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Spatial movements in response to baiting female white-tailed deer

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Abstract: A better understanding of the manipulation of white-tailed deer movement patterns in response to bait has implications for future management of increasing suburban herds. We gathered radio telemetry data for 10 female and 1 male deer over a 1-year period with artificial feeding stations activated in spring and fall. Data were triangulated in the computer program Topo!, transferred into home range program CALHOME, and imported into Arc View for analysis. Mean annual home range size was 57.7 ha with mean core area of 8.4 ha. Spatial changes in behavior of all deer were witnessed in response to bait including core area shifts, addition of another core area closer to a second active feeder, and significant collapse of home range and core area around an active feeder. If bait site overlap is not desired for management purposes, we recommend distribution every 50-60 ha to reduce multiple feeder usage. We also recommend bait site placement in wooded areas to shift core areas away from residences if homeowner conflicts are prevalent.

Key words: core area, does, 4-poster, home range, Lyme disease, management, *Odocoileus virginianus*, shifting, suburban, white-tailed deer

Movement of white-tailed deer (*Odocoileus virginianus*) into suburban areas is a relatively recent occurrence that has not yet been thoroughly studied. Public health and safety concerns related to increasing deer-vehicle collisions and increasing transmission rates of Lyme disease have prompted investigations of management options for suburban deer herds (Grand 1998). Though hunting has been effective in managing white-tailed deer populations in rural (Roseberry et al. 1969, McCullough 1984, Kufeld et al. 1988, VerCauteren and Hygnstrom 1998) and urban areas (McAninch 1993, Kuser 1995, Mayer et al. 1995, Kilpatrick and Walter 1999), legal constraints, perceived safety issues, public acceptance, and other factors have limited its use as a management tool in some urban and suburban herds (Kuser 1995, Mayer et al. 1995, Kilpatrick et al. 1997, Messmer and Hewitt 1998). Therefore, alternative options such as sharpshooting

programs (Drummond 1995, Jordan et al. 1995, Stradtman et al. 1995, DeNicola et al. 1997), trap and shoot programs (Jordan et al. 1995), translocation programs (Jones and Witham 1990, Bryant and Ishmael 1991, Drummond 1995, Ishmael et al. 1995), and immunocontraception (Underwood and Verret 1998, Rudolph et al. 2000, Walter 2000) have been explored. A better understanding of spatial movements in response to artificial bait sites could result in the more effective management of such populations.

Of particular concern in suburban areas is increased incidence of Lyme disease, as it is the most prevalent vector-borne human disease in the United States (George et al. 1997). There have been over 100,000 cases reported to National Centers for Disease Control, 90% of which have occurred in the northeastern United States (George et al. 1997). The disease is transferred by infection

with the spirochete *Borrelia burgdorferi*, which is most commonly transmitted by the black-legged tick (*Ixodes scapularis*) (formerly known as the deer tick, *I. dammini*) in the northeast United States. Immature stages of black-legged ticks are known to feed on a variety of vertebrate hosts. It has been estimated that 95% of adult females engorge themselves on deer (Wilson et al. 1988). Therefore, successful deer management in suburban areas is vital to reduce Lyme disease transmission.

To address risks associated with Lyme disease, a study was initiated by the United States Department of Agriculture/Agricultural Research Service (USDA/ARS) to control ticks using white-tailed deer as hosts. The 5-year USDA/ARS Northeast Area-Wide Tick Control Project includes study sites in Connecticut, Maryland, New Jersey, New York, and Rhode Island. At each of these 5 study sites, self-application acaricide feeding devices (4-posters), patented by the USDA/ARS (U. S. Patent #5,367,983) for the control of black-legged ticks on white-tailed deer, are distributed throughout private residences in treatment areas. The 4-poster allows deer to feed on bait while self-rolling the topical acaricide Point-Guard® (2% Amitraz) onto the head and neck region of the deer. The majority (83-89%) of female black-legged ticks attach to the head, neck, shoulders, and brisket of the animal (George et al. 1997). Through grooming, the acaricide will be transferred from this region to the groin and abdomen, regions of residual attachment. Targeting ticks on deer could potentially reduce incidents of Lyme disease in suburban neighborhoods.

To effectively treat deer with Amitraz, the best way to distribute 4-posters needed to

be determined. Deer home ranges in suburban areas vary considerably (Cornicelli 1992, Grund 1998, Kilpatrick and Lima 1999, Swihart et al. 1995). Therefore, it was necessary to establish home range estimates for this population and further assess variables that could affect home range and core area distribution in suburban areas.

Our objective was to determine movement patterns of deer in response to bait availability and the efficient distribution of 4-posters. We hypothesized deer would shift core areas but would not venture out of established home ranges in search of food or bait, unless unforeseen circumstances arose. Therefore, a goal of this study was to better understand deer habits in suburban settings through home range analysis, analysis of core movements in response to bait, and rigidity of the individual home range.

Study area

Our study area was a portion (4 km², 1.5 square miles) of the overall 13 km² (5 square miles) study site for the USDA/ARS Northeast Area-Wide Tick Control Project in southeastern New England (Figure 1). It consisted of a coastal, suburban, mixed-hardwood, with intermitted wetland region of Old Lyme, Connecticut. Oak (*Quercus sp.*) and maple (*Acer sp.*) dominated the site, with an abundance of hickory (*Carya sp.*) and ornamental plants. Understory vegetation primarily included Japanese barberry (*Berberis thunbergii*) and green briar (*Smilax sp.*). Interstate 95 bordered this site to the north, the Black Hall River to the east, Route 156 to the south, and the East River to the west.

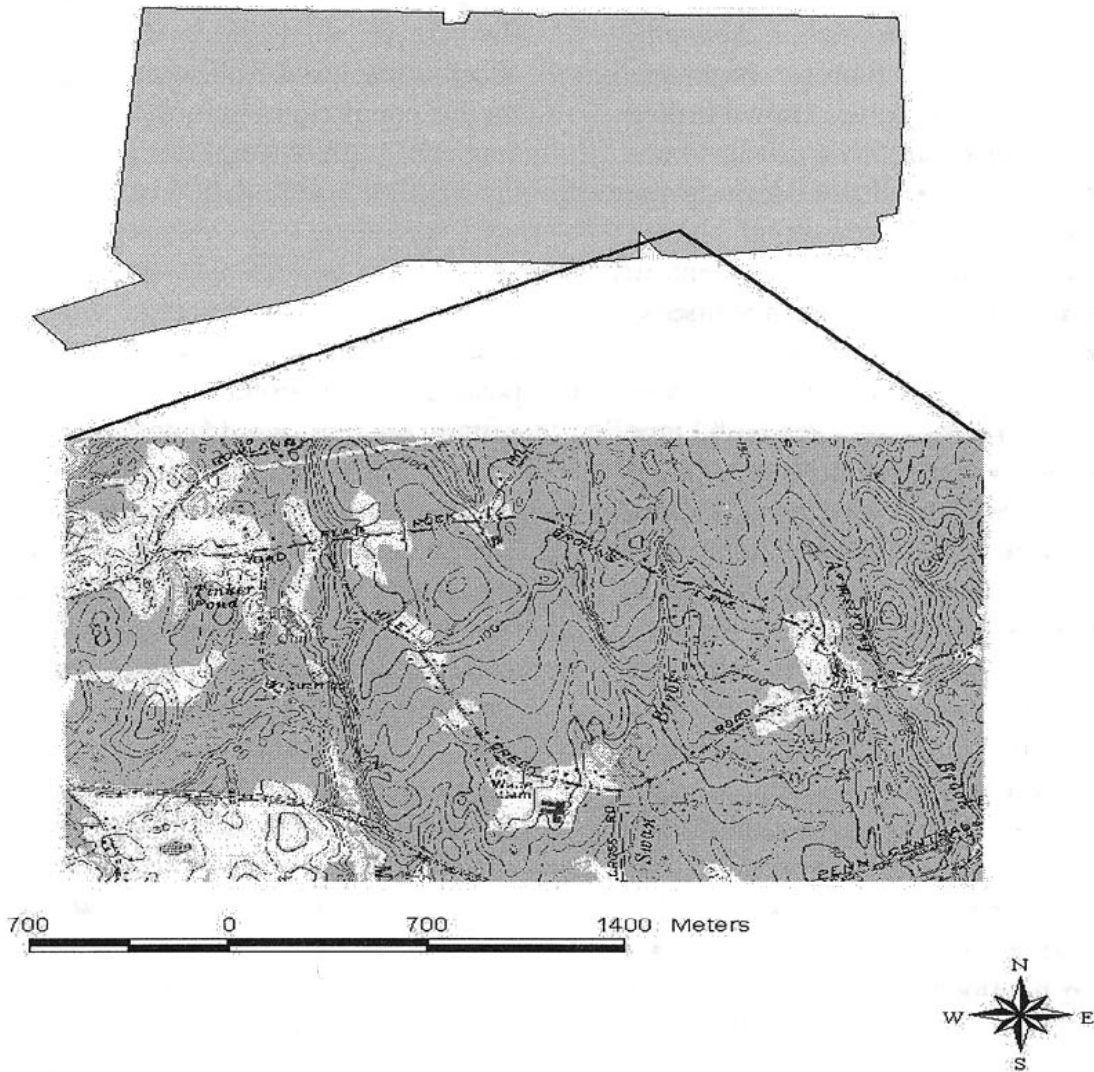


Figure 1. Study Area. Old Lyme, Connecticut, USA.

This residential area was highly endemic for Lyme disease, as determined by the Connecticut Department of Public Health (Stafford and DeNicola 1999). Informal interviews with residents revealed costly vehicle collisions and multiple cases of Lyme disease per household as well as per individual. The deer density in our study area was approximated at 39 per square mile

(15/km²) via an aerial snow count on 26 February 1999.

Methods

Eleven deer (10 female, 1 male) were captured using a dart gun (Pneu-Dart®, Williamsport, PA) with a combination of 250 ml Telazol® and 150 ml xylazine hydrochloride used for immobilization. Six, including the male, were captured from 3 to

10 December 1998 and fitted with battery-powered radio transmitters (Adv. Telem. Systems, Inc., Isanti, Minn.). The other 5 were captured from 8 to 15 April 1999 and also fitted with battery-powered radio transmitters. Anesthetized deer were aged using tooth replacement and wear (Severinghaus 1949) as adult (>2 years old: $n = 6$), yearling (>1 and <2 years old: $n = 2$), or fawn (<1 year old: $n = 3$). Reproductive status, tick abundance, and approximate weight were recorded. Effects of chemical immobilization agents were reversed with an intravenous administration of 15 mg yohimbine hydrochloride. Personnel trained by a wildlife veterinarian in humane capture and chemical restraint methods conducted this project.

Three 4-posters were filled with corn from 9 March to 27 April 1999 and then all 23 from 8 September to 15 December 1999. The 3 feeders activated in spring were outside known home ranges of several radio-collared deer. The 23 feeders activated in fall were both within and outside known home ranges and distributed among 16 feeding stations (Figure 2). Telemetry readings commenced 20 January 1999, using a portable, hand-held receiver (Communications Specialists, Inc., Orange, Calif.; model R-1000), hand-held 2-element antenna (Telonics, Inc., Mesa, Ariz.; model RA-14), and compass (Silva Ranger). Readings continued until 15 December 1999, with additional deer included as captured. The majority of readings were taken during periods of peak movement as described by Montgomery (1963): from dawn to midmorning and from mid to late afternoon, dark or longer. Other data points were gathered at times during the day when deer were bedded.

Radio telemetry readings were taken at permanently marked locations throughout the study site, accessed by vehicle. The abundance of roads in this suburban area and cooperating private landowners allowed us to obtain 2 bearings per deer per reading, approximately perpendicular (60° - 120°). When deemed necessary, a third or fourth reading was taken to assure accuracy. Because data collection often coincided with periods of high movement activity, frequent visual observations also were made and recorded.

Using a hand-held Global Positioning System (GPS) unit (Magellan ColorTRAK) and program Topo! (Wildflower Productions, 1998, version 1.2.4) telemetry locations were determined on the United States Geological Survey (USGS) topographic map feature, scale 1:12,000. Appropriate bearings were drawn from each marked location and Universal Transverse Mercator (UTM) (Grubb and Eakle 1988) coordinates were recorded at the intersection.

The adaptive kernel method (Worton 1989) feature of the program CALHOME (CALifornia HOME Range) (Kie et al. 1996) was used to calculate annual home ranges and core areas. This method was chosen as it is less sensitive to grid size than the harmonic means method (Dixon and Chapman 1980) and also minimizes the effect of outliers, unlike the minimum convex polygon method (Harris et al. 1990). Within CALHOME, home ranges were calculated using a 50 x 50-grid cell size and the 95% probability distribution to minimize the effect of outliers, leading to a more precise definition of home range.



Figure 2. Feeder (4 poster) distribution in Old Lyme, CT.

Though occasional excursions by animals beyond the "normal" home range existed, they were not considered part of it (White and Garrott 1990). Core activity areas were calculated using the 50% probability distribution.

Home ranges and core areas were determined using a reduced smoothing parameter or bandwidth. Decreasing 10% intervals of the original default bandwidth were used until the smallest least squares cross-validation (LSCV) score was reached, as it provides a better fit of the data while maintaining contiguous home ranges. Bertrand et al. (1996) and Kilpatrick and Spohr (2000), used similar approaches.

Initially, one daily telemetry reading was taken to assure independence between deer locations (Swihart and Slade 1985). However, multiple daily readings were later taken to witness movements within home range. LaBonte et al. (2000) found no difference in home range size with autocorrelated and non-autocorrelated data sets using the adaptive kernel method. However, as suggested by Seaman and Powell (1996), we estimated deer home ranges using > 30 telemetry locations.

Given these calculated home ranges, the data were then transferred from CALHOME into the Geographic Information Systems (GIS) program ArcView (ESRI, Redlands, Calif., Version 3.2). Once in ArcView, the home range data could then be overlaid onto a USGS 7.5-minute topographical map of the study site. Shifts in core areas were measured by change in distance (meters) from the active feeding station to the nearest edge of core area. Paired

r-tests were used to determine significance between home range sizes.

Of the 11 collared deer, 7 remained by the end of the study. Data from these 4 missing deer were included in comparable analyses and total home range size. The collared male dispersed 10.5 km north of the study area in October 1999. The other 3 deer either succumbed to collar failure, poaching, or the train that ran through the southern portion of the study site. Spring activation of 3 feeders could not be compared with winter feeder dormancy (20 January-8 March) due to insufficient telemetry locations ($n < 30$) for home range estimation due to death, collar failure, weather conditions, or failure to locate animals. However, intervals were included in analysis of total feeder dormancy versus total activation. Core areas also were compared during summer feeder dormancy and fall feeder activation.

Results Home

range and core area sizes

Mean annual home range size was 57.7 ha (SE = 6.0) for the year, ranging from 34.7 ha to 100.1 ha (Figure 3). Core area size during the same interval averaged 8.4 ha (SE = 0.9), ranging from 4.4 ha to 13.0 ha (Figure 3). Mean home range size of deer remained similar during total feeder dormancy ($\bar{x} = 54.0$ ha, SE = 8.3) and total feeder activation ($\bar{x} = 42.3$ ha, SE = 5.9, $P = 0.24$) (Figure 4). Core area sizes also remained similar from total feeder dormancy ($\bar{x} = 8.0$ ha, SE = 1.3) to total feeder activation ($\bar{x} = 7.6$ ha, SE = 1.1, $P = 0.54$) (Figure 5). Home range size remained similar between summer feeder dormancy ($\bar{x} = 52.5$ ha, SE = 11.4) and fall feeder activation ($\bar{x} = 38.2$ ha, SE = 7.2, $P =$

0.29), when all 23 feeders on the study site were active. Core area sizes also remained similar between summer feeder dormancy ($x = 6.4$ ha, $SE = 1.3$) and fall feeder activation ($x = 6.7$ ha, $SE = 1.3$, $P = 0.86$).

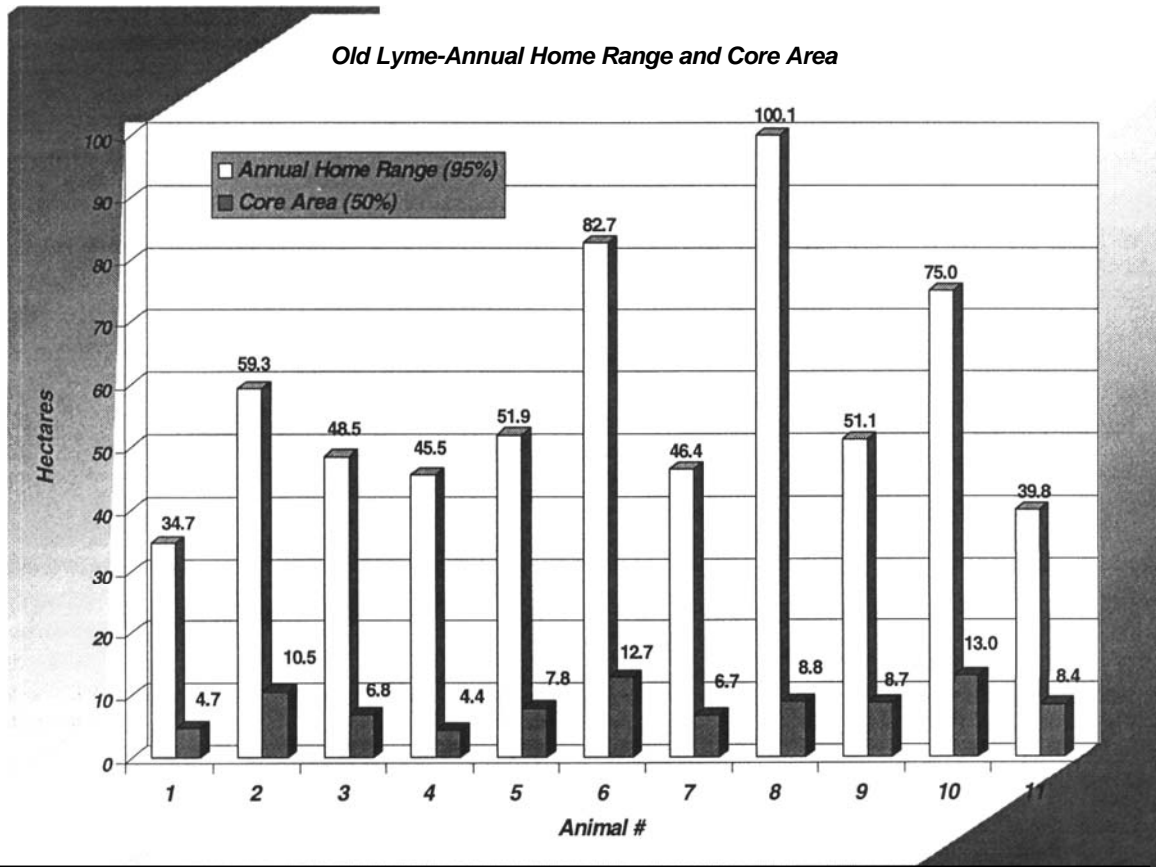


Figure 3. Mean annual home range and core area of Old Lyme deer.

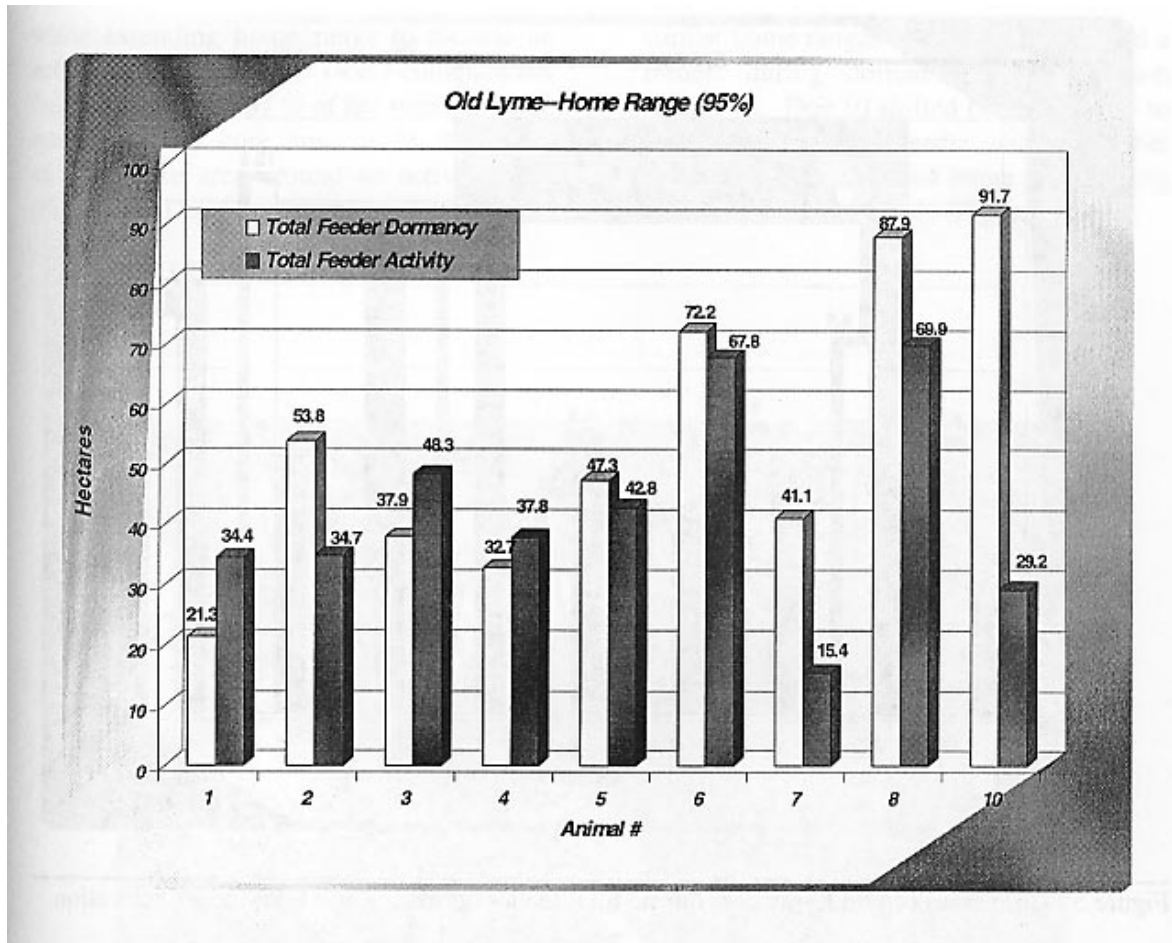


Figure 4. Home ranges of Old Lyme deer during total feeder dormancy and total feeder activation.

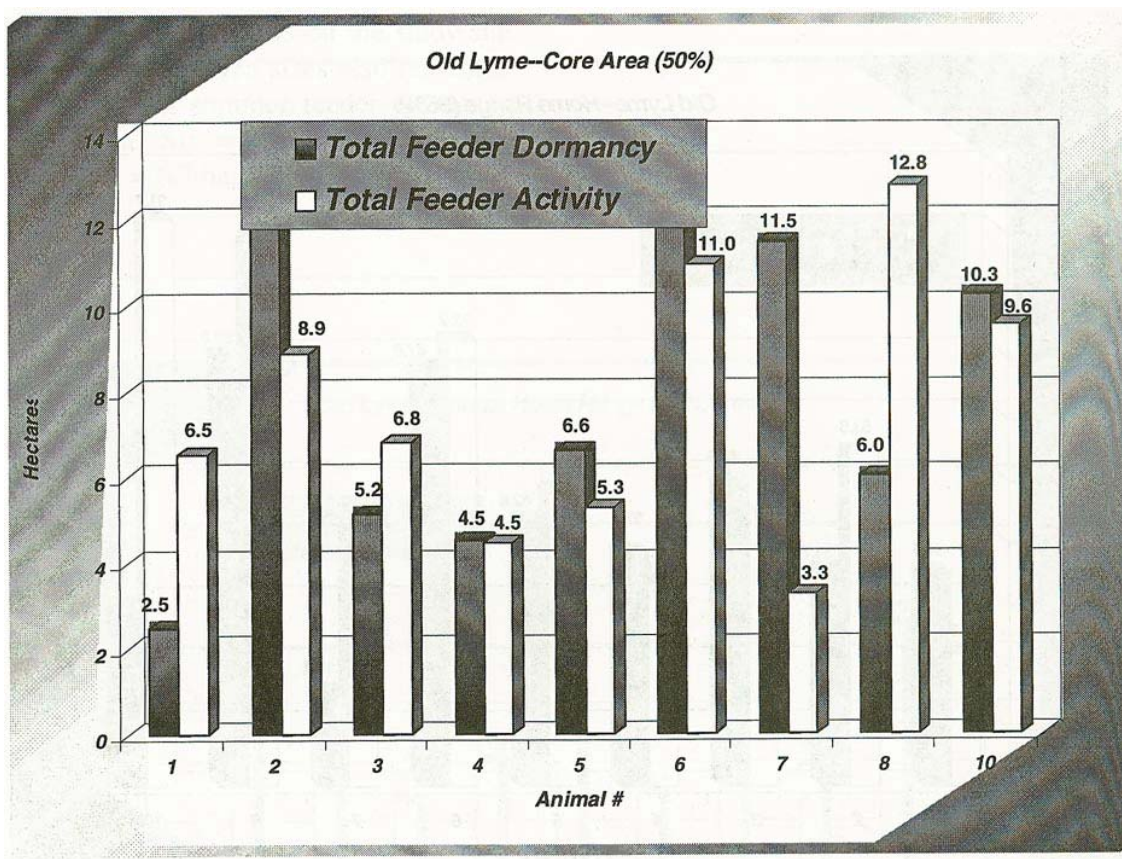


Figure 5. Core areas of Old Lyme deer during total feeder dormancy and total feeder activation.

Core area shifts

During total feeder activation, core areas of the original 6 deer averaged 115 m (SE = 47.3) closer to bait sites within their home ranges than during total feeder dormancy, including one doe whose core area encompassed the feeder. Core ranges of all deer averaged 134 m (SE = 90.5) closer to active feeders during fall feeder activation than during summer feeder dormancy. Core areas of 2 deer encompassed feeders during summer dormancy and 4 deer encompassed feeders during fall activation.

Additional responses

Core areas shifts were not always witnessed. Other unexpected changes in core areas occurred as well. During total feeder activation, the collared male abandoned a second dormant core area and established 1 rigid core area 135 m from an active feeder. In contrast, doe 1 maintained an active core area in the same area as her single dormant core area and added a second active core area 39 m from a feeder.

During fall activation, doe 4 maintained a dormant summer core area,

while extending home range to include an active feeder (Figure 6). Doe 7 collapsed her fall home range to 37 % of her summer home range and fall core area to 28 % of her summer core area around an active feeder (Figure 7). Doe 8 maintained

similar home ranges and core areas around a feeder, during dormancy and activation (Figure 8). Doe 10 shifted her core range to encompass an active feeder, and shrank her home range to 32% of her home range during summer feeder dormancy (Figure 9).

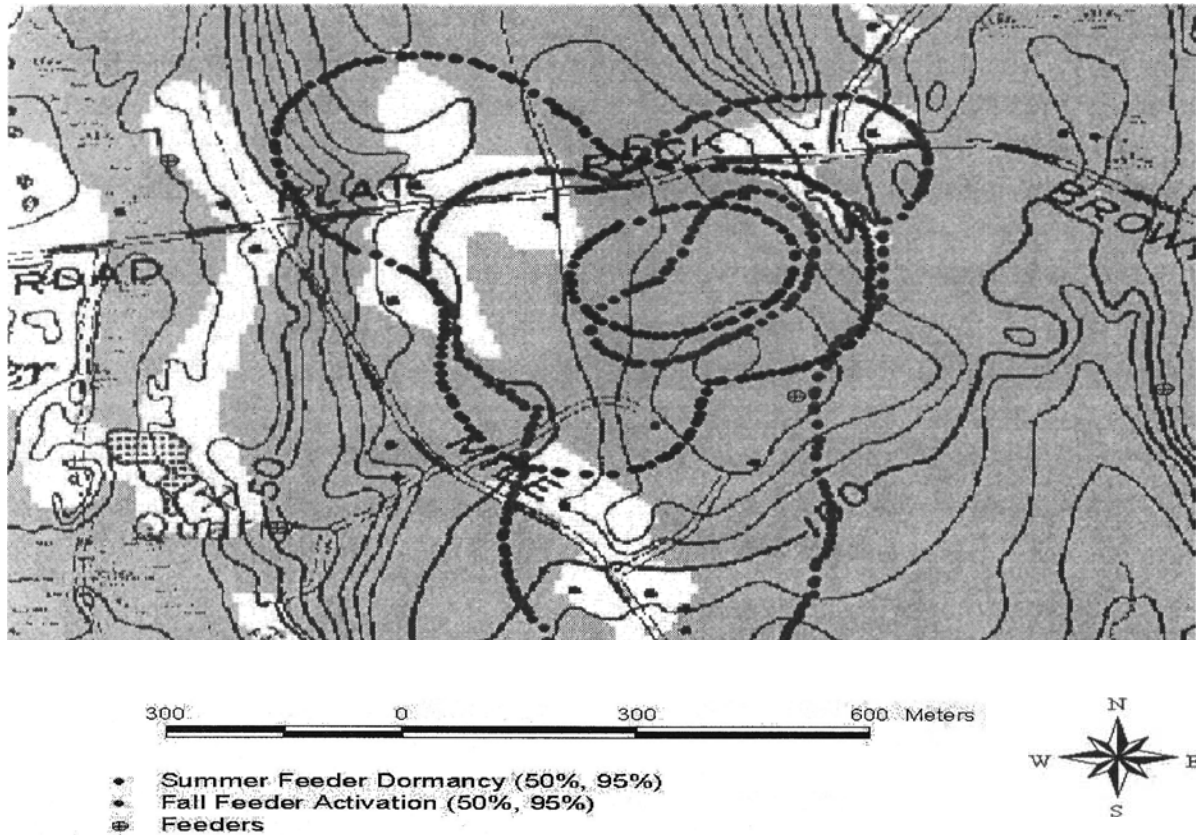


Figure 6. Doe 4 home range and core area during summer feeder dormancy and fall feeder activation.

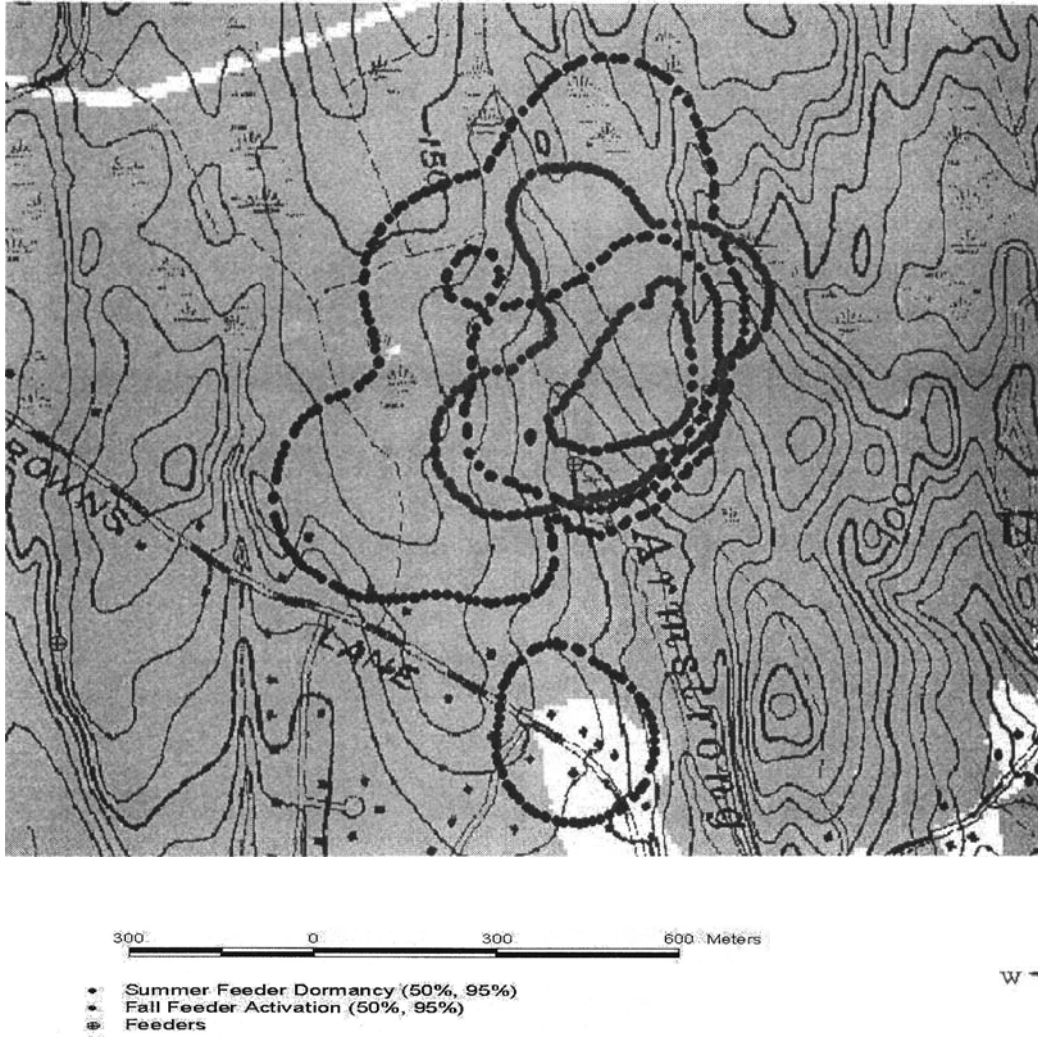


Figure 7. Doe 7 home range and core area during summer feeder dormancy and fall feeder activation.

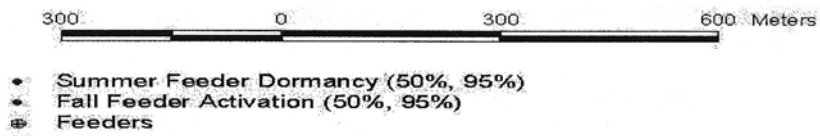
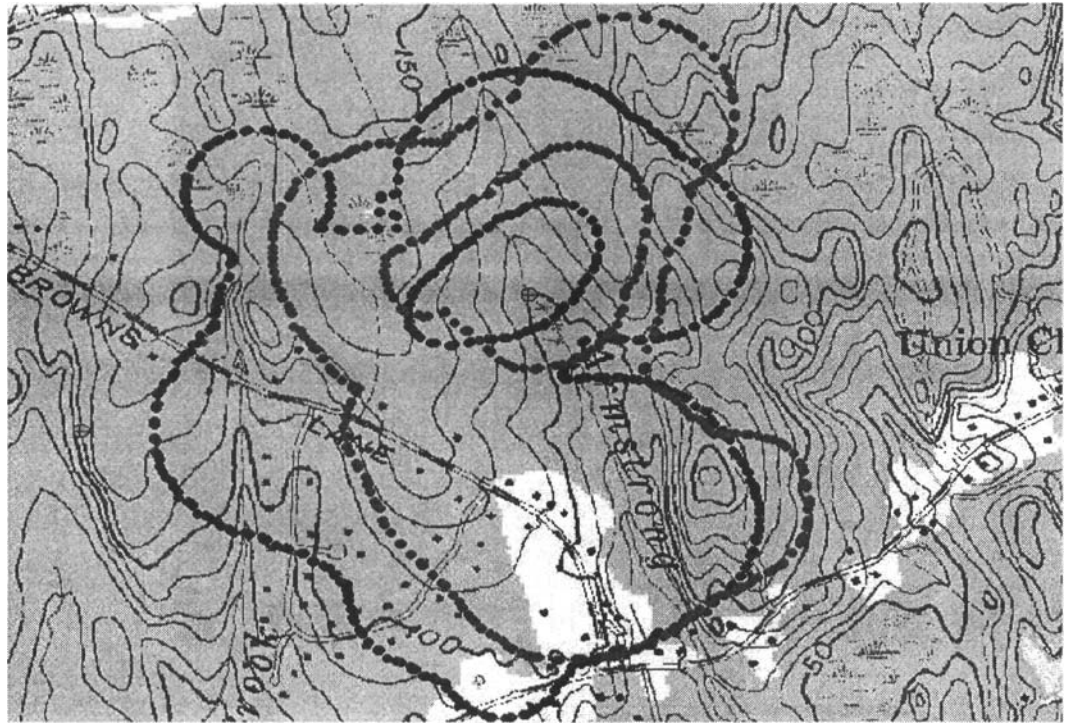


Figure 8. Doe 8 home range and core area during summer feeder dormancy and fall feeder activation.

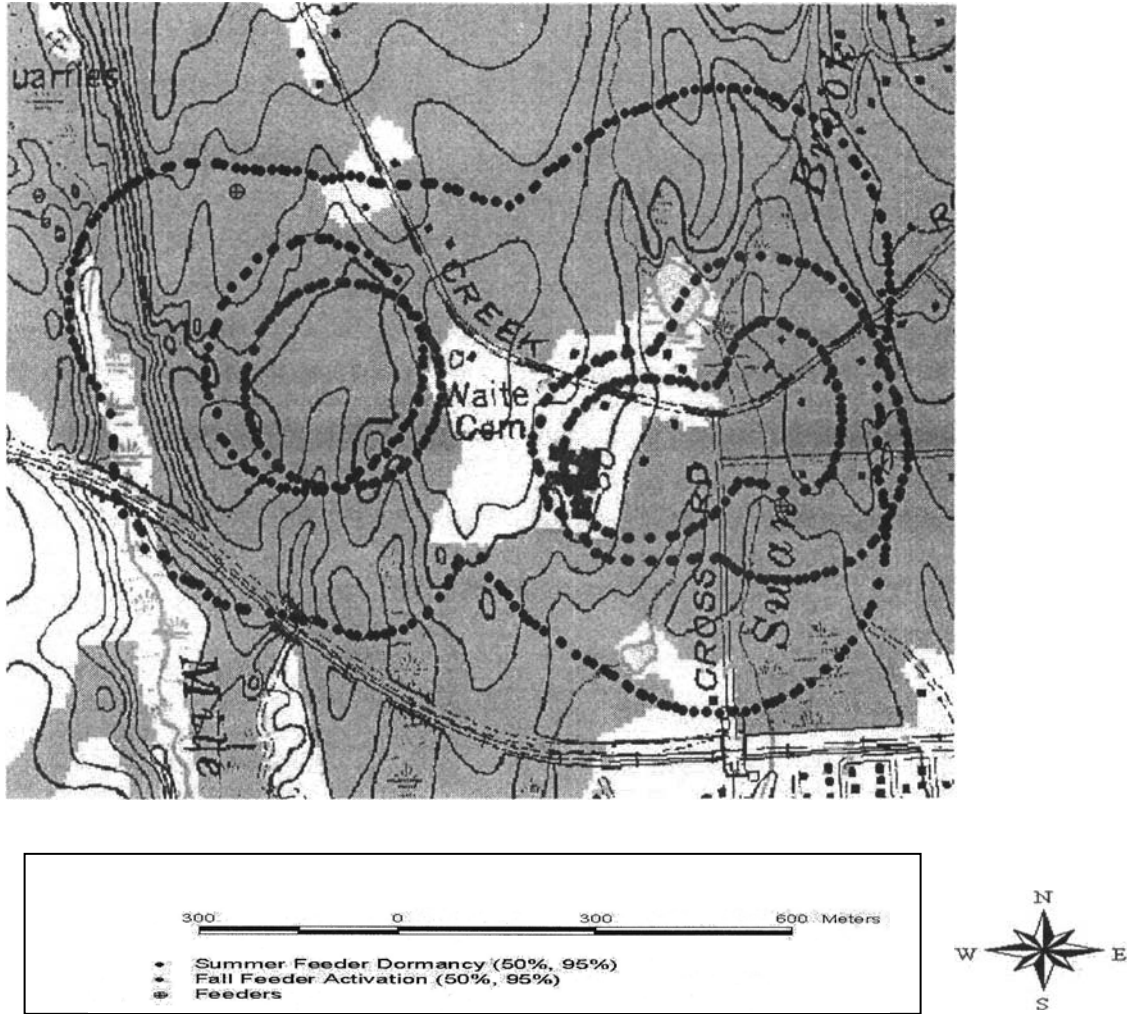


Figure 9. Doe 10 home range and core area during summer feeder dormancy and fall feeder activation.

Discussion

Home range and core area size

Though each decreased in size, neither home range nor core areas showed significant differences from feeder dormancy to feeder activity. However, every deer showed some type of spatial home range movement in response to a feeding station in their home range. We feel that multiple feeders within close proximity to core areas and home ranges of several collared animals made it difficult to quantify and interpret movement patterns. However, unexpected behavioral changes were witnessed around active feeders as a result. We believe core area size remained similar in all analyses because of this proximity to multiple feeders. This led to the establishment of multiple core areas, increased size, and preferred location as responses. Grund (1998) documented fall core ranges of deer in Minnesota to be smallest of the seasons. We saw no difference in core range size between summer and fall, despite fall activation. However, core shifts toward these feeders were evident throughout the study.

Home range sizes of deer in suburban Connecticut appear smaller than other rural studies throughout the United States. Annual home ranges of white-tailed deer were 77 - 178 ha in south-central Wisconsin (Larson et al. 1978), 170 ha in Nebraska (Vercauteren and Hygnstrom 1998), and 737 ha in Mississippi (Mottetal. 1985). However, total home range size of 57.7 ha and core areas of 8.4 ha are comparable to other studies in suburban areas. Annual home ranges of 41.3 ha and 43.2 ha were measured in Groton, Connecticut with core areas of 6.6 ha and 7.3 ha respectively (Kilpatrick and Lima 1999, Kilpatrick and Spohr 2000). Cornicelli (1992)

documented doe home ranges from 16.5 ha in summer to 40.1 ha in spring in a Carbondale, Illinois community.

Additional responses

Because multiple feeders were available to deer, decreased home range and core areas at times of feeder activity were not always witnessed. Also, the fawning season (mid-May - mid July) was included during feeder dormancy, when does have been shown to isolate themselves from other females, hereby decreasing home range size (Ozoga et al. 1982, Schwede et al. 1993, Bertrand et al. 1996). However, 3 responses were typically witnessed: complete core area shift toward the feeder, extreme diminished home range and core area around the active feeder, or establishment of a second core area in close proximity to a second active feeder within home range. Deer with 1 feeder in their home range typically exhibited the first and second behaviors. Deer with multiple feeders available tended to reflect this final behavior. There was a tendency for home ranges and core areas of these deer to increase, but differences were not significant.

Most deer had established annual home ranges that included 2 or more feeders. Other deer had 1 feeder within their home range during feeder dormancy and 2 or more during feeder activation. Proper feeder distribution is essential to be effective in the manipulation of home range and core area for management purposes.

Management implications

We believe the manipulation of home range and core area in response to bait can be used as part of management programs in some

suburban areas. Though different behaviors were witnessed, each deer altered home range and core area in some manner to accommodate supplemental feed. To effectively treat all deer on the study site with Amitraz, 4-poster devices should be placed every 50-60 ha to reduce multiple feeder usage and to increase deer predictability at bait sites (Kilpatrick and Spohr 2000).

Deer with larger home ranges may be capable of larger core area shifts. In suburban areas where home range size tends to be smaller, shifting may not be as evident. However, we feel that core area shifts of over 100 meters is significant enough to lure deer away from houses to secluded bait stations, where management actions can be taken safely and efficiently. Strategic bait site placement also could be used to shift deer ranges out of neighborhoods to reduce Lyme disease incidence, vehicle collisions, and damage to manicured landscapes.

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