Bobcat (<i>Lynx rufus</i>)	1	1 (0.03%)
Porcupine (<i>Hystricomorph hystricidea</i>)	1	1 (0.03%)
Small mammals	171	97 (3.05%)
Blue jay (<i>Cyanocitta cristata</i>)	160	92 (2.90%)
American crow (<i>Corvus brachyrhynchos</i>)	188	77 (2.42%)
Ruffed grouse (<i>Bonasa umbellus</i>)	16	15 (0.47%)
Wild turkey (<i>Meleagris gallopavo</i>)	19	6 (0.19%)
Black-capped chickadee (<i>Poecile atricapillus</i>)	6	5 (0.16%)
Sandhill crane (<i>Grus canadensis</i>)	12	5 (0.16%)
Unknown birds	13	10 (0.31%)
Total	10,006	3,177

in lowland coniferous forests, and red pine (*Pinus resinosa*) forest in plantations. Average annual snowfall in the study area is about 180 cm, and average annual rainfall is about 69 cm. August temperatures ranges from 11° C to 23° C, with a mean of 17° C; average annual temperature is about 4° C (National Oceanic and Atmospheric Administration 2013).

Methods

The study was conducted from August 20 to September 4, 2012. We first created a non-overlapping 8 m × 8 m grid across the study area, with each grid cell 2.5 km² (Figure 1). In each cell, we placed a camera (Bushnell Infrared Trophy Cameras; Bushnell Outdoor Products, Overland Park, Kan.) along an animal trail

with recent deer activity (e.g., fecal pellets or tracks) to increase detections. We attached each camera to a tree 70 to 80 cm above ground and programmed them to detect presence every 5 minutes. We programmed cameras to take 1 image with a 5-minute delay and record date and time for each image. We placed 7.5 L of whole-kernel corn (the maximum amount of bait allowed by the Michigan Department of Natural Resources) at each site 6 to 7 meters from the cameras on the first day of the survey; we re-baited sites every 3 days. We removed vegetation between the camera and bait to minimize false detections.

For each image, we recorded the number of detections by species or the lowest species group possible (e.g., small mammals). Images

without species were excluded from the data set. Images of the same species taken >60 minutes apart were considered independent detections (Bernard et al. 2013, Bridges et al. 2014, Gantchoff and Belant 2015). For each camera, we summed the total number of images and independent images by species (i.e., white-tailed deer, raccoons, and black bears; Figure 3) and species groups (i.e., other mammals and birds). We calculated the mean daily number of white-tailed deer and total number of species detected and used regression techniques to assess trends, accepting statistical significance at $P < 0.05$. We then calculated the mean number of detections by species or species group by time of day. We categorized images as day if occurring between sunrise to sunset (0650 to 2019 hours) and night as sunset to sunrise (2020 to 0649 hours; SunriseSunset 2013). All means are reported with ± 1 standard deviation.

Results

We obtained 11,194 images, including 10,006 images of animals comprising 3,177 independent detections of at least 19 species (Table 1). White-tailed deer comprised almost half of independent detections (47%), followed by raccoons (24%) and black bears (11%); however, overall nontarget detections were slightly greater (53%). Mean daily detections for white-tailed deer were greater than for other species (1.67 ± 1.0), followed by raccoons (0.76 ± 1.0) and black bears (0.40 ± 0.7 ; Figure 2). Mean daily number of species detected increased through day 9 (1.97 ± 1.2), then declined thereafter ($P < 0.001$; Figure 4). Similarly, mean daily number of white-tailed deer detections increased through day 8 (2.81 ± 2.27), then declined thereafter ($P < 0.001$). White-tailed deer (54%), black bear

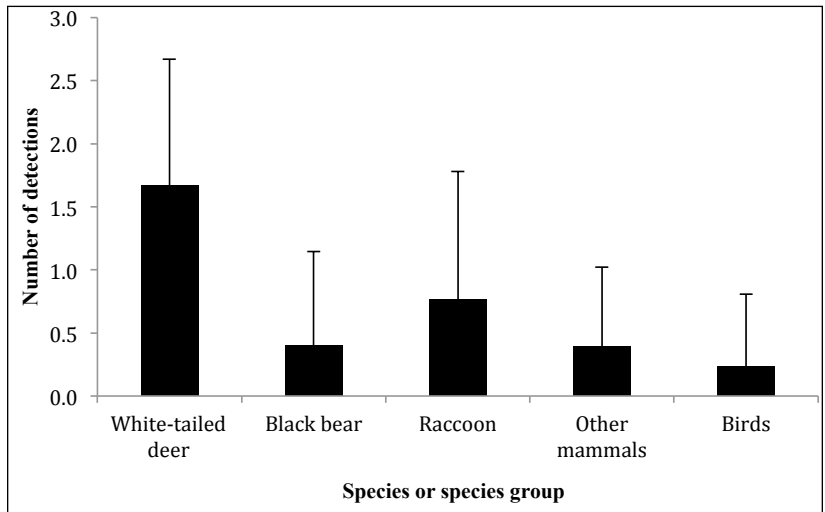


Figure 2. Mean daily number of detections of wildlife at bait sites for white-tailed deer, Upper Peninsula of Michigan, USA, August–September 2012.

(55%), and bird (82%) detections were greater during the day, whereas raccoons (77%) and



Figure 3. Black bear detected at a camera trap site for white-tailed deer.

other mammals (62%) detections were greater at night (Figure 5).

Discussion

Our results show that overall use of bait sites by nontarget species (>20 species) was similar to use by white-tailed deer. Of the ≥21 species observed, mammal detections (93 %, 14 species) were substantially greater than bird detections (7%, 7 species), although some bird-use may have gone undetected due to their small body size. Most nontarget mammal species detected at sites were opportunistic omnivores (e.g., bears, raccoons, coyotes [Barden et al. 1995]), or herbivores (e.g., snowshoe hares [*Lepus americanus*], squirrels [*Sciurus* spp.][O'Donoghue et al. 1997]), undoubtedly a consequence of corn used as bait. We observed an asymptotic increase in the number of species detected and number of white-tailed deer detected per day. The total number of species detected and number of white-tailed deer detections increase

through day nine and day 8, respectively, before declining. Although our study was only 16 days long, Seamans and VerCauteren (2006) also found a decline in white-tailed deer detections at bait sites during week two. As species adapt to using bait, it is likely that the amount of bait consumed by animals arriving at sites immediately following baiting increases, leaving little or no bait remaining for subsequent individuals, which in turn would reduce overall visitation at bait sites (optimal foraging theory [Lozano

1991]). We qualitatively observed increased consumption rates of corn by white-tailed deer immediately following placement through about day nine of the study. Deer-use of sites after bait consumption was low, which explains the observed decreased use of sites after this time.

Species detections by time of day varied and generally supported our predictions and previously described activity patterns, with more detection of white-tailed deer and black bears during the day (Lariviere

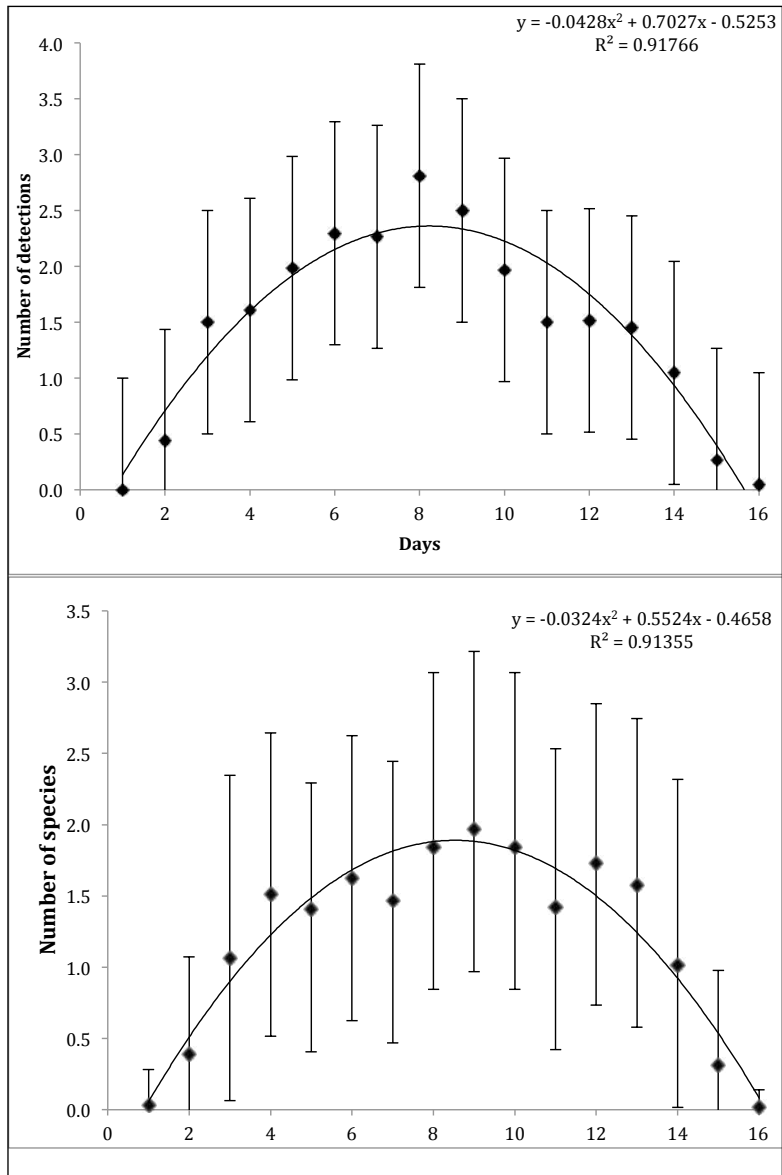


Figure 4. Mean daily number of species detected (a) and white-tailed deer detections at bait sites for white-tailed deer baited on day 0, 3, 6, 9, and 12, Upper Peninsula of Michigan, USA, August–September 2012.

et al. 1994, Kilgo et al. 2008). Our results for predominantly diurnal detections of black bears supports previous studies (e.g., Bridges et al. 2004), and concurs with increased foraging during late summer, though black bears may become more nocturnal during the legal hunting season (Stillfried 2012). Greenwood (1982) documented that nocturnal movements by raccoons were most often associated with locally abundant food, which supports our findings of greater nocturnal use; also, more bird detections during the day are correlated with general foraging behavior (Stouffer and Caccamise 1991, Engels and Sexton 1994).

Baiting can alter the spatial ecology of deer and nontarget species. Wehjte and Gompper (2011) found that raccoons formed aggregations at clumped food resources, with overlapping space use twice that of raccoons without access to these resources. Increased predator-prey interactions at bait sites are also possible (Wehjte and Gompper 2011). Cooper and Ginnett (2000) found that as species aggregate, nest predators may have a greater chance of finding and destroying nests near feeders. Dunn and Tessaglia (1994) found high rates of bird depredation by sharp-shinned hawks (*Accipiter striatus*) and coopers hawks (*Accipiter cooperii*) at anthropogenic food sources. Competition for clumped resources can also increase aggressive behavior among individuals (Desrochers and Hannon 1989, Orams 2002). Albert and Bowyer (1991) found increased aggression of bears at clumped anthropogenic resources. Zenaida doves (*Zenaida aurita*) also showed high rates of aggression at spatially clumped resources (Goldberg et al. 2001). However, baiting also can produce positive effects. Brittingham and Temple (1988) found that black-capped chickadees (*Parus atricapillus*) gained body mass and increased survival in areas with supplemental feed (Lambert and Demarais 2001). Benson and Chamberlain (2006) found that corn can represent a high proportion of summer and autumn diets of black bears; concentrated anthropogenic foods at bait sites

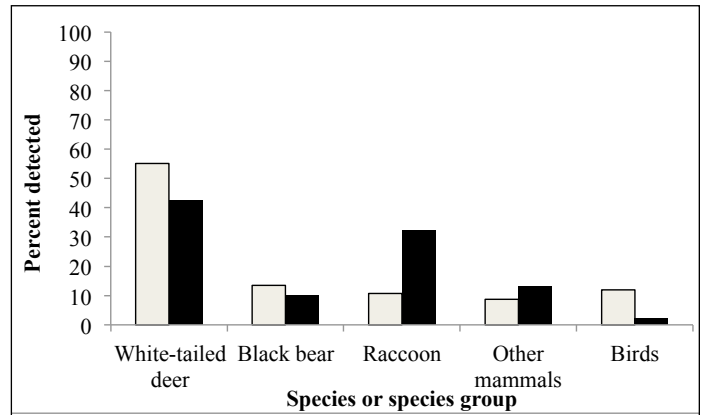


Figure 5. Percentage of detections during day (white) and night (black) for wildlife at bait sites for white-tailed deer, Upper Peninsula of Michigan, USA, August–September 2012.

can improve physiological condition in black bears (e.g., Partridge et al. 2001).

Along with altered species ecology, potential for disease transmission can also increase among target and nontarget species at bait sites (Brown and Cooper 2006, Sorenson et al. 2014). Campbell et al. (2013) estimated >5.2 billion contacts among nontarget wildlife species occur annually in Texas, where baiting is a common and legal hunting practice. These authors recommended against maintaining bait sites due to risk of disease transmission. Contact between domestic cattle and white-tailed deer at food resources has resulted in transmission of bovine tuberculosis (Schmitt et al. 2006, Ramsey et al. 2014). When aggregated raccoons interact at bait sites, parasites and rabies can be transferred among individuals (Wright and Gompper 2005). Daoust et al. (2000) documented salmonella at concentrations of black-capped chickadees related to activity at feeders. In addition to direct transmission of diseases, Lambert and Demarais (2001) found that baiting multiple species can cause fecal contamination of bait which poses a health risk.

Management implications

Baiting is used extensively to attract wildlife to areas for hunting and observation (Kilpatrick and Stober 2002). Although there are positive effects of baiting (Robb et al. 2008, Robb and McDonald 2008, Nestler 1949, Benson and Chamberlain 2006), negative effects, including altered species ecology and disease, can also occur after disease transmission. Research

assessing types of bait (Taylor et al. 2013) or techniques to distribute baits to reduce use by nontarget species and potential interactions among individuals and techniques is warranted. Wildlife officials and policy makers should consider the potential positive and negative implications on target and nontarget species ecology of baiting white-tailed deer.

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BRENT BOWMAN (author photos unavailable) is a research technician in the Department of Wildlife, Fisheries, and Aquaculture with the Carnivore Ecology Laboratory at Mississippi State University. He received his B.S. degree from Mississippi State University. His research interests include carnivore ecology, human–wildlife conflicts, and habitat management.

JERROLD L. BELANT is an associate professor in the Department of Wildlife, Fisheries, and Aquaculture and director of the Carnivore Ecology Laboratory at Mississippi State University. He received his B.S. and M.S. degrees from the University of Wisconsin–Stevens Point and his Ph.D. degree from the University of Alaska–Fairbanks. His research interests include carnivore ecology, resource selection, human–wildlife conflicts, and international conservation.

DEAN E. BEYER JR. is a wildlife research biologist for the Michigan Department of Natural Resources and adjunct professor in the Department of Fisheries and Wildlife, Michigan State University. He received his B.S. degree in wildlife biology from the University of Vermont and his M.S. and Ph.D. degrees in wildlife ecology from Michigan State University. His research interests include population dynamics of large mammals, abundance estimation, and predator–prey interactions.

DEBORAH MARTELL worked as a research associate for the Michigan Predator-Prey Project from May 2012 through May 2014. She earned her B.S. degree in natural resource conservation at the University of British Columbia and worked as a wildlife technician on various projects throughout North America. Her research interests include animal behavior and international conservation.