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HABITAT AND SPACE UTILIZATION OF BLACK BEARS IN CHEROKEE NATIONAL FOREST, TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Anthony Paul Clevenger

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ABSTRACT

Thirty-four black bears (Ursus americanus) were captured a total of 43 times in the Citico Creek area of the Cherokee National Forest (CNF) during 1982 and 1983. Seven yearlings from 3 families were immobilized and radio-collared in winter dens during February 1983 and their movements thereafter were monitored. A total of 1635 radio locations were collected from 20 bears. Data were collected during the entire study for 5 bears and continuous data were recorded for 8 bears from previous studies. The timing of family breakup occurred in 2 families between 29 May and 5 June, and 22 June and 25 June, respectively. Reassociations between mother and offspring and between siblings did occur after breakup. Summer and fall home ranges of adult males were 20 km^2 and 132 km^2, respectively, and were significantly larger ($P<0.002$) than summer and fall ranges of adult females, which were 4 km^2, respectively. The mean summer ranges of adults measured 11 km^2 while those of yearlings averaged 4 km^2. Fall ranges for adults were 77 km^2 and yearlings 20 km^2. The intra-year ranges of adult males from summer to fall increased significantly for both years ($P=0.025$). Such an increase has not been reported for adult males in Great Smoky Mountains National Park. This was probably due to hunter-related activities in CNF in the fall. Intra-year ranges remained constant for adult females during the study. The intra-year seasonal ranges of yearlings

increased significantly ($P<0.01$) from summer to fall and could be explained as pre-dispersal or exploratory movement behavior. Adult males and all yearlings shifted seasonal activity centers more than adult females. Extensive home range overlap occurred among adult males while little overlap was found among adult females. Yearlings, after separation from their mothers, became progressively independent of their mothers' range. Mean distances between mothers and offspring, and between siblings after family breakup, increased each month as family bonds began to weaken and exploratory movements took place. Notably long range movements by bears did occur, mainly into the Nantahala National Forest, North Carolina.

All bears used the Mesic Hemlock and Oak-Hickory forest types, stands in the 70 and older age class more than expected, and the early succession areas less than expected. Bears used the Mature Pine and Mature Hardwood forest types more than expected. In summer, adult bears used the Oak-Hickory forest type and stands between 30 to 49 and 70 to 89 years old; yearlings preferred the Cove Hardwood forest type, Mature Pine areas, and old age stands. In fall, adults preferred the Mesic Hemlock and Oak-Hickory forest types and stands between 10 to 20 and 70 to 89 years old; yearlings were indifferent to all forest types and forest stand age classes. The Oak-Hickory forest type appeared to be the most preferred and important of all forest types throughout the year for all bears. Yearlings used lower quality habitats during summer and fall, males particularly, possibly for avoiding conflicts with adults. Yearling

females remained within their mothers' range and occupied sub-optimum habitats.

Bears in the CNF are being impacted by illegal hunting and other related activities. This situation has been promoted by the relative ease of access to many parts of the Forest and inadequate law enforcement. The Tellico Bear Refuge appears to be effective and is complemented by adjacent wilderness areas in North Carolina. By reducing road access to many areas, the suitability of the Forest for black bears will be elevated.

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CHAPTER I

INTRODUCTION

The black bear (Ursus americanus) is the most common and widely distributed of the three species of ursids on the North American continent. It is a highly adaptable animal, an opportunist, that appears to be able to survive in close proximity to humans as long as there is abundant and suitable habitat nearby and a minimal amount of human harassment.

Black bears are adapted behaviorally and ecologically for a sylvan existence. They have evolved in the forested areas (Herrero 1972) and are generally more timid than the aggressive brown bear (U. arctos). Their claws are short and curved and their bodies are morphologically adapted to climbing; they are able to climb trees at an early age. Trees are vital to the survival and livelihood of black bears, which use them for protection, defense of offspring, denning, and their food value. Being omnivores, they feed heavily on the forests' abundant resources throughout the year. Foods include acorns, nuts, fruits, saprophytic plants, grasses, and assorted forest insects (Beeman and Pelton 1980, Eagle and Pelton 1983).

In the Southern Appalachian mountains today, black bears are in the same predicament that we find many large, wide-ranging mammals in North America. Once endowed with large expanses of continuous habitat relatively unaltered by man, these areas have

become patchy and smaller in size due to human need for natural resources and will to convert undeveloped roadless areas.

During the late 1960's, it appeared that black bears in the Southern Appalachians were declining or in questionable status. With no baseline population or habitat data available for bears in this region, it became apparent that research needed to be initiated investigating these topics and others that would aid in establishing management guidelines. In 1969, black bear research began in the Southern Appalachian mountains. Continuous research on black bear ecology has been conducted in Great Smoky Mountains National Park (GSMNP) since 1970. Here, the earliest studies focused primarily on basic ecology of black bears, including movements, activity patterns, diet, denning behavior and demographics (Marcum 1974, Beeman 1975, Eubanks 1976, Eagar 1977, Johnson 1978). In 1978, black bear research was first begun outside of GSMNP, in the Cherokee National Forest (CNF) on the Tellico Wildlife Management Area, and was conducted concurrently with GSMNP studies (Eiler 1981, Quigley 1982, Villarrubia 1982, Carr 1983, Garris 1983, Wathen 1983). Over the next 4 years, comparable research projects were initiated concerning activity patterns, movements, habitat utilization, reproduction and denning. Brody (1984a) in 1982 began research of black bear habitat use in relation to United States Forest Service (USFS) forest management practices in the Pisgah National Forest (PNF), North Carolina, adjoining the northeastern corner of GSMNP and it is continuing today. At the same time, this study was initiated at the southwestern corner of GSMNP in CNF.

Research into the movements, habitat use, and survival rates of subadult bears from family breakup until they reach adult age has not been documented in the Southern Appalachians and has rarely been reported for other areas of the United States (Rogers 1977, Alt 1978). Subadult bears, particularly males, are typically the least settled and often require several years before establishing themselves. In doing so, they may travel over large areas and move far from their mothers' home area. This information, if applied to areas subjected to hunting pressure, may provide insight as to the degree of hunting pressure (legal or illegal), survival rates of the subadult age class (necessary for population monitoring), and utility of bear refuges. Unfortunately, in this study, yearling bears were only monitored their first year, from family breakup (June) until denning. Additional time and effort would be required to monitor these subadults' movements, resource use, and survival if the above-mentioned information would want to be clarified.

This study was the third in a three-part series of Master's level research projects involving black bear habitat utilization and seasonal movements in the CNF initiated in 1978 by the Department of Forestry, Wildlife, and Fisheries, The University of Tennessee, Knoxville.

Specific objectives of the study were as follows:

-- to determine the timing of family breakup and duration of kinship bonds.

-- to determine the post-breakup patterns of space use among adult and yearling black bears.

-- to determine the patterns of habitat use by adult and yearlings.

CHAPTER II

STUDY AREA

Location

The Cherokee National Forest totals 4,905 km^2 (19,858 acres) forming a narrow strip, 24 km wide along the North Carolina state line; it is located in 10 East Tennessee counties: Carter, Cocke, Greene, Johnson, McMinn, Monroe, Polk, Sullivan, Unicoi, and Washington. The Forest is divided into six administrative Ranger Districts, three to the north of Great Smoky Mountains National Park and three to the south. The present research was conducted on the Tellico Ranger District (approximately 760 km^2) in the southern portion of the Forest. The study area within this district was located in Monroe County, Tennessee, 13 km east of Tellico Plains, and 72 km south-southwest of Knoxville. It is adjacent to the North Carolina boundary and includes the newly created Citico Creek Wilderness Area (131 km^2) (1984 Tennessee Wilderness Act) (Figure 1). The Citico Creek watershed was the focal point for the study; other major drainages include, Slickrock Creek, Doublecamp Creek, and Jake Best Creek.

Physiography and Geology

The area is part of the Blue Ridge Province and is in the northern Unicoi Mountains. The Unicoi Ridge is situated in a

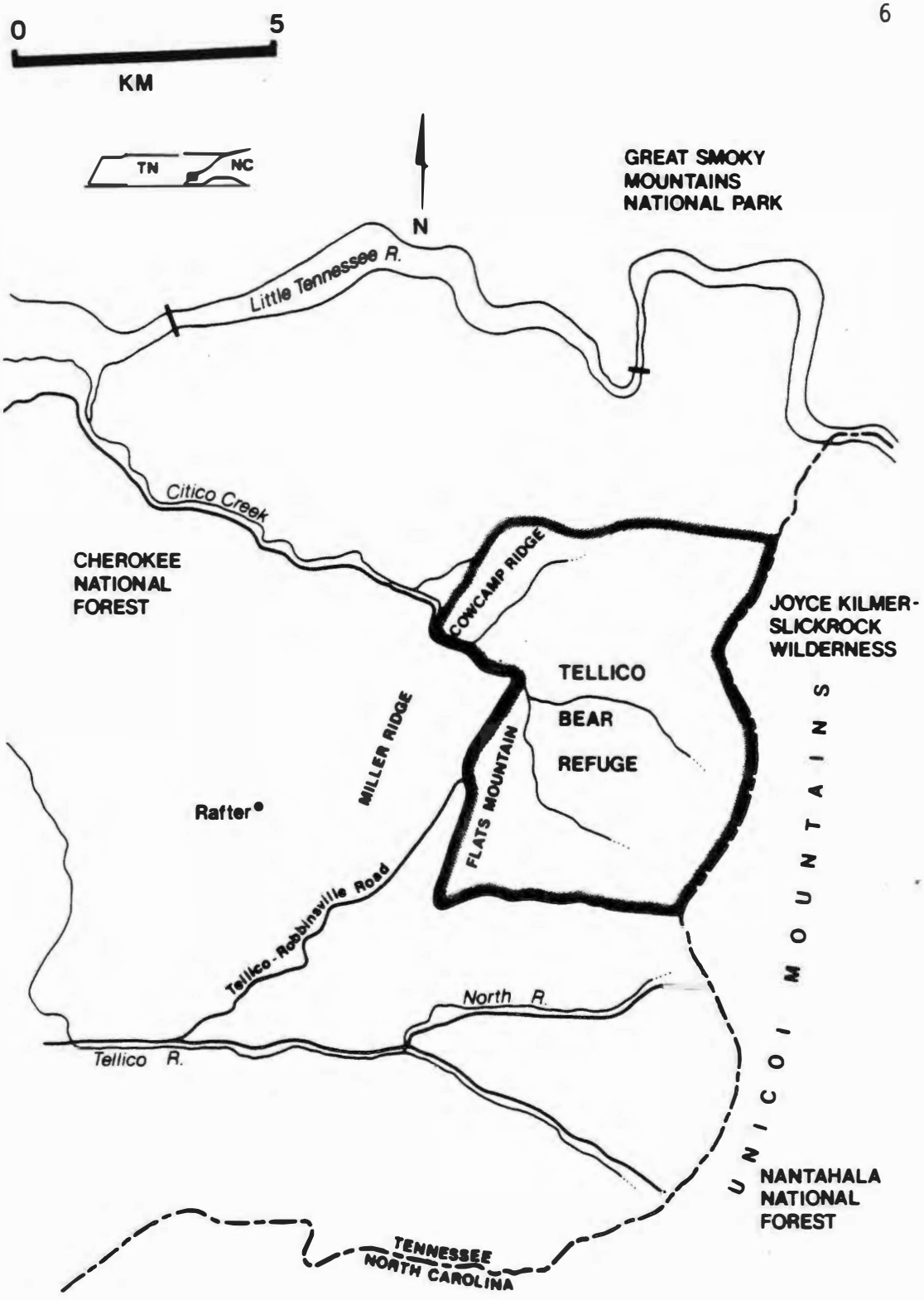


Figure 1. The Citico Creek Study Area in Cherokee National Forest, Tennessee.

north-south direction and delineates much of the Tennessee-North Carolina state line. Numerous spur ridges radiate from the Unicoi Ridge, the most prominent being Sassafrass and Pine Ridges. Elevations range from 450 m to 1550 m. The terrain is rugged and is characterized by steep mountains and perennial, fast-flowing, cold water streams and rivers. More than 90% of the area is on slopes exceeding 15% (USFS 1982).

Climate

Mean annual precipitation for the area is approximately 170 cm (70 in) (USFS 1982). Less than 3% of this occurs as snowfall, which averages 63 cm (25 in) per year. March is the wettest month; October is the driest. Rainfall increases significantly with elevation. Air temperatures are cooler than most of the surrounding region. Summer temperatures rarely exceed 32° C (90° F) except on the exposed ridges. Winter temperatures remain below freezing for extended periods with lows between -23° C (10° F) and -18° C (0° F) not uncommon. The period between the last frost in spring and the first in fall is generally from 2 May to 25 September.

Biota

Flora. Forests cover about 99% of the study area. The vegetation consists of second growth mixed hardwood or pine stands, most in the 50 to 69 year age class. Five major forest types or plant communities are present:

1) Cove Hardwood--This community occurs between elevations of 170 m to 1330 m on lower slopes, northerly slopes, coves, ravines, and moist flats. Predominating tree species are tulip poplar (Liriodendron tulipifera), white oak (Quercus alba), and northern red oak (Q. rubra). Understory species consist in part of strawberry bush (Euonymus americanus) and spicebush (Lindera benzoin) at lower elevations, serviceberry (Amelancier laevis), fire cherry (Prunus pensylvanica), and wild hydrangea (Hydrangea arborescens).

2) Oak-Hickory--This occurs in coves, mountain slopes, high valleys and flat ridge tops. Predominant species include southern red oak (Q. falcata), white oak (Q. alba), hickories (Carya spp.), post oak (Q. stellata), black oak (Q. velutina), chestnut oak (Q. prinus), and scarlet oak (Q. coccinea), shortleaf pine (Pinus echinata), Virginia pine (P. virginiana), and pitch pine (P. rigida). Understory species consist in part of sourwood (Oxydendrum arboreum), redbud (Cercis canadensis), buckthorne (Rhamnus spp.), and mountain laurel (Kalmia latifolia).

3) Pine--This type occurs on old fields, relatively infertile ridges, dry flats and slopes, and is found mostly below 1000 m in elevation. Predominant tree species include, white pine (P. strobus), shortleaf pine, Virginia pine, pitch pine and table mountain pine (P. pungens). Understory species consist of ericaceous species including, mountain laurel, blueberries (Vaccinium spp.), huckleberries (Gaylussacia spp.) and flame azalea (Rhododendron calendulaceum). Other species include blackberry (Rubus spp.) and holly (Ilex spp.).

4) Mesic Hemlock--This type occurs above 500 m in cool locations, moist coves and ravines and northern slopes. Predominant tree species include white pine, hemlock (Tsuga canadensis), yellow birch (Betula alleghaniensis), sugar maple (Acer saccharum), tulip poplar, basswood (Tilia americana), blackgum (Nyssa sylvatica), northern red oak, and cucumbertree (Magnolia acuminata). Understory species consist in part of rosebay rhododendron (R. maximum), dog hobble (Leucothoë spp.), and mountain laurel.

5) Northern Hardwoods--This forest type occurs above 1200 m on sites with adequate moisture and relatively high fertility. Predominant tree species include sugar maple, American beech (Fagus sylvatica), yellow birch, sweet birch (B. lenta), basswood, red maple (A. rubrum), hemlock, northern red oak, and black cherry (P. serotina). Understory species consist of mountain maple (A. spicatum), striped maple (A. pensylvanicum), and serviceberry. This community was distributed sparsely throughout the study area.

Fauna. Of about 754 vertebrate species listed for the state of Tennessee, the CNF provides important nesting and/or feeding habitat for approximately 495 of these (USFS 1984). This includes 32 species of amphibians, 150 species of birds, 247 fish, 43 mammals, and 23 reptiles. Linzey and Linzey (1971) list 59 species of mammals for GSMNP.

Wildlife on the Tellico District can be divided into three general categories: big game, small game, and non-game animals.

Big game animals that are present include black bear, wild turkey (Meleagris gallopavo), white-tailed deer (Odocoileus virginianus), and European wild hog (Sus scrofa). The small game category includes gray squirrel (Sciurus carolinensis), ruffed grouse (Bonasa umbellus), and raccoon (Procyon lotor) among others. A wide range of non-game species are found in the Forest, and the management of these has received increasing emphasis in recent years.

The largest variety of breeding songbird species south of the Lake States and Eastern Canadian border occurs in the southern Appalachian Mountains (King and Stupka 1950). This area supports about 120 species of breeding birds and can be compared to the Florida peninsula which supports about 70 species.

Other mammal species include striped skunk (Mephitis mephitis), gray fox (Urocyon cinereoargenteus), red fox (Vulpes vulpes), oppossum (Didelphis virginiana), bobcat (Lynx rufus) and woodchuck (Marmota monax). Species of special concern (USFS 1982) here include the star-nosed mole (Condylura cristata), woodland jumping mouse (Napeozapus insignis), and northern water shrew (Sorex palustris).

The areas' 160+ kilometers of perennial streams contain good populations of wild rainbow trout (Salmo gairdnerii), and in several creeks, eastern brook trout (Salvelinus fontinalis).

History and Land Use Pattern

The area's current vegetative cover is the direct result of human activity over the last 75 years. The dominant influences

have been logging and wildfires in the early 1920's. Logs were removed on tramways cut into the steep mountain slopes. The railway cuts and fills are still visible today. Near the end of the logging operations in 1925, a disastrous wildfire burned much of the area, killing two people and destroying many of the facilities necessary for timber harvesting operations (Lambert 1961). The high cost of replacement forced loggers to discontinue the operations. This left a few inaccessible, small stands of virgin timber uncut. The Forest Service bought the land in the early 1930's from Babcock Lumber Company and the Tellico River Company. Management direction since then has been to let natural processes heal the damage (USFS 1982). Current forest practices for the CNF are described in the CNF Timber Management Unit Plan (USFS 1976).

The entire CNF is considered a wildlife management area and its wildlife resources are administered in cooperation with the Tennessee Wildlife Resources Agency (TWRA). A portion of the study area is administered as the 124 km^2 Tellico Bear Refuge (Figure 1, page 6); no bear hunting is allowed. However, dogs are allowed for raccoon and grouse hunting on the Bear Refuge.

Socio-Economic Setting

The complexity and dynamic quality of the East Tennessee socio-economic environment make it impossible to produce generally applicable characterizations of the human populations involved. Much has been written about the populations of the region (Kephart 1976,

Frome 1980), often with an underlying assumption of a large degree of cultural unity in the area which has come to be known as "Appalachia." Poverty, illiteracy and a general isolation from the mainstream of American life come to mind when that term is used. While these characteristics are found among the local people, they are not the predominant conditions. There are, nonetheless, certain areas in Monroe County where poverty and illiteracy are higher than the state and national averages.

In the more mountainous areas, industrial development has been slow due both to lack of transportation facilities and scarcity of developable land. In these same areas, there is little potential for modern commercial agriculture, and therefore there are higher levels of unemployment, poverty, and associated social and economic problems. Monroe County has a population of 28,700 (1979), consisting of 3.3% minorities compared to 16.5% for the state (USFS 1984). The median income per household of $11,783 is below the state average ($14,152) and 19.1% of the population is below the poverty level (USFS 1984).

CHAPTER III

MATERIALS AND METHODS

Capture and Processing

Trapping. Field work for the study began in July 1982 and was terminated in December 1983. The capture of bears took place during the summer months of both years. In the study area, four different localities were selected for running a trapline based on the estimated bear density and the need for transmittered bears in the respective areas. These areas included Cowcamp Ridge, Doublecamp Creek, and Flint Branch (Figure 2). Individual traps generally were located in sites that appeared to be well-traveled by bears, i.e., gaps or passes on ridges and open, level clearings in creek bottoms. Traplines were checked daily from a vehicle on Cowcamp and Doublecamp Ridge, and on foot at Doublecamp Creek and Flint Branch.

Bears were captured by modified Aldrich foot snares using the methods described by Johnson and Pelton (1980). During both summers, bears were immobilized with M-99 (Etorphine hydrochloride, D-M Pharmaceuticals, Rockville, MD) at a dose of 1 mg per 45 kg. After processing, they were given an intravenous injection of the antagonist drug, M50-50 (Diprenophrine hydrochloride, D-M Pharmaceuticals, Rockville, MD), at a dose of 2 mg per 45 kg. The

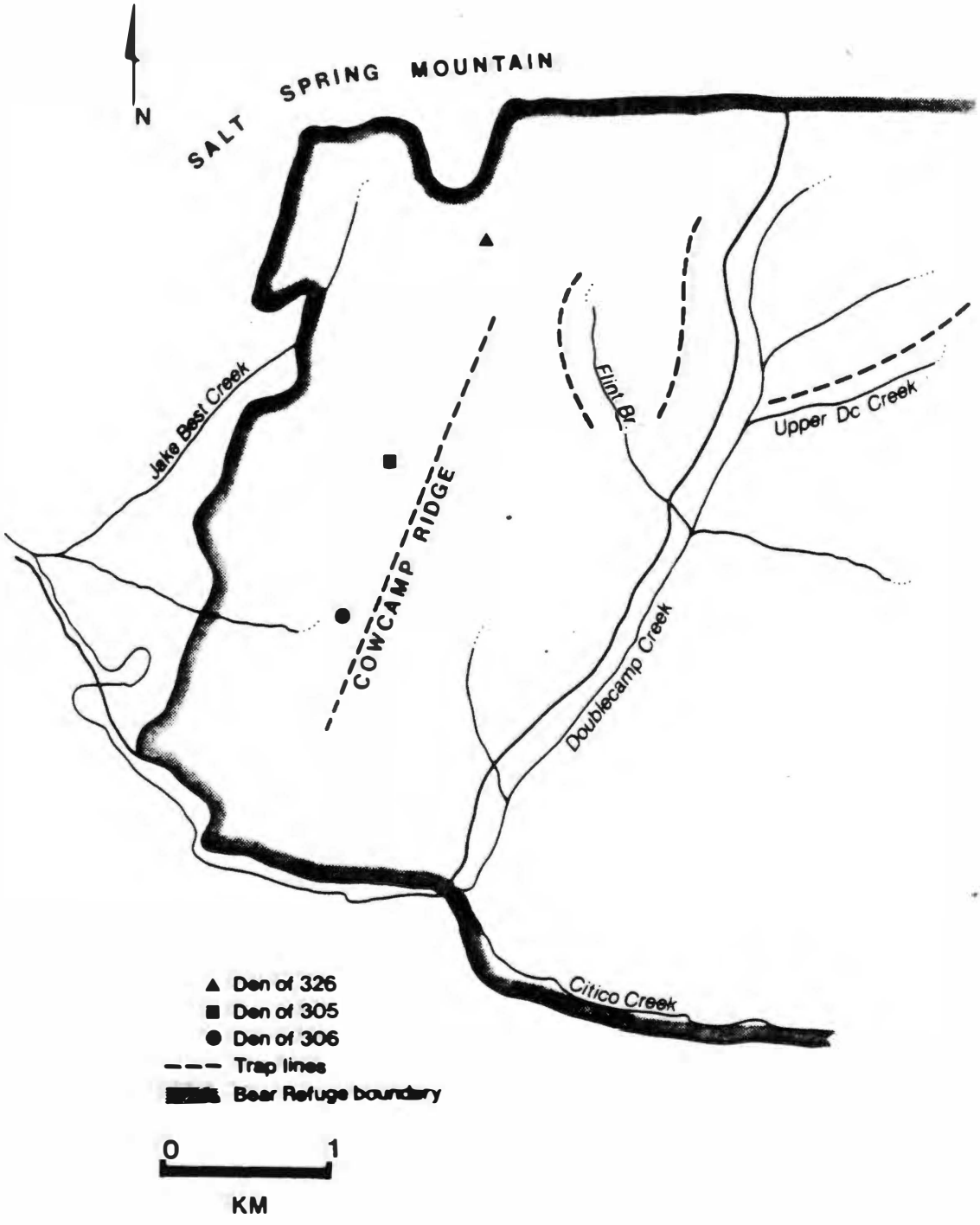


Figure 2. Traplines and Densites of Females With Yearlings in the Citico Creek Study Area, Cherokee National Forest, Tennessee.

immobilizing drug either was administered from a dart fired from a carbon-dioxide-powered pistol (Capchur, Palmer Chemical Company, Douglasville, GA) or by a jabstick and syringe. One free range capture also was made.

Unmarked bears were ear-tagged by a double color-coding system whereby males received a silver metal numbered tag in the right ear and a yellow numbered tag in the left ear, and females the reverse. The upper lip of each bear was tattooed with its eartag number for added identification. One first premolar was collected for age determination, using the techniques of Willey (1974) and Eagle and Pelton (1978). A spring scale was used to obtain the weight of each animal and body measurements were recorded. Other biological information recorded included: general condition, reproductive status, presence of scars, ectoparasites, and markings. Any injuries incurred from the capture, or otherwise, were treated with a spray disinfectant. Selected individuals were fitted with radio collars (Telonics Inc., Mesa, AZ).

Winter immobilizations. During January 1983, the winter dens of 3 radio-collared adult females with yearlings were visited (Figure 2). At the densite, the mothers initially were immobilized with a mixture of Ketamine hydrochloride (Bristol Laboratories, Syracuse, NY) and Rompum (Xylazine, Haver-Lockhart, Inc., Shawnee, KS) at a dose of 200 mg/100 mg per 45 kg body weight. The drug was administered by a hand-held syringe or jabstick and syringe

depending upon the bears' reactions to our presence. Once the mother became completely immobilized, each yearling in the litter then was immobilized by the same methods. Individual yearlings were sexed, ear-tagged, weighed and fitted with a radio collar. The radio collar of the mother was replaced if it was nearing its expiration date or readjusted if weight changes warranted it. These were the only biological data collected and modifications made as it was imperative to keep the handling time and disturbance to a minimum. Once the processing was completed, the mother was put back into the den along with the yearlings. If the occupied den was a ground den, an effort was made to rebuild and partially close off the den entrance with conifer branches in an attempt to keep the family from abandoning the den after recovering from the immobilizations.

Age classification. Four age classes of bears were recognized: 1) Cub--all bears less than 1 year of age; 2) Yearling--all bears between 1 and 2 years of age; 3) Subadult--all bears between 2 and 3 years old; and 4) Adult--all bears greater than 3 years old.

Radio Telemetry

Equipment. All of the radio transmitters used during the study operated at the 150-152 MHz range. All adults were fitted with motion-sensitive radio transmitters capable of emitting 2

different signal modes (Quigley 1982) determined by activity, while yearlings were fitted with single mode transmitters.

Radio collars consisted of the breakaway and static models. Breakaway radio collars were fastened with two 2-inch strips of surgical tubing and were designed to break away from the animal 1 to 2 years after installation. These collars were fitted on all yearlings and some smaller adults, i.e., bears which were growing. When used, several layers of electric tape were applied to the exposed surgical tubing to prevent bears from severing the tubes and shedding the collars prematurely. Static collars were fitted on adults or bears which were near or fully grown and were intended to remain on the animal.

A Telonics TR-2 receiver, coupled with a Telonics scanner/programmer, was used with a hand-held 2 element yagi antenna (Telonics RA-2A-H) in receiving signals from the transmitters. Other equipment used included headphones and occasionally a dipole or "whip" antenna while driving (and scanning frequencies) to determine if transmittered bears were in or near the area traveled.

Directional accuracy. Prior to the collection of radio telemetry location data, a test of directional accuracy was performed. Several transmitters were placed in known locations, half on ridge tops and half in creek bottoms. Approximately 100 readings were taken on these transmitters and a radio tracking margin of error (95% confidence limits) was established and used to construct "error polygons" (Springer 1979) delineating the animals' positions.

Data collection. Radio locations attained from the ground were by triangulation using the "loudest signal method" (Springer 1979). Often, 3-6 azimuths were required before a "fix" could be established to obtain one radio location. In the field, only 2 azimuths of these were selected to construct the error polygons. Attempts were made to keep the time between azimuths to a minimum so that the animal's movement may not introduce error into the calculation. The angle of their intersection was equally important. Only azimuths with intersections between 60°-120° were considered. Anything outside of this range formed large and narrow polygons, rendering the margin of error qualities ineffective.

Due to the rugged terrain in the study area, driving from one location to another to radio track was often time-consuming. Occasionally 1 hour would pass from the time of the first azimuth to the last. Mobility in most parts of the study area to radio track was difficult and therefore resulted in many radio locations being discarded.

The azimuths were entered into the computer program "PLOTEQ" (Brody 1984b) along with associated information, e.g., weather conditions, time, activity. From this program, the four corners of the error polygon and its center were given UTM coordinates (Universal Transverse Mercator Grid System). The program "NEWPLO" (Brody 1984b) was used with a Cal-Comp flatbed plotter to draw the error polygons on tracing paper at 1:24,000 scale. These were then overlaid directly onto USFS stand maps of the same scale.

Aerial tracking was conducted whenever transmittered bears could not be located in the study area and regularly during the fall months when movements became erratic and wide-ranging. A Cessna 172 or Skymaster aircraft with a 2 element Telonics RA-2A-H antenna mounted on each wing strut were used to radio track. The aerial homing technique used in locating the animals is described by Villarrubia (1982). Instead of calculating an error polygon, a circle with a diameter of 300 m was used marking individual locations (Quigley 1982). Because of the dense forest cover, radio-collared bears were very rarely seen while tracking from the air (n=2 bears; 0.47% of all aerial radio locations).

Data Analysis

Seasons. For this study, seasons were defined as the following:

Spring - 1 April to 15 June

Summer - 16 June to 15 September

Fall - 16 September to 15 December

These dates were based on my observations of the plant phenology and the period of availability of the primary food items (Beeman and Pelton 1980, Eagle and Pelton 1983) of each season. My basis for establishing the onset of each season is as follows: 1) Spring--bears become active after den emergence generally around the early part of April (Eiler 1981, Wathen 1983, this study). 2) Summer--soft mast or berries (*Vaccinium, Rubus, Gaylussacia* spp.) did not begin

to ripen until the middle of June, in some localities later. 3) Fall--hard mast (Quèrcus and Fagus spp.) did not reach maturity on the trees until the middle of September; this coincided with observations of bears in oak trees eating acorns and observations of broken limbs of oaks. Acorns generally were found to drop to the ground after the middle of September. This period of hard mast availability is supported by Stricklands' (1972) study of hard mast availability in the same study area.

Home range. Home ranges were calculated by several methods, but in most cases the minimum convex polygon method (Hayne 1949) was employed using the Fortran computer program TELEM (Koeln 1980). This technique was selected because of its graphic simplicity and wide historical use among studies of large mammals, particularly bears (Jonkel and Cowan 1971, Lindzey and Meslow 1977, and Hugie 1982). More importantly, it has been used in many black bear radio telemetry studies (occasionally with another method) in the Great Smoky Mountains and, therefore, could be applied directly for comparison (Beeman 1975, Garshelis and Pelton 1981, Quigley 1982, Villarrubia 1982, Carr 1983, Garris 1983, Brody 1984a).

The convex polygon method delineates an animals' home range by connecting the outermost points where 3 consecutive points of the polygon form an inside angle of less than 180°. This "non-probabilistic" method was applicable for these analyses because I could not meet the assumptions concerning temporal and spatial

homogeneity in sampling effort and locational independence of the "probabilistic" methods.

In calculating the area used by bears that moved erratically throughout the study area (typically in fall) and often spent short periods of time in one area before moving to another, a modification of the convex polygon method was necessary. Among these individuals, radio locations often were clustered about 2 areas. When this occurred, 2 separate convex polygons were constructed and the area of each combined; this eliminated large areas (often greater than the 2 polygons combined) that were not utilized by the animal or were only used for travelling between the two areas. When the radio locations were not clustered about 2 areas, but distributed widely throughout the study area, subjective selection of points was made in calculating the home range size. In all calculations, a minimum of 10 locations was required before calculating home ranges for individual bears.

Seasonal and annual home ranges were constructed for each bear and were then grouped into the following sex and age classes: adult male, adult female, yearling male, and yearling female. In other analyses, the home range sizes of adults were combined and compared to that of yearlings.

The Mann-Whitney U-test was used to analyze seasonal and annual differences in home range size between adults and yearlings (Sokal and Rohlf 1981), as were changes in home range size among each age and sex class from summer to fall for each year and seasonal changes between years.

Patterns of space use. A utilization distribution was calculated for each bear by the harmonic mean method of Dixon and Chapman (1980) using the Fortran computer program "UD." This distribution is derived from a reciprocal mean distance deviation (harmonic means) between each animal location and a superimposed calculation grid. Following the recommendations of Spencer and Barrett (1983), modifications were made to the original program to reduce biases. Each location is assigned a harmonic mean value based on that locations mean distance to all of the other locations. The harmonic mean center of activity is the location with the lowest harmonic mean value.

The literature presents data concerning the "center of activity" in several different ways. Whether termed center of activity (Hayne 1950), geometric center of activity (Dice and Clark 1953), or arithmetic mean center of activity (Tester and Siniff 1965, Sanderson 1966, and VanWinkle et al. 1973), all possess the same characteristics which make them misleading and disadvantageous as a measure of the center of animal activity (see Neft 1966).

The harmonic mean center possesses two important characteristics not found in the others that make it the "true" center of activity: (1) it must be located within the area under consideration, and (2) it is relatively insensitive to movements within the home range. Movements of harmonic centers of activity are likely to be sudden large shifts from one area of high activity to another and its location can be assured of having some biological significance.

The harmonic centers of activity were calculated for each individual bear and the respective UTM grid coordinates recorded. The distance between any 2 harmonic centers of activity were calculated using the Pythagorean theorem.

Bears were grouped into sex and age classes and mean distances between harmonic centers of activity were calculated for "intra-year" seasons (summer 1982 vs. fall 1982) and "inter-year" seasons (summer 1982 vs. summer 1983). A harmonic center of activity for each adult female with yearling(s) was calculated for the duration of their association. These locations then were compared with their respective harmonic centers of activity for the period after family breakup and mean distances were calculated.

The spatial distribution or home range of bears represented as convex polygons were calculated and plotted using the TELEM program. The respective locations were plotted with most of the polygons so that the intensity of use of specific areas could be determined.

The spatial distribution of adult males and females for 1982 and 1983 were plotted separately and analyzed. The points for adult females with yearlings were not plotted because the high density of points rendered the yearling points unidentifiable. Seasonal plots were made of adult females and their respective yearlings after family breakup. The responses by orphaned yearling bears to their mothers' vacated home range also were investigated.

Habitat utilization. The habitat parameters used in the following analyses were derived from the U.S. Forest Service CISC (Continuous Inventory of Stand Condition) data storage and retrieval system. This system divides the Forest into individual compartments and each compartment is further divided into units called "stands." CISC uses the stand as its basic management unit. Each stand is continuously updated with input into the system from changes due to re-examination, cutting, cultural treatment, and other site modifications (USFS 1979). Stands can range in size from 20 ha to 400 ha, but generally are 20 ha to 50 ha.

In telemetry studies that do not use the error polygon method, the radio location or "fix" is represented by a single point. Some environmental variable which encompass this point is then assigned to that location. In this study, error polygons were overlaid with U.S. Forest Service stand maps and the compartment and stand encompassed by the error polygon were recorded. If an error polygon fell over more than one stand, the fractional amount of each stand was estimated and recorded. Each telemetry observation was, therefore, assigned a compartment, stand, and percentage of the stand(s) covered. Using SAS (1982), these data were then merged with the CISC data set, by compartment and stand number, thereby giving each telemetry observation habitat variables from the CISC data set, e.g., stand forest cover type, stand age, etc. Telemetry observations were totalled for each bear by habitat variable to obtain a frequency of use percentage for each variable.

Availability of each habitat variable was calculated for each bear. The boundaries from which habitat variables were inventoried and totaled for each bear to obtain a frequency of availability by habitat variable were delineated by cumulative home ranges calculated by the harmonic mean method. For females, the contours encompassing 95% of the locations, and males 90% of the locations were delineated.

The following 3 habitat variables were selected for analysis of bear use: (1) forest type; (2) stand age; and (3) forest type/stand age. Four forest community types found on the Tellico District: (1) Cove Hardwood; (2) Mesic Hemlock; (3) Pine, and (4) Oak-Hickory. Each of the 4 communities is composed of the forest cover types with which it is most closely associated (Appendix A, Table 12).

The age of a stand was divided for analysis into 6 categories:

1) $\leq$ 9 years
2) 10-29 years
3) 30-49 years
4) 50-69 years
5) 70-89 years
6) 90 + years

For purposes of analysis, four categories of forest type/stand age were recognized: (1) Young Pine, (2) Mature Pine, (3) Young Hardwood, and (4) Mature Hardwood. The 2 habitat components were derived from the above forest type categories by combining the Mesic Hemlock group with the Pine group to form the Pine habitat

component. The Cove Hardwood group was combined with the Oak-Hickory group to form the Hardwood habitat component. The "Young" and "Mature" components of both habitat groups were classified as follows:

1. Young Pine $\leq$ 40 years
2. Mature Pine $\geq$ 41 years
3. Young Hardwood $\leq$ 50 years
4. Mature Hardwood $\geq$ 51 years

To determine habitat utilization, bears were grouped into sex and age classes and their respective utilization and availability data totaled. The hypothesis that bears used the available habitats in proportion to their occurrence was evaluated using chi-square goodness-of-fit tests in conjunction with the Bonferroni tests (Neu et al. 1974, Byers et al. 1984) of significance.

CHAPTER IV

RESULTS AND DISCUSSION

Capture and Processing

Trapping. The primary trapline during 1982-1983 was on Cowcamp Ridge where previous studies (Villarrubia 1982, Garris 1983) experienced the greatest trap success (Figure 2, page 14). This long ridge is located in the Tellico Bear Refuge and bait station work (Johnson 1984) has shown that this area may have one of the highest bear densities in the Tellico Ranger District. Numerous gaps on the ridge provide corridors for travel, and traps located there were the most successful. No attempts were made to trap bears outside the Refuge.

Cowcamp Ridge received the greatest trapping effort with 572 trapnights yielding 34 captures for a trap success rate of 16.8 trapnights per capture (Table 1). The second-most heavily trapped area was Doublecamp Ridge, amassing 131 trapnights and 8 captures totaling 16.4 trapnights per capture. Only 1 of the 4 traplines was unproductive, this being the Doublecamp Creek line (2 trapsites) having 22 trapnights and no captures. From efforts made to capture bears during this study, 748 trapnights (22 trapsites) were accounted for and ultimately produced 43 captures for a study total trap success rate of 17.4 trapnights per capture.

Table 1. Trapping Success on Citico Creek Study Area, Cherokee National Forest, Tennessee, 1982-1983.

Location (Duration)	Trapsites	Trap-nights	Captures (%)	Trapnights/ Capture
Cowcamp Ridge (13 July-9 Sept. 1982 intermittent) (3 Aug.-18 Aug. 1983) (7 Sept.-13 Sept. 1983)	14	572	34(79)	16.8
Doublecamp Ridge (3 Aug.-21 Aug. 1982 (28 June-5 Aug. 1983)	2	131	8(19)	16.4
Doublecamp Creek (3 Aug.-13 Aug. 1982)	2	22	0(0)	0.0
Flint Branch (23 Jul.-28 Jul. 1982)	4	23	1(2)	23.0
Total	22	748	43	17.4

During the course of 2 summer trapping seasons, physical and biological data were collected from 29 individual bears during 43 captures (Appendix B, Table 13). The captured animals were comprised of 23 males and 20 females including 3 yearlings and 4 cubs. Nine different bears were captured a total of 22 times. Of these recaptures, 6 bears were caught twice, 2 were caught 3 times, and 1 was captured 4 times.

There were no mortalities due to trapping or handling during the 2 summer seasons.

Age structure. Prior to the onset of this work, 2 consecutive, 2-year studies had been conducted involving trapping, tagging, and radio collaring of black bears on the same area using the same traplines (Villarrubia 1982, Garris 1983). Of the captures made during the present study, 24 (83% of all captures) were of new, untagged bears consisting of 17 males and 7 females (Table 2). Recaptures made of bears previously tagged in the earlier two studies totaled 5 (17%) comprised of 2 adult males and 3 adult females. In the above analyses, "subadult" bears are defined as all bears less than 3 years old.

Sixty-six individual bears were captured and marked (radio-collared and/or ear-tagged and tattooed) during the 6 years (Table 3). Males were captured more frequently than females (n=39 and n=27, respectively). More adult males (n=20) were marked than adult females (n=7) and among subadults, fewer males (n=19) were marked

Table 2. Sex and Age Classes of All Black Bears Marked and Re-captured in the Cherokee National Forest, Tennessee, 1982-1983.

Bear Capture	Male (age)	Female (age)	Total (%)
Untagged Bears	17 (14 adults, 3 subadults)	7 (3 adults, 4 subadults	24 (83)
Bears Marked[a]	21 (16 adults, 5 subadults)	13 (6 adults, 7 subadults)	34
Bears Captured[b]	19 (16 adults, 3 subadults)	10 (6 adults, 4 subadults)	29
Recaptures from Previous Studies	2 (2 adults)	3 (3 adults)	5 (17)

[a]Includes recaptures from previous studies and bears marked in winter dens.

[b]Excludes bears marked in winter dens.

Table 3. Sex and Age Classes of All Black Bears Marked and Re-captured in the Cherokee National Forest, 1978-1983.

	Male	Female	Total
Total Marked As:			
Adult	20	7	27
Subadult	19	20	39
Total	39	27	66
Total Recaptured:			
Adult	3	4	7
Subadult	4	11	15
Total	7	15	22

than females (n=20). A disproportionate number of subadult (n=39) bears were marked compared to adults (n=27).

Twenty-two of the 66 bears (33%) marked during the 6 year period were recaptured. A high recapture rate was found among adult females (4 of 7 bears) and subadult females (11 of 20 bears) and low recapture rates among adult males (3 of 20 bears) and subadult males (4 of 19 bears).

Sex ratios obtained from capture (or harvest) data can be biased by many variables (Bunnell and Tait 1981). Capture data from long term trapping efforts should be expected to show an unbalanced adult sex ratio favoring males in unhunted populations (Beeman 1975, Pearson 1975, Graber 1982, Smith 1985) and favoring females in heavily exploited populations (Rogers 1977, Beecham 1983). High proportions of subadult or nonbreeding bears and low proportions of adult males in a population generally is a characteristic of a heavily hunted population (McIllroy 1972, Kemp 1976). The data from the CNF presented here are extremely disproportionate in relation to other hunted populations. From 3 years of trapping data in Idaho, Beecham (1980) reported that in a hunted population subadults were slightly outnumbered by adults (47% vs. 53%) while an unhunted population favored the adult class (71% vs. 29%). Between 1968 and 1975, the population characteristics of black bears were studied at Cold Lake, Alberta, revealing that prior to the removal of 23 adult males, the population favored the adult sector (55% vs. 45%), and after their removal subadults increased

to 67% of the marked population compared to 35% for adults (Young and Ruff 1982). The theory proposed by Kemp (1976), working with the same population from 1968 to 1973, was that the population was being regulated by adult males.

The high recapture rate (and low capture success rate) is characteristic of adult females as they possess small home ranges with little or no overlap and a high degree of site fidelity (Rogers 1977, LeCount 1980). Traplines during the 6 year period reported herein were located in the same area (Cowcamp Ridge) each year and were in the Tellico Bear Refuge, protected from hunting, and few new adult females could be expected to move in and settle in this area. Subadult females generally utilize the smallest home range of all bears while inheriting part of their mothers' home range (Jonkel and Cowan 1971, Lindzey and Meslow 1977, Garshelis and Pelton 1981). Their movements and use of space are small, often making them a difficult sex/age class to capture if traps are spaced widely (Rogers 1977). Adult males have home ranges that are typically large, overlap one another and their movements generally are extensive (Amstrup and Beecham 1976, Reynolds and Beecham 1980, Young and Ruff 1982). In this manner, an adult male is able to include the ranges of many females within his own range and maximize his reproductive success (Lindzey and Meslow 1977). Subadult males may range over areas equal to or greater than those of adult males in attempts to establish breeding ranges (Eveland 1973, LeCount 1980, Quigley 1982). This behavior among adult and

subadult males increases their vulnerability to trapping and hunting and contributes to lower survival rates (Brody 1984a). Although a high number of adult and subadult males were marked during the 6 years, few were re-captured. These missing individuals may be the victims of illegal hunting; 10 of the tagged bears were killed during the legal hunts and illegal hunting is common in the CNF. The high capture rates of subadult males and low recapture rates also may be a result of the high degree of mobility of this sex/age class. Many may have been transients, moving through the study area in attempts to locate an area to settle. With the above considerations, the extent to which the age class ratio is skewed towards younger animals (59% vs. 41%), and supported by the low recaptures of adult and subadult males, one may surmise that the extrinsic pressure of illegal hunting is the major population regulating mechanism in the CNF.

Winter immobilizations. Ten individual bears from 3 families were immobilized in winter dens during January and February 1983. Three adult females with year old litters of 3 (2 females, 1 male), 3 (2 females, 1 male) and 1 (1 male) for total of 7 yearlings located in 2 ground dens and 1 tree den. The sexes of all 7 yearlings had been determined and all were ear-tagged as newborn cubs during the previous winter as part of a reproduction and denning study (Wathen 1983). Two yearlings of 1 litter were captured in foot snares as cubs during the summer of 1982.

There was 1 mortality during the winter immobilizations. The mother of a litter of 3 died unexpectedly while the entire family was immobilized at a tree den.

Radio Telemetry

Directional accuracy. To determine the ground radio tracking margin of error, tests of directional accuracy were performed during August 1982. More than 100 readings were taken on stationary transmitters located in different sites of the study area. These tests resulted in an 8.8° arc being used in error polygon calculations at the 95% level of confidence. The mean error polygon size was 16.7 ha and ranged from 5.6 ha to 88.2 ha. In comparison to the mean forest stand size of 14.3 ha, error polygons generally were found to be larger than the average forest stand, resulting in overlap of the two.

Transmitter installations. The previous study (Garris 1983) terminated in December 1981 and at this time transmitters were operating on 11 previously tagged bears (Villarrubia 1982, Garris 1983). At the onset of field work in July 1982, only 8 of the 11 bears could be accounted for. Of the 8 bears, 2 were adult males, 5 adult females, and 1 subadult female. Radio location data were collected from these 8 bears as soon as field work commenced.

During this study, a total of 15 radio collars were attached, 11 of the bears previously were unmarked and 4 were re-collared

(Appendix B, Table 14). Four unmarked bears were radio-collared during the summer trapping seasons (3 adult males and 1 adult female) and all 7 yearlings immobilized during the winter were equipped with breakaway radio collars. Four additional bears (1 adult male and 3 adult females) were re-collared including a female with yearlings in a winter den. The one adult male re-collared was an 8 year old that was first trapped and radio-collared on 2 June 1979 (Villarrubia 1982) and monitored during both years of the second telemetry study (Garris 1983). This bears' radio transmitter expired prior to the initiation of my work as radio signals were never received. He was trapped within the boundaries of his 1979 home range (Villarrubia 1982) on 3 August 1983 and re-collared.

Data collection. A total of 1909 radio locations were collected on 20 individual bears over the course of the study (Figure 3) and 274 (14%) were discarded for not meeting error polygon size and shape requirements. Of the 1635 locations utilized, the minimum and maximum number of locations recorded for individual bears were 17 (bear 547; 1.0% of total bear locations recorded) and 169 (bear 305; 10.3% of total bear locations recorded), respectively.

Approximately 4210 minutes (70+ hours) were spent radio tracking by air. A total of 421 radio locations (22% of total locations) were recorded in 45 separate flights ($\bar{x}$ = 9.3 radio locations/flight).

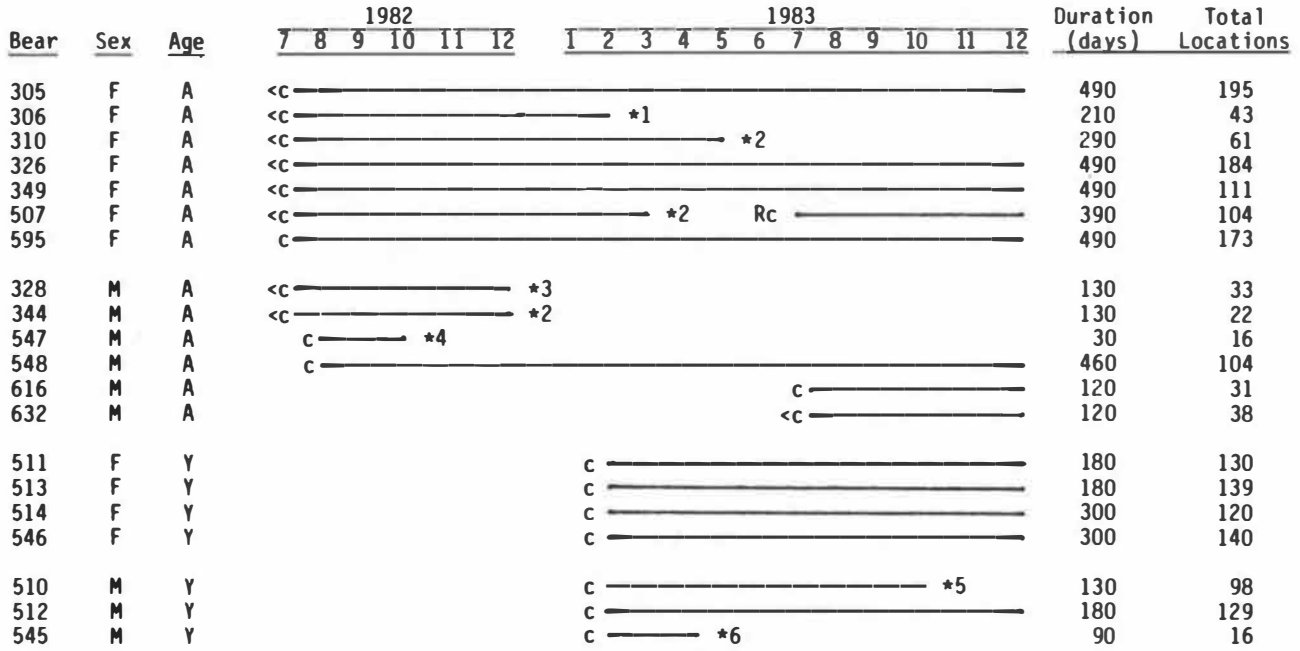


Figure 3. Duration of Radio Tracking, Trapping Record, Number of Locations, and Fate of 20 Black Bears in the Citico Creek Study Area, Cherokee National Forest, Tennessee, 1982-1983.

<c = Collared from previous studies
c = Collared
Rc = Re-collared
*1 = Died in den
*2 = Transmitter expired
*3 = Killed legally in Tennessee
*4 = Killed legally in North Carolina
*5 = Shed collar
*6 = Died of unknown cause

The mean tracking period for adult males was 165 ± 136 days (n=6) and adult females 407 ± 107 days (n=7); yearling males 133 ± 37 days (n=3) and yearling females 240 ± 60 days (n=4). Combining the sex and age classes of the bears, all bears were monitored for an average of 260 ± 170 days (n=20). The minimum and maximum tracking periods were 30 (bear 547) and 490 (bears 305, 326, 349, and 595) days, respectively, the latter being the duration of the study.

Radio location data were collected for the entire period of study for only 5 bears (20%), 1 adult male (bear 548) and 4 adult females (bears 305, 326, 349, and 595). Continuous radio location data were recorded for 8 bears from the previous 2 studies (Villarrubia 1982, Garris 1983). Of these, 2 initially were monitored during the summer of 1978, 1 in summer 1979, 4 in summer 1980, and 1 in summer 1981.

Family Separation

At the beginning of the study it was known that of 8 bears presently equipped with functioning radio collars, 4 were adult females with cubs of the year (G. Wathen, pers. communication). This familial situation presented an opportunity to focus on some of the lesser known aspects of black bear ecology and ursid ecology in general. The major hurdle in attempts to study family spacing patterns after separation (among other analyses) was the task of placing radio collars on the offspring while in association with the mother. The most auspicious time at which this can occur is

during the winter while the bears are denning and generally lethargic, making the immobilization process much easier.

Family units. At least 7 yearlings could be accounted for from the 4 families. The mothers of these families were numbered 305, 306, 326, 349 (Table 4). Yearlings were present in numbers of 3, 3, and 1 in the first 3 families, respectively. The female 349 was inaccessible during the previous winter denning work and her litter size was not determined (Wathen 1983).

During the winter of 1983, an effort was made to place radio collars on all the yearlings of the 4 families. The first 2 families (305 and 326) where this was attempted were located in ground dens and all yearlings in the litters were successfully radio-collared. The yearlings of 305 were tagged as 511, 512, 513; and the yearling of 326 as 510. The third family, bear 306, was located in a tree den approximately 6 m above the ground and all 3 yearlings were radio-collared and tagged as 514, 545, and 546. The fourth family, bear 349, was located in the Joyce Kilmer Wilderness Area (Nantahala National Forest), North Carolina, denning in a 30+ m tall tulip poplar tree and was inaccessible just as the previous winter.

There were 2 mortalities among the 3 families during this period. As mentioned above (see Winter immobilizations, page 35), bear 306, the mother of 3 yearlings died on 12 February 1983, during an immobilization at their tree den. It was decided that the yearlings should be radio-collared and their movements and activities monitored as orphaned yearlings.

Table 4. Family Units Monitored in the Cherokee National Forest, Tennessee, 1982-1983.

Mother	Yearling (Sex)	Comments
511	511 (F) 512 (M) 513 (F)	All members of family remained in radio-contact for the duration of the study.
306	514 (F) 545 (M) 546 (F)	Bear 306 died during a winter immobilization; yearling 545 died of unknown causes shortly after den emergence; yearlings 514 & 546 were radio-monitored from denning until end of study.
326	510 (M)	Bear 326 remained in radio-contact throughout study; yearling 510 removed radio collar, November 1983.

The second mortality was one of the yearlings (male 545) of the orphaned group. After the death of the mother, the 3 yearlings remained at the den for at least 2 weeks; they were located there on 27 February. By March 6, the 3 yearlings had abandoned the tree den. Two of the yearlings, male 545 and female 514, had taken up residence together in another tree den approximately 75 m from the original den (the densite of the third yearling, female 546, was not located but from activity monitoring it was evident that she re-denned). Male 545 and his sibling, female 514, were located at the new den throughout March and all of April, the last location being 24 April. Between this date and 5 May, male 545 left the den and soon thereafter died. He was found approximately 400 m away in a seemingly safe area (no roads) without any sign of predation or human-related mortality.

During periods of scarce food availability, either during years of mast and/or berry crop failures, or spring when little food is available, yearlings and even older-aged bears can be affected, occasionally ending in death by starvation (Jonkel and Cowan 1971). Rogers (1977) reported the successive deaths of 3 yearlings while in association with the mother during spring after a fall season of scarce food. In GSMNP, yearling bears in undernourished condition, have been observed wandering aimlessly and without apparent fear, into areas of human habitation (M. Pelton, pers. communication).

Intra-specific mortality among black bears is known and probably uncommon, though actual documentation is difficult to

present. Of 9 years of intensive monitoring of bear social relationships and movements, Rogers (1977) felt that predation by males was rare or non-existent. Others have reported bears killing trapped bears (Erickson 1957, Jonkel and Cowan 1971, LeCount 1982, D. Graber, pers. communication). Adult males have usually been implicated, although females are capable of cannibalism also (Troyer and Hensel 1962, Lindzey and Meslow 1977).

The orphaned yearling 545 was in excellent condition (14.0 kg) and the heaviest of the 3 littermates when immobilized during the winter. Emerging from his winter den without the accompaniment of his mother and faced with the regular paucity of food in the spring, may have led to deteriorating nutrition, lower body weight, and possibly starvation. Another possible source of mortality might have resulted from intra-specific predation. Adult males normally exclude subadults from their home ranges and may do so with overt aggression. Although there was no evidence of predation in the form of broken and/or gnawed bones, scats, etc., bears may kill younger bears with quick, forceful swats, without incurring bone damage, but causing hemorrhaging and eventual death. This method of killing was employed by black bears in 5 instances on caribou (Rangifer tarandus) calves in Denali National Park, Alaska, during May 1984 (pers. observation).

The radio-collared families of 305 and 326 including 4 yearlings and the remaining 2 orphaned yearlings were monitored from den emergence through the family breakup period and the subsequent 6 months of the study.

Timing of breakup. In black bears, families remain together for 1 1/2 to 2 1/2 years before separation occurs and the offspring begin a solitary existence (Jonkel and Cowan 1971). The timing of this separation is generally during early summer about the time when breeding begins. The cause or causes of family separation remain unclear, although there is much speculation.

The family of bear 305 was last located together on 29 May 1983 and on 5 June the family had separated. All of the yearlings were separated as well, none being further than 1 km apart. Female 326 and her lone offspring, male 510, were last located together on 22 June 1983 and by 25 June they had separated.

Rogers (1977), who studied black bear population dynamics and social relationships in Minnesota for 9 years, discovered that in 26 of 28 cases families had separated between 1 June and 3 July. Two families had separated at the end of May. While monitoring 4 families in Idaho, Reynolds and Beecham (1980) observed families separating between 25 May and 4 June. In Pennsylvania (Alt 1978), 5 females separated from their offspring in May and 1 in June. Jonkel and Cowan (1971) observed 2 females with yearlings on 20 June and 1 with yearlings on 23 June. Subsequent observations in early July found the first 2 females without yearlings. The observed dates of family breakup in this study agree with the few studies where data are available, indicating that the dissolution of the family primarily occurs in June but occasionally may take place in late May or early July.

The reasons why some families separate early while others late is not clear. Separation generally is thought to be caused by the mothers' sudden intolerance of her yearlings (Murie 1981, Rogers 1977) or by adult males during the breeding season (Egbert and Luque 1975, Herrero and Hamer 1977). The onset of breeding in Minnesota (Rogers 1977) and Tennessee (Eiler 1981, Wathen 1983) takes place after the earliest records of family breakup from these 2 areas (Rogers 1977, this study, respectively) which indicates that separation at times may possibly be induced by the mother.

Several characteristics of the mother may influence the timing of family breakup. These may include age, social status, number of prior litters, and the current number of yearlings. Age and reproductive history of the two mothers 305 and 326 in the study were different. The first to separate from her family was female 305. She was 11 years old and definitely was with her third, and possibly her fourth litter. The last to separate was female 326, a 5 year old with her first litter.

In GSMNP and the CNF, 2 different periods of estrous were noted by Wathen (1983): (1) 22 June to 12 July, and (2) 5 August to 18 August. The mean age of females in estrous during the first period was 4.6 years (n=5) while the mean for the second was 2.3 years (n=3). Eiler (1981) also observed that the majority of females in estrous during August were 2 year olds.

Since bears are believed to be induced ovulators (Wimsatt 1963, Erickson and Nellor 1964), it may be advantageous for an

adult female to separate from her offspring early, come into estrous and breed earlier (than most females). A mother that separates from her yearlings in late June or early July will become estrous later than most females and may risk losing the opportunity to breed. In the spruce-fir forest of Montana, Jonkel and Cowan (1971) noted that it may be deleterious for females to come into estrous late in the breeding season as many males may have moved higher into the mountains.

Reassociations. Mother and offspring reassociations of both families did take place after separation. On 7 June 1983 at least 2 and not more than 8 days after the breakup, the entire family of bear 305 was radio-located together. The following day, on 8 June, 2 of the yearlings had separated again while yearling male 512 was still with the mother. The family of bear 326 did not reassociate as quickly after breakup as did the family of bear 305. On 31 July and 14 September 1983, both mother and offspring were radio-located together.

Sibling reassociations were detected twice and involved the 2 orphaned yearlings (female 546 and female 514) rather than the 3 siblings of the family of bear 305. The reassociations occurred on 7 June and 8 September 1983.

Reynolds and Beecham (1980) noted "there were occasional reassociations between the female and one or both yearlings and also between the yearlings," though the exact numbers were not

reported. Rogers (1977) observed only one reassociation, between a mother and 2 yearlings 1 month after the initial family breakup. This family then rejoined for an additional 11 months before separating permanently in June of the following year. Reassociations between siblings were not reported by Rogers (1977).

Home Range

In the following analyses of home range size, 56 adult ranges were constructed; included were 11 adult male seasonal ranges, 21 adult female seasonal ranges, 16 adult seasonal ranges and 8 adult annual ranges. Of the yearling class, 18 home ranges and 6 annual ranges were constructed.

In calculating seasonal and annual home range sizes, a minimum of 10 locations were required per individual bear. Seasons were defined using the criteria noted earlier (page 19).

Seasonal ranges. Adult male home ranges were significantly larger than adult female ranges during summer and fall ($P < .002$) (Table 5). In comparison to yearlings, the combined adult summer ranges were significantly larger than the yearlings' summer ranges ($P=.10$) but not significantly larger than the fall and annual ranges ($P>.10$).

The outstanding factors which cause the discrepancy in home range size between adult males and females can be explained first by the difference in body size and weight between the two sexes. The energetic requirements of males are much greater than that

Table 5. Annual and Seasonal Home-Range Sizes (km^2) for Black Bears in the Cherokee National Forest, Tennessee, 1982-1983.

Category	$\bar{X}$	Range	n	Significance
Summer				
Adult Male	20	7-41	6	P < 0.002
Adult Female	4	1-8	9	
Fall				
Adult Male	132	29-248	5	P < 0.002
Adult Female	4	2-11	12	
Summer 1983				
Adult	11	2-41	8	P = 0.10
Yearling	4	3-6	6	
Fall 1983				
Adult	77	2-315	8	P > 0.10
Yearling	20	3-56	6	
Annual 1983				
Adult	53	5-342	8	P > 0.10
Yearling	30	4-66	6	

of females due to the males' larger size. Harestad and Bunnell (1979) found that black bears and other omnivores had the highest correlation between home range size and body weight when compared with herbivores and carnivores. Second, bears being polygamous species, the males roam widely over large areas during the breeding season encompassing the ranges of several females and in doing so increase their reproductive fitness. Third, during the fall in the Southern Appalachians, adult males are noted for their erratic and wide-ranging movements (Quigley 1982, Carr 1983, Garris 1983, this study). The food resource (hard mast) of black bears here during this season is patchy, widely dispersed and unpredictable in annual abundance. When food resources are dispersed in this pattern among mammals, large home ranges will result (Clutton-Brock and Harvey 1974). Fourth, adult females exhibit strong fidelity for their home range. The home range size of adult females and/or territoriality has been related to habitat quality (Amstrup and Beecham 1976, Lindzey and Meslow 1977) and a social order may prevail (Rogers 1977). Therefore, there is generally a minimum amount of home range overlap between unrelated females. During even the most severe food shortages, adult females will not increase their home range to the extent that males will.

Disparate home range sizes between the sexes have been reported in Washington (Poelker and Hartwell 1973), Alberta (Young and Ruff 1982), Maine (Hugie 1982), and Pennsylvania (Alt et al. 1976). Although these large range size differences are common throughout North

America, studies from California (Novick and Stewart 1982), Long Island, Washington (Lindzey and Meslow 1977) and Tennessee (Beeman 1975) noted slight differences between the sexes. The home range sizes of adult bears on the CNF during 1982-1983 appear to approximate those found for black bears in the Pisgah National Forest, North Carolina (Brody 1984a), GSMNP (Garshelis and Pelton 1981, Quigley 1982, Carr 1983) and previous studies on the CNF (Villarrubia 1982, Garris 1983).

The summer ranges of adult bears on the CNF were significantly larger than those of yearlings primarily because the yearlings restricted their movements to a portion of their mothers' range and rarely utilized the entire area during this season. During the fall, however, several yearlings (male 510, female 511, and male 512) increased their home range and roamed far from their mothers' ranges. These ranges were larger than any of the adult females for this season and approximated those of adult males.

Few studies have reported seasonal and/or annual home ranges of yearlings following family breakup (Rogers 1977, Reynolds and Beecham 1980, Carr 1983, Garris 1983). Of the studies with sample sizes greater than this study, Rogers (1977) found yearlings of both sexes (n=24) to have annual ranges of 1 to 7 km^2 while Reynolds and Beecham (1980) discovered yearlings (n=10) in Idaho with ranges of 5 to 9 km^2. The 6 yearlings monitored during this study had a mean annual home range of 30 km^2 (Table 5); the 3 yearlings (510, 511, 512) exhibiting long range fall movements away from their

mothers' range influenced this mean greatly as their annual home ranges were 58, 33, and 66 km^2, respectively. These movements can be described as exploratory or pre-dispersal movements, common among yearlings (Jonkel and Cowan 1971, Lindzey and Meslow 1977) and may be generated by the availability of food. The two aforementioned studies did not record movements this extreme for male or female yearlings and therefore reported a smaller mean annual home range size.

Seasonal differences. Changes in seasonal home range sizes were observed during the year ("intra-year") and from year to year ("inter-year") (Table 6). Adult male intra-year ranges increased significantly from summer to fall ($P=.025$) during both years and inter-yearly for the fall seasons ($P=.025$). No changes were observed inter-yearly for adult males during the summer season ($P>.10$). Intra-year and inter-year seasonal ranges of adult females remained nearly constant throughout the study and showed slight variations in sizes ($P>.10$).

The inter-year ranges for the summer and fall seasons of the adult class did not increase significantly in size and the intra-year summer to fall range sizes of adults did not differ significantly as well ($P>.10$) for either year. In contrast, the intra-year seasonal ranges of yearlings showed a significant increase from summer to fall ($P<.01$).

After reviewing the literature on black bear seasonal home range sizes from several studies in the Southern Appalachians,

Table 6. Changes in Home Range Sizes (km^2) for Black Bears in the Cherokee National Forest, Tennessee, 1982-1983.

Category Seasons (1-2)	$\bar{X}_1$-$\bar{X}_2$	n_1-n_2	Significance
Adult Males			
Summer 1982 - Fall 1982	18-34	3-3	P = 0.025
Summer 1983 - Fall 1983	22-198	3-3	P = 0.025
Summer 1982 - Summer 1983	18-22	3-3	P > 0.10
Fall 1982 - Fall 1983	34-198	3-3	P = 0.025
Adult Females			
Summer 1982 - Fall 1982	2-3	4-7	P > 0.10
Summer 1983 - Fall 1983	5-4	5-5	P > 0.10
Summer 1982 - Summer 1983	2-5	4-5	P > 0.10
Fall 1982 - Fall 1983	3-4	7-5	P > 0.10
Adults			
Summer 1982 - Fall 1982	9-51	7-10	P > 0.10
Summer 1983 - Fall 1983	11-77	8-8	P > 0.10
Summer 1982 - Summer 1983	9-11	7-8	P > 0.10
Fall 1982 - Fall 1983	51-77	10-8	P > 0.10
Yearlings			
Summer 1983 - Fall 1983	4-20	6-6	P < 0.10

it is evident that seasonal range sizes may or may not fluctuate intra-yearly or inter-yearly. Some years there will be little change in sizes of summer and fall ranges among adults while in other years the increase between the two seasons may be dramatic. The above has been observed in several studies that experience a hard mast failure one year and another year with an abundant mast supply (Carr 1983, Garris 1983). During the fall of 1980 when hard mast virtually was non-existent in GSMNP, adult males (and even females) increased the size of their home range (Carr 1983). Nevertheless, when an adequate supply of hard mast is available, the seasonal ranges of adult black bears in GSMNP remain nearly constant intra-yearly and inter-yearly (Table 7) (Garshelis and Pelton 1981, Quigley 1982, Carr 1983). However, during years with an adequate supply of hard mast in the CNF (Villarrubia 1982, Garris 1983, this study), the seasonal ranges of adult males were shown to increase considerably from summer to fall. Brody (1984a) also observed significant increases in adult male range size from summer to fall in the PNF during years of adequate mast abundance.

Though seasonal ranges are dependent primarily upon each bears' nutritional needs and food abundance, other factors may cause variation in range sizes. One such factor that is present in the CNF and PNF but not in GSMNP is hunting pressure. This activity only occurs during the fall, from mid-October until January in North Carolina and 2 weeks in December in Tennessee. Males that live in the CNF year-round frequently move to the Nantahala

Table 7. Comparison of Some Adult Male and Female Black Bear Summer and Fall Home Range Sizes in Hunted and Unhunted Populations in the Southern Appalachian Mountains, 1976-1983.

Area Study/Year	Male $\bar{X}$ Summer	Male $\bar{X}$ Fall	Female $\bar{X}$ Summer	Female $\bar{X}$ Fall
Great Smoky Mountain N.P. (Unhunted)				
Garshelis/1976-1977	8	11	4	4
Quigley/1978-1979	14	15	3	4
Carr/1980[a]	19	101	3	11
Carr/1981	23	23	3	3
Cherokee National Forest (Hunted)				
Garris/1980[a]	14	190	5	23
Garris/1981	28	46	13	11
This Study/1982-1983	20	132	4	4
Pisgah National Forest (Hunted)				
Brody/1982-1983	32	69	9	17

[a]Year of mast crop failure.

National Forest, North Carolina (NNF) during the fall to feed (Villarrubia 1982, Garris 1983, this study). While these males are theoretically protected from hunting (except the 2 week season) if they remain in Tennessee, they can be subjected to hunting pressure while in (or near) North Carolina, beginning mid-October.

Of 6 adult males monitored during the study, 4 moved to the NNF in the fall and all 4 were harassed by hunters and their dogs. Bear 616 moved from the Citico Creek study area to an area in NNF where hunting activity was high; he later moved to the CNF, resulting in a large fall home range size of 315 km^2. Bear 548 moved to the NNF in 1983 and was chased by dogs from the NNF to the Tellico Bear Refuge only 2 days after the North Carolina season opened; his fall home range size was 247 km^2. Bear 547 was illegally killed by North Carolina hunters in Tennessee during the North Carolina hunting season (pers. opinion). Lastly, bear 328 moved during fall 1982 from the Citico Creek study area south 24 km to the Tennessee-North Carolina border, then abruptly moved 30 km west, through unsuitable bear habitat and civilization, then returned northeast 42 km to the study area ending the fall with a large home range size of 419 km^2.

Three of 6 yearlings moved to North Carolina during the fall 1983 and they did not appear to be harassed by hunters. Their fall home ranges were exceedingly large for yearlings. In Idaho (Reynolds and Beecham 1980), yearling black bears remained within their mothers' home range and did not increase their range size

from summer to fall. Rogers (1977) noted that 5 of 24 yearlings (3 males, 2 females) in Minnesota increased their home range size from summer to fall as did the yearlings in this study. These seasonal increases in range size among yearlings may be a result of their exploratory or pre-dispersal movements during the fall which generally culminate in their return to their mothers' range to den for the winter.

Pattern of Space Use

Seasonal shifts of activity center. Changes in intra-year ranges of adult males and yearlings of both sexes from summer to fall were followed by shifts in harmonic centers of activity (Table 8). Among adult males, activity centers shifted a distance of 4.5 ± 2.8 km (n=5) while adult females (n=11) exhibited only a slight shift of 1.6 ± 0.8 km between seasons; this distance was significantly less than what was observed for adult males ($P<.01$). Yearlings (n=6) did show a large intra-year seasonal shift of 3.0 ± 2.8 km but this is largely a result of the extensive movements of 2 yearling males away from their mothers' ranges in the fall. Yearling females made the smallest shift in seasonal activity centers moving only a distance of 0.6 ± 0.4 km (n=4).

Significant changes in the location of intra-year seasonal activity centers have been noted in several studies (Reynolds and Beecham 1980, Garshelis and Pelton 1981, Carr 1983, and Garris 1983). All of these studies have attributed these geographic shifts

Table 8. Distances (km) Between Seasonal Activity Centers of Individual Black Bears in the Cherokee National Forest, Tennessee, 1982-1983.

Seasons	$\bar{X}$	Std.	N
Adult Males			
Summer to Fall (1982, 1983)	4.5	2.8	5
Summer 1982 to Summer 1983	5.2	-	1
Fall 1982 to Fall 1983	4.0	-	1
Adult Females			
Summer to Fall (1982, 1983)	1.6	0.8	11
Summer 1982 to Summer 1983	1.1	0.5	4
Fall 1982 to Fall 1983	2.0	1.8	4
Adults			
Summer to Fall (1982, 1983)	2.5	1.5	16
Summer 1982 to Summer 1983	1.9	1.2	5
Fall 1982 to Fall 1983	2.4	2.1	5
Yearling Males			
Summer 1983 to Fall 1983	7.7	7.6	2
Yearling Females			
Summer 1983 to Fall 1983	0.6	0.4	4
Yearlings			
Summer 1983 to Fall 1983	3.0	2.8	6

in seasonal activity centers to the clumped and patchy distribution of food sources in the fall (hard mast). Brody (1984a) did not observe significant geographic shifts in seasonal harmonic centers of activity for black bears in western North Carolina (n=13; 4 males, 9 females) although 3 bears which did exhibit wide-ranging, seasonally mediated movements were not included because of sparse data. This absence of location shifts in seasonal harmonic centers of activity was partially interpreted as a consequence of a near uniform distribution of hard mast producing species in the study area.

Shifts in inter-year seasonal activity centers for the summer and fall seasons were insignificant for adult females (n=4) and similar to the intra-year seasonal shifts shown above for adult females. Because only 1 adult male was monitored for the entire duration of the study, inter-year seasonal comparisons for summer and fall could not be made.

Home range overlap. The annual ranges of 7 adult males radio tracked during 1982 and 1983 were expansive and overlapped each other extensively (Figures 4 and 5, respectively). In 1982, males shared an average of 56% (range = 50-75%) of their ranges and in 1983, their ranges overlapped an average of 55% (range = 50-58%). The ranges of bears 548 and 616 overlapped the range of bear 632 by 100% during 1983. All other males were captured within the areas occupied by these 7 adult males. Generally adult

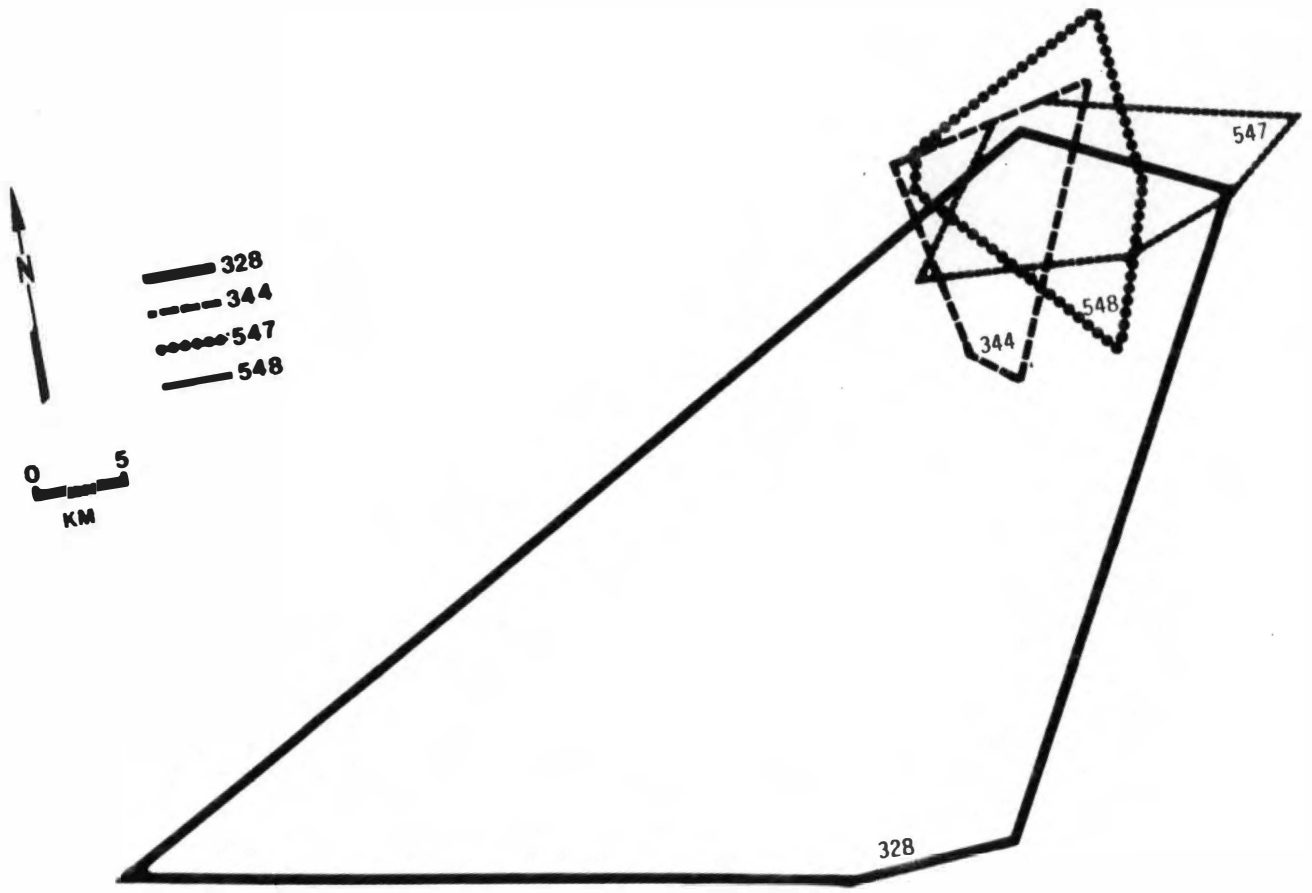


Figure 4. Annual Home Ranges of Four Adult Males in the Cherokee National Forest, Tennessee, 1982.

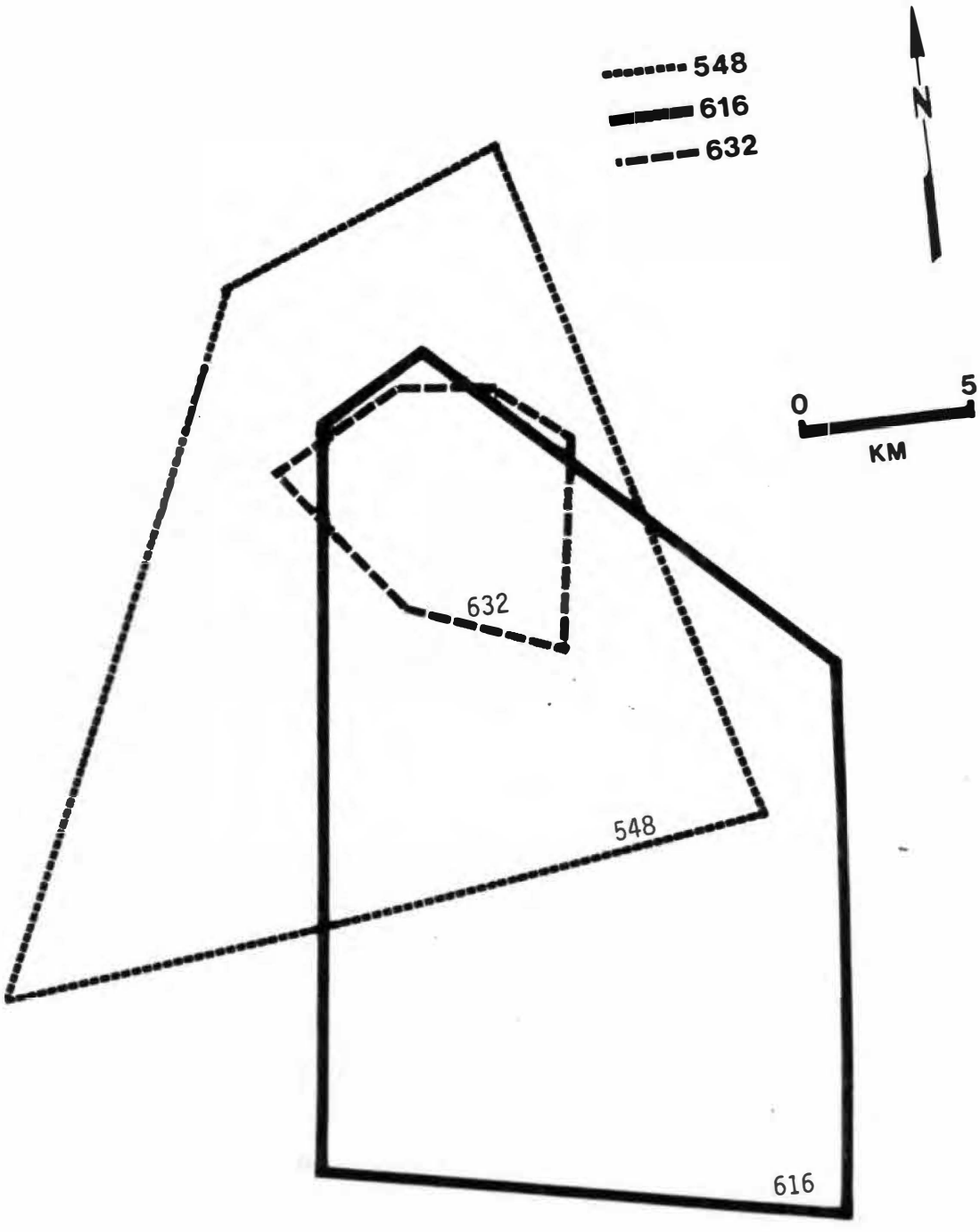


Figure 5. Annual Home Ranges of Three Adult Males in the Cherokee National Forest, Tennessee, 1983.

males avoided each other, although occasionally during the fall season, 2 males could be found within 100 m of each other.

The ranges of 12 adult females were plotted for the 1982 and 1983 period and differed from those of adult males (Figures 6 and 7, respectively). The 1982 ranges of 7 adult females overlapped an average of 14% (range = 4-22%) while in 1983, the mean ranges of 5 adult females overlapped 22% (range = 9-41%). The greatest amount of range sharing during 1982 and 1983 among adult females was by bear 305. An 11 year old matriarch, her range overlapped an average of 22% (range = 0-60%) over all adult females in 1982 and averaged 41% (range = 25-75%) in 1983. The relationships of the adult females were not known, but it is possible that several of the ranges with which she overlapped extensively were her offspring.

Extensive home range overlap among adult males appears to be a universal characteristic since the male reproductive strategy is to move over as large an area as possible and to breed with numerous females. By doing this, males are unable to actively defend territories of this magnitude, and home range overlap is common.

Whether influenced by population density, habitat quality, or other factors, adult females may or may not share home ranges with members of the same sex. In Alberta, temporal separation among adult females' use of garbage dumps was observed, which later corresponded with the allopatric home ranges they utilized (Young

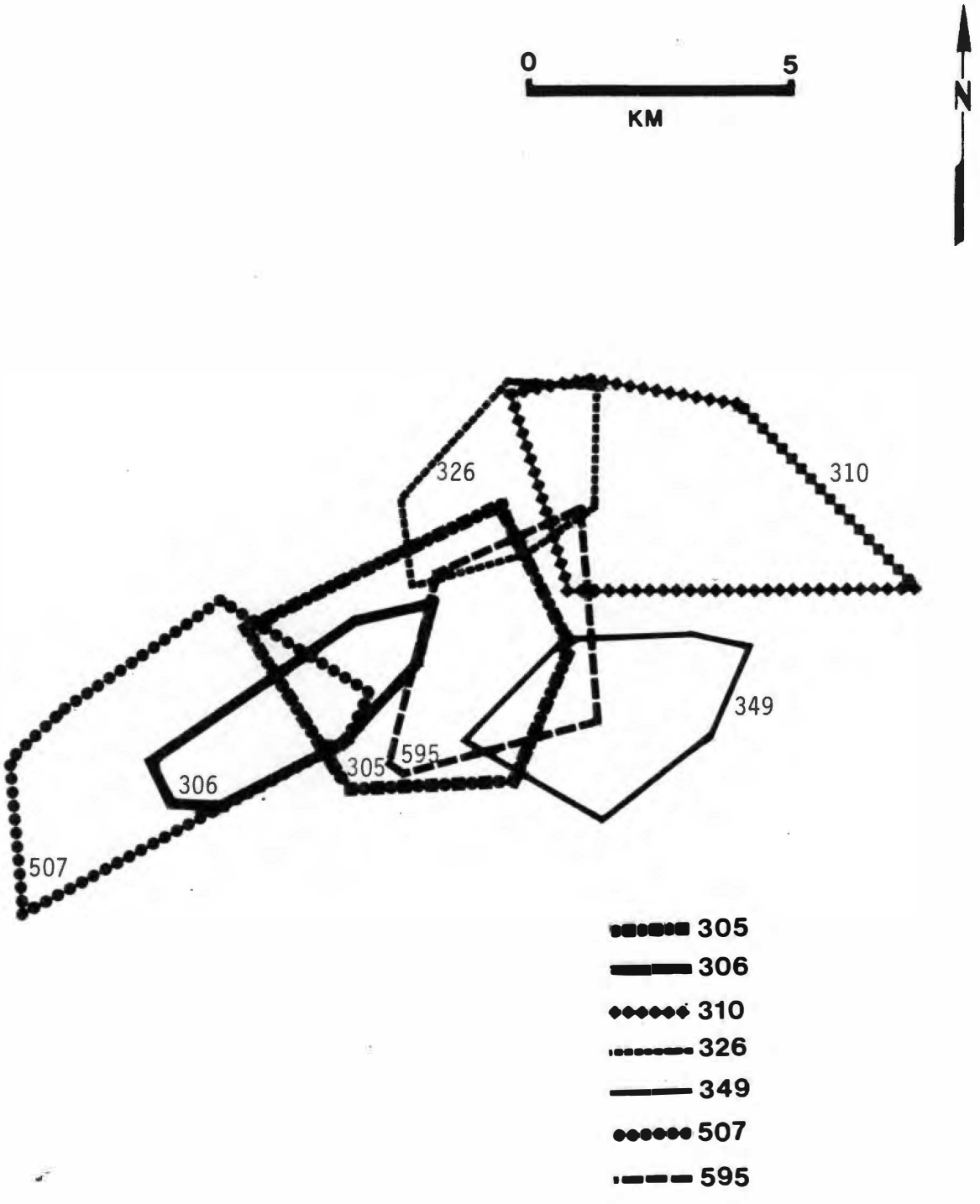


Figure 6. Annual Home Ranges of Seven Adult Females in the Cherokee National Forest, Tennessee, 1982.

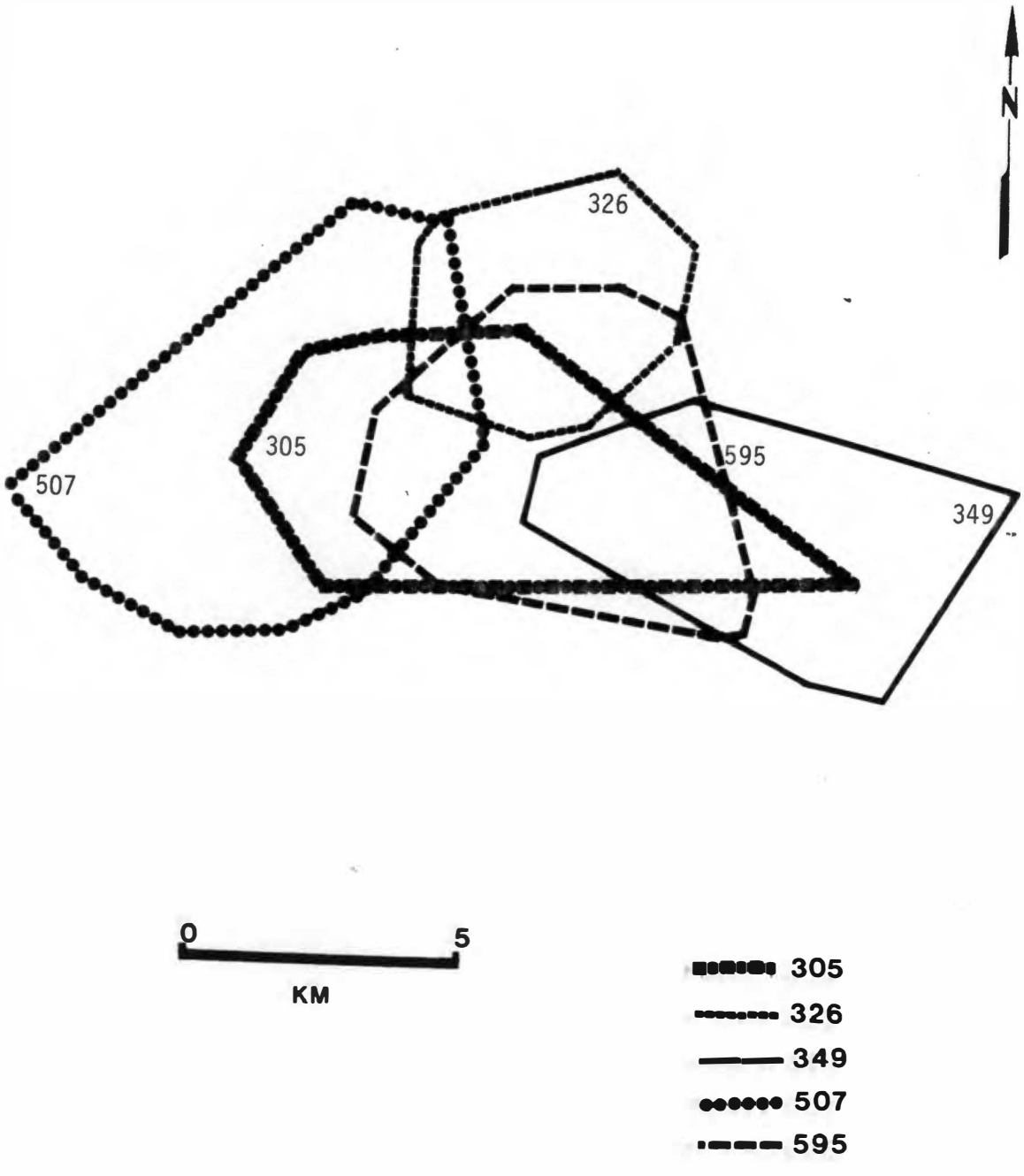


Figure 7. Annual Home Ranges of Five Adult Females in the Cherokee National Forest, Tennessee, 1983.

and Ruff 1982). Little range sharing was found among females in Arizona (LeCount 1980) and also Minnesota (Rogers 1977) and Montana (Jonkel and Cowan 1971). Evidence of home range sharing and mutual use of areas by females was found by Lindzey and Meslow (1977) on Long Island, Washington (1953 ha), who remarked that this social pattern among both sexes allowed relatively large numbers of bears to coexist on the island. Range sharing was reported to be common in Idaho (Amstrup and Beecham 1976) and Alaska (Modafferi 1982); Servheen (1983) did not discover male or female grizzly bears (Ursus arctos) in Montana to be territorial either, but noted that the seasonal changes in resource distribution were instrumental in establishing the social climate.

In the Southern Appalachians, studies of Garshelis and Pelton (1981) in GSMNP, Villarrubia (1982) in CNF, and Brody (1984a) in PNF noted range sharing among adult females while Quigley (1982) in GSMNP and this study did not find range sharing to be nearly as common. The conflicting results shown here for the same areas are an indication that whether females (or males) exhibit range sharing or allopatry is not completely understood. It is nearly impossible to be able to capture and mark all the bears in a given area; therefore, we cannot determine how these bears influence the radio-marked bears' patterns of space use. From what can be gleaned from the literature concerning space use among bears, there is a general tendency for unrelated adult females to respect each other's ranges and exhibit mutual avoidance and that population

density and habitat quality are important factors that will ultimately govern the social climate of a population.

Post-breakup spatial relationships. The spatial relationships between bears 305 and 326 and their yearlings after family breakup were analyzed in addition to the home ranges of the 2 orphaned yearlings and the vacated home range of their mother from the year before.

During the summer 1983, bear 305 and bear 326 each shared ranges with their yearlings after breakup (Figures 8 and 9, respectively). The ranges of the yearlings of bear 305 were nearly enclosed within the range of their mother; all sharing an average of 81% of their ranges with her. Bear 326 and her yearling 510 exhibited the same spatial relations as 43 of 46 (93%) radio locations of the yearling were within the mothers' home range.

In contrast, the fall ranges of yearlings increased in size greatly. Bear 305 centered her activities in the western edge of her home range while her yearlings used the northeastern corner and areas beyond (Figure 10). The fall range of 2 of her yearlings (female 511 and male 512) increased dramatically in size as they ventured into the NNF in North Carolina; although female 511 was not located as much (n=2) or resided as long (19 October to 29 October 1983) as her sibling 512, that was located 12 times between 20 September and 2 December 1983. Nearly identical patterns of movement occurred with yearling male 510, of bear 326 (Figure 11).

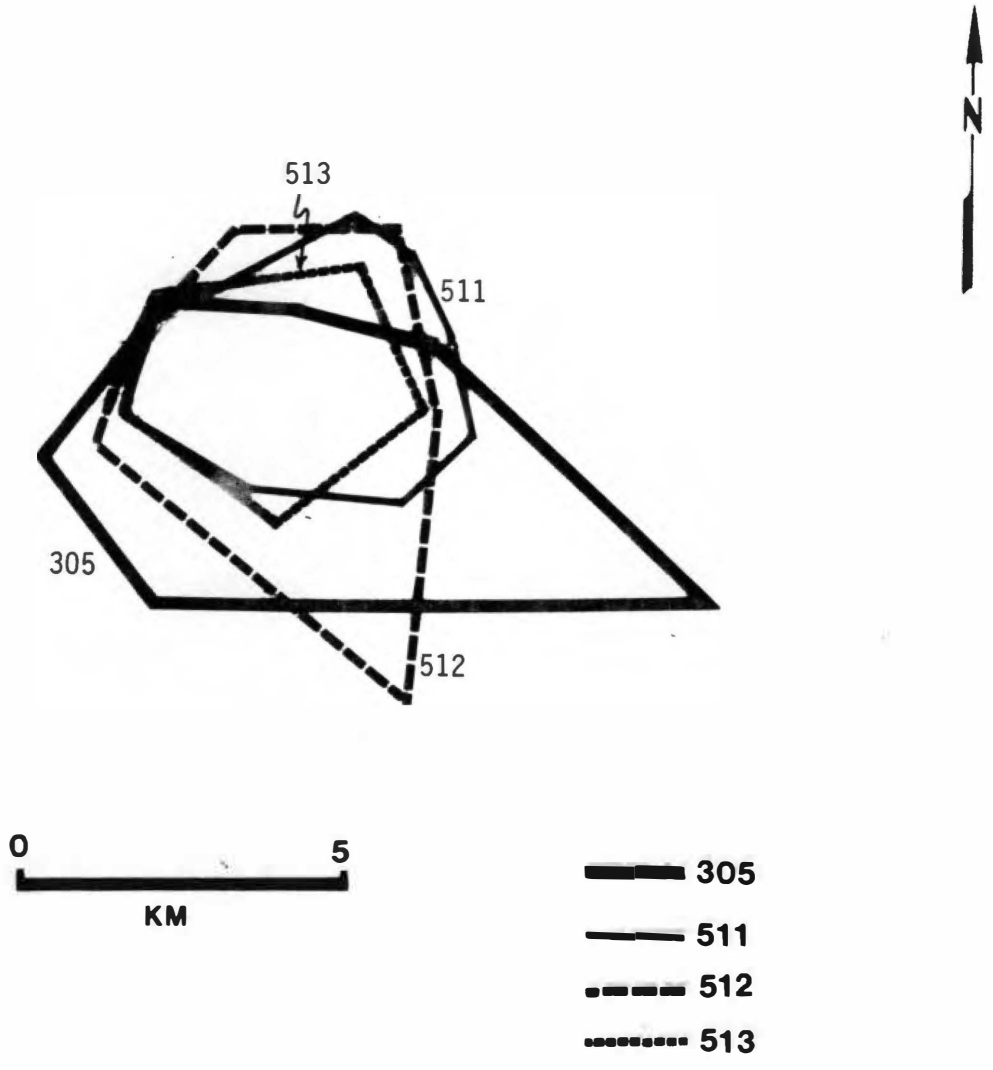


Figure 8. Summer Home Ranges of Bear 305 and Her Yearling Bears 511, 512, and 513, in the Cherokee National Forest, Tennessee, 1983.

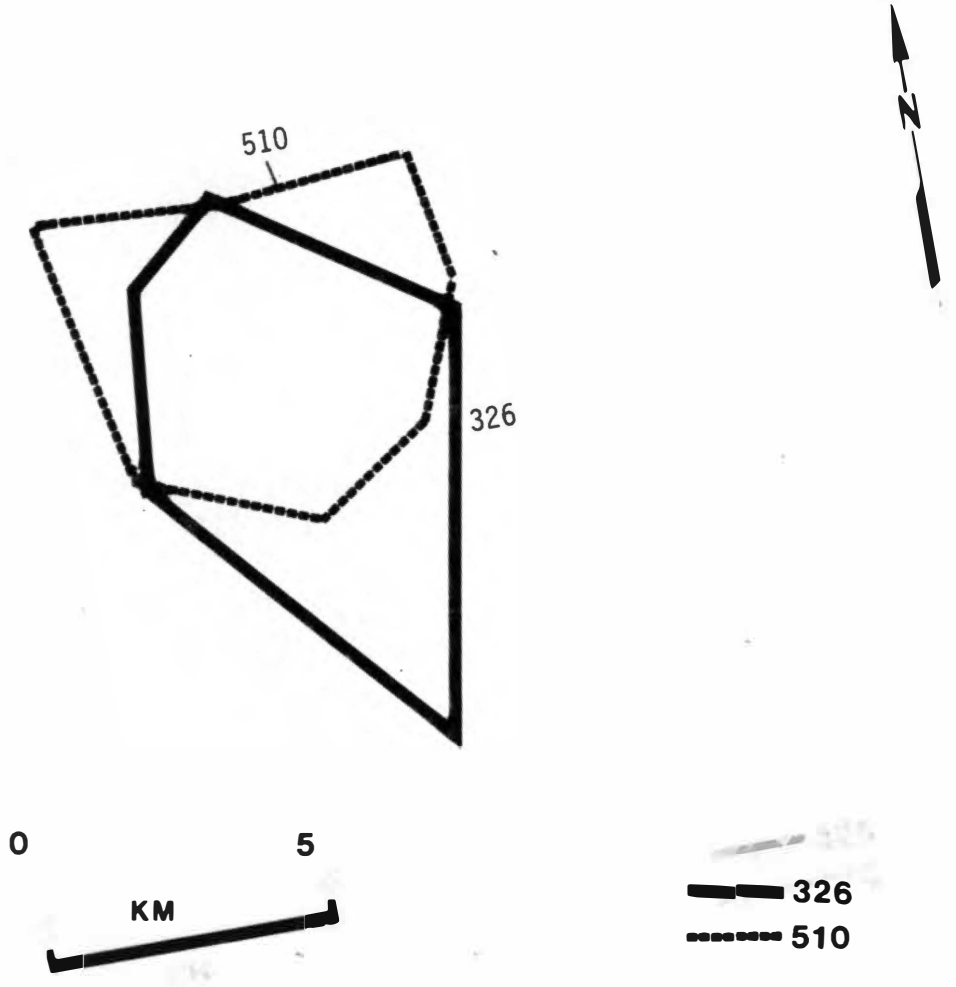


Figure 9. Summer Home Ranges of Bear 326 and Her Yearling Bear 510 in the Cherokee National Forest, Tennessee, 1983.

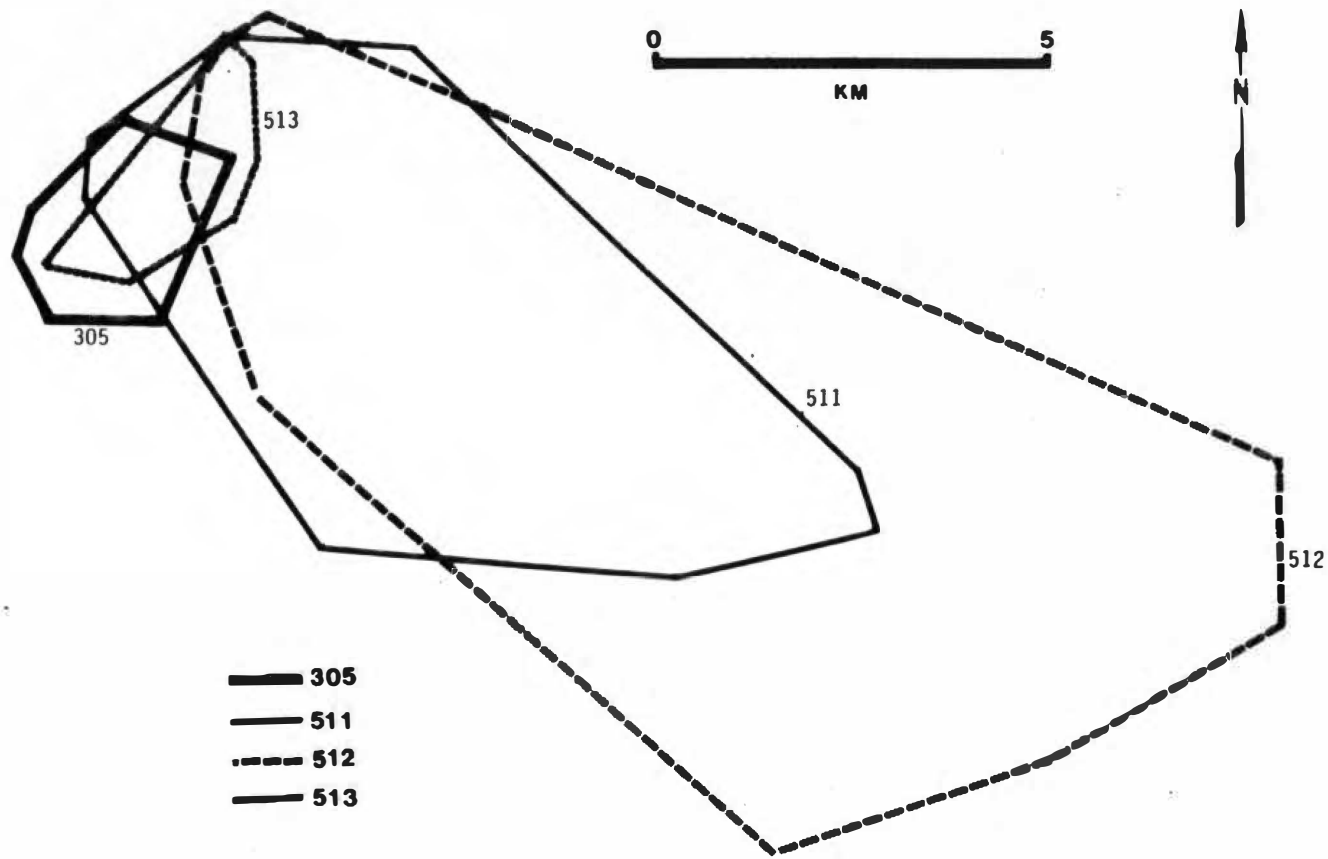


Figure 10. Fall Home Ranges of Bear 305 and Her Yearling Bears, 511, 512, and 513, in the Cherokee National Forest, Tennessee, 1983.

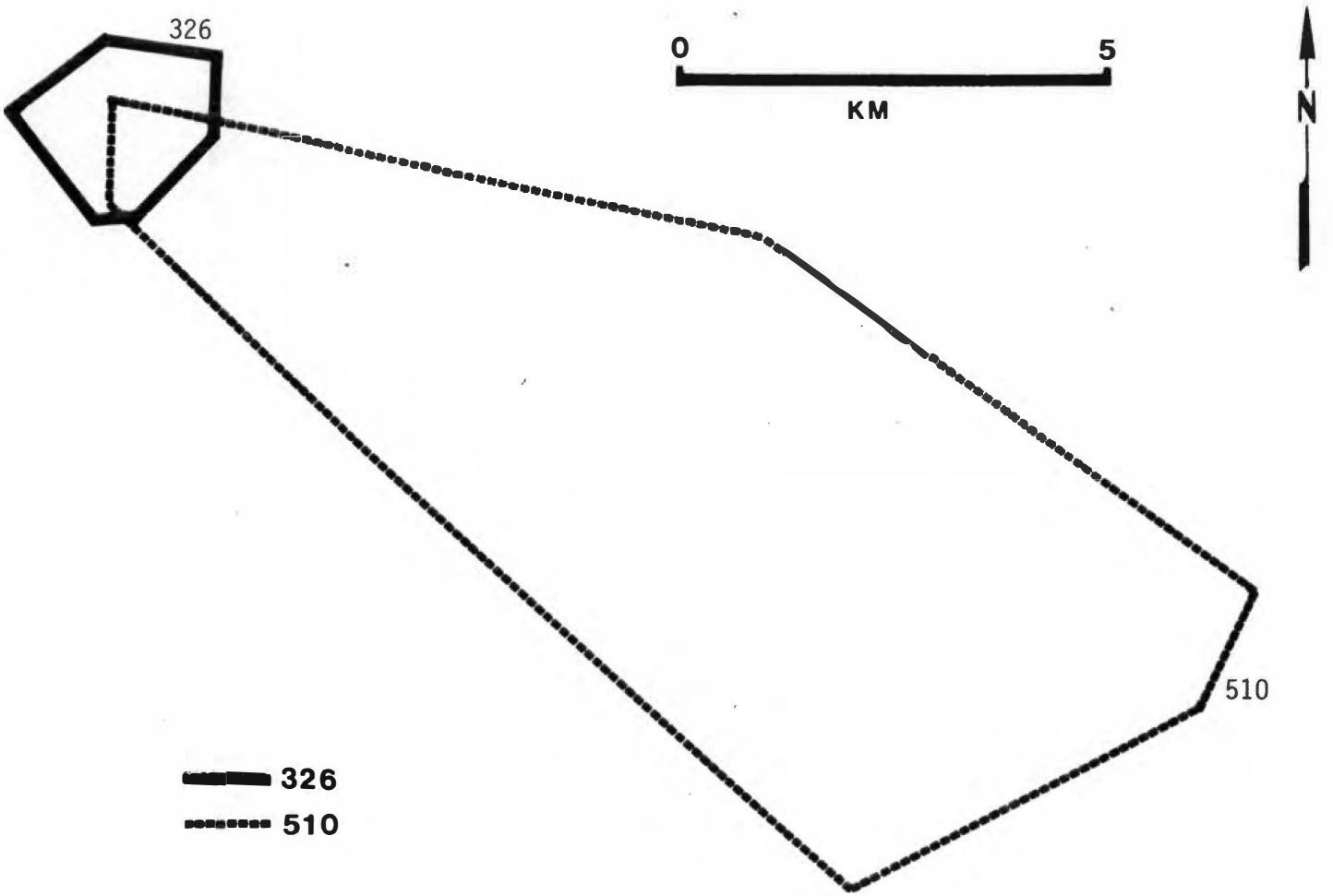


Figure 11. Fall Home Ranges of Bear 326 and Her Yearling Bear 510, in the Cherokee National Forest, Tennessee, 1983.

His range increased during the fall as he also went to the NNF from 18 September until 8 November 1983, being located 13 times before shedding his radio collar.

The spatial relations between mothers and offspring after family breakup have been discussed by several authors. Reynolds and Beecham (1980) found that 9 of 10 yearlings (6 male, 3 female) remained in the mothers' home range through the fall while 1 male moved 20 km away from the study area and eventually denned there. In Minnesota, 24 yearlings (10 male, 14 female) settled in areas of the mothers' home range after breakup and concentrated their activities there for at least a year (Rogers 1977). In a pattern much like what I observed in the CNF, 5 of the 24 yearlings (3 males, 2 females) left the mother's home range for up to 6 weeks during late summer or early fall and all but 1 returned there to den.

The initial space use patterns of the 2 orphaned yearlings after den emergence in spring 1983 were in the area of the vacated 1982 home range of their mother, bear 306 (Figure 12A). They shared more than 50% of their spring ranges within her old range, but the utilization of the mothers' area differed. Yearling 514 was located 8 of 17 (47%) times and yearling 546, 5 of 27 (19%) times inside the range of 306. These figures also may be misleading as only 39 radio locations were recorded for bear 306 between August and December 1982, and no location data from spring and early summer were collected. The vacant home range of bear 306 may be larger

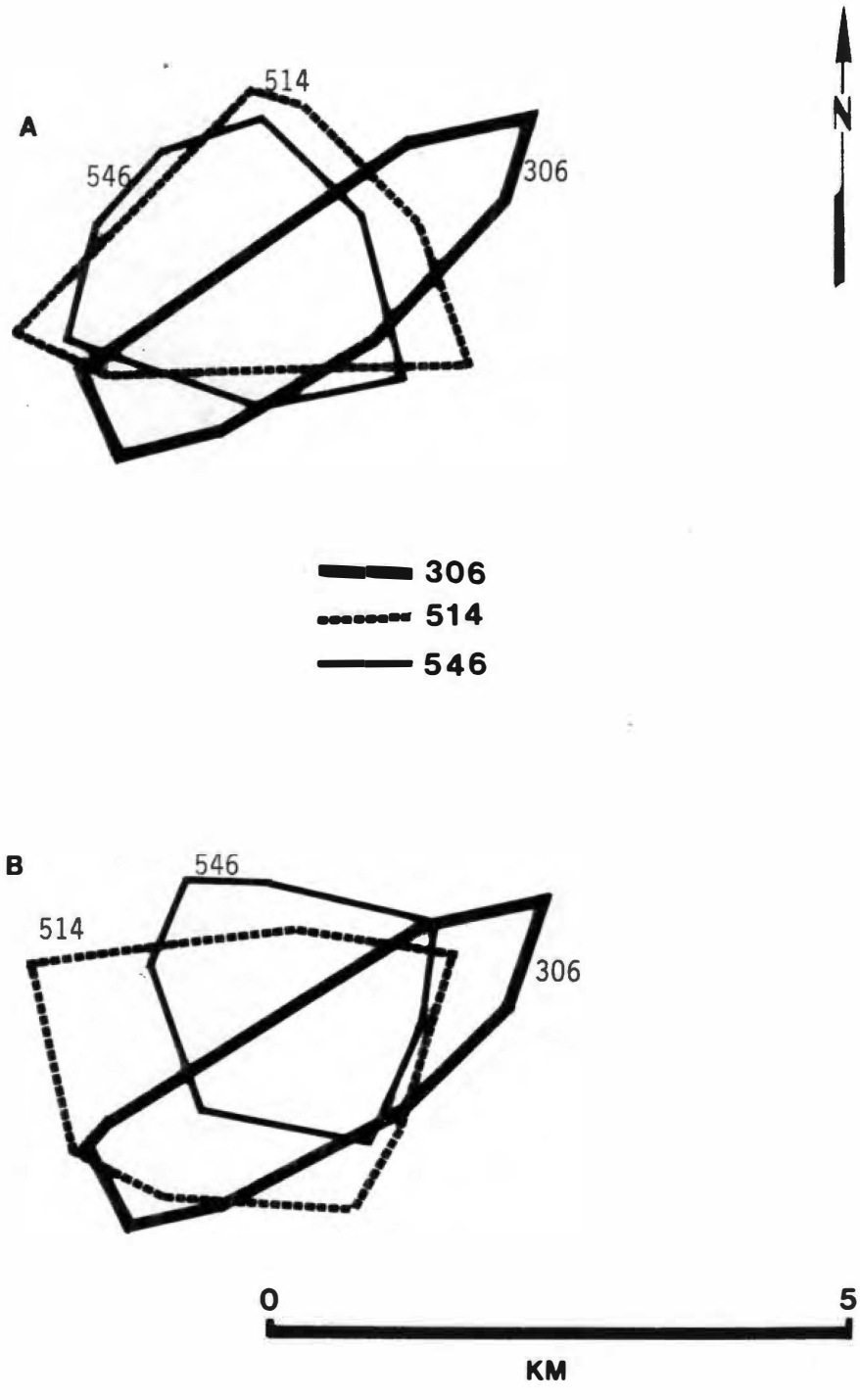


Figure 12. Home Ranges of Orphaned Yearling Bears 514 and 546 With Respect to the Vacated Home Range of Their Mother, Bear 306, in the Cherokee National Forest, Tenenssee, 1983. A. Spring Home Range. B. Summer Home Range.

than the data indicates. During the summer, a pattern of space utilization developed as yearling 514 concentrated nearly all her activity within the home range of her mother, while yearling 546 concentrated her activity near, but outside the mothers' home range (Figure 12B). During the fall, yearling 514 moved far outside the mothers' range but remained in Tennessee the entire time (Figure 13). Her sibling, bear 546, continued to use the same size area but shifted her activity to within her mothers' range. The movements and space use patterns shown here are not different from the unorphaned yearlings that accompanied their mothers until family breakup.

The mean distance between radio locations of mothers (bears 305 and 326) and their respective yearlings (bears 511, 512, and 513 and bear 510) from the time of family breakup until denning was analyzed to look at their spatial relations and dissolution of the family bond (Table 9). The first month after family breakup (June) the mean distance between all mothers (n=2) and yearlings (n=4) was 0.8 ± 0.02 km. In July, the mean distance increased significantly to 1.2 ± 0.1 km (P=.10) and continued to increase monthly (a significant increase again between August and September; P=.10) until it reached a maximum of 4.2 ± 18.8 km in October. In November the measure decreased to 2.9 ± 19.2 km.

Of the yearlings, males (n=2) and females (n=3) both were located at nearly the same distance from their mothers from June (males = 0.8 ± 0.4 km; females = 0.8 ± 0.5 km) until August (males

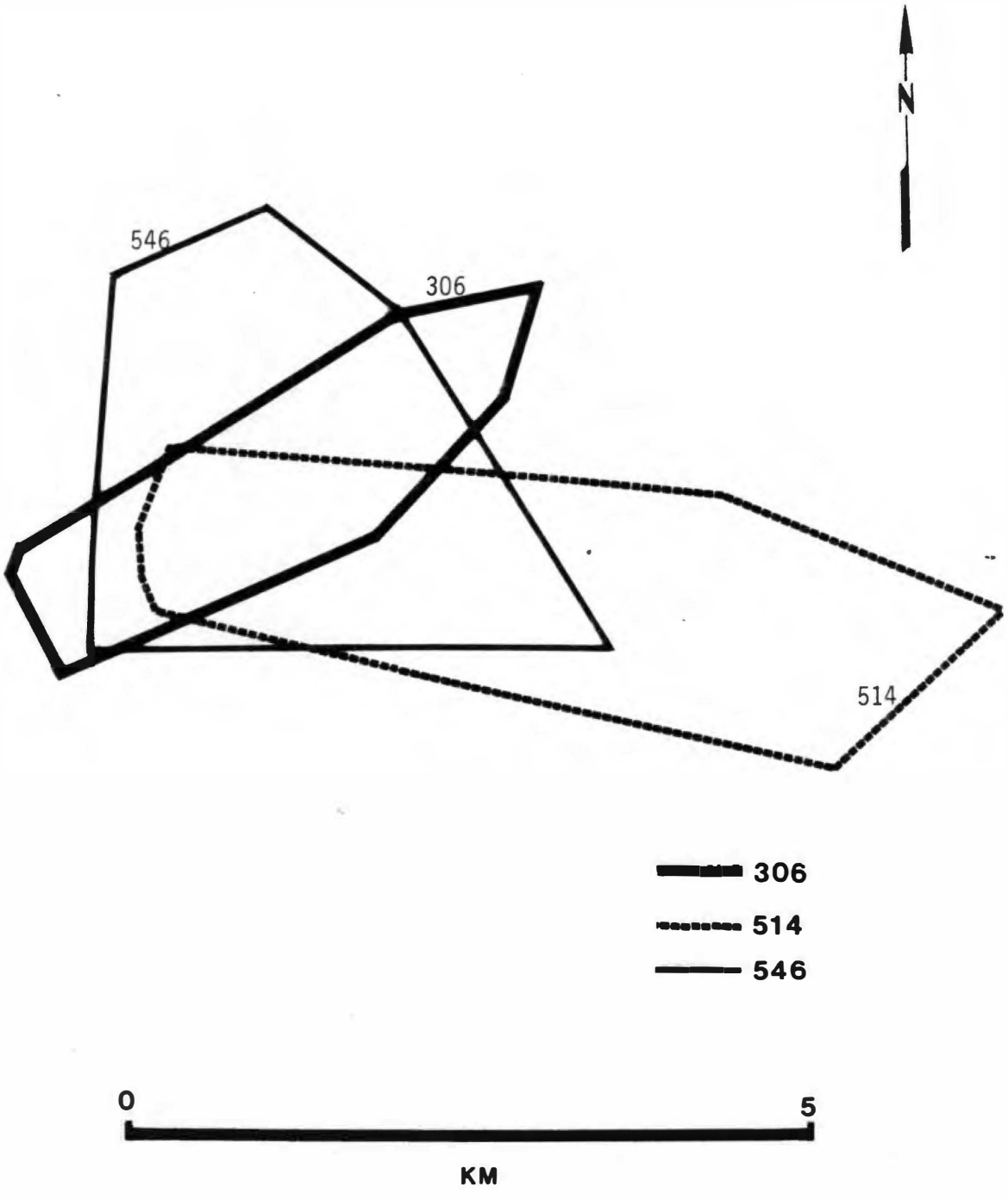


Figure 13. Fall Home Ranges of Orphaned Yearling Bears 514 and 546 With Respect to the Vacated Home Range of Their Mother, Bear 306, in the Cherokee National Forest, Tennessee, 1983.

Table 9. Mean Distance ± SD (km) Between Radio Locations of Female and Yearling Black Bears and Between Siblings After Family Breakup, Cherokee National Forest, Tennessee, 1983. Number of Paired Radio Locations Are in Parentheses.

Month	Females and Yearlings-Combined	Females and Yearlings		Siblings
		Males	Females	
June	0.8 ± 0.02 (52)	0.8 ± 0.4 (22)	0.8 ± 0.5 (30)	0.7 ± 0.2 (49)
July	1.2 ± 0.1 (84)	1.1 ± 0.8 (44)	1.4 ± 0.8 (40)	0.8 ± 0.2 (56)
August	1.3 ± 0.01 (53)	1.3 ± 1.4 (24)	1.4 ± 0.6 (29)	0.9 ± 0.3 (46)
September	2.7 ± 2.1 (66)	4.3 ± 4.8 (28)	1.4 ± 0.7 (38)	2.3 ± 1.6 (47)
October	4.2 ± 18.8 (45)	8.5 ± 4.5 (11)	2.8 ± 2.1 (34)	4.0 ± 1.2 (25)
November	2.9 ± 19.2 (57)	4.0 ± 3.2 (20)	2.3 ± 1.1 (37)	1.3 ± 0.1 (49)

= 1.3 ± 1.4 km; females = 1.4 ± 0.6 km) (Table 9). Beginning in September, males increased the mean distance to 4.3 ± 4.8 km and in October to 8.5 ± 4.5 km while the females were located at a mean distance of 1.4 ± 0.7 km and 2.8 ± 2.1 km, respectively. The November distance decreased for both sexes.

The mean distance between siblings after family breakup was also measured, but unfortunately with only one family (yearlings 511, 512, and 513 of bear 305) (Table 9). As with the spatial relations between mothers and yearlings, siblings reflected the same pattern; beginning at 0.7 ± 0.2 km in June and increasing the mean distance each month, reaching a maximum in October of 4.0 ± 1.2 km and decreasing in November to 1.3 ± 0.1 km.

Reynolds and Beecham (1980) also discovered that the mean distance between locations of mothers and yearlings and between siblings became greater as the season progressed (data only recorded through October). In Minnesota, yearlings in late summer or fall made long forays away from their mothers' ranges but eventually returned to den, indicating that these same spatial patterns between mothers and offspring may have occurred in this area of the species' range (Rogers 1977). Although mother and offspring and siblings may be able to recognize each other after breakup and reassociations occur among them (page 45), the family bond appears to become progressively weaker over time. Rogers (1977) found adult females sharing their home ranges with their offspring although avoiding them, giving nearly exclusive use of those areas to the young bears,

resulting in reduced competition for food between mothers and yearlings. From the little data presented here, it would be presumptuous to say that mothers in the CNF avoid their offspring after breakup; reassociations were known to occur (page 45).

Subadult dispersal normally occurs at the earliest 1.5 years (Jonkel and Cowan 1971) and often later (Rogers 1977). On Long Island, Washington (Lindzey and Meslow 1977), 5 yearlings (3 males, 2 females) remained within their mothers' range the first 7 months after breakup, enlarged their seasonal home ranges at 2 years of age, and dispersed from the island at 4 years. In the White River National Wildlife Refuge, Arkansas, Smith (1985) did not observe long range dispersal among young males (1, 2, or 3 years old) because of the lack of dispersal corridors and the juxtaposition of forested and agricultural areas in the White River basin. Dispersing males, therefore, had to establish ranges within or nearby their mothers' ranges. None of the yearlings in CNF dispersed during this study. All remained within or near their mothers' range; several predispersal forays were made during the fall but all returned and denned within their mothers' range.

Notable Movements

During the course of the study, several bears made long range movements (sometimes erratic in nature) venturing far from their normal area of occupancy. A movement was considered notable if it was more than twice the greatest length of the bears' home range. Normally these movements are made by males, typically during

the fall. Of 7 individuals that made extensive movements, 5 were males (2 yearlings, 3 adults) and 2 females (1 yearling, 1 adult). The movements occurred during summer (n=1) and fall (n=6).

Yearling male 510 resided within his mother's home range in the Citico Creek study area from family breakup until 18 September 1983 when he was located 14 km southeast in the NNF, North Carolina (Figure 14). He remained in the Little Santeelah and Deep Creek drainages until 8 November when he shed his radio collar. It is uncertain whether he returned to his mother's range to den or established himself away from it.

Yearling female 511 also resided within her mother's home range in the Citico Creek area after breakup (Figure 15). On 7 October 1983 she moved to Glenn Gap Branch in the NNF but by 11 October, she had returned 4 km to Tennessee and the Jeffrey Hell area, still outside of her mother's range. On 15 October, she was located again within her mother's range. After a brief stay, on 19 October she began returning to North Carolina and by 27 October she was in the NNF. She remained here for a short while; on 2 November she moved back once more to Tennessee but relocated herself the first 2 weeks on the periphery of her mother's range. Yearling 511 later denned within this range.

Yearling male 512 (sibling of 511) also left his mother's range on 18 September 1983 and traveled to the NNF (Figure 16). On 26 September, he was located in the Deep Creek drainage and only 0.7 km from yearling male 510. The next location, on

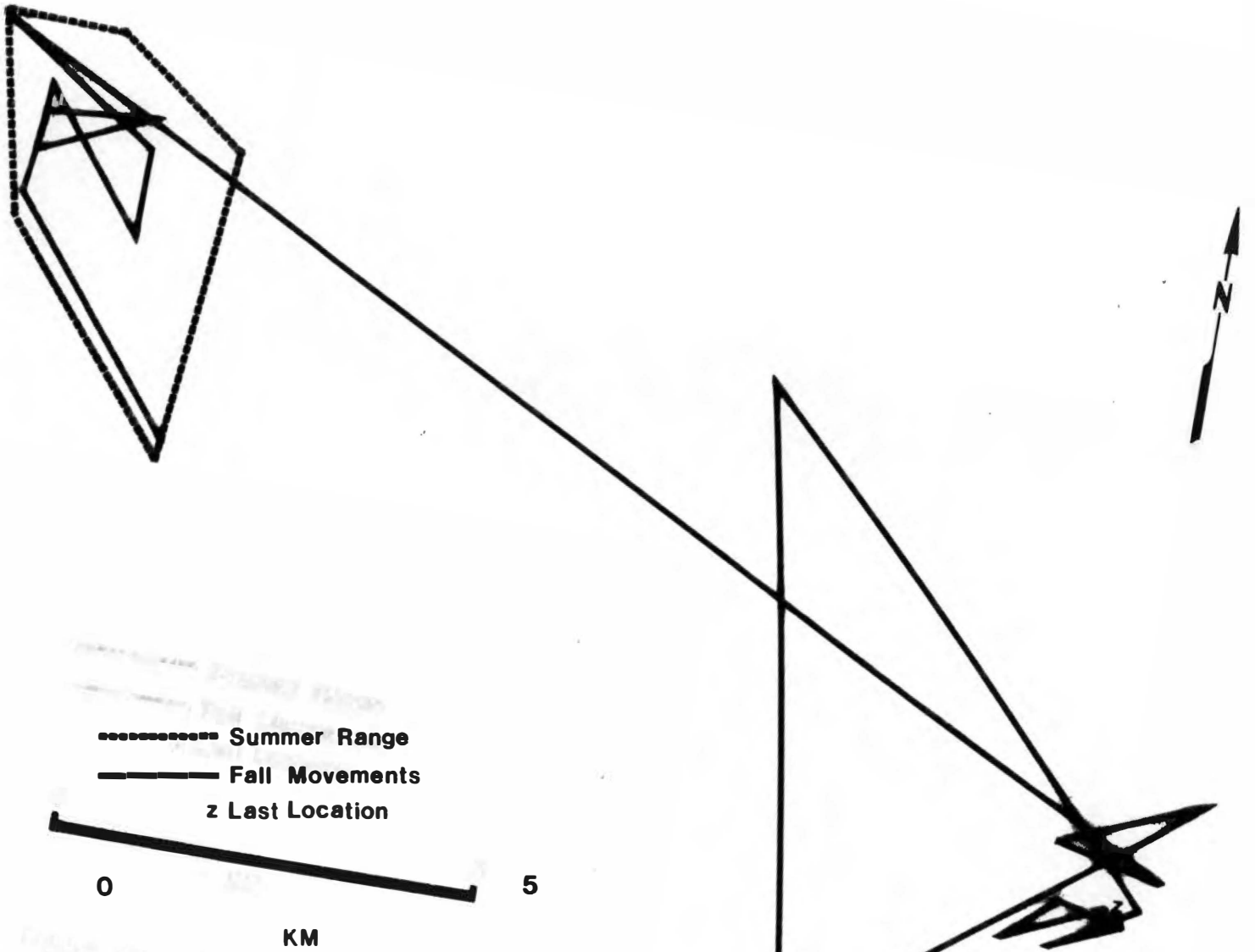


Figure 14. Fall Movements of Yearling Bear 510 in the Cherokee and Nantahalah National Forests, Tennessee and North Carolina Respectively, 1983.

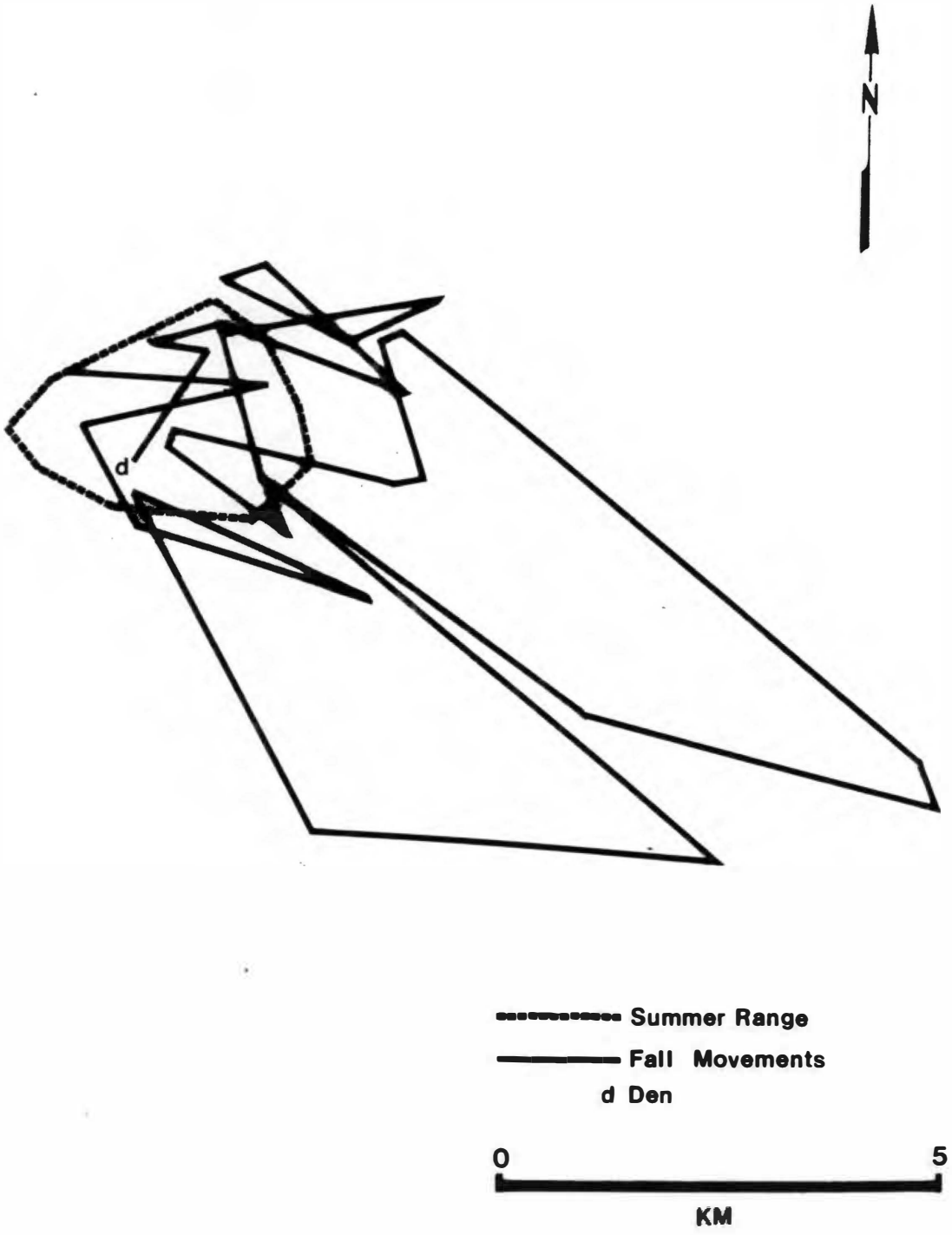


Figure 15. Fall Movements of Yearling Bear 511 in the Cherokee and Nantahalah National Forests, Tennessee and North Carolina, Respectively, 1983.

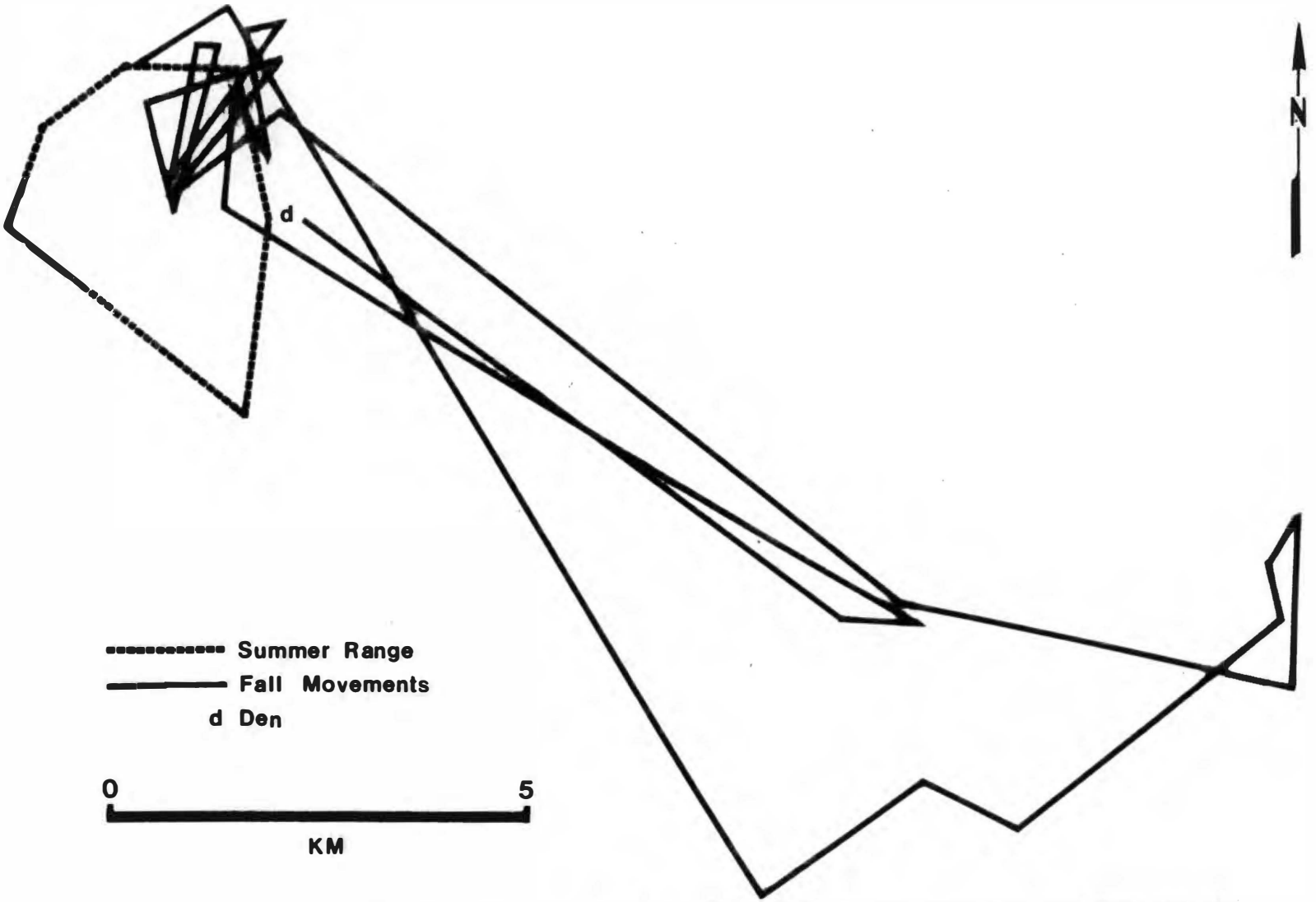


Figure 16. Fall Movements of Yearling Bear 512 in the Cherokee and Nantahalah National Forests, Tennessee and North Carolina, Respectively, 1983.

28 September, found the 2 in the same drainage 0.9 km apart. A captive-raised yearling female that was released in the Citico Creek study area in June 1983, soon thereafter traveled to the NNF, and on this date was located 0.9 km from yearling 510 and 0.5 km from yearling 512. The following month yearling 512 remained in this general area of the NNF before returning to the CNF on 29 October; he later denned on the periphery of his mother's range.

Extensive movements of yearlings have been noted by several authors (Rogers 1977, Alt 1978, Hugie 1982, Brody 1984a). Normally movements of this type reflect the seasonal feeding behavior of bears in the Southern Appalachians, whereby bears travel to areas known to be reliable for their fall food abundance. This behavior is not inherent among yearlings, but I assume it is learned through months of traveling during the fall under various conditions of food abundance and becoming familiar with the resources of the area. The movements shown here can best be described as pre-dispersal and exploratory movements as they were the first venture outside of their mothers' ranges. Two of the three yearlings radio-tracked until winter made several back-and-forth movements to their mothers' range and eventually denned there, indicating that home ranges were not established. Although selection does favor dispersing males and natal philopatry is widespread among female bears (Waser and Jones 1983), young females occasionally leave their mothers' range, for short or indefinite periods, as happened here (Rogers 1977, Alt 1978).

Bear 328, a 102 kg adult male, moved from the Citico Creek study area and his summer range on 22 August 1982. He had disappeared until 9 September when he was located by air 24 km to the south near Sugar Mountain and the Tennessee-North Carolina state boundary (Figure 17). He apparently made the same movement in fall 1980 when there was a mast crop failure (S. Garris, pers. communication). He remained in the Sugar Mountain-Waucheesi area and was last located there on 21 September before disappearing again. Nearly a month later on 19 October, he was found 30 km west in a remnant forested area near the town of Etowah, Tennessee. He remained here, moving about very little, until 31 October. On 6 November he was observed moving back towards the study area; he entered the CNF on 8 November, and reached the area of his summer range on 26 November, after traveling a triangular distance of 96 km and an area of 419 km^2. Later, on 7 December, he was killed legally outside of the Tellico Bear Refuge.

Bear 548, a 69 kg adult male, initially captured in August 1982, moved out of his 1983 summer range in early October and traveled to the NNF (Figure 18). On 16 October he was located on Art Stewart Ridge in North Carolina and soon thereafter was chased by hunting dogs back to the Tellico Bear Refuge and his summer home range, a distance of 19 km. He later left this area again and moved south a distance of 21 km where he was located on 30 October. Within a few days he had returned to the Citico Creek study area.

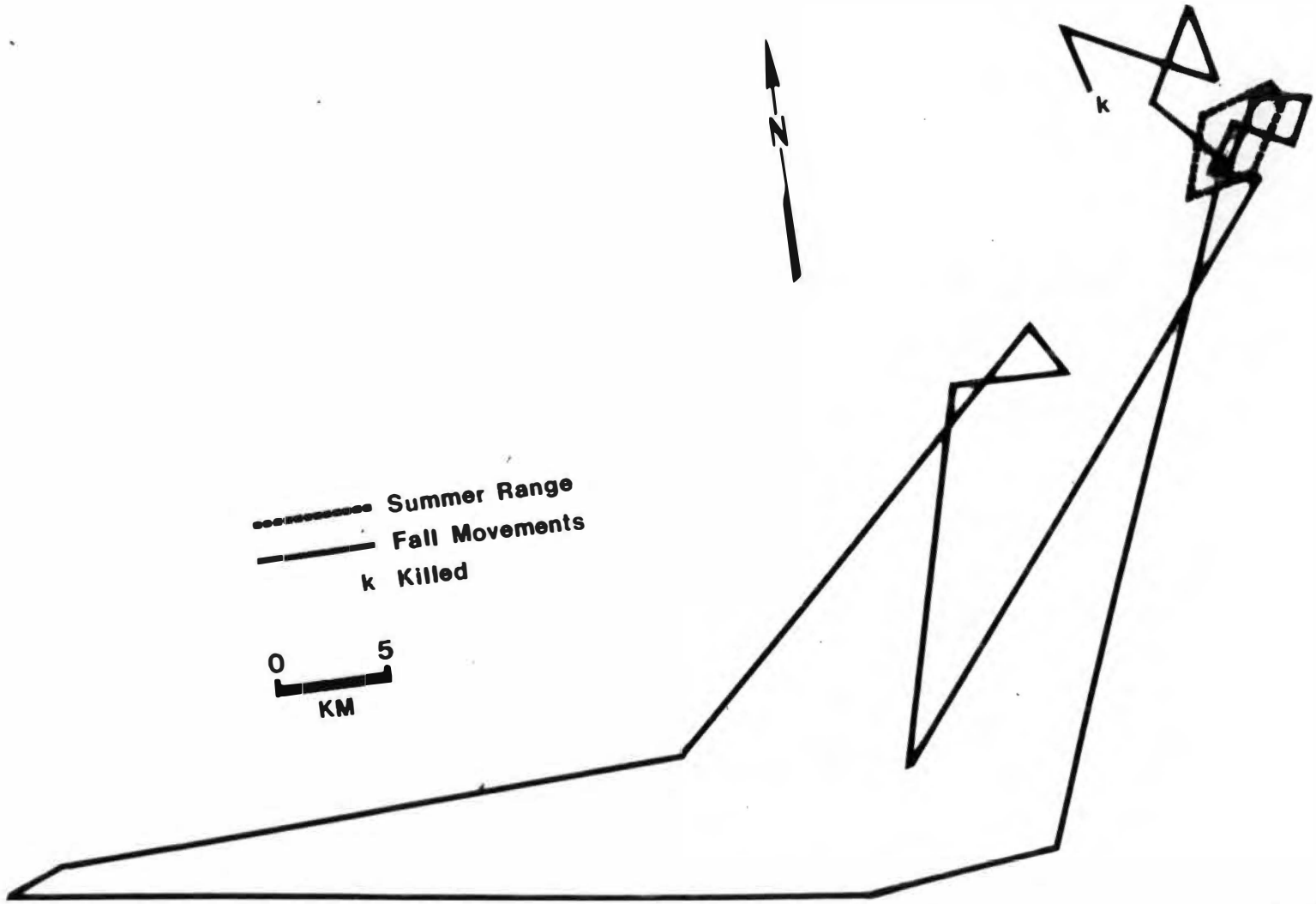


Figure 17. Fall Movements of Adult Male, Bear 328, in the Cherokee National Forest, 1982.

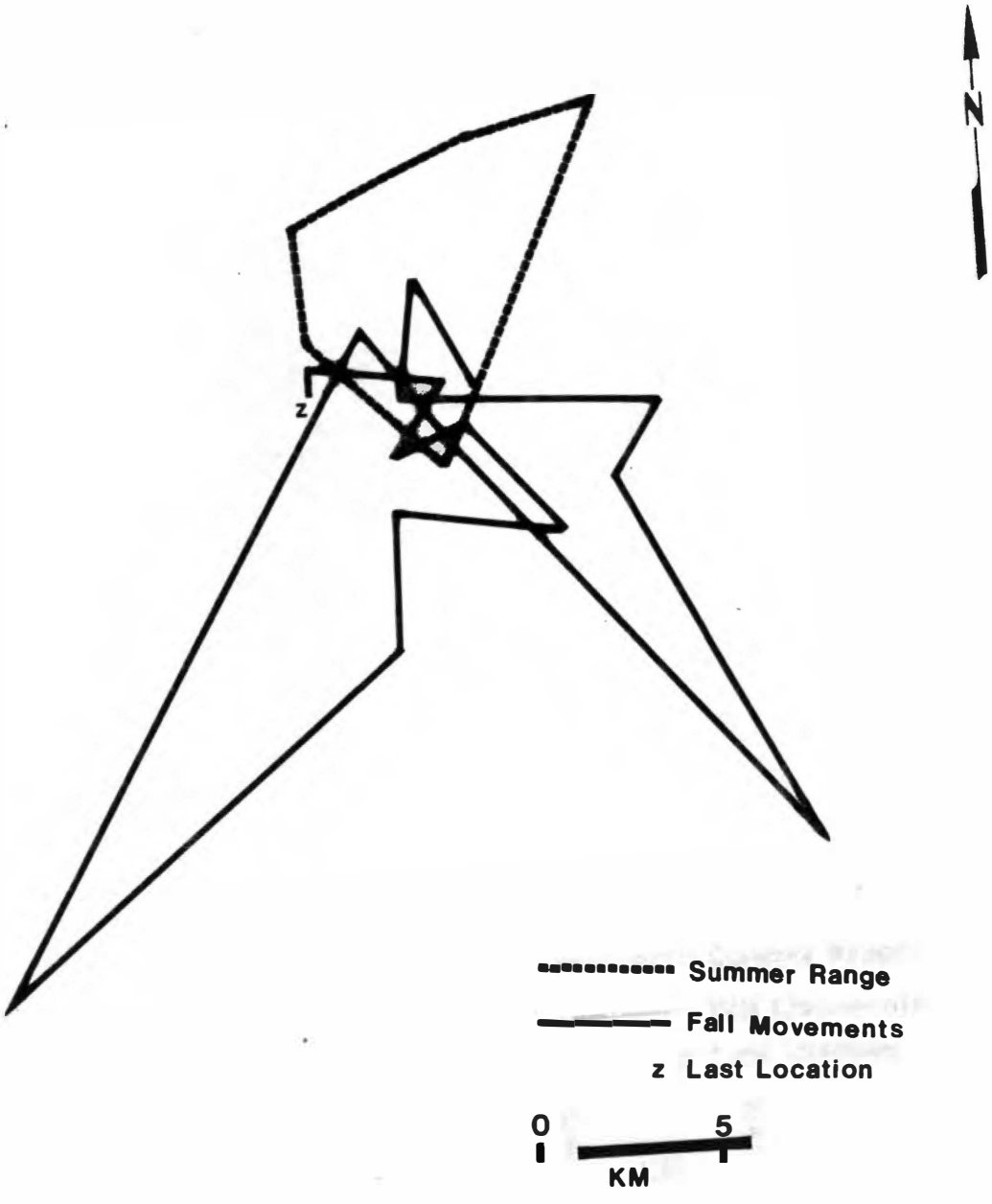


Figure 18. Fall Movements of Adult Male, Bear 548, in the Cherokee and Nantahalah National Forests, Tennessee and North Carolina, Respectively, 1983.

Bear 616 was a 52 kg adult male, captured in the Citico Creek study area on 4 August 1983; he utilized an area of 7 km^2 during the summer (Figure 19). On 26 September he was located southeast 16 km in the NNF. He remained in this area until 27 October when he was located further south 19 km in the Little Snowbird Creek area during the North Carolina bear hunting season. Many bears were found in this area and North Carolina bear hunters were able to tree several bears daily; being very selective, the hunters only killed the largest bears (D. Allen, North Carolina Game Commission, pers. communication). Within 1 week he had moved 15 km west into Tennessee and by 8 November he moved again 13 km north. He still continued to travel, moving 14 km to where he was found on 13 November, and on 18 November he had nearly returned the 14 km to the site of his 8 November location. On 21 November he was located 11 km northeast, once again in the NNF. His fall home range size was 315 km^2.

Adult males during the fall in the Southern Appalachians typically make long range movements away from their normal area of occupancy and increase their home range size dramatically (page 52) (Garshelis and Pelton 1981, Quigley 1982, Villarrubia 1982, Carr 1983, Garris 1983, Brody 1984a, this study). Some of the movements can be motivated by the abundance of fall food and the knowledge and familiarity of secure feeding sites. Their erratic nature possibly can be explained by the spatial distribution of the resources. However, there is always some uncertainty as we

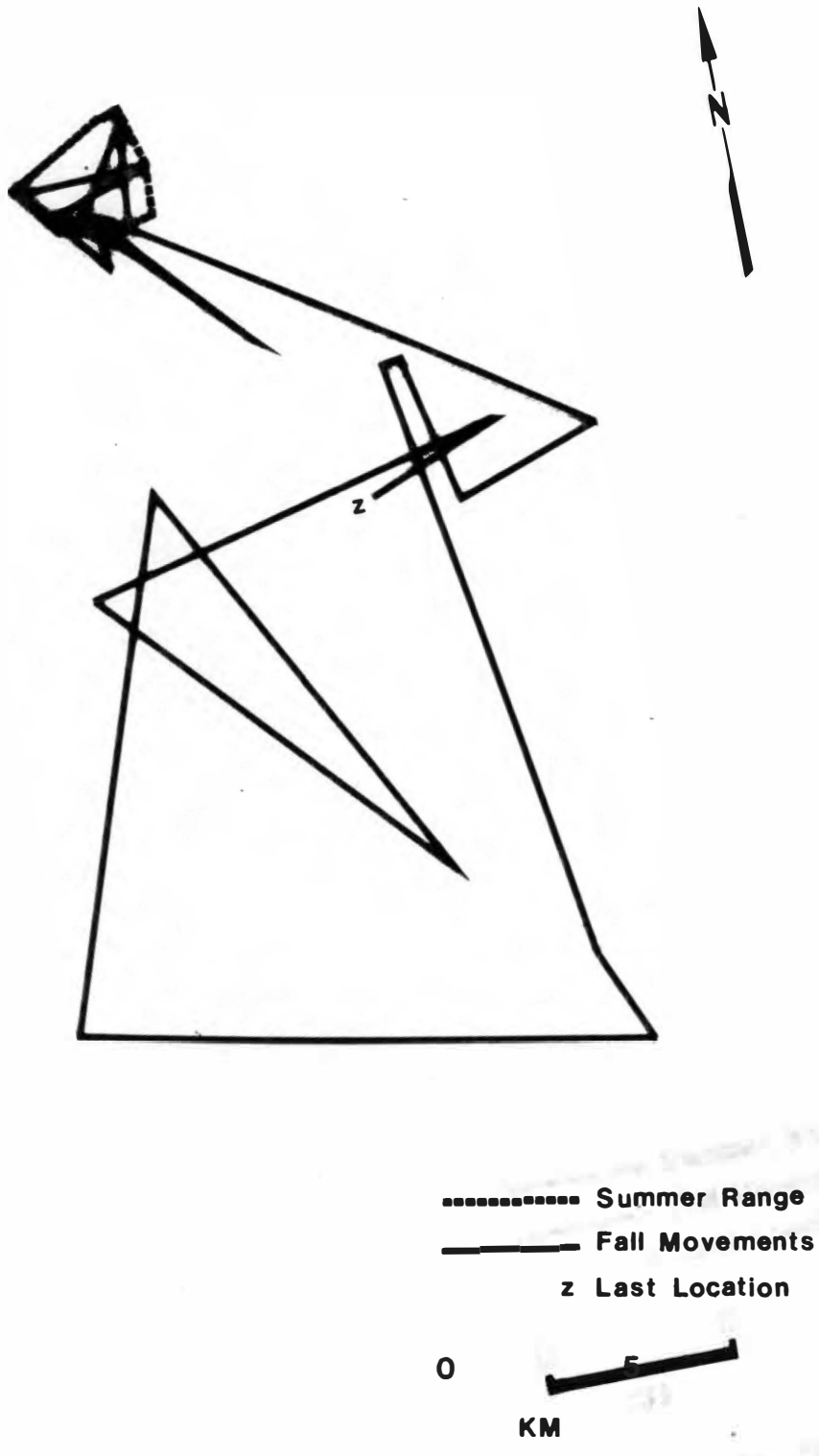


Figure 19. Fall Movements of Adult Male, Bear 616, in the Cherokee and Nantahalah National Forests, Respectively, 1983.

do not know all of the factors that may be influencing or playing an important role in these movements. The expansive fall home range of bear 328 is an example. After leaving the study area, he moved to a roadless area that he frequented during the fall 1980 when hard mast was scarce. His next long move west 30 km (19 mi), through large expanses of unsuitable habitat (farms and other non-forested areas) to a remnant forested area, may have been precipitated by factors other than just food availability. The movements of bear 548 and 616 exemplify the erratic nature of the fall movements and the lack of understanding we have for them. The influence of hunting dogs and hunters and the density of roads in an area is not fully understood but must certainly be important factors that can possibly precipitate these movements. The lack of suitable habitat, cover, refuge, and food resources, must certainly keep bears moving about, whether they are intentional moves to known areas of food abundance or mere wanderings in hopes of encountering food, as in an opportunistic strategy. Many of the movements observed in this study do appear to be wanderings (especially among the younger bears) that are occasionally interrupted by anthropogenic factors, which would explain the erratic movement patterns exhibited.

Bear 326, a 5 year old female with an established home range separated from her yearling on 25 June 1983. She continued to move throughout her home range during the summer although she left it for 2 days (Figure 20) being radio-located with adult male 548

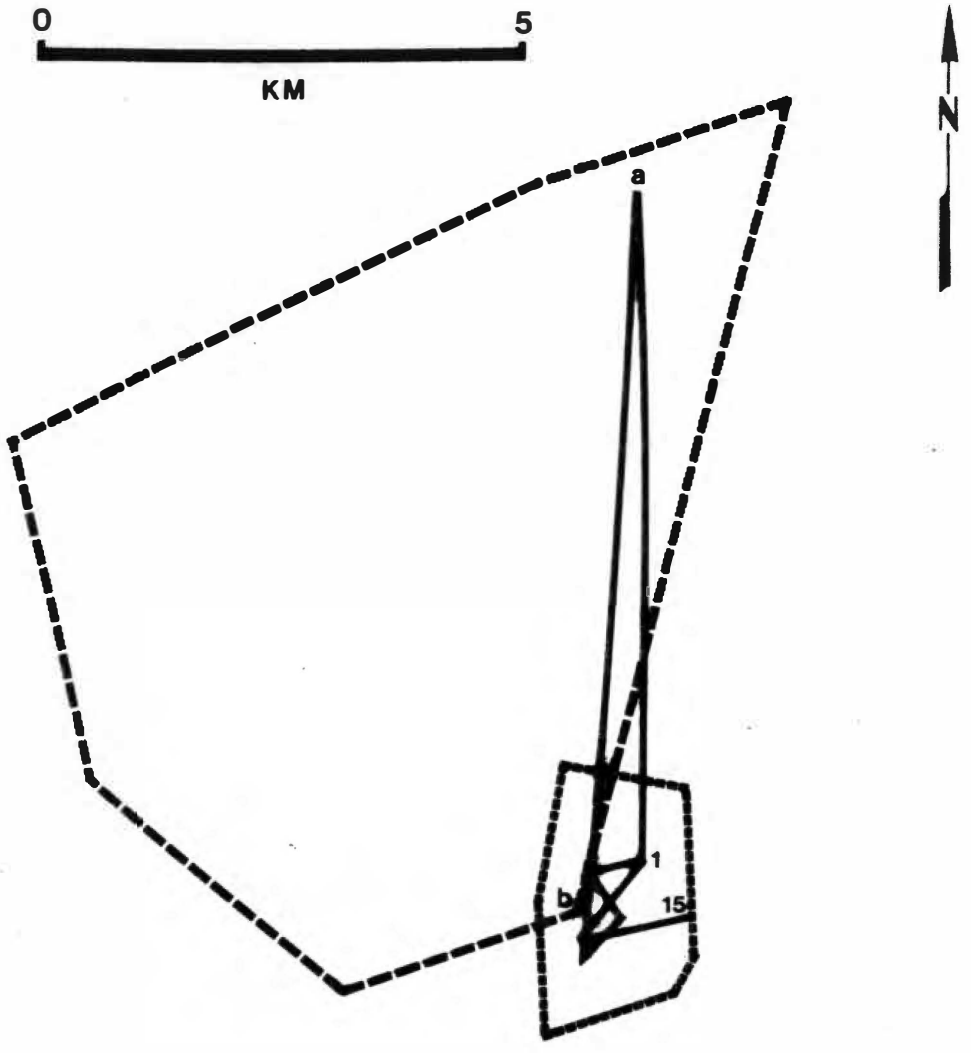


Figure 20. Notable Movement of Adult Female, Bear 326, Outside of Her Home Range, Cherokee National Forest, Tennessee, August 1983.

on 6 August far outside of her home range. Bear 548 entered the home range of bear 326 on 4 August. He was captured within the range the following day. While aerial tracking on 6 August, the 2 bears were radio-located together 7 km north of the home range of bear 326. She did not return to her home range until 8 August and was never observed to leave it thereafter.

Males concentrate their movements in areas of estrous females during the breeding season (Rogers 1977). The duration of estrous among black bears is not fully understood. Ammons (1974) found for 8 captive bears the period of sexual attractiveness to be 6 to 16 days ($\bar{x}$ = 9.75). Rogers (1977) believed that in wild bears the duration of female receptivity lasted only 4 days and the longest period that a female spent with a male during the breeding season was 5 days (intermittently). Bear 326 was captured on 3 August and was in estrous condition. She might still have been receptive on 5 August when male 548 was captured within her home area, and also 6 August when the 2 were radio-located together 7 km outside of her home area. In Minnesota (Rogers 1977) an adult female and adult male traveled together within the female's home range for nearly a day before they separated for a day and rejoined the following day. The type of movement exhibited by bears 326 and 548 where a female leaves her own home area and travels with a male far outside her normal range has never been recorded in the literature to my knowledge. Being a young bear and becoming estrous later than most other females (page 44) may create a physiological

urgency whereby they may readily alter their normal behavior in order to accommodate their reproductive requirements. This rare observation may offer evidence that reproductive behavior among black bears may be more flexible than previously thought.

Habitat Utilization

Of 1909 radio-telemetry locations made throughout the study, 1635 were used to analyze habitat utilization by black bears in the Citico Creek study area. Three habitat variables were quantified: (1) forest type, (2) stand age, (3) forest type/ stand age (pages 25-26). A chi-square procedure was utilized in the analysis, observed and expected frequencies of bear use of each variable were compared (Byers et al. 1984). All references to "less than" or "greater than" expected utilization are interpreted at a 0.10 level of significance.

Forest type. All radio-collared bears in the Citico Creek study area preferred the Mesic Hemlock and Oak-Hickory forest types and underused the Pine type during the study (Table 10). The Cove Hardwood forest type was used in proportion to its availability.

In the summer, adult males were disinclined to use the Mesic Hemlock forest type and used the others in proportion to their availability (Table 11). Adult females were disinclined to use the Cove Hardwood forest type during the summer and fall and showed no preference for the other forest types; adult males preferred the Oak-Hickory forest type above all others during the fall.

Table 10. Habitat Use by 19 Black Bears in the Cherokee National Forest, Tennessee, 1982-1983.

Category	Percent of Area	Percent Total Radio Locations	Significance[b]
FOREST TYPE			
Cove Hardwood	10.6	9.2	0
Mesic Hemlock	7.6	10.0	+
Pine	43.3	38.0	-
Oak-Hickory	38.5	42.8	+
STAND AGE			
≤ 9 years	5.0	3.0	-
10-29 years	7.4	9.1	0
30-49 years	18.3	18.1	0
50-69 years	59.5	54.6	-
70-89 years	8.2	11.6	+
90+ years	1.6	3.6	+
FOREST TYPE/ STAND AGE			
Young Pine	15.6	12.3	-
Mature Pine	36.2	39.6	+
Young Hardwood	6.5	1.0	-
Mature Hardwood	41.7	47.1	+

[a]Definitions of variables are given in Table 12 and pp. 25-26.

[b]- = Used in less proportion than available ($P \leq .10$).
0 = Used in proportion to availability ($P \leq .10$).
+ = Used in greater proportion than available ($P \leq .10$).

Table 11. Seasonal Habitat Use by Black Bears in the Cherokee National Forest, Tennessee, 1982-1983.

Category[a]	Percent of Area	Percent Radio Locations in Summer	Significance[b]	Percent of Area	Percent Radio Locations in Fall	Significance[b]
ADULT MALE (n=4)						
FOREST TYPE						
Cove Hardwood	12.6	12.3	0	12.6	8.3	0
Mesic Hemlock	8.0	2.1	-	8.0	4.5	0
Pine	46.4	56.0	0	46.4	41.8	0
Oak-Hickory	33.0	29.6	0	33.0	45.4	+
STAND AGE						
≤ 9 years	6.6	5.6	0	6.6	1.9	-
10-29 years	6.7	8.6	0	6.7	11.8	0
30-49 years	17.7	27.7	+	17.7	12.1	0
50-69 years	61.8	52.0	0	61.8	56.8	0
70-89 years	5.5	5.0	0	5.5	14.9	+
90+ years	1.7	1.1	0	1.7	2.5	0
FOREST TYPE/ STAND AGE						
Young Pine	16.7	14.4	0	16.7	13.8	0
Mature Pine	39.6	43.3	0	39.6	35.4	0
Young Hardwood	5.8	2.2	-	5.8	0.0	-
Mature Hardwood	37.9	40.1	0	37.9	50.8	+

Table 11 (Continued)

Category[a]	Percent of Area	Percent Radio Locations in Summer	Significance[b]	Percent of Area	Percent Radio Locations in Fall	Significance[b]
ADULT FEMALE (n=6;n=7)						
FOREST TYPE						
Cove Hardwood	7.8	3.4	-	7.9	5.1	-
Mesic Hemlock	5.8	7.6	0	6.9	9.5	0
Pine	34.7	38.0	0	37.9	39.8	0
Oak-Hickory	51.7	51.0	0	47.3	45.6	0
STAND AGE						
≤ 9 years	2.9	2.8	0	2.7	2.2	0
10-29 years	4.4	6.9	0	5.5	6.4	0
30-49 years	17.0	20.3	0	15.1	20.3	+
50-69 years	59.9	47.8	-	60.5	55.1	0
70-89 years	13.3	21.6	+	12.4	13.5	0
90+ years	2.5	0.6	-	1.8	2.5	0
FOREST TYPE/ STAND AGE						
Young Pine	11.1	11.1	0	11.1	11.4	0
Mature Pine	33.6	40.5	+	33.6	41.2	+
Young Hardwood	3.8	0.6	0	3.8	1.1	0
Mature Hardwood	51.5	47.8	0	51.5	46.3	0

Table 11 (Continued)

Category[a]	Percent of Area	Percent Radio Locations in Summer	Significance[b]	Percent of Area	Percent Radio Locations in Fall	Significance[b]
ADULT BEARS (n=9,n=11)						
FOREST TYPE						
Cove Hardwood	11.8	5.1	-	11.8	5.3	-
Mesic Hemlock	6.8	6.5	0	6.8	9.7	+
Pine	41.4	41.3	0	41.4	40.4	0
Oak-Hickory	40.0	46.8	+	40.0	44.6	+
STAND AGE						
≤ 9 years	5.2	3.5	-	5.2	1.2	-
10-29 years	6.3	7.8	0	6.3	12.4	+
30-49 years	16.8	21.4	+	16.8	20.7	0
50-69 years	61.3	51.1	-	61.3	50.5	-
70-89 years	8.6	15.2	+	8.6	12.7	+
90+ years	1.6	0.8	0	1.6	2.5	0
FOREST TYPE/ STAND AGE						
Young Pine	15.3	14.6	0	15.3	14.5	0
Mature Pine	38.1	39.4	0	38.1	40.0	0
Young Hardwood	5.3	1.3	-	5.3	1.6	-
Mature Hardwood	41.3	44.7	0	41.3	43.9	0

Table 11 (Continued)

Category[a]	Percent of Area	Percent Radio Locations in Summer	Significance[b]	Percent of Area	Percent Radio Locations in Fall	Significance[b]
YEARLING BEARS (n=6)						
FOREST TYPE						
Cove Hardwood	8.0	14.0	+	8.0	9.3	0
Mesic Hemlock	7.5	10.2	0	7.5	9.3	0
Pine	38.7	38.8	0	38.7	41.1	0
Oak-Hickory	45.8	37.0	-	45.8	40.3	0
STAND AGE						
≤ 9 years	1.1	2.9	0	1.1	1.9	0
10-29 years	9.4	9.5	0	9.4	1.5	-
30-49 years	19.1	13.6	-	19.4	25.5	0
50-69 years	57.8	58.8	0	57.8	44.0	-
70-89 years	9.0	7.7	0	9.0	11.4	0
90+ years	3.6	7.5	+	3.3	5.7	0
FOREST TYPE/ STAND AGE						
	12.5	11.6	0	12.5	11.9	0
Young Pine	33.2	38.0	+	33.2	41.6	+
Mature Pine	3.3	1.0	0	3.3	0.4	-
Young Hardwood	51.0	49.4	0	51.0	46.1	0
Mature Hardwood						

[a]Definitions of variables are given in Table 12 and pages 25-26.

[b]- = Used in less proportion than available ($P \leq .10$).
0 = Used in proportion to availability ($P \leq .10$).
+ = Used in greater proportion than available ($P \leq .10$).

During the summer, all adult bears underused the Cove Hardwood habitat and preferred the Oak-Hickory while yearling bears underused and preferred the exact opposite of the two forest types. All other types were used in proportion to availability. Adult bears during the fall showed preference for the Mesic Hemlock and Oak-Hickory types and underused the Cove Hardwood types while the yearlings used all the forest types proportionately.

In GSMNP, black bears showed a strong preference for the hardwood habitat type. Quigley (1982) found that overall, use of mast areas was significantly higher than expected; females preferred mast areas while males did not, and adults preferred mast areas more than subadults, especially during the summer and fall. Carr (1983) noted that bears in GSMNP were found most often in the Closed Oak, Open Oak and Pine, and Cove Hardwood forest types. In summer, Open Oak and Pine, and Closed Oak types were utilized more than expected; in fall, the Closed Oak forests were preferred.

In the PNF (Brody 1984a), both males and females avoided or were indifferent to the softwood and mixed hardwood-softwood types throughout the year. Both sexes preferred brush areas during the summer. In fall, males underutilized the White Oak-Red Oak-Hickory type while females the softwood and Chestnut Oak types; both sexes showed preference for the Yellow Poplar-White Oak-Northern Red Oak forest cover type.

Villarrubia (1982) discovered in the CNF that all radio-collared black bears preferred the Pine type and were indifferent

to the Mesic Hemlock and Oak-Hickory types. During the summer these same preferences and avoidances prevailed while in fall, all habitat types were used in proportion to their availability. Garris (1983), also working here, found bear use of hardwoods significantly higher than that of softwoods. Males overall preferred hardwood habitat types whereas females preferred the softwood habitats. In summer, both sexes utilized the pine areas more than expected and both preferred hardwoods in fall.

From the analyses of bear use of the available forest types in the CNF during this study, Oak-Hickory appears to be the most preferred and important forest type throughout the year. All of the adult bears utilized the Oak-Hickory forest type in summer and fall more than expected. During the summer, berries (Rubus, Gaylussacia, and Vaccinium spp.) are the preferred food of bears in the Smoky Mountains (Beeman and Pelton 1980, Eagle and Pelton 1983). The Oak-Hickory habitat provides summer foods in the form of huckleberries (Gaylussacia spp.) and blueberries (Vaccinium spp.) on their upper north-facing slopes (Harmon 1980). Berries are also commonly found in the early succession Pine habitat, which bears here used in proportion to its availability. Adult males showed strong preference in fall for the Oak-Hickory forest type while females were indifferent. This forest community differs from all others in that it is composed predominantly of hard mast producing species. Hard mast has long been known to be of vital importance to bears in the fall since it is the main food item

(Beeman and Pelton 1980, Eagle and Pelton 1983), is highly correlated with reproductive success (Rogers 1976), and being high in fats and carbohydrates, it is of important overwintering survival value.

Yearling bears underused the Oak-Hickory forest type during the summer while the adults preferred it. The Cove Hardwood area which was preferred by yearlings was under-utilized by adults. Rogers (1977) found that after family breakup, mothers shared their home range with their offspring but in doing so, avoided them, giving them exclusive use of certain parts of the range. When this occurred, the yearlings' ranges were in good bear habitat, better than their own mothers'. This did not happen in the CNF during this study as yearlings did not use the high quality habitat that the adults inhabited. Yearling and subadult males may take up residence in low quality habitats in order to avoid any possibly dangerous confrontations with adult bears, thereby maximizing their chances of survival. Yearling and subadult females reside within their mothers' ranges but may be relegated to the sub-optimum areas because of their non-breeding status.

Stand age. All bears preferred stands in the 70+ year old age class and under-utilized early succession stands and those of the 50 to 69 year old age class (Table 10, page 90). Stands greater than 70 years old are very productive in terms of bear foods (especially during the fall) and also provide suitable den trees. A closed overstory and open understories are ideal conditions for the growth of matted vegetation, e.g., blueberries (Vaccinium

spp.) and huckleberries (Gaylussacia spp.). All other age classes were used in proportion to their availability.

In the summer, adult males used the stands between 30 to 49 years old more than expected and were indifferent to all others (Table 11, page 91). It is difficult to correlate male movements during the summer with certain foods being available because the summer fruits are distributed evenly throughout the study area and much of their movement is related to breeding activity. Adult females underused stands between 50 to 69 and 90+ years, and preferred stands in the 70 to 89 year old class. The 70 to 89 age class is by far the largest represented covering nearly 60% of the females' ranges. Although summer foods are available in this class, much of their activity may be centered here whether it is related to feeding, sleeping, or other types of body maintenance. In the fall, adult males did not often use stands 9 years old and less and used stands of the 70 to 89 year old age class significantly higher than expected while adult females preferred stands of the 30 to 49 year old class. Stands in the 70 to 89 year age class are the most productive for oak species and since the distribution of hard mast is patchy, bear use of this habitat/age class will be more readily identifiable during the fall and even more so during years of low mast abundance.

Adult bears in the summer were indifferent to the 0 to 29 and the 50 to 69 year old age class, and preferred the 30 to 49 and 70 to 89 year old class. Yearlings overall were indifferent

to most stand age classes but did avoid the 30 to 49 age class and preferred the 90+ age class. Of the 6 stand age groupings, adults and yearlings differed in usage of the 30 to 49 year age class during the summer.

In the fall adults preferred stands of the 10 to 20 and 70 to 89 year old age class and underutilized the 0 to 9 and 50 to 69 year age classes. Yearlings underutilized stands of the 10 to 29 and 50 to 69 year age class and used all the remaining age classes in proportion to their availability. Adults and yearlings differed in usage of stands in the 10 to 29 year age class (adults preferring) but were in agreement by underusing the 30 to 49 year age class. Whether or not adults are able to exclude yearlings from the more productive stands in either season is uncertain since there is no habitat or forest type component involved in the analysis and other environmental factors can confound the relationship.

Forest type/stand age. For all bears in the study, the Young Pine and Hardwood forest types were underutilized while the Mature Pine and Hardwood types were used significantly more than expected (Table 10, page 90). In the summer, adult males did not often use the Young Hardwood forest type and were indifferent to all others while adult females preferred Mature Pine (Table 11). The Mature Hardwood forest type was used more than expected by adult males in the fall and the Young Hardwood was avoided. Adult females only preferred the Mature Pine forest types as during the summer.

Adult bears during the summer were indifferent to the Young Hardwood forest and yearlings preferred the Mature Pine areas, all other forest types were treated indifferently by the bears. In the fall, the same preferences and avoidances prevailed except that also the Young Hardwood forest type was underutilized by yearlings. Both age groups were not well represented in the Young Hardwood forest type probably because it occurred in less than 5% of their ranges. The Mature Pine forest is represented well (33-38%), which was highly preferred by yearlings throughout the year, may be an attractive habitat to the young bears because of its openness and protective qualities. Although these qualities may be found in the Mature Hardwood areas as well, the latter habitat is the better bear habitat and would be frequented by more adult bears.

CHAPTER V

SUMMARY AND CONCLUSIONS

1. Research was conducted in the Citico Creek area of the Cherokee National Forest (CNF) from July 1982 through February 1984 to determine habitat and space utilization of black bears.

2. Thirty-four individual bears were captured a total of 43 times during the study. Twenty-one males and 13 females were captured, including 3 yearlings and 4 cubs. Of these, twenty-four untagged and 5 tagged bears were from 2 earlier studies.

3. From 6 years of trapping and tagging data in the study area, 66 individual bears were marked including 20 adult males, 7 adult females, 19 subadult males, and 20 subadult females. Of these recaptured there were 3 adult males, 4 adult females, 4 subadult males, and 11 subadult females.

4. Ten individual bears from 3 families were immobilized in winter dens during 1983 to determine timing of family breakup and the subsequent familial spatial relationships. Seven yearlings from the 3 families were radio-collared. One adult female died during the immobilizations, and 1 yearling male died soon after den emergence.

5. Eight bears were equipped with radio-transmitters when the study began in July 1982. A total of 15 additional radio collars were attached to captured bears; 11 untagged bears were fitted with radio-collars and 4 bears were re-collared.

6. A total of 1,909 radio locations were collected from 20 individual bears; 274 were discarded for not meeting error polygon size and shape requirements and 1,635 were utilized in the analyses.

7. The mean tracking period for adult males was 165 ± 136 days (n=6) and adult females 407 ± 107 days (n=7); yearling males 133 ± 37 days (n=3) and yearling females 240 ± 60 days (n=4).

8. Radio location data were collected for the entire study for only 5 bears (1 adult male, 4 adult females) and continuous data were recorded for 8 bears from the previous 2 studies.

9. Family breakup occurred in 2 families between (1) 29 May and 5 June and (2) 22 June and 25 June, respectively. It is postulated that mothers induce separation from young in attempts to breed with males early in the summer.

10. Mother and offspring reassociations did take place for both families after separation. All of the offspring of one family were reunited with their mother on 7 June 1983. The second family reunited on 31 July and 14 September 1983. Sibling reassociations between orphaned yearlings occurred on 7 June and 8 September 1983. Family bonds apparently weakened with time but did not dissolve.

11. During the summer and fall, home ranges of 7 adult males (20 km^2 and 132 km^2, respectively) by the convex polygon method were significantly larger ($P<0.002$) than the home ranges of 12 adult females (4 km^2 and 4 km^2, respectively). Adult summer ranges were significantly larger than yearling ranges (11 km^2 vs. 4 km^2; $P=0.10$) but not during the fall (77 km^2 vs. 20 km^2).

12. Adult male intra-year ranges increased significantly ($P=0.025$) from summer to fall during both years and inter-yearly for the fall seasons ($P=0.025$). This seasonal increase was likely due to hunter-related activities in CNF in the fall. Intra-year and inter-year seasonal ranges of adult females were constant throughout the study. The intra-year seasonal ranges of yearlings increased significantly from summer to fall ($P<0.01$) and could be explained as pre-dispersal or exploratory movement behavior.

13. Seasonal shifts of harmonic mean centers of activity were analyzed. Adult males shifted seasonal activity centers a significantly greater distance than adult females. Yearlings showed a large seasonal shift as well, but this was attributed to long range fall movements by 2 individuals.

14. Home ranges of adult males overlapped over 50% during both years. The mean range overlap of adult females was only 14 and 22% in 1982 and 1983, respectively.

15. Spatial relationships between mother and offspring after family breakup and the orphaned yearlings with the vacated home range of their mother showed a gradual yearling independence from their mother's range as time progressed.

16. The mean distance between mothers and their offspring after breakup increased each month and reached a maximum in October 1983. Male yearlings were located on the average further from their mothers than female yearlings during September and October 1983 and female yearlings remained within or near their mothers'

range. However, during the months of June, July and August, male and female yearlings were located equidistant from their mothers. The mean distance between siblings after breakup also increased each month reaching a high in October indicating that family bonds weakened.

17. Notable long range movements were made during the study. Three yearlings (2 males, 1 female) moved into the Nantahala National Forest (NNF), North Carolina, during fall 1983. Adult male bear 328 moved over an area of 419 km^2 during the fall of 1983. Adult male bear 548 moved to the NNF also and ranged into the Tellico River watershed in fall 1983. Adult male bear 616 ranged into the NNF and Tellico River area in fall 1983 and used an area of 350 km^2. Many of these movements were attributed to human disturbances (hunters and dogs). One estrous adult female moved out of her summer range 7 km and was found with an adult male that was trapped within her home range 1 day prior.

18. All radio-collared bears in the study area preferred the Mesic Hemlock and Oak-Hickory forest types and underutilized the Pine forest type. No one forest type was preferred by adult males or female bears during the summer. In the fall, adult males preferred the Oak-Hickory forest type above all others. Adults as a whole preferred the Oak-Hickory forest and underused the Cove Hardwood forest type during the summer; yearlings preferred and avoided the reverse. In the fall, adults preferred the Mesic Hemlock and Oak-Hickory types while yearlings showed no preference.

19. All bears preferred stands in the 70+ age class and underused the early succession areas. In summer, adult males preferred stands between 30 to 49 years old and adult females preferred stands of 70 to 89 year age class. In fall, males used stands of the 70 to 89 year age class more than expected while females preferred the 30 to 49 year age class. Adults, as a whole, in summer preferred the 30 to 49 year, and the 70 to 89 year age classes. Yearlings preferred the 90+ age class. In fall, adults preferred stands of 10 to 20 and 70 to 89 years old while yearlings showed no preferences.

20. All bears used the Mature Pine and Hardwood forest types more than expected during this study. In summer, adult females preferred Mature Pine areas while adult males used all types in proportion to their availability. Mature Hardwood areas were preferred by males in the fall and females preferred Mature Pine. Adults during the summer were indifferent to all forest types while yearlings preferred the Mature Pine areas. In fall, all forest types were used in proportion to their availability by the age classes.

21. The Oak-Hickory forest type appeared to be the most utilized and important of all forest types throughout the year for all bears. Yearlings were found to use lower quality habitats during summer and fall, especially males, possibly for avoiding confrontations with adults inhabiting the higher quality habitats. Yearling females remained within or near their mothers' ranges and occupied sub-optimum habitats.

22. The age class ratio from the CNF bear population studied indicates that it is exploited and reductions in the population are occurring. Extrinsic pressure from illegal hunting is the primary cause. Inadequate law enforcement, coordinated poaching efforts, and numerous unlocked logging roads into all parts of the Forest have made the above possible and will continue until efforts are made to reduce them.

23. The Tellico Bear Refuge appears to be serving its purpose, creating a reservoir for breeding females protected from hunting. Poaching or any attempts at it during 1982 and 1983 in the Cowcamp Ridge area was nearly non-existent; poachers appear to respect some areas of the Refuge. In combination with the Citico Creek Wilderness and the adjacent Joyce Kilmer-Slickrock Wilderness areas in North Carolina, segments of the population remain relatively unmolested and aid in countering the negative pressures of illegal hunting. By blocking non-operative logging roads through gating or other effective means and operative roads once the activity is completed, access to many areas will be reduced and they will remain protected from human-related activities. This will result in a reduction in illegal hunting activity and the suitability of the bear range in the CNF will be elevated.

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APPENDIXES

APPENDIX A

Table 12. U.S. Forest Service Forest Cover Types and Their Respective Forest Community Types on Citico Creek Study Area, Cherokee National Forest, Tennessee.

Forest Type	Forest Cover Type (Code)
1. Cove Hardwood	White Pine-Cove Hardwood (09) White Pine-Upland Hardwood (10) Cove Hardwoods-White Pine-Hemlock (41) Upland Hardwoods-White Pine (42)
2. Mesic Hemlock	White Pine (03) White Pine-Hemlock (04) Hemlock (05) Hemlock Hardwood (08) Bottomland Hardwood-Yellow Pine (46) Yellow Poplar (50) Sweet Gum-Yellow Poplar (58)
3. Pine	Shortleaf Pine (32) Virginia Pine (33) Pitch Pine (38) Table Mountain Pine (39) Shortleaf Pine-Oak (12) Loblolly Pine-Hardwood (13) Slash Pine-Hardwood (14) Pitch Pine-Oak (15) Virginia Pine-Oak (16) Table Mountain Pine-Hardwood (20)
4. Oak-Hickory	Southern Red Oak-Yellow Pine (44) Chestnut Oak-Scarlet Oak-Yellow Pine (45) White Oak-Black Oak-Yellow Pine (47) Northern Red Oak-Hickory-Yellow Pine (48) Post Oak-Black Oak (51) Chestnut Oak (52) White Oak-Red Oak-Hickory (53) White Oak (54) Northern Red Oak (55) Yellow Poplar-White Oak-Northern Red Oak (56) Scarlet Oak (59) Sugar Maple-Beech-Yellow Birch (81)

APPENDIX B

Table 13. Summary of Data on Captured Black Bears in the Cherokee National Forest, Tennessee, 1982-1983.

Ear Tag[a] Left	Ear Tag[a] Right	Sex	Age[b]	Wgt (kg)	Capture Date	Capture[c] Site
R592	S592	Female	A	43	13 Jul 82	CCR
R595	S594	Female	A	41	15 Jul 82	CCR
R594	S593	Female	SA	31	15 Jul 82	CCR
R595	S594	Female	A	41	17 Jul 82	CCR
S326	Y326	Female	A	47	28 Jul 82	FB
Y346	S346	Female	A	55	7 Aug 82	DCR
S544	Y544	Female	A	50	10 Aug 82	DCR
Y542	S542	Male	Y	34	11 Aug 82	DCR
Y545	S545	Male	C	10	14 Aug 82	CCR
S546	Y546	Female	C	10	15 Aug 82	CCR
R592	S592	Female	A	48	16 Aug 82	CCR
S507	Y507	Female	A	49	18 Aug 82	CCR
Y547	S547	Male	A	70	20 Aug 82	CCR
Y548	S548	Male	A	69	20 Aug 82	CCR
Y348	S328	Male	A	102	20 Aug 82	DCR
R595	S594	Female	A	43	28 Aug 82	CCR
S546	Y546	Female	C	10	9 Sep 82	CCR
Y510	S510	Male	Y	20	15 Jan 83	DEN
S326	Y326	Female	A	--	15 Jan 83	DEN
S305	Y305	Female	A	--	22 Jan 83	DEN
S511	Y511	Female	Y	16	22 Jan 83	DEN
Y512	S512	Male	Y	17	22 Jan 83	DEN
S513	Y513	Female	Y	14	22 Jan 83	DEN
S306	Y306	Female	A	--	12 Feb 83	DEN
Y545	S545	Male	Y	14	12 Feb 83	DEN
S546	Y546	Female	Y	10	12 Feb 83	DEN
S514	Y514	Female	Y	14	12 Feb 83	DEN
Y515	S515	Male	A	57	17 Jun 83	CCR
S516	Y516	Male	A	82	21 Jun 83	CCR
Y518	S518	Male	A	63	5 Jul 83	CCR
Y519	S519	Male	A	82	10 Jul 83	DCR
O613	S613	Male	A	88	12 Jul 83	DCR
S592	R592	Female	A	41	14 Jul 83	CCR
S516	Y516	Male	A	82	17 Jul 83	DCR
O614	S614	Male	A	72	19 Jul 83	CCR
O631	S346	Female	A	66	1 Aug 83	DCR
O632	S632	Male	A	106	3 Aug 83	CCR
S633	Y326	Female	A	57	3 Aug 83	CCR
O616	S616	Male	A	52	4 Aug 83	CCR
O615	S615	Male	A	63	5 Aug 83	CCR
Y548	S548	Male	A	67	5 Aug 83	CCR
O617	S617	Male	A	76	7 Aug 83	CCR
S507	Y507	Female	A	52	7 Aug 83	CCR
S635	O635	Female	C	13	7 Aug 83	CCR
O636	S636	Male	SA	47	8 Aug 83	CCR
O637	S637	Male	A	54	9 Aug 83	CCR
S507	Y507	Female	A	52	9 Aug 83	CCR
Y512	S512	Male	Y	28	10 Aug 83	CCR
S639	O639	Female	C	9	13 Aug 83	CCR
Y519	S519	Male	A	82	14 Aug 83	CCR
S507	Y507	Female	A	52	17 Aug 83	CCR
O638	S638	Male	A	63	8 Sep 83	CCR
Y512	S512	Male	Y	35	13 Sep 83	CCR

[a] O = Orange
R = Red
S = Silver
Y = Yellow

[b] A = Adult
SA = Subadult
Y = Yearling
C = Cub

[c] CCR = Cowcamp Ridge
DCR = Doublecamp Ridge
FB = Flint Branch
DEN = Densite

Table 14. Capture, Marking, and Radio Transmitter Installation Data From Black Bears Captured and Released in the Citico Creek Study Area, Cherokee National Forest, Tennessee, 1978-1983.

Ear Tag[a]		Previous Tags[a]			Radio	Radio		
Left	Right	Left	Right	Tattoo #	Freq.[b]	Ser. #	Capture Date	Comments
Y163	Y164	-	-	-	-	-	6 June 1978	Initial
Y167	Y168	-	-	-	-	-	6 June 1978	Initial
Y301	M301	-	-	301	1.235	2316	23 June 1978	Initial
M305	Y305	-	-	305	1.340	2321	24 June 1978	Initial
M306	Y306	-	-	306	1.295	2319	25 June 1978	Initial
M307	Y307	-	-	307	1.250	2317	25 June 1978	Initial
Y303	M303	-	-	303	1.310	2320	28 June 1978	Initial
M308	Y308	-	-	308	-	-	9 July 1978	Initial
M304	Y304	-	-	304	-	-	3 Aug. 1978	Initial
M313	Y313	-	-	313	-	-	7 Aug. 1978	Initial
M304	Y314	-	Y304	304	-	-	11 Aug. 1978	Re-capture (8/3/78)
M307	Y307	-	-	307	1.250	2317	12 Aug. 1978	Re-capture (6/25/78)
M306	Y306	-	-	306	1.295	2319	13 Aug. 1978	Re-capture (6/25/78)
M308	Y308	-	-	308	1.070	2541	16 Aug. 1978	Re-capture (7/9/78)
-	Y315	R129	R128	315	1.054	2539	17 Aug. 1978	Released in study area
M305	Y305	-	-	305	1.340	2321	24 Aug. 1978	Re-capture (6/24/78)
M316	Y316	-	-	316	1.105	2543	24 Aug. 1978	Initial
Y303	M303	-	-	303	1.310	2320	31 Aug. 1978	Re-capture (6/28/78)
M307	Y307	-	-	307	1.250	2317	31 Aug. 1978	Re-capture (6/25.8/12/78)
Y317	M317	-	-	317	1.355	2546	1 Sept.1978	Initial
Y320	M320	R129	Y315	320	1.054	2539	28 Sept.1978	Re-capture (8/17/78)
Y322	M322	-	-	322	1.393	3751	2 June 1979	Initial
M331	Y331	-	-	331	1.288	3743	3 June 1979	Initial
Y334	M334	-	-	334	1.168	3735	5 June 1979	Initial
M326	Y326	-	-	326	-	-	7 June 1979	Initial

Table 14 (Continued)

Ear Tag[a]		Previous Tags[a]			Radio	Radio		
Left	Right	Left	Right	Tattoo #	Freq.[b]	Ser. #	Capture Date	Comments
M327	Y327	-	Y316	327	1.438	3757	8 June 1979	Re-capture (8/24/78)
Y335	M335	-	-	335	1.273	3742	10 June 1979	Initial
M306	Y306	-	-	306	1.295	2319	11 June 1979	Re-capture (6/25,8/13/78)
M305	Y305	-	-	305	1.340	2321	13 June 1979	Re-capture (6/24,8/24/79)
Y335	M335	-	-	-	-	-	14 June 1979	Re-capture (6/10/79)
M336	Y336	-	-	336	1.378	3749	15 June 1979	Initial
Y337	M337	-	-	337	1.363	3748	15 June 1979	Initial
Y309	M309	-	-	309	0.864	3733	18 June 1979	Initial
Y328	M328	-	-	328	1.198	3737 or 3339	28 June 1979	Initial
Y303	M303	-	-	303	1.310	2320	29 June 1979	Re-capture (6/28,8/31/78)
Y337	M337	-	-	337	1.363	3748	4 July 1979	Re-capture (6/15/79)
Y330	M322	Y322	M322	322	1.393	3751	5 July 1979	Re-capture (6/2/79)
M307	Y307	-	-	307	1.250	2317	7 July 1979	Re-capture (6/25,8/12,8/31/78)
Y332	M332	-	-	332	-	-	9 July 1979	Initial
M343	Y343	-	-	343	1.541	4688	12 July 1979	Initial
M338	Y338	-	-	338	1.530	4687	18 July 1979	Initial
Y344	M344	-	M304	304	1.531	4687	24 June 1980	Re-capture (8/3/78)
Y342	M342	-	-	342	1.021	2315	26 July 1980	Initial
M326	Y326	-	-	326	1.415	-	27 June 1980	Re-capture (6/7/79)
Y344	M344	-	-	304	1.531	4687	29 June 1980	Re-capture (8/3/78;6/24/80)
Y339	M339	-	-	-	-	-	9 July 1980	Initial
M306	Y306	-	-	306	1.611	4694	14 July 1980	Re-capture (6/25,8/13/78; 6/11/79)
Y347	M347	-	-	347	-	-	15 July 1980	Initial
M345	Y345	-	-	1	-	-	16 July 1980	Initial
Y348	M328	Y328	-	328	1.378	3749	16 July 1980	Re-capture (6/28/79)

Table 14 (Continued)

Ear Tag[a]		Previous Tags[a]			Radio	Radio		
Left	Right	Left	Right	Tattoo #	Freq.[b]	Ser. #	Capture Date	Comments
Y346	M346	-	-	346	1.691	4701	23 July 1980	Initial
M349	Y349	-	-	-	1.289	3743	8 Aug. 1980	Initial
M333	Y333	-	-	3	-	-	10 Aug. 1980	Initial
M348	Y310	-	-	310	1.078	2542	13 Aug. 1980	Initial
Y318	M314	-	-	318	-	-	13 Aug. 1980	Initial
M352	M351	-	-	352	1.680	-	18 Aug. 1980	Initial
M354	M353	-	-	354	-	-	18 Aug. 1980	Initial
M356	M355	-	-	356	1.168	3735	19 Aug. 1980	Initial
Y501	M501	-	-	-	1.220	-	18 July 1981	Initial
Y505	M505	-	-	505	-	-	6 Aug. 1981	Initial
M506	Y506	-	-	506	1.731	4704	10 Aug. 1981	Initial
M305	Y305	-	-	305	1.334	3746	12 Aug. 1981	Re-capture (6/24,8/24/78; 6/13/79)
M507	Y507	-	-	507	1.439	3757	14 Aug. 1981	Initial
M306	Y306	-	-	306	1.611	4694	15 Aug. 1981	Re-capture (6/25,8/13/78; 6/11/79;7/14/80)
R592	M592	-	-	592	-	-	13 July 1982	Initial
R595	M594	-	-	594	1.691	4701	15 July 1982	Initial
R594	M593	-	-	593	-	-	15 July 1982	Initial
R595	M594	-	-	594	1.691	4701	17 July 1982	Re-capture (7/15/82)
M326	Y326	-	-	326	1.415	-	28 July 1982	Re-capture (6/7/79;6/27/80)
Y346	M346	-	-	346	-	-	7 Aug. 1982	Re-capture (7/23/80)
M544	Y544	-	-	544	-	-	10 Aug. 1982	Initial
Y542	M542	-	-	542	-	-	11 Aug. 1982	Initial
Y545	M545	R65	-	54	-	-	14 Aug. 1982	Initial - cub of 306
M546	Y546	R66	-	546	-	-	15 Aug. 1982	Initial - cub of 306

Table 14 (Continued)

Ear Tag[a]		Previous Tags[a]			Radio	Radio		
Left	Right	Left	Right	Tattoo #	Freq.[b]	Ser. #	Capture Date	Comments
R592	M592	-	-	592	-	-	16 Aug. 1982	Re-capture (7/13/82)
M507	Y507	-	-	507	1.439	3757	18 Aug. 1982	Re-capture (8/14/81)
Y547	M547	-	-	547	1.640	1648	20 Aug. 1982	Initial
Y548	M548	-	-	548	1.168	3735	20 Aug. 1982	Initial
Y348	M328	Y328	-	328	1.378	3749	20 Aug. 1982	Re-capture (6/28/79;7/16/80)
R595	M594	-	-	595	1.691	4701	28 Aug. 1982	Re-capture 7/15,7/17/82)
M546	Y546	-	-	546	-	-	9 Sept.1982	Re-capture (8/15/82)
Y510	M510	-	-	-	1.830	12238	15 Jan. 1983	At den; yrlg of 326
M326	Y326	-	-	326	1.414	-	15 Jan. 1983	At winter den
M305	Y305	-	-	305	1.334	3746	22 Jan. 1983	At den
M511	Y511	-	-	-	1.810	12237	22 Jan. 1983	At den; yrlg of 305
Y512	M512	R61	-	-	1.111	12884	22 Jan. 1983	At den; yrlg of 305
M513	Y513	-	-	-	1.130	12886	22 Jan. 1983	At den; yrlg of 305
M306	Y306	-	-	306	1.610	4694	12 Feb. 1983	At den
Y545	M545	-	-	54	1.120	12885	12 Feb. 1983	At den; yrlg of 306
M546	Y546	-	-	546	1.860	12239	12 Feb. 1983	At den; yrlg of 306
M514	Y514	R64	-	-	1.141	12882	12 Feb. 1983	At den; yrlg of 306
Y515	M515	-	-	-	-	-	17 June 1983	Initial
M516	Y516	-	-	516	-	-	21 June 1983	Initial
M517	Y517	-	-	517	0.872	2537	30 June 1983	Initial
Y518	M518	2001	2002	-	-	-	5 July 1983	Released in study area
Y519	M519	-	-	219	-	-	10 July 1983	Initial
0613	M613	-	-	613	-	-	12 July 1983	Initial
M592	R592	-	-	625	-	-	14 July 1983	Re-capture (7/13.8/16/82)
M516	Y516	-	-	516	-	-	17 July 1983	Re-capture (6/21/83)
0614	M614	-	-	614	-	-	19 July 1983	Initial
0631	M346	Y346	-	346	-	-	1 Aug. 1983	Re-capture (7/23/80;8/7/82)

Table 14 (Continued)

Ear Tag[a] Left	Ear Tag[a] Right	Previous Tags[a] Left	Previous Tags[a] Right	Tattoo #	Radio Freq.[b]	Radio Ser. #	Capture Date	Comments
0632	M632	Y330	M322	632	1.370	15963	3 Aug. 1983	Re-capture (6/2,7/5/79)
M633	Y326	M326	-	326	1.760	4707	3 Aug. 1983	Re-capture (6/7/79;6/27/80; 7/28/82)
0616	M616	-	-	616	1.540	4688	4 Aug. 1983	Initial
0615	M615	-	-	615	-	-	5 Aug. 1983	Initial
Y548	M548	-	-	548	1.168	3735	5 Aug. 1983	Re-capture (8/20/82)
0617	M617	-	-	617	-	-	7 Aug. 1983	Initial
M507	Y507	-	-	507	0.100	8660	7 Aug. 1983	Re-capture (8/14/81;8/18/82)
M635	0635	-	-	-	-	-	7 Aug. 1983	Initial - cub of 507
0636	M636	2090	-	636	-	-	8 Aug. 1983	Initial
0637	M637	-	-	637	-	-	9 Aug. 1983	Initial
M507	Y507	-	-	507	0.100	8660	9 Aug. 1983	Re-capture (8/14/81;8/18/82; 8/7/82)
Y512	M512	-	-	512	1.110	12884	10 Aug. 1983	Re-capture (from den)
M639	0639	-	-	-	-	-	13 Aug. 1983	Initial - cub of 507
Y519	M519	-	-	219	-	-	14 Aug. 1983	Re-capture (7/10/83)
M507	Y507	-	-	507	0.100	8660	17 Aug. 1983	Re-capture (8/14/81;8/18/82; 8/7/82;8/9/83)
0638	M638	-	-	638	-	-	8 Sept.1983	Initial
Y512	M512	-	-	512	1.108	12884	13 Sept.1983	Re-capture (8/10/83)

[a] M = Metal
O = Orange
R = Red
Y = Yellow

[b] 150.____ MH_z
151.____ MH_z

VITA

Anthony Paul Clevenger, son of Patricia Malone and James Henry Clevenger, was born in Visalia, California on September 11, 1957. He graduated from Redwood High School in Visalia in 1975 and earned his Bachelor of Science degree in Conservation of Natural Resources from the University of California at Berkeley in March 1980. In July 1982, he entered the graduate program at The University of Tennessee, Knoxville. He initiated a cooperative research project in April 1985, between the United States and Spain, studying the endangered European brown bear in the Cantabrian Mountains of northern Spain. In March 1986, he received a Master of Science degree in Wildlife and Fisheries Science from The University of Tennessee, Knoxville.