Movements of Black Bears on the Pisgah National Forest

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Abstract: Nineteen black bears *(Ursus americanus)* equipped with transmitter units were monitored on the Pisgah National Forest, North Carolina from May 1981-December 1982. Home ranges of males (61.0 km^2) were 3.6 times greater than female home ranges (16.9 km^2). Fall shuffles were not observed possibly due to the abundance and diversity of mast on the study area. Extensive overlap between reproductive females was observed, and the home ranges of adult males overlapped some female home ranges more than others. Dispersal of 2 subadult males occurred after they began using the same area as an adult male. Increased activity and variation in travel distances during the fall suggested that bears were foraging for mast that would prepare them for denning. Bears used all oak types, except scarlet oak, according to mast abundance; scarlet oak areas were used the least of any oak forest type.

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In 1977, the black bear was listed as a "species of special concern" in North Carolina (Collins and Hamilton 1977). In response to this concern, North Carolina and other states in the Southeast initiated research to examine aspects of bear biology necessary for sound management (Pelton and Nichols 1972). An understanding of black bear ecology is essential for management, and studies of spatial distribution, activity and habitat use contribute towards this understanding (Alt et al. 1976).

Studies of bear movements, home range and habitat use have been conducted in the Great Smoky Mountains National Park (GSMNP) since the early 1970s (Pelton and Nichols 1972; Beeman 1975; Eubanks 1976; Beeman and Pelton 1980; Garshelis and Pelton 1980, 1981), and in hunted areas in the southeast (Stickley 1961, Ernst 1973, Rieffenberger 1973, Hardy 1974, Hamilton 1978, Lentz et al. 1980, Villarrubia 1982). This study reports on the home range, activity patterns, and

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habitat use of black bears in an area where bears are protected from hunting in western North Carolina. Unlike the GSMNP, this study was conducted where timber harvesting occurred, and information on forest types was available.

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Methods

Bears were studied on the 220-km^2 Pisgah Bear Sanctuary (PBS) located on the Pisgah National Forest in western North Carolina. The area was designated as a bear sanctuary by the North Carolina Wildlife Resources Commission (NCWRC) and bears could not be hunted legally. The study area was bordered by the Blue Ridge Parkway on the west and north, and by North Carolina Highways 191 and 276 on the east and south, respectively. A portion of the area extended north of the Parkway. Elevations ranged from 650 to 1,770 m. Major forest types included hemlock *(Tsuga canadensis),* cove hardwood, oak *(Quercus* spp.), pine *(Pinus* spp.), and pine-hardwood. Oak associations comprised nearly 90% of the forest types (U.S. Dep. Agric., For. Serv., Asheville, North Carolina). Eighty percent of the timber on the study area was in the 40 to 80-year age class, 17% was in age classes >80 years, and only 3% was in the <20-year age class (U.S. Dep. Agric., For. Serv., Asheville, North Carolina).

Fieldwork was conducted from May 1981 to December 1982. Bears were captured with modified Aldrich foot snares (Johnson and Pelton 1980) and were immobilized with a 2:1 mixture of ketamine and rompun. Three-year-old bears were considered adults because they are sexually mature (Collins 1973). Cubs and yearlings were classified as subadults. Bears were assigned alpha-numeric codes to distinguish individuals; numbers were prefixed by abbreviations denoting age class at capture and sex (A=adult, S=subadult, M=male, F=female).

All adult and some subadult bears were outfitted with transmitters (Telonics, Mesa, Arizona). Locations of bears were determined by using an 8-element, roof-mounted yagi antenna or a 2-element "H" antenna. No locations were accepted if the difference between the first and last bearings used to determine the location was >15 minutes, or if the area of the triangle formed by 3 bearings >0.2 km^2. If only 2 bearings defined a location, the angle formed by the bearings had to be between 45-135 degrees. Estimated triangulation error was ±5 degrees and maximum error polygons (Springer 1979) for "worst cases" involving a ±10 degree error on 2 bearings ranged from 0.08-0.25 km^2. To facilitate tracking, bears were separated into groups of a maximum of 5 animals that were using the same areas. Bears within the group being tracked were located at 22-hour intervals during 1 of 3 8-hour shifts (0700-1500, 1500-2300, 2300-0700 EST). Each shift was repeated twice during a

2-week period yielding a maximum of 30 locations per animal during a biweekly period.

The convex polygon method (Mohr 1947) was used to determine home range because it defined the area a bear used in its normal activities better than other methods tested and because of its use in many previous studies (Beeman 1975). Overlap was calculated as the percent of home range area in the region of overlap between 2 bears. Activity was determined in 2 ways: by the active or nonactive status of the mortality-sensing transmitters and by straight line distance travelled in 2 hours. Locations were plotted over Forest Service stand maps to determine the forest type associated with each location. Forest types were based on the Forest Service's Continuous Inventory of Stand Condition (CISC) data. Habitat preferences were determined using a chi-square test and Bonferoni procedure (Neu et al. 1974). The general linear models procedure of SAS (Statistical Analysis System) was used to conduct analysis of variance and Duncan's multiple range tests on activity and bihourly travel distance (Sokal and Rholf 1969). Individual bears were treated as sample units (K. Pollock, pers. commun.); therefore, mean travel distance and percent activity were calculated for individuals first and then averaged for each sex. The interaction term (e.g., bear × month) was used as the error term for $F-$tests and Duncan's multiple range tests.

Results and Discussion

Twenty-three bears were captured 29 times. Transmitter units (16 mortality collars, 3 ear-tag transmitters) were attached to 8 bears in 1981 and to 11 in 1982.

Home Range

The average annual convex area of males, 61.0 km^2, was 3.6 times greater than the average annual female home range of 16.9 km^2 ($P < 0.05$, Table 1). Male bears usually have home ranges 2-4 times the size of female ranges (Jonkel and Cowan 1971, Lindzey and Meslow 1977, Alt et al. 1980, Reynolds and Beecham 1980, Garshelis and Pelton 1981). Home range sizes determined from this study are similar to bear home ranges reported in other studies in the Southeast; 41 km^2 (male) and 15 km^2 (female) in the GSMNP (Garshelis and Pelton 1981), 15.4 km^2 (female) in northern Georgia (Ernst et al. 1973), and 91.0 km^2 (male) and 7.8 km^2 (female) in the coastal region of North Carolina (Hamilton 1978).

Most bears tended to use the same areas in the fall and summer, with the exception of 3 males who moved 6-11 km from summer and fall areas. By November, all 3 bears returned to the areas used during the summer. These results are in contrast to the extensive movements exhibited by bears during the fall shuffle in the GSMNP (Pelton 1976) and other areas (Jonkel and Cowan 1971, Piekielek and Burton 1975, Alt et al. 1976, Rogers 1977). The fall shuffle allows bears to forage on a seasonally abundant food source (Garshelis and Pelton 1981). Bears could meet all seasonal foraging needs within established summer home ranges during years of adequate mast production probably because of the diversity of oak types and the elevational

Table 1. Annual and seasonal convex home range areas[a] of bears captured on the Pisgah Bear Sanctuary, North Carolina, 1981–82.

Bear No.	Tracking Period	Annual[b] Home Range (km²)		Summer[c] Home Range (km²)		Fall[d] Home Range (km²)	
		1981(n)[e]	1982(n)	1981(n)	1982(n)	1981(n)	1982(n)
AM09	6/17/81– 7/29/81	—	—	34.1 (26)	—	—	—
AM15	8/20/81–11/17/82	—	87.2 (182)	—	74.2 (47)	47.2 (75)	43.6 (132)
AM20	9/13/81–10/14/82	—	69.7 (76)	—	19.3 (24)	45.5 (85)	40.1 (50)
Adult Male Ave.			78.5	34.1	46.8	46.4	41.9
SM16	8/29/81–11/07/81	—	—	—	—	14.5 (41)	—
SM17	6/4/82 – 7/11/82	—	—	1.4 (6)[f]	—	—	—
SM27	6/4/82 –11/17/82	—	43.5 (171)	—	14.9 (59)	—	40.2 (112)
SM45	6/13/82–11/17/82	—	—	—	102.4 (7)[f]	—	49.5 (85)
SM50	6/11/82– 9/17/82	—	43.7 (63)	—	40.8 (32)	—	10.1 (31)
SM57	6/16/82– 8/25/82	—	—	—	28.9 (55)	—	—
Subadult Male Ave.			67.3		28.2	14.5	33.3
Male Ave., both years		61.0		35.6		36.4	
AF14	7/16/81–10/15/81	11.8 (91)	—	8.2 (48)	—	9.2 (43)	—
AF19	9/6/81 –10/10/81	—	—	—	—	10.4 (34)	—
AF23	6/8/82 –10/18/82	—	24.6 (142)	—	9.9 (60)	—	19.4 (82)
Adult female ave.		11.8	24.6	8.2	9.9	9.8	19.4
SF03	6/8/82 –11/17/82	—	22.7 (215)	—	13.4 (77)	—	18.6 (138)
SF25	6/4/82 –11/17/82	—	8.4 (200)	—	5.8 (67)	—	6.2 (133)
SF56	6/15/82–10/20/82	—	—	—	0.5 (6)[f]	—	—
Subadult female ave.		—	15.6	—	9.6	—	12.4
Female Ave., both years		16.9		9.3		12.8	

[a]Mohr (1947).
[b]Annual = Jun–Dec.
[c]Summer = Jun–Aug.
[d]Fall = Sep–Dec.
[e]N = number of locations.
[f]If $N < 10$, home range estimate not used in calculating average.

extremes on the study area (Warburton 1984). No data were collected during a poor mast year.

Overlap

Females.—Two adult females, AF14 and AF19, were 4 years old and each had 3 cubs. Their fall home ranges overlapped extensively, and they foraged within 0.5-1.0 km of each other during a 2-week period (1 Oct.-15 Oct. 1981). SM16 was travelling with his mother (not captured), and his home range was used to reflect his mother's range (Poelker and Hartwell 1973). SM16 showed no overlap with either AF14 or AF19. A similar overlap pattern was observed in 1982. SM27 was probably travelling with his mother (not captured), and their home range overlapped extensively (80%) with AF23's range. Two subadult females monitored in 1982, SF03 and SF25, overlapped little with each other or with AF23.

The extensive overlap between AF14 and AF19 suggests they may have been siblings (Lindzey et al. 1976, Rogers 1977, Garshelis and Pelton 1981) and reflects the rich food supply on the study area (Jonkel and Cowan 1971). Such cases of relatedness would be expected in a protected population because hunting mortality would not influence social patterns.

Males.—Two adult males, AM15 and AM20, were 4 and 3 years old, respectively, and were tracked both years. In 1981, these 2 males and another adult male, AM09, shared about 10% of their home ranges. Each male maintained a larger area of exclusive use than reported by Beeman (1975).

Adult males covered large areas (61.0 km^2) and overlapped the ranges of subadult males. In 1982, when AM15 began using the same area as 2 subadult males (SM50, SM57), the latter moved 10 km from the sanctuary. AM15's range overlapped the area used by another subadult male, SM45; however, their locations were separated temporally. Subadult males are the sex-age group most likely to disperse (Lindzey et al. 1976, Alt 1978, Lentz et al. 1980), and adult males may play a role in prompting this dispersal (Beeman 1975, Rogers 1977).

Males and Females.—The home ranges of male bears tended to overlap areas used by females to different degrees. During 1981, the home range of AF14 was overlapped the greatest by AM09 (46%) whereas AM15's range completely overlapped that of SM16 and his mother (not captured). AM20's home range overlapped little (3-5%) with any female monitored in 1981. In 1982, AF23 and SM27 with his mother (not captured) shared 83% and 100% of their home ranges with AM15 respectively, and less than 20% with AM20.

The overlap patterns exhibited by bears on the PBS are similar to the social patterns observed in the GSMNP, where adult male ranges overlapped some female ranges more than others, and adjacent females (except possibly related pairs) showed little overlap (Garshelis and Pelton 1981). Male bear home ranges may overlap several female ranges (Jonkel and Cowan 1971, Amstrup and Beecham 1976, Beeman 1975), but males may avoid lactating females (Rogers 1977). These social patterns and the quality of habitat may dictate the maximum number of bears an

area can support and hence determine the overall productivity of the population in an area.

Many of the ranges of bears overlapped in the vicinity of the National Park Service campground and Pisgah Inn located on the Blue Ridge Parkway. Visual and radio locations confirmed that bears used these areas. Bear use of concentrated food sources associated with humans, such as dumps and campgrounds, occurs in many areas (Rogers 1977, Reynolds and Beecham 1980, Warburton 1982a). At times, 2 or 3 bears used this area simultaneously, and there seemed to be a mutual tolerance among those bears (Warburton 1982b). According to Rogers (1977), changing and differing food sources affect the bear's social systems.

Activity Patterns and Travel Distances

Both males and females exhibited similar activity patterns, ranging from 43-63% active from July-October (Fig. 1). The mean bihourly travel distances of males tended to be higher than female averages, and variability in movement distances was greater for males during each month (Fig. 2). Both sexes showed increased variability in movement distances in October because occasional long movements were made. Females showed a significant decrease in percent active fixes and travel distances during November ($P < 0.01$), whereas males did not show a decrease. The high standard deviation for male activity during November (0.33) re-

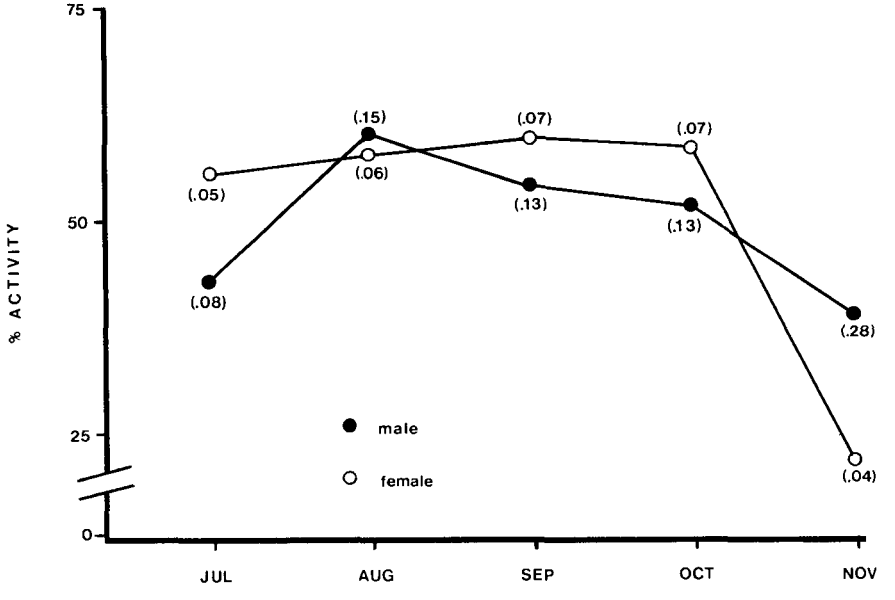

Figure 1. The mean percent activity of male and female black bears during 4-hour periods on the Pisgah Bear Sanctuary, North Carolina, 1981–82. Standard deviations are in parentheses.

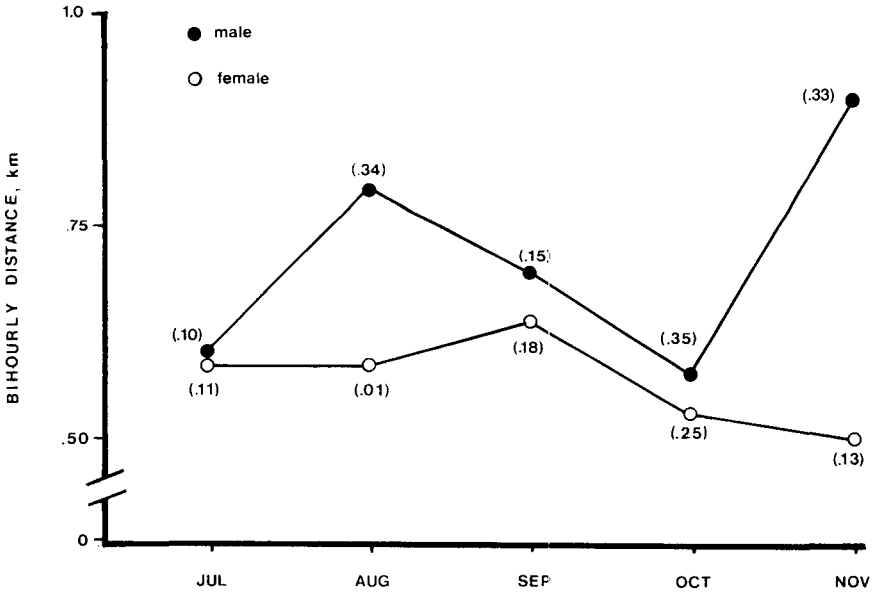

Figure 2. The mean distance travelled in approximate 2-hour intervals combined into 4-hour periods for male and female black bears on the Pisgah Bear Sanctuary, North Carolina, 1981–82. Standard deviations are in parentheses.

vealed that some males were much more active than other males. A midday lull in activity was characteristic for both sexes, and a trend from crepuscular to increasingly nocturnal activity from June-October was evident.

Bear activity and movements increase in the fall (Alt et al. 1976, 1980). This study and others (Amstrup and Beecham 1976, Rogers 1977, Hamilton 1978, Garshelis and Pelton 1980) have noted that bears become increasingly nocturnal as fall approaches. The high standard deviation in bihourly travel distances of both sexes during October reflects that bears were making some long movements to find mast and then spending several days foraging in 1 area. This increased activity corresponds to the physiological need to forage more intensively prior to denning than at other times (Alt et al. 1976, Garshelis and Pelton 1980). Reproductive success of females depends on pre-denning weight (Rogers 1976) and because females monitored in this study did not have to expend energy or risk increased mortality by making a fall shuffle, productivity on the PBS may have been enhanced (Warburton 1984).

Habitat use

Chi-square tests indicated that bears did not use habitats according to availability ($P < 0.05$ in all cases). Using a Bonferoni procedure (Neu et al. 1974) revealed that nonforested areas, upland hardwoods, and cove hardwoods were not

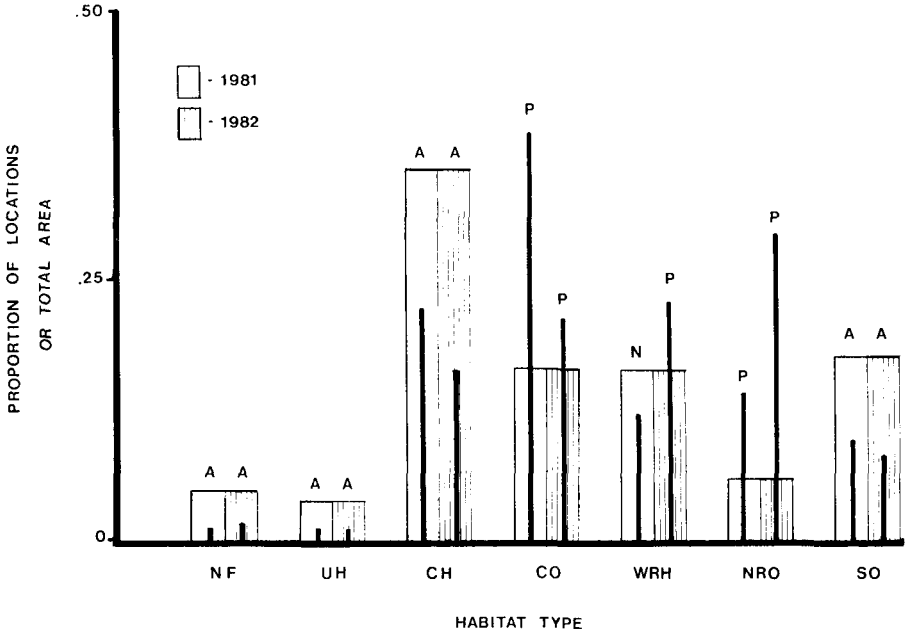

Figure 3. Habitat availability and utilization for all black bears outfitted with transmitters on the Pisgah Bear Sanctuary, North Carolina, 1981–82. Letters above vertical bars represent preference (P), avoidance (A), and neutrality (N) of habitat use as defined by Neu et al. (1974). Vertical bars represent proportions of total area for each habitat type. Vertical lines indicate the proportion of locations in the habitat type.

used in proportion to availability during both years (Fig. 3). Although bears exhibited a low preference for coves, 16-20% of locations were in these areas. Coves provide foods used in the spring and important fall foods such as grapes *(Vitis* spp.) and cherries *(Prunus serotina)* (Beeman and Pelton 1980). Coves also contain a dense understory of laurel *(Kalmia* supp.) and rhododendron *(Rhododendron* spp.) that may provide escape cover (Hamilton 1978).

Three of the 4 oak forest types were preferred by bears; scarlet oak stands were utilized little during both years. Bears switched fall habitat preferences, preferring the chestnut oak type in 1981 and northern red oak in 1982. The white oak-red oak-hickory type also received more use in fall 1982. This change in preferences may correspond to a change in the availability of these 2 mast crops observed by both NCWRC and Forest Service; chestnut oak was much more abundant than any other species in 1981, whereas northern red oak mast predominated in 1982. These results emphasize the need for maintaining a diversity of oak species in forested areas because of the variability in oak production (Strickland 1972). Lentz et al. (1980) stated that mast was important to bears in north Georgia during the fall and that both

red and white oak groups were needed to reduce the chances of mast failure. In the GSMNP, a diversity of mast is important in maintaining high bear populations (Beeman and Pelton 1980, Garshelis and Pelton 1981).

Management Considerations

A diversity of oak forest types in mast-producing ages and along a range of elevational extremes, should be the goal in any forested area managed for bears. The abundance and diversity of oaks on the Pisgah National Forest allowed bears monitored during this study to meet fall foraging needs within home ranges established during the summer. If productivity of females is low, then increasing the abundance and diversity of available mast may increase production levels. Females that do not have to migrate during the fall can spend more time feeding, and they may be less likely to be harvested. As noted in this study, increased overlap is also a byproduct of a rich food supply, and this may allow a greater number of bears to inhabit an area.

The importance of mast to bears and the increased activity and movement during the fall to procure mast makes bears susceptible to harvest during poor mast years (Pelton 1976). Methods of predicting mast crops would allow harvest seasons to be manipulated to reduce harvest during years of sparse mast production.

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