Behavioral Responses of Female White-tailed Deer to Small Game Hunting Activities

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Abstract: Environmental and anthropogenic stimuli can impact a variety of species' behavioral ecology. White-tailed deer (*Odocoileus virginianus*) respond both spatially and temporally to various types of disturbance; however, our understanding of how disturbance impacts deer behavior is typically regulated to studies where white-tailed deer are the targeted species. We used GPS data collected from female white-tailed deer ($n = 10$) to evaluate space use in response to small game hunting activities based on whether an individual was within the hunted area (actively disturbed) or outside (passively disturbed). We found that deer movements per 20-minute period did not differ between actively (59 m, SD = 26.21) and passively (57 m, SD = 52.82) disturbed individuals. We also found no difference in home range (99% utilization distributions) or core range (50% utilization distributions) size between actively and passively disturbed individuals. However, we found that actively (6.56%, SD = 11.05) disturbed individuals exhibited lower site fidelity to pre-hunting core ranges than those disturbed passively (21.03%, SD = 29.07). However, we found that white-tailed deer had high site fidelity to their pre-hunt home ranges during disturbance (84.2% [SD = 24.83]). Thus, we suggest that the impact of small game hunting on white-tailed deer is likely limited, and that any increase in small game hunting activity on private lands should have limited impact on white-tailed deer movements or distribution.

Key words: disturbance, Global Positioning System (GPS), movements, small game hunting, white-tailed deer

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A wide variety of environmental and anthropogenic stimuli can impact the movement ecology of wildlife (Jacoby et al. 2012). Stimuli causing changes in behaviors can have both positive and negative impacts on species demography (Sisson et al. 2000, Farhig 2007). Additionally, wildlife make temporally-specific behavioral decisions according to the intensity and frequency of stimuli:; therefore, movement patterns in response to stimuli may drive population level estimates of resource utilization (Frid and Dill 2002). Thus, the results of increased human activities could impact movements and space utilization for a variety of species (Frid and Dill 2002).

White-tailed deer (*Odocoileus virginianus*; hereafter deer) are a significant source of outdoor recreation and economic benefit, and the impacts of hunting on deer population demography has received considerable attention in previous studies (McGrath et al. 2018). Deer are known to respond spatially and temporally to various types of hunting (Autry 1967, Pilcher and Wampler 1982, Root et al. 1988). The vast majority of studies have exclusively focused on the response of deer to deer hunting activities, and spatial distribution and behaviors of deer are thought to be driven, in part, by the intensity of space use by deer hunters (Sullivan et al. 2018). Thus, any disturbance analogous to predation risk may impact deer behavior (Lima and Bednekoff 1999, McGrath et al. 2018). Because deer can recognize and respond to localized risk, the likelihood that hunting pressure at any time may impact space use (Sullivan et al. 2018) has implications for hunting activities on both private and public lands. For example, a suite of wildlife-related recreational opportunities exists in Louisiana, including small game hunting. Small game hunting has a long tradition in Louisiana; however, there are concerns from the white-tailed deer hunting community (S. Durham, LDWF, personal communication) that activities associated with small game hunting could influence the behaviors of white-tailed deer when it occurs simultaneously with white-tailed deer hunting (November–January). Specifically, deer hunters have indicated that small game hunting may influence the spatial distribution of white-tailed deer, thus potentially influencing deer hunter success and enjoyment.

Literature evaluating how white-tailed deer move and use space during periods of disturbance where they are not actively being pursued is limited. As most white-tailed deer hunting, and small game hunting, occurs on private lands in Louisiana, we conducted an experimental evaluation on the response of white-tailed deer to

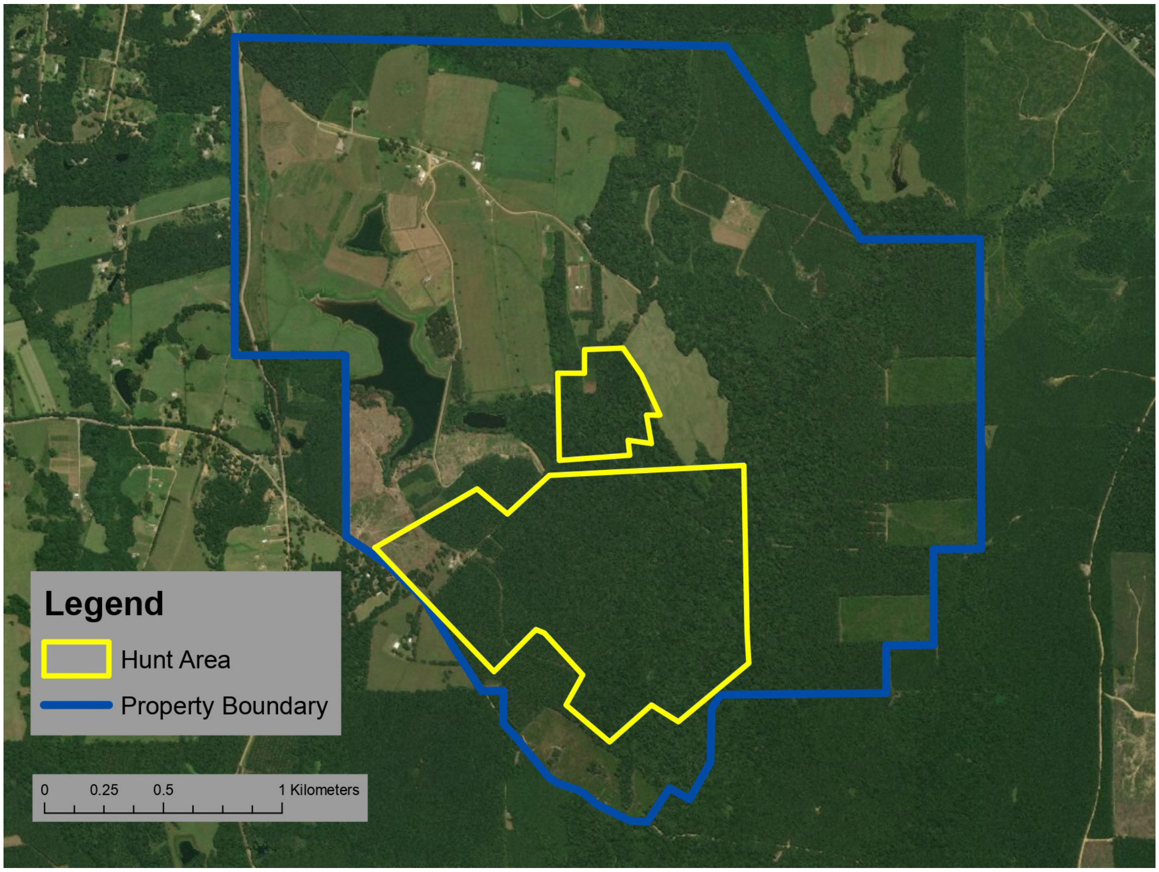

Figure 1. Property boundary and small game hunting area on Bob R. Jones/Idlewild Research Station, Louisiana, where we evaluated white-tailed deer response to small game hunting disturbance.

targeted activities associated with small game (e.g., rabbit, squirrels, upland birds) hunting with trained upland dogs. Using VHF/GPS collars on white-tailed deer, our objectives were to quantify movements and space use in responses of white-tailed deer during the conduction of non-target hunting activities for small game. From these data we hope to gain an understanding of how white-tailed deer move and utilize space when disturbed, but not targeted, in order to better theorize how they might move and utilize space when their hunting season overlaps that of small game.

Study Area

We conducted our research on the 818-ha Louisiana State University Agricultural Center-Bob R. Jones/Idlewild Research Station (hereafter Idlewild) in East Feliciana Parish, Louisiana (Figure 1). Idlewild was primarily a loblolly (*Pinus taeda*) and shortleaf pine (*P. echinata*) plantation intermixed with bottomland hardwoods along creek drainages with a hardwood midstory of sweetgum (*Liquidambar styraciflua*), southern red oak (*Quercus falcata*), yaupon (*Ilex vomitoria*), and black gum (*Nyssa sylvatica*). Approximately 363 ha were in improved pasture, agricultural crops, or infrastructure. Public access to Idlewild was restricted. No public hunting activity was allowed on the property, but a limited number (<10) of deer were harvested in February and March 2016 in association with other research studies. Deer were hunted on adjoining private properties surrounding the station, however.

Methods

We captured deer using baited drop nets during March–September 2016. We chemically immobilized each individual using Butorphanol-Azaperone-Medetomidine (BAM Kits, Wildlife Pharmaceuticals, Windsor, Colorado) following general dosing levels from Miller et al. (2009). We classified captured individuals by age (juvenile, yearling, adult) based on tooth wear and replacement (Severinghaus 1949) and ear-tagged individuals during captures. Each individual was also fitted with a neck collar with an integrated GPS-VHF transmitter equipped with a mortality sensor (Vectronic Aerospace GmbH, Berlin, Germany). Neck collars were programmed to collect spatial data once every 20 minutes during each day from 1 October 2016–4 March 2017. We programmed the collars to drop off 4 March 2017. We used handheld radio-telemetry receivers and 3-element Yagi antennas to monitor collared individuals at least once every week following capture. We monitored individuals daily via both triangulation and homing

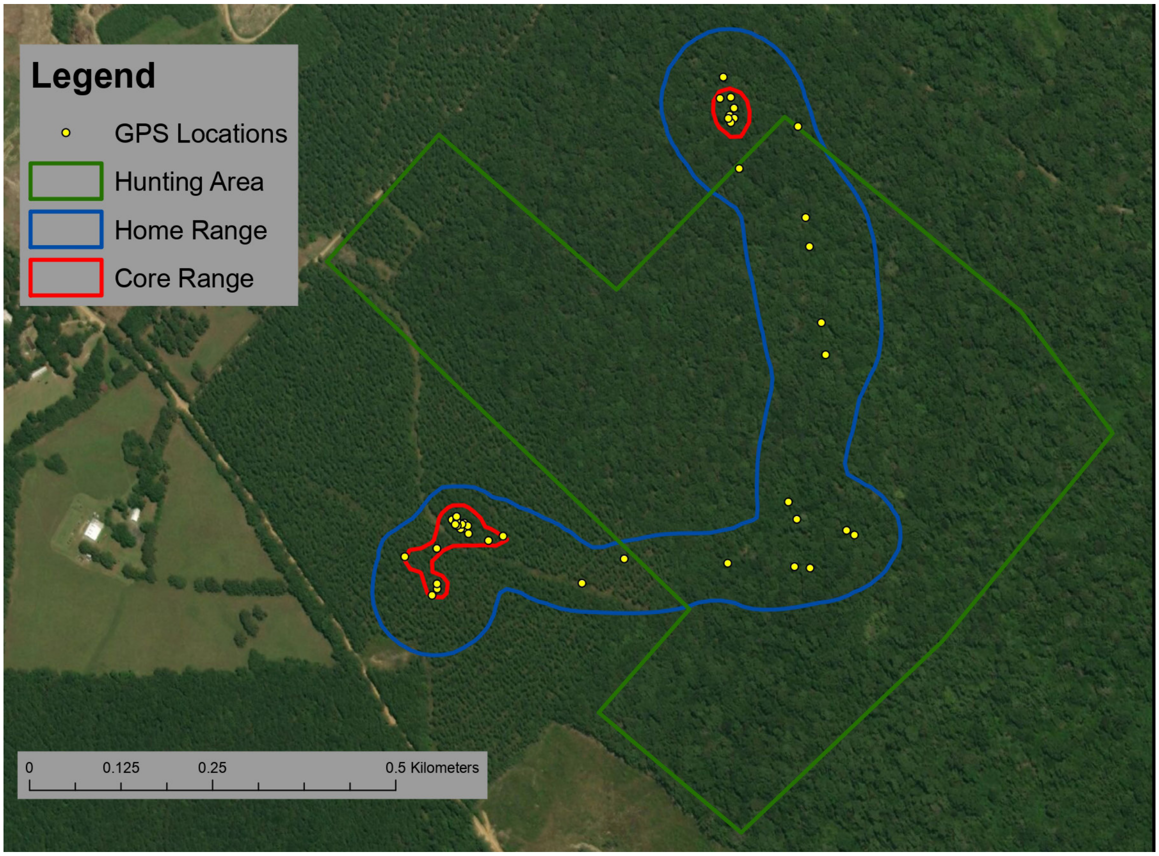

Figure 2. Example of home range and core range overlapping an actively disturbed site on the Bob R. Jones/Idlewild Research Station, Louisiana, 2016–2017.

Table 1. Small game hunting dates and area utilized for the hunt (hectares) on the Bob R. Jones/Idlewild Research Station in Louisiana during 2016–2017.

Date	Area (ha)
6 Dec 2016	3.72
13 Dec 2016	8.99
30 Dec 2016	11.56
12 Jan 2017	33.01
21 Jan 2017	18.23
1 Feb 2017	15.32
4 Feb 2017	21.95
10 Feb 2017	50.04
16 Feb 2017	50.08

at 1 month before disturbance experiment initiation through the end of the study to ensure disturbance activities would impact ≥1 marked deer. The Louisiana State University Institutional Animal Care and Use Committee (Protocol #A2015-10) approved capture and handling protocols.

We conducted nine small game hunting events (hereafter disturbance events) mimicking small game hunting activities at irregular intervals between 1 December 2016 and 31 January 2017 (Table 1). Small game hunting events on average lasted 3 (SD = 0.57) hours and consisted of 1–3 hunters with 2–3 trained upland hunting dogs (feists or English springer spaniels). During the experimental treatments, hunters were actively hunting, including shooting and retrieving game and conducting standard hunting dog work. We developed minimum convex polygons (hereafter, MCP) for each hunting event using GPS locations collected by the hunters. We defined any deer that was within 200 m of the MCP during a hunting event as actively disturbed (i.e., hunt activities were likely impacting deer) and any deer that was ≥200 m from the boundary of the MCP as passively disturbed (i.e., hunt activities were likely not impacting deer) (Figure 2). Our choice of 200 m was based on work by Sullivan et al. (2018) which depicted the distance at which deer were vulnerable to fixed stand hunters and from work by Freddy et al. (1986) which described flushing distances by deer when disturbed. We acknowledge, however, that our selection of 200 m is somewhat arbitrary; other boundary limits could be explored in future experiments.

We defined the pre-hunt (undisturbed) period as the period from 11 November to 6 December 2017 and the hunt period as 6 December to 16 February, tallying movements from 00:00 to 23:40 hours. We averaged daily distance values for pre-hunt and hunting periods to get the average daily distance traveled during each period. We used a dynamic Brownian Bridge movement model (hereafter, DBBMM) to build utilization distributions (UDs) at 50% (core ranges) and 99% (home ranges) ranges for each individual during the pre-hunt and hunting periods (Byrne et al. 2014). We calculated all UDs (Kranstauber et al. 2018) in R (R Core Team 2019) with R package move (Byrne et al. 2014). We kept window and margin size constant to account for changes in GPS sampling frequency because we failed to see any measurable effects of altering these values (Cohen et al. 2018). We calculated percentage of overlap between core and ranges between the pre-hunt and hunting UDs to determine if individuals exited their core or range during the hunt periods as a measure of disturbance response. We tested for differences between average daily distance traveled, core and range size, and frequency of overlap of the pre-hunt areas for passively and actively hunted individuals, using a two-sample t-test and a repeated measures analysis of variance using a random effect term for individual deer in R (R Core Team 2019).

Table 2. White-tailed deer specific frequency of occurrence for active and passive disturbed events on the Bob R. Jones/Idlewild Research Station in Louisiana during 2016–2017.

Collar ID	Age and sex	Passively hunted	Actively hunted
16470	Female yearling	6	3
16473	Female 3.5 years	7	2
16474	Female 1.5 years	9	0
16475	Female yearling	6	3
16476	Female yearling	7	2
16483	Female yearling	8	1
16484	Female 1.5 years	6	3
16485	Female 2.5 years	7	2
16486	Female 1.5 years	7	2
16487	Female 3.5 years	7	2

Table 3. Average daily distance (m) traveled by white-tailed deer during the pre-hunt period and when actively or passively disturbed on the Bob R. Jones/Idlewild Research Station in Louisiana during 2016–2017.

Collar ID	Pre-hunt (SD)	Passively hunted (SD)	Actively hunted (SD)
16470	72.93 (104.99)	55.58 (9.14)	56.28 (6.20)
16473	93.66 (132.13)	86.32 (68.95)	94.49 (42.77)
16474	76.48 (118.56)	45.17 (17.81)	–
16475	85.70 (127.47)	85.51 (69.69)	80.64 (42.36)
16476	67.37 (97.31)	53.87 (13.44)	54.27 (8.45)
16483	46.20 (61.18)	44.40 (8.58)	37.08
16484	57.91 (77.41)	52.19 (14.23)	56.50 (19.70)
16485	50.54 (68.12)	46.65 (7.64)	34.10 (6.46)
16486	48.35 (71.16)	50.90 (6.19)	56.57 (15.63)
16487	63.23 (96.69)	53.99 (9.26)	46.80 (5.49)
Overall average	66.24 (16.08)	57.46 (52.82)	59.04 (26.21)

Results

We captured and tagged 15 deer (3 males, 12 females); however, 5 (3 males, 2 females) of the captured deer died during the study due to hunting and vehicular collisions. We used the remaining 10 female deer, which were monitored for the entirety of our study period, for our analyses. We collected ~118,000 GPS locations during our study. The average distance deer moved per 20-minute sampling interval was 66.24 m (SD = 16.08, range = 46.20–93.66 m; Table 3) during the pre-hunt period. We identified 20 active interactions with collared deer during disturbance events (Table 2). Average distance moved when actively disturbed (59.04 m, SD = 26.21, range = 29.53–128.90 m) did not differ from average distance moved when passively disturbed (57.46 m, SD = 52.82, range = 16.66–342.22 m; t = 0.188, df = 64.93, P = 0.8513; Figure 3).

Average home range and core range during the pre-hunt period was 114.67 ha (SD = 41.90, range = 55.65–182.15 ha) and 7.24 ha (SD = 3.4, range = 3.96–14.44 ha; Table 4), respectively. Home range size was slightly larger for individuals passively disturbed (28.52 ha, SD = 84.12, range = 0.25–517.29 ha) than actively disturbed (20.68 ha, SD = 18.17, range = 0.30–63.25 ha), but was not significantly different (t = 0.718, df = 83.88, P = 0.4745). Average core range size was similar on both passively (0.76 ha, SD = 3.03, range = 0.03–19.65 ha) and actively disturbed days (0.68 ha, SD = 1.28, range = 0.04–4.63 ha; t = 0.185, df = 75.29, P = 0.8536).

Both passively and actively disturbed individuals had high fidelity to their pre-hunt home ranges (84.2% (SD = 24.83) and 88.5% (SD = 23.21), respectively. We found no evidence of differences in pre-hunt period overlap between actively and passively impacted individuals (t = -0.726, df = 32.69, P = 0.4729; Table 5). However, we did find evidence of core range overall differences when comparing the pre-hunt period to passively (21.03%, SD = 29.07, range = 0–100%) and actively disturbed individuals on hunt days (6.56%, SD = 11.05, range = 0.00–30.5%; t = 3.375, df = 80.79,

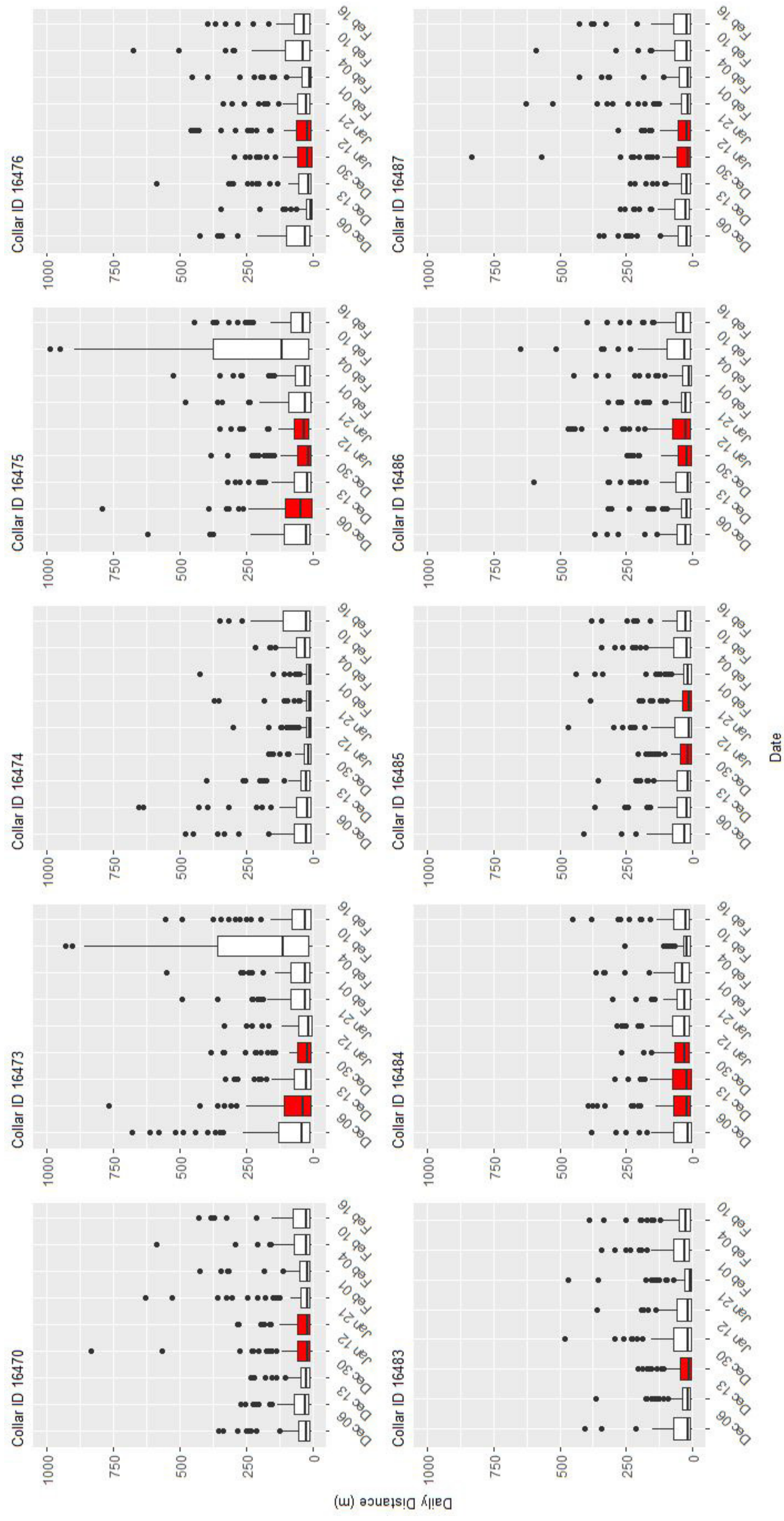

Figure 3. Deer-specific boxplots showing movement distances every 20 minutes relative to active (red; within 200 m of hunting activity) or passive (white; outside 200 m of hunting activity) disturbance classification on the Bob R. Jones/Idlewild Research Station in Louisiana during 2016–2017.

Table 4. Estimated core area (50%) and range size (99%) (ha) utilization distributions (UD) for white-tailed deer during the pre-hunt period and estimated average range size when being passively and actively disturbed on the Bob R. Jones/Idlewild Research Station in Louisiana during 2016–2017.

Collar ID	Pre-hunt 50% UD	Passively hunted 50% UD (SD)	Actively hunted 50% UD (SD)	Pre-hunt 99% UD	Passively hunted 99% UD (SD)	Actively hunted 99% UD (SD)
16470	7.82	0.19 (0.23)	0.46 (0.35)	120.06	53.25 (73.74)	20.46 (6.83)
16473	14.44	2.51 (6.13)	2.24 (2.67)	153.86	89.07 (176.59)	41.28 (27.62)
16474	5.24	0.25 (0.31)	–	106.89	5.72 (4.69)	–
16475	10.89	3.42 (7.95)	1.73 (2.51)	166.94	101.43 (205.09)	32.56 (27.18)
16476	9.94	0.54 (0.71)	0.16 (0.09)	182.15	17.30 (19.60)	13.86 (7.91)
16483	3.96	0.19 (0.22)	0.21	55.64	6.12 (8.22)	9.85
16484	5.39	0.40 (0.22)	0.33 (0.25)	83.95	18.13 (21.95)	20.39 (27.82)
16485	5.11	0.17 (0.14)	0.10 (0.09)	78.91	7.37 (7.65)	5.49 (7.33)
16486	4.57	0.21 (0.18)	0.21 (0.00)	80.45	12.15 (16.82)	11.90 (1.40)
16487	5.09	0.16 (0.15)	0.18 (0.01)	117.79	20.95 (17.00)	19.22 (13.05)
Overall Average	7.24 (3.4)	0.76 (3.03)	0.68 (1.28)	114.67 (41.90)	28.52 (84.12)	20.68 (18.17)

Table 5. Estimated percent of overlap for passively and actively disturbed individuals 50% and 99% ranges relative to estimated pre-hunt (undisturbed) 50% and 99% ranges on the Bob R. Jones/Idlewild Research Station in Louisiana during 2016–2017.

Collar ID	Passively hunted 50% UD (SD)	Actively hunted 50% UD (SD)	Passively hunted 99% UD (SD)	Actively hunted 99% UD (SD)
16470	3.60 (5.07)	9.93 (14.82)	81.97 (17.25)	89.16 (13.82)
16473	4.35 (5.59)	15.02 (15.01)	80.62(30.37)	95.57 (2.40)
16474	32.80 (34.32)	–	88.10 (24.01)	–
16475	2.62 (30.61)	5.46 (9.45)	77.46 (30.61)	98.35 (2.41)
16476	19.66 (18.99)	0 (0)	97.72 (3.56)	100 (0)
16483	47.05 (44.38)	0	76.97 (37.06)	87.35
16484	12.11 (12.16)	10.18 (17.62)	63.95 (36.85)	91.66 (8.99)
16485	35.61 (32.84)	0(0)	95.64 (6.64)	46.96 (66.42)
16486	25.48 (29.87)	12.26 (16.53)	86.82 (22.71)	100 (0)
16487	8.03 (12.64)	0 (0)	87.73 (15.55)	80.79 (27.17)
Overall average	21.03 (29.07)	6.56 (11.06)	84.23 (24.83)	88.57 (23.20)

$P = 0.001$). Repeated measures analysis of variance with fixed effect terms for hunt type (passive or active) and period (pre-hunt or hunt) using a random effect for individual deer indicated only small changes in movements (<5m per 20 min period) between pre-hunt and hunting periods and ~5 m change between passive and active hunting periods, neither of which was statistically ($p > 0.05$ for both fixed effects), or biologically significant.

Discussion

Our results found that female deer showed limited evidence of movement responses to disturbances due to small game hunting during our experimental treatments. Average female home ranges and core areas when individuals were actively and passively disturbed were similar to those found in South Carolina during the post-rut ($\bar{x} = 23.0$ ha, $\bar{x} = 4.4$ ha; Sullivan et al. 2017). However, we found that while female deer in our study had high fidelity to their pre-hunt home ranges (>83%), core area fidelity was significantly reduced (~15%) for individuals who were actively disturbed. Female white-tailed deer have shown high site fidelity and low dispersal rates in the northeastern United States (Aycrigg and Porter 1997, Lesage et al. 2000). Intense deer hunting activity has been previously shown to impact deer movements and home range areas (Root et al. 1988, Sullivan et al. 2018). However, female white-tailed deer have been found to return to home ranges post-hunt (D'Angelo et al. 2003). While our results show that core area fidelity was low when disturbed, pre-hunt home range fidelity for the same period was high. Thus, although disturbed, female white-tailed deer were likely move around locally as we did not find evidence that actively disturbed white-tailed deer abandoned their pre-hunt home ranges.

Deer being actively hunted show responsive movements both spatially and temporally (Autry 1967, Pilcher and Wampler 1982, Root et al. 1988, D'Angelo et al. 2003, Little et al. 2016, Sullivan et al. 2018). Previous literature on the impact of hunting on non-target wildlife has been shown to influence behavioral responses, specifically contributing to home range displacement (Grignolio et al. 2011, Mori 2017). We realize that deer movements and response to upland game hunting in our study may differ under higher small game hunting intensity as high intensity hunting activities targeting deer have been shown to impact movements onto refuge areas (Little et al. 2016, Sullivan et al 2018). Low intensity hunts have been found to displace individuals from home ranges; however, individuals still show high site fidelity and low dispersal rates from home ranges (D'Angelo et al. 2003).

Due to deer movements and mortality before our study initiated, our study represents a subset of all possible deer-small game hunter interactions, in that we were restricted to evaluating response from those individuals that were both GPS tagged and available to be disturbed on our study site. We attempted to maintain a moderate (1/weekly) level of small game hunting disturbance as small game hunters on average hunt 10 days out of the year (U.S. Department of the Interior 2011); thus, increased activities, such as interactions multiple times per day or week may influence white-tailed deer differently from our results. Therefore, further work should consider increased intensity of disturbance, perhaps via replicated targeting of individual white-tailed deer across a private-public interface to determine if variation in movement and space use adjusts during non-target hunting events.

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