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Deer response to exclusion from stored cattle feed in Michigan, USA

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ABSTRACT

Disease and damage from white-tailed deer (*Odocoileus virginianus*) continually threaten the livelihood of agricultural producers and the economy in the United States, as well as challenge state and federal wildlife managers. Threats can be partially addressed by excluding free-ranging deer from livestock-related resources. Throughout the year, use of stored livestock feed by deer in northern Lower Michigan (MI), USA fluctuates, though their presence is relatively consistent. Since 2008, use of livestock areas and resources by deer has been reduced through intensive efforts by livestock producers in cooperation with state and federal agencies. These efforts focused on excluding deer from stored cattle feed in areas where deer were abundant. We monitored deer activity from Jan 2012 to June 2013 on 6 cattle farms in northern MI using GPS collars to evaluate behavioral effects of excluding deer from stored feed. We characterized areas deer occupied before and after installing 2361 m of fences and gates to exclude deer from stored cattle feed. Following fence installation, 9 deer previously accessing stored feed shifted to patterns of habitat use similar to 5 deer that did not use stored feed. However, continued attempts to regain access to stored feed were made at low frequencies, emphasizing the need to maintain the integrity of fences and keep gates closed for damage prevention and biosecurity.

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1. Introduction

Wildlife species frequently exploit accessible high-quality feed destined for livestock (VerCauteren et al., 2003; Atwood et al., 2009; Tsukada et al., 2010). Contamination of livestock feed by wildlife often occurs as well, rendering feed unusable and creating a source for dissemination of pathogens (Daniels et al., 2003; VerCauteren et al., 2003; Tsukada et al., 2010). A primary concern of livestock producers and wildlife managers in northeastern Lower Michigan (MI), USA is the potential for contamination of stored feed with bovine tuberculosis (bTB) bacteria (*Mycobacterium bovis*) by infected white-tailed deer (*Odocoileus virginianus*; Palmer et al., 2004a,b; Knust, 2008).

Many methods for deterring deer exist, though relative levels of efficacy vary considerably along with associated costs, maintenance, longevity, and ease of use (VerCauteren et al., 2006a,b, 2008; Brook, 2010). The level of motivation of deer to breach exclusionary installations usually is the primary factor in resulting efficacy (Gilsdorf et al., 2002; VerCauteren et al., 2006a, 2010; Lavelle et al., 2010). During winter and other periods of increased nutritional needs (i.e., parturition, gestation), deer become highly motivated to gain access and consume feed stored for cattle, focusing on feed of high nutritional value (VerCauteren et al., 2003; Knust, 2008). To minimize access to high quality feed by deer, various proven fence designs are available (VerCauteren et al., 2006a; Knust, 2008; Lavelle et al., 2010). We assessed the effects of installing exclusionary fences around stored cattle feed by monitoring deer visitation rates to these sites as well as in adjacent land cover types before and after installation. Our objectives were to: (1) evaluate the efficacy of exclusionary fences on deer activity at the stored feed, and (2) examine whether the fences caused shifts in deer home range size or land cover usage patterns.

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2. Materials and methods

2.1. Study area

We conducted our study on 6 privately owned cattle operations in the northeastern Lower Peninsula of MI, USA within Montmorency, Presque Isle, and Alpena Counties. Average size of cattle operations was 169 ha (SD = 73.84) and 210 cattle (SD = 222.13). This area was within the core endemic area of bTB in MI (Walter et al., 2012; Berentsen et al., 2013) and provided highly suitable habitat for deer (Felix et al., 2007). We condensed land cover types in our study areas into five classes: (1) stored feed, including all developed areas associated with stored feed sites; (2) farmyard, including roads, buildings, animal pens, and residential homes; (3) cattle pasture, including grassy areas devoted to cattle grazing; (4) natural areas, including upland and lowland forests, wetlands, and shrub or scrub stands, and (5) crops, including all row crops and alfalfa. Although livestock production occurs in this area, densities were low, only averaging 1 beef-cattle farm per 21.5 km^2 and 1 dairy-cattle farm per 130.0 km^2 (Berentsen et al., 2013). Elevations range from 150 to 390 m above sea level with annual precipitation averaging 72.5 cm of rain and 175 cm of snow (Sitar, 1996). Winter snow depths seldom exceed 50 cm, usually melting by mid-April (Beyer et al., 2010). Weather in this region was notably more variable than elsewhere in the state with average summer temperatures of 24.8 °C and average winter temperatures of −10.8 °C (Sitar, 1996). Regional deer densities were estimated at 10 deer/km^2 (O'Brien et al., 2011), although concentrations of deer around accessible food during winter reached 19 deer/km^2 (Beyer et al., 2010) and have been reported as high as 35 deer/km^2 (Sitar, 1996). In conjunction with the estimated deer densities the apparent bTB prevalence rates in deer in the region fluctuated around 2% (O'Brien et al., 2011).

3. Fence design and construction

Experimental treatments in the form of exclusionary gates and fences were installed around stored livestock feed accessible to deer at all study sites, thus applied to all study animals within the vicinity. More specifically, we constructed fences or installed gates on existing structures to enclose stored feed and exclude deer ("exclosure" hereafter). A fence contractor prepared all sites and installed posts prior to installing fence to facilitate simultaneous construction of fences across sites and to minimize potential confounding factors such as weather. All fence installation was completed in January 2013 after deer use of stored feed had been documented.

Construction and design varied to fit requirements unique to each site and cattle producer. Fence material (Black Plastic Net; Kencove Farm Fence Supplies, Blairsville, PA) was provided to cooperating producers at no cost. If producers elected to install a more permanent fence, they could substitute woven-wire mesh (i.e., Solidlock® Game Fence 2096-6; Bekaert, Marietta, GA) at their expense. We installed plastic mesh fences at 2.0-m high (with 0.1-m fence material draped on ground outside the stored feed to deter entry) and woven-wire mesh tight to the ground and 2.4-m high. We attached plastic mesh with hog rings at 1-m increments to 12-ga high-tensile-steel wire run at ground level, 0.9 m, and 2.0 m. Having sufficient rigidity, woven-wire mesh was attached directly to wood posts with 4-cm galvanized-steel staples. Gate and corner posts, as well as in-line h-braces (every 100 m) were constructed of treated wooden posts (10.2-cm or 15.2-cm square and 3.0-m long) set 0.6-m deep in concrete 3-m apart and connected by horizontal 10.2-cm square posts with diagonal wire strainers. Gates were fabricated by a local contractor and consisted of 2.13-m tall welded 3.5-cm diameter galvanized-steel pipe frames covered with woven-wire mesh. Following installation, we conducted weekly inspections of fences at each site and made necessary adjustments and repairs as needed.

4. Site-specific details

Site 1: We constructed a 491-m long, 2.4-m tall, woven-wire mesh fence (1.16-ha) on 23 January 2013 to protect high moisture corn, silage, and round hay bales. Land cover types adjacent to the farm were dominated by: 47% natural areas and 43% crops.

Site 2: We installed six 2.3-m tall gates on a pre-existing 0.04-ha metal pole barn on 24 January 2013 to protect round hay bales. Land cover types adjacent to the farm were dominated by: 65% natural areas and 32% crops.

Site 3: We constructed a 709-m long, 3.10-ha, 2.0-m tall plastic mesh deer fence on 19 January 2013 to protect high moisture corn, haylage, and silage. Land cover types adjacent to the farm were dominated by: 53% natural areas and 41% crops.

Site 4: We constructed a 623-m long, 1.48-ha, 2.0-m tall plastic mesh deer fence on 30 January 2013 to protect high moisture corn, haylage, round hay bales, and silage. Land cover types adjacent to the farm were dominated by: 53% crops and 45% natural areas.

Site 5: We constructed a 709-m long, 3.10-ha 2.0-m tall, plastic mesh deer fence on 15 January 2013 to protect silage, beets, and potatoes. Land cover types adjacent to the farm were dominated by: 71% natural areas, 15% crops, and 13% cattle pasture.

Site 6: We completed (added 2 gates) a pre-existing 623-m long, 1.48-ha, 2.3-m tall 4-strand electrified poly-rope fence on 30 January 2013 to protect round hay bales. Land cover types adjacent to the farm were dominated by: 71% natural areas and 28% crops.

5. Deer capture and monitoring

Movements of deer were monitored before and after fence installation to evaluate behavioral effects of excluding them from stored feed resources. To achieve this, we captured and collared free-ranging adult female deer with netted cage traps (VerCauteren et al., 1999), air-cannons (Schemnitz et al., 2009), and remote chemical immobilization (Kilpatrick et al., 1997) primarily in January of 2012 and 2013, though also as needed throughout the study to maintain ≥3 collared deer per site. Trap locations were dispersed across suitable habitat on each farm, thus all deer were considered potential study animals. Collared deer were located weekly with very high frequency (VHF) receivers and observed when possible to ensure good health and collar fit was maintained throughout the study. We used VHF-equipped GPS collars (TGW-4501, Telonics, Inc., Mesa, AZ) to record locations of deer every 2 h for the duration of the study and used programmed collar-release mechanisms (CR-2a, Telonics, Inc., Mesa, Arizona, USA) to facilitate data retrieval at the conclusion of the study. Accuracy testing of GPS collars at a fixed location (n = 348 fixes) revealed a median position error of 8.5 m and a 95% circular error of probability of 21.4 m. All procedures were approved by the Institutional Animal Care and Use Committee of the U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Wildlife Services-National Wildlife Research Center (USDA-APHIS-WS-NWRC, QA-1940) and conducted under Michigan Department of Natural Resources Scientific Collector's Permit SC1455.

6. Data processing

We focused all analyses to within 120 days before and 120 days after installation of fences. We also ran all of our analyses with 30-day periods before and after fence installation to determine if