HABITAT USE BY AMERICAN BLACK BEARS IN THE SANDHILLS OF FLORIDA

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Abstract: We used compositional analysis to determine seasonal and annual habitat use by black bears (*Ursus americanus floridanus*) on Eglin Air Force Base (Eglin AFB), Florida, 1994–1996. Habitat use was nonrandom for annual ($P = 0.0027$), summer ($P = 0.0002$), and fall ($P = 0.0006$) periods. Riparian zones had the highest annual use followed by swamps, pine plantations, sandhills, and open areas. Annual use of riparian zones and swamps differed ($P = 0.025$), and each showed greater use than the remaining habitat associations. Riparian zones and swamps also ranked highest for summer and fall. Sandhills received their highest rank, third, in the fall. The high use of riparian zones demonstrates the importance of habitats associated with rivers and streams to black bears on Eglin AFB.

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Key words: American black bear, compositional analysis, Eglin Air Force Base, habitat, radiotelemetry, riparian zones, sandhills, *Ursus americanus floridanus*

Black bears are listed as threatened by the State of Florida. They remain in just 8 relatively disjunct populations, largely due to land conversion for agriculture and urban development (Cox et al. 1994, Pelton and van Manen 1994; Fig. 1). Their imperiled status coupled with recent increases in bear–vehicle collisions on Eglin AFB prompted interest in the dynamics of the bear population there and in identifying habitats important to bears on the base.

Habitat use has been evaluated for black bear populations in Ocala National Forest (NF) (Wooding and Hardisky 1994), Osceola NF (Mykytka and Pelton 1990, Wooding and Hardisky 1994), Apalachicola NF (Seibert 1993) in north and central Florida, and near Big Cypress National Preserve in south Florida (Land 1994). However, no information is available from the small population (40–70 bears; Freedman 2000) at Eglin AFB in northwest Florida. Our objective was to determine annual and seasonal habitat use by black bears at Eglin AFB.

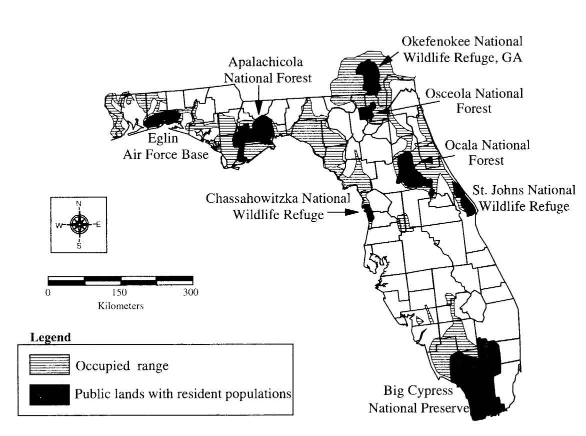

Fig. 1. Distribution of black bears in Florida and vicinity, 1994–96.

STUDY AREA

Eglin AFB (1,875 km^2) is bounded by private land to the north and east and the Gulf of Mexico to the south and west. It is characterized by rolling hills dissected by numerous seepage streams. Plant communities are diverse and range from sandhills and pine production areas to wetland and riparian habitats (Table 1). The Florida Natural Areas Inventory (FNAI) documented 35 natural communities on Eglin AFB (Provencher et al. 1996).

Seventy-two percent of Eglin AFB is comprised of sandhills and pine production areas. Many of these areas contain a dense oak (*Quercus* spp.) midstory and understory of shrubs, vines, and saw palmetto. Dominant tree species include longleaf pine, slash pine, sand pine, turkey oak, laurel oak, and sand live oak. Twelve percent of the land has been cleared for airfields, test ranges, right-of-ways, and administrative areas. Test ranges are maintained in an open grass condition. The remaining areas are comprised of wetland and riparian habitats. Dominant tree species in those habitats include titi, slash pine, redbay, magnolias, and bald cypress.

METHODS

Trapping and Handling

We trapped black bears with spring-activated foot snares and immobilized them with a mixture of Ketaset (8.81mg/

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Table 1. Primary overstory and understory plant species of 5 habitat associations on Eglin Air Force Base, Florida, 1994–1996.

Habitat type	Plant species
Sandhills	Longleaf pine (*Pinus palustris*)
	Turkey oak (*Quercus laevis*)
	Laurel oak (*Q. hemisphaerica*)
	Sand live oak (*Q. geminata*)
	Blueberry (*Vaccinium* spp.)
	Saw palmetto (*Serenoa repens*)
	Greenbriar (*Smilax* spp.)
Pine production areas	Slash pine (*P. elliottii*)
	Sand pine (*P. clausa*)
	Sand live oak
	Blueberry
	Saw palmetto
	Greenbriar
Wetlands	Slash pine
	Titi (*Cyrilla racemiflora*)
	Black titi (*Cliftonia monophylla*)
	Redbay (*Persea borbonia*)
	Bald cypress (*Taxodium distichum*)
	Blackgum (*Nyssa biflora*)
	Sweet gallberry (*Ilex coriacea*)
	Bitter gallberry (*I. glabra*)
	Fetterbush (*Lyonia lucida*)
Riparian zones	Southern magnolia (*Magnolia grandiflora*)
	Sweetbay magnolia (*M. virginiana*)
	Slash pine
	Titi
	Laurel oak
	Florida anise (*Illicium floridanum*)
	Bitter gallberry
	Saw palmetto
	Greenbriar
Open areas	Turkey oak
	Runner oak (*Q. pumila*)
	Bluestem (*Andropogon* spp.)
	Broomsedge (*A. virginicus*)
	Woolly panicum (*Panicum* spp.)

kg; ketamine hydrochloride, Bristol Laboratories, Syracuse, New York, USA), Rompun (4.41mg/kg; xylazine hydrochloride, Haver-Lockhart, Inc., Shawnee, Kansas., USA), and Carbocaine (0.88 mg/kg; mepivicaine hydrochloride, Winthrop Laboratories, New York, New York, USA). The drug was administered with a jab stick or carbon dioxide-powered dart pistol at a dosage of 1 ml/ 22.7 kg of estimated body weight. We fitted all captured bears with radio collars (Telonics, Inc., Mesa, Arizona, USA).

Radiotelemetry

We determined the locations of radiotagged bears using triangulation techniques with 5-element, vehicular roof-mounted antennas (Wildlife Materials, Inc., Carbondale, Illinois, USA) using the loudest signal method (Mech 1983). Telemetry stations were established at known locations that could be identified accurately on U.S. Geological Survey topographic maps. We plotted each station and assigned an identification number; Universal Transverse Mercator coordinates were recorded to the nearest 10 m.

We obtained ≥2 azimuths to estimate bear locations. We selected azimuths based on the following criteria: (1) the angle between all azimuths had to be 60–120° and (2) the time interval between all azimuths had to be ≤20 minutes. Individual bears were located 2–5 times/week. For all locations, we recorded the observer, azimuth, and time of day for each bearing.

We also obtained hourly locations on selected individuals during 24-hour tracking periods conducted 1–2 times during the early summer, late summer, and fall seasons (Stratman 1998). We used the software program TELEM 88 (Coleman and Jones 1988) to generate animal location coordinates from the azimuth and telemetry station data. We collected radiolocations from November 1994 through October 1996.

Habitat Use Analysis

We obtained habitat data including coverage maps for streams, rivers, wetlands, roads, and habitat types in a digital database from the Natural Resources Division, Jackson Guard, Eglin AFB. They determined habitat types from aerial photographs and field surveys conducted by FNAI and digitized habitat features from 1:24,000 maps using a cell grid density of 10 m (10- x 10-m cells). We converted the database into Arc/Info format (Environmental Systems Research, Inc., Redlands, California, USA) for manipulation and reclassification. Because the habitat coverage map contained over 20 habitat types, we grouped habitats based on floral, faunal, and geophysical similarities (McWhite et al. 1993) for analysis (Table 2).

We defined 5 habitat associations: sandhills, pine production areas, riparian zones, swamps, and open areas. Pine production areas are managed strictly for timber and pulpwood production (McWhite et al. 1993), thus we separated them from sandhills to determine their use by bears. Riparian zones were areas ≤50 m from a river and ≤25 m from a stream; these distances were generally where vegetational composition between riparian zones and other habitat associations differed. Open areas consisted of cleared airfields, test ranges, right-of-ways, clearcuts, and sewage spray fields. Home range perimeters, estimated with the 95% adaptive kernel method (Worton 1989), and locations of radiocollared bears were formatted and uploaded into Arc/Info.

We used compositional analysis to determine seasonal and annual habitat use by black bears (Aebischer et al. 1993). Sample size was the number of tracked animals, not the number of radiolocations. We regarded serial cor-

Table 2. Plant communities and land uses for 5 habitat associations on Eglin Air Force Base, Florida, 1994–1996.

Habitat association	Hectares (%)	Plant community or land
Sandhills	90,196 (51%)	Sandhill
		Sandpine–oak forest
		Scrub
		Upland mixed forest
		Upland pine forest
Pine production areas	38,490 (21%)	Pine production
Open areas	23,400 (12%)	Air fields
		Developed areas
		Power line right-of-way
		Roads
		Sewage disposal areas
		Test ranges
Swamps	20,314 (12%)	Baygall
		Depression marsh
		Dome swamp
		Floodplain forest
		Hydric hammock
		Mesic flatwoods
		Sandhill upland lake
		Scrubby flatwoods
		Wet flatwoods
		Wet prairie
Riparian zones	15,082 (4%)	Seepage slope
		Slope forest
		Upland hardwood forest
		Xeric hammock

relation between radiolocations as irrelevant because locations were collected consistently throughout the sampling period and sampling intensity was uniform (Aebischer et al. 1993). Thus, we included the diel locations in the analysis, which provided a more precise estimate of proportional habitat use.

For each bear, we weighted habitat composition by the square root of the number of locations, because the number of radiolocations was not consistent for all bears (Aebischer et al. 1993). Aebischer et al. (1993) noted that a 0% use value implies that use was so low that it was not detected, and this meaning should be preserved in the analysis. Therefore, all 0% use values were replaced with 0.001%, which was less than any existing value in either available or utilized compositions (Aebischer et al. 1993). Because a minimum sample size of 6 was required to show a significant difference from zero at $P < 0.05$ (Aebischer et al. 1993), we considered the sample sizes for sex and age classes insufficient for analysis. We tested the effects of individual habitat selection and found no significant individual effects ($P = 0.242$); therefore, the data were pooled.

We defined summer as 1 June–30 September and fall as 1 October–31 January (Stratman 1998). Spring was not included as a season because of low sample sizes. When we detected nonrandom use ($P < 0.05$), we ranked habitat associations in order of increasing relative use.

Triangulation Error Analysis

To determine the effects of telemetry error on estimates of habitat use, we placed test collars in areas where bears were typically located to simulate actual bear locations and signal strength. All observers located test collars using procedures previously described. We then determined the distance from the estimated location to the true location for each observer to estimate an error distribution (Schmutz and White 1990).

Because the number of locations and mean error was different between observers, we weighted error distances by the percent of locations collected by each observer. The error distances for the observers with the most locations were weighted proportionately more than those with the fewest number of locations. We then calculated the number of random locations needed to approximate the error distribution and generated a set of simulated error locations at uniform random azimuths from the original radiotelemetry coordinates based on the weighted distribution of distances test collars were from triangulated locations (Stratman 1998). We recorded habitat characteristics for each set of simulated locations for comparison with the habitat characteristics of the original telemetry locations.

We used compositional analysis to determine the effects of telemetry error on habitat use by testing each set of simulated error locations against the original data. If a difference was detected ($P < 0.05$), we concluded that telemetry error significantly affected habitat use estimates.

RESULTS

We collected 1,891 location estimates from 9 bears (3F, 6M) to determine annual habitat use. Seasonal habitat use was based on 10 bears (3F, 7M) located during summer (1,049 locations) and fall (794 locations). We obtained 77 locations on test collars. The mean error and number of locations for each observer (A–F) were A: $\bar{x}$= 71 m, 1,402 locations; B: $\bar{x}$= 219 m, 301 locations; C: $\bar{x}$= 216 m, 92 locations; D: $\bar{x}$= 191 m, 30 locations; E: $\bar{x}$= 218 m, 32 locations; and F: $\bar{x}$ = 278 m, 34 locations. Ninety percent of the estimated locations were <390 m from the test location, and 50% were <155 m. The percent of locations for annual, summer, and fall seasons that were classified differently using the simulated data set was 10%, 7.7%, and 8.5%, respectively.

Annual habitat use by black bears was not random ($\Lambda = 0.0576$, $F = 20.46$, $P = 0.0027$). Riparian zones ranked highest among the 5 habitat associations on an annual basis (Table 3). Use differed ($P = 0.025$) between riparian zones and swamps, and each showed greater use than the remaining habitat associations. Although sandhills was the most available habitat to bears, it ranked fourth in annual use.

Habitat use also was nonrandom during summer (Λ = 0.038, F = 37.95, P = 0.0002) and fall (Λ = 0.0541, F = 26.20, P = 0.0006). For both seasons, riparian zones ranked highest followed by swamps (Table 3). There was a difference in use between riparian zones and swamps during summer (P = 0.001), but no difference for fall (P = 0.132). Open areas were used less ($P < 0.05$) than all other habitat associations, both annually and seasonally.

There was no overall effect of telemetry error on annual (P = 0.7342), summer (P = 0.2611), or fall (P = 0.4064) habitat use estimates. Telemetry error had a limited effect on the ranking of habitats. The ranking of habitat associations for annual and fall habitat use did not change. For summer, the ranking of pine production areas and sandhills was reversed.

DISCUSSION

The high proportion of locations collected by the observer with the smallest mean error was a primary factor in reducing the effects of telemetry error on habitat use. The relatively high proportion of misclassified locations was attributed to the large number of bear locations near habitat edges. Misclassified locations did not significantly change use values because many of them were transposed between habitat types, thus, canceling each other out.

Black bears on Eglin AFB demonstrated distinct habitat preferences. Riparian zones and swamps ranked highest among the habitats available to bears. In contrast, bears in Osceola NF preferred large swamps (Mykytka and Pelton 1990); in Ocala NF, they favored flatwoods and sand pine scrub habitats (Wooding and Hardisky 1994); and in southwest Florida, they preferred pine–palmetto habitats and agricultural–disturbed areas (Land 1994). This diversity of habitat use by black bears in Florida demonstrates the adaptability of bears to differences in landscapes and habitat availability.

Riparian zones represent <5% of the land area on Eglin AFB. The high use of riparian zones by black bears reflects the uniqueness of this habitat feature and its importance to black bears on the area. This is the first time riparian zones have been reported to be the primary habitat type used by black bears in the Southeast.

The network of riparian zones allowed bears to travel over large areas while remaining near escape cover. Also, most of the dense vegetation adjacent to streams ranged from 10–100 m wide. The closed canopy and dense understory of fetterbush, gallberry, saw palmetto, and greenbriar (*Smilax* spp.) likely enhanced their attractiveness to bears by providing food, escape cover, and seclusion. In fragmented habitat in Louisiana, bears used drainage ditches as narrow as 10 m for movement through agricultural areas and denned in drainages only 140 m wide (Weaver et al. 1992, Anderson 1997). However, riparian zones were not the most frequently used habitat available to bears in that area.

In this study, bears used riparian zones because they provided an annual source of food as well. In some situations, high edge-to-area ratio can be detrimental to bear populations because of the potential increase in human-induced mortality (Hellgren and Vaughan 1994). However, the high edge-to-area ratio on Eglin AFB, coupled with the plant species composition and moist environment, provided abundant food resources during most of the year. Because bear movements and home range sizes are largely affected by the distribution and abundance of foods (Garshelis and Pelton 1981, Rogers 1987, Smith and Pelton 1990), maintaining plant species diversity, especially primary bear foods, within and adjacent to riparian zones could effectively minimize the area needed to satisfy the nutritional needs of black bears on Eglin AFB.

Bears used swamps throughout the year, but mostly in late fall and winter. However, many of the swamps used by bears on Eglin AFB were narrow bands within riparian zones; some were <5 ha in size. These bands of swamp likely enhanced the attractiveness of the riparian zones to bears because of their dense vegetation and inaccessibility. An increase in the bear population likely would increase the importance of these small patches of swamp for long-term survival of black bears on Eglin AFB.

Pine production areas were used significantly more than sandhills during the summer season. Although pine production areas consisted primarily of slash pine and sand pine plantations, the majority of use by bears occurred in slash pine. Most sand pine areas were closed canopy forests with little or no understory; bears probably were not attracted to sand pine because of the lack of food in these areas. However, Wooding and Hardisky (1994) noted that the use of sand pine scrub on Ocala NF, Florida, corresponded to the availability of hard mast there.

Sandhills ranked higher during fall than during other seasons. This was primarily due to the mast failure of saw palmetto in 1995, when bears switched to acorns as the primary fall food (Stratman and Pelton 1999). Because oak mast is an important fall food for bears, sandhill habitats near riparian zones and swamps that contain a mature oak midstory can minimize travel to escape cover.

MANAGEMENT IMPLICATIONS

The high use of riparian zones demonstrates the importance of habitats associated with rivers and streams to black bears on Eglin AFB. The unique network and dendritic

Table 3. Ranking matrices for annual and seasonal habitat use by black bears on Eglin Air Force Base, Florida, 1994–96. Each mean element in the matrix was replaced by its sign; a triple sign represents significant deviation from random at P < 0.05.

Season Habitat type	Habitat type					
	Riparian	Swamp	Pine	Sandhills	Open	Rank
Annual						
Riparian		+++	+++	+++	+++	1
Swamp	---		+++	+++	+++	2
Pine	---	---		+	+++	3
Sandhills	---	---	-		+++	4
Open	---	---	---	---		5
Summer						
	Riparian	Swamp	Pine	Sandhills	Open	Rank
Riparian		+++	+++	+++	+++	1
Swamp	---		+++	+++	+++	2
Pine	---	---		+++	+++	3
Sandhills	---	---	---		+++	4
Open	---	---	---	---		5
Fall						
	Riparian	Swamp	Sandhills	Pine	Open	Rank
Riparian		+	+++	+++	+++	1
Swamp	-		+++	+++	+++	2
Sandhills	---	---		+	+++	3
Pine	---	---	-		+++	4
Open	---	---	---	---		5

pattern of riparian areas effectively links habitats throughout Eglin AFB and vicinity. This network of natural protected corridors enables black bears to move to various seasonal feeding areas as well as providing food, thermal relief in summer, escape cover, and denning habitat. Because bears use a variety of foods that are only seasonally available, habitat diversity is important to satisfy their dietary needs. In addition, management of upland habitats adjacent to riparian zones and swamps for soft and hard mast production would provide foraging areas for bears while minimizing travel to escape cover.

Human demands on the landscape will inevitably cause bear populations to become more fragmented and isolated. Proper management of riparian zones on Eglin AFB could provide a valuable tool to link other isolated bear populations in Florida. The future of this small isolated population is in jeopardy unless management strategies are implemented to preserve and enhance critical habitats for bears. Because of their limited availability, management of riparian zones is a key element to the survival of black bears on Eglin AFB. The integrity of riparian zones must be preserved if this population is to persist.

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