The Texas Journal of Agriculture and Natural Resource 21:32-42 (2008)

Spatial Distributions of Adult Male White-Tailed Deer Relative to Supplemental Feed Sites

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ABSTRACT

Nutrient intake of deer in south Texas is lowest in late summer and winter; therefore, supplemental food may be provided during these times by managers. When natural food resources become scarce, white-tailed deer (*Odocoileus virginianus*) may shift home ranges or core areas to incorporate supplemental food sources. Thus, supplemental food sources may influence daily movements and home range characteristics of deer. To examine how deer were distributed relative to supplemental feed sites, 48 adult male white-tailed deer were radio collared and tracked from October 2002 to August 2004. The average density of supplemental feeders within deer home ranges was 47% lower in year 1 and 18% lower in year 2, than the density of feeders in the study area (>0.19 supplemental feeders/mile^2). Home ranges of deer with feed (n = 17, 635.6 ± 64.5 acres) were larger (t_{25} = 3.44, *P* = 0.002) than deer home ranges without feed (n = 14, 379.8 ± 37.1 acres). In both years, there was no difference among seasons in the distance between deer locations and supplemental feeders (*P* ≥ 0.495). Furthermore, there was no difference (*P* ≥ 0.667) between the distances deer were found from supplemental feeders compared to the distance random points were from supplemental feeders during years 1 and 2. These data demonstrated that supplemental feeders had little effect on deer spatial dynamics. Therefore, it appears that other habitat components may have had a stronger influence on deer movements than supplemental protein feeders alone. Our results will help wildlife managers determine how many supplemental feeders to install based on average density and distances deer were located to these resources during times of above average rainfall.

We thank C. Rush, D. Lee, J.B. Finley and the Callaghan Ranch, C.J. Zabransky, R.S. Lyons, and B.M. Ballard for project support. We also thank S.M. Cooper, and B.K. Strickland for helpful comments on earlier drafts. Cooperative funding was provided by the San Antonio Livestock Exposition, Inc., Hilliard Family Foundation, and Houston Safari Club. This is contribution number 07-112 of the Caesar Kleberg Wildlife Research Institute.

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KEYWORDS: Home range, movements, *Odocoileus virginianus*, protein, supplemental feeders, white-tailed deer

INTRODUCTION

Providing pelleted supplemental feed is a common practice during winter to increase survival of cervids (Baker and Hobbs 1985, Carhart 1943, Smith 2001). In northern latitudes, white-tailed deer (*Odocoileus virginianus*) are exposed to harsh winters with reduced food availability, and increased energetic costs (Moen 1976). However, in south Texas, deer may be limited nutritionally during hot, dry summers or need access to feed year-round to supplement low-quality vegetation. For this reason, year-round supplemental feeding (Payne and Bryant 1994) is a common practice in Texas where white-tailed deer are intensively managed (Cooper et al. 2006). An estimated 47% of hunting leases in Texas provide supplemental feed for white-tailed deer (Thigpen et al. 1990). Adult male white-tailed deer on a study area with an intensive supplemental feed program (Webb et al. 2007a) had greater survival compared with other studies of adult males without access to feed (DeYoung 1989, Ditchkoff et al. 2001). However, Webb et al.'s (2007a) study did not show direct evidence that providing supplemental feed was the reason for increased survival.

Animal distributions may be changed when supplemental feed is provided. Altering herbivore distribution has the potential to alter vegetation communities by concentrating animals near feeders, which creates localized areas of high population density (Cooper et al. 2006). If food is readily available, then animals may browse more selectively (Stephen and Krebs 1986) potentially damaging highly palatable plants (Anderson and Katz 1993, Murden and Risenhoover 1993, Augustine and Jordan 1998, Cooper et al. 2006). Cooper et al. (2006) found deer browsing was heavier near feed sites compared to control sites, yet feeder sites appeared to have little effect on home range size of deer.

Little information exists on how year-round supplemental feeding affects deer movements and home range size and shape. Competition at supplemental feed stations may be decreased with increased densities of feed stations (Bartoskewitz et al. 2003). Supplemental feed use by deer during winter in Ontario was lower than expected; possibly due to low densities of feeders (Schmitz 1990). Therefore, it is necessary to determine proper density of supplemental feeders to maximize benefits to deer and avoid wasting resources in establishing excessive numbers of supplemental feeders. Our objectives were to: 1) determine what effect supplemental feeder distribution had on adult male white-tailed deer home ranges, and 2) determine how adult male deer movements were influenced by supplemental feeders.

MATERIALS AND METHODS

Study Area

We conducted our study on a free-ranging population of white-tailed deer on the Callaghan Ranch (27°48'59"N, 99°18'49"W) from October 2002 through August 2004. The Callaghan Ranch is located in Webb County, Texas 26.7 miles northeast of Laredo,

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TX. The ranch consisted of 85,000 acres of mesquite- (*Prosopis glandulosa*) dominated shrubland (McCoy 2001). The ranch was stocked with domestic cattle at a rate of 1 animal unit/51.9 acres and deer density was estimated to be 1 deer/28.2 acres in 2002 and 1 deer/30.6 acres in 2003 (Callaghan Ranch, unpublished data) based on helicopter surveys not corrected for visibility bias. Free water was distributed across the ranch through earthen stock ponds, concrete troughs, and ephemeral creeks at a density of 0.32 permanent water sources/mile² (Webb et al. 2007b). Supplemental feed sites with pelleted, protein feed were distributed across the study area at an average density of approximately 1 feed site/0.24 mile². Supplemental feeders (1-2/pen) were housed in a circular feed pen (i.e. supplemental feed site) ≥59 feet in diameter and constructed of 2.8 foot tall hog feedlot panels. Supplemental feed sites were constructed to exclude cattle and feral pigs (*Sus scrofa*). Corn was also fed as bait during the hunting season (October through January) along roads and in timer feeders.

Webb County is in the Western Rio Grande Plains of Texas. Cattle ranching and leasing hunting rights for white-tailed deer and other game are primary land-based economic activities. Webb County had an average daily maximum temperature in July of 98.2 F, an average daily minimum in January of 43.3 F, and received a mean annual rainfall of 19.8 inches. Most rainfall (70%) usually fell between April and September (Sanders and Gabriel 1985). Total annual rainfall was 19.2, 25.7 and 27.2 inches in 2002, 2003 and 2004, respectively (Laredo, Texas; National Climatic Data Center 2002, 2003, 2004).

Capture and handling

We captured 19 adult, (estimated ≥4 years-of-age) male white-tailed deer on the Callaghan Ranch during October 2002 using a net-gun fired from a helicopter (Webb et al. 2008). In addition, we recaptured 13 known-age adult males (5.5 years-of-age) originally captured and radio-collared as yearlings in 1998 as part of another study (McCoy et al. 2005). The next year we caught 3 additional adult males (estimated ≥4 years-of-age) in October 2003 and 13 additional adult males (estimated ≥4 years-of-age) in March 2004. To minimize mortalities due to capture myopathy, we did not pursue deer for more than 8 min (DeYoung 1988).

Upon capture, we manually restrained and blindfolded deer then aged them according to tooth replacement and wear (Severinghaus 1949) using site-specific known-age jaws as reference. We placed colored ear-tags and radio-collars equipped with both movement and mortality sensors (Advanced Telemetry Systems, Inc., Isanti, Minnesota) on deer ≥4 years-of-age. We released deer at the site of capture within 20 min to minimize stress. Capture and handling procedures were approved by the Texas A&M University-Kingsville Institutional Animal Care and Use Committee (Permit No. 2003-5-14).

Radio-telemetry

We located deer 1-2 times/week during diurnal, nocturnal, and crepuscular time periods using a Telonics TR-2 radio-receiver with TS-1 scanner (Telonics, Inc., Mesa, Arizona) and a null-peak radio telemetry system consisting of 2 yagi 4-element antennas (Advanced Telemetry Systems, Inc., Isanti, Minnesota). We estimated bearings to the transmitter using the null-peak radio telemetry system and a hand-held compass. We took compass bearings ≥12 m from the truck to reduce interference and corrected for declination (White and Garrott 1990) by adding 6.5º to the final bearing total.

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We estimated locations using 2-5 bearings and Location of a Signal software (LOAS; Ecological Software Solutions™, Sacramento, CA). Locations derived from ≥3 bearings were estimated by the Maximum Likelihood Estimator (Lenth 1981) and those derived from 2 bearings were calculated by Best Biangulation Estimator in LOAS. We converted locations to a Geographic Information System (GIS) for use in Arc-View 3.2 software (Environmental Systems Research Institute, Inc., Redlands, CA.). We obtained relocations on deer ≥12 hours apart to reduce autocorrelation. Visual observations were recorded with a differential GPS (DGPS) unit and were used in the final estimation of home range size.

To assess accuracy of the null-peak radio telemetry system, we randomly placed radio transmitters throughout the study area and georeferenced them with a DGPS unit. Mean telemetry error (n = 13) was 89.5 yards ± 12.8 (SE) for locations with ≥3 bearings.

Home range estimation

We used the fixed kernel home range estimator (Worton 1989) to generate 95% home ranges using the Animal Movement Extension (Hooge and Eichenlaub 1997) in ArcView 3.2 software for deer that were tracked 1 full year and that had ≥30 locations. We used the reference bandwidth (h_{ref}) when calculating the 95% probability polygons. We calculated annual home ranges from 15 October 2002 to 14 October 2003 (year 1) and 15 October 2003 to 25 August 2004 (year 2).

Data collection

We mapped all supplemental feeders within the study area using a DGPS and brought the data into ArcGIS 8.2 software. We monitored supplemental feeders to determine number of months per year they contained pelleted feed. Supplemental feeders were never empty more than 3 consecutive weeks and never empty more than 2 months total within a given year. Therefore, supplemental feeders with feed for ≥10 total months/year and not empty >3 consecutive weeks were considered available to deer year-round.

To determine if supplemental feeders had an effect on deer home range placement, we compared supplemental feeder density (supplemental feed sites/mile^2) within annual home ranges of deer to the density of feeders available on the study area. Seaman et al. (1999) recommended that a minimum of 30 locations be obtained for kernel home range estimators. In this analysis, we used only deer that were tracked 1 full year and that had ≥30 locations.

We defined the study area by creating a minimum convex polygon around all deer telemetry locations and buffering out 89.7 yards (the average error of our telemetry system). We excluded areas outside the ranch boundary from the analysis because we did not have access to map feed sites.

To assess seasonal effects of supplemental feeders on deer movements we used telemetry locations within season to determine mean minimum distance to supplemental feeders. We defined seasons by calendar dates (i.e. spring, summer, fall, winter). For each deer within each season we calculated the distance (yards) from each telemetry location to the nearest supplemental feed site using the spatial join function in ArcGIS 8.2 software. Although this analysis did not involve deer home ranges, only telemetry locations within season, we only used deer that were tracked for 1 full year and had ≥30 locations.

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To determine if deer were found closer than expected to supplemental feeders within each deer's home range, we generated 1,000 random points using a random point generator in ArcGIS 9.x. Only deer that were tracked 1 full year and that had ≥30 locations were used in the analysis when generating random locations within home ranges. All random locations within a home range were used to determine mean minimum distance to supplemental feed sites. The mean minimum distance of random locations were compared to the mean minimum distance of actual telemetry locations pooled across seasons to determine if actual deer locations were closer than expected to supplemental feeders within the home range.

Statistical analysis

We assessed the influence of supplemental feeders on the location of deer home ranges within the study area using a 1-sample *t*-test by comparing the density of supplemental feed sites within home ranges to the density available on the entire study area. Because the density of supplemental feed sites within the study area changed through the construction of additional supplemental feed sites at the end of year 1, we analyzed the 2 years separately. A 2 sample *t*-test was used to assess home range size differences for deer with feed and without feed in their home ranges. A Satterthwaite approximation was used because of unequal variance.

We used a randomized complete block design (RCBD) analysis of variance (ANOVA) with deer as blocks to test for seasonal (i.e. treatment) differences within year for distance (i.e. response) to nearest supplemental feed site. We used a paired *t*-test to test if actual annual distances from deer locations to supplemental feeders were different from random location distances to supplemental feed sites. Last, we calculated the percent of locations for each deer, regardless of whether they had a supplemental feed site within their home range, to the nearest supplemental feed site within 4 distance categories (0-547, 547-1,094, 1,094-1,640, and 1,640-2,187 yards). We conducted all analyses using SAS (SAS Institute, Inc. 1989). We concluded statistical significance for $P \leq 0.05$. Means are reported ± SE.

RESULTS

During this study, we monitored 48 male deer. Not all deer survived an entire year; therefore, we excluded these deer from annual home range analyses. This left 31 deer (21 deer in year 1 and 10 deer in year 2) in our study. Deer ranged in age from 4.5 to ≥8.5 years-of-age.

Average number of relocations used during years 1 and 2 were 56 ± 1.3 and 40 ± 1.2, respectively. Average 95% fixed kernel home range size was 512.4 ± 50.4 acres and 557.7 ± 74.4 acres for years 1 and 2, respectively (Webb et al. 2007c). Home ranges of deer with feed (n = 17, 635.6 ± 64.5 acres) were larger ($t_{25} = 3.44$, $P = 0.002$) than deer home ranges without feed (n = 14, 379.8 ± 37.1 acres).

Average density of supplemental feed sites in deer home ranges was 47% lower in year 1 (0.1 ± 0.006 feeders/mile^2; $P = 0.006$) than the average density of supplemental feed sites on the study area (0.188 feeders/mile^2). There was no difference in year 2 between feeder density in home ranges (0.235 ± 0.049 feeders/mile^2; $P = 0.333$) and across the study area (0.285 feeders/mile^2). During year 1, 57% (12 of 21) of deer did not

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have any supplemental feed sites within their home range, whereas 20% (2 of 10) of deer in year 2 did not have any supplemental feed sites within their home range.

More deer were found within 547-1,094 yards of supplemental feed sites during year 1 (Figure 1). During year 2, more deer were found within 547 yards of supplemental feed site (Figure 1). Also during year 2, no deer were found >1,640 yards from supplemental feed sites (Figure 1). When all locations were combined for all seasons and both years; 34.3, 51.3, 14.1, and 0.3% of locations were in distance groups 0-547, 547-1,094, 1,094-1,640, and 1,640-2,187 yards, respectively. Averaged across years, 86% of deer locations were within 1,094 yards of a supplemental feed site, and >99% were within 1,640 yards of a supplemental feed site. The farthest deer were located from supplemental feed site at any time was 1,675 yards, and the closest was 0 yards (deer was in supplemental feeder pen).

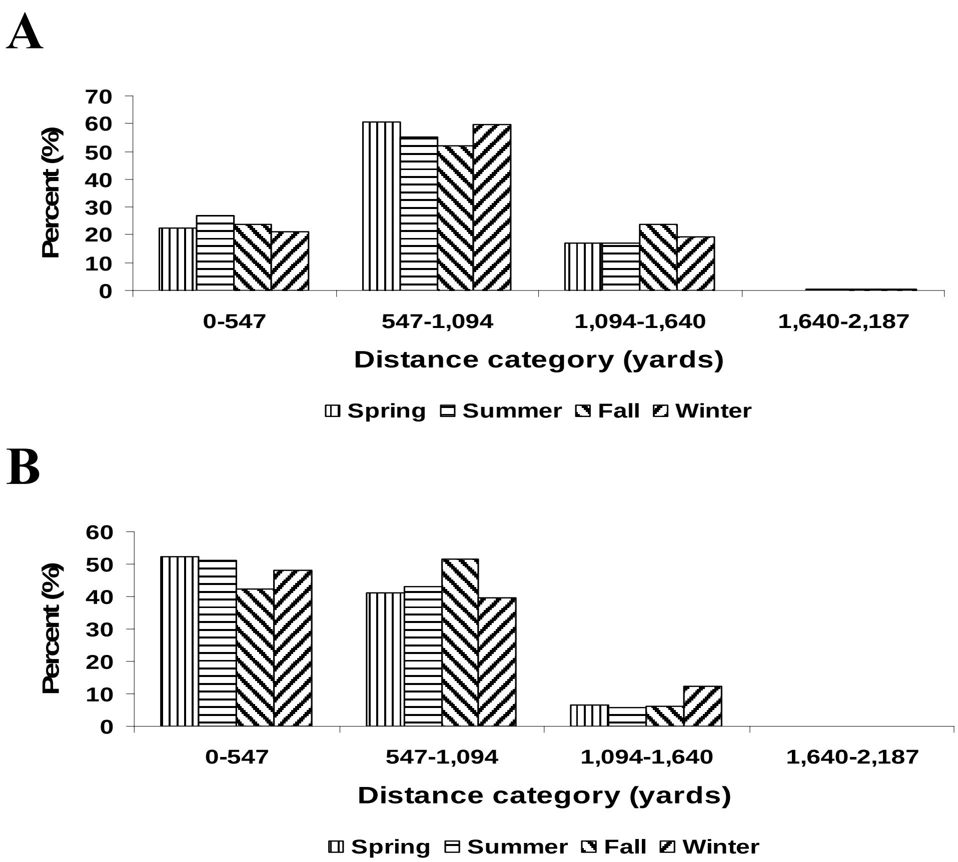

Figure 1. Percent deer locations in categories describing the distance to the nearest supplemental feed site (yards) for spring, summer, fall, and winter during year 1 (A; 15 October 2002 – 14 October 2003) for 21 deer and year 2 (B; 15 October 2003 – 25 August 2004) for 10 deer on the Callaghan Ranch, Webb County, Texas.

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In both years, there was no difference among seasons in the distance between deer locations and supplemental feed sites ($P \geq 0.495$; Table 1). There was no difference ($t = -0.44$, df = 20, $P = 0.667$) between the distances deer were found from supplemental feed sites during year 1 (806 ± 56 yards) compared to the distance random points were from supplemental feed sites (810 ± 54 yards). During year 2, distances deer were found from supplemental feed sites (618 ± 83 yards) did not differ ($t = -0.34$, df = 9, $P = 0.74$) from the distance random points were from supplemental feed sites (623 ± 75 yards).

Table 1. Mean minimum distances (yards) to supplemental feed sites for actual telemetry locations within home ranges on the Callaghan Ranch, Webb County, Texas for 2 years. During year 1 deer were tracked from October 15, 2002-October 14, 2003 and during year 2 from October 15, 2003-August 25, 2004.

	Fall	Winter	Spring	Summer	Seasonal[a]	
Year	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	*F*	*P*
1	808 ± 59	821 ± 57	793 ± 57	804 ± 60	$F_{3,20} = 0.42$	0.738
2	647 ± 72	639 ± 93	588 ± 90	600 ± 95	$F_{3,9} = 0.82$	0.495

[a]Results of ANOVA testing the difference in distance among seasons.

DISCUSSION

Our results show that permanent supplemental feed sites had little effect on adult male white-tailed deer movements within home ranges and home range location, but appeared to influence home range size. Cooper et al. (2006) found that supplemental feed, in the form of shelled corn, had little effect on home range size of deer in Texas. However, fawn home ranges in New Hampshire were influenced by feeding sites (Tarr and Perkins 2002). Like supplemental feed, permanent sources of water in south Texas did not affect male deer home range location or movements (Webb et al. 2007b). Even though supplemental feed sites did not appear to affect home range location, it did appear that the shape and size of the home range was affected. If supplemental feed sites were not found within home ranges, then supplemental feed sites were on the periphery of the home range, and it was possible deer used these resources at times other than when we located deer.

Optimal foraging predicts home range size is inversely related to forage abundance (Ford 1983). As a result of increased deer density, forage availability could decrease resulting in increased home range sizes (Harestad and Bunnell 1979, McNab 1963). Despite relatively high deer densities, forage conditions were likely good to excellent during the study as a result of above average rainfall (25.7 and 27.2 inches for years 1 and 2, respectively). Therefore, water (Webb et al. 2007b) and native forage were plentiful so deer movements and home range size were probably minimized as a result. However, home range size of deer with a supplemental feed site in their home range was larger than deer without feed. This may indicate that deer with larger home range sizes had to expand their home range to include a supplemental feed site. Cooper et al. (2006)

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also found that deer expanded home ranges to include supplemental feed sites during the breeding season.

Supplemental feed is only one habitat component of deer; therefore, other environmental or habitat factors, and their juxtaposition, may have more of an influence on deer home range location and movements. Deer with supplemental feeders in their home ranges could shift core use areas closer to these resources. Previous studies found that feeders tended to be located on the periphery of core areas (Cooper et al. 2006).

Distances deer were located from supplemental feeders generally reflected the distribution of supplemental feeders. Because the density of supplemental feeders on the study area was relatively high (>0.19 supplemental feeders/mile^2) deer were never far from a supplemental protein feeder. The distribution of supplemental feeders on the study area was reflected in the average distance deer were located from them. If deer do travel to feed sites, then this may have a positive effect on deer because they do not have to make long-distance movements to supplemental food sources, which could conserve energy.

These data provide a measurement of adequate supplemental feeder distribution for deer in south Texas during relatively wet years. However, during drier years, deer may require a greater density of supplemental feeders, or need to consume more when at a feeder, to help meet daily and seasonal nutritional requirements. Females and other age classes may have different nutritional needs compared to adult male deer, which may require a different density of supplemental feeders. Therefore, greater densities of supplemental feed sites may be necessary in some instances.

Although some deer did not have supplemental feeders within home ranges, a shift in home range location or size most likely would have included a supplemental feed site. During dry years, deer may expand or shift their home range to include a permanent food source within their home range. We interpret our data to show a density of about 1 supplemental feeders /0.77 mile^2 is sufficient to minimize movements to supplemental feeders based on home range size and movements of white-tailed deer. Therefore, at the recommended density, deer will never be farther than 1,083 yards from a feeder (Figure 2). Our results will help wildlife managers determine how many supplemental feeders to install based on average density and distances deer were located to these resources during times of above average rainfall. Due to the potential for localized range degradation from long-term supplemental protein feeding in fixed locations (Cooper et al. 2006), supplemental feeders should be moved to new locations every few years.

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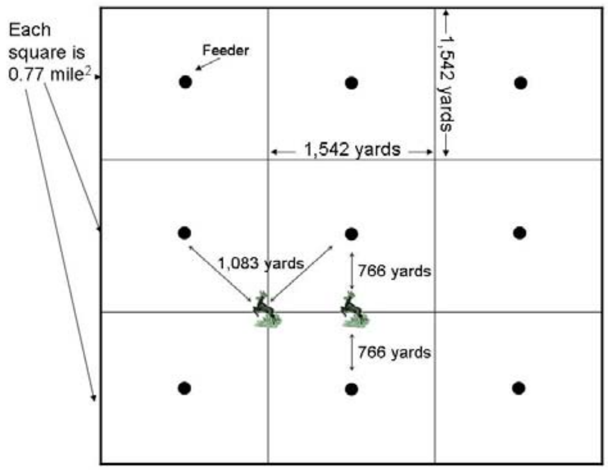

Figure 2. Density of 1 supplemental feed site /0.77 mile² and distances deer were located from them.

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