

HOME RANGE INCREASE OF LACTATING FEMALE WHITE-TAILED DEER FOLLOWING HERD REDUCTION

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Abstract: Substantial increases in numbers of suburban white-tailed deer (*Odocoileus virginianus*) have created an urgent need to manage these populations. With this study, we hope to better understand behavioral changes in response to a population reduction to assist in predicting effective long-term management strategies. We monitored movements of 12 female deer by visual observation in a 176-ha enclosure in southern Connecticut from May 1999 to August 2000. Deer in the enclosure had a population density of 13 deer/km² and male:female sex ratio of 1:1.3. Results are compared with those of a previous study on the same site in 1992-93, when mean population density was 39 deer/km² and male:female sex ratio was 1:2. Mean annual home range size increased from 17.2 ha in 1993 to 58.2 ha in 2000. Core ranges also increased from 3.5 ha to 7.6 ha. Lactating does significantly reduced home range size during the fawning period and isolated themselves from other does, then began to increase social activity and home range size toward late autumn and through winter. Although does exhibited high home range fidelity, reduced aggressive social interactions resulting from a population reduction could have resulted in increased home range size. After a herd reduction, it may take time for suburban residents to witness any change in localized deer abundance. Residents in fawning areas may experience continued browse damage to garden plantings and a sustained number of ticks due to a substantial decrease in home range size during this time. As a consequence of these behaviors, we suggest that communities using deer removal as a management strategy be prepared to continue this practice in subsequent years to help maintain healthy local herds at socially acceptable levels.

Key words: Connecticut, fawning, home range increase, lactation, *Odocoileus virginianus*, population reduction, white-tailed deer

Throughout the eastern United States, there is considerable interest in reducing local white-tailed deer populations. Management efforts to decrease deer densities will alleviate pressure on local native vegetation and ornamental trees and shrubs (Alverson et al. 1988, Ward 2000),

reduce deer-vehicle collisions (DeNicola et al. 2000), and reduce numbers of black-legged ticks (*Ixodes scapularis*) thereby reducing the prevalence of Lyme disease (Wilson et al. 1990, Daniels et al. 1993, Deblinger et al. 1993, Stafford 1993). Home ranges of suburban deer are smaller than those documented in earlier studies of rural populations (Rongstad and Tester 1969, Tierson et al. 1985, Cornicelli 1992, Grund 1998). Habitat distribution and quality are believed to affect home range

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size (Schoener 1981, Ford 1983, Mace et al. 1983, Kilpatrick et al. 2001). Aggressive social interactions may also determine the extent of deer movements, especially in high-density populations (Ozoga et al. 1982, Schwede et al. 1993). We wished to better understand potential changes in deer behavior following population reductions.

This study examines changes in home range size in a reduced-density deer population. Comparative home range data were derived from Bertrand et al. (1996). During this original 1992-93 study on the same site, population density was reduced from 68 deer/km² to 39 deer/km² in late 1992, resulting in significant increases in home range sizes of both lactating and non-lactating does. However, some confounding variables (i.e., male harvest caused a change in sex ratio) prevented a clear determination of cause and effect in relation to deer density and home range size. The population density during the 1999-2000 study averaged 13 deer/km². Our primary objective was to determine changes in home range size of does in response to a significant population reduction.

Following parturition, some does isolate themselves to establish the mother-infant bond and for additional protection from predators (Lent 1974, Ozoga et al. 1982). Home range size is reduced because of this isolation behavior (Ozoga et al. 1982, Scanlon and Vaughan 1985). However, in southern Connecticut does did not reduce their home range size during the fawning and post fawning periods under high densities (Bertrand et al. 1996). We predicted that if home range size increased in response to population reduction, a measurable decrease in home range size would occur during the fawning period.

Study Site

Our study area was a 176-ha enclosure composed primarily of deciduous forest, fields, and wetlands in southern Connecticut (DeNicola 1996). A 3-m fence delimited the site, effectively isolating animals from the surrounding urban development. Habitat composition remained unchanged and, to prevent starvation at high density, *ad libitum* supplemental whole corn was provided in 3 90-kg open trough feeders from 1992 through this study. All deer on site had been captured by drop net or dart rifle (Pneu-Dart, Williamsport, Pennsylvania, USA). Deer secured via drop net were subsequently immobilized with 200 mg ketamine hydrochloride and 100 mg xylazine hydrochloride (DeNicola and Swihart 1997). A combination of 250 mg Telazol® and 150 mg xylazine hydrochloride was used to remotely immobilize all remaining animals. Anesthetized animals were immediately fitted with a mask, treated with an ophthalmic ointment, and ear-tagged. Effects of xylazine hydrochloride were reversed with an administration of 15 mg yohimbine hydrochloride. All does were fitted with radio transmitters (Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA).

Following the 1992-93 study, the enclosed deer population was reduced gradually over time while conducting fertility control studies (DeNicola et al. 1997a, DeNicola et al. 1997b). In May 1999, a population of 21 white-tailed deer (9 M 12 F) inhabited the study site. Of the 12 original females, 10 remained on the southern half of the study site and the other 2 inhabited the northern half, resulting in respective densities of approximately 17 deer/km² and 7

deer/km². Bucks used the entire study site.

METHODS

Home range data were gathered from 20 May 1999 through 21 August 2000. Data were gathered during periods of peak movement as described by Montgomery (1963), from dawn to midmorning and from mid to late afternoon, dark, or longer. To ensure accuracy, visual observations accounted for the majority of data; radio telemetry was used first to locate the general vicinity of does. Deer on site were accustomed to human presence and were approachable from 30-50 m. This allowed us to visually confirm locations without disturbance. An extensive road network throughout the site permitted data collection from a vehicle. Triangulation measures were taken using a portable, hand-held receiver (Model R-1000, Communications Specialists, Inc., Orange, California, USA) and hand-held 2-element antenna (model RA-14; Telonics, Inc., Mesa, Arizona, USA) when visual contact was infeasible.

Initially, one reading was taken daily to ensure independence between deer locations (Swihart and Slade 1985). However, we felt movements of deer within an approximate 1-hour interval on the study site were substantial enough to warrant recognition. Swihart and Slade (1985) stated that autocorrelation of data points will cause negatively biased estimates of home range size. Because of our relatively small study area, we believed that the hour interval was enough time for the individuals to delineate their entire stationary home range, particularly at times of peak activity. This time interval was consistent throughout monitoring, thus home range estimates

should not be affected by length of this sampling interval and autocorrelation (Otis and White 1999).

We quantified home ranges for the entire 15-month study and then analyzed data separately for 2 consecutive 6-week periods (pre-fawning and fawning) for every adult doe on site during the 2000 fawning season, as per Bertrand et al. (1996). The presence of a large udder was used to determine whether a doe was lactating. This initial classification was later confirmed by nursing activity and by the consistent presence of a fawn. For each lactating doe, the 6-week pre-fawning period ended at her estimated date of parturition, at which time the 6-week fawning period commenced. Median parturition date was estimated to be 23 May 2000. Because data collection began in late May 1999, sample sizes were not adequate to accurately estimate home range during the 1999 fawning period. However, home ranges of the 8 lactating does in spring and summer 2000 were estimated using > 30 data points, as suggested by Seaman and Powell (1996). Social affiliations were also calculated for these intervals and determined by percentage of locations in which a doe was within 24 m of another.

A hand-held global positioning system receiver (Magellan ColorTRAK) was used to establish several permanent telemetry locations throughout the study area. These, along with the feeding stations, were permanently demarcated on the United States Geological Survey (USGS) topographic map feature of the computer program Topo! (Wildflower Productions, 1998, version 1.2.4). Coordinates (decimal degrees) of each visual observation were determined using this feature. In cases of non-visual observations, appropriate compass

bearings were drawn from each marked location and coordinates were recorded at the intersection. Telemetry results were pooled with visual observations. We feel telemetry error had negligible impact on results based on the extensive road network that permitted visual access to 80% of the site. As a result, locations gathered with telemetry were restricted to several "blind" areas, each approximately 1 ha. Decimal degree coordinates were then entered into the LatLong conversion program of the home range computer program CALHOME (CALifornia HOME Range) (Kie et al. 1996), and converted to Universal Transverse Mercator (UTM) (Grubb and Eakle 1988), North American Datum (NAD) 1927 coordinates. The output file from each doe was imported into the program ArcView (Version 3.1, Environmental Systems Research Institute, Inc., Redlands, California, USA).

A scanned version of the USGS 7.5-minute topographical quadrangle geocoded in UTM NAD 1927 was also imported into ArcView. We were able to overlay deer locations precisely on the quad. We then used the Animal Movement extension of ArcView (Hooge and Eichenlaub 1997) to conduct all home range analyses. Within the Animal Movement extension, we used the adaptive kernel method (Worton 1989) feature to calculate home range and core area. We calculated home ranges using the 95% confidence interval to minimize the effect of outliers, leading to a more precise definition of home range. Core activity areas were calculated using the 50% confidence interval.

RESULTS

We recorded 2,297 locations for 9 does over the duration of the study. From

215 - 272 ($\bar{x} = 255$) observations were obtained per animal. Observations ($\bar{x} = 246$) were also recorded for 2 female fawns born in May 1999 until the end of the study. There were partial annual observations ($\bar{x} = 79$) for 3 other does. These were included in the calculation of total home range size, but excluded from comparisons of pre-fawning and fawning, as their on-site presence did not coincide with the 2000 fawning period.

To relieve any inbreeding pressure that may have existed, 1 buck and 1 doe were recruited on site in autumn 1999. These animals were seen wandering the outside perimeter of the fence and were allowed on site. The same autumn, 2 does and 1 buck died and the addition of 5 fawns gave a density of 13 deer/km² through 1999. Male:female ratio during the 1999 pre-fawning period was 1:1.3, then 1:1.2 post-fawning. There were 4 lactating does during spring 1999 and 8 in spring 2000. The ninth doe did not have a fawn during the 2000 fawning season, possibly due to stress caused by a large cyst on her left lower foreleg which impeded her ability to walk. No does on site were included in both the 1992-93 and 1999-2000 studies.

One of the 2 surviving doe fawns born in May 1999 was forced to disperse by the lactating dam during the May 2000 pre-fawning period. The fawn subsequently established an adjacent range of comparable size (40.6 ha) to the dam (37.8 ha). The other fawn remained with the dam through the pre-fawning and fawning periods, as the dam remained barren. After the death of this dam, the fawn remained in her established home range while making occasional excursions outside her established territory for several hours at a time.

Mean home range size of all does for

the duration of the study was 58.2 ha (SE = 7.1), ranging from 21.1 ha to 119.9 ha. Mean core area size for the same interval was 7.6 ha (SE = 1.0), ranging from 2.4 ha to 14.2 ha. Home ranges of does in 1993 were estimated to be 17.2 ha (SE = 1.5) with mean core area size of 3.5 ha (SE = 0.4). Does in our reduced-density population showed a 238% increase in mean annual home range and a 43% increase in core area compared with the 1993 population (Bertrand et al. 1996).

We recorded 378 locations for the 9 does during the pre-fawning period (\bar{x} = 42) and 448 locations during the fawning period (\bar{x} = 50). Lactating does exhibited a mean pre-fawning home range of 64.1 ha (SE = 8.7) with mean core area size of 9.7 ha (SE = 2.0); a 375 % increase in home range (13.5 ha) from 1993. Home range size of lactating does during the fawning period decreased significantly (\bar{x} = 30.0 ha, SE = 6.4, P = 0.002) from pre-fawning ranges and was more than double the 1993 fawning period (\bar{x} = 14.5 ha, SE = 4.9) (Fig. 1). Though mean core area size for lactating does also decreased from pre-fawning to fawning, the difference was not significant (\bar{x} = 5.1 ha, SE = 1.4, P = 0.09). Core area sizes of all 9 does (including non-lactating) decreased significantly from pre-fawning ranges (P = 0.04). Fawning home ranges decreased an average of 54% from the pre-fawning period, ranging from 23% to 75% decrease. Core areas decreased an average of 52%, ranging from an increase of 80% to a decrease of 91% for the same interval.

One doe (#4) occupying the northern portion of the study area was the direct offspring of a doe included in the original 1992-93 study. Mean annual home range and core area size of this doe were the smallest of all does on site (21.1 ha and 2.4 ha respectively). The other northern

doe, several generations removed from the 1992-93 herd, exhibited a much larger home range (56.2 ha) and core area (6.8 ha).

Lactating does were affiliated with other lactating does during 59% of all locations during the pre-fawning period. In comparison, lactating does were affiliated with other lactating does only during 7% of all locations during the fawning period.

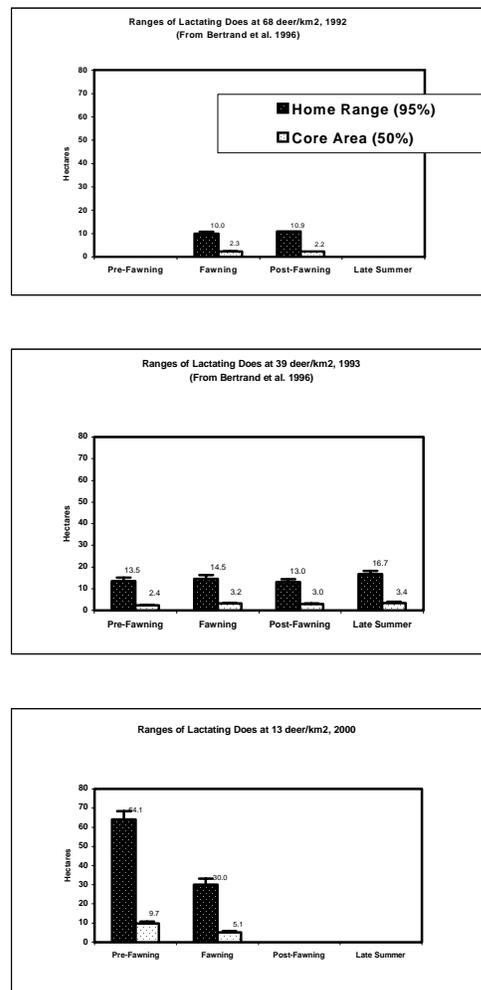


Fig. 1. Mean kernel home range and core area sizes (SE) of lactating does during various intervals, southern Connecticut.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Annual home range sizes varied among does on site; however, they were geographically rigid. As mentioned previously, 2 does established ranges in the northern portion of the study site, whereas the rest remained in the southern half. One of the 2 died during the study but the recruited doe subsequently established her range in the northern half. There were no geographic barriers or notable differences in habitat deterring deer from the northern half of the study area. Variation in relative distribution was a result of differential fertility control treatments and removal efforts (A. J. DeNicola, unpublished data). Southern does established their separate core ranges, were generally social, and rarely seen alone, other than during fawning. Mean annual home ranges of southern does began to extend northward throughout the study. The original northern does rarely, if ever, were seen together. The recruited doe was on site for several months before we observed an interaction between her and the remaining northern doe.

We believe that mean annual home ranges of does are more geographically rigid than we had anticipated, consistent with Tierson et al. (1985) and Kilpatrick et al. (2001). Specifically, we did not see does from the southern portion of the site abandoning established ranges to settle in the northern portion despite the significantly lower population density, consistent with the findings of Behrend et al. (1970), Porter et al. (1991), McNulty et al. (1997), and Kilpatrick et al. (2001).

Home ranges varied considerably in size. Though does found on the southern portion of the site had comparable ranges,

the two northern does showed great discrepancy. The behavior of #4 as a fawn was learned in a high-density population and her mean annual home range, core area size, and location mimicked that of the deer in the previous study. However, the other northern deer several generations removed from the 1993 herd, exhibited a much larger mean annual home range and core area. Her conflicting behavior further leads us to believe in the learned behavior of #4. There was less generational overlap in some does because of select euthanasia of adults for data collection purposes.

In the Adirondacks, Tierson et al. (1985) found that 1- and 2-year-old female deer established home ranges adjacent to and often overlapping the range of their female parent and other social group members. They also found these young females followed similar seasonal movement patterns as adults. Based on these observations, we suggest that this learned behavior from higher density populations will be reflected in years following removal programs, regardless of population density. Anecdotal observations (A. J. DeNicola, unpublished data) noted a gradual range expansion by individuals and over generations.

Henderson et al. (2000) determined that does surviving a 50% population reduction increased seasonal home range by 30% compared with a control herd. Other studies have also confirmed the inverse relationship between population density and home range size (Marchinton and Jeter 1967, Ellisor 1969, Marshall and Whittington 1969). On our study site, where natural browse was abundant and *ad libitum* supplemental feed had been provided since 1992, the same inverse relationship was witnessed (Fig. 2).

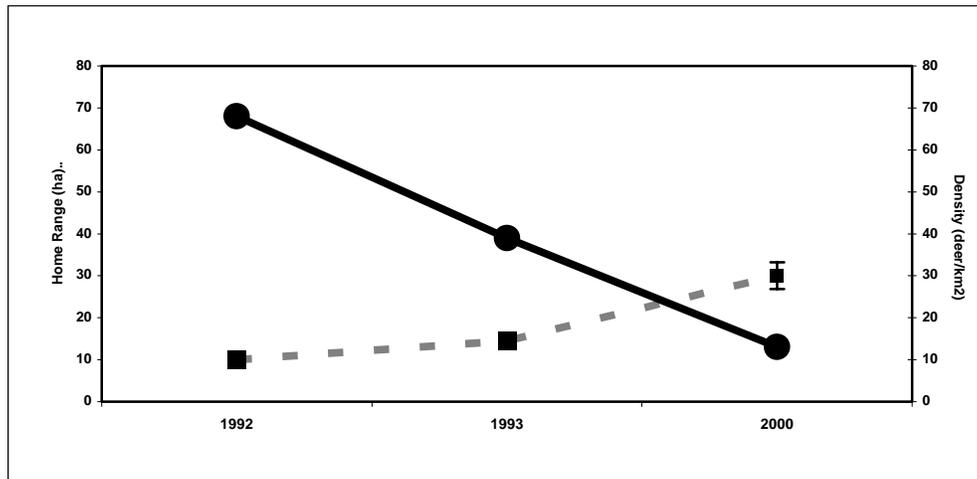


Fig. 2. Relationship between fawning home range size (95% kernel) and deer density in the same 176-ha enclosure, southern Connecticut. (▪ Fawning home range, • deer density).

Our results support our prediction: home ranges increased in response to a population reduction and a measurable decrease in home range usage occurred during the fawning period. Fawning ranges of lactating does more than doubled in size from 1993 and tripled from 1992. This significant increase in fawning space, in addition to a marked decrease in sociability, should allow does sufficient time and resources to select an optimum fawning area removed from other does, leading to a stronger establishment of the mother-infant bond (Lent 1974, Ozoga et al. 1982). This additional protection and uninterrupted isolation should increase fawn survival, as 93% of fawn mortalities in southern Texas occurred within 32 days of parturition (Cook et al. 1971). We did not witness any aggressive social interactions as previously described for high-density populations by Ozoga et al. (1982) and Schwede et al. (1993).

Does in high-density populations may not be able to reduce home range during

the fawning period (Ozoga et al. 1982, Bertrand et al. 1996). In our reduced-density population, we found a significant 53% decrease in home range of lactating does from pre-fawning to the fawning period and a corresponding decrease in social activity. However, core area size did not differ significantly for lactating does. Two lactating does increased core area size during the fawning period. During the pre-fawning period, these does were affiliated with each other during 100% of observations. We believe these does were in competition for fawning space and increased core area as a result.

Based on our research, general patterns of home range size and movements will exist following herd reductions at localized levels of high deer densities. We suggest these results are not site specific and similar behavioral results will be witnessed in a suburban setting.

As previously mentioned, several studies have documented an inverse relationship between deer density and home range size (Marchinton and Jeter

1967, Ellisor 1969, Marshall and Whittington 1969, Bertrand et al. 1996, Henderson et al. 2000). In addition, deer surviving reduction programs should maintain geographically rigid home ranges initially (Tierson et al. 1985, Kilpatrick et al. 2001). Our findings reaffirm those of Behrend et al. (1970), Porter et al. (1991), McNulty et al. (1997), and Kilpatrick et al. (2001) who noted that habitat voids created by reduction programs may not be immediately occupied by adjacent does.

Social interactions or learned behavior of existing does may be the cause of limited home range expansion immediately following a reduction. This learned behavior will most likely be lost in subsequent generations following continued density reductions resulting in larger ranges under lower densities. Nevertheless, some suburban residents may witness little change in localized deer population density during this time. The eventual increasing home range sizes of does in the managed area will relieve local pressure, but increase overall size of the affected area. Hence, residents of affected areas should experience less economic damage to backyards and manicured landscapes, fewer deer-vehicle collisions, and less abundant tick populations. However, residents in fawning areas may experience increased browse damage and tick abundance due to substantially reduced ranges during this season. Fawn survival may increase as a function of the ability of does to reduce home range during this time, thereby increasing recruitment rates. In addition, a lower density of animals should allow for abundant and more nutritious food sources, also contributing to increased herd health. Consequently, we advise communities that decide on deer removal as a management option to be prepared to

continue these practices in following years to maintain local herds at socially acceptable levels.

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