

# BLACK BEAR HABITAT USE IN RELATION TO FOOD AVAILABILITY IN THE INTERIOR HIGHLANDS OF ARKANSAS

JOSEPH D. CLARK,<sup>1</sup> Arkansas Game and Fish Commission, #2 Natural Resources Dr., Little Rock, AR 72205 and Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701

DANIEL L. CLAPP,<sup>2</sup> Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701

KIMBERLY G. SMITH, Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701

BELINDA EDERINGTON, Arkansas Game and Fish Commission, #2 Natural Resources Dr., Little Rock, AR 72205

*Abstract:* A black bear (*Ursus americanus*) food value index (FVI) was developed and calculated for forest cover type classifications on Ozark Mountain (White Rock) and Ouachita Mountain (Dry Creek) study areas in western Arkansas. FVIs are estimates of bear food production capabilities of the major forest cover types and were calculated using percent cover, mean fruit production scorings, and the dietary percentage of each major plant food species as variables. Goodness-of-fit analyses were used to determine use of forest cover types by 23 radio-collared female bears. Habitat selection by forest cover type was not detected on White Rock but was detected on Dry Creek. Use of habitats on Dry Creek appeared to be related to food production with the exception of regeneration areas, which were used less than expected but had a high FVI ranking. In general, pine cover types had low FVI rankings and were used less than expected by bears. Forest management implications are discussed.

*Int. Conf. Bear Res. and Manage. 9(1):309-318*

Black bear populations in the eastern United States are much reduced, largely due to land conversion that resulted in habitat loss and fragmentation (Maehr 1984). Schoen (1990) stated that "part of our task in managing bear habitats is to identify what habitats are important to bears and determine the optimal or sometimes minimal habitat mix necessary for maintaining populations at desired or viable population levels." Although food is only one component of an organism's habitat requirements, it is especially important for bears because of their large size and relatively inefficient digestive system (Pritchard and Robbins 1990). It is important to determine what foods are most critical to bears and the forest management practices that produce those foods.

Although a number of habitat use studies have been conducted on black bears in North America (Beeman and Pelton 1977, Warburton 1984, Brody and Pelton 1989, Unsworth et al. 1989, Hellgren et al. 1991), few studies have attempted to link habitat use with food availability (Kansas and Raine 1990, Noyce and Coy 1990). It is not only important to determine the habitats that are selected for by bears, but it is perhaps more important to determine why those habitats are selected. The objective of this study was to quantify food production and relative value associated with a variety of silvicultural practices and forest cover types and compare that to black bear habitat use for 2 study

areas in the Interior Highlands of Arkansas.

This study was funded under provisions of the Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act), administered by the Arkansas Game and Fish Commission. Additional funding was provided by the Ozark National Forest (NF), the Arkansas Cooperative Fish and Wildlife Research Unit, and Environmental Systems Company, Inc. C.J. Amlaner, P.S. Gipson, M.R. Pelton, and T.B. Wigley provided advice on study design and, along with D.L. Garshelis, R.L. Kirkpatrick, and T.E. Martin, helped edit earlier manuscripts. Special thanks go to graduate student S.G. Hayes and a number of technicians for their assistance in the field. Appreciation is also extended to W.F. Limp, J.A. Farley, and J.J. Lockhart from the Arkansas Archaeological Survey for their valuable assistance in using the Geographic Information System (GIS).

## STUDY AREAS

Bears were reintroduced into each of the Ozark Mountain and Ouachita Mountain physiographic regions of Arkansas in the 1950s and 1960s and the resulting bear populations remain allopatric, being separated by the Arkansas River Valley and Interstate Highway 40 (Smith et al. 1991). Therefore, 2 areas were selected for study: the White Rock area, located in the Ozark

<sup>1</sup> Present address: Cooperative Park Studies Unit, National Biological Survey, 274 Ellington Plant Sciences Building, Department of Forestry, Wildlife, and Fisheries, University of Tennessee, Knoxville, TN 37901-1071.

<sup>2</sup> Present address: 1 McDougall Street, Kittery, ME 03904.

Mountain region, and the Dry Creek area, in the Ouachita Mountain region.

White Rock (414 km<sup>2</sup>) is part of the Ozark National Forest and was one of the original bear release sites. The area is characterized by flat-topped mountains and ridges separated by narrow valleys and fast-flowing streams. Dominant tree species include white oak (*Quercus alba*), northern red oak (*Q. rubra*), black oak (*Q. velutina*), and mockernut hickory (*Carya tomentosa*) on north-facing slopes, and shortleaf pine (*Pinus echinata*) and blackjack oak (*Q. marilandica*) on south-facing slopes. Eighty-three percent of the forested area on White Rock is comprised of upland hardwood forest and the remainder is in shortleaf pine types. White Rock lies in the Boston Mountains natural division between the Springfield Plateau to the north and the Arkansas River Valley to the south.

The Dry Creek study area (518 km<sup>2</sup>) is located in the Ouachita National Forest and has similar vegetative characteristics to White Rock except that a higher proportion of the area is in pine forest types (68%). Bears were reintroduced approximately 35 km south of Dry Creek. The Ouachita Mountains are bounded by the Arkansas River Valley to the north and the Gulf Coastal Plain to the south.

## MATERIALS AND METHODS

### Food Production

*Soft Mast.*—Relative fruit production of 20 species of the most common soft mast foods were assessed on the Dry Creek and White Rock study areas to monitor yearly trends in fruit productivity. When fruits began ripening, 50 individual plants of each species were scored according to fruit abundance with the following scale: 0 = almost no fruit, 1 = below average fruit production, 2 = average fruit production, 3 = above average fruit production, and 4 = bumper crop (Noyce and Coy 1990). Plants were scored during the interval when fruits had matured and had begun to ripen until ripened fruits had begun to fall.

We sampled plants both within the forest stand and along road edges, because shade-intolerant species along forest edges tend to have higher production than within the forest. Blackberry (*Rubus* spp.) and pokeweed (*Phytolacca americana*) were scored solely along forest edges and in regeneration areas because of their limited abundance within the forest stand. Plants were sampled within a variety of forest types with no more than 10 individuals scored in any 1 particular stand.

*Hard Mast.*—Production of hard mast (i.e., acorns and hickory nuts) was assessed during fall when fruits were fully matured. Mast production was monitored on approximately 50 individuals each of 6 species of oaks (white oak, post oak [*Q. stellata*], black oak, northern red oak, southern red oak [*Q. falcata*], and blackjack oak) and 2 species of hickories (shagbark [*Carya ovata*] and mockernut). Trees were scored by ocularly estimating the percentage of the total live crown that had acorns and the percent number of twigs that were bearing acorns. Percentages were then assigned to categories: 0 (0-5%), 1 (6-33%), 2 (34-66%), or 3 (67-100%) (Whitehead 1980; R. Fowler, unpubl. rep., Ark. Game and Fish Comm.). Average number of acorns per twig also was estimated and assigned to the following categories: 0 (0 acorns), 1 (1-2 acorns), 2 (3-4 acorns), 3 (5-6 acorns), or 4 ( $\geq 7$  acorns).

Mast indices were calculated in both study areas for each individual species, for all 6 oaks combined, and for both hickories combined. Numbers of trees in each category were multiplied by that category number, the total quantity was summed, and then that was divided by the total number of trees sampled (Whitehead 1980).

*Abundance of Important Bear Food Plants.*—The abundance of major bear-food plants was quantified during summer through vegetation analysis within major forest types. Based on percent total acreage within each study area, 12 of the most common forest types were selected for sampling; 5 different stands within each forest type were sampled. All stands were randomly selected and represented a variety of aspects and elevations.

Forest stands to be sampled were located on USGS quadrangle maps and observers paced to the center of each stand. Parallel transects, 150 m in length and separated by 50 m, were oriented parallel to the slope in the middle of each stand, which allowed sampling at varying elevations. Each transect contained five 10- by 10-m plots (Hays et al. 1981), spaced at 25-m intervals along the outside of each transect for a total of 600 plots on each study area.

All bear-food plants large enough to produce fruit were assessed. Cover codes representing the percentage of the plot each species covered, 1 (0-5%), 2 (6-25%), 3 (26-50%), 4 (51-75%), 5 (76-95%), 6 (>95%), were assigned to each species within the plot and to those originating outside the plot that had vegetative structures within the plot.

*Food Value Ranking of Forest Types.*—Food value ranking of forest types to black bears at the White Rock and Dry Creek areas was determined by season according to use and availability of soft and hard mast

food items. A food value index (FVI), similar in principal to a method developed by Kansas and Raine (1990), was calculated for each forest type each season at both study areas by multiplying average percent cover, mean fruit production ranks, and average frequency of occurrence in scats (Clapp 1990) of major seasonal plant food items. Products were then summed to derive the FVI for each forest type. Thus, this index incorporates abundance of food plants, a measure of yearly fruit production, and a measure of the relative frequency of the food items in bear diets. FVIs were then ranked in descending order from highest to lowest to estimate the relative food value of each forest type to bears on each area.

### Trapping and Handling

Black bears were trapped on the 2 study areas with spring-activated foot snares and, to a lesser extent, barrel traps. Rugged topography and limited access precluded strictly random placement of traps; the objective of trap placement was to obtain complete coverage of the areas, avoiding any large gaps in the sampling pattern. The majority of trap locations were along ridgetops and were within 150 m of a road.

Bears were tranquilized with a 2:1 mixture of ketamine hydrochloride (Ketaset, Bristol Lab., Syracuse, N.Y.) and xylazine hydrochloride (Rompun, Haver-Lockhart, Inc., Shawnee, Kans.) (200 mg xylazine hydrochloride, 400 mg ketamine hydrochloride/kg) administered with a jab stick (Clark 1991). Adult female bears were fitted with MOD-500 radio collars (Telonics Inc., Mesa, Ariz.). Bears were selected for radiotagging regardless of their location within study areas to avoid biases by habitat type.

### Radiotelemetry

Locations of radio-tagged bears were determined by triangulation techniques from the ground with cartop 5-element Yagi antennas (Wildlife Materials, Inc., Carbondale, Ill.) using the loudest signal method (Springer 1979, Mech 1983). Rugged terrain and large home ranges of radio-collared animals precluded use of permanent radio towers.

Azimuths were plotted on 1:24,000 U.S. Geological Survey (USGS) quadrangle maps until 3 were obtained that formed a triangle approximately  $\leq 0.13$  km<sup>2</sup> in size. Locations not meeting those criteria or those formed when the time interval between first and last azimuths exceeded 50 min were rejected. This procedure helped identify azimuths that were severely affected by signal bounce or when significant animal movements occurred (Schmutz and White 1990).

Fixed-wing aircraft were occasionally used to find bears whose radio signals could not be located by ground radiotracking.

Universal Transverse Mercator (UTM) coordinates of the observer, azimuth, and time of day (Central Standard Time) were recorded for each bearing. Azimuths and observer coordinates were converted to animal location coordinates with the microcomputer software package TELEM (Coleman and Jones 1986). The location was the arithmetic mean of the triangle formed by the 3 azimuths. Individual bears were located approximately every 20 hrs. The relatively constant time frame provided locations that presumably would minimize sampling bias (Dunn and Gipson 1977) and serial correlation and would result in locations throughout the diel period. Radiolocations were obtained from May through November 1988. Serial correlation among radiolocations was tested with methods of Swihart and Slade (1985a, 1985b, 1986) with microcomputer program HOME RANGE (Ackerman et al. 1990).

### Habitat-Use Analysis

Habitat characteristics of bear radiolocations were determined from a digital database developed with the Geographic Resources Analysis and Support System (GRASS 3.0), a GIS developed by the Army Corps of Engineers (Const. Eng. Res. Lab., Champaign, Ill.). GRASS allows the creation, manipulation, and analysis of various data layers such as site data (e.g., radiolocations), cell files (e.g., forest cover types), and vector files (e.g., roads).

Forest cover type data were obtained in the form of detailed coded maps and corresponding computer printouts of stand data from the U.S. Department of Agriculture (USDA) Forest Service as developed through their Continuous Inventory of Stand Condition (CISC) management system (U.S. For. Ser. 1981). Those data were digitized into GRASS from 1:24,000 USGS quadrangles using a cell grid density of 10 m (10- by 10-m cells). The resultant map could then be manipulated and reclassified according to condition class, cover type, and various combinations or groupings of stand characteristics. Condition class rather than stand age was chosen because differences in soil quality can result in dramatic differences in vegetative characteristics in stands of the same age. Some cover types that occurred with low frequency were reclassified into a miscellaneous category so that cell counts would be valid for goodness-of-fit analyses (Dixon and Massey 1969). UTM coordinates of trapsites and radiolocations were formatted and

uploaded into GRASS.

Chi-square goodness-of-fit tests were used to determine whether differences existed between expected usage based on availability and observed frequency of usage by female bears according to forest cover type classification. When habitat selection was detected ( $P < 0.05$ ), Bonferroni confidence intervals were determined for observed frequencies (Neu et al. 1974, Byers et al. 1984). If expected frequencies were outside that confidence interval, then that habitat type was considered to be used greater than or less than expected. Categories were pooled so that at least 1 observation was expected in each and no more than 20% of the categories contain  $<5$  expected observations (Dixon and Massey 1969). Locations of all individual bears were pooled to increase sample sizes (Allredge and Ratti 1986). Seasonal feeding periods were delineated based on major dietary shifts: early summer soft mast (4 Jun to 30 Jun), late summer soft mast (31 Jun to 27 Sep), and fall soft and hard mast (28 Sep to 1 Dec) (Clapp 1990).

To test the hypothesis that bears spent an inordinate amount of time in protective cover adjacent to regeneration areas (primarily clearcuts) between foraging periods, or as an avoidance response to our activities while radiotracking, an analysis was performed to determine if numbers of locations along the periphery of regeneration areas were greater than expected. A map was generated characterizing areas of habitat within proximity zones of specified 200-m widths adjacent to regeneration areas with the "distance" tool within GRASS. Chi-square goodness-of-fit analyses were similarly performed to determine whether use was nonrandom and whether certain width categories were used less than or greater than expected.

Black bears are a wide-ranging species and must be evaluated on a landscape scale (Schoen 1990); therefore, we wanted to determine bear habitat use for relatively large geographic areas in and around USDA Forest Service landholdings. To establish study area boundaries that were most consistent with that national forest-wide objective, trapline locations were used as fundamental units for defining study area dimensions. We wanted to assess habitat use on a wide scale and include areas that might not be selected by bears, not just those within home ranges of females we radiotagged. Arcs with the radius of the average home-range size of adult females (estimated with the 95% harmonic mean method) were circumscribed around each trapline to create a peripheral boundary for each study area (Clark 1991). Expected values for habitat availability were based on those peripheral boundaries.

### Triangulation Error Analysis

The power of chi-square goodness-of-fit tests to detect habitat selection is decreased by increasing habitat complexity, decreasing precision of triangulation bearings, and decreasing sampling effort (White and Garrott 1986, Nams 1989). Test collars were placed throughout both study areas in topographic positions and distances from the observer consistent with typical bear radiolocations. Those test collars were then located using procedures described above and distance from the true location to the calculated location was determined to estimate an error distribution (Schmutz and White 1990). A set of simulated coordinates was generated at uniform random azimuths from the original radiotelemetry coordinates based on the distribution of distances test collars were from triangulated locations. Goodness-of-fit analyses were repeated for the simulated data set and a new chi-square value and the percentage that it differed from the original chi-square value was calculated. This enabled us to obtain an indirect measure of effects of triangulation error on the power of the statistical tests to detect habitat selection for the various map layers.

Large telemetry errors relative to the habitat mosaic will result in trends toward random scatter in locations, i.e., no habitat selection and a chi-square value approaching 0. A large change in chi-square from the original to the simulated data set would indicate relatively weak statistical power.

In addition, the percentage of error-generated locations classified differently from the original set of locations is given (White and Garrott 1986). The values are given as descriptive statistics to show the relative effects that telemetry error, habitat patchiness, or sample size may have on the analysis.

## RESULTS AND DISCUSSION

Eleven female bears  $\geq 2$  years of age captured on White Rock were radiocollared and 12 were collared on Dry Creek. Serial correlation among radiolocations was detected for most radio-tagged bears ( $P < 0.05$ ). Powell (1987) suggested that all movements by a bear depend on past experiences and that no 2 telemetry locations are ever truly independent, even though they may not appear statistically correlated. Adult female bears on the 2 study areas moved a distance equivalent to the mean home-range diameter (6.7 km) in an average of about 16 hrs (Clark 1991). Thus, we considered locations  $\geq 16$  hrs to be independent because that time should be sufficient for a bear to traverse its home range, even though it might not choose to do so.

A total of 1,664 radiolocations remained (676 on White Rock and 988 on Dry Creek) after excluding locations of individual bears <16 hours apart. The standard deviation of the number of radiolocations of individual females was relatively low ( $\bar{x} = 79.5$ ,  $SD = 26.32$ ) and, consequently, radiolocations were pooled for habitat analyses.

One hundred twenty-seven locations were obtained on test collars. Ninety percent of the estimated locations were within 444 m of the actual location of the test collar and 50% were within 159 m. The error estimate of 401 m corresponds with Springer's (1979) 86% error polygon formed when 3 arcs intersect, each with a 95% confidence limit. The resultant area surrounding each location is 0.51 km<sup>2</sup>, the area with an 86% probability of containing the animal.

During early summer on White Rock, when pokeweed berries, blackberry, and blueberry (*Vaccinium* spp.) constituted a major portion of bear diets (Clapp 1990), white oak–red oak–hickory and shortleaf pine regeneration areas had highest FVI values (Table 1). During late summer, when bears consumed mostly pokeweed berries, black cherry (*Prunus serotina*), blackberry, and blueberry, white oak–red oak–hickory regeneration areas had the highest FVI values. Fruits of pokeweed, Carolina buckthorn (*Rhamnus caroliniana*), devil's walkingstick (*Aralia spinosa*), spicebush (*Lindera benzoin*), and greenbriar (*Smilax* spp.) were the most important soft mast items in fall diets; white oak–red oak–hickory and shortleaf pine seedling and sapling stands had highest FVI values during fall on White Rock. White oak–red oak–hickory mature and immature sawtimber stands ranked highest in hard mast production during fall.

On Dry Creek, white oak–red oak–hickory immature poletimber and sawtimber stands scored highest during early summer whereas shortleaf pine regeneration areas had highest FVI values during late summer (Table 2). During fall, white oak–red oak–hickory immature sawtimber stands ranked highest in soft mast food production followed by shortleaf pine regeneration areas, whereas white oak–red oak–hickory low quality poletimber stands and shortleaf pine–oak mature sawtimber stands were highest in hard mast production.

Selection by forest cover types was not detected on the White Rock study area during early summer ( $\chi^2 = 7.5$ , 5 df,  $P = 0.18$ ) or fall ( $\chi^2 = 16.6$ , 12 df,  $P = 0.16$ ) but nonrandom use was detected during late summer ( $\chi^2 = 42.3$ , 12 df,  $P < 0.0001$ ). However, when the simulated data set incorporating triangulation error was similarly analyzed for late summer on White Rock, the chi-square value fell 53.5% (Table 3) to

**Table 1.** Food value indices (FVIs) for soft mast species during early summer and late summer and soft and hard mast species during fall on the White Rock study area.

Forest cover type	Percent occurrence	Early summer FVI	Late summer FVI	Fall FVI	
				Soft	Hard
WO-RO-H, Immature sawtimber <sup>a</sup>	33.0	103	105	53	16,708
WO-RO-H, Immature poletimber	29.2	150	154	29	14,710
WO-RO-H, Low quality poletimber	5.4	328	351	170	14,709
WO-RO-H, Mature sawtimber	5.0	159	162	167	17,346
SP, Immature sawtimber	4.8	76	76	36	11,386
SP, Seedling and sapling	4.6	461	574	507	8,486
SP, Immature poletimber	3.3	228	214	102	6,451
WO-RO-H, In regeneration	2.4	1,293	1,839	467	711
WO-RO-H, Seedling and sapling	2.1	338	344	526	11,482
SP, Mature sawtimber	1.8	242	253	43	12,904
WO, Immature poletimber	1.7	330	326	36	12,884
SP, In regeneration	1.1	506	621	53	2,489

<sup>a</sup> SP: shortleaf pine, WO-RO-H: white oak–red oak–hickory, WO: white oak.

19.71 which was not different from random use ( $P > 0.05$ ). The forest cover type may have been too heterogeneous relative to the sample size of telemetry locations as evidenced by the relatively high proportion of misclassified locations and the large changes in the chi-square value with the simulated data set relative to the Dry Creek data (Table 3). Therefore, further habitat analyses for White Rock were not performed.

In contrast, cover type selection was detected on the Dry Creek study area during early summer ( $\chi^2 = 148.0$ , 10 df,  $P < 0.0001$ ), late summer ( $\chi^2 = 346.4$ , 10 df,  $P < 0.0001$ ), and fall ( $\chi^2 = 145.1$ , 10 df,  $P < 0.0001$ ). The misclassification rate and the change in the chi-square value with the analysis of a simulated data set incorporating triangulation error on Dry Creek was much smaller than that for White Rock (Table 3)

**Table 2. Food value indices (FVIs) for soft mast species during early summer and late summer and soft and hard mast species during fall on the Dry Creek study area.**

Forest cover type	Percent occurrence	Early	Late	Fall FVI	
		summer FVI	summer FVI	Soft	Hard
SP, Immature sawtimber <sup>a</sup>	24.0	330	222	185	4,109
SP, Mature sawtimber	15.6	1,120	37	39	5,640
SP, Seedling and sapling	11.7	1,177	130	134	2,965
SP, Immature poletimber	8.6	1,080	74	62	5,808
WO-RO-H, Immature poletimber	8.3	2,023	240	383	7,429
SP, In regeneration	7.2	1,639	1,201	496	4,056
WO-RO-H, Immature sawtimber	6.6	2,580	960	572	7,393
SP-O, Immature sawtimber	3.8	1,076	37	179	7,216
WO-RO-H, Low quality poletimber	1.6	1,832	517	407	8,992
SP-O, Mature sawtimber	1.2	896	480	136	8,129

<sup>a</sup> SP: shortleaf pine, WO-RO-H: white oak-red oak-hickory, SP-O: shortleaf pine-oak.

and the Bonferroni analyses (Neu et al. 1974, Byers et al. 1984) produced minimal changes in those classes shown to be used greater than or less than expected (Tables 4, 5, and 6).

During early summer on Dry Creek, regeneration areas, immature sawtimber, and mature sawtimber stands of shortleaf pine, as well as immature and mature sawtimber stands of shortleaf pine-oak were used by bears less than expected and immature poletimber stands of white oak-red oak-hickory were used greater than expected (Table 4). During late summer, all shortleaf pine forest types were used less than expected (Table 5) whereas immature poletimber stands of white oak-red oak-hickory were used greater than expected. During fall, immature poletimber and immature sawtimber stands of white oak-red oak-hickory types were used greater than expected and shortleaf pine regeneration areas, immature poletimber, and immature sawtimber stands were used less than expected (Table 6).

Generally, black bear habitat use appeared to relate to soft mast food production as measured with FVIs on

Dry Creek with the exception of pine regeneration areas (Tables 4, 5, and 6). Forest cover types that were used greater than expected ranked high in soft mast production, whereas those used by bears less than expected generally ranked low. Regeneration areas were an exception, however, being used less than expected during all seasons even though the soft mast FVIs were ranked fourth, first, and second during early summer, late summer, and fall, respectively. Bears on Dry Creek spent more time than expected in pole-sized white oak-red oak-hickory stands during summer where blueberry production was particularly high (Clapp 1990). Habitat use during fall also appeared to be related to hard mast FVIs, with habitats being used greater than expected ranking third and fourth and habitats used less than expected ranking sixth, eighth, and ninth.

Significant selection for habitats according to distance from regeneration areas existed on Dry Creek during early summer, late summer, and fall (Table 3). Bears on Dry Creek generally used habitats near regeneration areas less than expected, and used habitats distant from regeneration areas greater than expected during all seasons but especially during late summer (Table 7).

Even though food value rankings were high, the non-use of pine and hardwood regeneration areas during summer is in contrast to a similar analysis of black bear habitat use in North Carolina (Brody 1984) where clearcuts were used greater than expected during summer by both sexes. The non-use of regeneration areas may be related to the low use of all pine cover types rather than to any particular silvicultural technique, because clearcuts are more prevalent with shorter rotation length pine management. However, exclusion of female bears from the most productive habitats by males has been reported (Jonkel and Cowan 1971, Garshelis and Pelton 1981, Rogers 1987, R.B. Wielgus, Univ. British Columbia, unpubl. data). If foraging in clearcuts is mostly by males in the Interior Highlands, that could explain the significant amount of feeding sign we observed in those areas but relatively low numbers of radiolocations of females there.

Fall foods, particularly acorns, are thought to be critical to prepare bears for the rigors of winter denning and production of young (Rogers 1976, Beeman and Pelton 1977, Willey 1978, Eagle and Pelton 1983, Clark et al. 1987). Pelton (1989) referred to this period of hyperphagy as the driving force behind the population dynamics of the species. That is further substantiated here in that habitat use during fall appears to be strongly motivated by availability of hard mast.

**Table 3.** The percentage of locations that were classified incorrectly (PCI) and the percent change in chi square from the simulated data sets (PCCS) from goodness-of-fit analyses of female black bears on the White Rock and Dry Creek study areas, 1988.

	White Rock				Dry Creek			
	Chi-square	P	PCI	PCCS	Chi-square	P	PCI	PCCS
Forest cover								
early summer	7.5	0.1845	7.1	24.9+ <sup>a</sup>	148.0	<0.0001	2.2	3.0+
late summer	42.3	<0.0001	9.1	53.5- <sup>b</sup>	346.4	<0.0001	4.5	12.7-
fall	16.6	0.1635	4.7	38.2+	145.1	<0.0001	6.2	1.8-
Distance from regeneration areas								
early summer					67.7	<0.0001	11.8	6.6-
late summer					168.9	<0.0001	3.9	8.2-
fall					52.9	<0.0001	7.6	21.5+

<sup>a</sup> Simulated chi-square > original value.

<sup>b</sup> Simulated chi-square < original value.

**Table 4.** Availability and use (%) of forest cover types during early summer by 10 female black bears, a similar analysis of a simulated data set incorporating triangulation error, and associated FVI rankings (soft mast) on the Dry Creek study area (*n* = 142).

Forest cover type	FVI rank soft mast	Random availability	Actual data	Simulated data
			Use	Use
WO-RO-H, Immature sawtimber <sup>a</sup>	1	6.6	9.0	9.8
WO-RO-H, Immature poletimber	2	8.3	29.9+ <sup>b</sup>	29.3+
WO-RO-H, Low quality poletimber	3	1.6	3.0	6.0
SP, In regeneration	4	7.2	0.2-	1.5-
SP, Seedling and sapling	5	11.7	8.2	8.3
SP, Mature sawtimber	6	15.6	3.0-	1.0-
SP, Immature poletimber	7	8.6	6.7	6.8
SP-O, Immature sawtimber	8	3.8	0.0-	1.5
SP-O, Mature sawtimber	9	1.2	0.0-	0.0-
SP, Immature sawtimber	10	24.0	10.4-	5.2-

<sup>a</sup> SP: shortleaf pine, WO-RO-H: white oak-red oak-hickory, SP-O: shortleaf pine-oak.

<sup>b</sup> + = use > availability and - = use < availability (*P* < 0.05).

### MANAGEMENT IMPLICATIONS

Habitat use by radio-tagged females appeared to be strongly motivated by food as evidenced by the correspondence between habitats used greater than or less than expected and their FVI rankings. It is not surprising that the fit was not better given the coarseness of the evaluation method, telemetry triangulation error, and because bears engage in activities other than foraging. It is apparent, however, that white oak-red oak-hickory stands of immature poletimber and sawtimber had great food value and were heavily used by bears even though those habitats comprised only 15% of the Dry Creek area. The eastern portion of the study area had the largest, most contiguous stands of those forest types and home-range overlap of that area was extensive, with 8 of 12 and 10 of 12 female home ranges containing those stands during 1988 and 1989, respectively (Clark 1991). Poletimber and immature sawtimber stands of white oak-red oak-hickory are not common on Dry Creek and are less common to the Ouachita Mountain region as a whole. Bear populations exist at low densities in the Ouachita Mountains where those hardwood forest types are absent (J. Clark, unpubl. rep., Ark. Game and Fish Comm.).

FVIs were higher on Dry Creek than White Rock during early summer, largely due to a bumper blueberry crop during 1988, and FVIs were larger on White Rock during fall. White oak-red oak-hickory forest types are much more extensive and widely distributed on White Rock than Dry Creek. Besides a more heterogeneous habitat mosaic contributing to a

**Table 5. Availability and use (%) of forest cover types during late summer by 12 female black bears, a similar analysis of a simulated data set incorporating triangulation error, and associated FVI rankings (soft mast) on the Dry Creek study area ( $n = 430$ ).**

Forest cover type	FVI rank soft mast	Random availability	Actual data	Simulated data
			Use	Use
SP, In regeneration <sup>a</sup>	1	7.2	3.1 <sup>-b</sup>	2.9-
WO-RO-H, Immature sawtimber	2	6.6	4.1	4.6
WO-RO-H, Low quality poletimber	3	1.6	3.1	2.6
SP-O, Mature sawtimber	4	1.2	0.5	0.2-
WO-RO-H, Immature poletimber	5	8.3	29.4+	27.3+
SP, Immature sawtimber	6	24.0	12.2-	12.0-
SP, Seedling and sapling	7	11.7	7.4-	6.2-
SP, Immature poletimber	8	8.6	4.8-	6.2
SP-O, Immature sawtimber	9	3.8	4.5	4.6
SP, Mature sawtimber	10	15.6	8.6-	10.3-

<sup>a</sup> SP: shortleaf pine, WO-RO-H: white oak-red oak-hickory, SP-O: shortleaf pine-oak.

<sup>b</sup> + = use > availability and - = use < availability ( $P < 0.05$ ).

reduction in power of the goodness-of-fit test to detect selection, habitat selection forces may not be as strong on White Rock where food resources are less patchy compared to Dry Creek.

The most striking example of noncorrespondence between FVIs and habitat use by bears was the low summer use of shortleaf pine regeneration areas, where FVIs were high. Likewise, proximity analyses failed to detect higher than expected use near those regeneration areas. Most of those areas were associated with intensive pine management in the western portion of the study area and the non-use of clearcuts may have been related to the general non-use of all pine cover types. Nevertheless, soft mast production in regeneration areas was high and efforts to increase cover in those areas (e.g., stream buffer strips, islands of standing timber, irregular boundaries, a reduction in size) could increase their value to bears. Seed tree or shelterwood regeneration methods would make those areas more accessible to females with cubs; the standing trees would provide avenues of escape for the young.

This noncorrespondence between FVIs and bear habitat use in regeneration areas may be the most

**Table 6. Availability and use (%) of forest cover types during fall by 11 female black bears, a similar analysis of a simulated data set incorporating triangulation error, and associated FVI rankings (soft and hard mast) on the Dry Creek study area ( $n = 416$ ).**

Forest cover type	FVI rank			Actual data	Simulated data
	Soft mast	Hard mast	Random availability	Use	Use
	WO-RO-H, Immature sawtimber <sup>a</sup>	1	4	6.6	12.7+ <sup>b</sup>
SP, In regeneration	2	9	7.2	2.2-	1.5-
WO-RO-H, Low quality poletimber	3	1	1.6	4.4	6.0
WO-RO-H, Immature poletimber	4	3	8.3	17.3+	29.3+
SP, Immature sawtimber	5	8	24.0	13.2-	5.2-
SP-O, Immature sawtimber	6	5	3.8	3.4	1.5
SP-O, Mature sawtimber	7	2	1.2	0.7	0.0-
SP, Seedling and sapling	8	10	11.7	9.8	8.3
SP, Immature poletimber	9	6	8.6	4.1-	6.8
SP, Mature sawtimber	10	7	15.6	14.8	1.0-

<sup>a</sup> SP: shortleaf pine, WO-RO-H: white oak-red oak-hickory, SP-O: shortleaf pine-oak.

<sup>b</sup> + = use > availability and - = use < availability ( $P < 0.05$ ).

important management implication of this study. It should be pointed out that the FVIs and bear habitat use for most forest types are not completely independent. Foraging represents a large proportion of habitat use and the FVI includes the result of this foraging (food residues) in its calculation. Therefore, when noncorrespondence occurs, there is evidence that strong pressures are influencing its (non-)use, despite the presence of rich food resources.

Coping with increasing pressures on a finite resource base represents, perhaps, the greatest challenge to bear managers. A better understanding of the habitat needs of bears, particularly food resources, will enable managers to make informed decisions regarding land-use changes. Our technique is admittedly coarse, does not account for insects, other animal matter, or graminoids in bear diets, and was evaluated during only 1 field season. However, the method allowed us to objectively assess the value of a variety of forest cover

**Table 7. Availability and use (%) of distance categories from regeneration areas during summer by female black bears on the Dry Creek study area. Sample sizes were 136, 413, and 403 during early summer, late summer, and fall, respectively.**

Distance category	Random availability	Early summer use		Late summer use		Fall use	
		Actual	Simulated	Actual	Simulated	Actual	Simulated
0-200 m	15.1	5.1 <sup>a</sup>	5.9-	8.5-	9.2-	8.4-	8.3-
200-400 m	12.6	6.6	5.1-	7.7-	7.7-	8.2-	8.3-
400-600 m	14.8	5.1-	7.4-	10.7	10.6	13.4	11.4
600-800 m	12.3	9.6	8.8	7.0-	6.7-	12.2	9.1
800-1,000 m	11.3	16.9	13.2	7.5-	8.4	10.7	14.3
1,000-1,200 m	8.4	5.9	11.8	8.2	8.4	11.2	13.2
1,200-1,400 m	7.1	14.7	11.0	10.2	8.7	9.9	9.9
1,400-1,600 m	5.7	8.1	8.8	9.9	11.6+	7.9	8.1
1,600-1,800 m	4.4	7.3	5.9	11.4+	11.1+	6.7	6.5
1,800-2,000 m	3.1	8.1	10.3	9.2+	8.4+	6.7+	6.5
2,000-3,000 m	5.1	12.5	11.8	9.7+	9.2	4.7	4.4

<sup>a</sup> + = use > availability and - = use < availability ( $P < 0.05$ ).

types to bears for food and greatly added to our understanding of the use/availability analyses.

## LITERATURE CITED

- ACKERMAN, B.B., F.A. LEBAN, M.D. SAMUEL, AND E.O. GARTON. 1990. User's manual for program home range. For. Wildl. and Range Expt. Sta. Tech. Rept. 15. Univ. Idaho, Moscow. 79pp.
- ALLDREDGE, J.R., AND J.T. RATTI. 1986. Comparison of some statistical techniques for analysis of resource selection. *J. Wildl. Manage.* 50:157-165.
- BEEMAN, L.E., AND M.R. PELTON. 1977. Seasonal foods and feeding ecology of black bears in the Smoky Mountains. *Int. Conf. Bear Res. and Manage.* 3:141-147.
- BRODY, A.J. 1984. Habitat use by black bears in relation to forest management in Pisgah National Forest, North Carolina. M.S. Thesis, Univ. Tenn., Knoxville. 123pp.
- \_\_\_\_\_, AND M.R. PELTON. 1989. Effects of roads on black bear movements in western North Carolina. *Wildl. Soc. Bull.* 17:5-10.
- BYERS, C.R., R.K. STEINHORST, AND P.R. KRAUSMAN. 1984. Clarification of a technique for analysis of utilization-availability data. *J. Wildl. Manage.* 48:1050-1053.
- CLAPP, D.L. 1990. Availability and consumption of foods and importance of habitats used by black bears in Arkansas. M.S. Thesis, Univ. Arkansas, Fayetteville. 119pp.
- CLARK, J.D. 1991. Ecology of two black bear populations (*Ursus americanus*) in the Interior Highlands of Arkansas. Ph.D. Diss., Univ. Arkansas, Fayetteville. 228pp.
- \_\_\_\_\_, W. R. GUTHRIE, AND W. B. OWEN. 1987. Fall foods of black bears in Arkansas. *Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies* 41:432-437.
- COLEMAN, J.S., AND A.B. JONES, III. 1986. Users guide to TELEM: Computer analysis system for radio-telemetry data. Dep. Fish. and Wildl., Virginia Polytech. Inst. and State Univ., Blacksburg. 96pp.
- DIXON, W.J., AND F.J. MASSEY. 1969. Introduction to statistical analysis. McGraw-Hill, New York, N.Y. 638pp.
- DUNN, J.E., AND P.S. GIPSON. 1977. Analyses of radio telemetry data in studies of home range. *Biometrics* 33:85-101.
- EAGLE, T.C., AND M.R. PELTON. 1983. Seasonal nutrition of black bears in the Great Smoky Mountains National Park. *Int. Conf. Bear Res. and Manage.* 5:94-101.
- GARSHELIS, D.L., AND M.R. PELTON. 1981. Movements of black bears in the Great Smoky Mountains National Park. *J. Wildl. Manage.* 45:912-925.
- HAYS, R.L., C. SUMMERS, AND W. SEITZ. 1981. Estimating wildlife habitat variables. U.S. Fish and Wildl. Serv. FWS/OBS-81/47. 111pp.
- HELLGREN, E.C., M.R. VAUGHAN, AND D.R. STAUFFER. 1991. Macrohabitat use by black bears in a southeastern wetland. *J. Wildl. Manage.* 55:442-448.
- JONKEL, C.J., AND I.M. COWAN. 1971. The black bear in the spruce-fir forest. *Wildl. Monogr.* 27. 57pp.
- KANSAS, J.L., AND R.M. RAINE. 1990. Methodologies used

- to assess the relative importance of ecological land classification units to black bears in Banff National Park, Alberta. *Int. Conf. Bear Res. and Manage.* 8:155-160.
- MAEHR, D. 1984. Distribution of black bears in eastern North America. *East. Workshop Black Bear Res. and Manage.* 7:74.
- MECH, L.D. 1983. *Handbook of radio-tracking.* Univ. Minn. Press, Minneapolis. 108pp.
- NAMS, V.O. 1989. Effects of radiotelemetry error on sample size and bias when testing for habitat selection. *Can. J. Zool.* 69:1631-1636.
- NEU, C.W., C.R. BYERS, AND J.M. PEEK. 1974. A technique for analysis of utilization-availability data. *J. Wildl. Manage.* 38:541-545.
- NOYCE, K.V., AND P.L. COY. 1990. Abundance and productivity of bear food species in different forest types of northcentral Minnesota. *Int. Conf. Bear Res. and Manage.* 8:169-181.
- PELTON, M.R. 1989. The impacts of oak mast on black bears in the Southern Appalachians. Pages 7-11 in C.E. McGee, ed. *Proc. Workshop on South. Appalachian Mast Manage.* Univ. Tennessee, Knoxville.
- POWELL, R.A. 1987. Black bear home range overlap in North Carolina and the concept of home range applied to black bears. *Int. Conf. Bear Res. and Manage.* 7:235-242.
- PRITCHARD, G.T., AND C.T. ROBBINS. 1990. Digestive and metabolic efficiencies of grizzly and black bears. *Can. J. Zool.* 68:1645-1651.
- ROGERS, L.L. 1976. Effects of mast and berry crop failures on survival, growth and reproductive success of black bears. *Trans. North Am. Wildl. and Nat. Resour. Conf.* 41:431-438.
- \_\_\_\_\_. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. *Wildl. Monogr.* 97. 72pp.
- SCHOEN, J.W. 1990. Bear habitat management: a review and future perspective. *Int. Conf. Bear Res. and Manage.* 8:143-154.
- SCHMUTZ, J.A., AND G.C. WHITE. 1990. Error in telemetry studies: effects of animal movement on triangulation. *J. Wildl. Manage.* 54:506-510.
- SMITH, K.G., J.D. CLARK, AND P.S. GIPSON. 1991. History of black bears in Arkansas: over-exploitation, near elimination, and successful reintroduction. *East. Workshop Black Bear Res. and Manage.* 10:3-8.
- SPRINGER, J.T. 1979. Some sources of bias and sampling error in radio triangulation. *J. Wildl. Manage.* 43:926-935.
- SWIHART, R.K., AND N.A. SLADE. 1985a. Testing for independence of observations in animal movements. *Ecology* 66:1176-1184.
- \_\_\_\_\_, AND \_\_\_\_\_. 1985b. Influence of sampling interval on estimates of home-range size. *J. Wildl. Manage.* 49:1019-1025.
- \_\_\_\_\_, AND \_\_\_\_\_. 1986. The importance of statistical power when testing for independence in animal movements. *Ecology* 67:255-258.
- UNITED STATES FOREST SERVICE. 1981. *Silvicultural examination and prescription handbook--Region 8.* Atlanta, Ga. 50pp.
- UNSWORTH, J.W., J.J. BEECHAM, AND L.R. IRBY. 1989. Female black bear habitat use in West-Central Idaho. *J. Wildl. Manage.* 53:668-673.
- WARBURTON, G.S. 1984. An analysis of a black bear sanctuary in western North Carolina. M.S. Thesis, N.C. State Univ., Raleigh. 121pp.
- WHITE, G.C., AND R.A. GARROTT. 1986. Effects of biotelemetry triangulation error on detecting habitat selection. *J. Wildl. Manage.* 50:509-513.
- WHITEHEAD, C.J. 1980. *Wildlife research reports: a qualitative study of mast production in the Southern Appalachian region of Georgia, North Carolina, and Tennessee.* Tenn. Wildl. Resour. Agency Tech. Rep. 80-2. 97pp.
- WILLEY, C.H. 1978. The Vermont black bear. *Sci. Tech. Bull. Vermont Fish and Game Dep.* 73pp.