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Prescribed fire affects female white-tailed deer habitat use during summer lactation

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ABSTRACT

Prescribed fire commonly is used to manage habitat for white-tailed deer (*Odocoileus virginianus*). Although the effects of fire on forage availability for deer have been studied, how female deer use burned areas is not well known, particularly as it relates to fire season and the years-since-fire. We used GPS tracking data from 16 adult female white-tailed deer to assess the effects of fire season and years-since-fire on habitat use during summer lactation. Females selected unburned drainages and older (>1 yr-since-fire) burned areas, and avoided recently burned areas. Individuals with a greater percentage of their summer core area burned expanded the size of their summer home range but did not change summer core area size. Furthermore, summer core area site fidelity (i.e., % overlap between 2011 and 2012 core areas) decreased as the percentage of the 2011 summer core area burned in 2012 increased. Female deer increased selection of burned areas as years-since-fire increased, likely because there was a temporary loss of cover immediately following fire with plants slowly regenerating the subsequent growing seasons. Likewise, to avoid areas depleted of cover, females shifted their core areas away from recent burns when possible but increased their core area size when burned areas were unavoidable (i.e., a large portion of their home range was burned). Burning large contiguous areas may initially have a negative effect on female deer during lactation because of the depletion of cover.

1. Introduction

Prescribed fire commonly is used in the longleaf pine (*Pinus palustris*) ecosystem (LLPE) for restoration and maintenance of plant communities and fire-dependent fauna (Aschenbach et al., 2010; Beckage et al., 2005; Fill et al., 2012; Van Lear et al., 2005). Fire-related research often has focused on the appropriate season, application techniques, and frequency of fire (Aschenbach et al., 2010; Beckage et al., 2005; Fill et al., 2012; Lashley et al., 2014a; Stambaugh et al., 2011; Van Lear et al., 2005). However, few studies have reported adaptations of fauna following fire and little is known about the effects of fire season and frequency on some fauna.

Growing-season fire (i.e., May and June) in the LLPE overlaps the lactation period of white-tailed deer (*Odocoileus virginianus*; hereafter deer). Thus, reproductive females may be sensitive to growing-season fires because the lactation period is the most nutritionally stressful period for white-tailed deer (Hewitt, 2011). Additionally, female deer may be negatively affected by growing-season fires during lactation if available cover declines (McCord et al., 2014), because lactating females require dense cover for protection from predators (Kie and Bowyer, 1999; Naugle et al., 1997). Alternatively, female deer may be positively affected by growing-season fire because young, regenerating plant growth stimulated by fire is more palatable and higher in nutrients than older plant tissue (Jones and Case, 1990; Leigh et al., 1991; Lewis et al., 1982; Wood, 1988). Furthermore, fire can increase forage availability for several growing seasons after the fire (Edwards et al., 2004; Lashley et al., 2011; Masters et al., 1993, 1996).

Few studies have directly evaluated the effects of prescribed fire on deer habitat use. Ivey and Causey (1984) reported deer avoided recently burned areas in the same year as the fire in favor of unburned drainages, unless fire spread through the area in a mosaic configuration and retained some cover. However, they

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had a small sample size (2 individuals). Meek et al. (2008) reported no selection for burned areas in Texas, but concluded drought conditions during their study hindered regeneration of high-quality forbs, and thus negated the expected benefit of the burn to deer. Hence, because of small sample sizes and confounding weather conditions, little information exists on how deer respond to fire. Moreover, to our knowledge, no information exists on the influence of season of fire and years-since-fire on deer selection of burned areas, which is important because season and timing can be manipulated within a prescribed fire management plan.

Given the importance of fire in many ecosystems (Bowman et al., 2009) and the ecological and economic importance of white-tailed deer (Waller and Alverson, 1997), we measured the movement of female deer following fire in the LLPE. We hypothesized that female deer would select more recently burned areas to take advantage of the high-quality forages expected to regenerate following fire. To test this hypothesis, we evaluated the effects of fire season and years-since-fire on burned area selection, space use (i.e., 95% home range and 50% core area sizes), and core area site fidelity (i.e., area of overlap in core area between years). Furthermore, we evaluated the effects of percent summer home range and core area burned on the amount of space used by female deer and site fidelity of core areas across years.

2. Materials and methods

2.1. Study area

We conducted our study at Fort Bragg Military Installation, a 73,469-ha property owned by the U.S. Department of Defense and located in the Sandhills physiographic region in the LLPE of central North Carolina. Uplands were dominated by longleaf pine forests and managed with growing-season prescribed fire on a 3-yr fire-return interval (Lashley et al., 2014a). Some areas are missed during the targeted burn year and burned in the following dormant season (December–March). Treating missed areas in this manner results in a small area of the study site (i.e., ~15% during the study period) burned greater than 3 years prior and burned during the dormant season. Densely vegetated (primarily *Lyonia* spp. and *Ilex* spp.) drainages were interspersed throughout the landscape and infrequently burned because of moisture. Deer population density was low (3–5 deer/km^2), and harvest records corrected for hunter effort indicated the deer population declined from 1989 to present (Lashley et al., 2015), commensurate with the initiation of the current growing-season dominated fire regime at Fort Bragg (Cantrell et al., 1995).

2.2. Deer capture

We captured 16 female deer ⩾1.5-year-old using tranquilizer guns, January–May, 2011. We used Telazol (5 mg/kg; Midwest Veterinary Supply, Burnsville, MN), xylazine hydrochloride (2.5 mg/kg; Congaree Veterinary Pharmacy, Cayce, SC), and ketamine hydrochloride (5 mg/kg; Midwest Veterinary Supply, Burnsville, MN) in 2-cc transmitter darts. We fit 200-g tracking collars (Wildcell, Lotek Wireless Inc., Newmarket, Ontario, Canada) and ear tags on each individual. At 80-min post-injection, we reversed the xylazine hydrochloride with tolazoline hydrochloride (10 mg/kg; Midwest Veterinary Supply, Burnsville, MN) and visually monitored the deer from a distance until full recovery. The tracking collars transmitted global positioning system relocations to a remote site via the short messaging service network. All data were uploaded to Movebank (www.movebank.org) (Wikelski and Kays, 2014). In Movebank, we censored data that were obvious collar error (e.g., positions outside the continental United States) as well as data from first 2 weeks of deployment (~3% of locations) because of potential capture bias to movements (Quinn et al., 2012). Deer capture and handling protocols were approved by the North Carolina Wildlife Resources Commission and the North Carolina State University Institutional Animal Care and Use Committee (10-143-O).

2.3. Fire data

We categorized all portions of the study area based on fire history using a Geographic Information System and data provided by Fort Bragg. We designated 10 categories based on the last fire occurrence: (1) same year as a growing-season fire (April–June; 0yrG); (2) same year as a dormant-season fire (December–March; 0yrD); (3) 1 year post growing-season fire (hereafter 1yrG); (4) 1 year post dormant-season fire (1yrD); (5) 2 years post growing-season fire (2yrG); (6) 2 years post dormant-season fire (2yrD); (7) 3 years post growing-season fire (3yrG); (8) 3 years post dormant-season fire (3yrD); (9) 4 or more years post growing-season fire (4yrG); and (10) the drainages that were rarely or never burned and generally contained relatively dense cover (Fig. 1). We distinguished each season and year-since-fire as its own category because managers set fire prescriptions on a yearly and seasonal scale. Fort Bragg has an extensive manmade firebreak network, which parcels burned areas into individual units about 43 ha in size (Lashley et al., 2014a).

2.4. Summer home range and core area calculation

We used the adehabitat package (Calenge, 2006) of R statistical software version 3.0.1 (R Foundation for Statistical Computing, Vienna, Austria) to calculate a summer 95% home range (hereafter home range) and summer 50% core area (hereafter core area) using the classical kernel method for each individual for each 3-month summer season (Worton, 1989). We imported each home range and core area into ArcMAP 10.0 (ESRI, Redlands, California) and overlaid each with the 10 delineated burn categories. We used the Geographical Information System to calculate the area of the 2011 and 2012 home ranges and core areas, the percentage of core areas overlapping between years (i.e., site fidelity), the change in size of home ranges and core areas from 2011 to 2012, the percentage of the 2011 home ranges and core areas that were burned in 2012, and the percentage of each burn classification (i.e., 0yrG–4yrG and 0yrD–3yrD) in the home range by individual each year (Fig. 1). Also, we calculated the percentage of relocations occurring in each burn classification each year.

2.5. Data analysis

To determine selection of burn category by female deer, we calculated use (percentage of relocations in each burn category) versus availability (percentage of the 95% home range in each burn category) and performed a compositional analysis in the R statistical software (Aebischer and Robertson, 1992; Aebischer et al., 1993). We assumed the diel period did not influence deer selection of burned areas (Meek et al., 2008) or general use of some areas for cover or foraging (Coulombe et al., 2011) and did not stratify relocations by time of day. Additionally, we wanted to determine how individuals responded to newly burned areas in their core area and home ranges. Therefore, we fit standard least squares regression models to determine if newly burned areas affected site fidelity of core areas and change in size of the home range and core area from 2011 to 2012, using the percentage of the 2011 home range and core area burned in 2012, and the percentage of the 2012 home range and core area burned in 2012 as predictor variables. Also, we fit standard least squares regression models to determine