Journal of Mammalogy, 88(2):468–476, 2007

FACTORS INFLUENCING HOME-RANGE SIZE OF FEMALE FLORIDA BLACK BEARS

Melissa A. Moyer, J. Walter McCown, and Madan K. Oli*

Department of Wildlife Ecology and Conservation, 110 Newins-Ziegler Hall, University of Florida,
Gainesville, FL 32611, USA (MAM, MKO)
Florida Fish and Wildlife Conservation Commission, 4005 S Main Street, Gainesville, FL 32601, USA (JWM)

The manner in which space is utilized by animals is influenced by several factors, including habitat quality and the distribution and abundance of resources. We used 4 years (2000–2003) of radiotelemetry data to investigate the space-use pattern of female Florida black bears (*Ursus americanus floridanus*) in the Ocala National Forest and an adjacent residential community of Lynne, north-central Florida. Annual home-range size (95% fixed kernel density estimator) ranged from 3.8 km^2 to 126.9 km^2, and averaged (± *SE*) 24.2 ± 3.55 km^2. Home ranges were largest during 2000 when a drought led to a forest-wide mast failure, suggesting that abundance of food resources can substantially influence space-use pattern. Home-range sizes during autumn (19.92 ± 4.59 km^2) were substantially larger than during summer (8.26 ± 0.99 km^2). Although annual home-range size did not differ between the 2 study sites, home ranges in summer were smaller in Lynne (5.30 ± 1.01 km^2) than in Ocala National Forest (9.82 ± 1.29 km^2), whereas home ranges in autumn were twice as large in Lynne (35.76 ± 13.91 km^2) as in Ocala National Forest (13.24 ± 1.80 km^2). We suggest that site-specific differences in the size of seasonal home range are due to differences in habitat characteristics and the degree of habitat fragmentation between the 2 study sites.

Key words: Florida black bear, home range, kernel density method, minimum convex polygon, space use, *Ursus americanus floridanus*

Intraspecific variation in home-range size has been shown to be influenced by resource availability (Lariviere and Messier 2001; Oehler et al. 2003; South 1999; Van Orsdol et al. 1985), population density (Kjellander et al. 2004; Lindzey et al. 1986; Oli et al. 2002; Young and Ruff 1982), social factors (Boydston et al. 2003; Grigione et al. 2002), and anthropogenic influences such as habitat fragmentation (Beckmann and Berger 2003; Crooks 2002; Gehring and Swihart 2004).

The American black bear (*Ursus americanus*) is a large, solitary carnivore with an extensive space requirement and a polygynous mating system. Given this mating system, female black bears are thought to select a home range based on the abundance of resources, whereas male bears establish a home range in relation to the presence of females (Clutton-Brock 1989; Sandell 1989). Spatial patterns of females are influenced at multiple scales, directly or indirectly, by the distribution and temporal availability of resources (Lindzey and Meslow 1977; Smith and Pelton 1990). Within the broad geographic range, home-range size decreases along the latitudinal gradient from north to south (Gompper and Gittleman 1991; Powell 1987; Schenk et al. 1998). Local environmental variation further influences home-range size and smaller home ranges are commonly documented in more productive habitats (Koehler and Pierce 2003; Oli et al. 2002; Smith and Pelton 1990).

Home ranges of bears inhabiting diverse habitats tend to be smaller than those occupying more homogeneous habitats because available food sources vary with plant phenology and edge habitat may influence abundance (Garshelis and Pelton 1981; Klenner 1987; Reynolds and Beecham 1980). Annual and seasonal fluctuations in resource availability, due to normal seasonal variation, drought, or mast failure, also may add temporal variation to female home-range size (Garshelis and Pelton 1981; Jonkel and Cowan 1971; Rogers 1987; Schooley 1994). Female black bears with cubs may have somewhat different resource and safety requirements compared to females without cubs (Alt et al. 1980; Hellgren and Vaughan 1990; Lindzey and Meslow 1977; Smith and Pelton 1990).

The Florida subspecies of the American black bear (*U. a. floridanus*) is listed as a threatened species by the state of Florida and exists in fragmented populations centered on public

---

* *Correspondent: olim@wec.ufl.edu*

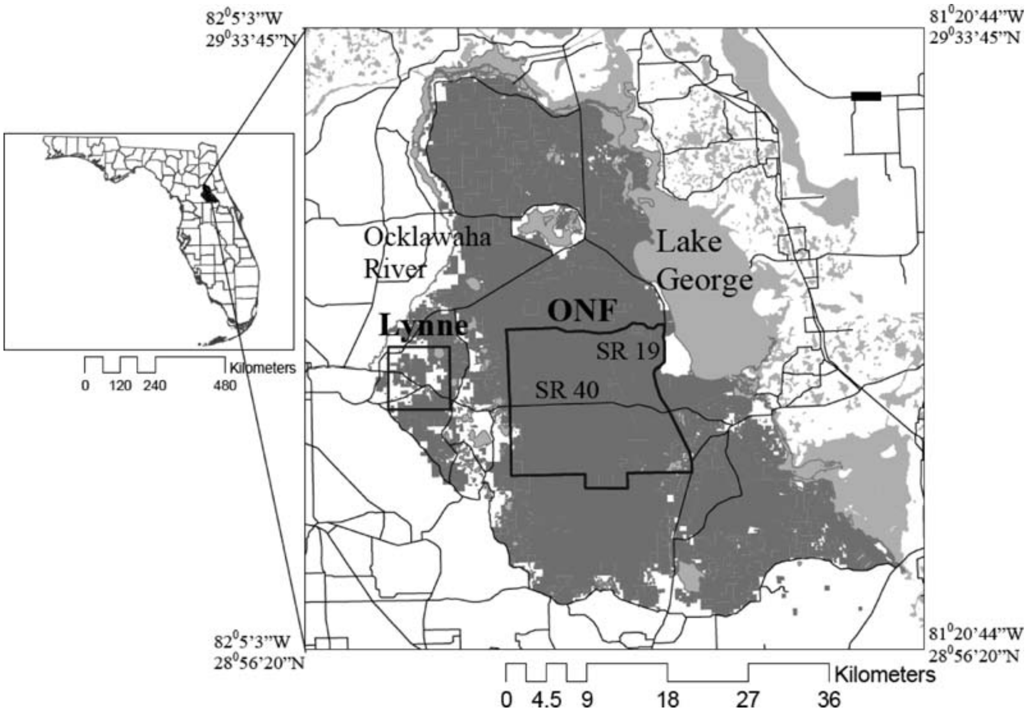


FIG. 1.—The location of the Ocala National Forest in north-central Florida. ONF and Lynne are the 2 study sites within Ocala National Forest. ONF is located in the central forest, north and south of State Road 40 and bounded on the east by State Road 19. Lynne is located to the west in the matrix of public (dark gray) and private (white) lands. Black lines represent roads, and water bodies are gray.

land (Dixon et al. 2006). Although long-term studies have been conducted in many parts of the country (e.g., Alt et al. 1980; Powell 1987; Reynolds and Beecham 1980; Rogers 1987), less is known about factors influencing home-range size of Florida black bears (but see Dobey et al. 2005; Maeher et al. 2003; Wooding and Hardisky 1994). Because of the latitudinal gradient of home-range size (Gompper and Gittleman 1991; Powell 1987), one would expect the home-range size of the Florida black bear, near the southern tip of the geographic distribution, to be smaller than in populations occupying northern habitats. However, habitat types, resource availability, and fragmentation of black bear habitat in Florida differ substantially from regions where the majority of black bear research has been conducted. These factors may offset the expected effect of latitude on home-range size.

Using data from female black bears radiocollared during 2000–2003, our objectives were to investigate space-use patterns. We examined seasonal and annual variation in home-range size, and examined differences in the pattern of space use by bears inhabiting a contiguous forested habitat and those inhabiting a fragmented habitat that experienced a greater degree of human activities and more patchily distributed resources. Because the degree of urbanization and available food resources have been suggested to influence home-range size (Beckmann and Berger 2003), we expected home ranges of bears inhabiting the contiguous habitat to be smaller than those of bears occupying fragmented habitat. When food resources are scarce, animals would have to travel more widely to obtain sufficient resources; thus, we also predicted that home-range size in 2000 would be larger than that in other years because a severe drought led to a mast failure.

MATERIALS AND METHODS

Study area.—Our study was conducted in the Ocala National Forest in north-central Florida. Ocala National Forest is the largest contiguous public land in central Florida and supports one of the largest of the 9 subpopulations of black bears in Florida (Dixon 2004; Dixon et al. 2006). Two study sites were designated within Ocala National Forest, ONF and Lynne (Fig. 1). The ONF study area is approximately 500 km^2 and was centered on State Road 40 along a ridge of ancient sand dunes primarily vegetated by sand pine scrub, xeric oak scrub, and open prairies (FWC 2003). Human disturbance due to selective logging, clear-cutting, and prescribed burning practices within the forest provides much of the heterogeneity in forest cover type and stand age. Elevations range from 15 m above sea level near Juniper Springs to 53 m above sea level in the north-central part of the forest. The forest as a whole sustains a high degree of recreational activity such as camping, hunting, and off-road vehicle activity.

The Lynne study area is located approximately 20 km west of ONF and encompasses a matrix of United States Forest Service and privately owned land in the residential community of Lynne. Elevations in Lynne were lower than those in ONF and ranged from 0 to 12 m above sea level. The predominant forest cover types are swamp forests and pine flatwoods and there was greater fragmentation due to human developments such as roads, businesses, houses, and pastures (FWC 2003).

Because both the degree of urbanization and available food resources have been shown to influence home-range size (Beckman and Berger 2003), home ranges of bears in the 2 study areas were analyzed separately.

North-central Florida experienced substantial variation in rainfall and drought conditions over the course of the study. The Palmer Drought Severity Index in north-central Florida at the beginning of September was −4.41, −2.57, 2.73, and 3.94 in 2000, 2001, 2002, and 2003, respectively (Southeast Regional Climate Center 2004, *Drought and Agriculture Information,* http://www.dnr.state.sc.us/climate/sercc/climateinfo/drought/html). A Palmer Drought Severity Index of −4 and below signifies extreme drought conditions, 0 signifies near-normal conditions, and +4 and above signify extreme moist conditions. A mast failure in 2000 resulted from these extreme drought conditions.

Field methods.—We began trapping and radiocollaring black bears in summer 1999 and continued through autumn 2002. Although bears were trapped from May through December, the most intensive trapping occurred during summer months. We trapped bears using spring-activated Aldrich foot snares (Aldrich Snare Co., Clallam Bay, Washington) baited with donuts or a combination of corn and donuts. We set traps near dusk along access roads and continuously monitored the traps to ensure that trapped bears were immediately processed. We anesthetized bears with Telazol (Fort Dodge Laboratories, Fort Dodge, Iowa) delivered through a CO_2-charged dart delivery system. Once sedated, bears were ear-tagged and lip-tattooed for individual identification. We extracted a premolar to estimate age from cementum annuli (Willey 1974). We fitted female bears with a motion-sensitive radiocollar (Telonics, Mesa, Arizona) that had a leather connector to allow the collar to fall off in 2–3 years. A female was considered an adult, and included in analyses, at 3 years of age or less than 3 years if she reproduced at an earlier age (Garrison 2004; Garrison et al., in press). Reproductive status of radiocollared females was determined by visiting their dens during March–April (Garrison 2004). All procedures were approved by the University of Florida's Institutional Animal Care and Use Committee and meet the guidelines recommended by the American Society of Mammalogists (Animal Care and Use Committee 1998).

We located adult females an average of once per week during 1999–2001, twice per week in 2002, and 3 times per week in 2003. The majority of locations were obtained from the ground during daylight hours (0900–1800 h) using a 4-element hand-held antenna and a Telonics receiver (Telonics, Mesa, Arizona), but bears also were tracked 1–4 times per month from a fixed-wing aircraft. For each bear, ≥ 3 compass bearings were obtained within 30 min. Point locations from ground telemetry were estimated using the program Locate II (Pacer Software 1990). We obtained aerial locations from a fixed-wing aircraft by circling at low altitude, pinpointing the position of the radiocollared bear, and marking the location on a map. Telemetry error was estimated by comparing estimated locations of test collars (some test collars were used to obtain ≥ 1 locations), dropped collars, and natal dens of females to their actual locations. The average ground telemetry error was 152.6 m ($n = 312$, $SD = 180.1$), and the average aerial telemetry error was 251 m ($n = 25$, $SD = 270.3$).

To quantify the availability of food during autumn, we monitored abundance of mast produced by 6 species of plants known to be important components of the diet of Florida black bears (Maeher and Brady 1984) on 60 permanent transects (each 100 m long) during 2000–2002. Mast production was occularly estimated, and mast produced by each plant was classified as absent (no visible fruit), sparse, moderate, or abundant (see McCown et al. [2004] for details).

Data analysis.—Although the number of locations is an important consideration for robust estimates of home-range size, recommendations regarding how many locations are needed are variable (Belant and Follmann 2002; Gehrt and Fritzell 1998; Koehler and Pierce 2003; Seaman and Powell 1996). Based on results of Koehler and Pierce (2003), we required a minimum of 25 locations per female for estimation of annual or seasonal home range.

We estimated seasonal and annual home-range size for each year of the study using both the 95% fixed kernel density estimator (kernel) and the 95% minimum convex polygon (MCP) for comparison to other studies and to evaluate differences in results based on the home-range estimation method selected (Millspaugh and Marzluff 2001). We used the program CALHOME (Kie et al. 1994) to estimate 95% MCP home ranges and the Animal Movement extension of ArcView 3.2 (Hooge et al. 1999) to estimate 95% fixed kernel home ranges with least squares cross validation (Seaman and Powell 1996). We estimated annual home ranges from locations collected from May to December. For seasonal analysis of home ranges, summer was designated as May–August and autumn was designated as September–December. The beginning of September was chosen as the transition between summer and autumn based on the start of the availability of acorns at this time (Maeher and Brady 1984), the end of the breeding season, and to equalize sampling effort across seasons. We did not include locations collected during the winter and spring months of January–April in our analyses because of substantial variation in denning chronology among females (Garrison 2004).

We used general linear models (SAS procedure GLM—SAS Institute Inc. 1999) to simultaneously assess the influence of several factors on home ranges estimated using MCP and kernel methods. Annual and seasonal home ranges were analyzed separately. The independent variables included in the annual home-range models were the year of study (2000, 2001, 2002, or 2003), study area (ONF or Lynne), and reproductive status of females (with or without cubs). Seasonal home-range models were slightly different in that season (summer or autumn) was included as an effect, and we only included data collected in 2002 and 2003 because of insufficient data before 2002. As previously mentioned, the number of locations has been shown to influence home-range size (Belant and Follmann 2002; Millspaugh and Marzluff 2001; Seaman et al. 1999). In order to remove any potential effect of the number of locations on home-range size, we used the residuals of the regression of log-

Table 1.—Annual home-range sizes for female black bears in north-central Florida, estimated using 95% fixed kernel density estimator (Kernel) and 95% minimum convex polygon (MCP) methods. Average home-range size (± *SE*) is presented by year (2000–2003), by study area (ONF and Lynne), and by reproductive status of the female (with or without cubs). Sample size (*n*) is the number of home ranges used to estimate average home-range size and the number in parentheses is the number of different females included when averages spanned multiple years. "Locations" is the average number of locations (± *SE*) used to estimate each home range.

Variable	*n*	Locations	Home-range size (km^2)	
			Kernel	MCP
Year				
2000	14	35.57 ± 1.51	42.58 ± 9.96	34.96 ± 15.42
2001	11	39.09 ± 1.69	22.54 ± 3.04	17.56 ± 4.44
2002	15	62.13 ± 2.10	15.52 ± 2.90	18.32 ± 7.27
2003	8	79.25 ± 3.75	10.62 ± 1.76	15.69 ± 3.97
Study area				
ONF	37 (24)	49.38 ± 2.88	25.89 ± 4.44	22.75 ± 6.17
Lynne	11 (7)	60.64 ± 5.59	18.54 ± 3.86	21.92 ± 9.43
Reproductive status				
With cub	21 (18)	54.71 ± 4.06	32.07 ± 7.49	30.19 ± 11.39
Without cubs	27 (21)	49.81 ± 3.44	18.09 ± .88	16.62 ± 2.34
Combined	48 (30)	51.96 ± 2.62	24.2 ± 3.55	22.6 ± 5.18

Table 2.—Seasonal home-range sizes for female black bears in north-central Florida, estimated using 95% fixed kernel density estimator (Kernel) and 95% minimum convex polygon (MCP) methods. Average home-range sizes in summer (S) and autumn (F) are presented by year (2002–2003), by study area (ONF and Lynne), and by reproductive status of the female (with or without cubs). Sample size (*n*) is the number of home ranges used to estimate average home-range size and the number in parentheses is the number of different females included when averages spanned multiple years. "Locations" is the average number of locations (± *SE*) used to estimate home ranges.

Variable	Season	*n*	Locations	Home-range size (km^2)	
				Kernel	MCP
Year					
2002	S	15	32.27 ± 0.95	9.53 ± 1.50	7.10 ± 1.87
	F	19	33.00 ± 0.423	21.47 ± 6.39	16.54 ± 5.73
2003	S	14	43.21 ± 1.42	6.90 ± 1.22	4.41 ± 0.74
	F	8	40.25 ± 2.67	16.23 ± 3.36	15.68 ± 4.09
Study area					
ONF	S	19 (15)	38.21 ± 1.66	9.82 ± 1.29	7.05 ± 1.50
	F	19 (16)	36.37 ± 1.30	13.24 ± 1.80	11.56 ± 2.05
Lynne	S	10 (7)	36.30 ± 2.27	5.30 ± 1.01	3.41 ± 0.60
	F	8 (5)	32.25 ± 1.26	35.76 ± 13.91	27.49 ± 12.90
Reproductive status					
With cub	S	14 (14)	39.79 ± 1.76	6.55 ± 1.04	4.36 ± 0.54
	F	11 (11)	34.18 ± 1.54	22.93 ± 10.04	19.17 ± 9.80
Without cubs	S	15 (14)	35.47 ± 1.86	9.86 ± 1.58	7.14 ± 1.92
	F	16 (15)	35.81 ± 1.41	17.85 ± 3.83	14.30 ± 2.47
Combined					
	S	29 (22)	37.55 ± 1.32	8.26 ± 0.99	5.80 ± 1.04
	F	27 (21)	35.15 ± 1.04	19.92 ± 4.59	16.28 ± 4.17

transformed home-range size on the number of locations as the response variable in each model.

Initially, we included all main effects and all 2-way interactions in each general linear model. We then removed nonsignificant ($\alpha = 0.05$) interaction terms in a stepwise fashion such that the least significant interaction term was removed each time. The model was refitted sequentially until all main effects and only significant interaction effects remained in the model as per Slade et al. (1997). We further explored the significant interaction effects in the final model using the least squares means multiple comparisons.

RESULTS

Of the 53 radiocollared females, 35 met criteria for estimation of at least 1 annual or seasonal home range. The average (± *SE*) number of locations per annual home range varied from 36 ± 2 in 2000 to 80 ± 4 locations per bear in 2003 (Table 1). The average number of locations per seasonal home range varied from 32 ± 1 for summer 2002 to 43 ± 1 for summer 2003 (Table 2).

Annual home-range size estimated using the 95% kernel density estimator ranged from 3.8 km^2 to 126.9 km^2, and averaged 24.2 ± 3.55 km^2. The average home-range size was much larger in 2000 than in subsequent years. When data for the year 2000 were excluded from analyses, the average home ranges were much smaller (kernel method; 16.64 ± 1.80 km^2). Combining data across years, average home-range size was larger for females with cubs than for females without cubs. Using the kernel method, home ranges in ONF were larger than those in Lynne; however, the home-range sizes estimated using the MCP method did not differ substantially between sites. Although kernel home-range estimates were slightly larger than MCP estimates, the 2 methods followed the same general trend (Tables 1 and 2).

Average home-range size in summer was smaller than that in autumn (Table 2). Home-range size in summer (estimated using the kernel method) varied from 0.34 km^2 to 21.35 km^2 and averaged 8.26 ± 0.99 km^2. Home-range size in autumn varied from 1.78 km^2 to 119.32 km^2 and averaged 19.92 ± 4.59 km^2. Females with cubs had smaller home ranges during the summer than females without cubs, whereas the average home range in autumn was larger for females with cubs. Female bears in ONF had larger home ranges in summer, but smaller home ranges in autumn than those in Lynne. The pattern of home-range sizes estimated using the MCP method did not qualitatively differ from that based on kernel method.

Factors influencing annual home ranges.—The final general linear models for annual home ranges included the main effects of year, study area, and reproductive status, and the interaction effect of year and reproductive status (Table 3). None of the variables considered significantly influenced annual home-range size. However, the interaction between year and reproductive status was significant, indicating that reproductive status did influence home-range size but that pattern of influence varied with year.

TABLE 3.—Factors influencing annual home ranges estimated using 95% fixed kernel density estimator (Kernel) and 95% minimum convex polygon (MCP) methods. Final general linear models for each home-range estimation method are given, including all main effects and significant interaction effects. Degrees of freedom (*d.f.*), mean square, value of *F*-statistic (*F*), and observed significance level (*P*) are given for each effect.

Method	Source	*d.f.*	Mean square	*F*	*P*
Kernel					
	Year	3	0.415	1.12	0.3529
	Study area	1	0.494	1.33	0.2557
	Reproductive status	1	0.359	0.97	0.3311
	Year × reproductive status	3	1.317	3.55	0.0230
	Error	39	0.371		
MCP					
	Year	3	0.474	0.81	0.4950
	Study area	1	1.161	1.99	0.1663
	Reproductive status	1	0.070	0.12	0.7299
	Year × reproductive status	3	6.825	3.90	0.0158
	Error	39	22.760		

TABLE 4.—Factors influencing seasonal home ranges estimated using 95% fixed kernel density estimator (Kernel) and 95% minimum convex polygon (MCP) methods. Final general linear models for each home-range estimation method are given, including all main effects and significant interaction effects. Degrees of freedom (*d.f.*), mean square, value of *F*-statistic (*F*), and observed significance level (*P*) are given for each effect.

Method	Source	*d.f.*	Mean square	*F*	*P*
Kernel					
	Year	1	0.439	0.75	0.3906
	Season	1	9.108	15.58	0.0003
	Study area	1	0.028	0.05	0.8274
	Reproductive status	1	1.582	2.71	0.1064
	Year × reproductive status	1	3.546	6.07	0.0173
	Season × study area	1	6.187	10.58	0.0021
	Error	49	0.585		
MCP					
	Year	1	0.104	0.18	0.6739
	Season	1	11.564	19.91	<0.0001
	Study area	1	0.00002	0.0	0.9951
	Reproductive status	1	1.158	1.99	0.1642
	Year × reproductive status	1	3.417	5.88	0.0190
	Season × study area	1	4.250	7.32	0.0094
	Error	49	0.581		

During 2000 and 2002, females with cubs had larger home ranges than females without cubs ($P = 0.011$, $P = 0.035$, respectively), a pattern not observed in 2001 and 2003. The most striking difference was that the average home-range size of females with cubs during 2000 was not only significantly larger than females without cubs during the same year but was significantly larger than home ranges for females without cubs in 2001 ($P = 0.026$), females without cubs in 2002 ($P = 0.001$), and females with cubs in 2003 ($P = 0.006$).

Factors influencing seasonal home ranges.—Season was the only significant main effect in the final general linear model using the kernel home ranges, with larger home ranges during autumn than summer (Table 4). Reproductive status by year, and season by study area were both significant 2-way interaction terms. The significant interaction of reproductive status and year reflects the pattern seen for the annual home ranges. Least squares means indicated that females without cubs had significantly larger home ranges than females with cubs during 2003 ($P = 0.012$).

The interaction of season and study area suggested that the pattern of seasonal variation in home-range size differed between study areas. Least squares means indicated that autumn home ranges in Lynne were larger than summer ($P < 0.001$); however, the seasonal difference in home-range size was not significant in ONF ($P = 0.545$). Additionally, autumn home ranges were significantly larger in Lynne than in ONF ($P = 0.024$), but during summer, average home-range size in ONF was larger than in Lynne ($P = 0.032$).

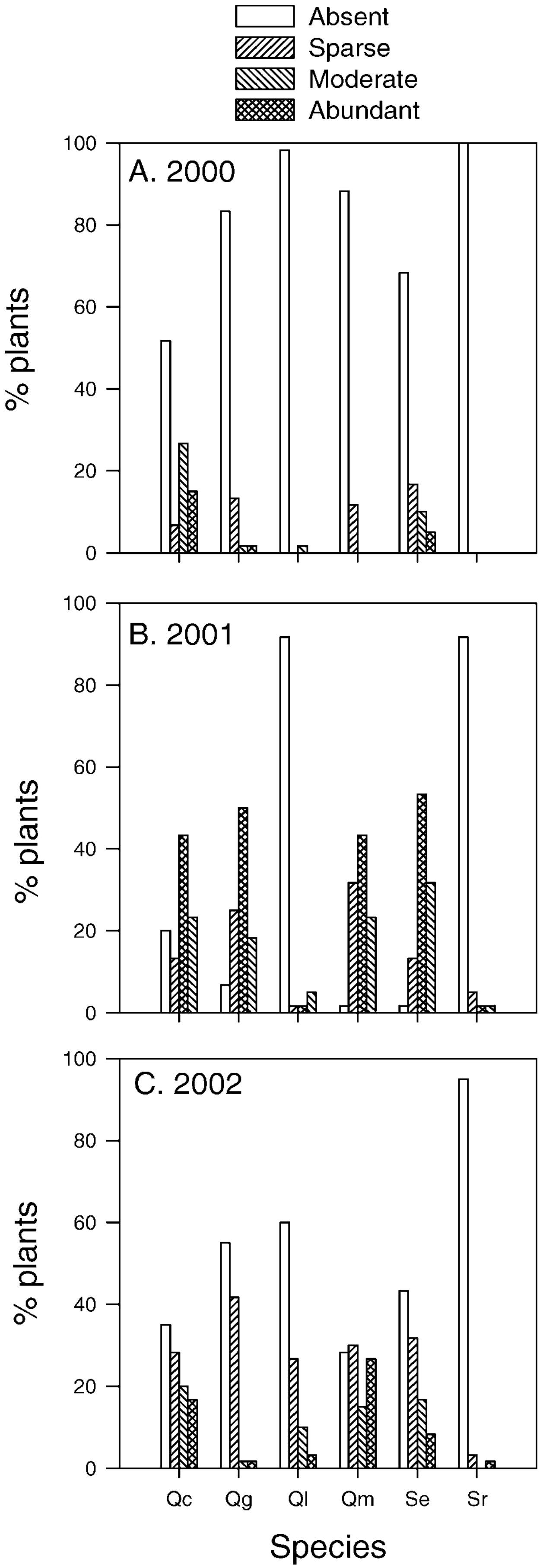
Results of general linear model analyses were generally similar for home ranges estimated using the 2 methods (i.e., 95% MCP and 95% kernel), although P-values were slightly different (Table 3).

Mast production during autumn.—The drought of 2000 caused a major mast failure; the proportion of sampled plants that had little or no fruit was close to 100% in 2000 (Fig. 2). With the exception of *Quercus chapmanii*, most species of plants produced substantially less fruit in 2000 compared to other years (Fig. 2).

DISCUSSION

The pattern of space use by female Florida black bears and how space requirements change with spatial or temporal variation in environmental conditions can help guide conservation and management of this subspecies within an increasingly human-dominated landscape. The Florida black bear is already restricted to 17% of its historic range in Florida (Wooding 1993), and only 40% of currently available potential black bear habitat is in public ownership (Maehr et al. 2001). The bears in ONF occupy primarily federal lands; however, the bears in Lynne use a matrix of publicly and privately owned land and are highly susceptible to further encroachment. As the human population of Florida continues to expand, and space becomes an increasingly limited commodity, understanding both average and extreme spatial use patterns, as in times of drought, becomes critical to preserving the Florida black bear.

Published reports indicate that home ranges of black bears vary substantially in North America, with larger home ranges for bears occupying northern habitats than for those occupying more productive habitats in the southeast (Powell 1987; Schenk et al. 1998). For example, home-range size of female black bears averaged 295 km^2 in Manitoba, Canada (Pacas and Paquet 1994), 72 km^2 in Pennsylvania (Alt et al. 1980), and 48 km^2 in Michigan (Hirsch et al. 1999) and Quebec, Canada (Samson and Huot 1998). Home ranges of moderate sizes for female black bears have been reported from 3 study sites in Washington ($\bar{X}$ = 18–28 km^2—Koehler and Pierce 2003), Virginia–North Carolina ($\bar{X}$ = 27 km^2—Hellgren and Vaughan 1990), and the Smoky Mountains of Tennessee ($\bar{X}$ = 15



km^2—Garshelis and Pelton 1981). Some of the smallest home ranges for female black bears have been reported by Lindzey and Meslow (1977) from southwestern Washington ($\bar{X} = 2.4$ km^2) and by Oli et al. (2002) from southeastern Arkansas ($\bar{X} = 4.9$ km^2); authors of both of these studies attributed unusually small home ranges to high productivity of the habitats.

The average home-range size in Ocala was not as small as expected based solely on latitude. The productive habitat in the floodplains of Arkansas and the eastern forests of the Smoky Mountains (Garshelis and Pelton 1981; Oli et al. 2002) likely allowed for smaller home ranges than documented in this study. However, the average home-range size in Ocala is comparable to those reported from Okefenokee and Osceola populations in northern Florida (Dobey et al. 2005). Our results indicate substantial annual variation in home-range size, with significantly larger home ranges of females with cubs in 2000 when a prolonged drought and the subsequent acorn mast failure led female bears to search for food over a vast area as compared to what they typically use. These results, as well as those of Dobey et al. (2005), suggest that conservation plans for the Florida black bear must consider the increased space requirements during years of drought and other unfavorable environmental conditions.

Resource availability and habitat productivity have a tremendous influence on home-range size (Koehler and Pierce 2003; Samson and Huot 1998; Smith and Pelton 1990). The greater degree of habitat fragmentation and associated anthropogenic effects in Lynne would lead us to believe that home ranges would be larger in order to meet nutritional needs, as has been shown in other carnivores (Riley et al. 2003).

The larger home ranges in autumn in Lynne may be related to habitat fragmentation as well as temporal fluctuations in resource availability. The community of Lynne, located within our study site, supports a resident human population of 3,760 individuals, and contains interspersed houses, farmlands, and a network of paved roads; consequently, the bear habitat is dissected by human developments (FWC 2003). The ONF study site, on the other hand, is composed entirely of public land and supports no resident human population. Habitat fragmentation reduces the total amount of forest cover within a given area compared to contiguous habitat. During autumn, bears in Lynne primarily traveled out of the residential part of Lynne to the less-developed banks of the Ocklawaha River or into ONF (Figs. 1 and 2), most likely to take advantage of food sources not available within their summer home ranges. A more thorough investigation of home-range size and daily movement differences between ONF and Lynne would be needed to more clearly define the differences between the 2 sites.

←

FIG. 2.—Estimated relative abundance (percentage of plants with mast in 1 of the 4 categories) of mast produced by 6 species of plants in sand pine–scrub oak habitat in Ocala National Forest during autumn of A) 2000, B) 2001, and C) 2002. Plant species are *Quercus chapmanii* (Qc), *Q. germinata* (Qg), *Q. laevis* (Ql), *Q. myrtifolia* (Qm), *Sabal etonia* (Se), and *Serona repens* (Sr).

Previous studies on black bears have indicated that home-range sizes may be different between females with cubs and females without cubs (Alt et al. 1980; Hellgren and Vaughan 1990; Lindzey and Meslow 1977; Smith and Pelton 1990). More specifically, these studies have documented smaller home-range sizes for females with cubs during summer when cub mobility is restricted, and larger home ranges for females with cubs during autumn (Alt et al. 1980; Lindzey and Meslow 1977; Smith and Pelton 1990). In this study, when annual home ranges are averaged across years, females with cubs used larger home ranges than females without cubs (Table 1). This trend was most pronounced during the mast failure of 2000; the difference in home-range sizes of females with and without cubs was significant only for 2000. Total nutritional requirements of females with cubs are greater than females alone, which may explain the increase in home-range size.

Several authors have suggested that estimates of home ranges using the MCP method may be problematic (e.g., Millspaugh and Marzluff 2001; Powell et al. 1997; Seaman et al. 1999; Seaman and Powell 1996; White and Garrot 1990). In our study, factors influencing home-range size did not differ based on the home-range estimation method. The final general linear models for annual and seasonal home ranges had the same significant main and interaction effects regardless of home-range estimation method used, although exact P-values were quite different. However, differences were found in cases where significant interaction effects were further analyzed using least squares means. These differences may be partially due to small sample sizes, as well as technical differences between methods. Home ranges estimated using the MCP method might contain large areas that are not used by the individual (Fig. 2), whereas the corresponding home range estimated using the kernel method might consist of several discontinuous polygons that more accurately estimate total area used. However, the fact that both models found identical factors to be significant influences on home-range size reinforces the importance of these factors in influencing home ranges.

We conclude that the space-use pattern of female Florida black bears varies seasonally, with substantially larger home ranges during autumn, and that bears' space requirements (particularly those of females with cubs) increase greatly during years of mast failures, and perhaps also in response to other unfavorable environmental conditions. We suggest that conservation plans for the Florida black bear should allow for increased space requirements during years of mast failures. Managers also should be cognizant of the fact that bears inhabiting urban habitats may exhibit different spatial response to unfavorable environmental conditions (e.g., mast failures) than bears occupying contiguous forested landscapes.

ACKNOWLEDGMENTS

We gratefully acknowledge the Florida Fish and Wildlife Conservation Commission for funding and logistical support. Additional support was provided by the Florida Department of Transportation, Wildlife Foundation of Florida, United States Forest Service, African Safari Club International, Jennings Scholarship, and University of Florida Department of Wildlife Ecology and Conservation. We thank T. Eason, M. Cunningham, J. Dixon, E. Garrison, and D. Masters for help in the field. J. Clarke, G. Cumming, M. Sunquist, and an anonymous reviewer provided helpful comments on an earlier draft of the manuscript. Florida Fish and Wildlife Conservation Commission pilots J. Wisniesky, J. Johnston, and P. Crippen assisted with telemetry flights. This study also was supported in part by the Florida Agricultural Experiment Station.

LITERATURE CITED

ALT, G. L., G. J. MATULA, F. W. ALT, AND J. S. LINDZEY. 1980. Dynamics of home range and movements of adult black bears in northeastern Pennsylvania. International Conference on Bear Research and Management 4:131–136.

ANIMAL CARE AND USE COMMITTEE. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. Journal of Mammalogy 79:1416–1431.

BECKMANN, J. P., AND J. BERGER. 2003. Rapid ecological and behavioural changes in carnivores: the responses of black bears (*Ursus americanus*) to altered food. Journal of Zoology 261:207–212.

BELANT, J. L., AND E. H. FOLLMANN. 2002. Sampling considerations for American black and brown bear home range and habitat use. Ursus 13:299–315.

BOYDSTON, E. E., K. M. KAPHEIM, M. SZYKMAN, AND K. E. HOLEKAMP. 2003. Individual variation in space use by female spotted hyenas. Journal of Mammalogy 84:1006–1018.

CLUTTON-BROCK, T. H. 1989. Mammalian mating systems. Proceedings of the Royal Society of London, B. Biological Sciences 236:339–372.

CROOKS, K. R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488–502.

DIXON, J. D. 2004. The conservation genetics of the Florida black bear. M.S. thesis, University of Florida, Gainesville.

DIXON, J. D., M. K. OLI, M. C. WOOTEN, T. H. EASON, J. W. MCCOWN, AND D. PAETKAU. 2006. Evaluating the effectiveness of a regional corridor for the Florida black bear. Conservation Biology 20:155–162.

DOBEY, S., D. V. MASTERS, B. K. SCHEICK, J. D. CLARK, M. R. PELTON, AND M. E. SUNQUIST. 2005. Ecology of Florida black bears in the Okefenokee–Osceola ecosystem. Wildlife Monographs 158:1–41.

FWC (Florida Fish and Wildlife Conservation Commission). 2003. Florida vegetation and land cover data derived from 2003 Landsat ETM+ imagery. Florida Fish and Wildlife Conservation Commission, Tallahassee.

GARRISON, E. P. 2004. Reproductive ecology, cub survival and denning ecology of the Florida black bear. M.S. thesis, University of Florida, Gainesville.

GARRISON, E. P., J. W. MCCOWN, AND M. K. OLI. In press. Reproductive ecology and cub survival of Florida black bears. Journal of Wildlife Management.

GARSHELIS, D. L., AND M. R. PELTON. 1981. Movements of black bears in the Great Smoky Mountain National Park. Journal of Wildlife Management 45:912–925.

GEHRING, T. M., AND R. K. SWIHART. 2004. Home range and movements of long-tailed weasels in a landscape fragmented by agriculture. Journal of Mammalogy 85:79–86.

GEHRT, S. D., AND E. K. FRITZELL. 1998. Resource distribution, female home range dispersion and male spatial interactions: group structure in a solitary carnivore. Animal Behaviour 55:1211–1227.

GOMPPER, M. E., AND J. L. GITTLEMAN. 1991. Home range scaling—intraspecific and comparative trends. Oecologia 87:343–348.

Grigione, M. M., et al. 2002. Ecological and allometric determinants of home-range size for mountain lions (*Puma concolor*). Animal Conservation 5:317–324.

Hellgren, E. C., and M. R. Vaughan. 1990. Range dynamics of black bears in great dismal swamp, Virginia–North Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 44:268–278.

Hirsch, J. G., L. C. Bender, and J. B. Haufler. 1999. Black bear, *Ursus americanus*, movements and home ranges on Drummond Island, Michigan. Canadian Field-Naturalist 113:221–225.

Hooge, P. N., W. Eichenlaub, and E. Solomon. 1999. The animal movement program. United States Geological Survey Alaska Biological Science Center, Gustavus.

Jonkel, C. J., and I. M. Cowan. 1971. The black bear in the spruce–fir forest. Wildlife Monographs 27:1–57.

Kie, J. G., J. A. Baldwin, and C. J. Evans. 1994. CALHOME: home range analysis program electronic user's manual. United States Forest Service Pacific Northwest Research Station, Gekeler Lane, La Grande, Oregon.

Kjellander, P., A. J. M. Hewison, O. Liberg, J. M. Angibault, E. Bideau, and B. Cargnelutti. 2004. Experimental evidence for density-dependence of home-range size in roe deer (*Capreolus capreolus* L.): a comparison of two long term studies. Oecologia 139:478–485.

Klenner, W. 1987. Seasonal movements and home range utilization patterns of the black bear, *Ursus americanus*, in western Manitoba. Canadian Field-Naturalist 101:558–568.

Koehler, G. M., and D. J. Pierce. 2003. Black bear home range sizes in Washington: climatic, vegetative and social influences. Journal of Mammalogy 84:81–91.

Lariviere, S., and F. Messier. 2001. Space-use patterns by female striped skunks exposed to aggregations of simulated duck nests. Canadian Journal of Zoology 79:1604–1608.

Lindzey, F. G., K. R. Barber, R. D. Peters, and E. C. Meslow. 1986. Responses of a black bear population to a changing environment. International Conference on Bear Research and Management 6:57–63.

Lindzey, F. G., and E. C. Meslow. 1977. Home range and habitat use by black bears in southwestern Washington. Journal of Wildlife Management 41:413–425.

Maehr, D. S., and J. R. Brady. 1984. Food habits of Florida black bears. Journal of Wildlife Management 48:230–235.

Maehr, D. S., T. S. Hoctor, L. J. Quinn, and J. S. Smith. 2001. Black bear habitat management guidelines for Florida. Florida Fish and Wildlife Conservation Commission, Tallahassee, Technical Report 17:1–83.

Maeher, D. S., J. S. Smith, M. W. Cunningham, M. B. Barnwell, J. L. Larkin, and M. A. Orlando. 2003. Spatial characteristics of an isolated Florida black bear population. Southeastern Naturalist 2:433–446.

McCown, W., P. Kubilis, T. Eason, and B. Scheick. 2004. Black bear movements and habitat use relative to roads in Ocala National Forest. Florida Fish and Wildlife Conservation Commission, Tallahassee.

Millspaugh, J. J., and J. M. Marzluff. 2001. Radio tracking and animal populations. Academic Press, Inc., San Diego, California.

Oehler, M. W., R. T. Bowyer, and V. C. Bleich. 2003. Home ranges of female mountain sheep, *Ovis canadensis nelsoni*: effects of precipitation in a desert ecosystem. Mammalia 67:385–401.

Oli, M. K., H. A. Jacobson, and B. D. Leopold. 2002. Pattern of space use by female black bears in the White River National Wildlife Refuge, Arkansas, USA. Journal for Nature Conservation 10:87–93.

Pacas, C. J., and P. C. Paquet. 1994. Analysis of black bear home range using a geographic information system. International Conference on Bear Research and Management 9:419–425.

Pacer Software. 1990. Locate II, version 1.3. Pacer Software, Truro, Nova Scotia, Canada.

Powell, R. A. 1987. Black bear home range overlap in North Carolina and the concept of home range applied to black bears. International Conference on Bear Research and Management 7:235–242.

Powell, R. A., J. W. Zimmerman, and D. E. Seaman. 1997. Ecology and behaviour of North American black bears: home ranges habitat and social organization. Chapman & Hall, London, United Kingdom.

Reynolds, H. V., and J. J. Beecham. 1980. Home range activities and reproduction of black bears in west-central Idaho. International Conference on Bear Research and Management 4:181–190.

Riley, S. P. D., et al. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. Conservation Biology 17:566–576.

Rogers, L. L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildlife Monographs 97:1–72.

Samson, C., and J. Huot. 1998. Movements of female black bears in relation to landscape vegetation type in southern Quebec. Journal of Wildlife Management 62:718–727.

Sandell, M. 1989. The mating tactics and spacing patterns of solitary carnivores. Pp. 164–182 in Carnivore behavior, ecology, and evolution (J. L. Gittleman, ed.). Cornell University Press, Ithaca, New York.

SAS Institute Inc. 1999. SAS/STAT user's guide, version 8. SAS Institute Inc., Cary, North Carolina.

Schenk, A., M. E. Obbard, and K. M. Kovacs. 1998. Genetic relatedness and home-range overlap among female black bears (*Ursus americanus*) in northern Ontario, Canada. Canadian Journal of Zoology 76:1511–1519.

Schooley, R. L. 1994. Annual variation in habitat selection—patterns concealed by pooled data. Journal of Wildlife Management 58:367–374.

Schwartz, C. C., and A. W. Franzmann. 1992. Dispersal and survival of subadult black bears from the Kenai Peninsula, Alaska. Journal of Wildlife Management 56:426–431.

Seaman, D. E., J. J. Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. Journal of Wildlife Management 63:739–747.

Seaman, D. E., and R. A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075–2085.

Slade, N. A., L. A. Russell, and T. J. Doonan. 1997. The impact of supplemental food on movements of prairie voles (*Microtus ochrogaster*). Journal of Mammalogy 78:1149–1155.

Smith, T. R., and M. R. Pelton. 1990. Home ranges and movements of black bears in a bottomland hardwood forest in Arkansas. International Conference on Bear Research and Management 8:213–218.

South, A. 1999. Extrapolating from individual movement behaviour to population spacing patterns in a ranging mammal. Ecological Modelling 117:343–360.

Van Orsdol, K. G., J. P. Hanby, and J. D. Bygott. 1985. Ecological correlates of lion social organization (*Panthera leo*). Journal of the Zoological Society of London 206:97–112.

White, G. C., and R. A. Garrot. 1990. Analysis of wildlife radio-tracking data. Academic Press, Inc., New York.

Willey, C. H. 1974. Aging black bears from first premolar tooth sections. Journal of Wildlife Management 38:97–100.

Wooding, J. B. 1993. Management of the black bear in Florida. Staff report to the commissioners. Florida Game and Fresh Water Fish Commission, Tallahassee.

Wooding, J. B., and T. S. Hardisky. 1994. Home range, habitat use and mortality of black bears in north-central Florida. International Conference on Bear Research and Management 9:349–356.

Young, B. F., and R. L. Ruff. 1982. Population dynamics and movements of black bear in east central Alberta. Journal of Wildlife Management 46:845–860.

Submitted 1 June 2006. Accepted 18 August 2006.

Associate Editor was Floyd W. Weckerly.