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Investigation of Adult Male White-tailed Deer Excursions Outside Their Home Range

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and Mark C. Conner³

Abstract - Although male and female *Odocoileus virginianus* (White-tailed Deer) exhibit high site fidelity throughout the year, individuals occasionally leave their home ranges on short excursions during the fall and winter months. Although motives for these extraneous movements are difficult to discern, excursions are likely the function of the breeding season, food sources, limited escape cover, and/or human disturbances. From 2003–2007, we examined GPS collar locations of 32 adult male White-tailed Deer at Chesapeake Farms, MD. Seasonal excursions ($n = 37$), defined as movements lasting a minimum of 6 hours and venturing at least 0.5 km from 95% kernel home-range contours, were examined relative to possible motives related to food resources, breeding, and hunting pressure. Sixty-three percent ($n = 20$) of adult males made at least one excursion outside their home range immediately before or during breeding season. Based on the seasonal timing of excursions, breeding-season-related motives were likely the driving force behind the majority of adult male White-tailed Deer excursions, whereas hunting pressure and food resources were not a probable cause.

Introduction

GPS data from previous research conducted at Chesapeake Farms, MD, indicated that some male *Odocoileus virginianus* (White-tailed Deer) traveled significant distances outside their normal home range for periods lasting between 6–28 hours, with most excursions occurring immediately before and during the fall breeding season (Tomberlin 2007). Just before breeding season, male activities intensify (i.e., rubbing, scraping, sparring, and searching for estrous females) and movement and home ranges increase (Guyse 1978, Hawkins and Klimstra 1970, Hosey 1980, Tomberlin 2007). Additionally, White-tailed Deer may temporarily leave their home range to avoid hunting pressure and other disturbances (Hood and Inglis 1974, Naugle et al. 1997, Vercauteren and Hygnstrom 1998). Dispersal movements are predominantly made by juvenile (1.5-year-old) male White-tailed Deer and result in permanent emigration (Brinkman et al. 2005, McCoy et al. 2005, Rosenberry et al. 1999, Shaw 2005), whereas excursions are temporary movements outside an established home range.

As estrus approaches, females concentrate movement and scent markings within their core areas (Fraser 1968, Holzenbein and Schwede 1989, Ivey and

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Causey 1981, Marchinton 1968, Nelson and Mech 1981), which may increase the chance of males detecting females by focusing activities within a small area (Holzenbein and Schwede 1989, Ozoga and Verme 1975). As females enter estrus, males stimulated by olfactory and behavioral cues instigate male-male competition (Cox and Boeuf 1977) and separate individual females from the matriarchal herd and tenaciously follow them for 1–6 days (Brown 1971, Crawford 1962, Hawkins and Klimstra 1970, Holzenbein and Schwede 1989). By luring courting males into a chase and venturing outside her core area, females might attract attention from other potential mates. Once engaged in the chase, males might easily be led outside their home range and into unfamiliar territory, possibly bringing multiple males together and stimulating intrasexual competition (Cox and Boeuf 1977, Emlen and Oring 1977). After being tended and bred, females will decrease activity, return to core areas, and resume normal levels of movement and activity (Cox and Boeuf 1977, Holzenbein and Schwede 1989, Ozoga and Verme 1975). However, females not bred might initiate a search strategy to find a mate during her 24-hour window of receptivity (Ozoga and Verme 1975). Excessive movement of females during the rut might indicate poor male breeding performance in a herd (Holzenbein and Schwede 1989) or may be a byproduct of extremely low deer densities where the odds of two deer encountering one another are small (D'Angelo et al. 2004). In rare instances, females may make excursions outside their home range during the breeding season even with abundant mature males in the population (Kolodzinski 2008).

Excursions by adult male White-tailed Deer are not easily studied because of their unpredictability and difficulty of detection using conventional radio telemetry equipment. Excursions may represent exploratory searches for estrous females (Guyse 1978, Hawkins and Klimstra 1970, Hosey 1980, Moore and Marchinton 1974), a new food source, or may be a male chasing an unreceptive female (Richardson and Petersen 1974), a male being led by an estrous female back to her core area (Cox and Boeuf 1977, Holzenbein and Schwede 1989), a male leading a receptive mate away from intrasexual breeding competition (Moore and Marchinton 1974), or female incitation of male competition (Cox and Boeuf 1977). However, excursions by adult males are not fully understood and may not be limited to these motives. Hence, our objectives were to describe adult male White-tailed Deer excursions during the fall and winter of 2003–2007 at Chesapeake Farms and compare male and female movements to identify simultaneous overlapping excursions.

Field-Site Description

We conducted the research at Chesapeake Farms located on the Eastern Shore of the Chesapeake Bay in Kent County, MD, 10 km southwest of Chestertown (39°10'N, 76°10'W), with a mean elevation of 13 m above sea level (McLeod and Gates 1998). Owned and operated by DuPont Agricultural Enterprise, Chesapeake Farms was a 1300-ha wildlife management and agricultural research demonstration area. Approximately 50% of the study area was forested with non-alluvial swamps that consisted primarily of *Quercus* spp. (Oaks), *Liquidambar*

styraciflua L. (Sweetgum), *Nyssa sylvatica* Marsh. (Black Gum), and *Acer rubrum* L. (Red Maple). *Smilax* spp. (Greenbriar), *Clethra alnifolia* L. (Sweetpepper Bush), and *Vaccinium corymbosum* L. (Highbush Blueberry) dominated the understory. Cash crops (*Zea mays* L. [Field Corn], *Glycine max* (L.) Merr. [Soybeans], and *Triticum* spp. [Winter Wheat]) composed 20% of the study area. Fallow fields composed 13% of the farm (*Dactylis glomerata* L. [Orchard Grass], *Trifolium* spp. [Clover], *Sorghum* spp. [Sorghum], and *Lolium multiflorum* Lam. [Rye]). The remaining 17% was composed of nonforested wildlife cover and manmade waterfowl impoundments (Shaw 2005).

Shaw (2005) estimated deer density to be 33 deer/km², and the majority of deer harvest occurred during Maryland's two-week shotgun season from the first Saturday after Thanksgiving for two continuous weeks. Because of initial antler-harvest restrictions (≥ 7 points) implemented in 1994 and more stringent criteria (≥ 40 cm outside antler width) enforced in 1997, male age class structure on Chesapeake Farms shifted from a traditional harvested population (mostly 1.5-year-old males) to predominantly ≥ 2.5 -year-old males (Shaw 2005). The fall 2007 male:female ratio estimate was 1:1.5 and has remained biologically stable since 2002, when intensive doe harvest to curb excessive crop depredation ceased (M. Conner, Chesapeake Farms, Chestertown, MD, unpubl. data).

Methods

From June–August 2003–2007, we captured 32 (2003 [$n = 3$], 2004 [$n = 3$], 2005 [$n = 9$], 2006 [$n = 10$], and 2007 [$n = 7$]) adult male (≥ 2.5 years old) White-tailed Deer. In the field, we estimated deer age using antler and body characteristics (Richards and Brothers 2003). We used a Dan-Inject JM Standard dart projector (Dan-Inject, Inc., Fort Collins, CO) and 3-ml radio transmitter darts (Pneu-dart, Inc., Williamsport, PA) to administer anesthetic drug combinations of 2.4 ml Telazol (200 mg/ml; Fort Dodge Animal Health, Fort Dodge, IA) and 0.6 ml Xylazine (450 mg/ml; Wildlife Laboratories, Inc., Fort Collins, CO) (Kreeger et al. 2002) or 0.5 ml Medetomidine (20 mg/ml; Wildlife Laboratories, Inc., Fort Collins, CO), 1.0 ml Ketamine (200 mg/ml; Fort Dodge Animal Health, Fort Dodge, IA) and 1.4 ml Telazol (200 mg/ml) (Muller et al. 2007). The transmitter dart allowed us to track the deer using radio telemetry equipment (Telonics, Inc., Mesa, AZ). If the animal was not fully sedated when located, we administered an additional 1.1 ml Ketamine (200 mg/ml) booster intramuscularly.

Once fully immobilized, we applied eye ointment (Paralube, Pharmaderm, Melville, NY) to prevent corneal drying and blindfolded the animal to minimize stress. The deer were positioned sternally or on their right side for processing. We monitored vital signs (open airway, pulse, respiration, temperature) initially and every 15 minutes throughout the procedure. We surgically removed darts, flushed the puncture with Betadine (Purdue Pharma, L.P., Stamford, CT), and applied antibiotic cream (Farnam Companies, Inc., Phoenix, AZ) to the wound. A broad-spectrum antibiotic (i.e., LA 200; 1 ml/11.34 kg; Pfizer Animal Health, Exton, PA) was administered intramuscularly to two sites in the hindquarter. We fitted each deer with a Lotek 3300L GPS collar (Lotek Engineering, Newmarket, ON,

Canada) and tightened them within 8 cm of the neck to accommodate neck swelling associated with breeding season. Although each collar was equipped with a 32-week time-delay release mechanism, a remote release mechanism allowed us to disengage the collar in case of emergency. To assist in field identification, each deer received colored and numbered cattle ear tags (National Band and Tag, Co., Newport, KY). Also, we placed uniquely numbered Monel tags (National Band and Tag, Co., Newport, KY) in both ears.

At 70 minutes post injection, we reversed Xylazine/Telazol anesthetized deer with 3.3 ml Tolazoline (100 mg/ml; Lloyd Laboratories, Shenandoah, IA), half intramuscularly and half intravenously. We used 10.0 ml atipamezole (5 mg/ml; Pfizer Animal Health, Exton, PA) to intramuscularly reverse deer anesthetized with Medetomidine/Ketamine/Telazol. Seventy minutes was adequate time for the Telazol and/or Ketamine to dissipate from the deer and eliminate the risk of anesthetic relapse (Tomberlin 2007). We monitored deer until they were capable of independently leaving the processing site. The research protocol was reviewed and approved by the Institutional Animal Care and Use Committee at North Carolina State University (#05-024-0).

We programmed 3300L Lotek GPS collars to collect hourly fixes from June–February 2003–2007, 20 minute fixes from 5 November–12 December 2006, and 5-minute fixes from 15 October–15 December 2007. GPS collars recorded geographic coordinates, date, time, environmental temperature, fix status, and a position dilution of precision (PDOP) value with each fix. Collars were equipped with a mortality sensor that triggered after 8 hours of inactivity and emitted a double pulse VHF signal. To ensure collars were properly functioning and study animals were alive, deer were monitored twice weekly using radio telemetry equipment.

To delete possible erroneous fixes from the dataset, we filtered fixes through a pre-determined set of quality-control screenings and omitted all three dimensional (3D) fixes with PDOP > 10 and two dimensional (2D) fixes with PDOP > 5 from analyses (Adams 2003, D'Eon and Delparte 2005, Tomberlin 2007). In addition to the PDOP filter, we omitted all fixes with altitudes outside the range of -100 m to 100 m (D'Eon and Delparte 2005, Tomberlin 2007). Also, we removed malfunctioned fixes as indicated by VHF pulse rates or absent VHF signal (Tomberlin 2007).

After data censoring, we imported GPS fixes for each deer into ArcMap 9.2 (Environmental Systems Research Institute, Inc., Redlands, CA). We projected all data in Universal Transverse Mercator (UTM) North American Datum (NAD) 1983 Zone 18 North (m). We used top-hour fixes from 7 days post capture to the end of the data-collection period to generate fixed kernel home ranges (95%) using Kernel Density Estimator and Percent Volume Contour in Hawth's Analysis Tools (Beyer 2004). We chose a smoothing parameter (200) based on close examination of a wide range of possible values and comparing corresponding polygons to true distribution of GPS fixes (Laver 2005).

We documented excursions outside of the fixed kernel home ranges (95% volume) and required movements to exceed 0.5 km from the home-range contour, encompass six or more continuous hours, and occur between 24 September and

the collar release date (individual specific). Each movement was classified as either exhibiting continuous movement throughout the excursion or including a period of little to no movement (≥ 3 hours) during the excursion outside the animal's home range. Repeated excursions by the same individual were noted and analyzed independently. We omitted adult male White-tailed Deer movements transiting between disjunct home ranges.

We defined 24 September–14 October as fall, 15 October–4 November as prebreed, 5 November–25 November as breeding, 26 November–16 December as postbreed, and 17 December–collar release date as winter. During 2003–2007, the Maryland two-week firearms season was conducted from 29 November–13 December, 27 November–11 December, 26 November–10 December, 25 November–9 December, and 24 November–8 December, respectively (Tomberlin 2007). Specific motives for adult male White-tailed Deer excursions included food-resource explorations (fall, postbreed, and winter), searching for receptive females (prebreed and breeding), chasing females (prebreed and breeding), breeding estrous females (breeding), or hunting-avoidance movements (firearms season).

During May–August 2006, 14 female White-tailed Deer (>1.5 year old) were captured (same protocol as male White-tailed Deer) with 1.6 ml Telazol (200 mg/ml) and 1.4 ml Xylazine (200 mg/ml) (reversal: 4 ml of 100 mg/ml Tolazoline) and collared with Televilt Tellus Basic GPS collars (Televilt/TVP Positioning AB, Lindesburg, Sweden) to study movement during the breeding and fawning seasons (Kolodzinski 2008). GPS collars were programmed to collect 45-minute-interval (1 October–31 January and 1 April–31 July) and 1-hour-interval (1 February–31 March and August 1–September 30) fixes for 365 days following deployment (Kolodzinski 2008). To further investigate adult male excursions during the White-tailed Deer breeding season, we compared female movements to adult male excursions during the prebreed and breeding periods by overlaying GPS fixes in ArcMap 9.2.

Results

Thirty-seven adult male White-tailed Deer excursions were documented, with the highest number ($n = 14$) occurring during the breed period (Fig. 1). Mean minimum distance traveled was 778 m ($SE = 293$ m), with a range of 506–1500 m (median = 665 m). Mean excursion duration was 10.5 hours ($SE = 6.2$ hours), with a range of 6–40 hours. Fifty-nine percent ($n = 22$) of excursions occurred during the combined prebreed and breeding periods. Although the number of study animals steadily decreased because of mortality or collar malfunction, 63% ($n = 20$) of the adult males made at least one excursion (Fig. 2). Interestingly, 41% ($n = 15$) of excursions were characterized by continuous movement (Fig. 3), and 59% ($n = 22$) by periods of little to no movement (Fig. 4). Also, 59% ($n = 22$) of excursions occurred at least partially during daylight hours. During Maryland's two-week firearms season, we documented five excursions (2003 [$n = 1$], 2004 [$n = 1$], 2005 [$n = 2$], and 2007 [$n = 1$]). On three occasions (during prebreed period [$n = 1$] and breeding period [$n = 2$]), males made repeat excursions to the same locations. None of the 37

adult male excursions followed the same movement paths at the same time as any of the collared female White-tailed Deer.

Discussion

A total of 63% of the GPS-collared adult male White-tailed Deer on Chesapeake Farms made excursions outside of their home range. Because the majority

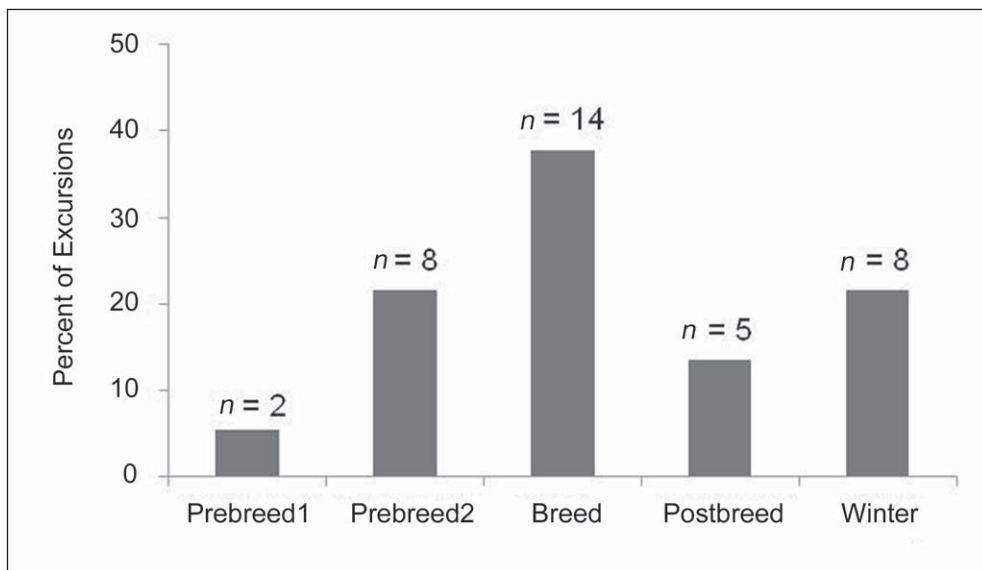


Figure 1. Percent of adult male White-tailed Deer excursions by breeding period, Chesapeake Farms, MD, 2003–2007.

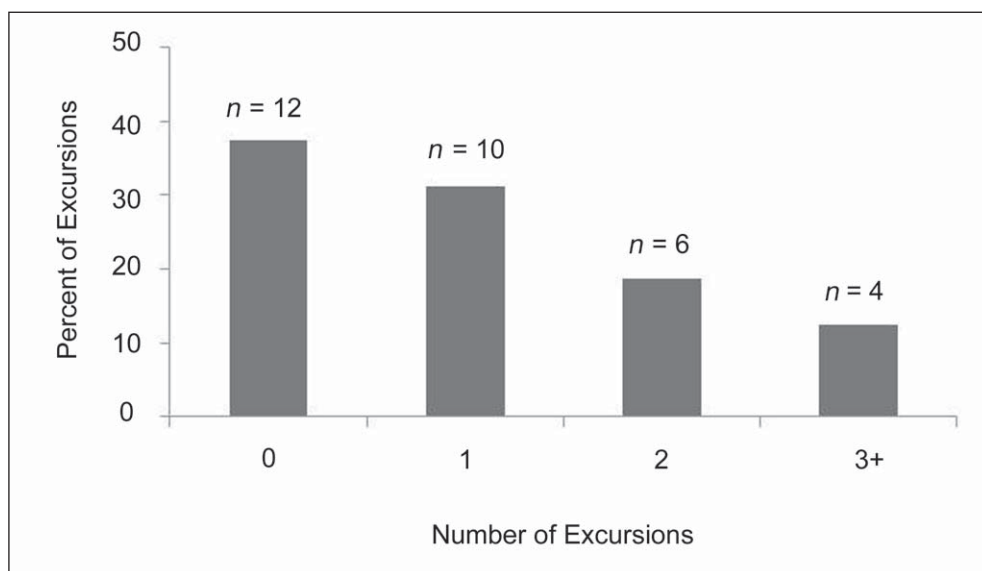


Figure 2. Percent of adult male White-tailed Deer making 0, 1, 2, or 3+ excursions, Chesapeake Farms, MD, 2003–2007.

of excursions occurred during the prebreed and breeding periods, breeding season activities were likely the most common cause of these movements. Because the deer population at Chesapeake Farms was characterized by older age class

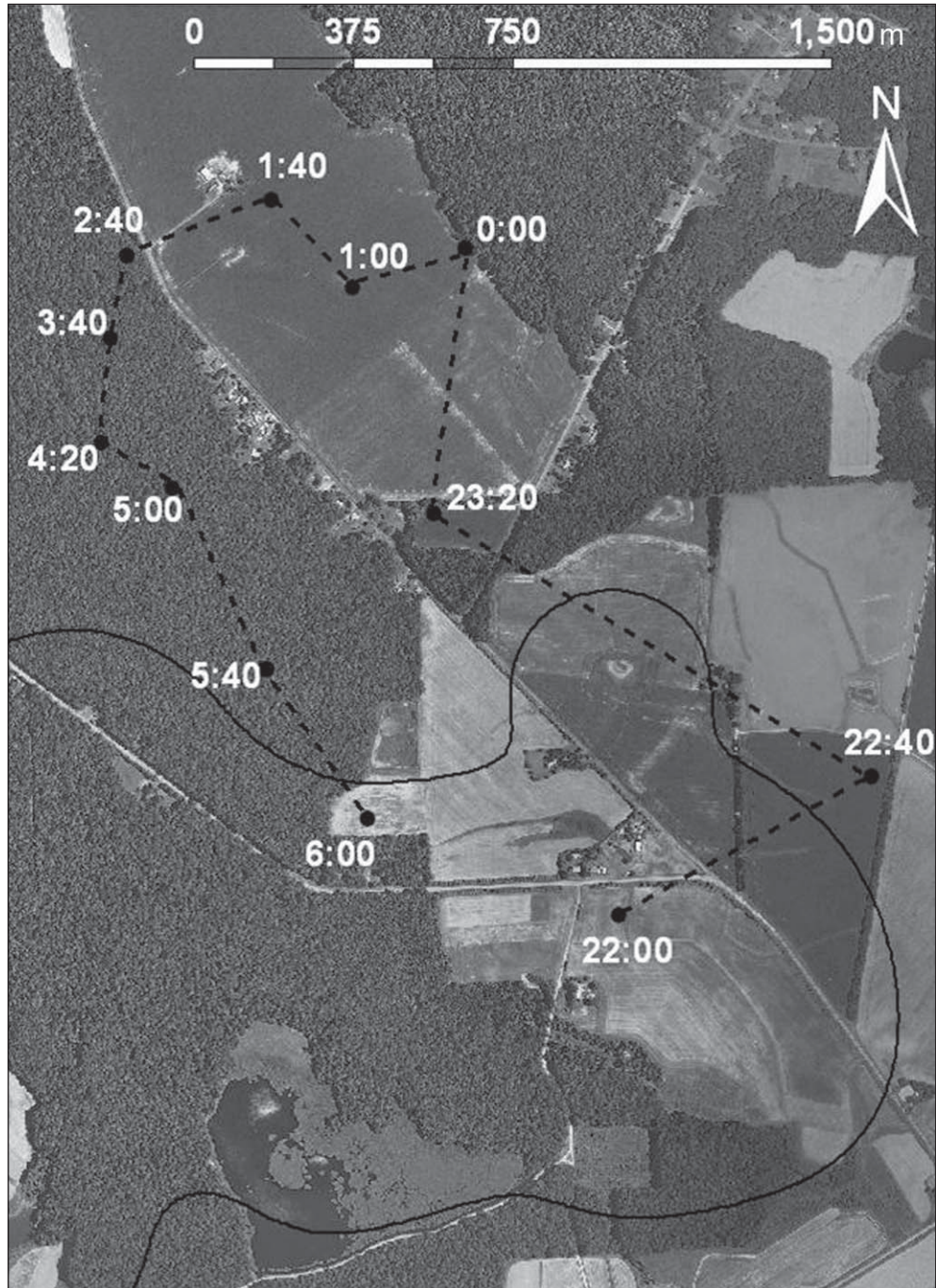


Figure 3. Continuous excursion by a 3.5-year-old adult male White-tailed Deer, Chesapeake Farms, MD, 8–9 November 2006 (22:00–6:00); 95% fixed kernel home range is represented by outlined polygon.

males and a nearly balanced sex ratio, the secondary rut (when unbred females enter their second estrus cycle) was probably insignificant compared to other regions (Clutton-Brock et al. 1997, Geist 1971). However, a minimal secondary rut

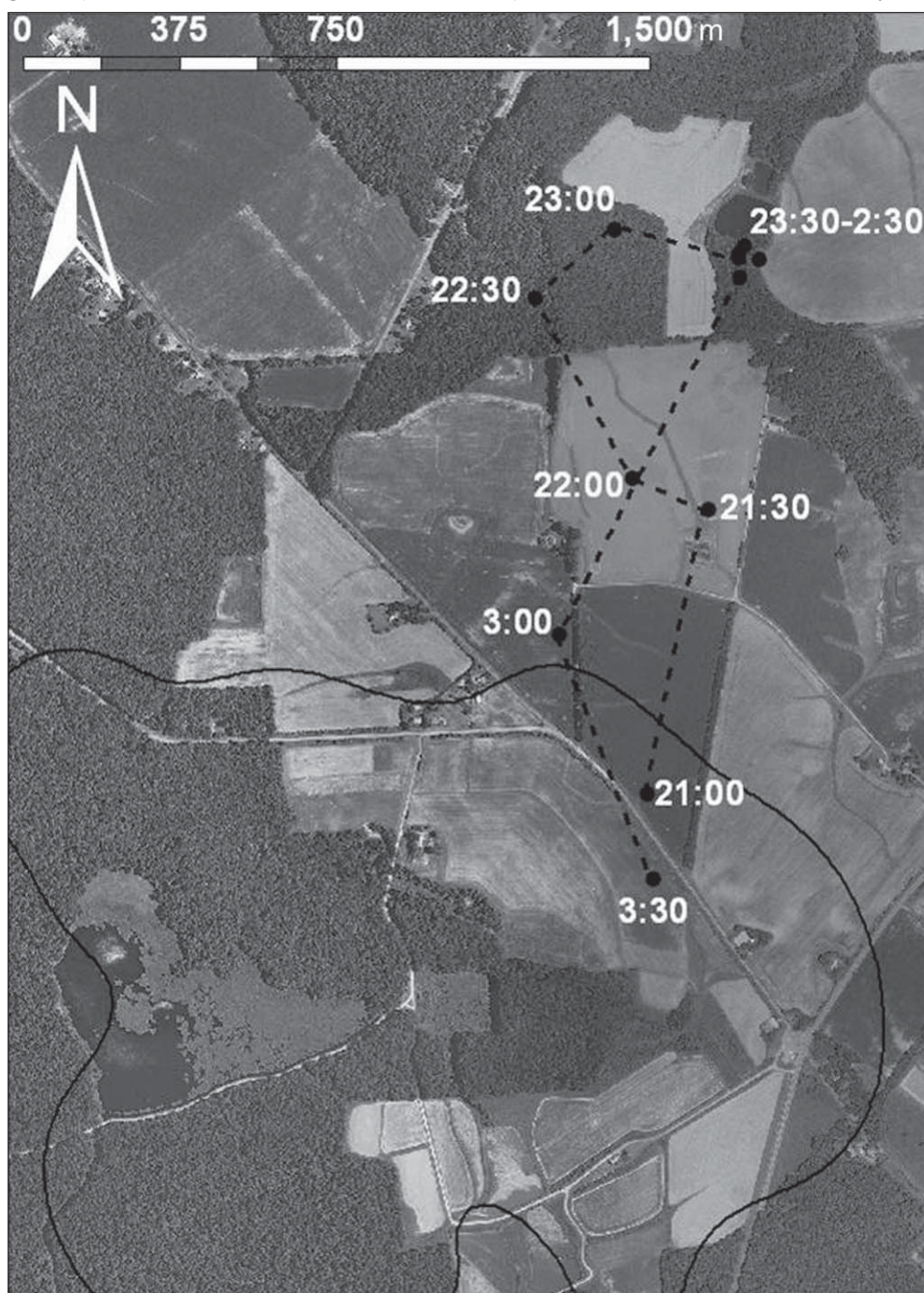


Figure 4. Excursion with a delay by a 3.5-year-old adult male White-tailed Deer, Chesapeake Farms, MD, 12–13 November 2007 (21:00–3:30); 95% fixed kernel home range represented by outlined polygon.

within the core of Chesapeake Farms did not preclude surrounding properties under different management schemes and resulting herd demographics (i.e., heavily skewed sex ratio and fewer adult males) from having pronounced secondary rut activity. Therefore, after the principal breeding period, it is plausible that males took advantage of later breeding opportunities by venturing outside Chesapeake Farms' boundaries during the postbreed period.

Excursions characterized by continuous movement or associated with a period of no movement indicate that some motives are more likely than others. For example, a male searching unsuccessfully for receptive females outside his home range would likely continue moving through previously unoccupied territory (at least during the time when the deer was wearing the GPS collar) before returning to his normal home range. However, a male tending a receptive female might attempt to isolate her from intraspecific competition and mate with her as many times as possible (Hirth 1977). It is purely speculative, but repeated excursions by the same male might suggest revisiting a female group to check for receptive mates, utilizing a food resource that was discovered by previous experiences, or returning to a natal range. With only three repeat excursions documented, it would appear that most excursions were not explorations for new food sources as one or two trips to a distant food source probably would not justify the risk and energy expenditure of those excursions—making late breeding season activities or natal range re-visitation more likely explanations.

Five male excursions did occur during Maryland's two-week firearms season (all 5 of these excursions occurred within the postbreed study period); however, it is unlikely they were prompted by hunting pressure. Based on fine-scale movement data collected during the 2006 (20-minute fixed interval) and 2007 (5-minute fixed interval) firearms season, we compared adult male movement during daylight hours to known hunter locations (Karns 2008). Whether disturbed by hunters or vehicles, flight distances never exceeded 600 m, and no deer left its home range in response to hunting-related disturbances (Karns 2008). Other researchers (Altmann 1958, Hood and Inglis 1974, Lagory 1987, Naugle et al. 1997) noted some White-tailed Deer temporarily left their home ranges in direct response to hunting and other intrusive activities, especially where security and escape cover were limiting factors in a landscape. At Chesapeake Farms, based on low levels of hunting pressure, abundant cover, and flight distance data from adult males during 2006 and 2007, we concluded that hunting pressure was an unlikely explanation for adult male excursions.

Yearling males are disproportionately vulnerable during lengthy dispersal movements through unfamiliar territory (Nelson and Mech 1986, Roseberry and Klimstra 1974). Similarly, adult males venturing on excursions are highly vulnerable to hunter harvest, antagonistic encounters with competing males, and other mortality factors in areas where they are less intimately familiar (Swenson 1982). In 2005, a 5.5-year-old study animal was killed in a vehicle collision while crossing a two-lane road that was not previously encountered during its collared period; in 2006, a 3.5-year-old research subject was superficially wounded by an archery hunter while making an excursion. A majority

of excursions occurred at least partially during daylight and exposed deer to potential hunter harvest.

Although Kolodzinski et al. (2010) used different criteria to quantify excursions in female White-tailed Deer at Chesapeake Farms, all five females (≥ 1.5 year old) with complete datasets exhibited at least one extraneous movement outside 95% home-range contours. Interestingly, only one (made by the 1.5-year-old female in the study) of the excursions was documented outside the peak of breeding-season activity (Kolodzinski et al. 2010). Consistent with the findings of Kolodzinski et al. (2010), D'Angelo et al. (2004) documented female White-tailed Deer excursions occurring in close proximity with their estrous cycles. It is also known that 1.5-year-old females and even 6-month-old female fawns may enter estrus up to several months later than adult females (Nixon 1971, Ozoga and Verme 1982). It is likely that the later excursion by the 1.5-year-old female corresponded with her belated estrus cycle (Kolodzinski et al. 2010). Although no data is available for the proportion of young breeding females at Chesapeake Farms, combining the relatively mild climate with abundant resources, it is not unlikely that at least a small fraction of the female fawns and certainly some 1.5-year-old females are successfully bred during December and subsequent months as individuals reach puberty. Young females exhibiting late estrous cycles may account for an extended breeding season and may partially explain male White-tailed Deer excursions during the postbreed and winter periods as they pursue additional opportunities to reproduce.

Female excursions might be expected in a low-density population (D'Angelo et al. 2004) or where sexually mature males were lacking, but Chesapeake Farms possesses a high-density population and abundant older-aged males. Kolodzinski et al. (2010) postulated that female White-tailed Deer may be engaging in a discrete form of mate selection, even in an environment with seemingly abundant quality mates. With adult males and adult females displaying extraneous movements during the breeding season, both sexes may be instrumental in increasing genetic flow and heterozygosity. It is commonly accepted that juvenile male dispersal is the predominant source of landscape genetic flow in White-tailed Deer populations (Nelson 1993).

Ideally, to study potential simultaneous movements of males and females, all deer in the same geographic area would have GPS transmitters. Obviously the costs and logistics of doing this are nearly prohibitive, especially in a high-density population like at Chesapeake Farms. Although none of the female movement data mirrored any adult male excursions during the 2006 prebreed and breeding periods, we believe this could simply be an artifact of having too few deer with GPS collars. Studying a lower-density herd might be more feasible logistically, but the motives for excursions would likely be different. Additional studies are needed to determine the cause and frequency of extraterritorial excursions of adult males during breeding and hunting seasons.

Although two adult males used multiple home ranges or exhibited evidence of adult dispersal, movements in transit between home ranges were not included in our analyses. Webb et al. (2007) reported that 15% of adult

male White-tailed Deer (usually 2.5–3.5-year-olds) disperse and permanently vacate their natal range. We were unable to find compelling evidence in the literature suggesting reasons why adult males that occupy high quality habitat (i.e., Chesapeake Farms, MD) would maintain two separate home ranges, and the behavior may simply be explained as the idiosyncrasies of a few individuals (<10%). In more northern latitudes, where White-tailed Deer populations migrate between summer and winter ranges, special caution must be taken to avoid misclassifying migratory movements as extraneous excursions (Brinkman et al. 2005, DePerno 1998, Nixon et al. 2008, Tierson et al. 1985). Also, the inherent nature of a fixed kernel home range dictates that some locations are located outside the 95% contour. Therefore, rigorous criteria (i.e., minimum distance and length-of-time requirements) must be selected for identifying true excursions to keep superficial wandering movements and erroneous locations from being misclassified as excursions.

It appears the White-tailed Deer breeding season (whether the peak of adult female conception in mid-November or younger females entering estrus later in December and January) motivates the majority of adult male excursions, but it is difficult to hypothesize plausible motives for excursions occurring during the fall period. At Chesapeake Farms, excursions put individual deer at risk of mortality (particularly due to hunter harvests and vehicle collisions), but movements into unfamiliar environments do not occur frequently enough to drastically impact the survival rate of older age class cohorts. Researchers recognize that yearling male dispersal plays a major role in landscape ecology processes such as gene flow and disease transmission (McCoy et al. 2005, Rosenberry et al. 1999, Schauber et al. 2007); however, the role of adult male White-tailed Deer excursions in these same processes is commonly overlooked.

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