Adult White-tailed Deer Seasonal Home Range and Habitat Composition in Northwest Louisiana

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Abstract: Despite decades of interest and research, many questions remain about seasonal movements and habitat use of white-tailed deer (*Odocoileus virginianus*), particularly in the Southeast. The advent of GPS-based telemetry has made detailed studies of year-round movements feasible. We assessed monthly habitat use for adult male ($n = 15$) and female ($n = 15$) deer at Barksdale Air Force Base in northwestern Louisiana using GPS radio collars collecting locations at hourly intervals over approximately one year. Males had larger monthly home ranges (97–380 ha) than females (44–181 ha), particularly in fall and winter; however, habitat use was similar between sexes. Early-successional habitats, such as openings and shrub communities, were used more than expected by both sexes throughout the year, as were mature bottomland hardwood stands. Thinned hardwood stands and wetland habitats were used less than expected. Our results suggested that deer of both sexes were able to obtain resources to support their year-round needs in a seasonally consistent, relatively small, area and that management to benefit deer at the site has been generally successful in producing high quality habitat.

Key words: compositional analysis, habitat use, home range, *Odocoileus virginianus*, white-tailed deer

Journal of the Southeastern Association of Fish and Wildlife Agencies 3:243–252

Like many species, white-tailed deer (*Odocoileus virginianus*) require a mosaic of habitat types to acquire necessary resources throughout the year. The availability and spatial arrangement of habitats affects home range size and shape, habitat use, and movements to access these resources which may include basic needs such as food, cover, and water as well as travel corridors, breeding opportunities, and adequate fawning locations (Stewart et al. 2011). White-tailed deer movements and home ranges vary greatly across the species range and are influenced by variables such as habitat quality, age and sex of deer, and season (Miller et al. 2003). Defining spatial and temporal use of various habitats can aid managers in understanding the effectiveness of habitat management actions.

Variation in home range size and habitat use among seasons, sexes, and age classes may be indicative of habitat quality, where small home range size and limited seasonal change in use indicate high quality habitat and the year-round availability of necessary habitat components (Miller et al. 2003). Sexual segregation of habitats may occur due to competition, differences in body size between sexes, social factors, and predator avoidance (Bleich et al. 1997, Main et al. 1996). In Michigan, even with extensive habitat use overlap, males used more closed forests while females used more open woodlands and grasslands (Beier and McCullough 1990). In contrast, LaGory et al. (1991) reported males used pastureland more while females preferred forested habitats in Georgia.

White-tailed deer home range size and habitat use have been reported for a variety of geographic areas and landscape types (see reviews by Miller et al. 2003 and Stewart et al. 2011). In the Eastern United States, a wide range of silvicultural and other habitat management techniques, including timber harvest, thinning, burning, and planting of food plots, are commonly recommended to improve habitat quality for deer (Moreland 1996, Diefenbach and Shea 2011). However, it is often difficult or expensive to obtain use information at a sufficiently fine spatial or temporal scale to evaluate use of these modified habitats following implementation of habitat management practices. With the greatly increased availability of GPS radiocollars, gathering location data at fine spatial and temporal scales has become nearly routine; with the result that managers can evaluate the effectiveness of habitat management activities in terms of increased deer use.

We examined year-round home range and habitat use on Barksdale Air Force Base (hereafter, Barksdale) in Bossier Parish, Louisiana. Barksdale was an ideal location to study white-tailed deer seasonal home range and habitat use dynamics because it is a large contiguous tract of land spanning multiple ecosystems found in Louisiana. Furthermore, Barksdale has an active deer management program (see below for more details) and controlled access for hunting and other purposes; however, the base had little infor-

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mation regarding the effects of their management program. Habitat use information is currently limited in Louisiana, especially in the northwest portion of the state (Thayer et al. 2009). We quantified annual and monthly home ranges and habitat composition to identify seasonally preferred habitat types. By quantifying use of selected habitats, particularly areas managed to improve habitat quality (e.g., thinned pine and hardwood stands or wildlife openings), we can better understand the effectiveness of current management practices. Furthermore, large home range sizes or pronounced seasonal shifts in range may suggest opportunities to improve deer habitat quality at the Base.

Study Area

The study was conducted at Barksdale in Bossier City, Bossier Parish, Louisiana. Barksdale consists of approximately 9,000 ha, of which approximately 2,000 are covered by Air Force operations, office buildings, and living quarters (Main Base). The remaining 7,000 ha (East Reservation) are largely undeveloped and consist of upland pine-dominated forests and bottomland hardwood forests (Figure 1). The East Reservation is used for recreation, hunting and fishing, timber production, and oil and natural gas production. The base Natural Resources Department actively manages forests to maximize timber production and wildlife-associated recreation. Forest management practices include timber extraction, burning, thinning, and herbicide usage. Burning occurs on an approximate four-year rotation in upland pine stands and most pine stands are thinned approximately once every ten years. Barksdale has an active hunt program, including Louisiana's archery season (1 October–31 January) and managed deer hunts on selected days during Louisiana's rifle season (approximately early November to mid-January). Access is limited to Air Force personnel and their families. Barksdale implemented a Quality Deer Management strategy (Hamilton et al. 1995) in 2003 for managing their deer herd. Since this change in management, approximately 200 deer are harvested per year and the buck: doe ratio is estimated at 1:2.

Barksdale is located in the South Central Plains ecoregion of Louisiana and consists of three sub-regions: Red River bottomlands in the west, Pleistocene fluvial terraces in the middle, and tertiary uplands in the east (USEPA 2006). Mean annual precipitation for these sub-regions ranges from 129 to 160 cm (USEPA 2006). Temperatures range from –1 to 16 C during winter months and 21 to 34 C during summer months (USEPA 2006). Within the East Reservation, forests and forested wetlands in the western bottomlands along Red Chute Bayou consist of a variety of oak species (*Quercus* spp.), sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa sylvatica*), American elm (*Ulmus americana*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), and bald cypress (*Taxodium distichum*), (USEPA 2006). The eastern highlands are dominated by pine plantations, mixed pine-hardwoods, and hardwood drainages consisting of shortleaf pine (*Pinus echinata*), loblolly pine *(Pinus taeda*), a variety of oak species, hickory species (*Carya* spp.), and sweetgum (USEPA 2006).

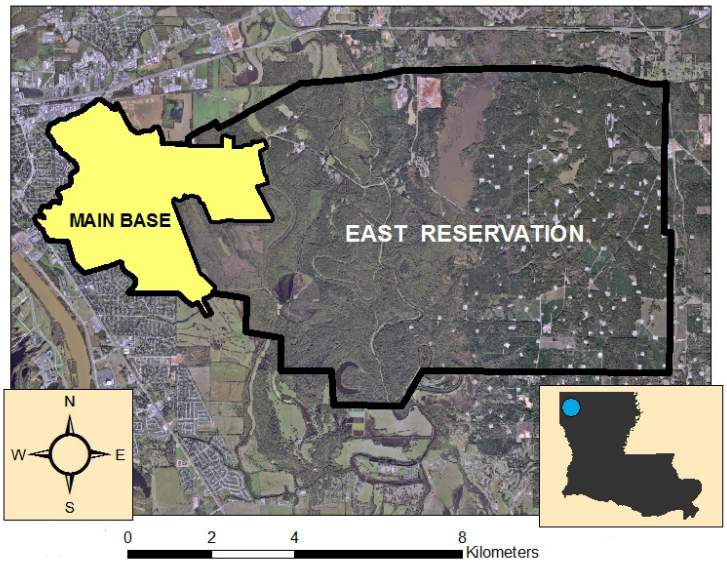

Figure 1. Study area at Barksdale Air Force Base, Bossier Parish, Louisiana, used for capture and GPS radiotelemetry of male and female white-tailed deer in 2009–2010.

Methods

We captured adult deer using a combination of rocket nets and dart projectors. Capture efforts were distributed evenly across the East Reservation at permanent bait sites of shelled corn and salt licks during four trapping seasons: from winter to spring (1 January–30 April), and late summer to early fall (1 August–20 November) in 2009 and 2010.

All deer were tagged with a National Band and Tag Company model 1055-49 metal self-piercing ear tag containing a unique six digit number (National Band and Tag Co., Newport, Kentucky). Age was estimated by tooth wear and replacement (Severinghaus 1949). Darted deer were chemically immobilized using a Pneu-Dart X-Caliber model dart projector with Pneu-dart Type P 1- and 2-cc transmitter darts (Pneu-dart, Inc., Williamsport, Pennsylvania). Darts were loaded with a mixture of Telazol (5 mg/kg) and xylazine hydrochloride (2.49 mg/kg) (Amass and Drew 2006). Eighty minutes after darting, we injected the deer intramuscularly with 3 cc Tolazoline (100 mg/ml) to reverse the Xylazine component of the immobilization mixture (Safe-Capture International, Inc., Mt. Horeb, Wisconsin). All deer capture and handling procedures were in accordance with the Stephen F. Austin State Univer-

sity Institutional Animal Care and Use Committee (protocol no. 2010-002).

We fitted deer ≥1.5 years old of both sexes with Sirtrack GPS/VHF model TGC191 collars with a schedule of one fix per hour over an approximately one-year period following initial deployment (Sirtrack-Wildlife Tracking Solutions, Havelock North, New Zealand). Collars placed on males contained an expandable elastic section to allow for neck swelling during the rut. Collars were bright reflective orange in an attempt to reduce hunter based mortality. These collars were equipped with an 8-hour time-delayed motion sensor to detect mortalities and a fixed automatic drop-off date approximately one year after deployment (January–February for winter-captured deer and August-September for summer caught deer).

We assessed location error by placing each collar at a random location on the site for 1–4 weeks after collars were remotely detached from the animal. From these locations, we averaged distances from GPS locations to the known location of the collar then combined individual collar location errors to derive an average study-wide location error (Saltz 1994, Salbosa 2009).

Home Range Generation

We downloaded location data from the GPS collars and plotted them in ArcGIS (ArcGIS 9.2; ESRI, Inc., Redlands, California). The locations were used to generate annual and monthly 95% home range and 50% core area fixed-kernels through the Home Range Tools (HRT) application for ArcGIS (Bluesky Telemetry Inc. 2008) using 50% and 40% proportions of the reference bandwidth (Href). We selected bandwidth visually by reducing the home range boundary just prior to fragmentation into multiple polygons (Berger and Gese 2007, Jacques et al. 2009). With large sample sizes from GPS data, the reference bandwidth tends to overestimate home range and the LSCV method tends to underestimate home range (Kie et al. 2010). This method is repeatable and proportions of Href have been utilized in several studies using GPS data (Bertrand et al. 1996, Kie et al. 2002).

Available Habitat

We analyzed habitat composition by comparing percentages within home ranges and core areas to the available habitat. Our primary measure of availability was a generated 95% minimum convex polygon (MCP) using all deer GPS locations obtained during the study (Figure 2, Johnson 1980). Half of our collared deer traveled off base with an average max distance of <1.5 km from the base boundary. However, 1 male traveled ~ 6.5 km off base, effectively doubling the size of the available habitat based on a single individual. Furthermore, use of habitats within the Barksdale

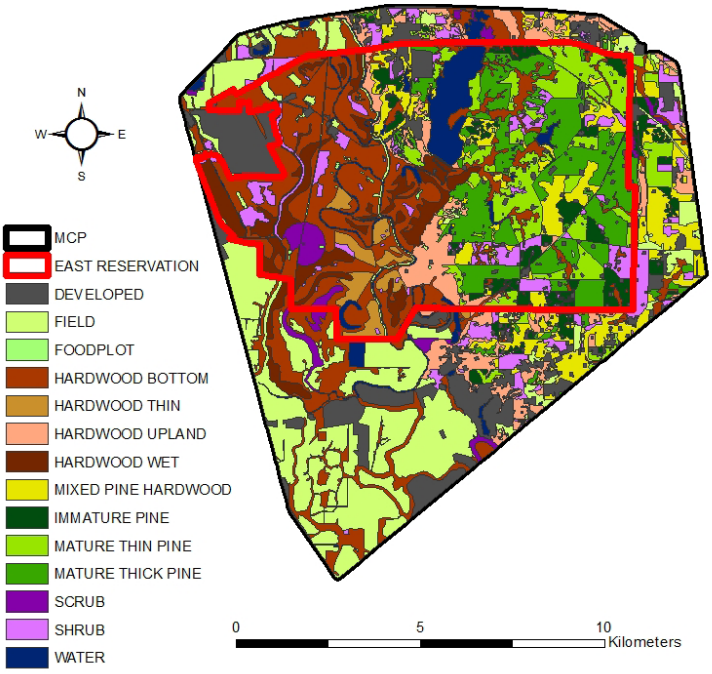

Figure 2. Available habitats within the 95% minimum convex polygon (MCP) for white-tailed deer habitat composition comparisons. Boundary was determined by the 95% MCP of all white-tailed deer locations generated from 30 individuals in 2009–2010 and encompasses 14,616 ha in Bossier Parish, Louisiana.

boundary was important for management decisions on the base. Therefore, we considered a second measure of availability for just the area within the base boundary.

We created two habitat maps in ArcGIS by manually digitizing habitat-type polygons using Barksdale's 30-m resolution satellite imagery from 2009, timber harvest maps, topographic maps, soils maps, and pre-existing land cover maps. Polygons were classified into 14 habitat types: (1) developed (housing, office buildings and equipment, well pads, and paved roads); (2) field (pastures, levees, and un-mowed fields); (3) food plot (areas planted specifically for deer forage); (4) hardwood bottom (seasonally dry hardwoods in the Red River bottomlands sub-region and hardwood drainages in the tertiary uplands sub-region); (5) thinned hardwoods (hardwood stands thinned to a basal area between 13 and 18 m^2/ha); (6) hardwood upland (hardwoods in the ridges between the Red River bottomlands and tertiary uplands sub-regions); (7) hardwood wet (seasonally wet hardwoods in the Red River bottomlands sub-region); (8) mixed pine hardwood (ecotones where hardwood bottoms and upland pines meet); (9) immature pine (post canopy closure and pre first thinning); (10) mature thinned pine (any post immature pine stand with basal area between 13 and 18 m^2/ha); (11) mature unthinned pine (any post immature pine stand with basal area ≥27 m^2/ha); (12) shrub (clear cut stands to canopy closure); (13) scrub [seasonally wet areas dominated by buttonbush

Table 1. Area and percent of total area for habitat classes available to white-tailed deer within a 95% minimum convex polygon (MCP) of all deer locations and within the East Reservation boundary at Barksdale AFB, Bossier Parish, Louisiana, in 2009 and 2010.

	95% MCP		East Reservation	
Habitat class	**Area (ha)**	**%**	**Area (ha)**	**%**
Hardwood bottom	3,030.4	20.7	1,983.1	26.8
Field	2,587.5	17.7	113.4	1.5
Developed	1,571.7	10.8	257.9	3.5
Mature unthinned pine	1,320.3	9.0	1,230.2	16.6
Mixed pine hardwood	1,071.2	7.3	442.3	6.0
Mature thinned pine	925.1	6.3	780.8	10.5
Hardwood upland	873.9	6.0	324.1	4.4
Shrub	826.9	5.7	433.6	5.9
Hardwood wet	689.0	4.7	611.2	8.3
Water	622.7	4.3	464.1	6.3
Immature pine	560.6	3.8	374.2	5.1
Thinned hardwoods	241.3	1.7	235.6	3.2
Scrub	252.5	1.7	113.5	1.5
Food plot	43.1	0.3	43.1	0.6
Total	14,616.2	100	7,407.1	100

(*Cephalanthus occidentalis*) and wetland vegetation]; (14) water (lakes, ponds, and rivers). We verified the classifications and boundaries with targeted field visits and consultation with Barksdale natural resources staff.

The 95% MCP encompassed 14,616 ha (Figure 2). Hardwood bottoms were the dominant habitat-type, followed by fields, development, mature unthinned pine, mixed pine hardwood, mature thinned pine, hardwood uplands, shrub, hardwood wet, water, immature pine, scrub, hardwood thins, and food plots (Table 1). The Barksdale Air Force Base East Reservation (ER) boundary encompassed 7,407 ha (Figure 2). Hardwood bottoms again were the dominant habitat-type, followed by mature unthinned pine, mature thinned pine, hardwood wet, water, mixed pine hardwood, shrub, immature pine, hardwood uplands, development, hardwood thins, scrub, field, and food plots (Table 1). Fields and developed areas were much more abundant in the 95% MCP than the ER and consisted of larger contiguous areas such as pastures, golf courses, and housing developments. Open and developed areas on the ER were levees, powerline rights-of-way, and well pads. All other habitat types were comparable in relative abundance between the two boundaries. Open water was eliminated from the analysis. Fields and food plots were combined because food plots comprised <1% of available area and they were structurally similar.

Data Analysis

To determine if data from 2009 and 2010 could be pooled, we examined the effects of year (2009 or 2010) and age (juvenile [1.5–3 years] and adult [≥3.5 years]) on male home range size using two-way analysis of variance (ANOVA; SAS 2008). We also compared female home range size between years using one-way ANOVA. We used two-way ANOVA to compare home range and core area size with month and sex as independent effects.

We used compositional analysis to define habitat use and rank habitats in order of preference (Aebischer et al. 1993). For each sex, we used multivariate analysis of variance (MANOVA) to determine if annual and monthly used habitats were different from available habitats and to rank habitats by use. If a habitat type was not represented in an individual deer's habitat composition, a small nonzero value (0.001) was used (Aebischer et al. 1993). Based on the number of individual collared deer compared to the number of habitat types (Aebischer et al. 1993), some habitat classes were either combined or removed for compositional analysis. Monthly habitat compositions were compared to determine fine scale habitat composition changes. Statistical significance was determined at $\alpha = 0.05$.

Results

Between 2009 and 2010, we captured 30 deer that were ≥1.5 years old (15 males and 15 females) and fitted them with GPS collars. We collected >200,000 hourly locations over a combined 207 months. Data collection typically lasted longer for females (11 months/individual) than males (6.5 months/individual) as half of all collared males were either illegally harvested on Barksdale (31.2%) or legally harvested when deer wandered off base property (18.8%). In contrast, only 1 female was harvested (legally) during the project. Hunter harvest was the only cause of adult mortality during the study. Collar error (radius = 22.1 m; area = 0.15 ha) was smaller than the average 95% home range patch size (14.38 ha) and 50% core area patch size (5.03 ha).

Male home range size did not differ between years (df = 3, 16, $P = 0.74$) or age groupings (df = 3, 16, $P = 0.26$). Female home ranges were also similar between years (df = 1, 13, $P = 0.32$). Therefore, we pooled data across study years and male ages.

Annual male home range was 346.0 ha and core area was 68.6 ha, while annual female home range was 122.6 ha and core area was 22.4 ha. Male deer had larger home ranges (df = 23, 236, $P < 0.0001$) and core areas (df = 23, 236, $P < 0.0001$) than female deer in all months. There was an interaction between month and sex for both the home range (df = 23, 236; $P = 0.01$) and core area (df = 23, 236; $P = 0.0008$) potentially reflecting much greater monthly variation for males than females. In particular, males had much larger monthly home ranges and core areas compared to females in fall and winter (November–March; Figure 3).

Annually, female habitat use differed from available, except

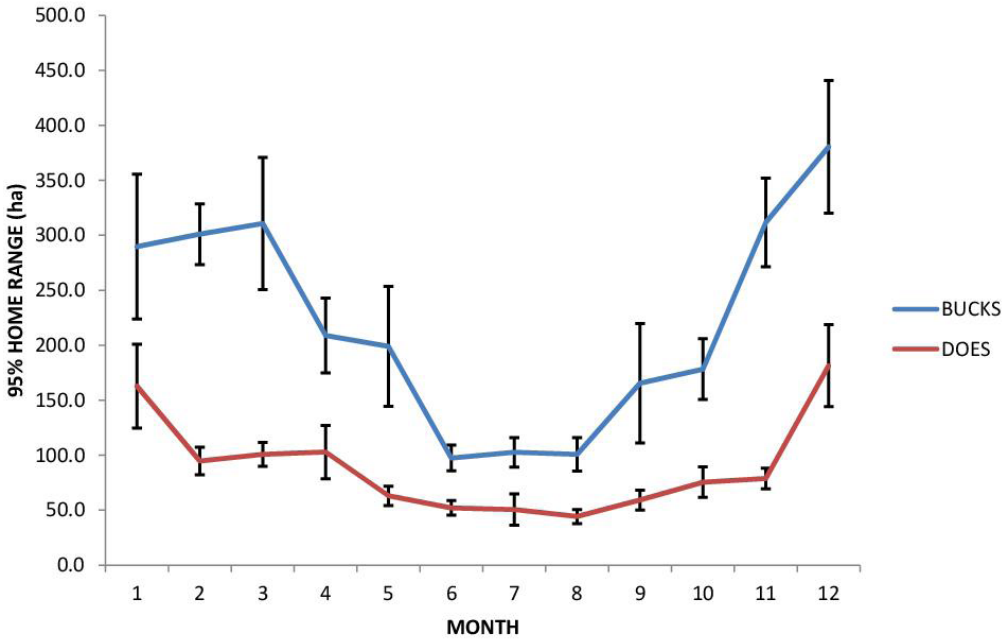

Figure 3. Comparison of monthly 95% kernel home range sizes calculated for male and female white-tailed deer fitted with GPS collars on Barksdale Air Force Base, Bossier Parish, Louisiana, 2009 to 2010. Males had larger core areas and home ranges ($P < 0.0001$).

Table 2. Annual habitat ranks for adult female white-tailed deer radio tracked near Barksdale AFB, Bossier Parish, Louisiana, in 2009 and 2010. Boundaries were used to define available habitat and were created using 95% minimum convex polygon (MCP) of all deer locations collected, and using the East Reservation on Barksdale AFB. *P*-values determine whether habitat use differed from random within a boundary. Habitat ranks within a boundary are read across the row.

				Habitat rank[c]											
Boundary[a]	**UD%**[b]	***P***	**Wilks' λ**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
ER	95%	0.0046	0.006	SH	FF	DEV	HWB	MIX	HWU	MP1	HWW	MP2	SC	IP	HWT
				(A)	(AB)	(AB)	(ABC)	(ABC)	(CD)	(BCD)	(CDE)	(CDE)	(DE)	(CDE)	(D)
ER	50%	0.009	0.009	SH	FF	HWB	DEV	MIX	MP1	SC	MP2	HWU	IP	HWW	HWT
				(A)	(AB)	(ABC)	(BCD)	(ABCDE)	(ABCDEF)	(CDEF)	(BCDF)	(CDEF)	(CEF)	(CDEF)	(F)
MCP	95%	0.0249	0.019	SH	HWB	MP1	MIX	HWW	MP2	DEV	IP	HWU	FF	SC	HWT
				(A)	(AB)	(ABC)	(BC)	(BCD)	(ABCD)	(BCD)	(BCD)	(BCD)	(CD)	(CD)	(C)
MCP	50%	0.1476	0.066	SH	HWB	MP1	MP2	MIX	HWW	IP	DEV	SC	FF	HWU	HWT
				(A)	(AB)	(ABC)	(ABC)	(BC)	(BC)	(BC)	(C)	(BC)	(C)	(BC)	(C)

a. Boundaries used for percent habitat availability: ER (East Reservation), MCP (95% Minimum Convex Polygon).
b. UD% is utilization distribution, either 95% fixed kernel home range or 50% kernel core area
c. Habitat Type Abbreviations: Developed (DEV), Fields and Food plots (FF), Hardwood Bottom (HWB), Hardwood Thin (HWT), Hardwood Upland (HWU), Hardwood Wet (HWW), Mixed Pine Hardwood (MIX), Immature Pine (IP), Mature Thinned Pine (MP1), Mature Unthinned Pine (MP2), Scrub (SC), Shrub (SH).

in core areas in the 95% MCP boundary (Table 2). Within each boundary, home range and core area habitat use reflected similar ranks and relative importance. Shrub habitats were ranked highest, followed by hardwood bottoms. Thinned hardwood stands were least important. The primary differences between the results based on the 95% MCP and the ER boundaries were in the use of fields and food plots and developed areas. These open habitats were more important on the ER than in the 95% MCP. They were also more prevalent on the 95% MCP (28.5%) than on the ER (5%).

We saw only minor changes in habitat use among months for female deer (Table 3). Results were similar among utilization distributions and availability boundaries, so we present only the 95% utilization distribution and the 95% MCP. While the highest and lowest ranked habitat types remained consistent throughout the year, other types varied in importance with season. Mature pine stands were ranked high with less use of thinned stands from winter to spring and unthinned stands during the summer. Mixed pine hardwood stands and hardwood uplands showed consistent

Table 3. Habitat ranks for adult female white-tailed deer 95% home ranges in Bossier Parish, Louisiana, 2009 to 2010. *P*-values determine whether habitat use differed from random within a 95% minimum convex polygon (MCP). Habitat ranks within a month are read across the row.

				Habitat rank[a]											
Month	***n***	***P***	**Wilks' λ**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	12	0.102	0.002	SH	HWB	MP2	DEV	MIX	MP1	HWU	FF	IP	HWW	SC	HWT
				(A)	(AB)	(ABC)	(BCD)	(ABCD)	(ABCDE)	(ABCDE)	(CD)	(BCDE)	(CDE)	(CE)	(CE)
2	12	0.109	0.002	HWB	SH	MP1	MP2	MIX	DEV	HWU	HWW	IP	SC	FF	HWT
				(A)	(A)	(AB)	(AB)	(AB)	(AB)	(ABC)	(ABC)	(ABC)	(C)	(BC)	(C)
3	12	0.049	0	SH	HWB	MP2	MIX	MP1	DEV	IP	HWU	HWW	SC	FF	HWT
				(A)	(AB)	(ABC)	(ABCD)	(ABCD)	(BCD)	(BCDE)	(ABCE)	(CDE)	(E)	(CDE)	(E)
4	12	0.107	0.002	SH	HWB	MP1	MP2	MIX	DEV	HWU	IP	FF	SC	HWW	HWT
				(A)	(AB)	(ABC)	(ABCD)	(ABCD)	(BCE)	(BCDE)	(BCDE)	(CDE)	(CD)	(CDE)	(CD)
5	14	0.025	0.019	SH	HWB	MP2	MP1	DEV	MIX	SC	HWW	IP	FF	HWU	HWT
				(A)	(AB)	(ABC)	(BC)	(BC)	(BC)	(BC)	(BC)	(BC)	(C)	(BC)	(C)
6	14	0.330	0.127	SH	HWB	MP1	MP2	DEV	IP	HWW	MIX	SC	FF	HWT	HWU
				(A)	(AB)	(ABC)	(BC)	(BC)	(BC)	(BC)	(BC)	(BC)	(C)	(C)	(C)
7	14	0.071	0.039	SH	HWB	MP2	MP1	HWW	DEV	MIX	FF	SC	IP	HWU	HWT
				(A)	(AB)	(ABC)	(ABCD)	(ABCD)	(BCD)	(ABCD)	(CD)	(CD)	(CD)	(CD)	(D)
8	14	0.117	0.056	SH	HWB	MP1	DEV	MP2	MIX	HWW	FF	IP	SC	HWT	HWU
				(A)	(AB)	(ABC)	(BCDE)	(ABCDE)	(BCDE)	(BCE)	(BCDE)	(BCDE)	(BCDE)	(CDE)	(D)
9	14	0.059	0.034	SH	HWB	MP2	MP1	DEV	HWW	MIX	IP	FF	SC	HWT	HWU
				(A)	(AB)	(ABC)	(ABC)	(BC)	(BC)	(BC)	(BC)	(BC)	(C)	(C)	(BC)
10	13	0.057	0.011	SH	HWB	DEV	MP2	MP1	MIX	FF	HWU	IP	HWW	SC	HWT
				(A)	(AB)	(ABC)	(ABCD)	(ABCDEF)	(ABCDF)	(DEF)	(BDEF)	(BCDEF)	(BCDEF)	(EF)	(E)
11	12	0.189	0.005	SH	HWB	DEV	MP1	MP2	HWU	MIX	FF	IP	HWW	SC	HWT
				(A)	(AB)	(AB)	(ABC)	(ABC)	(ABC)	(ABC)	(BC)	(BC)	(C)	(C)	(C)
12	12	0.144	0.003	SH	HWB	DEV	MIX	MP2	MP1	HWU	HWW	IP	FF	SC	HWT
				(A)	(AB)	(AB)	(ABC)	(BC)	(BC)	(C)	(C)	(C)	(C)	(C)	(C)

a. Habitat Type Abbreviations: Developed (DEV), Fields and Food plots (FF), Hardwood Bottom (HWB), Hardwood Thin (HWT), Hardwood Upland (HWU), Hardwood Wet (HWW), Mixed Pine Hardwood (MIX), Immature Pine (IP), Mature Thinned Pine (MP1), Mature Unthinned Pine (MP2), Scrub (SC), Shrub (SH).

intermediate use with less use of upland hardwoods during the summer. Seasonally wet hardwoods, scrub habitats, and immature pine stands had little importance overall, with slightly increased use during the summer.

Based on female composition results and preliminary male compositional results, we further combined habitats to analyze male habitat use. Scrub and shrub were combined into one "shrub" habitat class. Hardwood uplands and mixed pine hardwoods were combined into "hardwood upland mixed." Mature thinned and unthinned pines were combined into "mature pine." In preliminary habitat composition results for months with the most collared males, these habitat types did not differ in rank in any month ($P < 0.05$). We had sufficient numbers of males to statistically evaluate habitat use composition in five months (April, September, October, November, and December). In the remaining months, we were only able to rank habitat types in order of significance due to low numbers of collared males.

Annually, male habitat use differed from availability (Table 4). Habitat compositional trends were similar for males and females. Shrub habitats and hardwood bottoms were consistently important for all months (Table 5). Fields and food plots and developed areas were more important on the ER than in the 95% MCP. Immature pine stands showed consistent intermediate use. Other habitats fluctuated between seasons. Mature pine stands showed little use except during the fall and early winter. Hardwood upland mixed habitats were ranked low to intermediate use in the spring and summer seasons and increased in rank in the fall. Hardwood wet habitats showed higher use during the spring season and intermediate to low use during the rest of the year. Hardwood thins showed little use except during late winter and early spring.

Table 4. Annual habitat ranks for adult male white-tailed deer radio tracked near Barksdale AFB, Bossier Parish, Louisiana, in 2009 and 2010. Boundaries were used to define available habitat and were created using 95% minimum convex polygon (MCP) of all deer locations collected, and using the East Reservation on Barksdale AFB. P-values determine whether habitat use differed from random within a boundary. Habitat ranks within a boundary are read across the row.

				Habitat Rank[c]								
Boundary[a]	**UD%**[b]	***P***	**Wilks' λ**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
ER	95%	0.0003	0.039	FF	SH	DEV	HWB	HUM	MP	IP	HWW	HWT
				(A)	(A)	(B)	(BC)	(ABCD)	(BCE)	(CDE)	(BDE)	(DE)
ER	50%	0.0018	0.068	SH	FF	HUM	HWB	DEV	MP	IP	HWW	HWT
				(A)	(AB)	(BC)	(ACD)	(CD)	(BCDE)	(CDE)	(CE)	(E)
MCP	95%	0.0001	0.030	SH	HWB	MP	IP	HUM	HWW	DEV	FF	HWT
				(A)	(AB)	(BC)	(BC)	(BC)	(C)	(BC)	(C)	(C)
MCP	50%	0.0003	0.041	SH	HWB	MP	HUM	IP	FF	HWW	HWT	DEV
				(A)	(AB)	(ABC)	(BC)	(BCD)	(BCD)	(CD)	(BCD)	(D)

a. Boundaries used for percent habitat availability: ER (East Reservation), MCP (95% Minimum Convex Polygon).

b. UD% is utilization distribution, either 95% fixed kernel home range or 50% kernel core area.

c. Habitat Type Abbreviations: Developed (DEV), Fields and Food plots (FF), Hardwood Bottom (HWB), Hardwood Thin (HWT), Hardwood Wet (HWW), Hardwood Upland Mix (HUM), Immature Pine (IP), Mature Pine (MP), Shrub (SH).

Table 5. Habitat ranks for adult male white-tailed deer 95% home ranges in Bossier Parish, Louisiana, 2009 to 2010. *P*-values determine whether habitat use differed from random within a 95% minimum convex polygon (MCP). Habitat ranks within a month are read across the row.

				Habitat rank[a]								
Month	***n***	***P***	**Wilks' λ**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	6	–	–	HWB	SH	HWT	HWW	FF	HUM	PI	PM	DEV
				(A)	(AB)	(ABC)	(ABC)	(BC)	(AC)	(ABC)	(ABC)	(ABC)
2	6	–	–	HWB	HWW	SH	HWT	FF	PM	HUM	PI	DEV
				(A)	(AB)	(ABC)	(ABCD)	(D)	(ABCDE)	(ABCDE)	(ABDE)	(BD)
3	7	–	–	SH	HWB	HWW	HWT	FF	PI	HUM	PM	DEV
				(A)	(AB)	(ABC)	(ABC)	(C)	(BC)	(BC)	(ABC)	(BC)
4	9	0.2047	0.009	SH	HWB	HWW	PM	PI	HWT	FF	HUM	DEV
				(A)	(AB)	(AB)	(B)	(B)	(B)	(B)	(B)	(B)
5	8	–	–	SH	HWW	HWB	FF	PM	PI	HUM	HWT	DEV
				(A)	(AB)	(AB)	(B)	(B)	(B)	(B)	(B)	(B)
6	7	–	–	SH	HWB	FF	PM	PI	HUM	HWW	DEV	HWT
				(A)	(AB)	(AB)	(B)	(AB)	(B)	(AB)	(B)	(B)
7	7	–	–	SH	HWB	FF	PM	PI	DEV	HWW	HUM	HWT
				(A)	(AB)	(AB)	(B)	(B)	(B)	(AB)	(B)	(B)
8	7	–	–	SH	HWB	PI	DEV	HWW	FF	PM	HUM	HWT
				(A)	(AB)	(BC)	(ABC)	(ABC)	(ABC)	(BC)	(BC)	(C)
9	11	0.003	0.006	SH	HWB	PM	HUM	PI	HWW	FF	DEV	HWT
				(A)	(AB)	(BC)	(BC)	(BC)	(BC)	(BC)	(B)	(C)
10	13	0.005	0.043	SH	HWB	PM	HWW	HUM	PI	DEV	FF	HWT
				(A)	(AB)	(BC)	(ABCD)	(BCD)	(BCD)	(BCD)	(CD)	(C)
11	14	0.003	0.056	SH	HWB	PM	HUM	PI	DEV	FF	HWW	HWT
				(A)	(AB)	(ABC)	(ABC)	(BC)	(BC)	(C)	(C)	(C)
12	10	0.0669	0.172	SH	HWB	PI	HWT	HUM	FF	PM	HWW	DEV
				(A)	(AB)	(ABC)	(ABC)	(BC)	(C)	(BC)	(AC)	(C)

a. Habitat Type Abbreviations: Developed (DEV), Fields and Food plots (FF), Hardwood Bottom (HWB), Hardwood Thin (HWT), Hardwood Wet (HWW), Hardwood Upland Mix (HUM), Immature Pine (IP), Mature Pine (MP), Shrub (SH).

Discussion

Burt (1943; 351) defined home range as the "area traversed by an individual in its normal activities of food gathering, mating, and caring for its young." Therefore, the availability and distribution of resources determine the extent of the home range. Compared to other studies in the Southeast (e.g., Humphreys and Nelson 2000, Mott et al. 1985, Sargent and Labisky 1995, Thayer et al. 2009), home ranges on Barksdale were small, suggesting that high quality habitat is present at Barksdale. Although home range and core area size differed among months, large-scale shifts in habitat use in response to changing food supplies were not seen (Vanderhoof and Jacobson 1993). Significant changes in seasonal home range and core area size likely reflected behavioral movement changes based on the biological season (e.g., rut and parturition; Hasapes 2012). This differed from reported seasonal variations in habitat use by white-tailed deer associated with seasonal changes in resources (Dasmann and Taber 1956, Mackie 1970, Loft et al. 1984, Murphy et al. 1985) and suggest that deer at Barksdale meet year-round habitat needs within the same range. Similarly, Beier and McCullough (1990) found no change in habitat use from spring to fall.

Furthermore, males between 1.5 and 2.5 years old often have larger home ranges than adult males (McCoy et al. 2005, Webb et al. 2007, Thayer et al. 2009), partially due to dispersal movements. On Barksdale, there was no difference in home range size between adults and juveniles, possibly indicating that juvenile males at Barksdale can establish a home range without extensive travel to find available space and resources.

We did not see major seasonal shifts in habitat use for males or females, suggesting that the assortment and distribution of habitat types allow deer to meet resource requirements without having to shift ranges seasonally. Hardwood bottoms were highly available and utilized throughout the year. Hardwood bottoms provide year-round food (Moore et al. 1960, Segelquist and Green 1968), especially hard mast during the fall and winter, and cool thermal cover during high temperatures in the summer (Ockenfels 1980, Tucker 1981). However, they provide little screening cover when found in large contiguous tracts with a thick canopy cover. Both male and female deer selected shrub habitats year-round. Shrub habitats provide large quantities of forage during the growing season and less during winter (Harlow and Downing 1969, Wentworth et al. 1990, Johnson et al. 1995). These habitats also provide good screening cover in all seasons, and their year-round high use suggests deer at Barksdale may be seeking areas of thick cover. Hunting pressure on Barksdale is quite high (1 hunter/3.5 ha) and screening cover may be particularly important when the season is open (1 October to 15 February).

Fields, food plots, and developed areas were highly selected throughout the year when small and limited in the landscape; however, large open areas were avoided. Deer may avoid these open habitat types when in large contiguous tracts (e.g., in the 95% MCP) and use them when in small patches across the landscape (in the ER). Food plots in the Southeast have been commonly used in wildlife habitat management since 1935 (Halls and Stransky 1969, Larson 1969) with reported high utilization (Handly and Scharnagel 1961, Webb 1963, Johnson et al. 1987, Davis 1988, Vanderhoof and Jacobson 1993) especially in winter and early spring when acorns are scarce and plant growth in food plots is rapid (Wentworth et al. 1990). Food plots on Barksdale are planted with both cool-season and warm-season forage to provide food during winter and late-summer stress periods (Higginbotham and Kroll 1993), while fields provide increased amounts of forbs during the growing season (Johnson et al. 1995) and potential bedding cover when overgrown. Similar to high use of shrub habitats, the high use of small developed areas year round may be due to potential edge effects increasing understory productivity for forage during the growing season and cover during the hunting season.

As thinning habitats is a common practice for increasing natural forage for deer (Barick 1951, Beck and Harlow 1981, Moreland 1996), we expected thinned habitats to rank higher in importance than related unthinned habitats. However, we found deer use of thinned pine stands was no different than unthinned pine stands indicating both habitats supplied equally sufficient forage for deer. Thinned hardwood bottoms were ranked considerably lower than adjacent unthinned hardwood bottoms. The reasons for this are not clear, but thinned hardwoods were minor components of both the 95% MCP (1.7%) and the ER (3.2%).

Similar to Beier and McCullough (1990), we found that males and females overlapped in habitat use. McCullough et al. (1989) theorized that spatial overlap between sexes was inversely related to habitat resource availability in order to reduce intersexual competition. This indicates that males and females at Barksdale can separate spatially, thus eliminating the need to use different habitats to reduce competition.

Management Implications

Our results emphasize the utility of creating a mosaic of habitats to provide all resource requirements for white-tailed deer throughout the year. In particular, creation of small open areas and shrub-dominated communities can be very beneficial in areas dominated by closed-canopy forests. In a well-managed landscape, we found that deer of both sexes were able to meet year-round habitat needs in a relatively small, consistent area. We also found that habitats with effective screening cover were used more than expected in

all seasons. Although we did not test for the impacts of hunting on deer habitat use, most seasonal changes in habitat use coincided with hunting season (basically October to January). Hunting was the only source of mortality for marked adult deer over three years of study at the site (Hasapes 2012); therefore, it may be that presence of hunters affected habitat use during this season. As is commonly recommended, creation of early-successional habitats across the landscape through timber harvest or prescribed fire will likely benefit deer.

Acknowledgments

This project was funded primarily by the U.S. Air Force, Barksdale Air Force Base. S. Hasapes was supported by additional funds from the Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University. We are grateful to the Barksdale Natural Resource Department and especially to M. Stroupe, M. Gates, and M. Gibson, for logistical and field support. This work was improved by early reviews by H. Williams and J. Kroll. Finally, we thank S. Collins, R. Holton, G. Minor, B. Shuman, E. Thomas, and R. Wiggins for their assistance in the field.

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