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Habitat Utilization and Seasonal Movements of Black Bears in the Great Smoky Mountains National Park

Patrick C. Carr
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Patrick C. Carr entitled "Habitat Utilization and Seasonal Movements of Black Bears in the Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Ralph W. Dimmick, Boyd L. Dearden, Edward R. Buckner

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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HABITAT UTILIZATION AND SEASONAL MOVEMENTS OF BLACK BEARS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Patrick C. Carr

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ABSTRACT

A radiotelemetry study to determine seasonal movements and habitat utilization of black bears (*Ursus americanus*) in the Great Smoky Mountains National Park was undertaken from June 1980 to May 1982. Annual home range size in a year of poor hard mast production was 119 km^2 and 13 km^2 for males and females, respectively, and 36 km^2 and 6 km^2 in a year of good hard mast production. Bear movements were governed by seasonal food availability. Bears exhibited an affinity to summer home ranges but traveled to widely dispersed fall ranges. Seasonal range shifts were more evident in years of poor hard mast than good hard mast. Eleven of 14 radiocollared bears traveled extensively in fall 1980, a poor mast year. Three of 6 females and every one of 8 males traveled to various parts of North Carolina; bears spent time in the Park, the Cherokee National Forest, the Nantahala National Forest, and private lands adjoining these federal lands. Three males were killed illegally, 1 was hunter-harvested, and the 7 other bears returned to the study area from fall 1980 ranges. Only 1 bear traveled widely in fall 1981, and no radiocollared bears were killed. Bears used different forest cover types non-randomly during different seasons. Oak forests are extremely important to bear survival in the Southern Appalachians. Abundant spring fruits, summer berries, and fall hard mast make the oak types critical habitat for

bears. Bears regularly crossed roads and trails and used areas around roads and trails according to their spatial arrangement in their home ranges. Limiting road access into bear range is important to bear survival.

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CHAPTER I

INTRODUCTION

Black bears are adaptable mammals and exist in greater numbers than the other 2 bear species native to North America. They inhabit a wide variety of habitats and can live in close proximity to humans. However, the low reproductive potential of bears, combined with high mortality from poaching, overharvest, and damage and nuisance control, can hold bear numbers at precariously low levels. Bears range over large areas to fulfill their needs (Pelton 1979), especially when food is scarce (Rogers 1977) and vegetation diversity is limited (Amstrup and Beecham 1976, Lindzey and Meslow 1977).

Human encroachment and development, such as new roads and subdivisions, intensive agriculture, and extensive timber operations, reduce available bear habitat. Loss of habitat is the most pressing problem facing black bears in the east (Harlow 1961, Taylor 1971, Pelton 1979); which makes southeastern bear populations especially vulnerable (Pelton 1979). The area encompassing the Great Smoky Mountains National Park and the Cherokee National Forest is the only remaining stronghold for black bears in Tennessee.

The Great Smoky Mountains National Park provides protected status to black bears. Illegal hunting and damage and nuisance control actions result in some reduction in bear numbers. However, the Park serves as a sanctuary for bears and supplies the Cherokee National Forest and surrounding areas with additional bears (LaFollette 1974, Villarrubia 1982), supplementing populations that are only half the density of those in the Park (K. Johnson, Univ. of Tenn., pers. comm.). The Cherokee National Forest presently is under intensive timber management. The effects of clearcutting and other timber management activities and the access created by new logging roads is not fully understood at the present time. It has been postulated that such activities may be detrimental to black bear populations (Pelton 1979, Villarrubia 1982).

Habitat requirements of black bears in this region are not well documented. Bear use of softwood and hardwood forest cover types (Lentz 1980, Villarrubia 1982, Garris 1983) and mast-producing forest types (Quigley 1982) has been reported but different methodologies in collection and analysis of data have yielded varying results. Bears rely on seasonally abundant fruits and nuts and can travel over large areas to obtain these foods (Rogers 1976, 1977; Beeman and Pelton 1980; Hugie 1982). Bear mortality is higher and reproductive success lower in years of hard mast shortages, both from hunting (Beeman and Pelton 1980) and lowered nutritional status (Eiler 1981, Wathen 1983). A description of the seasonal and annual ranges of bears and the habitats utilized by them should assist in the management of the species in the Southern Appalachians. The objectives of this study were:

1) to delineate areas of black bear use, both yearly and seasonally;

2) to describe the habitat types used by black bears;

3) to describe temporal bear movements.

CHAPTER II

STUDY AREA

Research was conducted in the Great Smoky Mountains National Park (GSMNP or Park), which lies on the border of Tennessee and North Carolina. Trapping and all ground telemetry were undertaken in the northwestern portion of the Park, referred to as the Bunker Hill area because of a prominent ridge (Bunker Hill Lead) which bisects the area. The Bunker Hill area is located in Blount County, TN and is bounded by U.S. Highway 129 to the west, the Park boundary to the north, Cades Cove to the east, and the TN-NC border to the south, comprising an area of approximately 155 km^2 (Fig. 1). However, due to extensive movements by individual animals, this project examined the movements and habitat use of a group of black bears over a larger area of nearly 900 km^2 in Tennessee and North Carolina (Fig. 1).

The Great Smoky Mountains and surrounding areas are part of the Unaka Mountain range in the Blue Ridge province of the Southern Appalachian Highlands (Fenneman 1938:173). The predominate soil types are of the Ramsey association and are characterized by low water storage capacity, medium to high acidity, and moderate fertility (Soil Survey 1953). The topography of the area consists of steep ridges extending outward from the main ridge of the Appalachian chain, which delineates the border between Tennessee and

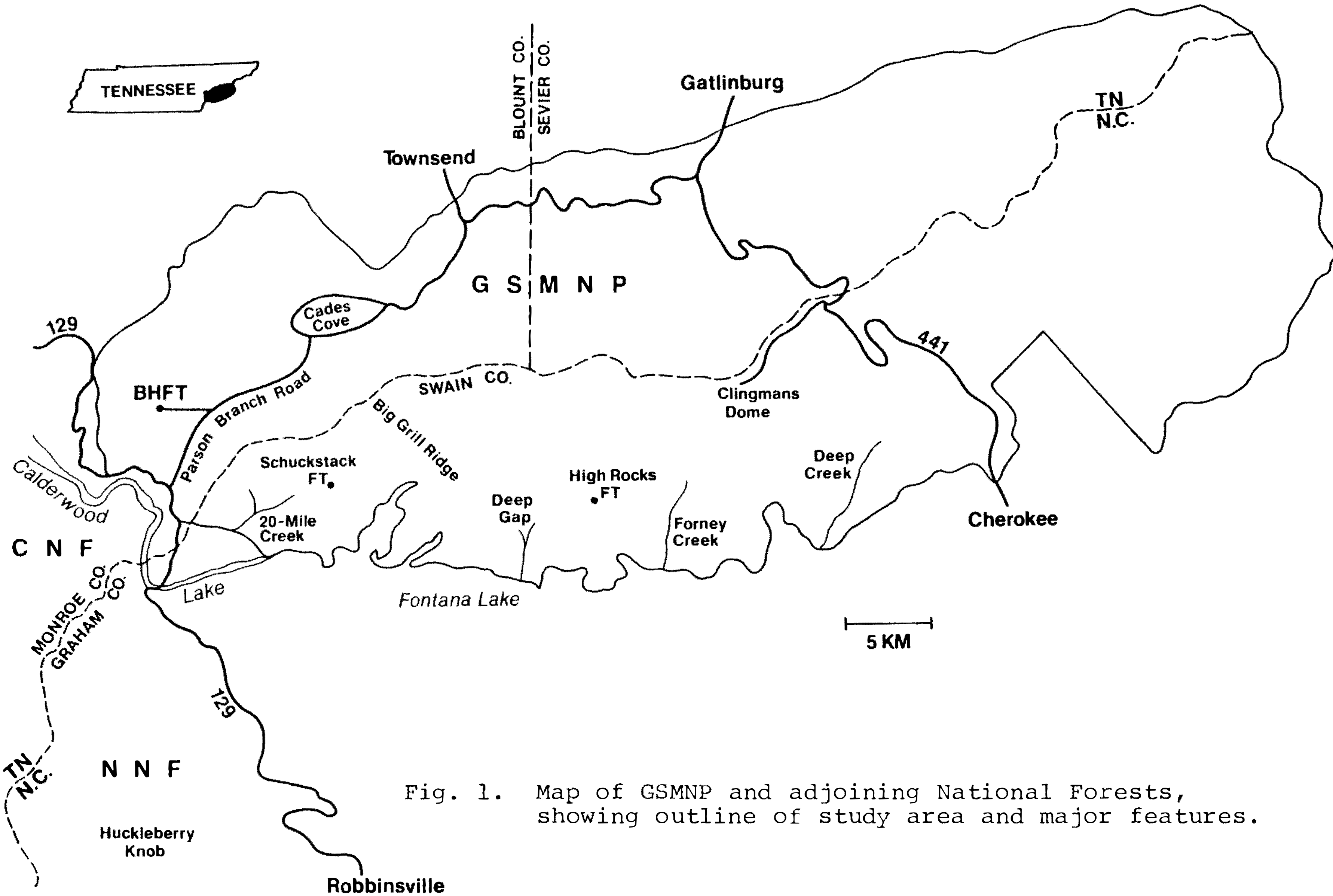

Fig. 1. Map of GSMNP and adjoining National Forests, showing outline of study area and major features.

North Carolina. The ridges are separated from one another by narrow valleys cut by fast-flowing streams (King and Stupka 1950). Elevation ranges from 265 m, where Abrams Creek flows into the Little Tennessee River at Chilhowee Lake, to 2,024 m at Clingman's Dome; the majority of the study area is at an elevation of greater than 760 m.

The climate has been described as warm-temperate rain forest (Thornthwaite 1948) but a variety of microclimates are evident because of elevation changes, aspect, and topography. Precipitation varies with elevation, ranging from 140 cm/year to over 220 cm/year from lowest to highest elevations. July is the wettest month and September or October the driest. Temperature is also influenced by elevation. Temperatures decline about 4 C per 1,000 m rise in elevation and annually average about 6 C at high compared to 14 C at low elevations. Temperatures are usually coldest in February and warmest in July or August (U.S. Dept. Commerce 1972).

Vegetation in the GSMNP is extremely diverse, benefiting from the many microhabitats and microclimates which are created by the varied precipitation, elevation, topography, and aspects. King and Stupka (1950) identified approximately 1,300 species of flowering plants, including 131 native trees and over 2,400 non-flowering plants, including 50 ferns and fern allies, 330 mosses and liverworts, 230 lichens, and 1,800 fungi. In fact, King and Stupka consider the Smokies as one of the richest botanical areas in the eastern United States, excluding the Florida peninsula.

The vegetation of the GSMNP has been classified by by various authors (Cain 1935, Shanks 1954, Whittaker 1956, Golden 1974); the classification by Shanks will be used in this study (Table 1). Shanks listed 6 broad forest types along with 2 non-forest types. The closed oak, open oak and pine, and cove hardwood types were the most important forest types with respect to use by black bears in this study.

The closed oak forest forms a closed canopy, dominated by oaks with hickories and red maple. The understory is variable ranging from dense, but not continuous, to sparse. Huckleberry, blueberry, greenbrier, and herbaceous species are common understory plants.

The open oak and pine type is commonly found on dry exposed ridges and slopes. The understory, containing huckleberry and blueberry, tends to form a dense, continuous mat, expecially in conjunction with mountain laurel. Fire was a major influence on this type before active fire suppression began with the formation of the Park.

The cove hardwood type is found in sheltered coves and valleys, usually in close proximity to water. In certain localities the rhododendron and mountain laurel understory can be extremely dense. When rhododendron is not present, the understory contains a rich herb flora. The above descriptions are a compilation from Keever (1953),

Table 1. Forest types and their important trees and shrubs in the GSMNP.

Forest type	Important species
Cove hardwood	Eastern hemlock (*Tsuga canadensis*) Silverbell (*Halesia monticola*) Yellow buckeye (*Aesculus octandra*) Sugar maple (*Acer saccharum*) Yellow birch (*Betula alleghaniensis*) Tulip poplar (*Liriodendron tulipifera*) Beech (*Fagus grandifolia*) Black cherry (*Prunus serotina*) Basswood (*Tilia heterophylla*) Hydrangea (*Hydrangea arborenscens*) Dog hobble (*Leucothoe editorum*) Sweetshrub (*Calycanthus floridus*) Rhododendron (*Rhododendron maximum* and *R. catawbiense*)
Hemlock	Eastern hemlock Yellow birch Silverbell Frazier magnolia (*Magnolia fraseri*) Rhododendron Mountain laurel (*Kalmia latifolia*) Dog hobble
Northern hardwood	Beech Yellow birch Yellow buckeye Suger maple Mountain maple (*Acer spicatum*) Hydrangea Witch-hobble (*Viburnum alternifolium*) Dogwood (*Cornus alternifolia*)
Closed oak	White oak (*Quercus alba*) Chestnut oak (*Q. prinus*) Northern red oak (*Q. rubra*) Black oak (*Q. velutina*) Pignut hickory (*Carya glabra*) Mockernut hickory (*C. tomentosa*) Sourwood (*Oxydendrum arboreum*) Black locust (*Robinia pseudoacacia*) Mountain laurel Greenbrier (*Smilax rotundifolia*)

Table 1 (continued).

Forest type	Important species
Open oak and pine	Scarlet oak (*Quercus coccinea*) Sassafras (*Sassafras albidum*) Pitch pine (*Pinus rigida*) Table mountain pine (*P. pungens*) Virginia pine (*P. virginiana*) Mountain laurel High bush blueberry (*Vaccinium simulatum*) Hairy blueberry (*V. hirsutum*) Huckleberry (*Gaylussacia baccata*)
Spruce-fir	Red spruce (*Picea rubens*) Fraser fir (*Abies fraseri*)

Source: Shanks (1954)

Shanks (1954), Woods and Shanks (1959), Beeman (1975), and Harmon (1980).

The fauna, while not as diverse as the flora, is still very rich. Linzey and Linzey (1971) list 59 species of mammals in the GSMNP and 6 which probably were extirpated. The black bear, white-tailed deer (*Odocoileus virginianus*), and European wild hog (*Sus scrofa*) are the large mammals inhabiting the Park. Over 200 species of birds, 30 species of reptiles, 39 species of amphibians, and 70 species of fish are also found in the GSMNP.

CHAPTER III

METHODS AND MATERIALS

Capture

Bears were captured using Aldrich spring-activated foot snares (Bacus 1964) and barrel traps constructed from 2, 50-gallon oil drums (Eiler 1981:10). Trapsites were selected by prebaiting (Johnson and Pelton 1980a). Captured bears were immobilized with an intramuscular injection of M-99 (etorphine hydrochloride, D-M Pharmaceuticals, Rockville, MD) at a dosage of 1 cc/45 kg estimated body weight administered with a projectile syringe fired from a CO_2 pistol (CAP-CHUR, Palmer Chemical Co., Douglasville, GA) or with a syringe mounted on a 2 m jabstick. Immobilized bears were ear-tagged, lip-tatooed, weighed, measured, and examined for general condition. Reproductive condition of the bears was noted (Eiler 1981:12-13). External parasites, hair, and blood were collected. One premolar tooth was extracted for aging; age was determined by counting cementum-annuli after cross-sectioning and staining (Willey 1974, Eagle and Pelton 1978). After they were processed, bears were injected intravenously with M50-50 (diprenophine hydrochloride) at a dosage of 2 cc/45 kg to reverse the effects of the M-99.

Radiotelemetry

Selected bears were fitted with radiocollars. The radiocollars and receivers (Telonics, Mesa, AZ) were operating on the 150-152 Mhz range, and were equipped with reset motion-sensitive activity monitors, commonly called mortality sensors. The transmitter emits a slow pulse (75-80 beats/minute) when the collar does not move for a predetermined time period, either 2 or 5 minutes, indicating inactivity. If the collar moves, the transmitter emits a fast pulse (96-100 beats/minute), indicating activity. The reset monitor then will not return to the slow pulse rate until the collar is stationary for 2 or 5 minutes. Quigley et al. (1979) found that mortality sensors tend to overestimate activity because of the time delay for inactivity, so activity readings were taken, then checked 5-10 minutes later. If the pulse rate was inactive, the bear was listed as inactive and not rechecked. If the pulse rate was active and rechecked as active, the bear was listed as active. If the pulse rate became inactive during the initial reading or the recheck, the bear was listed as inactive. The method reduced the tendency to overestimate active readings (Quigley 1982:27-28, this study Appendix A). Activity readings were taken at various times throughout the day and night, both during daily relocation of the bears and during 24-hour tracking sessions.

Daily relocation of radiocollared animals was done by ground triangulation, using antennas mounted on 9 m masts or held in the hand, and aerial location, using antennas mounted on the wing struts of a Cessna 172. Ground triangulation consisted of walking or driving to easily identifiable map features and recording the compass azimuth of the direction that the signal was loudest (Springer 1979) for each individual bear. The location was obtained by plotting 2 to 4 azimuths/bear and recording the polygon or point where the azimuths crossed (Heezen and Tester 1967). The time between azimuths was generally less than 15 minutes. Each bear location was assigned to the Universal Transverse Mercator (UTM) grid cell that the point or largest portion of the polygon was occupying and given an X and Y coordinate. This system has been tested for accuracy in the GSMNP and has been found to be accurate to within a 150 m radius circle (Garshelis 1978:15, Quigley 1982:14); accuracy in this study was verified with test collars, recovery of dropped collars, and 15 visuals on bears being radiotracked.

Aerial relocation was accomplished using a switchbox connected to the receiver and the antennas on the right and left wing strut; initially both antennas were receiving. When a bear's signal was heard, the operator listened to one, then the other antenna separately and directed the pilot. The pilot would turn toward the signal and fly tighter and tighter circles until 1 wing of the plane was pointing directly in the direction of the bear. The operator would mark the bear location on USGS 7½-minute quadrangle maps to be assigned a UTM coordinate once on the ground. This method was far quicker than ground tracking (most locations fixed with 10 minutes of hearing the signal) and accuracies equal to ground tracking were obtained (2 visuals, 5 recoveries of dropped collars located from the air). Aerial radiotracking also allowed location of far-ranging bears in roadless areas.

Sessions of 24-hour radiotracking were conducted to determine total daily movements, circuity of daily travel, and activity patterns. These sessions consisted of personnel manning 2 mast antennas and obtaining simultaneous activity readings and azimuths for bears with radio range every hour during the session. Locations were recorded by plotting the hourly azimuths.

Data analysis

Sex and age groups. The sex and age breakdown of radiocollared animals was:

males: adult, age $>$ 4 years
subadult, age $<$ 4 years and age $>$ 1 year
yearling, age = 1 year;

females: adult, age $>$ 4 years
with cubs, traveling with cubs of the year
breeding, solitary or with yearlings in the spring and early summer, solitary and pregnant in fall
subadult, age $<$ 4 years.

All breeding females in this study gave birth to cubs in the winter following being solitary (Wathen 1983:126-128).

Seasons. Seasons were defined as spring, den emergence (usually April) to 31 May; summer, 1 June to 31 August; and fall, 1 September to den entry (usually December). This breakdown was derived from previous work (Beeman 1975, Garshelis 1978, Quigley 1982, Villarrubia 1982), food habits (Beeman 1971, Eagle 1979), bear movements, and personal observation of phenological changes occurring in the study area during the study.

Activity. Activity patterns were analyzed using least-squares means, analysis-of-variance (SAS 1979:237-263, Garshelis and Pelton 1980). Activity was defined as a discrete variable, with a value of 1 for active or 0 for inactive, in relation to date, time of day, weather conditions, age, sex, and reproductive status of the bear. Activity, then, was expressed as a probability of activity (0=inactivity, 1=most activity) under a given set of conditions rather than as a percentage of bears active (Garshelis and Pelton 1980).

Movements. Movements were defined using locations from 24-hour and daily radiotracking. Data from 24-hour tracking was used to determine total daily movements and circuity of daily travel. Calculations were based on at least 8 locations for a minimum 12 hour period. Circuity was calculated by dividing the net movement in the defined period by the total distance traveled in that period; a scale ranging from 1 (straight line movement) to 0 (completely circular movement) was used to describe circuity of daily travel (Garshelis 1978:19). Also, the distance between sequential daily locations, 1 day apart, was used as an index to movement and activity within the various sex and age classes (Alt et al. 1976, 1980; Amstrup and Beecham 1976).

Seasonal movements. Seasonal shifts in activity centers were used to determine the extent of seasonal movements. Seasonal activity centers were defined by summing the daily locations for each bear and taking the arithmetic mean. Distances from summer 1980 to summer 1981, fall 1980 to fall 1981, spring 1981 to summer 1981, summer 1980 to fall 1980, and summer 1981 to fall 1981 activity centers were compared to evaluate movements between seasons and geographic stability of and affinity to seasonal ranges.

Home range. Estimation of seasonal and annual home range size was accomplished by connecting the outermost bear locations and calculating the area of the convex polygon (Brinker 1969:248-250). When bears exhibited seasonal shifts in home range with 2 or more distinct clusters of locations, a corridor was drawn connecting the areas of activity (Quigley 1982:18-19). This corridor was constructed by connecting the last location in a cluster with the first location in the next cluster and using any locations in between as guides. In this way the home range size was not overestimated by including areas which the bear did not use when traveling from 1 area to another.

Habitat utilization. Overstory vegetation was categorized using Shanks' (1954) classification on Miller's (1934) vegetation map of the GSMNP, U.S. Forest Service prescription maps, and aerial photographs from flights in 1979 and 1980. The study area was divided into forest cover types of closed oak, open oak and pine, cove hardwood, northern hardwood, hemlock, and spruce-fir, and non-forest types of grass, disturbed areas (like powerlines), and water. Daily locations were assigned the forest type which comprised the major portion of the UTM grid cell. The percentage of each forest type in the study area was determined using the dot-grid method (Bryan 1943). Differential use of forest cover types was tested using Chi-square goodness of fit tests and the Bonferroni approach (Neu et al. 1974) at the 0.05 level of significance. The impact of roads and trails was assessed by examining the frequency at which bears crossed and used the area within 200 m of roads and trails. Chi-square goodness of fit tests and the Bonferroni approach at the 0.05 level were used.

CHAPTER IV

RESULTS AND DISCUSSION

Traplines were opened intermittently June through September 1980 and April through September 1981. Trapping efforts resulted in 42 captures of 31 different bears. Also, 1 female cub was captured in a tree and 1 adult male was immobilized in a winter tree den. Capture information is detailed in Appendix B. Twenty-one different bears were radiocollared during this study, including 11 males and 10 females. Four males and 4 females were monitored both years of the study. A total of 2,245 locations and 6,322 activity readings were recorded. The radiotracking history of bears in the study is depicted in Figure 2.

The average age of captured bears was 6.0 years (range 2-10) for females and 3.7 years (range cub-8) for males. This age discrepancy is similar to that reported from other studies (Poelker and Hartwell 1973:126, Pelton 1976, Hugie 1982:41); it is likely caused by the greater mobility and thus vulnerability to mortality of males compared to females (Beeman and Pelton 1980, Hugie 1982:114, this study p. 49). Another factor which influenced average age was different trapping success for the young female cohort versus the young male cohort. While 1 male cub was captured twice, 3 different yearling males were captured 5 times, and 5, 2-year-olds were captured 6 times, there were no cub or yearling females and only 1 each of 2- and 3-year-old

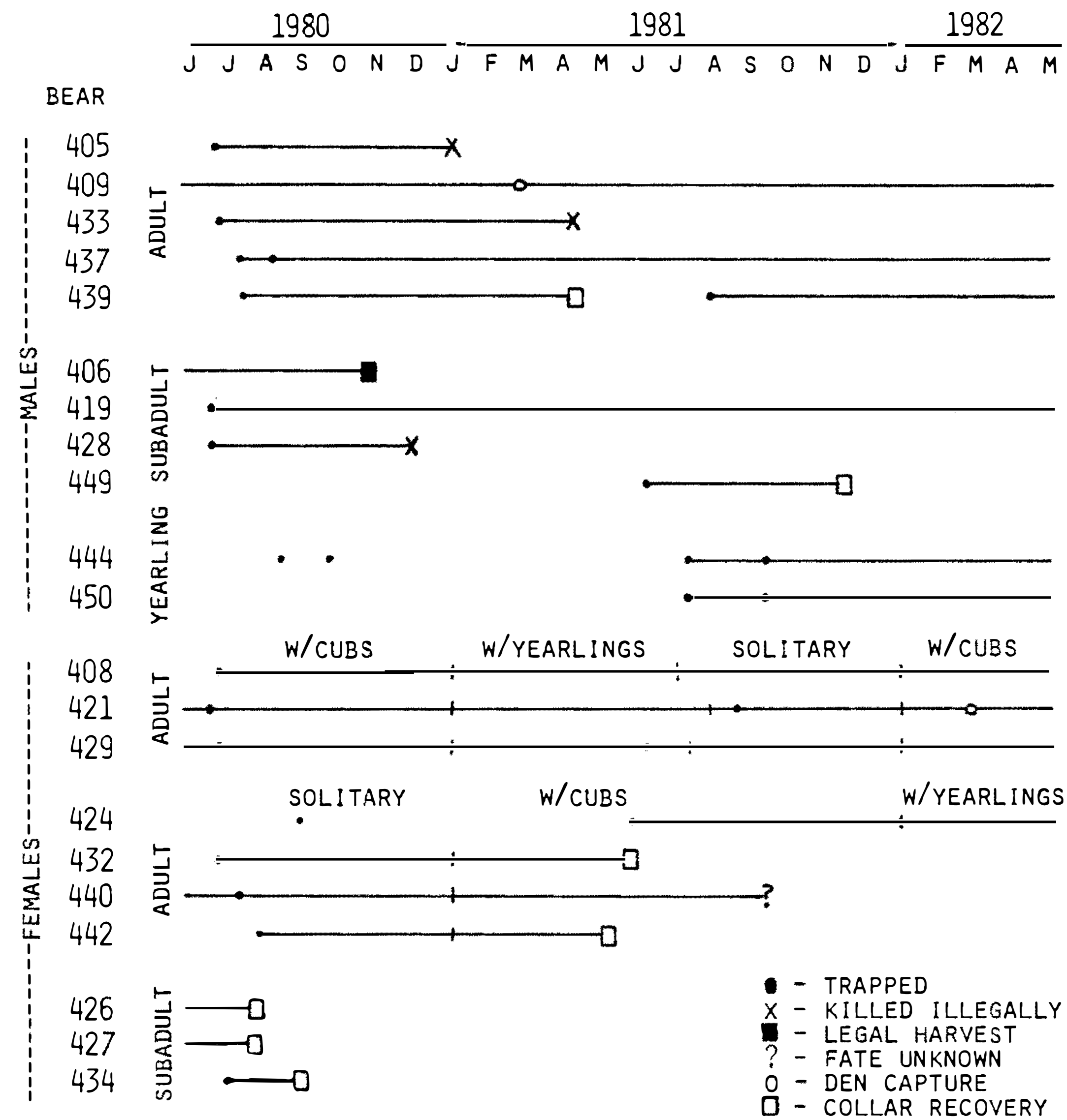

Fig. 2. Duration of radiotracking, reproductive condition, and fate of 21 black bears in the Bunker Hill area, GSMNP, 1980-82.

females trapped in this study. Rogers (1977:49) felt that only very intensive trapping would yield captures of the young female cohort because of the extremely small movements and home ranges of this group.

The average age of monitored bears was 6.3 years for females and 4.0 years for males; this age structure is representative of the trapping age structure. Again, the young female cohort was not well-represented in telemetry data, so discussion about this group will be limited.

Activity

Activity of black bears in the Smokies varied by season and exhibited a crepuscular pattern; bears were more diurnal than nocturnal (Figs. 3 and 4). This activity pattern is similar to findings by Garshelis and Pelton (1980), Quigley (1982:33), Villarrubia (1982:35), and Garris (1983:53) for bears in the Southern Appalachians, but differed from results in other eastern habitats, where bears were more nocturnal (Matula 1976:113, Hamilton 1978:79). Activity was low in spring, apparently because bears were adjusting after extremely reduced activity in dens. Activity became highest during the summer breeding season; synchrony of high activity probably increased reproductive success (Alt et al. 1976). Activity levels began to decline in the fall but not as rapidly in October (Fig. 5) when mature acorns are falling (Strickland 1972:17-18). After October, activity diminished to low levels at the onset of denning.

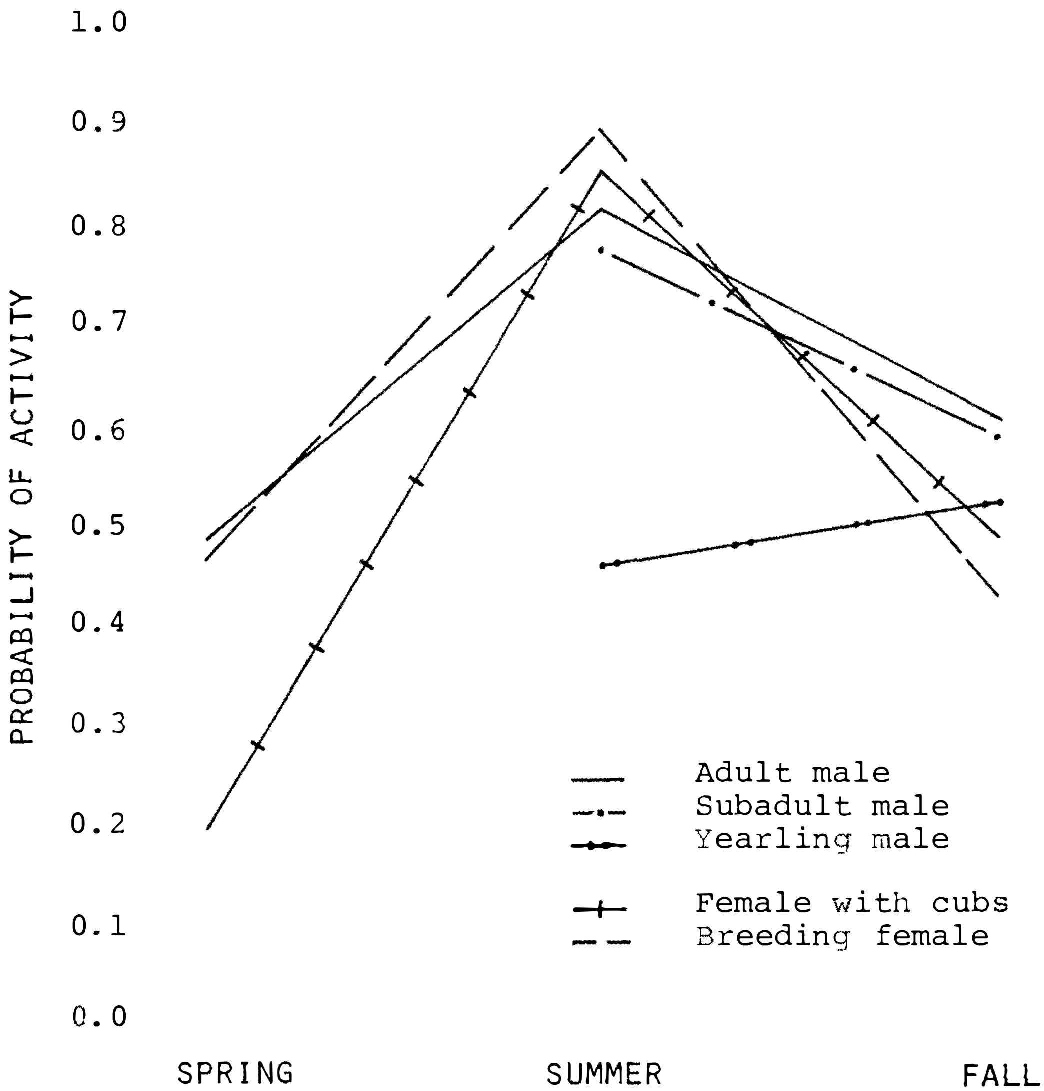

Fig. 3. Seasonal activity levels of different sex and age groups of black bears in the GSMNP, 1980-82.

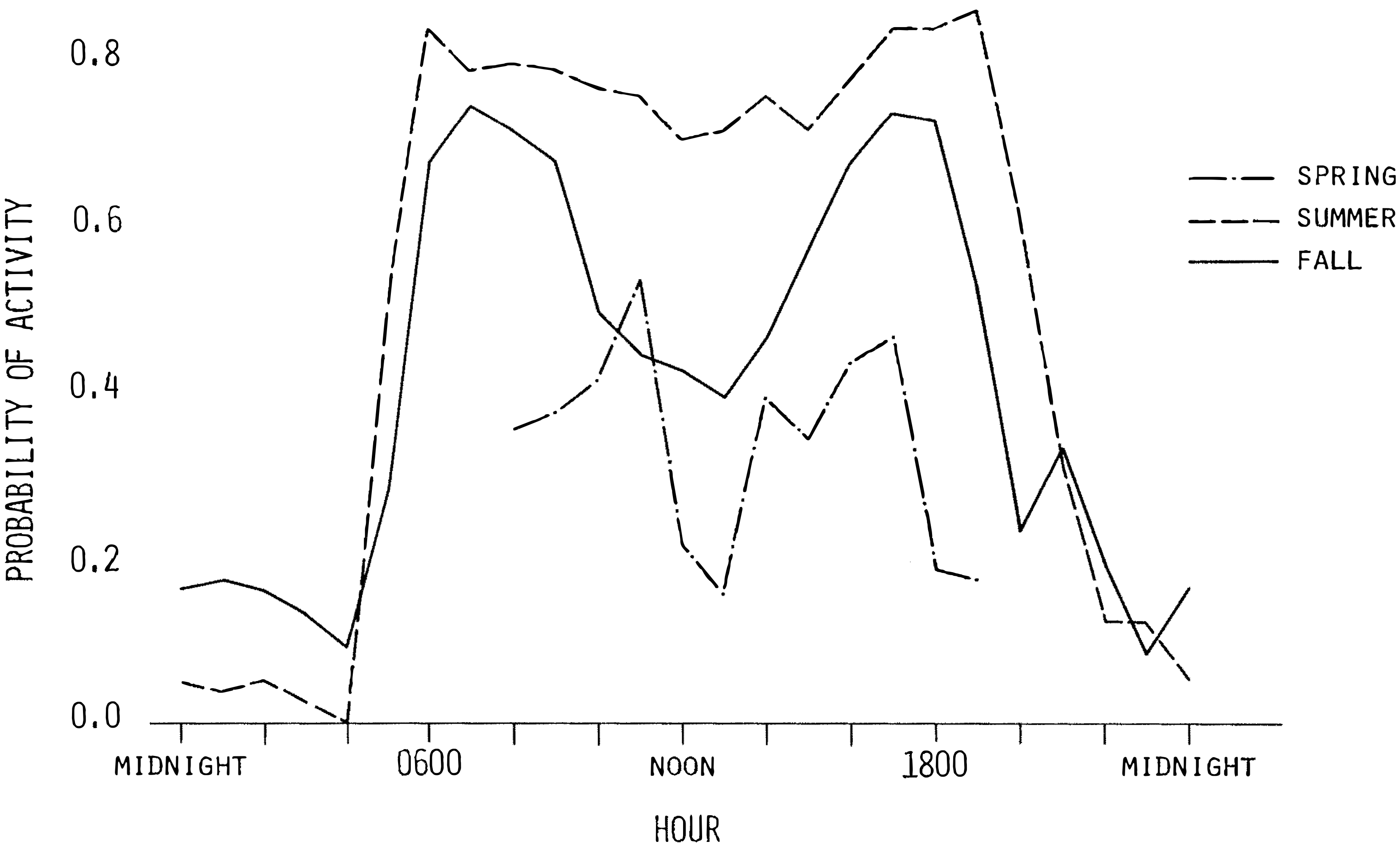

Fig. 4. Hourly probability of activity for black bears in the GSMNP, 1980-82.

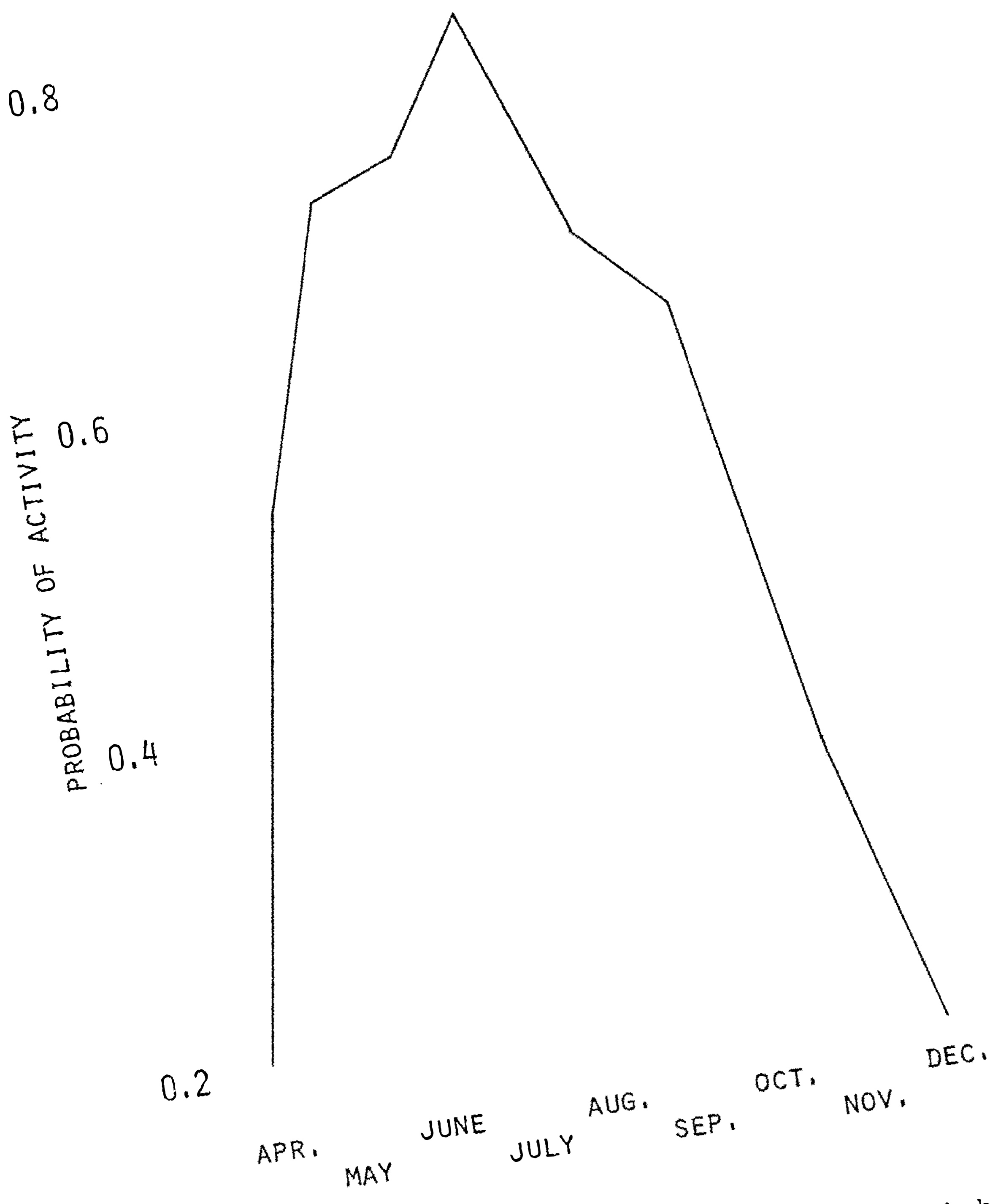

Fig. 5. Monthly probability of activity for black bears in the GSMNP, 1980-82.

Activity of adult bears peaked in August (Fig. 6). Females in the Smokies were observed in estrus in mid-August (Eiler 1981:43, Wathen 1983:43); late summer breeding probably contributed to high activity levels. Changing food regimes and social influences may also have contributed to high August activity. Males began long movements in August, about the time that immature acorns began falling (Strickland 1972:16). Bears were observed feeding on acorns in trees during the last week of August. Females with cubs had the highest activity of all groups in August; this may be the result of increased interaction within the family group because weaning probably occurs then (Wathen 1983:49-50). Females with cubs remained more active in the fall than other bears, except yearling males; maternal attention and increased foraging activities by the family group was probably the cause. High fall activity of yearling males may be related to the wandering nature of Bear 450 (p. 34). and the apparent dispersal movements of Bear 444 (p. 34).

Home range

Home range size of adult males was larger than that of adult females, both annually and seasonally (Table 2). Home range sizes for individual bears are presented in Appendix C; annual home range diagrams are presented in Appendix D. Larger sizes of male ranges are a common denominator in previous studies on black bears (Table 3), even though data collection and methods of range calculation

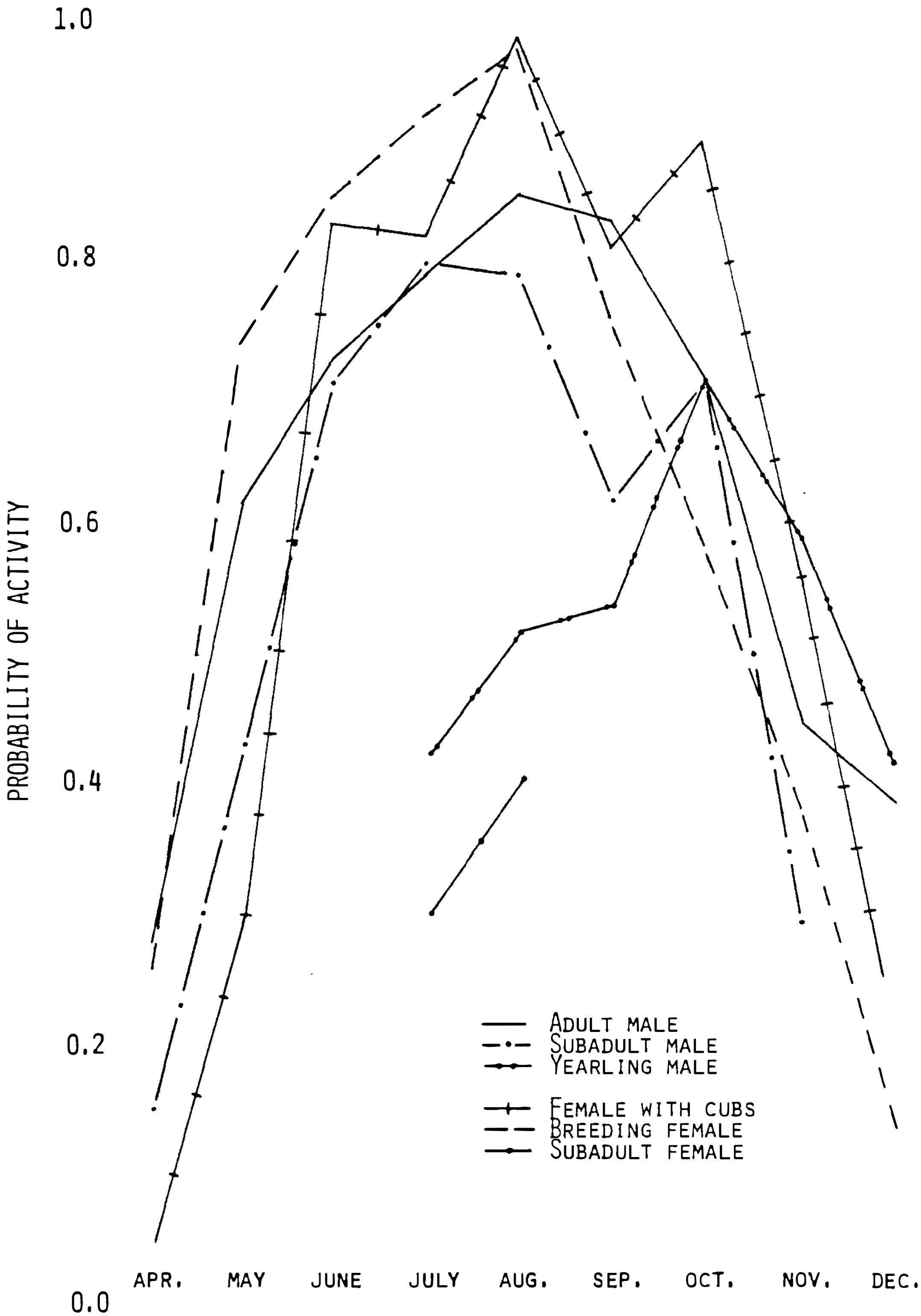

Fig. 6. Activity levels of black bears by month and sex/age group in the GSMNP, 1980-82.

Table 2. Seasonal and annual home range sizes (km^2) of black bears in the GSMNP, 1980-81.

Reproductive status	Spring (n)	Summer (n)	Fall 1980 (n)	Fall 1981 (n)	Annual 1980 (n)	Annual 1981 (n)
			MALES			
Adult	7.7 (2)	20.9 (8)	101.1 (5)	23.5 (3)	127.8 (5)	52.3 (3)
Subadult		12.9 (4)	94.0 (3)	14.3 (2)	97.1 (2)	18.7 (2)
Yearling		2.1 (2)		26.5 (2)		27.4 (2)
			FEMALES			
Breeding[a]	1.7 (3)	3.7 (6)	15.7 (3)	3.6 (3)	17.2 (3)	5.9 (3)
With cubs	0.7 (2)	3.1 (5)	7.5 (3)	3.7 (1)	8.4 (3)	4.6 (1)
Subadult		5.0 (1)				

[a]With yearlings in spring, solitary and breeding in summer, solitary and pregnant in fall

Table 3. Annual home range sizes (km^2) for black bears in North America.

Location	Source	Method	Male	Female
Michigan	Erickson and Petrides (1964)	Trap-recapture	52	26
Montana	Jonkel and Cowan (1971)	Trap-recapture	31	5
Washington	Poelker and Hartwell (1973)	Telemetry--CP[a]	52	5
Washington (island)	Lindzey and Meslow (1977)	Telemetry--CP	5	2
Arizona	LeCount (1980)	Telemetry--MA[b]	29	18
Idaho	Amstrup and Beecham (1976)	Telemetry--CP	112	49
Idaho	Reynolds and Beecham (1980)	Telemetry--MA	60	12
California	Novick and Stewart (1982)	Telemetry--CP	36	25
Alberta	Young and Ruff (1982)	Telemetry--MA	119	20
Maine	Hugie (1982)	Telemetry--CP	1721	43
			438	22
Pennsylvania	Alt et al. (1976)	Telemetry--CP	280	65
North Carolina	Hardy (1974)	Telemetry--MA	175	11
North Carolina	Hamilton (1978)	Telemetry--MA	91	8
Louisiana	Taylor (1971)	Telemetry--MA	111	20
Tennessee	Beeman (1975)	Telemetry--CP	12	8
Tennessee	Garshelis (1978)	Telemetry--CP	21	8
Tennessee	Quigley (1982)	Telemetry--CP	32	5
Tennessee	Villarrubia (1982)	Telemetry--CP	30	12
Tennessee	Garris (1983)	Telemetry--CP	192	22
			60	15
Tennessee	This study	Telemetry--CP	119	13
			36	6

[a]Convex polygon

[b]Minimum area

differed. The males of most sexually dimorphic species occupy larger areas than females because of greater metabolic requirements (Harestad and Bunnell 1979). Also, male bears can increase their reproductive success by being highly mobile and breeding with many females (Amstrup and Beecham 1976, Herrero 1979), while females probably occupy the minimum area required for self-maintenance and care of young (Amstrup and Beecham 1976).

Size of home range appears to be related primarily to food availability (Hardy 1974:102, Beeman 1975:74, Alt et al. 1976, Amstrup and Beecham 1976, Eubanks 1976:54, Lindzey and Meslow 1977, Payne 1978, Garshelis and Pelton 1981, Hugie 1982:114, Garris 1983:38); small home range sizes have been attributed to highly diverse habitats with much interspersion. High diversity and interspersion would support a greater abundance of food species and allow the bear to shift to more abundant food items when 1 food item is scarce. Habitat diversity is great in the Smokies (p. 6); diversity and interspersion is greater in the interior portion of the Park than in the northwest portion because of greater elevation changes (pers. observ.). Black bears in this study had larger home range sizes (averaged over 2 years) than those reported from the interior of the Park (Beeman 1975, Garshelis 1978).

Examining the annual life cycle for black bears in the Smokies will shed more light on seasonal and annual home range sizes. In the spring the bears are in a "negative foraging period" (Poelker and Hartwell 1973: 116-117), losing weight (Beeman 1975:159) while feeding on herbaceous materials and early season fruits such as squawroot (Conopholis americana) (Eagle 1979:54, Beeman and Pelton 1980). Home range size at this time is small compared to other seasons (Table 2). Bears appear to be adjusting after the winter denning period; activity levels are low and daily movements are small. Females with cubs of the year have extremely small home ranges in spring due to the limited mobility of the cubs (Lindzey and Meslow 1977, Rogers 1977:75, Alt et al. 1980, pers. observ.).

The ripening of berries and onset of breeding bring about increased traveling and home range sizes in the summer. Activity increases with the breeding season and bears expand their home range while foraging on high energy berries (Eagle 1979, Beeman and Pelton 1980). In the Bunker Hill area, blueberries and huckleberries are found in nearly continuous mats along ridges in the open oak and pine and closed oak forest types (Harmon 1980, pers. observ.) and foraging bears can fulfill their food demands in almost any part of their breeding range (Quigley 1982:53). Subadults are attempting to establish stable home ranges among the dominant adults during the summer (Lindzey and Meslow 1977, Quigley 1982:66), and are traveling extensively (p. 36). Yearling males occupied their mother's summer range (Fig. 7), thus inhabited only a small area. Yearling males in Minnesota (Rogers 1977:121) and Idaho (Reynolds and Beecham

Fig. 7. Summer home range overlap of adult female (429) and her male yearlings (444, 450) after family breakup, 1981.

1980) used only a small portion of their mothers' summer home range. Summer ranges of bears, therefore, reflect a concentrated food resource, breeding behavior, and other social pressures.

Summer range sizes of adult males were larger than those of all other sex and age groups. Breeding females had larger summer range size than females with cubs. The reproductive success of the breeding portion of the population would be enhanced by larger ranges and increased movements.

In fall bears switch to acorns (Eagle 1979:45, Beeman and Pelton 1980), foods that are low in protein but high in carbohydrates (Strickland 1972:38, Eagle 1979:78). Bears increase fat reserves by utilizing acorns, enabling them to survive the winter denning period and the following spring. The availability of hard mast during fall has been linked to the reproductive success of female bears in the Smokies (Eiler 1981:74,89; Wathen 1983:61,66). In the Smokies, acorn distribution is in patches rather than evenly distributed (Garshelis and Pelton 1980, Quigley 1982:52, pers. observ.) and years of poor acorn production are common (LaFollette 1974:72, Beeman and Pelton 1980). During acorn shortages, the bears utilize such soft mast crops as grapes (Vitis sp.) and cherries (Eagle 1979, Beeman and Pelton 1980, Eiler 1981:73), but acorns are the preferred fall food item.

Fall home range sizes differed by year and reproductive status. Sizes of fall ranges in 1980, a year of poor hard mast, were significantly greater ($P < 0.01$, binomial test) than in 1981, a year of good hard mast (GSMNP fall mast survey, unpubl.), averaging 2 and 4 times as great for males and females, respectively. Bears in Maine (Hugie 1982:63), Minnesota (Rogers 1977:108), and Tennessee (Garris 1983:38) also showed extensive fall forays to areas of food availability. Breeding females in 1980 had larger fall ranges than females with cubs, but in 1981 the sizes of fall home ranges of these 2 groups were similar. Breeding females (pregnant and solitary in fall) weigh significantly more than females with cubs going into winter dens (Alt 1980, Eiler 1981:62, Wathen 1983:97); in years of poor production of hard mast they use larger areas while searching for acorns and other available foods.

Although Quigley (1982:53) reported a reduction in home range size with age, due to stability and incorporation into the social structure, 5 of 6 bears monitored for 2 more years (#'s 408,409, 419, 421, 429, 439) showed drastic increase in home range size in 1980 and then reduction in 1981. The difference was larger fall home ranges in 1978 and 1980 compared to 1979 and 1981, years of poor versus good mast production. Table 4 details home range size for 7 bears monitored in both 1980 and 1981. It appears that once stable summer ranges are established, there is no great change in size; however fall range sizes vary according to fall mast production.

Table 4. Summer, fall, and annual home range sizes (km^2) of 7 black bears in the GSMNP monitored in 1980 and 1981.

Bear	Reproductive status	Summer 1980	Summer 1981	Fall 1980	Fall 1981	Annual 1980	Annual 1981
			MALES				
419	Subadult	15.9	8.1	101.0	14.6	143.5	17.9
409	Adult	6.1	23.4	102.9	36.9	131.1	61.4
437	Adult	32.0	27.3	116.5	14.9	173.2	36.0
439	Adult	40.7	20.6	178.4	18.7	207.8	59.4
			FEMALES				
408	With cubs	3.4		10.2		10.5	
	Breeding[a]		1.6		2.6		4.2
421	With cubs	2.8		5.5		6.2	
	Breeding[a]		5.4		4.2		8.6
429	With cubs	4.1		6.8		8.5	
	Breeding[a]		3.2		4.0		5.0

[a]Solitary and breeding in summer, solitary and pregnant in fall

Dispersal

Dispersal by young bears in the Smokies has not been documented, only implied (Johnson and Pelton 1980a). Beeman (1975:75) reported an observation of a 2-year-old male 15 km from where it was captured as a cub, but this observation was in the fall, a time when large-scale movements are normal (p.45). Dispersal by subadult males occurs in late summer or early fall in Maine (Hugie 1982: 117). Yearling males in Minnesota roamed widely but dispersed rarely or not at all (Rogers 1977); in Pennsylvania yearling and 2-year-old males were the most common dispersers (Alt 1978). However, dispersal from an island in Washington occurred most commonly at 4 years of age (Lindzey and Meslow 1977). Three instances pertaining to potential dispersers are related here.

Yearling male #450 did not disperse but did wander during fall 1981, his first fall alone. He traveled to the same area which he went to in 1980 with his mother (#429), then to the westernmost part of the Park. Bear 450 returned back to the Bunker Hill area and denned in his mother's summer range, remaining there after emergence until May 1982, the completion of this study.

Yearling male #444, sibling to #450, established a 1981 fall home range 6.2 km north of his mother's summer range and 12.2 km north of the area the family group used in fall 1980. Bear 444 had not returned to his mother's summer range by May 1982. It is not known whether Bear 444 traveled any further from his natal home range, but if his movements were dispersal, the distance is less than the 23 km average (range 5-53 km) reported in Pennsylvania (Alt 1978) and 85 km average (range 27-217 km) in Minnesota (Rogers 1977:145).

Bear 419 was captured as a yearling 17 June 1979 during the previous study in the Bunker Hill area. He was radiotracked from then until late October 1979, when he dropped his collar (Quigley 1982:130); Bear 419 had a range of 27.7 km^2 during that time period (Quigley 1982: 133). On 15 June 1980, Bear 419 was recaptured and recollared; he was then a 2-year-old and was monitored until the completion of the study. The displacement of his summer range between 1980 and 1981 was 2.5 km from his natal range but he was only 3 years old.

Bear 419 may have established a summer range in the Bunker Hill area because of the absence of adult males in the area after the mast shortage of 1980. Mortality of adult males in the Smokies is higher during a hard mast shortage (Beeman 1975:98, Beeman and Pelton 1980, Garshelis and Pelton 1981, this study, p. 49), as was the case in Minnesota (Rogers 1976), Virginia (Stickley 1957), and Wisconsin (Schorger 1949) during food shortages. Only 2 males older than 4 years of age were captured in 1981 compared to 9 in 1980; trapping intensity in 1981 was half that in 1981 (Appendix E). An absence of adult males in the area may have reduced social pressures and allowed Bear 419 to establish a summer range close to his natal range.

Daily movements

Analysis of daily movements can help in the understanding of seasonal range size. Adult males had the greatest total daily movement of all sex and age classes during both summer and fall (Table 5). Females with cubs exhibited less total daily movements than breeding females, and yearling males had the lowest total daily movements.

Although the total daily movement of breeding females was greater than females with cubs, the net daily movement of breeding females was less than females with cubs. Breeding females traveled in more circuitous routes than females with cubs, thus traveling greater distances around their summer ranges. Males apparently locate estrous females by scent (Rogers 1977:84). By traveling greater distances in circular routes, breeding females can increase their probability of meeting a potential mate in their breeding range because adult males are traveling longer distances in more linear routes at the same time. Rogers (1977:84) also found that females in estrus traveled greater distances around their territories. Increased reproductive success would be the likely result of these movement patterns.

Subadult males traveled the most linearly in the summer; this may be due to social pressures on subadult males in their attempts to find and establish a summer home range.

Table 5. Daily movement (km) of black bears in the GSMNP, 1980-81.

Reproductive status	Total daily movement $\bar{X}$	Range	n	Net daily movement $\bar{X}$	Range	n	Circuity $\bar{X}$	Range	n
SUMMER									
Adult males	12.2	6.8-22.3	7	2.7	1.0-4.2	7	0.24	0.09-0.47	7
Subadult males	8.2	3.8-12.1	4	3.3	1.9-5.2	4	0.44	0.23-0.60	4
Yearling males	6.5	3.1- 9.1	4	1.1	0.4-1.6	4	0.21	0.04-0.39	4
Breeding females	10.2	4.6-15.4	10	0.9	0.2-1.8	10	0.09	0.02-0.22	10
Females with cubs	9.2	5.6-12.3	7	1.1	0.2-1.7	7	0.14	0.02-0.29	7
Subadult females	9.5	8.6-10.4	2	1.3	0.4-2.3	2	0.13	0.04-0.22	2
FALL									
Adult males	13.2	8.4-25.2	4	4.0	1.0-9.9	4	0.26	0.11-0.39	4
Subadult males	11.3	11.1-11.5	2	1.0	0.4-1.6	2	0.09	0.03-0.15	2
Yearling males	7.2		1	0.2		1	0.03		1
Breeding females[a]	12.6	5.4-16.8	5	1.0	0.5-1.5	5	0.09	0.03-0.15	5
Females with cubs	8.3	5.8-12.1	6	1.1	0.2-2.2	6	0.14	0.02-0.25	6

[a]Pregnant and solitary in fall

Fall movements by subadult males did not exhibit these linear movements.

Total daily movements by breeding females in fall were greater than their summer movements and are likely related to greater foraging in preparation for denning and parturition. Pregnant females entered dens at significantly greater weights than females with cubs (Alt 1980, Eiler 1981:62, Wathen 1983:97), and traveled greater distances to fall foraging areas in times of hard mast shortages.

The distance between sequential daily locations, one day apart, varied by season and reproductive status (Table 6). Daily movement was at its lowest point in the spring; activity and home range size were also lowest in spring. The need for an adjustment period for bears coming out of dens, the low nutritional value of food supplies, and the limited mobility of newborn cubs would contribute to restricted spring movements.

Daily movements increased in the summer. The influences of breeding likely contributed to greater daily movements; home range sizes also increased at this time. Subadult males moved the greatest distance between sequential daily locations; this was likely due to more linear movements while trying to establish stable summer ranges (p. 36). Yearling males moved the least distance each day; it is during summer that these bears become independent, however movement is generally restricted to their mother's summer range.

Table 6. Distance (km) between sequential daily locations, one day apart, for black bears in the GSMNP, 1980-81.

Reproductive status	Spring $\bar{X}$	Spring Range	Spring n	Summer $\bar{X}$	Summer Range	Summer n	Fall $\bar{X}$	Fall Range	Fall n
Adult males	0.9	0.3-2.1	15	2.2	0.3-6.6	35	2.0	0.5-9.9	21
Subadult males				2.6	0.9-5.2	17	1.9	0.4-9.4	12
Yearling males				0.6	0.1-1.6	24	0.6	0.1-1.6	13
Breeding females[a]	0.5	0.0-1.6	64	0.9	0.1-2.3	92	1.0	0.2-3.7	33
Females with cubs	0.4	0.0-0.8	18	0.8	0.0-1.8	56	0.9	0.2-2.2	19
Subadult females				1.4	0.7-2.3	5			

[a]With yearlings in spring, solitary and breeding in summer, solitary and pregnant in fall

Daily movements decreased in the fall for adult and subadult males, but increased for females and stayed the same for yearlings. The males settled in areas of food availability and remained there until they denned or were killed. Breeding females and females with cubs moved further each day, probably because of greater foraging by pregnant individuals (p. 32, 38) and family groups.

Seasonal movements

Geographical stability of annual and seasonal home ranges of black bears has been reported by many researchers (Erickson and Petrides 1964, Jonkel and Cowan 1971, Poelker and Hartwell 1973, Amstrup and Beecham 1976, Lindzey and Meslow 1977, Rogers 1977, Alt et al. 1980). Bears in the GSMNP display seasonal range shifts along with geographic stability (Beeman 1975, Garshelis 1978). Garshelis (1978:49-50) stated that radiotracking bears in the GSMNP for 1 complete year would yield more data than seasonally tracking over many years because of these shifts. Seasonal range shifts have been related to food availability (Poelker and Hartwell 1973:62, Hardy 1974:82, Amstrup and Beecham 1976, Lindzey and Meslow 1977, Rogers 1977:108-111, Hugie 1982:96), as bears are opportunistic omnivores relying on seasonally abundant foods. Bears utilize available foods like fruits, berries, and nuts as they ripen, and bear movements are governed by the timing of food maturation.

The displacement of seasonal activity centers is shown in Table 7. Bears showed greater affinity to summer home ranges than fall ranges. This same affinity was found in Minnesota (Rogers 1977:66) and Maine (Hugie 1982:63), as bears reestablished mating ranges and territories. The distance between summer activity centers was but a fraction of the distance between fall activity centers for bears monitored both years of this study.

Bears traveled greater distances to fall ranges in 1980 than 1981, which can be attributed to the poor mast crop in 1980. Increased movements by bears in the fall during poor mast years is a common occurrence in the Smokies (LaFollette 1974, Beeman 1975, Pelton and Burghardt 1976, Beeman and Pelton 1980). Males traveled greater distances to fall ranges than females; this should be expected in light of the larger home ranges (p. 24) and greater mobility (p. 36) of the males. Competition for preferred fall mast may also play a role (Garshelis 1978: 38; this study, p. 43).

Bears established ranges in areas of seasonal food availability. Summer ranges averaged 43% closed oak and 32% open oak and pine; fall ranges averaged 62% closed oak and 7% open oak and pine. While berries are found in both closed oak and open oak and pine forest types, prime acorn availability and preferred species of oaks (Strickland 1972, Garshelis and Pelton 1981) are found in the closed oak forests. Bears in Pennsylvania (McLaughlin 1981),

Table 7. Distance (km) between seasonal activity centers for black bears in the GSMNP, 1980-81.

Sex/age group[a]	1980 Summer-fall (n)	1981 Summer-fall (n)	Spring-summer (n)	Summer-summer (n)	Fall-fall (n)
BF in 80	4.07 (3)	0.73 (1)	0.32 (1)	0.14 (1)	
FWC in 80	2.55 (3)	0.43 (3)	0.50 (3)	0.18 (3)	2.73 (3)
Female total	3.31 (6)	0.50 (4)	0.46 (4)	0.17 (4)	2.73 (3)
AM	26.57 (5)	4.26 (3)	2.48 (2)	1.26 (3)	19.33 (3)
SM	14.94 (2)	1.17 (2)		2.48 (1)	24.64 (1)
Male total[b]	23.25 (7)	3.03 (5)	2.48 (2)	1.56 (4)	20.66 (4)
YM		4.10 (2)	0.46 (2)	0.12 (2)	9.72 (2)

[a]BF in 80 = breeding females in 1980, would be females with cubs in 1981
FWC in 80 = females with cubs in 1980, would be breeding females in 1981
AM = adult males
SM = subadult males
YM = yearling males

[b]Male total includes only adult and subadult males because yearling male activity centers would have been influenced by mother in previous year

Maine (Hugie 1982), Virginia (Stickley 1957), and Georgia (Lentz 1980) tended to concentrate in areas where hard mast is available in fall. In years of poor mast availability, the percentage composition of closed oak forests in fall ranges was more striking than that in good mast years (p. 57).

The timing of the range shift in fall appears to be related to maturation and drop of acorns. Acorn drop begins the last 2 weeks of August with immature acorns falling first; peak acorn drop occurs in the middle of October (Strickland 1972:16-18). In 1980, a year of poor hard mast production, the males in the study left summer ranges during the middle of August (Table 8) while 2 of the 3 females that left the area left in the middle of October. Males apparently searched out areas of acorn availability earlier than females; intense competition for prime oak areas may be the cause (Garshelis 1978:38). Males in this study appeared to occupy prime oak areas in the fall, consisting of 65% closed oak compared to 54% for females, and traveled significantly greater ($P < 0.01$, binomial test) distances to 1980 fall ranges than females. Indeed, the 2 largest males (#433 and #439) traveled the greatest distance, to the Deep Creek area about 50 km from the Bunker Hill area.

Also in 1980, poor red oak and no white oak acorn production was recorded on the Bunker Hill area (GSMNP fall mast survey, unpubl.). Eleven of 14 bears moved into closed oak forests on the North Carolina side of the Park.

Table 8. Timing of fall movements by black bears in the GSMNP, 1980.

Bear	Sex/age[a]	Date out	Date returned	Fate
405	AM	8-23 to 8-26		Killed illegally, 12-12-80 to 1-28-81
409	AM	8-22	12-6-80 to 1-28-81	Denned-Bunker Hill area
433	AM	8-16		Denned-Deep Creek area Killed illegally, 3-25-81 to 4-15-81
437	AM	8-9 to 8-22	12-13-80 to 1-28-81	Denned-Bunker Hill area
439	AM	8-12	Before 7-28-81	Denned-NNF, NC, Dropped collar 4-81
406	SM	about 8-15		Hunter-harvest, NNF, NC, 10-20-80
419	SM	8-12	11-28 to 12-1	Denned-Bunker Hill area
428	SM	9-20 to 9-22		Killed illegally, 11-27 to 12-1
429	FC	10-7 to 10-10	11-22 to 11-27	Denned-Bunker Hill area
440	SF	9-12 to 9-15	12-13 to 12-17	Denned-Bunker Hill area
442	SF	10-7 to 10-10	11-22 to 11-27	Denned-Bunker Hill area

[a]AM=adult male, SM=subadult male, FC=female with cubs, SF=solitary female

Strickland (1972:28) reported greater acorn yields at higher elevations for northern red oak, the dominant species in North Carolina closed oak forests (Keever 1953). In fall 1980, males were found at higher elevations than females (Fig. 8). In 1981 both white and red oak production was good. Bears remained in the Bunker Hill area and males were found at lower elevations than females, where acorn production probably was best (Garshelis 1978:41).

Extensive movements

Previous researchers in the GSMNP (Beeman 1975, Eubanks 1976, Garshelis 1978, Quigley 1982) have described extensive movements that can be related to scarcity of fall food, principally acorns; this study was no exception (Table 9). A poor fall hard mast crop was recorded for 1980 (GSMNP fall mast survey, unpubl.) and 11 of 14 radiocollared bears left the Bunker Hill area (Fig. 9). In 1981, a year of good hard mast production, (GSMNP fall mast survey, unpubl.), only 1 bear, a yearling male (#450), traveled outside of the Bunker Hill area.

Three of 6 females (2 solitary, 1 with cubs) and all 8 males were involved in fall forays in 1980. Movements were oriented in a south and eastward direction from the Bunker Hill area; no bears were located on the TN side of the Park east of Cades Cove. Bears were located on the NC side of the Park, from the western boundary to U.S. Highway 441, the Cherokee National Forest (CNF), TN, the

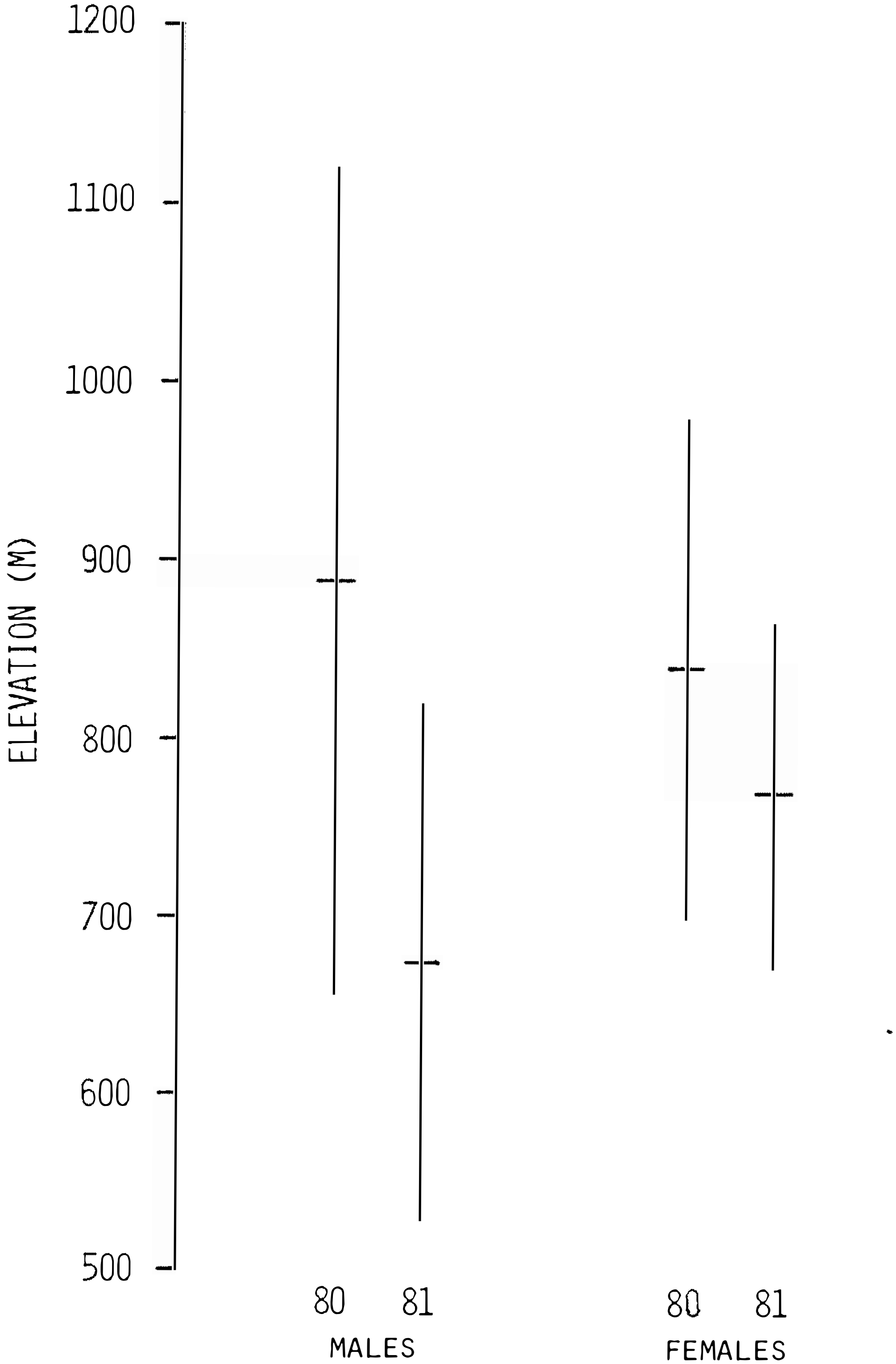

Fig. 8. Elevation means and standard deviations of fall radiolocations of black bears in the GSMNP, 1980 vs. 1981.

Table 9. Extensive movements by black bears in the GSMNP, 1980.

Bear	Sex	Age	
405	M	4	to Deep Gap, GSMNP-27 km SE of BHFT[a]
406	M	3	to Cold Spring Knob, CNF-13 km SW of BHFT to Santeelah Creek, NNF-21 km S of BHFT
409	M	5	to Little Fodderstack, CNF-13 km SW of BHFT to Forney Creek, GSMNP-34 km SE of BHFT
419	M	2	to Deep Gap, GSMNP-27 km SE of BHFT
428	M	2	to 20-Mile Creek, GSMNP-9 km SE of BHFT to Forney Creek, GSMNP-34 km DE of BHFT to 20-Mile Creek, GSMNP-9 km SE of BHFT
433	M	8	to Deep Creek, GSMNP-49 km SE of BHFT
437	M	4	to Shuckstack and Big Grill Ridge, GSMNP-13 km SE and E of BHFT
439	M	6	to Little Fodderstack, CNF-13 km SW of BHFT to Deep Creek, GSMNP-49 km SE of BHFT to Big Grill Ridge, GSMNP-13 km E of BHFT to Huckleberry Knob, NNF-23 km S of BHFT
429	F	5	to 20-Mile Creek, GSMNP-9 km SE of BHFT
440	F	5	to Shuckstack, GSMNP-10 km SE of BHFT
442	F	8	to Shuckstack, GSMNP-11 km SE of BHFT

[a]BHFT = Bunker Hill Fire Tower

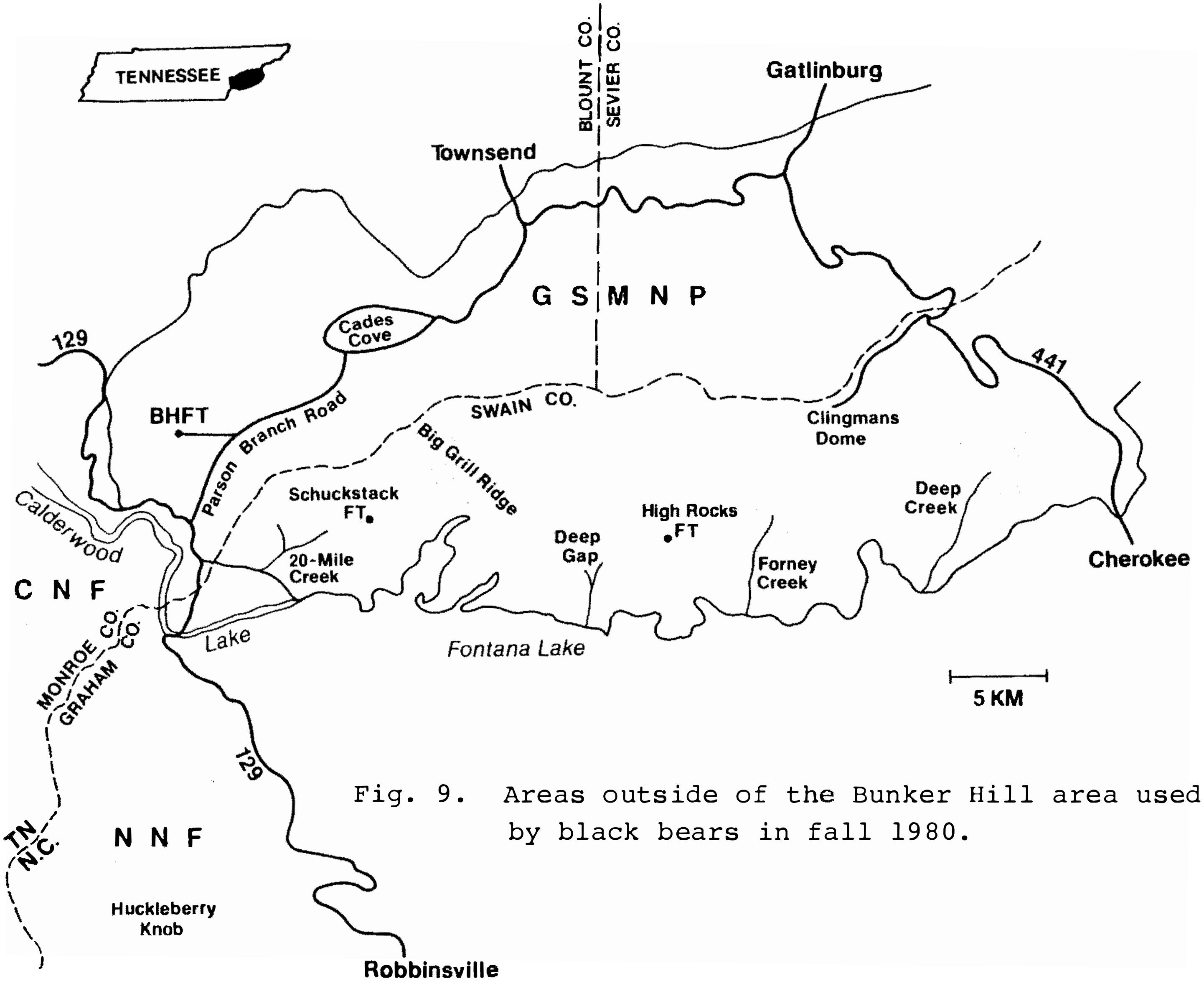

Fig. 9. Areas outside of the Bunker Hill area used by black bears in fall 1980.

Nantahala National Forest (NNF), NC, and private lands adjoining these federal lands. Three males (2 adults, 1 subadult) were killed illegally on the NC side of the Park, 1 subadult male was hunter-harvested in NNF, 1 male denned in the NNF, and the other 3 males and 3 females returned to the Bunker Hill area and denned.

The 3 illegal kills were in areas reported to be under heavy poaching pressure; the accessibility created by trails and afforded by boats from Fontana Lake combined with the relative remoteness of these areas makes law enforcement difficult (W. Cook, GSMNP, pers. comm.). Bear 405 was killed in the Deep Gap area sometime between 12 December and 28 January 1981. Poor flying conditions precluded a more exact determination of the actual date. Bear 433 traveled to the Deep Creek area, where he eventually denned; he was killed there in April 1981. Bear 428 traveled to the 20-Mile Creek area and remained there until 19 Novemeber 1980, when he was found in the Forney Creek area. He had traveled at least 28 km in the 5 day period of 14-19 November; he immediately returned (within 2 days) to the 20-Mile area and was found there on 21 November. Bear 428 was killed on Dalton Ridge, 1 km northeast of 20-Mile Creek between 27 November and 1 December 1980. It is speculated that #428 was chased from this area by poachers with dogs, because he immediately returned, and subsequentially was killed the next week.

By far the most extensive movements by a bear in this study were those of #439. He first traveled to the CNF, then moved to the Deep Creek area (Fig. 9), where he stayed for 19 days. Leaving Deep Creek, he went to Big Grill Ridge, but then could not be located until 14 February 1981, when he was found on Huckleberry Knob, NNF. The minimum distance traveled by #439 between clusters of fall locations would include 13 km from the Bunker Hill area to CNF, 59 km from CNF to Deep Creek, 37 km from Deep Creek to Big Grill Ridge, and 29 km from there to Huckleberry Knob, a total fall traveling circuit of at least 138 km and a one way distance of 63 km. Bear 439 dropped his collar in NNF but was recaptured in the Bunker Hill area on 28 July 1981, 23 km from his last location in NNF. A point to note is that this bear was missing its left front paw when recaptured; this may have been due to a trapping injury sustained on 10 July 1980. While movements such as these constituted distances of nearly 70 km from summer ranges, they are small in comparison to the 200 km distances reported in Minnesota (Rogers 1977).

Quigley (1982:136-139) reported exceptional movements by some of these same bears. Five bears, #405, 406, 409, 414 (this study 440), and 422 (this study 439), were found in some of the same areas in 1978 as they were in 1980, and #409 was found in the same area in 1979 as in 1981. The mast crop was rated poor in 1978 and 1980, and medium to good in 1979 and 1981 (TWRA 1981, GSMNP fall mast survey, unpubl.). Black bears have the ability to learn (Bacon and Burghardt 1976) and remember (Rogers 1977, Johnson 1978); experience and learning may have played a major role in these bears returning to areas used previously.

There are 3 main points exhibited by these movements: 1) bears have the ability to learn and remember areas of seasonal food availability from past experiences; 2) bear movements in the GSMNP can encompass at least half the length of the Park and its entire width; 3) mortality during years of poor hard mast production is higher than during years of good mast production. The extensive movements in search of acorns result in bears being more vulnerable to hunting, both illegal and legal, in the Park and in surrounding areas.

Habitat utilization

Black bears inhabit forested areas in the eastern United States in close proximity to humans. Bear habitat has been described as rugged terrain inaccessible to man and his activities (Stickley 1957, Willey 1978, Pelton 1979). Black bears, as a species, are very adaptable (Herrero 1979) and can coexist with humans providing hunting pressure, both legal and illegal, is restricted and adequate habitat is maintained. Hunting pressure can be reduced by restricting access (Pelton 1979, Villarrubia 1982:92), setting seasons and hunting methods to protect the adult females (Conley 1974, Johnson and Pelton 1980b, Hugie 1982:173), and improving human attitudes about bears (Pelton and Burghardt 1976). The first step toward maintaining adequate habitat is defining those habitat types important to black bears.

Loss of forested areas has reduced black bear numbers in the east (Harlow 1961, Taylor 1971, Burghardt et al. 1972, LaFollette 1974, Lowman 1975, Pelton 1979). Studies to determine important forest types have been undertaken and the results show that use of areas by bears depends primarily on food availability. Bears utilized upland hardwood types in Maine (Hugie 1982), Pennsylvania (McLaughlin 1981), Tennessee (Villarrubia 1982, Garris 1983), and Georgia (Lentz 1980). Hardwood swamps are important in the east, because of the food and cover they provide (Harlow 1961, Hardy 1974, Matula 1976). Researchers in the GSMNP showed that bears utilized the closed oak and cove hardwood forests more intensively than other types (Beeman 1975), males excluded females from preferred oak areas in the fall (Garshelis and Pelton 1981), and females preferred heath and mast-producing areas, but males did not (Quigley 1982). These studies, however, did not analyze any locations which occurred outside of the range of ground-tracking antennas. In order to assess fully habitat use by black bears in the GSMNP, all movements of bears must be considered.

Bears from the Bunker Hill area exhibited non-random use of the different forest types depending upon seasonal food availability (Table 10, Fig. 10). In spring males used the open oak and pine types more than expected by chance and the cove hardwood forests less than expected; females

Table 10. Forest type utilization by black bears in the GSMNP, 1980-82.

Forest type[a]	Proportion of total area	Spring 95% C.I. of locations[b]	Spring Use +,-,0[c]	Summer 95% C.I. of locations	Summer Use +,-,0	Fall 95% C.I. of locations	Fall Use +,-,0
			MALES				
CO	0.600	0.625-0.389	0	0.631-0.503	0	0.701-0.601	+
OOP	0.093	0.429-0.209	+	0.362-0.244	+	0.186-0.110	+
CH	0.199	0.154-0.020	-	0.158-0.096	-	0.230-0.148	0
NH	0.061	0.091-0.000	0	0	-	0.009-0.000	-
Other	0.047	0.091-0.000	0	0.028-0.000	-	0.019-0.000	-
			FEMALES				
CO	0.547	0.675-0.524	0	0.560-0.456	0	0.609-0.495	0
OOP	0.226	0.324-0.188	0	0.364-0.268	+	0.229-0.141	0
CH	0.178	0.198-0.090	0	0.215-0.135	0	0.306-0.206	+
Other	0.048	0	-	0	-	0.016-0.000	-

[a]CO=closed oak, OOP=open oak and pine, CH=cove hardwood, NH=northern hardwood

[b]95% confidence interval of percentage of locations in that forest type

[c]+=used more than expected, -=used less than expected, 0=used in proportion to occurrence on the study area

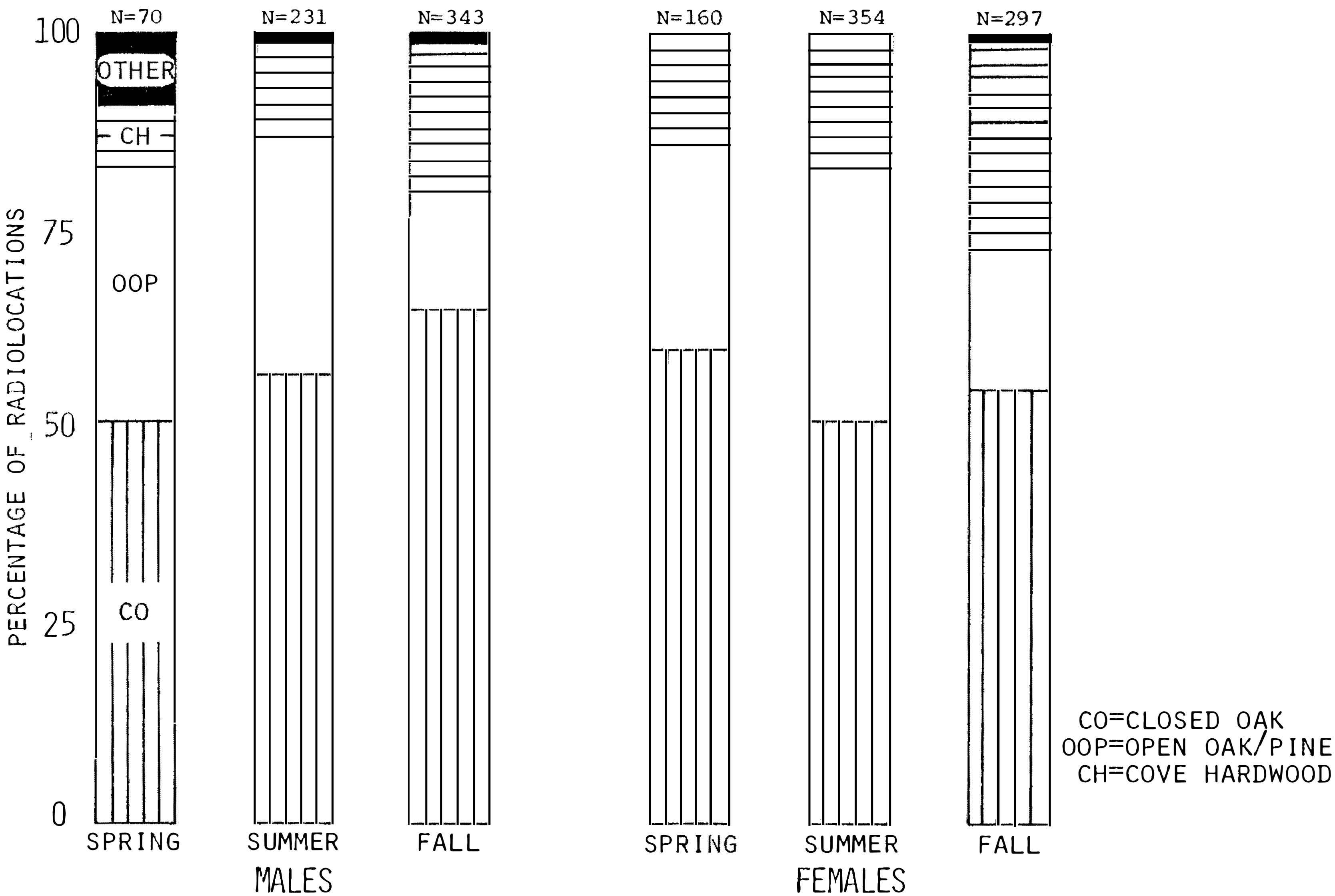

Fig. 10. Percentage of radiolocations in different forest types by season, 1980-82.

used the forest types in proportion to their occurrence on the study area. Open oak and pine forests were used more than randomly expected in summer by both males and females. Closed oak and open oak and pine forest types were used more than expected in fall by males but not by females, who used the oak types in proportion to their occurrence and the cove hardwood type more than expected. Further analysis of seasonal ranges was conducted for a more specific look at forest type use.

The use of oak types in spring can be related to food availability. Females were located more often than expected in the closed oak type (Table 11); adult males were found more often than expected in the open oak and pine type. Bears utilize squawroot and herbaceous matter in the spring (Eagle 1979, Beeman and Pelton 1980). Squawroot is a parasitic saprophyte on tree roots, primarily oak (Beeman 1971:27) and the herb understory is common on mid and lower slopes in the oak forest types (Harmon 1980:14-15). Squawroot and herb availability, then, should be greatest in oak forests, accounting for the bears' use of these types.

Overall, bears used the open oak and pine forest type more than expected in summer (Table 10). The whole area defined by bear movements consists of about 9% open oak and pine and 60% closed oak forest types; however, summer ranges in the Bunker Hill area contain about 43% open oak and pine and 32% closed oak forest types. In summer ranges bears utilized the closed oak type more than expected and the open

Table 11. Forest type utilization by black bears in spring ranges in the GSMNP, 1981-82.

Reproductive status	Number of locations	Closed oak 0.600[a] 0.430[b]	Open oak-pine 0.093 0.322	Cove hardwood 0.199 0.183	Other 0.108 0.065
			MALES		
Adult	53				
Utilization[c]		0	+	-	0
95% C.I.[d]		0.644-0.374	0.447-0.195	0.146-0.004	0.173-0.016
Subadult	16				
Utilization		0	0	0	0
95% C.I.		0.745-0.255	0.539-0.085	0.287-0.000	0.180-0.000
			FEMALES		
With yearlings	117				
Utilization		+	0	0	-
95% C.I.		0.687-0.509	0.335-0.177	0.209-0.081	0
With cubs	43				
Utilization		+	0	0	-
95% C.I.		0.751-0.459	0.386-0.126	0.244-0.036	0

[a]proportion of spring ranges comprised of that forest type--males

[b]proportion of spring ranges comprised of that forest type--females

[c]+=used more than expected, -=used less than expected, 0=used in proportion to occurrence in spring ranges

[d]95% confidence interval of percentage of locations in that forest type

oak and pine type in proportion to its occurrence (Table 12). Adult females used the open oak and pine forests more in summer than either fall or spring, and all bears used this type more in summer than fall (Fig. 11). The dense blueberry and huckleberry groundcover would provide abundant foods. Bears also use the closed oak forests in summer because closed oak forests on upper north-facing slopes contain a dense understory of huckleberry and blueberry (Harmon 1980:15). The presence of blueberry and huckleberry understories strongly influences forest type use by bears in summer.

Fall habitat use differed between 1980 and 1981 (Table 13 and Fig. 12). The fall hard mast crop in 1980 was nearly a complete failure; in fact, the white oak crop was a failure and the red oak group produced poorly (GSMNP fall mast survey, unpubl.). The hard mast crop was rated good in fall 1981. Bear utilization of the closed oak forest type was more than expected in 1980 by adult and subadult males and breeding females. In 1981, only subadult males showed greater use of the closed oak type. The percentage of fall locations in the closed oak forest type was higher in 1980 than 1981 for all groups except subadult males. It appears that in times of food shortages, utilization of those forest types producing preferred foods becomes more intense.

In the Smokies fall foods other than acorns are not very common (Eagle 1979, Beeman and Pelton 1980). Eiler

Table 12. Forest type utilization by black bears in summer ranges in the GSMNP, 1980-81.

Reproductive status	Number of locations	Closed oak 0.430[a]	Open oak-pine 0.322	Cove hardwood 0.183	Other 0.065
		MALES			
Adult	119				
Utilization[b]		+	0	-	-
95% C.I.[c]		0.644-0.466	0.403-0.235	0.165-0.053	0.039-0.000
Subadult	64				
Utilization		+	0	-	-
95% C.I.		0.759-0.523	0.356-0.144	0.165-0.023	0.047-0.000
Yearling	48	0	0	0	-
95% C.I.		0.641-0.359	0.466-0.200	0.273-0.061	0
		FEMALES			
Breeding	186				
Utilization		0	0	0	-
95% C.I.		0.550-0.406	0.401-0.265	0.244-0.132	0
With cubs	143				
Utilization		+	0	0	-
95% C.I.		0.627-0.463	0.369-0.219	0.221-0.101	0
Subadult	25				
Utilization		0	0	0	-
95% C.I.		0.716-0.324	0.503-0.137	0.304-0.016	0

[a]proportion of summer ranges comprised of that forest type

[b]+=used more than expected, -=used less than expected, 0=used in proportion to occurrence in summer ranges

[c]95% confidence interval of percentage of locations in that forest type

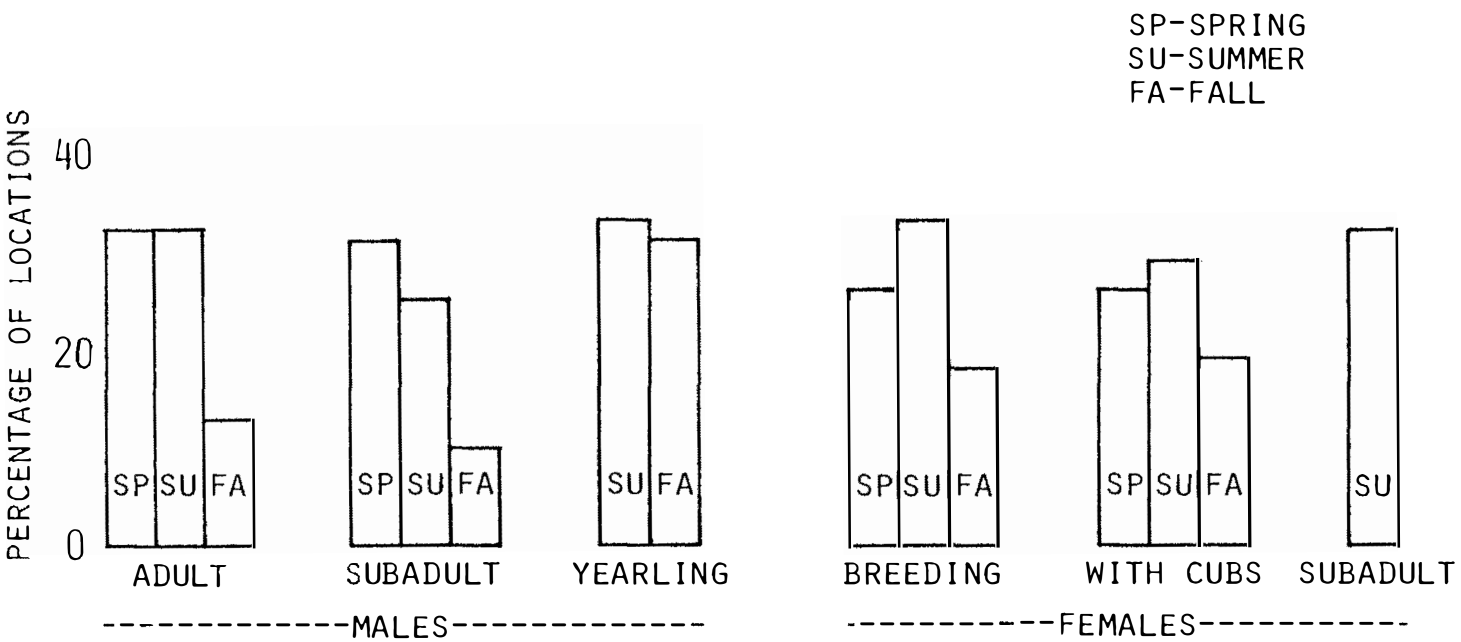

Fig. 11. Percentage of radiolocations in open oak and pine forest type by season, 1980-82.

Table 13. Forest type utilization by black bears in fall ranges in the GSMNP, 1980 vs. 1981.

Reproductive status	Number of radiolocations	Closed oak +,-,0[a,b]	Open oak-pine +,-,0	Cove hardwood +,-,0	Other +,-,0
		MALES			
Adult					
Fall 80	117	+	0	0	-
Fall 81	72	0	0	0	0
Subadult					
Fall 80	63	+	0	0	-
Fall 81	38	+	-	0	0
		FEMALES			
Breeding					
Fall 80	82	+	-	0	-
Fall 81	89	0	0	0	-
With cubs					
Fall 80	96	0	-	+	-
Fall 81	30	0	0	0	0

[a] +=used more than expected, -=used less than expected, 0=used in proportion to occurrence in fall ranges

[b] 95% confidence intervals are found in Appendix F

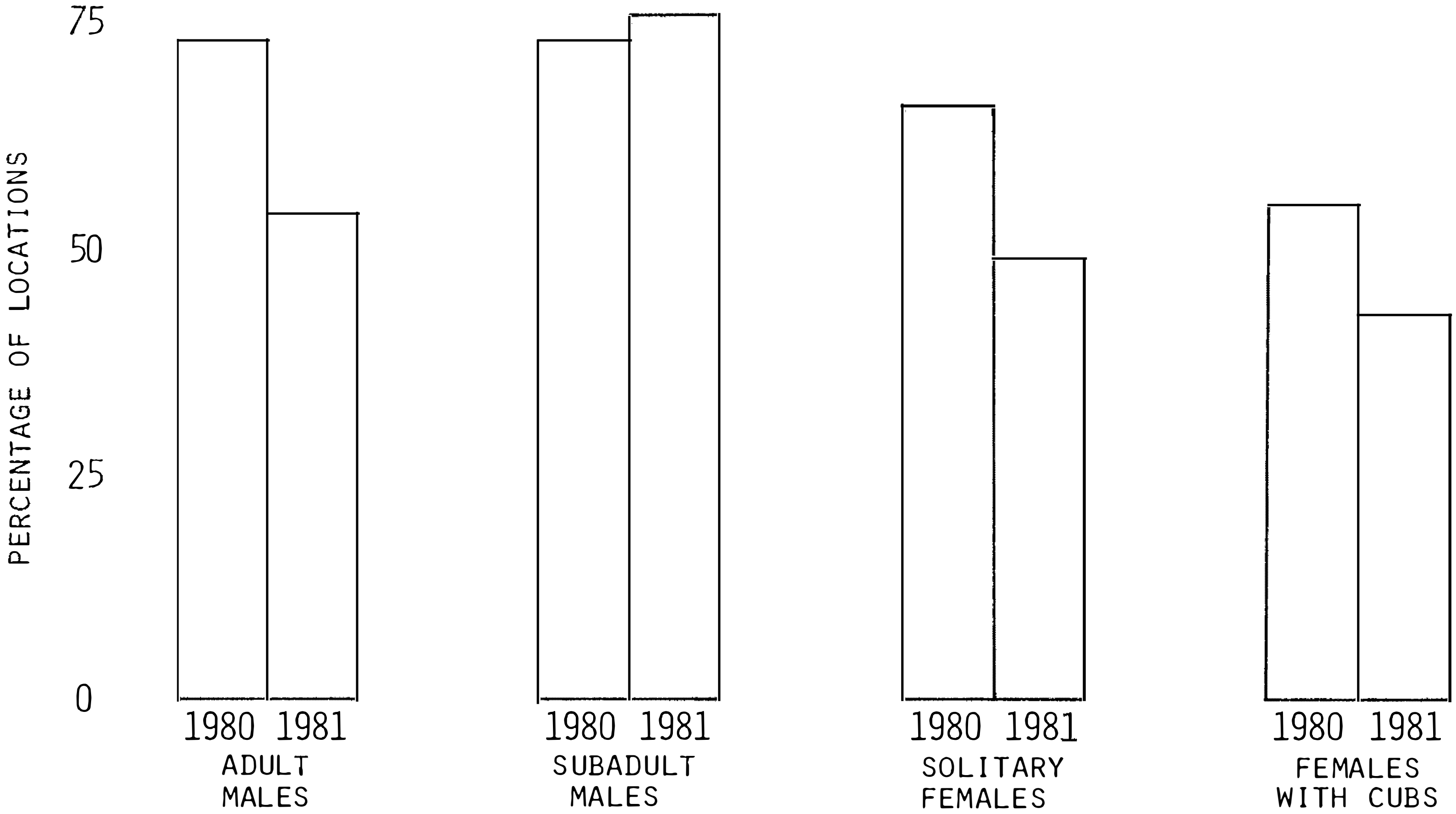

Fig. 12. Percentage of fall radiolocations in closed oak forest type, 1980 vs. 1981.

(1981:73) reported that cub production in 1979 may have been saved after the poor hard mast crop of 1978 when a bumper crop of grapes was recorded. Garshelis and Pelton (1981) speculated that cherries may have caused bears to remain in summer home ranges longer when the cherries were abundant. Females with cubs in 1980 used the cove hardwood type more than expected (Table 13) and may have been relying more on cherries and grapes in the fall than can be realized by this cover type analysis. Shanks (1954) listed cherry as an important species in the cove hardwood forest type, and in fall 1980, bear scats containing grape remains were found in the cove hardwood forests (pers. observ.). There is no good survey yet developed to measure the abundance of these soft mast crops; their impact on lessening the effects of fall hard mast shortages is not well documented, only implied.

The importance of the oak forests to black bears in the Southern Appalachians cannot be overstated. Bears utilized and preferred the closed oak forest type during all seasons. Abundant spring fruits and herbs, summer berries, and fall hard mast make the oak forest critical to bear survival in this region.

Use of roads

Avoidance of roads by bears has been demonstrated in other studies in eastern habitats (Rieffenberger 1974, Hamilton 1978, Brown 1980, Quigley 1982, Villarrubia 1982), but other researchers have detected no avoidance (Hardy 1974, Lentz 1980, Hugie 1982, G. Alt, Pennsylvania Game Comm., pers. comm.). Roads may even attract bears in national parks because food is easily obtainable from garbage cans and tourists (Pelton and Burghardt 1976). Bear movements in the present study did not appear to be hampered by the presence of roads and trails. Bears regularly crossed roads, trails, and other structures (Table 14) as they occurred in their home ranges and utilized the areas around the roads and trails (Table 15). It appears that the spatial arrangement of bear home ranges in relation to roads and trails, rather than behavioral adjustments by the bears, is more a determining factor on whether individuals will cross roads or use areas around roads.

Roads, by themselves, offer no barrier to bear movements and habitat use, but the access provided by roads into bear range could prove detrimental to the bears, especially remnant populations in marginal habitat. Access is a major component of hunter success when hunting bears (Jonkel and Cowan 1971:24, Villarrubia 1982:92) because the majority of hunters hunt within about 2 km of roads (Collins 1970 in LaFollette 1974). Females inhabiting areas close to roads would be especially vulnerable to harvest if hunter pressure is great. Road access into bear range, therefore, should be restricted to protect the breeding part of the population.

Table 14. Frequency at which black bears crossed different structures during 1980-82.

Season (n)[a]	Trail	No public access road	Limited public access road	State highway	Reservoir	Powerline
			MALES			
Spring (69)	13	1	1	1	0	6
Summer (231)	52	19	54	16	4	15
Fall (344)	152	31	41	13	13	11
			FEMALES			
Spring (160)	12	6	22	0	0	0
Summer (354)	46	66	134	0	0	0
Fall (297)	53	33	59	0	0	0

[a]number of locations recorded in that season

Table 15. Utilization of the area within 200 m of trails, roads, and powerlines by black bears in the GSMNP, 1980-82.

Reproductive status[a]	Trails	Roads: No public access	Roads: Limited public access	Roads: State highway	Powerline
			SPRING		
AM	-[b]	0	0	0	0
FY	0	+	+	-	-
FC	-	0	+	-	-
			SUMMER		
AM	-	+	+	0	0
SM	0	0	+	0	-
YM	+	0	+	-	-
BF	0	+	+	-	-
FC	0	+	+	-	-
SF	0	+	0	-	-
			FALL		
AM	0	-	0	-	-
SM	-	0	+	-	-
YM	+	-	+	-	-
PF	0	+	+	-	-
FC	0	0	+	-	-

[a]AM=adult male
SM=subadult male
YM=yearling male
FC=female with cubs
FY=female with yearlings
BF=breeding female
PF=pregnant female
SF=subadult female

[b]+=used more than expected, -=used less than expected, 0=used in proportion to occurrence on the study area (95% confidence intervals)

CHAPTER V

SUMMARY AND CONCLUSIONS

1. A trapping and radiotelemetry study on black bears was conducted in the Great Smoky Mountains National Park from June 1980 to May 1982. Thirty-one bears were captured a total of 42 times. A total of 2245 locations and 6322 activity readings were recorded.

2. The average age of captured bears was 6.0 years for females and 3.7 years for males. The age discrepancy was likely due to the greater mobility, thus vulnerability, of males and unequal trapping success for females versus males less than 4 years old.

3. Activity patterns of bears followed a crepuscular pattern, with bears being more diurnal than nocturnal. Activity was highest in August, probably due to late season breeding and commencement of fall movements in response to acorn availability.

4. Males had larger home ranges than females, both annually and seasonally. Seasonal range size was governed by feeding habits, food availability, breeding and social influences, and presence of cubs.

5. Fall range sizes were directly related to acorn availability, with larger sizes occurring during poor mast crops.

6. Dispersal patterns were not clear. One yearling appeared to disperse a limited distance; another yearling

did not disperse. One subadult male may have established a summer range close to his natal range due to an absence of adult males.

7. Adult males had the greatest total daily movements of all sex and age classes during both summer and fall. Breeding females had greater total daily movements in more circuitous routes than females with cubs thereby increasing reproductive success. Subadult males traveled in linear routes trying to establish summer ranges. Fall daily movements by pregnant females reflected greater foraging and weight gains.

8. Daily movement was least in spring, increased in summer, and was related to reproductive status in fall. Males decreased movements, as a result of settling into a feeding area, and females increased movements, in response to greater foraging by pregnant females and family groups.

9. Seasonal range shifts were more evident in years of poor hard mast than good hard mast. Bears showed affinity to summer ranges but traveled to widely dispersed fall ranges in response to acorn availability. The timing of the fall range shift appears to be related to acorn drop.

10. Eleven of 14 radiocollared bears displayed extensive movements in fall 1980. Three of 6 females left the Bunker Hill area, went about 9 km into North Carolina, then returned and denned in the Bunker Hill area. All eight males left the Bunker Hill area and settled into different areas of the GSMNP, CNF, and NNF. The longest distance

moved was 62 km from the Bunker Hill area by 2 adult males. Three males were killed illegally, 1 was hunter-harvested, 3 denned back in the Bunker Hill area, and 1 denned in NNF.

11. Individual bears showed learning and remembering ability because they returned to areas of seasonal food availability which they had used in previous times.

12. Bears used different forest types non-randomly during different seasons. Bears preferred areas of seasonal food availability. Bears were found most often in the closed oak, open oak and pine, and cove hardwood forest types. Open oak and pine and closed oak types were utilized more than would be randomly expected in summer because of the abundant blueberry and huckleberry understory found there. Closed oak forests were used more than expected in fall due to acorn availability.

13. Fall habitat use differed in 1980 and 1981. Bears were found in the closed oak type a greater percentage of time in fall 1980 than fall 1981. In times of food shortages utilization of those forest types producing preferred foods becomes more intense.

14. Male bears searched out areas of acorn availability earlier in the fall than females. Males apparently occupied areas of prime acorn availability.

15. Oak forests are extremely important to black bears in the Southern Appalachians. Abundant spring fruits, summer berries, and fall hard mast make the oak types critical to bear survival.

16. Bears regularly crossed roads and trails and used areas around these structures according to their spatial arrangement in home ranges. Limiting road access into bear range is important to bear survival.

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APPENDICES

APPENDIX A

Table 16. Hourly movements (km/hr) when simultaneous activity readings were taken by different recorders during 24-hour tracking sessions.

Recorded	Movement	(n)	Significance, t-test
A	0.77	335	t=5.04, $p < 0.0001$
I	0.47	136	
A	0.77	335	t=5.21, $p < 0.0001$
I with change	0.34	26	
I	0.47	136	t=1.34, $p = 0.186$, ns
I with change	0.34	26	

Table 17. Simultaneous activity readings taken by different recorders during 24-hour sessions.

Recorder 1	Recorder 2	(n)	Significance, sign test
A with change	A	26	z=1.82, $p < 0.05$
A with change	I	29	z=1.09, $p = 1.38$, ns
I with change	A	62	z=2.04, $p < 0.05$
I with change	I	75	z=0.00, $p = 1.00$, ns

APPENDIX B

Table 18. Capture information for black bears in the Bunker Hill area of the GSMNP, 1980-81.

Date	Lip tattoo	Ear tags	Sex	Weight (kg)	Age	Recapture	Comments
15 June 80	419	LO419 RM419	M	43	2	Yes, 1979	Radiocollar attached.
16 June 80	421	LM97 RO421	F	45	5	Yes, 1979	Lactating; radiocollar left on.
18 Aug. 81	421	LM97 RO421	F	50	6	Yes, 1980	Replaced radiocollar.
16 June 80	428	LO428 RM428	M	34	2	No	Radiocollar attached.
26 July 80	428	LO428 RM428	M	41	2	Yes, 1980	Radiocollar replaced.
17 June 80	405	LO405 RM405	M	66	4	Yes, 1979	Radiocollar replaced.
21 June 80	408/ E60	LM408 RO408	F	52	9	Yes, 1978	With 3 cubs. Radiocollar attached.
21 June 80	A	LM430	F	6	Cub	No	Cub of #408, pulled from tree.
21 June 80	429	LM429 RO429	F	50	5	Yes, 1979	Lactating; radiocollar left on.
5 June 81	429	LM429 RO429	F	43[a]	6	Yes, 1980	Radiocollar left on.

Table 18 (continued)

Date	Lip tattoo	Ear tags	Sex	Weight (kg)	Age	Recapture	Comments
22 June 80	432	LM432 RO432	F	52	8	No	Radiocollar attached.
22 June 80	433	LO433 RM433	M	136 (est)	8	Yes, 1979	Radiocollar replaced. Left upper canine broken.
1 July 80	434	LM434 RO434	F	36	3	Yes, 1979	Breakaway radiocollar attached.
1 July 80	435	LO435 RM435	M	50	2	No	Bear died from heat exhaustion.
8 July 80	437	LO437 RM437	M	69	4	No	Radiocollar attached. Right canine broken.
5 Aug. 80	437	LO437 RM437	M	67	4	Yes, 1980	Radiocollar left on.
10 July 80	439	LO439 RM439	M	96	6	Yes, 1979	Radiocollar attached. 2nd digit of left fore paw torn by biting.
28 July 81	439	LO439 RM603	M	78	7	Yes, 1980	Radiocollar attached. Left front paw missing.
10 July 80	440	LM440 RO440	F	48	5	Yes, 1978	Radiocollar replaced.

Table 18 (continued)

Date	Lip tattoo	Ear tags	Sex	Weight (kg)	Age	Recapture	Comments
11 July 80	441	LO441 RM441	M	52	3	No	
26 July 80	442/ E1	LM442 RO442	F	60	8	Yes, 1976	Radiocollar attached.
6 Aug. 80	443	LO443 RM443	M	51	4	No	
6 Aug. 80	445/ E23	LO445 RM445	M	82	8	Yes, 1977	
6 Aug. 80	446	LO446 RM446	M	105	8	No	
13 Aug. 80	438	LO438 RM438	M	56	4	No	
13 Aug. 80	B	LO444 RM444	M	10	Cub	No	Cub of #429.
26 Sep. 80	B	LO444 RM444	M	12	Cub	Yes, 1980	Cub of #429.
7 July 81	444/ B	LO444 RM444	M	22	1	Yes, 1980	Cub of #429. Both #444 and #450 caught in same barrel trap. Radiocollar attached.

Table 18 (continued)

Date	Lip tattoo	Ear tags	Sex	Weight (kg)	Age	Recapture	Comments
11 Sep. 81	444	LO444 RM444	M	30	1	Yes, 1980	Radiocollar left on.
14 Aug. 80	447	LO447 RM447	M	91	5	No	Left index digit broken.
30 Aug. 80	424	LM424 RO601	F	64	8	Yes, 1979	
24 May 81	424	LM424 RO601	F	43[a]	9[b] 10	Yes, 1980	With 2 cubs. Radiocollar attached.
1 Sep. 80	436	LM436 RO436	F	50	5	No	Lactating.
21 Sep. 80	448	LO448 RM448	M	64	3	No	
7 Feb. 81		RM409	M		6	Yes, 1978	Immobilized in tree den. Radiocollar replaced.
4 June 81	449	LO449 RM449	M	43[a]	2	No	Radiocollar attached.
4 June 81	602	LO602 RM602	M	43[a]	2	No	

Table 18 (continued)

Date	Lip tattoo	Ear tags	Sex	Weight (kg)	Age	Recapture	Comments
6 July 81	450	LO450 RM450	M	22	1	No	Cub of #429. Radiocollar attached.
7 July 81	450	LO450 RM450	M	22	1	Yes, 1981	Cub of #429. Both #450 and #444 caught in same barrel trap.
9 Sep. 81	450	LO450 RM450	M	30	1	Yes, 1981	Radiocollar left on.
28 July 81	604	LO604 RM604	M	68	4	No	
18 Aug. 81	605	LM605 RO605	F	48	4	Yes, 1979	
12 Sep. 81	606	LM606 RO606	F	32	2	No	
12 Sep. 81	607	LO607 RM607	M	32	1	No	

[a] Weight understated due to inadequate scales (43 kg maximum)

[b] Age differed from different tooth sections

APPENDIX C

Table 19. Seasonal and annual home range sizes (km^2) for individual black bears in the GSMNP, 1980-82.

Bear	Reproductive status	1980 summer	1980 fall	1981 spring	1981 summer	1981 fall	1982 April[a]	1980 annual	1981 annual
405	Adult	5.7	37.4					45.0	
409	Adult	6.1	102.9	11.0	23.4	36.9	7.5	131.1	61.4
433	Adult	11.5	70.4					81.9	
437	Adult	32.0	116.5	4.4	27.3	14.9		173.2	36.0
439	Adult	40.7	178.4		20.6	18.7	5.6	207.8	59.4
406	Subadult		138.8						
419	Subadult	15.9	101.0		8.1	14.6		143.5	
428	Subadult	11.9	42.1[b]					50.6[b]	
449	Subadult				15.6	14.1			20.0
444	Yearling				2.6	6.3	2.0		8.1
450	Yearling				1.6	46.6	0.1		46.6

Table 19 (continued)

Bear	Reproductive status	1980 summer	1980 fall	1981 spring	1981 summer	1981 fall	1982 April	1980 annual	1981 annual
				FEMALES					
408	With cubs	3.4	10.2					10.5	
	Breeding[c]			1.6	3.2	2.6			4.2
421	With cubs	2.8	5.5					6.2	
	Breeding			1.8	5.4	4.2			8.6
429	With cubs	4.1	6.8					8.5	
	Breeding			1.6	3.2	4.0			5.0
424	With cubs				1.7	3.7			4.6
432	Breeding	4.6	16.5					17.5	
	With cubs			0.4					
440	Breeding	3.5	22.5					25.2	
	With cubs			0.9	3.2				
442	Breeding	2.2	7.9					9.0	
434	Subadult	5.0							

[a]April 1982 spring ranges not included in analysis

[b]range size including when chased by poachers: Fall=47.4, annual=55.9

[c]with yearlings in spring, solitary and breeding in summer, solitary and pregnant in fall

APPENDIX D

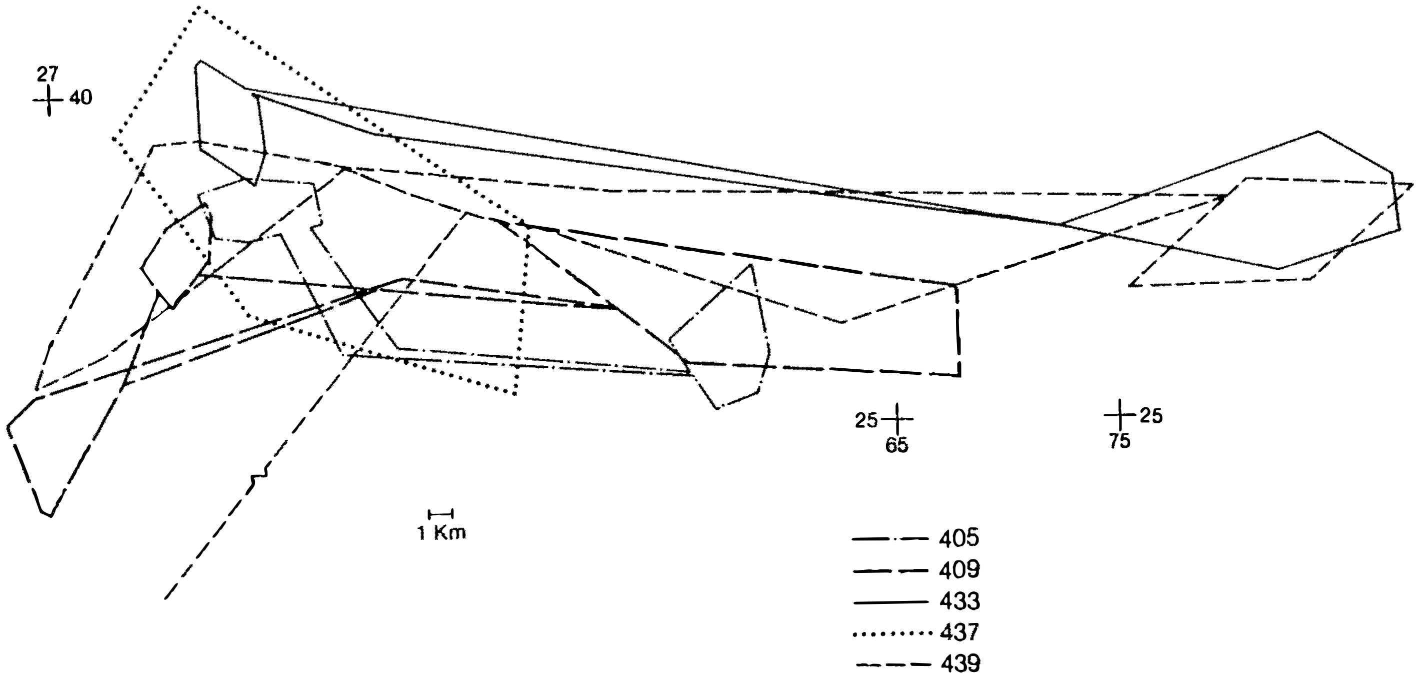

Fig. 13. Annual home ranges of adult male black bears in the GSMNP, CNF, and NNF, 1980.

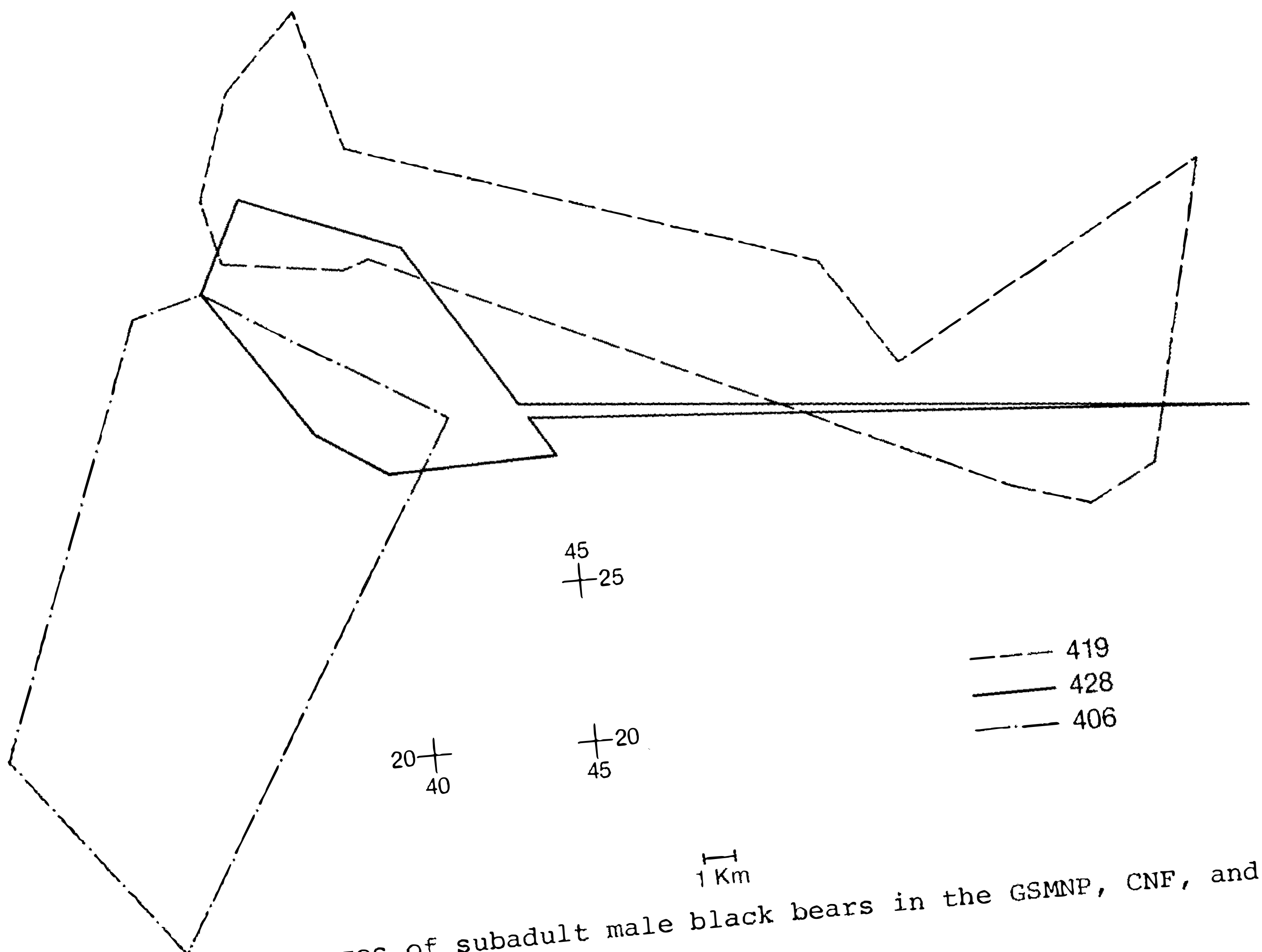

Fig. 14. Annual home ranges of subadult male black bears in the GSMNP, CNF, and NNF, 1980.

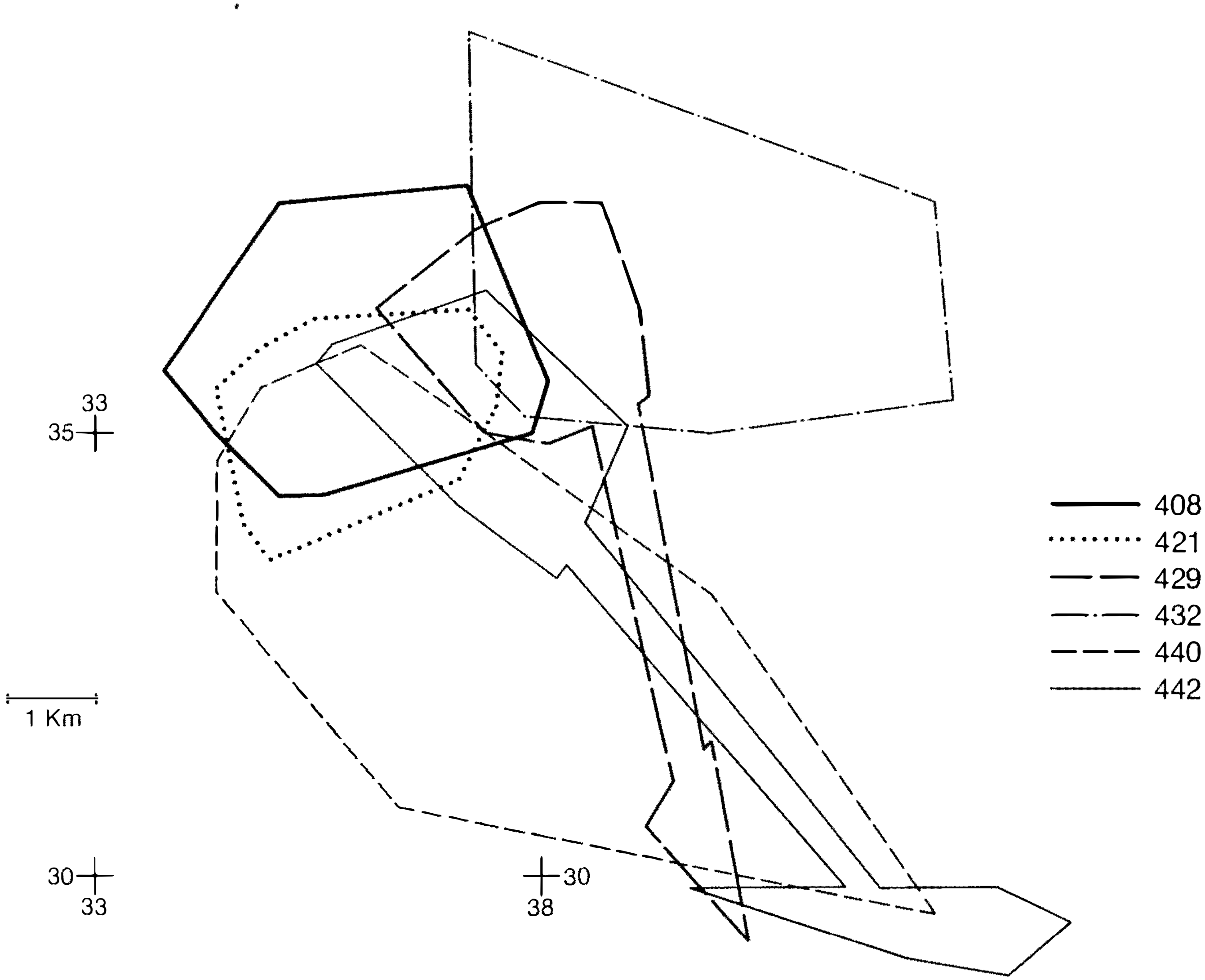

Fig. 15. Annual home ranges of adult female black bears in the GSMNP, 1980.

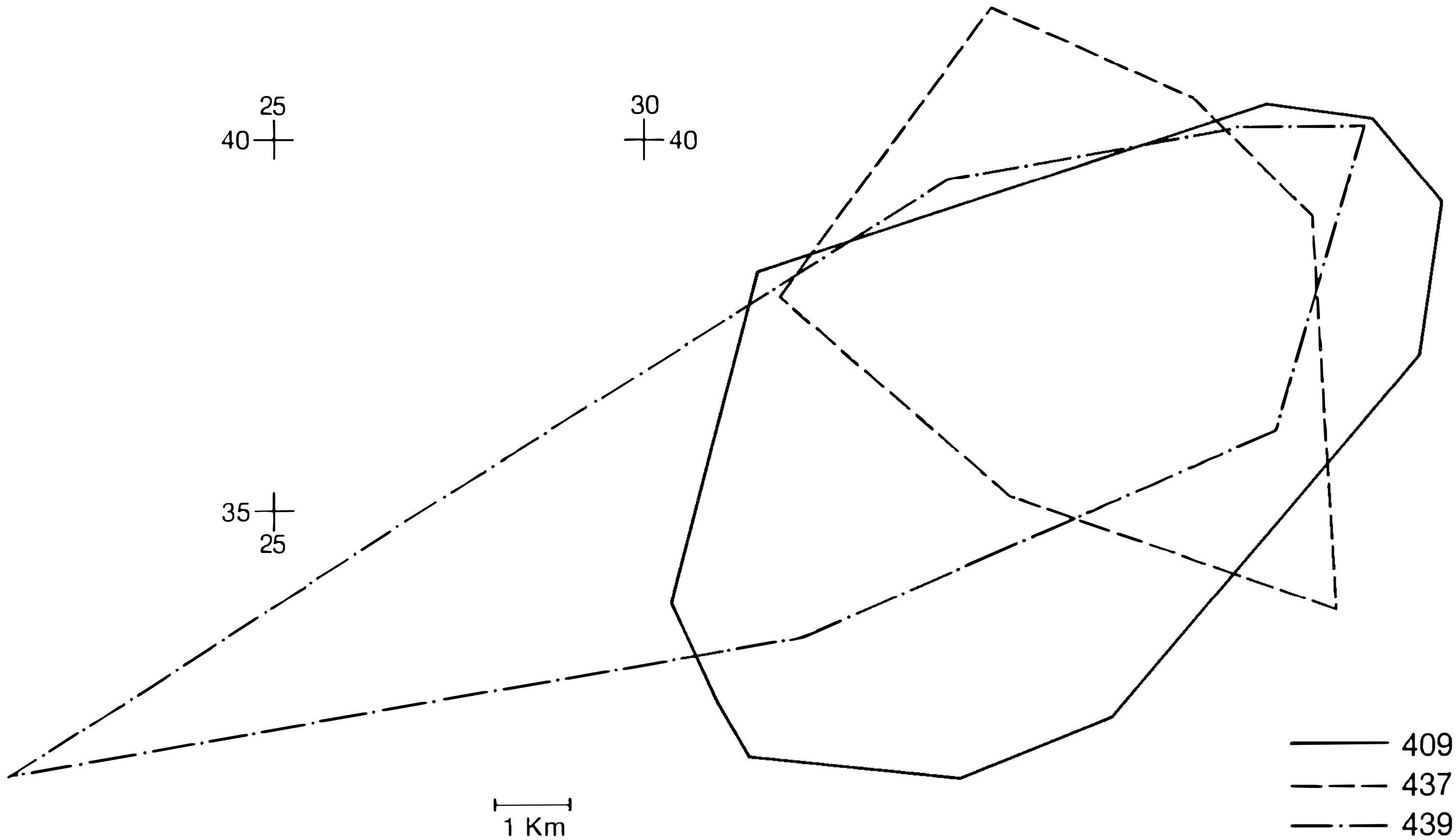

Fig. 16. Annual home ranges of adult male black bears in the GSMNP and CNF, 1981.

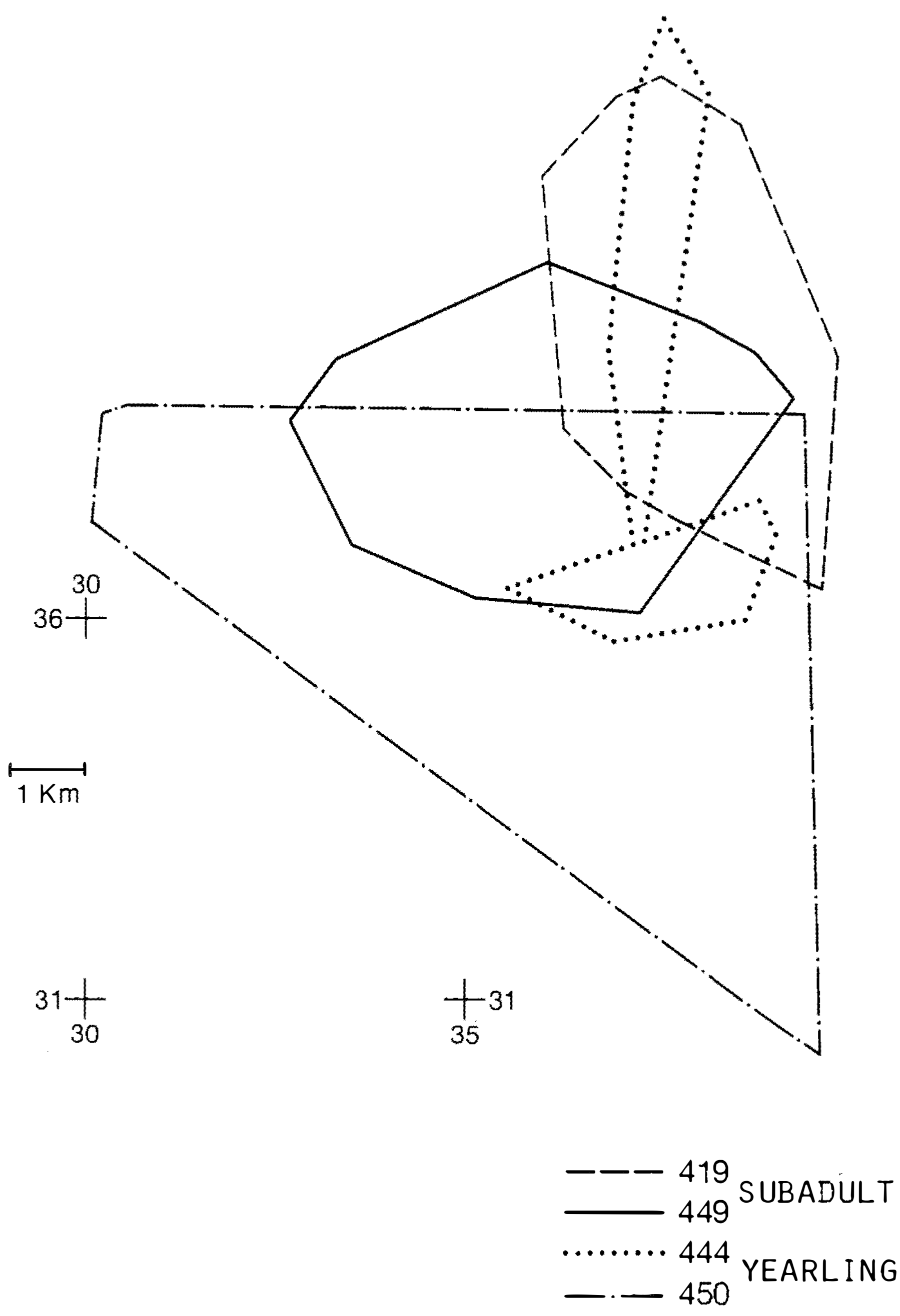

Fig. 17. Annual home ranges of subadult and yearling male black bears in the GSMNP, 1981.

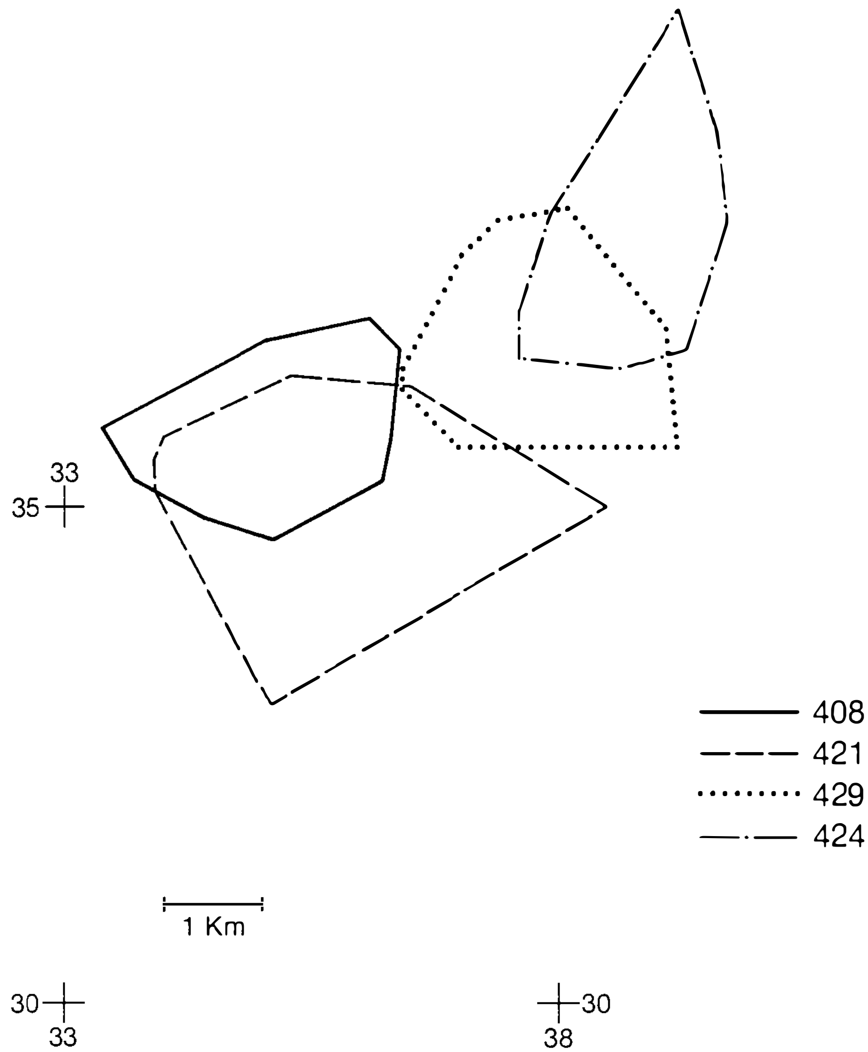

Fig. 18. Annual home ranges of adult female black bears in the GSMNP, 1981.

APPENDIX E

Table 20. Comparison of 1980 and 1981 trapping success in Bunker Hill area, GSMNP.

Year	Trapnights	Bear visits	Bear captures	Trapnights per visit	Trapnights per capture	% sites visited within 5 days (n)
1980	241	61	28	3.95	8.61	50.0 (36 of 72)
1981	123	34	15	3.62	8.20	50.0 (22 of 44)

APPENDIX F

Table 21. 95% confidence intervals for forest type utilization by black bears in the fall in the GSMNP.

Reproductive status	Closed oak 95% C.I.	Closed oak % of fall area	Open oak-pine 95% C.I.	Open oak-pine % of fall area	Cove hardwood 95% C.I.	Cove hardwood % of fall area	Other 95% C.I.	Other % of fall area
MALES								
Adult								
Fall 80	0.807-0.645	0.600	0.103-0.017	0.093	0.278-0.132	0.199	0.026-0.000	0.108
Fall 81	0.657-0.427	0.430	0.334-0.138	0.332	0.285-0.103	0.183	0.066-0.000	0.065
Subadult								
Fall 80	0.840-0.620	0.608	0.167-0.023	0.118	0.269-0.081	0.187	0	0.087
Fall 81	0.898-0.628	0.436	0.202 0.008	0.317	0.202-0.008	0.188	0.077-0.000	0.059
FEMALES								
Solitary								
Fall 80	0.762-0.556	0.547	0.145-0.025	0.226	0.350-0.162	0.178	0	0.048
Fall 81	0.598-0.390	0.436	0.362-0.178	0.317	0.324-0.148	0.188	0	0.059
With cubs								
Fall 80	0.651-0.453	0.547	0.203-0.067	0.226	0.405-0.219	0.178	0	0.048
Fall 81	0.610-0.256	0.436	0.539-0.195	0.317	0.255-0.011	0.188	0.156-0.000	0.059

VITA

Patrick C. Carr was born 12 February 1958 in Scranton, Pennsylvania. He lived his life in Moscow, Pennsylvania and attended schools in that area. He graduated from North Pocono High School in 1976 and in the fall of that year entered the Pennsylvania State University. He graduated with honors in May 1980 with a Bachelor of Science degree in Environmental Resource Management. In June of 1980 he entered the University of Tennessee at Knoxville. He graduated in December 1983 with a Master of Science Degree in Wildlife and Fisheries Science.

Mr. Carr has worked for the Pennsylvania Game Commission, the New York Zoological Society, and the National Park Service and was president of the University of Tennessee Chapter of the Wildlife Society in 1981-82.