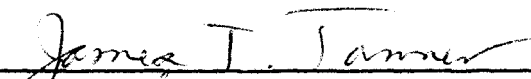
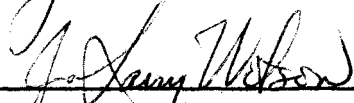


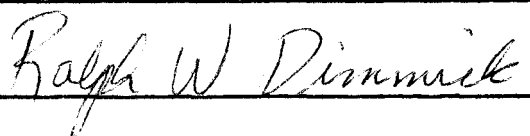
To the Graduate Council:

I am submitting herewith a dissertation written by Larry Eugene Beeman, entitled "Population Characteristics, Movements, and Activities of the Black Bear (Ursus americanus) in the Great Smoky Mountains National Park." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Ecology.


Michael R. Pelton, Major Professor

We have read this dissertation
and recommend its acceptance:



Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

POPULATION CHARACTERISTICS, MOVEMENTS, AND ACTIVITIES
OF THE BLACK BEAR (URSUS AMERICANUS) IN THE GREAT
SMOKY MOUNTAINS NATIONAL PARK

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee

Larry Eugene Beeman

June 1975

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ABSTRACT

Information on population characteristics, movements, and activities of the black bear (Ursus americanus Pallas) are limited. This is especially true in Southeastern United States where land use practices have eliminated the black bear from much of its former range. The Great Smoky Mountains National Park offers one of the few remaining areas in the Southeast where suitable habitat for the black bear is assured. The present study was conducted to assess various aspects of population ecology of the black bear. Techniques pertaining to collecting information on black bear movements and activities are also limited. Therefore, a large portion of the study revolved around the methodology and testing equipment for collecting such data.

Animals with a long life span like the black bear are good subjects for the study of seasonal and annual physiological changes of individuals. By taking growth measurements at various seasons and between years some conclusions were made about the growth of black bears. Males grew faster, longer, and larger than females. Significant variations between individual bears existed although a general trend of rapid growth during the late summer and fall and a slow weight loss during the winter and spring was

noticed. These physiological changes appeared to be related to food availability, nutrition, and breeding behavior.

The bear population was largely adults (68 percent) with cubs and yearlings (14 percent) and subadults (18 percent) making up the remainder of the population. The high average survival rate (78.3 percent) for adults was counterbalanced by a low reproductive rate. The average litter size was 2.1 cubs and only 17.4 percent of the females had cubs.

Adult females and subadult males confined their movements to 720 (1780 acres) and 650 hectares (1606 acres), respectively. One adult male was more mobile and covered an area of 1901 hectares (4695 acres) during 1972 and expanded it to 2242 hectares (5538 acres) the following year.

Panhandler bears concentrated their activities to areas around trail shelters although they also foraged for native foods. These bears were opportunist feeders and readily adapted to feeding on native foods when backpackers were less numerous during the fall and early winter.

Due to the close association of various habitat types created by various topographic positions, bears confined their movements to relatively small areas. There was overlapping of home ranges although areas mutually exclusive to other bears of the same kind were noticed. The

closed oak forest type was preferred during all seasons and bears would concentrate in areas of an abundant food supply.

Bears were active at all times of a 24-hour period but were most active from 1800 to 2400 hours and least active 1200 to 1800 hours. Movements during a 24-hour period were quite varied but ranged to over 20 kilometers.

Most panhandler bears were males and moving them to various areas inside the Park has been only partially successful due to their homing abilities. Previous homing experience and age are important considerations when moving bears to remote areas of the Park.

Bears entered their dens in early December and emerged sometime after March. Cavities high in over-mature trees appeared to be the favorite type of den.

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CHAPTER I

INTRODUCTION

The Great Smoky Mountains National Park (GSMNP or Park) has the largest protected population of black bears (Ursus americanus Pallas) in southeastern United States. This population may act as a refuge for a breeding population of bears; thus, surpluses could be used to stock large forested areas of the states and national forests where the species has been extirpated. Also, the black bear is quite important economically. Tourism in the areas surrounding the GSMNP is a major economic component. The 42-county area surrounding the GSMNP contains 8,900 tourist-related businesses that employ 37,482 area residents. It was estimated that in 1972, 17 million travelers spent 200 million dollars in this area (Copeland and Copeland, 1973). Approximately half of these travelers visited the Park, and the black bear was considered a major attraction by a large proportion of the Park visitors (Burghardt et al., 1972). Considering the popularity, wide distribution, and economic importance of the black bear, very little research has been conducted on this animal.

This study was originated in the GSMNP by the Departments of Forestry and Psychology at The University of

Tennessee in conjunction with the National Park Service to aid in management of the black bear as an important component of the Smoky Mountains ecosystem. The study was begun in 1969 and is still in progress. The general objective of the study was to delineate the ecology and behavior of the black bear in the GSMNP.

Four studies have been completed and one study is still in progress describing the history and some aspects of black bear behavior in the GSMNP. Lafollette (1974) described the historical events that have affected the black bear in the GSMNP. Bacon (1973) described ingestive behavior, food preferences, visual capacities of color vision and form discrimination, learning, and retention of black bears. Pruitt (1974) described various modes of communication between black bears; these included several different facial expressions and body postures. Ludlow (1974) described the copulatory mating behavior of black bears. A study of social interaction among bears and between people and bears is still in progress.

Two studies on black bear ecology have been completed. Beeman (1971) described the seasonal food habits of the black bear in the GSMNP. Population densities of black bears in the GSMNP is described and discussed by Marcum (1974).

This particular study of the black bear in the GSMNP

discusses some aspects of population dynamics, growth rate, denning behavior, habitat use, and movements of bears. Objectives of the study include:

(1) To determine daily and seasonal movements of black bears in the GSMNP.

(2) To delineate movement differences in bears between age classes and sexes.

(3) To determine home range and concentrated activity of bears in the Park, especially in areas of human activity.

(4) To evaluate homing ability of black bears in the Park.

(5) To determine den site selection and denning periods.

(6) To determine the population parameters of reproductive rate, growth rate, percent males and females, age structure, and survival rate.

Early studies of black bears and their use of the habitat recognized the mobility and wide-ranging movements of this species (Cahalane, 1947; Seton, 1929; Scott, 1947; Schroger, 1949; Spencer, 1955; Trippensee, 1948). More recent studies have demonstrated that black bears prefer to establish a home area and generally limit their movements within the confines of this area (Erickson et al., 1964; Ernst, 1972; Jonkel and Cowan, 1971; Poelker and

Hartwell, 1973; Stickley, 1961; Taylor, 1971). While the homing of many animals has been studied, the ability of black bears to return to their home area is not fully understood. Studies by Harger (1967), Erickson et al. (1964), Sauer et al. (1969), and Wasem (1968) have provided good evidence that bears do, indeed, have the ability to home. However, the degree of this homing ability is unknown.

Population characteristics have been studied in various parts of the country: North Carolina (Collins, 1973), Wyoming (Barnes and Bray, 1967), Michigan (Erickson et al., 1964), Florida (Harlow, 1961), Montana (Jonkel and Cowan, 1971), Washington (Poelker and Hartwell, 1973), Maine (Spencer, 1955), and Virginia (Stickley, 1961). Most of these studies provide excellent data for comparative purposes with this study.

Den site selection by black bears appears to be quite varied: a simple ground depression (Morse, 1937), under tree roots (Aldous, 1937), base of hollow trees (Bromlei, 1973), drainage culverts (Barnes and Bray, 1967), under cabins (Jonkel and Cowan, 1971), and tree cavities (Switzenberg, 1955). All these studies indicate that bears are inactive for periods during the winter although the length of inactivity is variable among areas and between years of the same area.

While there is a substantial amount of knowledge about certain aspects of black bears in various areas of North America, there are still large gaps in the understanding of this animal. This is especially true in the complex ecosystem of the GSMNP, where little is known about the black bear.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

I. LOCATION AND PHYSIOGRAPHY

The Great Smoky Mountains National Park (GSMNP or Park) is located along the common border of North Carolina and Tennessee. This area includes sections of Blount, Sevier and Cocke counties in Tennessee and Swain and Haywood counties in North Carolina. The Park boundary encompasses approximately 2072 square kilometers (512,000 acres) of mountainous terrain. Areas of Nantahala, Pisgah and Cherokee National Forests border the Park boundary. A transmountain road (US 441) bisects the Park from Gatlinburg, Tennessee to Cherokee, North Carolina. Two other major roads run parallel just inside the northern boundary of the Park; State Road 73 running from Gatlinburg to Townsend, Tennessee and Laurel Creek Road extending from Townsend to Cades Cove (Figure 1).

The study for the most part was restricted to the Tennessee portion of the Park located west of US 441 encompassing approximately 520 square kilometers (125,000 acres). Approximately 64 kilometers (40 miles) of paved roads, 88 kilometers (55 miles) of unimproved fire roads,

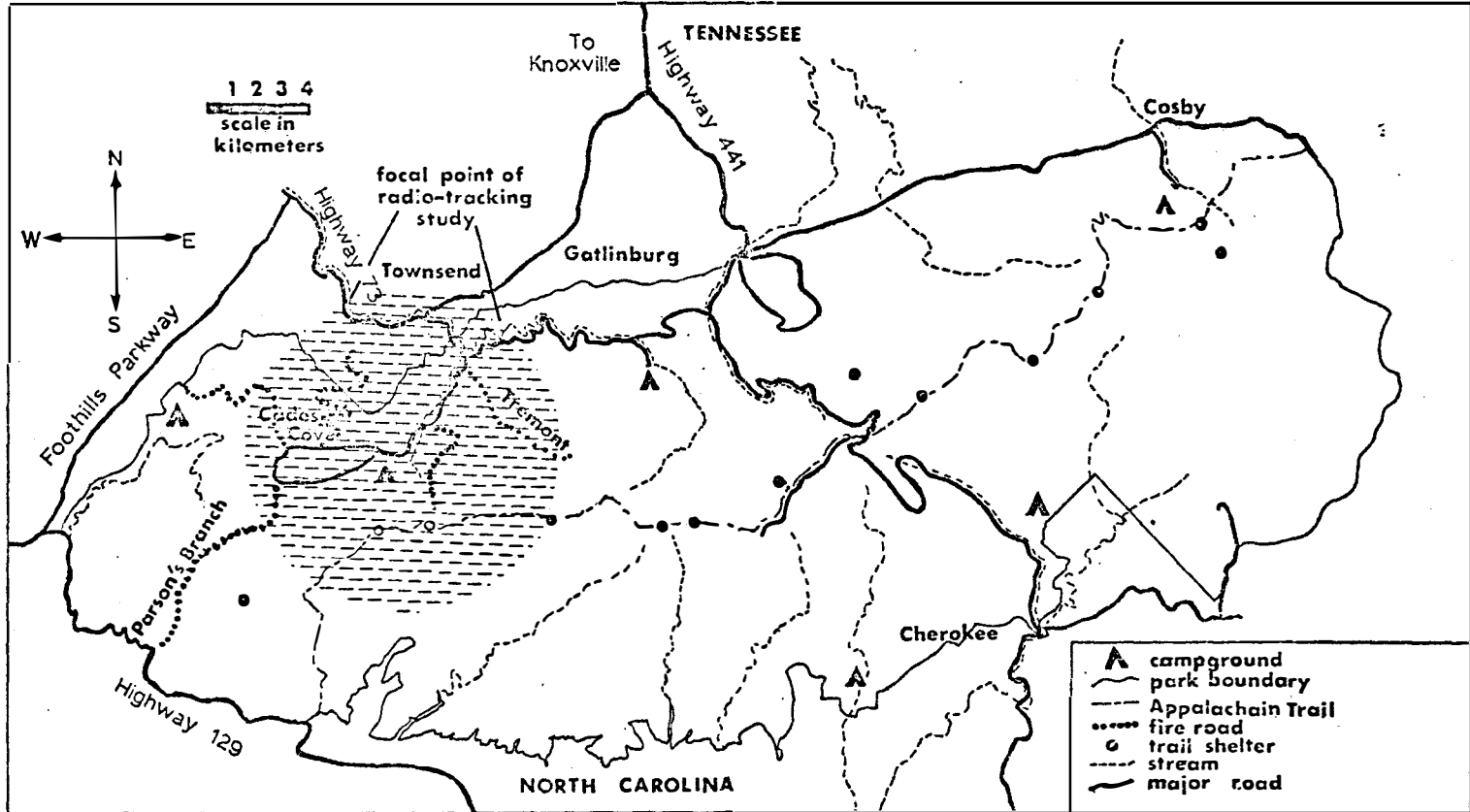


Figure 1. Map of study area, the Great Smoky Mountains National Park located in Tennessee and North Carolina.

400 kilometers (250 miles) of maintained foot trails and more than 240 kilometers (150 miles) of abandoned trails exist in this section of the study area (Marcum, 1974). Most of the area is accessible only by foot trails, especially at higher elevations (Figure 1).

Located in the Southern Appalachians, the GSMNP is part of the Unaka Mountains (Fenneman, 1938) with the main ranges running northeast to southwest. The range varies from 230 to 2025 meters (888 to 6,643 feet) in elevation and appears as a long sinuous ridge connecting irregular spaced domes. Just outside the Park, lower ridges and foothills spread on each side. The mountains are stream-eroded to physiographic maturity; in form they are subdued (Fenneman, 1938) but still rugged. Over 960 kilometers (600 miles) of mountain streams dissect the Park and drain into the Oconaluftee and Tuskaseegee Rivers in North Carolina and Big Pigeon, Little Pigeon, Little Tennessee and Little Rivers in Tennessee. Most of the mountain tops and ridges are rounded, and nearly all the mountain's surface is covered with a mantle of soil and vegetation. Valleys are cut deep into the mountain mass, with steep slopes and narrow flats. The slopes form most of the mountain area; it has been estimated that less than 10 percent of the Park's surface is on slopes less than 10 degrees (Message from President Roosevelt, 1902).

II. CLIMATE

While other areas in Eastern United States have been glaciated, submerged and exposed to great climatic change (Fernald, 1931), the Southern Appalachians have offered a sanctuary for many species of plants and animals. The topography of the Southern Appalachians offered various conditions of elevations and moisture that allowed species of diverse habitat adaptations to survive while many times they were extirpated in other nearby geographical areas (Whittaker, 1956).

Due to the high relief, the area is generally characterized by a cool temperature and high amounts of precipitation in relation to the surrounding areas. However, climate varies considerably from one slope to another as well as lower to upper reaches of drainages. Thus, the topography of the Smokies renders all average climatic values of limited local significance. Temperature decreases at an average rate of 4.07°C per 1000 meters rise in elevation that results in the temperature difference of 6° to 9°C between the valleys and the higher mountains (Shanks, 1954a). The mean temperatures range from 23.6°C at Gatlinburg to 14.7°C at Newfound Gap in July to 3.9°C and -5.2°C , respectively, in January.

Precipitation also varies with altitude and season.

Precipitation increases sharply with altitude; it increases approximately 50 percent by the lower limits of the spruce-fir zone (1370 to 1570 meters). Average annual precipitation ranges from 130 to 150 centimeters in the lower valleys to over 200 centimeters at higher elevations. Although not well documented, there also exist contrasting differences of precipitation between the northern and southern facing slopes (Whittaker, 1956).

III. FLORA

Maturity of plant cover might be expected due to the age and maturity of the mountains. Primary succession is nearly completed; almost all vegetation is either topographic climax or secondary (Whittaker, 1956).

The GSMNP has the largest variety of plants known to any area in Eastern United States. There are more than 1,300 species of flowering plants, including 130 species of native trees identified in the Smokies (King and Stupka, 1950). The variety of habitat ranging from mesic valleys to dry slopes and ridges and a variety of temperature fluctuations cause the appearance of many vegetation types in different areas (Whittaker, 1956). Several botanists have attempted to classify the vegetation of the GSMNP. For the purpose of this study the classification presented by Shanks (1954b) will generally be followed. This classification

includes six broad physiognomic forest types: cove hardwood, hemlock, northern hardwood, closed oak, open oak and pine stands and spruce fir (Figure 2). Table 1 lists the forest types and their dominant tree species.

The cove hardwood forests occur in sheltered situations, at elevations below 1370 meters where soils are deep and well-aerated due to mull type humus. Due to the generally northern exposure on the Tennessee side of the Park, the cove forests often broaden out and extend higher in elevation than on the southern exposed North Carolina side. In some localities the understory is extremely dense, and is dominated by impenetrable thickets of rhododendron (Rhododendron maximus) and mountain laurel (Kalmia latifolia) (Shanks, 1954b; National Park Service, 1969).

The hemlock forest is commonly found along streams in sheltered topography up to 1000 meters. It also occurs on exposed slopes and ridges at middle altitudes and up to nearly 1540 meters where it stops rather abruptly. The sites are generally drier than those of the cove hardwood forests with an increase in subcanopy heath. At the higher elevations, the hemlock forest is most distinctive with a hemlock (Tsuga canadensis) dominance of 70 to 80 percent, a dense heath growth and a poor herb stratum.

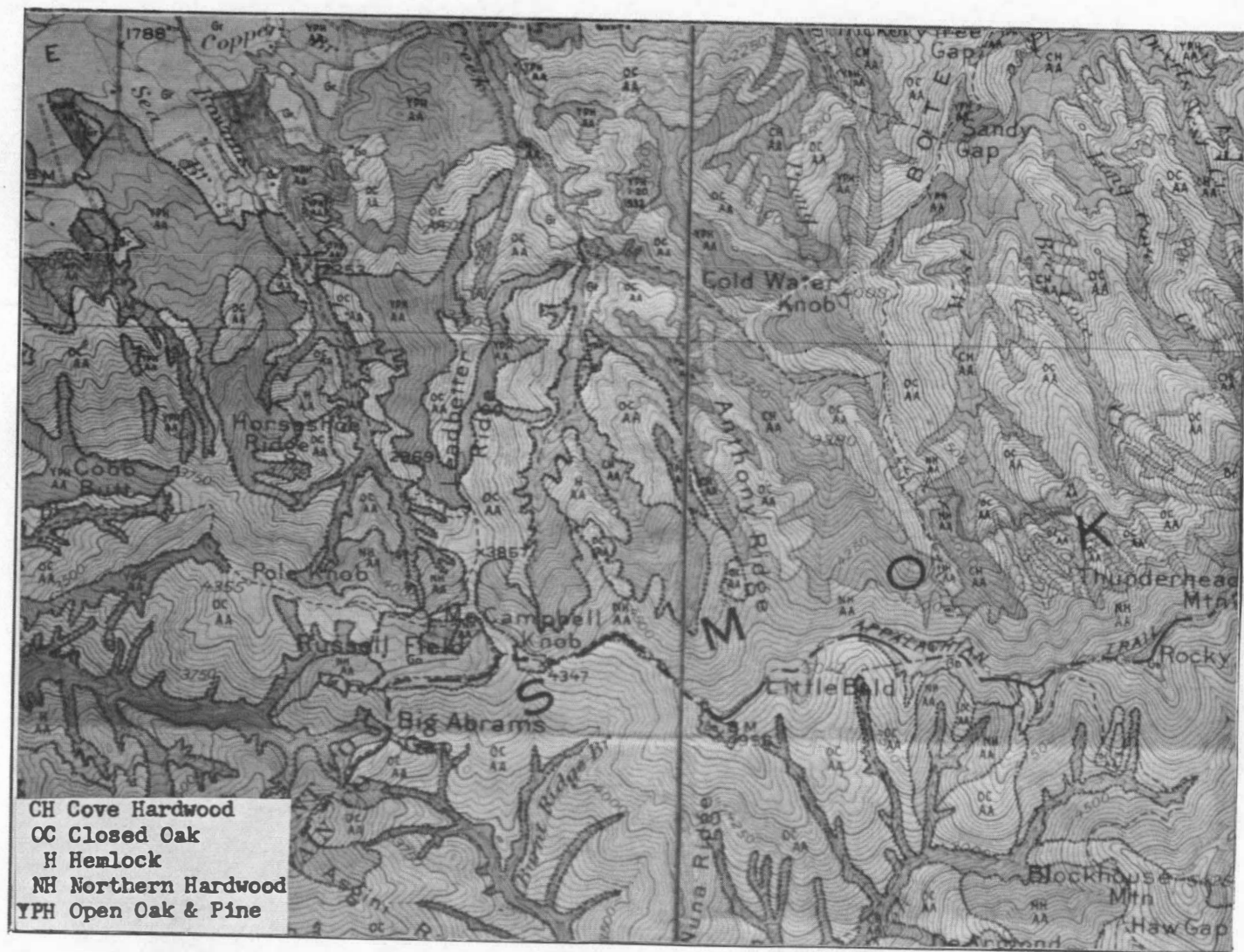


Figure 2. Forest types in the central part of the radiotracking study in the GSMNP.

TABLE 1. Forest associations and their important tree species in the GSMNP

Forest Association Type	Important Species
Cove hardwood	<u>Eastern hemlock (Tsuga canadensis)</u> <u>Silverbell (Halesia monticola)</u> <u>Yellow buckeye (Aesculus octandra)</u> <u>Sugar maple (Acer saccharum)</u> <u>Yellow birch (Betula alleghaniensis)</u> <u>Tulip poplar (Liriodendron tulipifera)</u> <u>Beech (Fagus grandifolia)</u>
Hemlock	<u>Eastern hemlock</u> <u>Yellow birch</u> <u>Silverbell</u> <u>Fraser magnolia (Magnolia fraseri)</u> <u>Rhododendron (Rhododendron maximum and R. catawbiense)</u> <u>Mountain laurel (Kalmia latifolia)</u>
Northern hardwood	<u>Beech</u> <u>Yellow birch</u> <u>Yellow buckeye</u> <u>Sugar maple</u> <u>Mountain maple (A. spicatum)</u>
Closed oak	<u>White oak (Quercus alba)</u> <u>Chestnut oak (Q. prinus)</u> <u>Northern red oak (Q. rubra)</u> <u>Black oak (Q. velutina)</u> <u>Pignut hickory (Carya glabra)</u> <u>Mockernut hickory (C. tomentosa)</u> <u>Sourwood (Oxydendrum arboreum)</u> <u>Black locust (Robinia pseudoacacia)</u>
Open oak and pine	<u>Scarlet oak (Quercus coccinea)</u> <u>Sassafras (Sassafras albidum)</u> <u>Pitch pine (Pinus rigida)</u> <u>Table mountain pine (P. pungens)</u>
Spruce-fir	<u>Red spruce (Picea rubens)</u> <u>Fraser fir (Abies fraseri)</u>

Source: R. E. Shanks, "Reference list of native plants in the Great Smoky Mountains," Botany Department, The University of Tennessee, 1954. (Mimeographed.)

At the lower elevations, hardwoods are commonly found with less heath and more herbs. Below 750 meters, the hemlock forest and cove hardwood forest merge to form an ecotone (Shanks, 1954b; Whittaker, 1956; National Park Service, 1969).

The northern hardwood forest is a mesic forest dominated by yellow birch (Betula alleghaniensis) and American beech (Fagus grandifolia). The northern hardwoods are closely related to the upper cove forests, but with a limited tree size and a subalpine cast of flora. The herb coverage varies from 40 to 60 percent and is largely sedges (Shanks, 1954b; National Park Service, 1969).

The closed oak forests are found on intermediate to dry slopes, at low and middle elevations. Various species of oak (Quercus spp), hickories (Carya spp), and red maple (Acer rubrum) make up a large percentage of the canopy. The understory is dense in some places but not continuous; coverage varies from 50 to 80 percent at middle elevations to 20 to 50 percent below 760 meters (Shanks, 1954b; National Park Service, 1969).

Shanks (1954b) classifies open oak and pine stands and heath balds together because neither has a stratum which forms a closed canopy. The open oak and pine stands are found on dry exposed slopes and ridges with rocky terrain. Whereas the trees normally do not form a closed

canopy, the shrub layer may be quite dense and is often dominated by mountain laurel. The northern red oak (Quercus rubra) of the closed oak forests is replaced by scarlet oak (Q. coccinea) in the drier stands; otherwise the same species are dominant. Table-mountain pine (Pinus pungens), Virginia pine (P. virginiana) and shortleaf pine (P. echinata) are plentiful on the dry sites (Stupka, 1960; National Park Service, 1969).

The spruce-fir forests are characteristic of the Canadian zone. Red spruce (Picea rubens) is dominant in the lower limits of the forest type (1350 to 1650 meters). Fraser fir (Abies fraseri) becomes a codominant at 1675 to 1860 meters and the dominant species above 1890 meters. There is a trend of decreasing importance of hardwoods toward higher elevations, and a corresponding increase in more xeric sites. The growth of trees is so dense that shrubs and other plants are practically absent over wide areas (Shanks, 1954b; Stupka, 1960; National Park Service, 1969).

Grassy balds and pastoral fields are two additional habitat types not included in Shanks' (1954b) six forest types. Both were created by human disturbance; grassy balds are presently giving way to shrubs and small trees while the pastoral fields are still being maintained. The change from the forest to grassy balds is abrupt.

The balds are dominated by mountain oat grass (Danthonia compressa) and common cinquefoil (Potentilla canadensis var. carolinensis), serviceberry (Amelanchier laevis), blueberry (Vaccinium spp.) and blackberry (Rubus spp.). In order to maintain the historical aspect of early pioneer settlements and the mountain culture, the National Park Service has leased approximately 1215 hectares to be kept in pasture land for several hundred head of cattle.

The central part of the study area where most of the black bear studies were conducted included the following percentages of each forest type (Figure 2, page 12): cove hardwood, 31.6 percent (1182 hectares), hemlock forest, 2.0 percent (180 hectares), northern hardwood, 21.7 percent (787 hectares), closed oak, 35.2 percent (1315 hectares), open oak and pine stands, 8.7 percent (324 hectares), and grass, 1.5 percent (135 hectares). No spruce-fir is located in the central part of the study area.

IV. MAMMALS

The Southern Appalachians do not harbor an exceptionally rich variety of mammals. Linzey and Linzey (1971) state that 59 species of mammals have been recorded and an additional six species are listed as extirpated. Approximately 25 of the species are members of the family Rodentia.

Besides the black bear, other large mammals include whitetailed deer (Odocoileus virginianus) and European wild hog (Sus scrofa). While found in all areas of the Park, the largest concentration of deer in the GSMNP exists in the Cades Cove area. The pastoral setting maintained by the NPS in Cades Cove has created good deer habitat by creating pastures per se and increasing the percentage of interface between the forest and fields. This good habitat plus the complete protection of the herd has allowed the deer population to reach high densities (Fox and Pelton, 1973).

Although not totally understood, perhaps the biggest impact on the flora and fauna in the Park besides man is the introduction of the exotic European wild hog. Being an exotic species and posing the threat of altering the ecosystem of the Park, the hog has been the target of concern and attempted control and eradication programs. Since the original introduction (approximately 50 years ago) at Hooper's Bald, North Carolina, the feral hog population has continued to increase in numbers and range to include most of the GSMNP. Some of the effects of the hog's impact on understory vegetation and competition with native species for food is discussed by Henry and Conley (1972), Belden (1972), and Strickland (1972). However, the total impact of the European wild hog remains unknown.

V. HISTORICAL EVENTS AFFECTING BLACK BEARS

Exploitation

The American Indian in his simple way of life managed to live in relative harmony with the forest. The annual burning of underbrush was his major influence on the Southern Appalachians. This burning, which had been practiced for centuries, probably kept the forest in an open condition (National Park Service, 1969).

Then came the mountain settler. His occupation of the Smokies undoubtedly was a major factor affecting the black bear habitat. With time the number of settlers increased, and their clearing, logging, grazing, farming and burning practices began to devastate the landscape. When the valleys were practically all cleared, the increasing demands for lands to cultivate led to clearings successively higher up the mountain slopes with a slope of 20 and even 30 and 40 degrees. Since the fertility of these areas was short lived, they were cleared, cultivated and abandoned in rapid succession (National Park Service, 1969).

However, the vegetational changes brought about by the mountain settlers was minor in comparison to the havoc caused by the lumber companies. The National Park Service (1969) estimated that approximately two billion board feet

were removed from the Park. By 1920 logging railroads had penetrated most of the Park's watersheds to reach the slopes of the mountain ridges and peaks. The fastest and cheapest way of getting timber out of the remote areas was "ball hooting" or rolling the logs down the slopes. This procedure smashed even medium-sized trees and left a "clearcut" track. Logs were tumbled downstream ripping out the shallow creek bottoms. Clearing routes for skidders and the ground skidding process themselves eroded the forest soil. Slash left behind was burned and thus destroyed the forest humus (National Park Service, 1969).

These clearing and logging activities influenced over half of the bear's natural habitat in the Park. As vegetation was destroyed and/or altered, good bear habitat was limited to areas less disturbed. The undisturbed areas were essentially the higher ridges and peaks in the Park (Lafollette, 1974).

Chestnut Blight

The chestnut blight, caused by the fungus Endothia parasitica, eliminated the chestnut (Castanea dentata) as an important species of the area that is now the GSMNP proper. While no method is available to demonstrate the value of the chestnut to the black bear, certain conclusions

can be drawn from related data. Beeman (1971) stressed the importance of mast as a food source during the fall of the year. The chestnut was found throughout the Park below 600 meters to above 1500 meters and is a valuable source of carbohydrates and fats (Waino and Forbes, 1941).

The blight began approximately in 1925 (Gravett and Marshall, 1926) and was slow in killing individual trees. Not until the late 1940's was the chestnut eliminated for all practical purposes. This slow death made possible for adjacent trees to adjust to new conditions and occupy much of the space left vacant (Woods and Shanks, 1959). For this reason, closure of the canopy in the chestnut openings was decidedly different from closure of openings created by cutting. The slow death of the blight-killed chestnuts made possible for trees already present to gradually adjust to the new environmental conditions and occupy the newly-created space (Woods and Shanks, 1959).

Woods and Shanks (1959) found that the chestnut was replaced primarily by chestnut oak, Northern red oak and red maple (Table 2). Other less important replacement species that produce fruit eaten by bears (Beeman, 1971) include scarlet oak, white oak, black oak, beech, pignut hickory, mockernut hickory and black gum. Working in North Carolina, Keever (1953) found chestnut oak, Northern red oak, and pignut hickory as the primary replacement species (Table 2).

TABLE 2 . Relative abundance of major tree species replacing chestnut in the GSMNP

Species	% Replacement Species	
	Woods and Shanks (1959)	Keever (1953)
Chestnut oak	17	22.2
Northern red oak	16	24.4
Red maple	13	2.5
Hemlock	6	
Scarlet oak	4	1.2
White oak	2	9.2
Black oak	2	
Beech	2	
Pignut hickory	1.5	16.6
Mockernut hickory	1.5	
Sourwood	4	1.3
Tulip tree	4	4.9
White pine		0.43
Sivlerbell	5	0.14
Sassafras (<u>Sassafras albidum</u>)	1	0.02
Sweet birch (<u>Betula lenta</u>)	3	5.7
Black gum	1	1.8
Black locust	4	1.3
Dogwood	2	
Pitch pine	2	
Table mountain pine	1	
Yellow birch	1	
Sugar maple	1	
Striped maple	1	
Shortleaf pine (<u>Pinus echinata</u>)		

VI. BEAR MANAGEMENT BY THE NATIONAL PARK SERVICE

While the GSMNP does provide a sanctuary for the black bear, it also creates conditions for bears and people to come into close contact. Due to the concentration of people along the roadsides and trail shelters along the Appalachian Trail, most of the bear-human interactions occur here. Most interactions have centered around the bear's choice of food. The combination of food availability from Park visitors and the opportunistic, omnivorous, and adaptable behavior of the black bear has created management problems for the National Park Service (NPS). Thus, the only management of the black bear in the Park has dealt strictly with attempting to protect both people and bears by keeping them separated. The present NPS policy of preserving areas in their natural condition does not allow for habitat management.

Since the loss of wariness and an increase of boldness toward people in black bears appears to be a function of food availability, the NPS has taken the following steps to reduce unnatural food availability: feeding of bears is prohibited, all garbage and trash must be packed out of the back country, "bear proof" garbage cans have been installed, garbage is picked up daily and hauled to areas far removed from the Park, and the interpretive service of

the Park's naturalist division disperses information concerning the ramifications of feeding bears. While all these management steps have reduced the availability of human food to bears, it has not been eliminated. Thus, the behavior and movements of 3 to 10 percent of the bear population is still influenced by the availability of unnatural food (Beeman and Pelton, 1975).

Once a bear has habituated itself to unnatural foods and appears to present a potential danger to Park visitors, the NPS has adopted the policy of moving this individual. Since 1967, 76 bears have been moved a total of 156 times to remote areas of the Park. The results of this management procedure are discussed in Chapter IV.

CHAPTER III

MATERIALS AND PROCEDURES

I. CAPTURE OF BLACK BEARS

Due to the availability of cured ham from a local restaurant in Townsend, Tennessee, this bait was used in a majority of traps set. Besides being readily available and cost-free, the cured ham offered the advantages of not requiring refrigeration for several days before use and not becoming rancid after used as bait. Erickson (1957) indicated that rancid bait becomes unattractive to bears. Sardines were used occasionally as bait and proved satisfactory. Cans of sardines were easily carried into remote areas and appeared effective in attracting bears but had the disadvantage of becoming rancid after four or five days.

In remote areas only accessible by foot, bears were attracted by prebaiting before a trap was set in an effort to increase trapping efficiency (in terms of man-hours expended per bear capture). Prebaiting consisted of either hanging approximately 2.5 kilograms of ham or four to five cans of sardines wrapped in burlap. Prebaiting was generally located in the upper reaches of small drainages,

taking advantage of the cool air mass moving down the valley during the night and thus dispersing the odor from the bait. Occasionally prebaiting was established in gaps along ridges where bears would often cross from one drainage into another drainage. Once a prebait was disturbed by a bear, a trap was set within a few meters of the site. This technique allowed the trapping crew of only two people to more effectively use their time in areas only accessible by foot.

Traps

Culvert traps similar to those described by Erickson (1957), Stickley (1961), and Barnes and Bray (1967) were used for trapping along roadsides, campgrounds and picnic areas. No particular effort was made to conceal the trap since bears did not appear to hesitate entering the trap.

European wild hog traps were occasionally used for trapping bears. These traps were constructed of 10 gauge chain link fencing welded to 3/4 inch iron pipe framing. The door was constructed of 3/4 inch plywood. The traps were approximately 2 meters long, 1 meter wide and 1 meter high and were similar in design to those described by Williamson and Pelton (1971).

Hog traps were set for black bears using the same technique as described by Fox (1972) except bait was tied

to the trigger mechanism so that the door closed when the bait was pulled. Six of the ten bears captured in hog traps during 1972 escaped by breaking through the fencing material or the plywood door. Due to the high rate of escape and costly destruction to the trap, the use of hog traps was abandoned in 1973.

In remote areas with no access by road, the Aldrich spring-activated snare was used. The snare consists of two separate parts: a 1/4 inch steel spring and a 3/16 inch steel cable. The type of snare sets used are described by Marcum et al., (1974). Logs were used to construct a wedge to force the bear into the front side of the snare set.

In situations where bears were accustomed to the presence of people, it was time-saving to capture these animals by administering the immobilizing drug by a projectile syringe without first capturing the animal. Syringes were fired from either a CO₂-charged or a powder-charged Cap Chur gun (Palmer Chemical and Equipment Co.). Needle length depended on the size and condition (amount of fatty tissue) of the bear. The powder-charged gun was effective from 20 to 70 meters depending upon the powder-charge used (very low, low or high). The CO₂-charged pistol was only accurate under 10 meters while the rifle was effective up to 25 meters. Caution was

exercised with the powder-charged rifle to prevent using high charges at close ranges.

Immobilization of free-roaming bears by using the capture guns was successful 23 out of the 27 attempts in 1972 (Appendix A). Due to the emphasis of capturing "back-country" bears in 1973, no bears were captured using this method. These guns (especially the CO₂-charged pistol) proved quite satisfactory for immobilizing bears trapped in culvert traps, hog traps, and Aldrich spring-activated snares.

Bears were immobilized by injections of M99 (Etorphine hydrochloride, American Cyanamid Co.) or Sernylan (Parke, Davis and Co.). The M99 and Sernylan were administered in solution at concentrations of 1 mg/cc and 100 mg/cc, respectively. The M50-50 (diprenorphine) was used as the M99 antagonist and was given in solution at 2 mg/cc. No antagonist is available for Sernylan. In every case except one intravenous injection, both drugs were administered intramuscularly. To insure the drug entered the muscle tissue rather than the fatty tissue needles used were approximately 1.9 centimeters for bears weighing less than 45 kilograms, 3.2 centimeters for bears weighing between 45 and 137 kilograms and 3.8 centimeters for bears weighing greater than 137 kilograms. Weights of bears were estimated before

drug injection and later checked on a spring scale after immobilization of the animal. Induction is defined as the period from drug injection until the bear appeared incapable of walking; slight pedal and/or head movement may still be present. Recovery time is defined as the time from M50-50 injection until the bear appeared capable of walking with apparent normal balance. The recovery time was calculated from the time of the initial dose in the case of Sernylan.

Table 3 summarizes the results of immobilizing 80 bears with M99 and 13 bears with Sernylan. Since all bears in this study recovered after being immobilized with these two drugs, the wide range of dosages illustrated in Table 3 suggests black bears have a wide range of tolerance for M99. Bears were at first immobilized with M99 at the dosage of 2.2 mg/100 kg of body weight. After experimenting, the dosage was lowered to 1.6 mg/100 kg of body weight. This dosage appeared satisfactory for handling bears. For Sernylan between 175 and 220 mg/kg of body weight proved satisfactory for immobilizing bears. Below the lower limit of this range, bears become only partially immobilized with Sernylan and were often difficult to handle. There was some evidence that as dosage increases, the induction period decreases (Beeman et al., 1974).

TABLE 3 . Dosages, latency period and recovery period for bears injected with Etorphine (M99) and Sernylan during 1970-74 in the GSMNP

Drug	Sample	Avg. Dosage mg/100 kg Body Weight (Range)	Avg. Induction Time-Min. (Range)	Avg. Recovery Time-Min. (Range)
Etorphine				
Males				
2 year old cubs,	31	2.22(0.84-6.78)	9.8(4.0-30.5)	21.7(0.5-120) ^a
yearlings	15	2.60(1.00-6.43)	7.3(3.0-12.0)	21.7(5.0-120) ^a
Females				
2 year old cubs,	31	2.03(0.83-3.26)	8.1(3.0-30.0)	16.6(5.0-30.0) ^a
yearlings	3	2.84(2.00-4.90)	2.7(2.5-3.0)	24.0(6.0-45.0) ^a
Sernylan				
Males				
2 year old cubs,	2	187(88-288)	9.7(8.0-13.0)	221.3(110-367)
yearlings	2	272(250-294)	3.8(2.5-5.0)	166.0(150-182)
Females				
2 year old cubs,	7	301(293-310)	7.8(5.0-10.5)	303.5(180-427)
yearlings	2	415(169-660)	8.8(4.5-13.0)	163.5(97-230)

^aAfter injection of antagonist (all injections of M50-50 except one were intramuscular).

M99 was generally used due to the availability of an antagonist. This provided a safety factor in addition to reducing the time a bear was kept in anesthesia. Sernylan was used in situations when the recovery time was not an important factor.

II. TAGGING AND MEASURING

After immobilization, each bear was examined closely; the various measurements and other information are shown in Appendix I. The bear was weighed using portable spring scales and a hoist (the weights of 12 back-country bears were estimated). A 1-1/2 inch numbered, colored, plastic tag (cattle rototags, Nasco Company, Fort Atkins, Wisconsin) was placed in each ear for future identification. Tag colors included red, yellow, white, blue, green and pink. The use of green and pink tags was abandoned after 1971 because of confusion with blue and white when identifying individual bears at night. A number was tattooed on the smooth inner surface of the lower lip for further identification in the event that the ear tags were lost.

III. AGING

Bears were aged by either the cementum-annuli similar to the technique described by Willey (1974) or

estimated by using relative body size and dental wear. For the cementum-annuli technique, either the first or fourth premolar was extracted and processed by the following procedure:

- (1) Decalcify tooth in 20 percent formic acid for 48 hours.
- (2) Flush tooth in running water and return to a water-filled vial to await sectioning.
- (3) Mount decalcified teeth on tissue holders of microtome-cryostat using OCT (Carolina Biological Supply Company, Burlington, North Carolina).
- (4) Make longitudinal tooth sections 12 to 16 micrometers thick, collecting sections cut through the center of the tooth so the entire pulp cavity is visible.
- (5) Mount 4 to 8 sections per slide and allow to dry.
- (6) Stain teeth for 20 minutes in a solution of 1 part Geimsa Blood Stain (Carolina Biological Supply Company) to 10 parts of distilled water.
- (7) Rinse in two baths of distilled water for 15 seconds each.
- (8) Dry slides in a vertical position on a slide warmer at 40° C.
- (9) Bathe slides in xylene for 15 minutes.
- (10) Mount cover glasses with cover bond.

(11) Examine prepared slides through a binocular microscope with transmitted light at 40X to 100X magnification.

(12) View sections along the entire length of the cementum although annuli are most distinct either at the root tip or directly adjacent to the crown.

IV. BEAR SIGHTINGS

Sightings of marked and unmarked bears by research and National Park Service personnel were recorded from 1970 through 1973. In addition, postcard questionnaires along with a brief explanation of the research project and the need of park visitor assistance for locating bears were distributed by Park rangers (Appendix I). Backpackers were asked to note the date, location, estimated size and litter size (if cubs) and the color of tags in each ear. The postcards were pre-addressed and post-paid requiring the Park visitor only to drop the card in the mail after their backpacking experience.

V. RADIOTRACKING EQUIPMENT AND MONITORING TECHNIQUES

Radiotracking equipment included a transmitting unit, radio-receiver, and receiving antennas. All the equipment except one receiver was manufactured by Dav-Tron Electronics, Minneapolis, Minnesota. AVM Instrument Company, Champaign,

Illinois, manufactured the other receiver.

The transmitting units varied in weight from 760 to 1138 grams (Figures 3 and 4). All transmitters emitted pulsating signals although the frequency and tone quality varied with each transmitter. The frequency ranged from 150.815 to 151.050 megahertz with a gap of 0.015 to 0.025 megahertz between the frequency of transmitters.

There were 15 fixed stations spaced from 0.1 to 3 kilometers apart where a majority of the azimuths for locating the animal were recorded (Figure 5). An additional 38 stations were added and used when the animal moved into locations where it was difficult or impossible to receive the signal. Directional readings were drawn at the appropriate points on the map and the bear's location determined at the intersection of the directional lines.

The accuracy was checked by randomly placing transmitters throughout the study area and recording azimuths from various locations. In most of these situations the error was less than ± 3 degrees but occasionally was greater. The degree of error is difficult to transform into a linear error since distance from the transmitter and the geographical relationship between the two reading points must be known.



Figure 3. Transmitter and battery pack that were attached around the bear's neck.



Figure 4. Bear wearing a transmitter shortly after it had been attached.

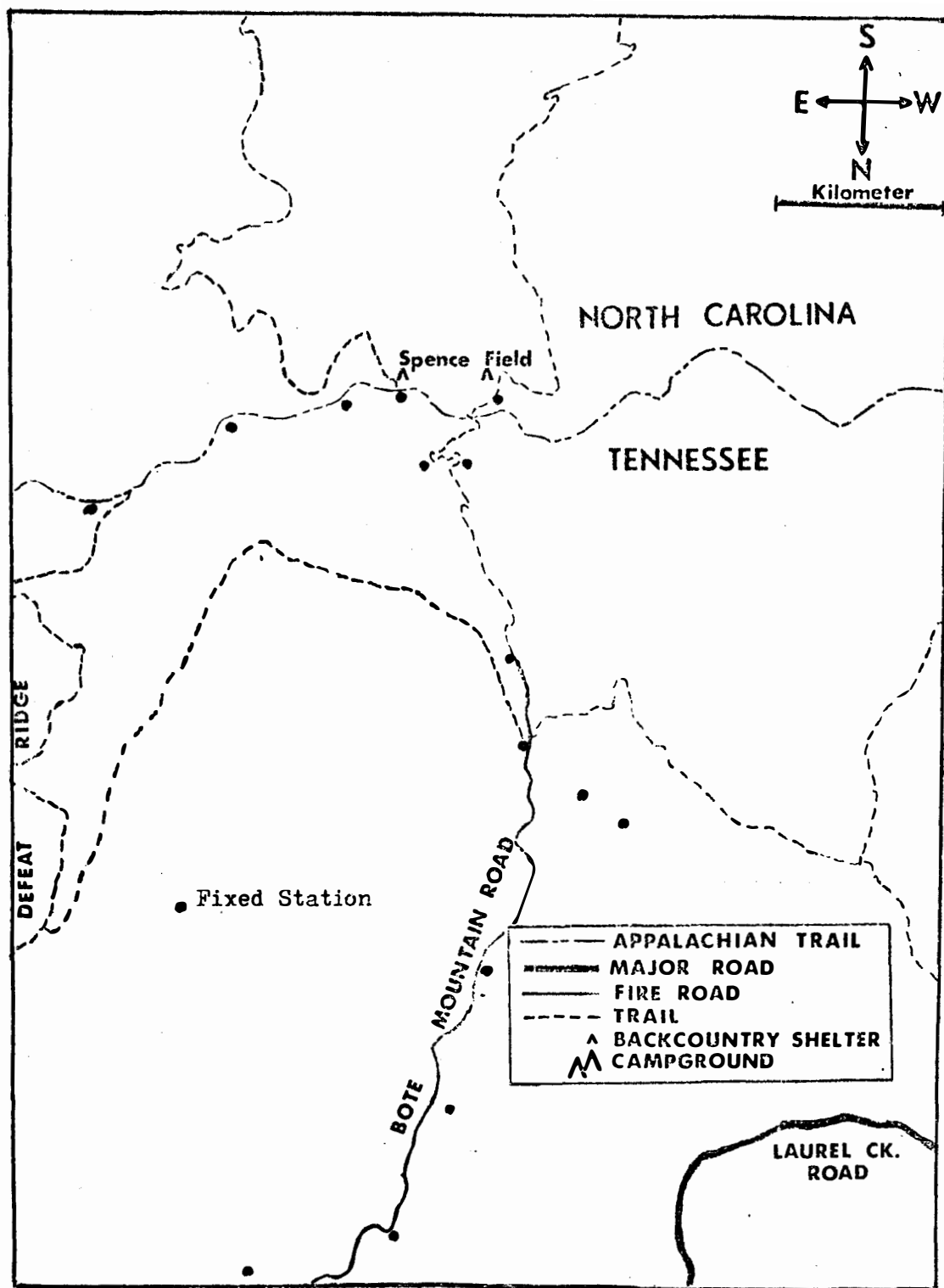


Figure 5. Fixed stations from which radiotracking readings were recorded during 1972-73 in the GSMNP.

One of the objectives of this study was to determine the feasibility and effectiveness of radiotracking in the densely forested mountains with steep valleys and narrow ridges of the GSMNP. Therefore, much of the time was devoted to the practical aspects of determining the functioning of the equipment in this topography and secondly, to determine what areas within the Park have the best topographic features and accessibility to conduct such a study. A combination of trial and error and knowledge of the topography was used in delineating what results could be collected and which areas would be most suitable for radiotracking.

A watershed outlined by two trails and two roads was selected for the centralized radiotracking area. These roads and trails allowed relatively good access but more importantly one of the roads and two of the trails followed crests of ridgetops. Ridgetops allowed for good radiotracking positioning both for the focal point of the study area as well as to the adjacent watersheds. Even with this amount of access to the back-country, the area was too remote and bears too wide-ranging to achieve a completely systematic method of tracking from day to day. However, during predetermined periods, diel movements were recorded by attempting to locate a particular bear once an hour. All of the successful attempts were done in

the back-country along Bote Mountain Road and Spence Field.

Compilation of all locations for each bear was made to determine how sufficiently the bear had been monitored so that movement patterns could be described. This determination was influenced by the period of tracking and intensity of tracking during this period. To aid in describing the movement and activities of bears, movement patterns similar to those developed by Marchinton (1968) were used. The following were included:

(1) Minimum home range. The area enclosed by a line connecting the outer radio locations of the bear during the entire period of radiotracking. The technique is similar to the modified minimum area method described by Harvey and Barbour (1965). Although this method is somewhat subjective, knowledge of the terrain was used to aid in determining the boundaries of the home range.

(2) Home range length. A line segment formed by the two bear locations that are the greatest distance apart.

(3) Home range width. A line segment perpendicular to the home range length connecting the extreme boundaries of the minimum home range at the widest point.

(4) Distance between extreme diel locations (EDL).

The greatest distance between two bear locations during a 24-hour period.

(5) Average EDL. The arithmetic mean of all EDL's for an individual bear.

(6) Minimum total diel distance (MTDD). The sum of distances between sequential locations of an individual bear during a 24-hour period. These data are only cursory estimates since the sampling sequence of one hour was frequently not achieved.

(7) Average MTDD. The arithmetic mean of all MTDD's collected for an individual bear.

During the study 25 transmitters were placed on 20 different bears. Two bears with transmitters were recaptured and were refitted with new transmitters. One bear had a series of four transmitters attached although only three functioned properly. Selection of poor geographical areas for radiotracking, a poorly constructed transmitting antenna, and the ability of some bears to remove transmitters were the obvious problems early in the study. With experience these problems were generally corrected, enabling at least some data to be recorded from all the transmitters during 1973.

CHAPTER IV

RESULTS AND DISCUSSION

I. MOVEMENTS AND ACTIVITIES

There appear to be two cohorts of bears with different behavioral characteristics. The back-country cohort limit their movements to the more remote areas of the Park and avoid people. Back-country bears are wary and many are thought to have never been observed by Park visitors. The panhandler cohort, while utilizing remote areas of the Park, frequently enter areas where people dispose of food. Each panhandler bear, when feeding on human foods, limits its activities to one particular roadside site, picnic area, campground or trail shelter (Appendices B and E). While these two cohorts most assuredly form one interbreeding population, the panhandler cohort has distinct behavioral characteristics that require additional management procedures.

On the basis of 261 captures (Appendix B) of more than 100 bears and several hundred visual observations, it was determined that black bears are not unlike most mammals with particular individuals habitually using certain areas. However, the location of back-country and

panhandler bears (when they were not interacting with people) could not adequately be determined from trapping and observational data. To more precisely define the movements and activities of bears radiotracking was employed.

Twenty transmitters were attached to bears during 1972 and 1973 (Table 4). Four transmitters produced little or no data because of various reasons. The large muscular neck of males was one of the major problems encountered that was never totally solved; the neck circumference is often larger than the skull circumference. For this reason and the inability to capture adult males in an area that had relatively easy access to the ridge-tops, only one adult male was successfully radiotracked. It was concluded that access to aerial tracking will be necessary to successfully radiotrack most adult males due to their wide-ranging movements. Old transmitters were replaced with new transmitters on three bears. The one adult male radiotracked had four transmitters attached. One transmitter was ripped off immediately after being attached. Two transmitters yielded meaningful data and the last transmitter was attached in 1974 and was still on the bear March 1, 1975.

Any effects on behavior and movement caused by the transmitter were difficult to diagnose. A few bears were

TABLE 4. A summary of movement parameters of 12 bears radiotracked in the GSMNP during 1972 and 1973

Bear No.	Telemetry Study Period	Sex	Age ^b (Years)	No. of Bear Locations ^c	Movement Parameters ^a			Appendix Ref. No.	Transmitter Fate
					Min. Home Range (ha)	Home Range Lgt. (km)	Home Range Wdt. (km)		
Y30	7-6-72 to 3-1-73	F	4.5	64	738	9.1	3.2	154-155	Removed (nonfunct.) 8/7/73
R53	6-19-73 to 3-1-74	F	8.5	109	600	4.3	3.2	200-202	Changed 9/12/73, 2nd trans. Removed 6/26/74 (nonfunct.)
Y52	7-3-73 to 12-20-73	F	4.5	74	1178	5.7	4.0	203-206	Changed 9/25/73, 2nd trans. Removed 6/16/74 (nonfunct.)
B50	8-28-72 to 1-3-73	F	8.5	50	750	5.4	3.8	152-153	Removed (nonfunct.) 9/6/73
B50	9-6-73 to 10-8-73	F	9.5	9	675	5.6	2.8	152-153	Unknown
W52	6-17-73 to 7-17-73	F	11.5	19	565	4.6	2.1	189	Unknown
Y70	9-17-73 to 10-8-73	F	11.5	15	542	5.2	2.3	199	Unknown
				Subaverage	721	5.7	3.1		
W30	7-13-72 to 10-14-72	M	2.5	63	615	4.6	2.4	184	Unknown
W67	9-27-73 to 10-15-73	M	2.5	19	532	3.5	2.6	228	Unknown
W66	7-12-73 to 2-20-74	M	2.5	56	797	3.5	3.3	229	Unknown
Y60	8-9-73 to 1-10-74	M	2.5	10	228	3.6	1.2	220-223	Removed 6/22/74 (nonfunct.)
R55	6-17-73 to 10-4-73	M	3.5	24	1080	11.2	3.0	230	Unknown
				Subaverage	650	5.3	2.6		
R26	7-15-72 to 8-20-72	M	5.5	15	1901	6.7	4.2	148-151	Lost 1st trans. immediately, 2nd trans. lost during winter
R26	6-29-73 to 10-2-73	M	6.5	87	2242	7.3	6.0	148-151	Broke off collar during Oct. of 1973
				Subaverage	2072	7.0	5.1		
				Total average	888	5.7	3.2		

^aSee methods for explanation of symbols.

^bAge when transmitter attached.

observed tugging at the collar soon after being attached; two bears successfully removed the collar within a short time after it was attached. However, observations of bears with transmitters in addition to no detection of abnormal movement patterns indicated that an adjustment to the transmitting unit and collar was made in a relatively short time.

None of the 10 bears recaptured wearing transmitters showed any signs of skin abrasions nor "outgrowing" their collar. Growth of bears, and thus their neck size, was cause for concern early in the study. It was feared that the transmitter collar might hinder neck development or even strangle the bear. However, the neck musculature in males is so massive that chance of strangulation is remote. In fact, if the transmitter were tight, neck muscles simply grow around the collar. Females didn't present a problem. The neck musculature is not massive and is much smaller in circumference than their skull's circumference. Therefore, collars could be attached rather loosely around the neck of females.

The summary of movement parameters of bears radio-tracked are presented in Table 4. All of these bears were captured in an area of the Park that supports a very high bear density (1 bear/109 hectares) (Marcum, 1974).

However, the relatively easy access alluded to earlier, and not population density, was the major criterion for selecting this area as a focal point for the telemetry study. The major physical features of the central part of the study are shown in Figure 6.

Home Range Description

A method to define the limits of a particular animal range has been a problem in all studies of animal movements. Movement patterns of animals are related to the animal's biological needs and the capacity of a certain land area to support the animal. Therefore, even with the shortcomings of manipulating a sampling of bear locations to determine home range, it is important to retain the home area concept and relate it to habitat use. Telemetry enables large quantities of data to be collected so that a more detailed description of movement can be made than from the more traditional methods of observation and recapture. While the lines drawn to define bear movements are still artificial, the confidence of their interpretative value is increased.

Adult female Y30. Bear Y30 was a 4.5 year old female that weighed 54.5 kilograms and appeared to be in good physical condition. She was captured on July 6, 1972

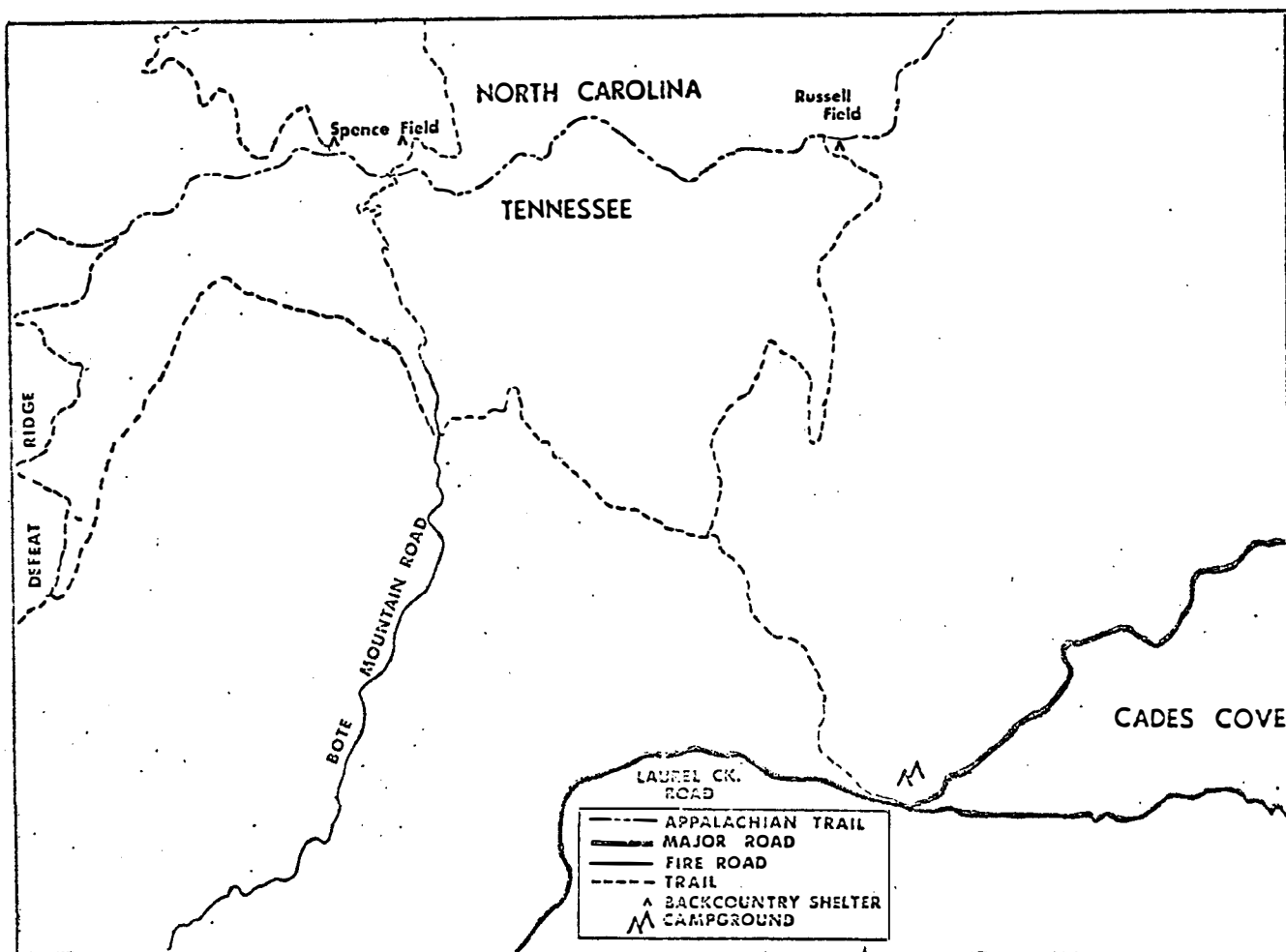


Figure 6. Major physical features of the central part of the radio-tracking study in the GSMNP.

near the Appalachian Trail and in close proximity to Spence Field. This bear was classified as a panhandler in and around the Spence Field trail shelter and was quite aggressive towards people. Movements and activities of Y30 were consistently limited to a long northeast to southwest strip along the Appalachian Trail from the peak of Thunderhead to Russell Field. Her home range measured 9.1 kilometers long, 3.2 kilometers wide, and encompassed a 738 hectare (1823 acres) area (Figure 7).

Y30 was acclimated to people and had learned the association between people and food not only at the trail shelters but also of backpackers along the Appalachian Trail. For example, Y30 followed three hikers for several kilometers along the Appalachian Trail to a trail shelter on Spence Field, then stayed the entire night in front of the shelter. Members of the research team also frequently observed Y30's persistent behavior as she would continually circle backpackers. Twenty-four visual observations were made of Y30 during 1972 (Appendix E). These observations indicate that Y30 spent much time at the Spence Field shelters with frequent movements to the peak of Thunderhead Mountain and Russell Field trail shelter. Additionally, approximately 90 percent of all radiolocations of Y30 were within a 1 kilometer radius of Spence Field.

Even with the high percentage of time spent in

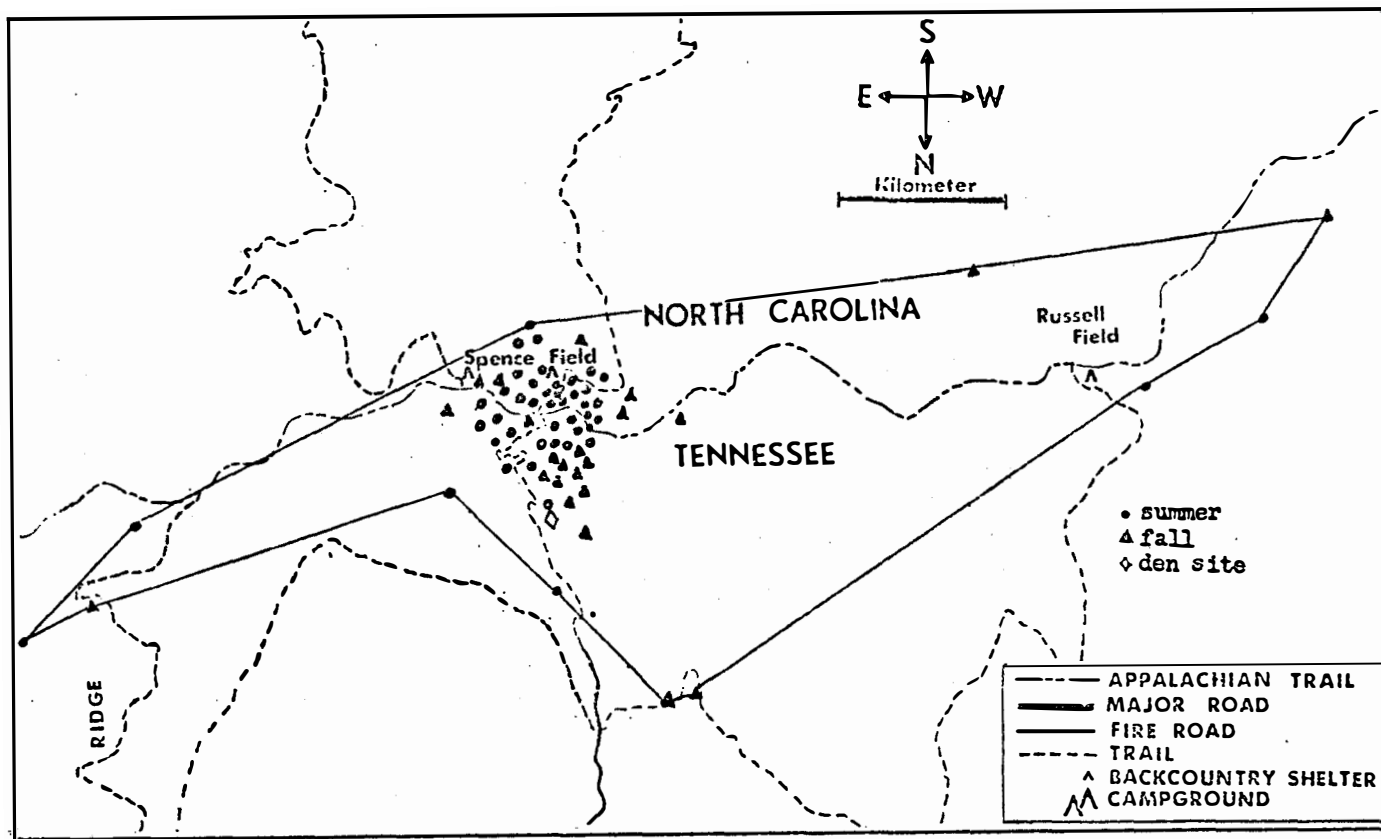


Figure 7. Home range of Y30, a 4.5 year old female, as determined by radiolocations during 1972 in the GSMNP.

obtaining food from backpackers, Y30 was also observed eating serviceberries, blackberries, and blueberries along Spence Field. As soon as the numbers of backpackers declined in early September, the activities and movements of Y30 concurrently switched from the Appalachian Trail to lower elevations on the Tennessee side of the Park (Figure 7).

The home range of Y30 varied from an elevation of 960 to 1650 meters. Most of the summer movements were along the Appalachian Trail and thus were at the higher elevations. The fall movements were centered around the eventual den site (elevation of 1277 meters) of Y30.

Although bear Y30 was radiotracked only during 1972 and early 1973, her activities and movements did not appear to deviate during the summer of 1973. She made daily treks to Spence Field and once again was very bold toward people (Appendix E). In 1974, Y30 either changed her activities or died during the previous winter as she was never observed.

Adult female R53. Bear R53, an 8.5 year old female, was captured on June 19, 1973. She weighed only 32.7 kilograms and was very thin. This bear was recaptured on September 12, 1973, and had improved her physical condition by gaining 10.5 kilograms. During the second capture she

had lost all her upper incisors by biting at the culvert trap. However, no ill-effects were detected as she successfully denned and survived the winter into the next summer.

Bear R53's movements were well defined and limited to a home range area of 600 hectares (1485 acres, Figure 8). Her home range was 4.3 kilometers long and 3.2 kilometers wide and was somewhat linear along a north-south direction. The Appalachian Trail on one side and Bote Mountain Road on the other side appeared to serve as geographical boundaries for setting the limits of movements on two sides of the home range. Basically, R53's home range covered the east-facing slope of Bote Mountain and the adjacent valley bottom. Bear R53 spent much time along the Bote Mountain Road (the western edge of her home range).

In October of 1972, R53 could not be found and was assumed to have left the area of her summer range. Even though R53 was not located during the first three weeks of October, several days of searching indicated she was not in the surrounding watersheds. During the last week in October, R53 returned and later denned in the area of her summer range. Fall is a critical time for consuming large quantities of food, and R53 likely moved to an area where acorns and other mast foods were more abundant

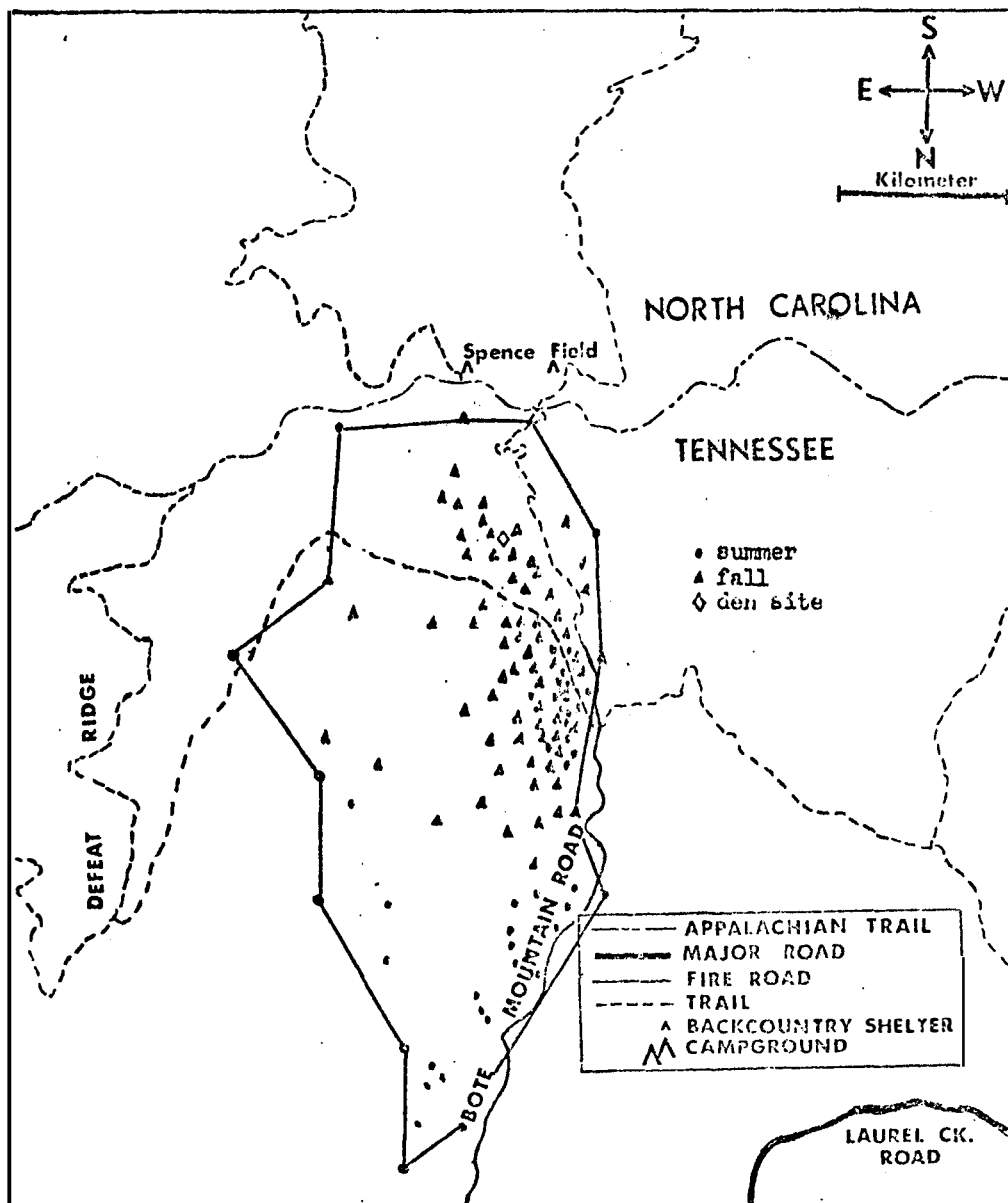


Figure 8. Home range of R53, an 8.5 year old female, as determined by radiolocations during 1973 in the GSMNP.

(lower elevations) and returned to den after reaching a point of satiety.

The movements of R53 covered an elevation range of 630 to 1450 meters. Except for the sudden three-week absence previously discussed, there were no abrupt changes between her summer and fall movements (Figure 8). There appeared to be a slight activity shift of R53 to limit her movements to a small area surrounding her den site (1207 meters) in the waning days before denning in early December.

Bear R53 was captured in the back-country (Appendix B, ref. nos. 202-202) and was never observed except during the captures. R53's movements appeared to be secretive and completely wary of people. This bear was recaptured in the summer of 1974 along Bote Mountain Road in the same area utilized the previous year.

Adult female Y52. Bear Y52, a 4.5 year old female, was captured on July 3, 1973. She weighed 32.3 kilograms and was very thin. Y52's home range of 1178 hectares (2910 acres) was the largest recorded for females (Figure 9). Her home range was approximately 5.7 kilometers long and 4.0 kilometers wide and was linear in a northwest to southeast direction. The range of Y52 approached the Appalachian Trail on the south. The ridge tops of Defeat

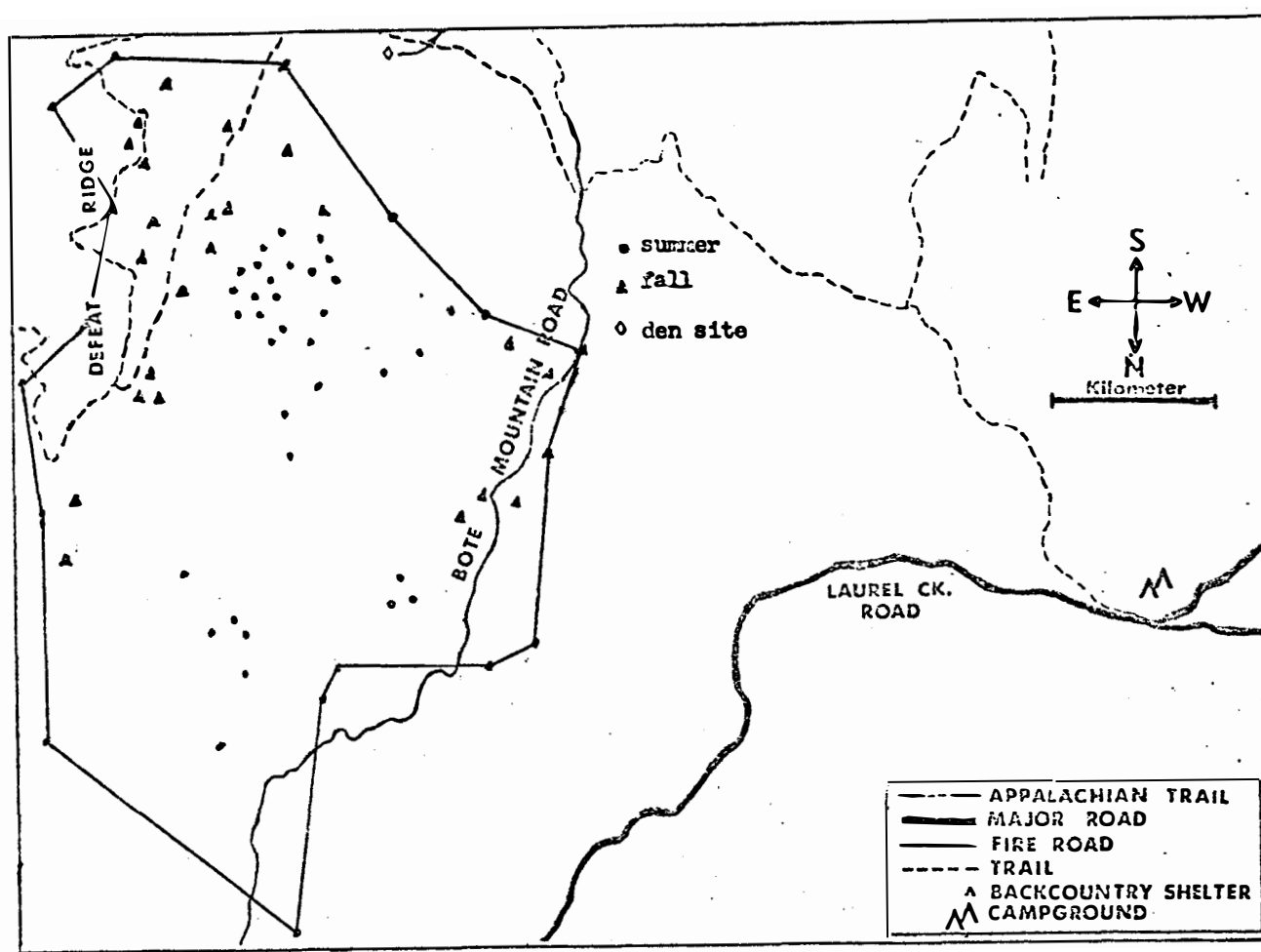


Figure 9. Home range of Y52, a 4.5 year old female, as determined by radiolocations during 1973 in the GSMNP.

Ridge on the east and Bote Mountain on the west appeared to serve as geographical boundaries. The movements of this bear included the entire watershed between Bote Mountain and Defeat Ridge. No obvious center of activity was detectable although bear Y52 was more frequently located in the northern end of her home range.

During the fall, bear Y52 appeared to spend a large percentage of time in the southern part of her range although the change from summer was not abrupt. As discussed earlier concerning bear R53, Y52 left her summer range and was not located for a period of three weeks. However, in late October, Y52 returned and later denned early in December. It was interesting to note that the den site of Y52 was approximately 1 kilometer out of her established summer and fall range. Whether she actually moved outside her home range to den or recording of the summer movements was incomplete is unknown. Also, the den site of Y52 was just 400 meters from the den site of R53 (both adult females). The movements of Y52 ranged from an elevation of 540 to 1350 meters and were in an area that is little utilized by people. This bear was never reported to be observed except during the four captures (Appendix B, ref. nos. 203-206). Two of these captures were in 1974 and were in the same area as the established home range of the previous year.

Adult female B50. The movements of bear B50, an 8.5 year old female, were recorded for both 1972 and 1973 (Figure 10). The bear was originally captured August 28, 1972 at Spence Field. At this time she weighed 68.2 kilograms and appeared to be in good physical condition. She was lactating and had one cub that was estimated to weigh between 9 and 11 kilograms. These two bears spent much time at Spence Field and were considered panhandlers. While not as aggressive as bear Y30, she occasionally would display aggressive behavior toward people. The belief that sows with cubs are more aggressive than other bears was not readily apparent with B50.

During 1972, bear B50 and her cub ranged over a 750 hectare (1852 acres) area. The home range shape was 5.4 kilometers long and 3.8 kilometers wide and slightly elongated in a north-south direction. The major activities of the sow and cub were limited to Spence Field and the valley extending south from Spence Field in North Carolina. Although the trail shelters were a center of activity for this bear, Spence Field appeared to be along the northern border of the established home range. Approximately 80 percent of the radiolocations of B50 were within a 1 kilometer radius of Spence Field. During several trips by members of the research team during June

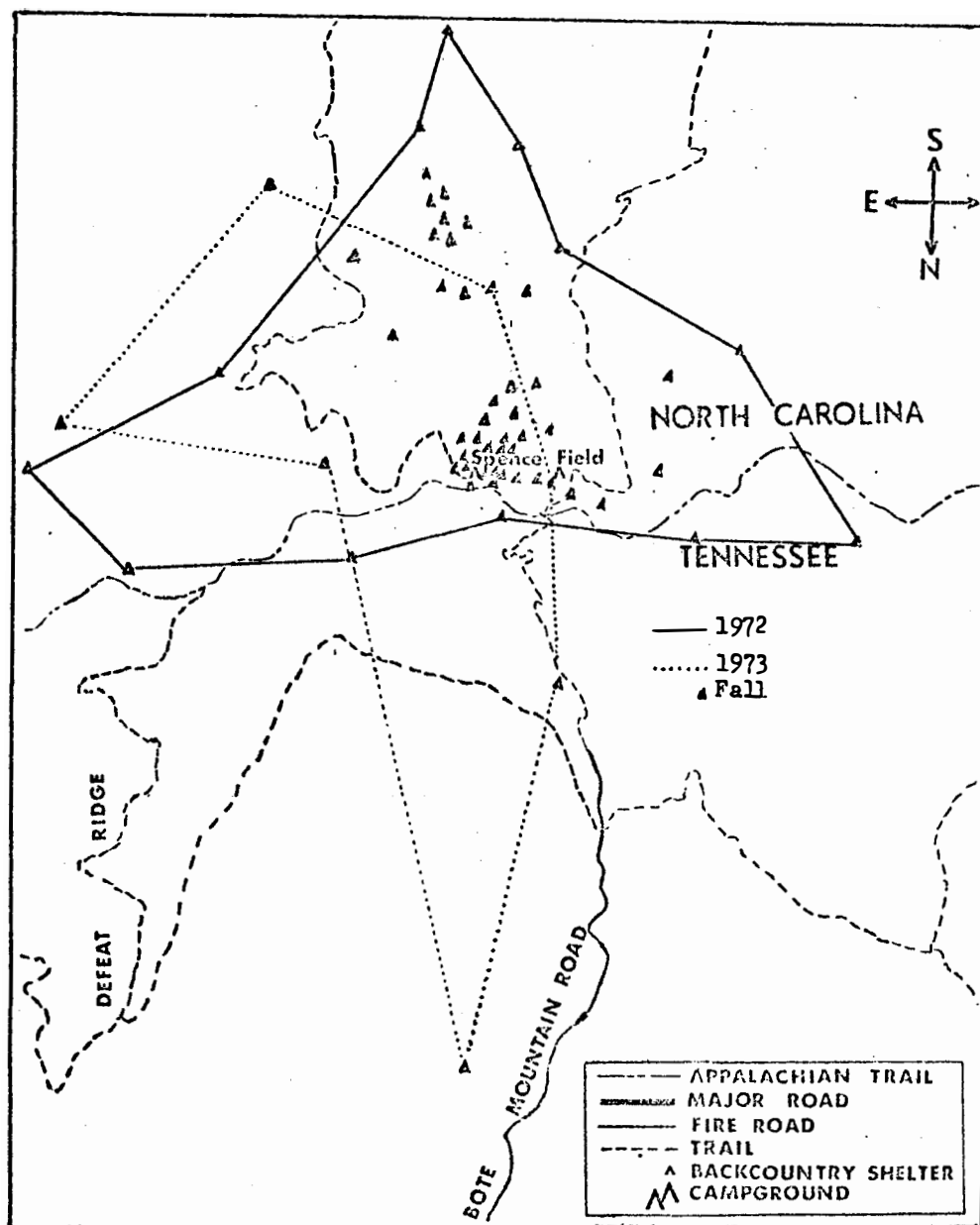


Figure 10. Home range of B50, an 8.5 year old (1972) female, as determined by radiolocation during 1972 and 1973 in the GSMNP.

and July, this sow and cub were never seen. In late August B50 was finally captured and tagged. From this date until October 27, B50 and her cub were frequently observed at Spence Field. The following year B50 was observed all during the summer without young (Appendix E). This indicates that B50 appeared to be somewhat more wary of people when she was accompanied by a young cub. Towards the end of the summer when the cub was approaching nine months, B50 appeared to be less inhibited about approaching people. When she was barren in 1973, there was no hesitation about contacting people early in the summer.

On September 6, 1973, B50 was again captured and collared with a transmitter. She was now barren and appeared in excellent physical condition weighing 78.6 kilograms. Since only 10 radiolocations and 12 visual observations (all at Spence Field) were made, B50's home range was likely not fully recorded. Her movements during this time were limited to an area of 5.6 kilometers long and 2.8 kilometers wide and encompassed a 675 hectare (1667 acres) area. Bear B50 generally used the same area as the previous year although she was once located in 1973 further down into the watershed between Bote Mountain and Defeat Ridge than in 1972.

During 1972, the movements of B50 were limited to a

narrow elevation band of 1260 to 1620 meters. This elevation band was slightly altered to include areas ranging from 1050 to 1440 meters during 1973.

Bear B50 was not captured in 1974 but was once again observed at Spence Field (Appendix E). All of these observations were made from August 19 to 24. No cubs were reported but this was not documented by a member of the research team.

Adult female W52. Bear W52, an 11.5 year old female weighing 52.3 kilograms was captured on June 17, 1973. Except for her teeth, the general condition of this animal appeared to be good. One canine was broken off near the gum line and another was cracked. Also, one of the first upper premolars was broken into two sections. These dental injuries appeared to be old and not related to the trauma of trapping.

The transmitter of W52 never functioned properly. Its pulsating signal was very weak and difficult to identify. The signal became weaker with time and was never received after a month's operation. Only 17 locations were made and indicated a home range of 565 hectares (1396 acres, Figure 11). The home range was 4.6 kilometers long and 2.1 kilometers wide and covered the west-facing slope of Bote Mountain and the adjacent valley. Movements

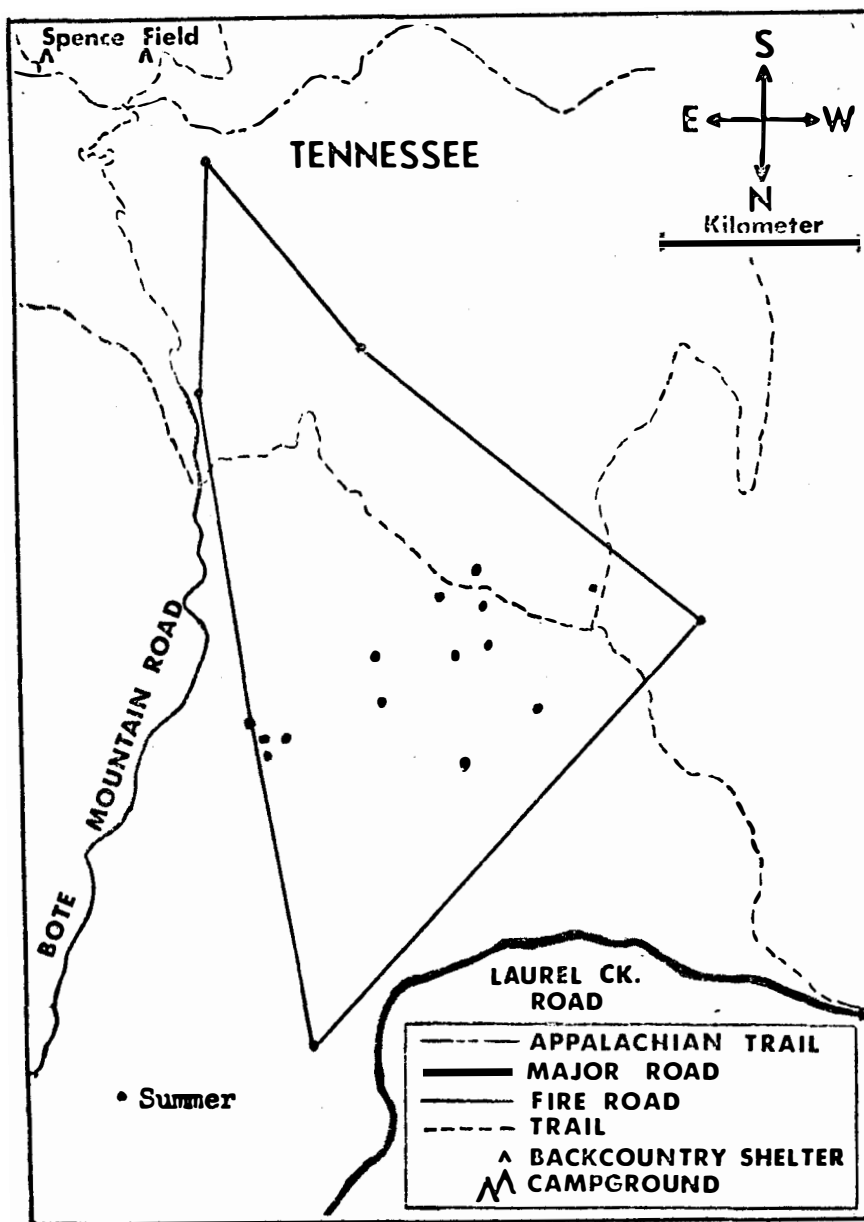


Figure 11. Home range of W52, an 11.5 year old female, as determined by radiolocations during 1973 in the GSMNP.

of W52 approached the Appalachian Trail on the south and Laurel Creek Road on the north.

The movements of W52 varied from an elevation of 690 meters near Laurel Creek Road to 1410 meters near the Appalachian Trail at Spence Field. This bear was never reobserved nor recaptured after the initial capture in 1973.

Adult female Y70. Bear Y70 was another 11.5 year old female. This bear was trapped on September 9, 1973 and radiotracked until October 8, 1973. She weighed 54.5 kilograms and was in good physical condition, although the fat layer was thin for early fall. Y70 was trapped at Spence Field although never observed near the trail shelters.

Bear Y70 used a 542 hectare (1339 acres) area that was 5.2 kilometers long and 2.3 kilometers wide (Figure 12). The movements of this bear were limited to a narrow strip along the ridge of Bote Mountain and across the Appalachian Trail into North Carolina. The movements ranged in elevation from 840 to 1590 meters. As previously mentioned Y70's movements appeared to encompass the shelters at Spence Field. However, Y70 was never reported as having visited the shelters and hence was not considered a panhandler bear.

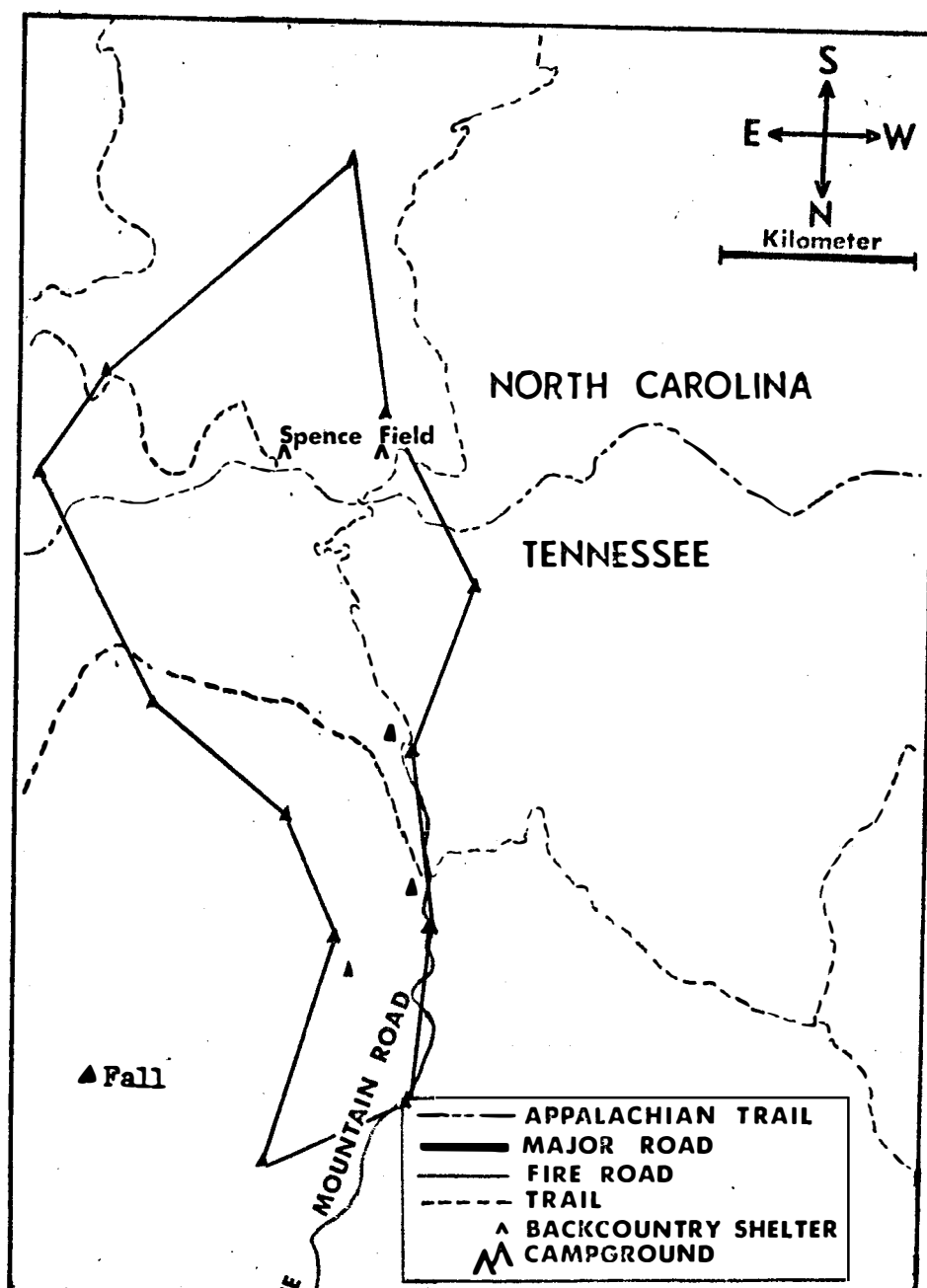


Figure 12. Home range of Y70, an 11.5 year old female, as determined by radiolocations during 1973 in the GSMNP.

October 8, 1973 was the last radio contact with this bear. As has been mentioned earlier for bears R53 and Y52, Y70 also appeared to vacate the area used the previous month. However, Y70 was never known to have returned. Since the transmitter was properly functioning until this time and Y70 was not recaptured the following year, it was suspected that this bear never returned rather than an equipment failure.

Subadult male W30. Bear W30 frequently visited Spence Field and was considered a panhandler bear. This bear was trapped on July 13, 1972, and appeared to be in excellent physical condition--a 2.5 year old weighing 27.3 kilograms. The movements of bear W30 included a 615 hectare (1519 acres) area; 4.6 kilometers long and 2.4 kilometers wide (Figure 13). However, this bear was also located five times (including three different directions) outside its apparent home range. On August 17, 1972, W30 was located approximately 1 kilometer from the peak of Thunderhead Mountain on the Tennessee side of the Park. After returning to Spence Field, W30 was located on September 1 approximately 3 kilometers south of Spence Field on the North Carolina side of the Park. The last long-range movement by W30 was observed at Moore's Spring shelter on October 14. This was the last date W30 was ever observed or located.

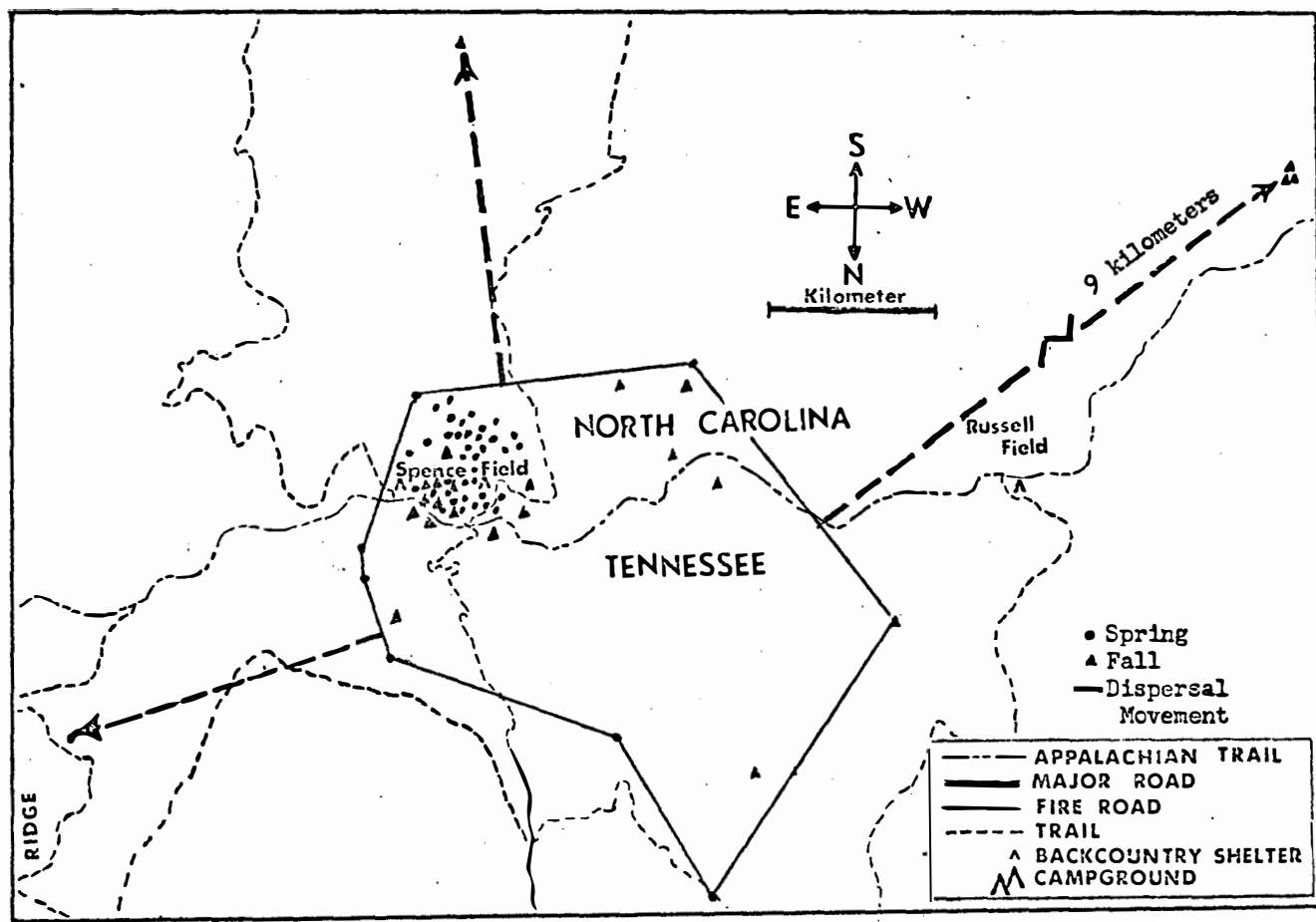


Figure 13. Home range of W30, a 2.5 year old male, as determined by radiolocations during 1972 in the GSMNP.

During the summer, bear W30 was frequently located at Spence Field. Seventy-seven percent of the radio-locations were within a 1 kilometer radius of Spence Field. This bear was rather wary of people at first, only coming to the shelters at night. However, with increased exposure to people, W30 became bolder and would occasionally enter the Spence Field area during the day.

The home range of W30 during the summer included areas on both sides of the Appalachian Trail and ranged in elevation from 900 to 1470 meters. The center of activity, located at Spence Field, was in the northeast corner of the home range.

Subadult male W67. Bear W67, a 2.5 year old male, was trapped on September 27, 1973. This bear weighed 45.5 kilograms and was in good physical condition although not fat for the fall season. The movements of W67 were followed for only 18 days and included a 532 hectare (1314 acres) area that was 3.5 kilometers long and 2.6 kilometers wide (Figure 14). Since the transmitter appeared to be functioning quite well up through this time, it was suspected the bear simply moved out of the general area. Bear W67 was captured in an area that had been trapped intensively all summer and likely would have been caught before September 27, if present. Additionally, this

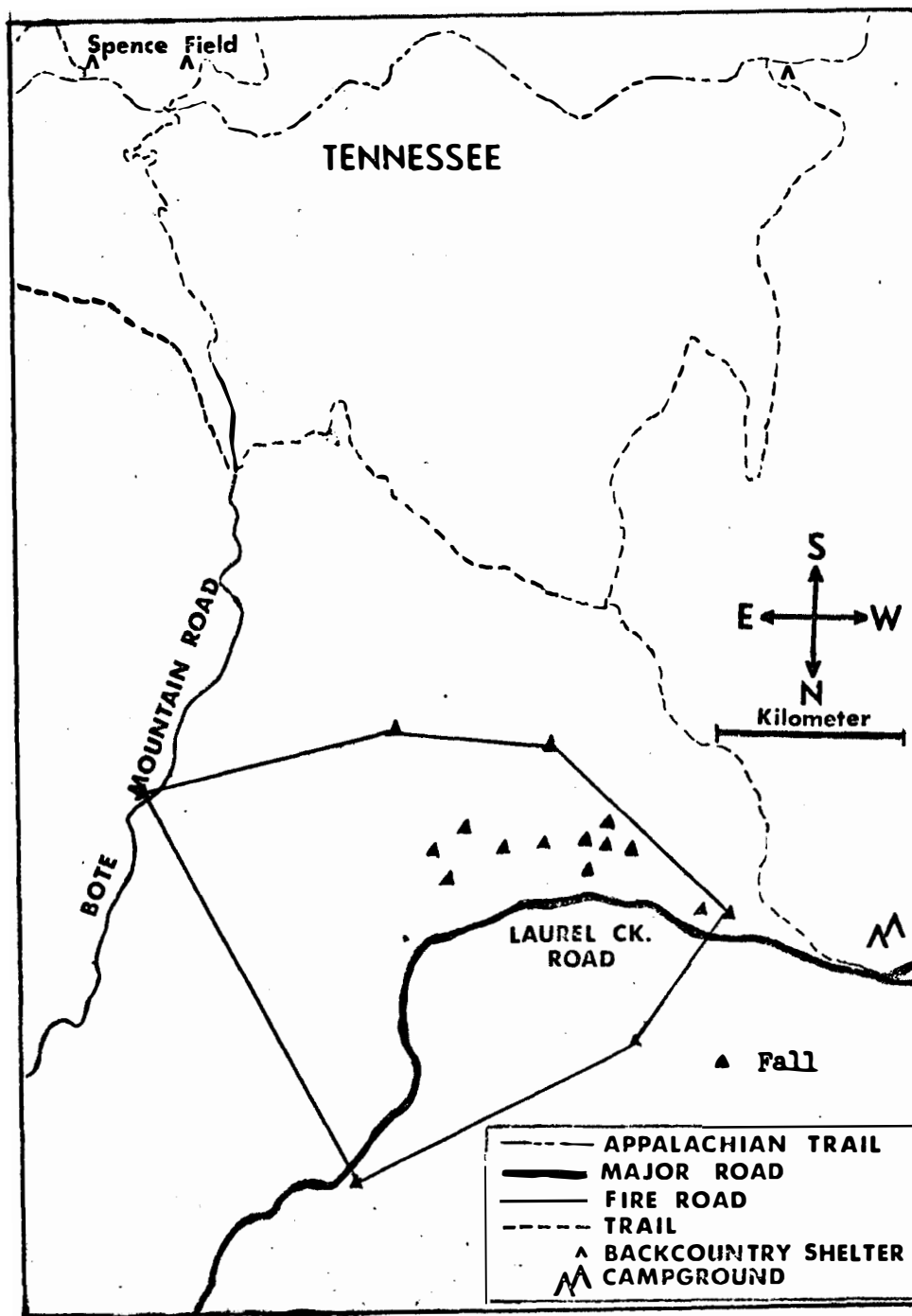


Figure 14. Home range of W67, a 2.5 year old male, as determined by radiolocations during 1973 in the GSMNP.

bear was not recaptured in 1974 even with intensive trapping efforts in the area of its original capture. These data suggest bear W67 was making a dispersal movement in search of a home area when captured. However, this is only circumstantial evidence. The transmitter could have stopped functioning, and the trapping results may not be conclusive.

During the time that W67 was radiotracked, its movements were concentrated along Laurel Creek Road about 3 kilometers from Cades Cove Campground and ranged in elevation from 480 to 1020 meters.

Subadult male R56. Bear R56, a 2.5 year old, was captured on July 12, 1973. This bear weighed 42.3 kilograms and was relatively fat for this time of year. Its movements encompassed an area 3.5 kilometers long, 3.3 kilometers wide, and an area of 797 hectares (1969 acres) (Figure 15). The home range was generally outlined on three sides by Defeat Ridge, Bote Mountain Road, and the Appalachian Trail.

Bear R56 concentrated its activities along the ridge of Bote Mountain and was only occasionally located along the ridge top of Defeat Ridge. Its movements covered an elevation range of 600 to 1510 meters although most of the locations were above 1000 meters. R56 was

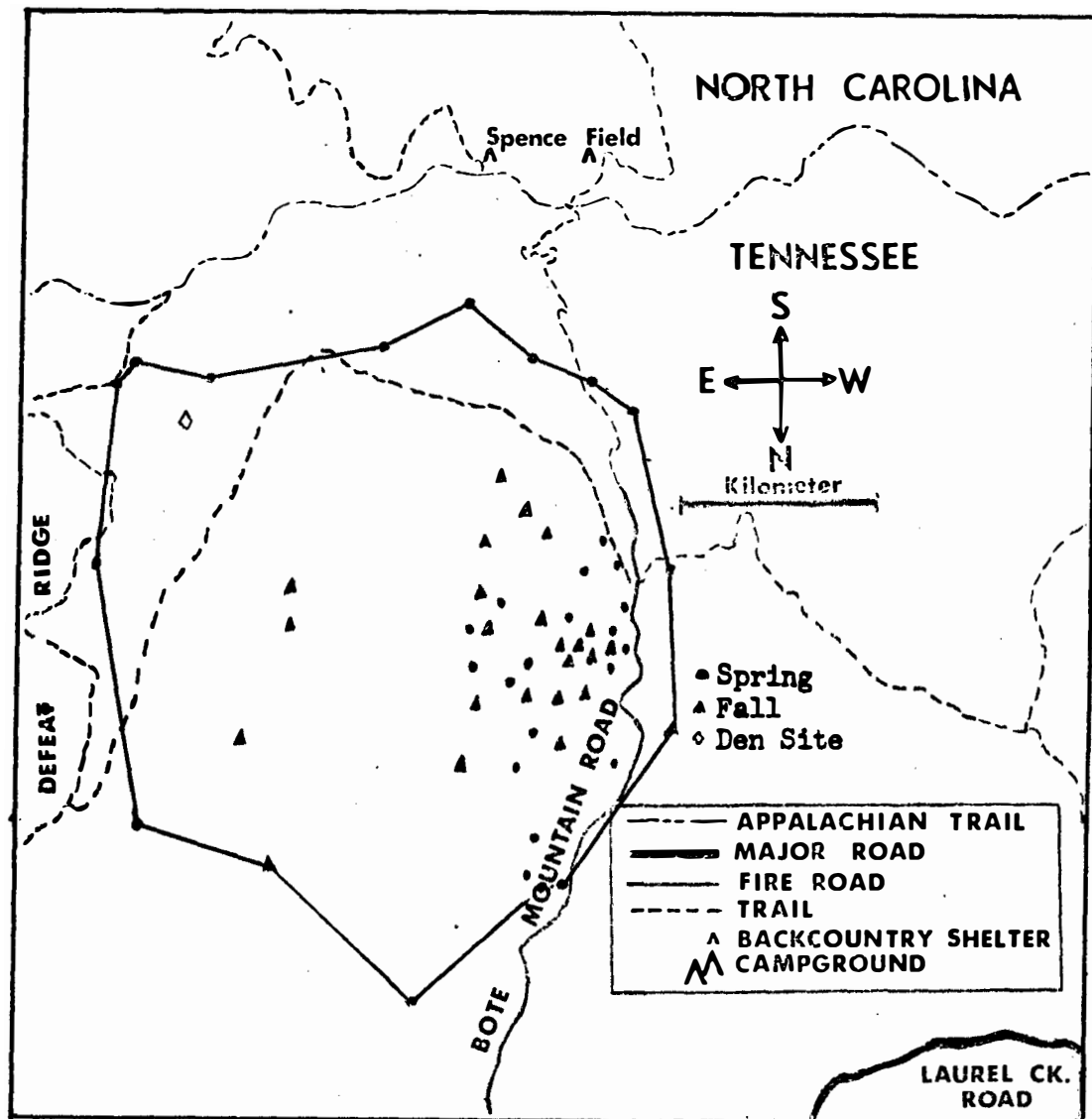


Figure 15. Home range of R56, a 2.5 year old male, as determined by radiolocations during 1973 in the GSMNP.

observed two different nights using Bote Mountain Road to travel from one area to another. However, this bear stayed in the back-country and was never observed except during the captures.

Bear R56 appeared to have established a home area and limited its movements to this area during the summer and early fall. However, R56 could not be found during a three-week period in October. Very likely he temporarily moved to an area with abundant mast. At the end of October, R56 returned and denned approximately one kilometer from the peak of Thunderhead Mountain. Radio contact was lost on February 20, 1974, and R56 was never reobserved or recaptured. If not dying of some mortality factor, it was suspected that R56 moved out of the area or at least shifted his home range in 1974. Trapping efforts during 1974 were quite intensive in this area, and R56 would likely have been captured if still present.

Subadult male Y60. Bear Y60, a 2.5 year old, was trapped on July 24, 1973. He weighed 33.2 kilograms and appeared in good physical condition. Sixteen days later Y60 was recaptured and had gained 3.6 kilograms.

The 10 recorded movements of Y60 were limited to a 228 hectare (563 acres) area. The home range measured 3.6 kilometers long and 1.2 kilometers wide (Figure 16).

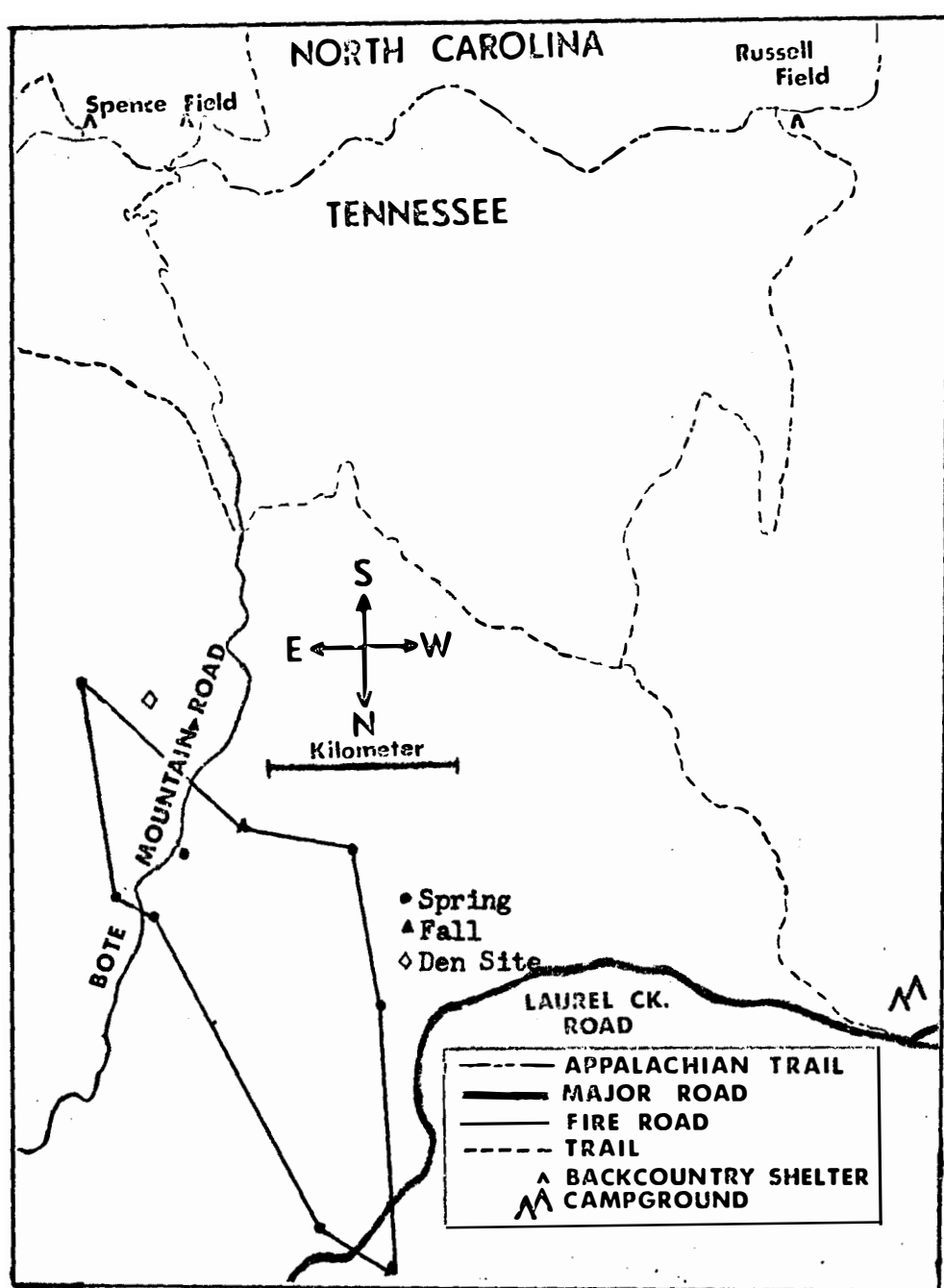


Figure 16. Home range of Y60, a 2.5 year old male, as determined by radiolocations during 1973 in the GSMNP.

The range generally included both the east and west slopes of Bote Mountain with no apparent geographical features of the terrain acting as a boundary. The transmitter never functioned properly so detailed movements of Y60 were not obtained. His movements covered an elevation range of 510 to 900 meters. No concentrated areas of activity could be diagnosed with only 10 locations.

Bear Y60 was located in a den on December 15. However, five days later Y60 left the den and was never relocated until the following year. On June 22, 1974, Y60 was captured at the junction of Anthony Creek Trail and Bote Mountain Road. This was approximately 2 kilometers farther up Bote Mountain than any location of the previous year. On July 4, 1974, Y60 was again captured 1.5 kilometers below Spence Field on the Anthony Creek Trail. Since only 10 locations were obtained during 1973, the total home range was likely not completely outlined. The captures during 1974 suggest that Y60 had established a home area and that this home area is larger than described in 1973.

Subadult male R55. Bear R55, a 3.5 year old male, was captured on June 17, 1973 in the Cades Cove campground. This bear was never observed before or after its capture

in the campground. Hence, it was not considered a pan-handler animal. R55 weighed 39.5 kilograms and was in good physical condition although rather small for a 3.5 year old male.

The movements of R55 could be described as restless and searching. The home range is quite subjective in the case of R55 but totaled 1080 hectares (2668 acres). The bear's range was 11.2 kilometers long and 3.0 kilometers wide (Figure 17). Its movements ranged from an elevation of 540 to 1250 meters. Activities of R55 were basically located in two separate areas. One area included the valley between Bote Mountain and Defeat Ridge. The other area was on the northwest end of Cades Cove at the base of Rich Mountain. Early in the summer R55 was found in the Bote Mountain area. Later this bear moved to Rich Mountain and remained there for approximately two weeks. Next, R55 returned to Bote Mountain and stayed in this area for a two- to three-week period. Just as before, this bear returned to the Rich Mountain area and was never relocated after October 4. Bear R55 was not recaptured in 1974 and was believed to have dispersed out of the area. This bear appeared to have the pattern of limiting its activities to small local areas and then suddenly making a relatively long trek to another area.

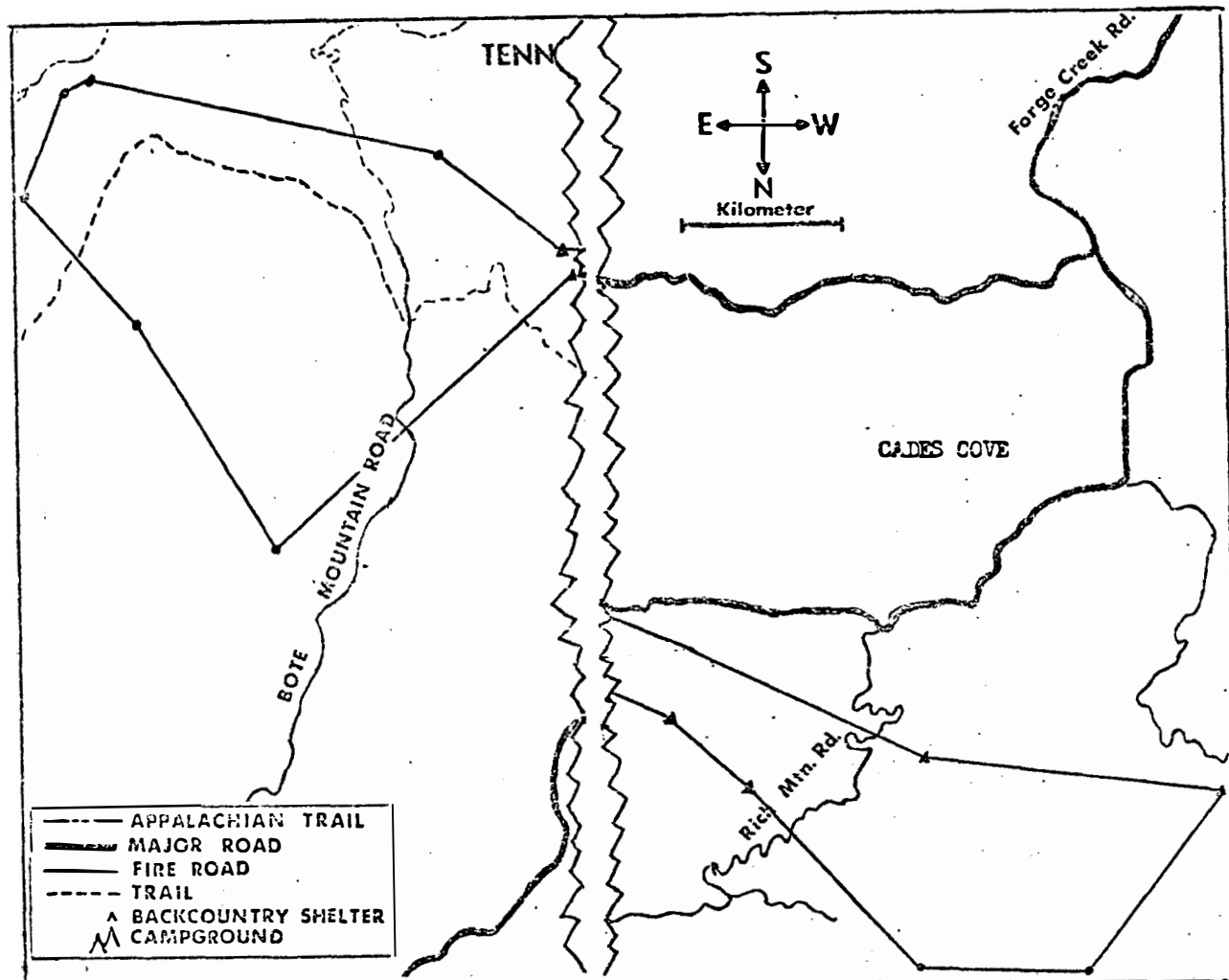


Figure 17. Home range of R55, a 3.5 year old male, as determined by radiolocations during 1972 in the GSMNP.

Adult males. Four attempts were made to radio-track three different adult males. As previously mentioned, adult males posed the problem of simply keeping the transmitter on the animal. Two bears removed the collars immediately and a third was never relocated after attaching the transmitter. The fourth attempt was successful and this bear (R26) had a total of three transmitters that have yielded some location data. This bear has been trapped four times during the last three years (Appendix B, Ref. Nos. 148-151). Bear R26 was 4.5 years old when captured for the first time on June 20, 1972 and was extremely large for this age and season of the year (113.6 kilograms). Since that original capture, his weight fluctuated between 92.3 and 110.5 kilograms over the next two years.

During 1972, the home range of R26 encompassed a 1901 hectare area (4695 acres) with length and width dimensions of 6.7 by 4.2 kilometers (Figure 18). Generally the movements covered the east and west slopes of Bote Mountain from the peak to the base. The Appalachian Trail appeared to be the southern limit of R26's movements. The home range veered out in the northeast corner to include Cades Cove campground. R26 only occasionally visited Spence Field and was not considered a panhandler bear.

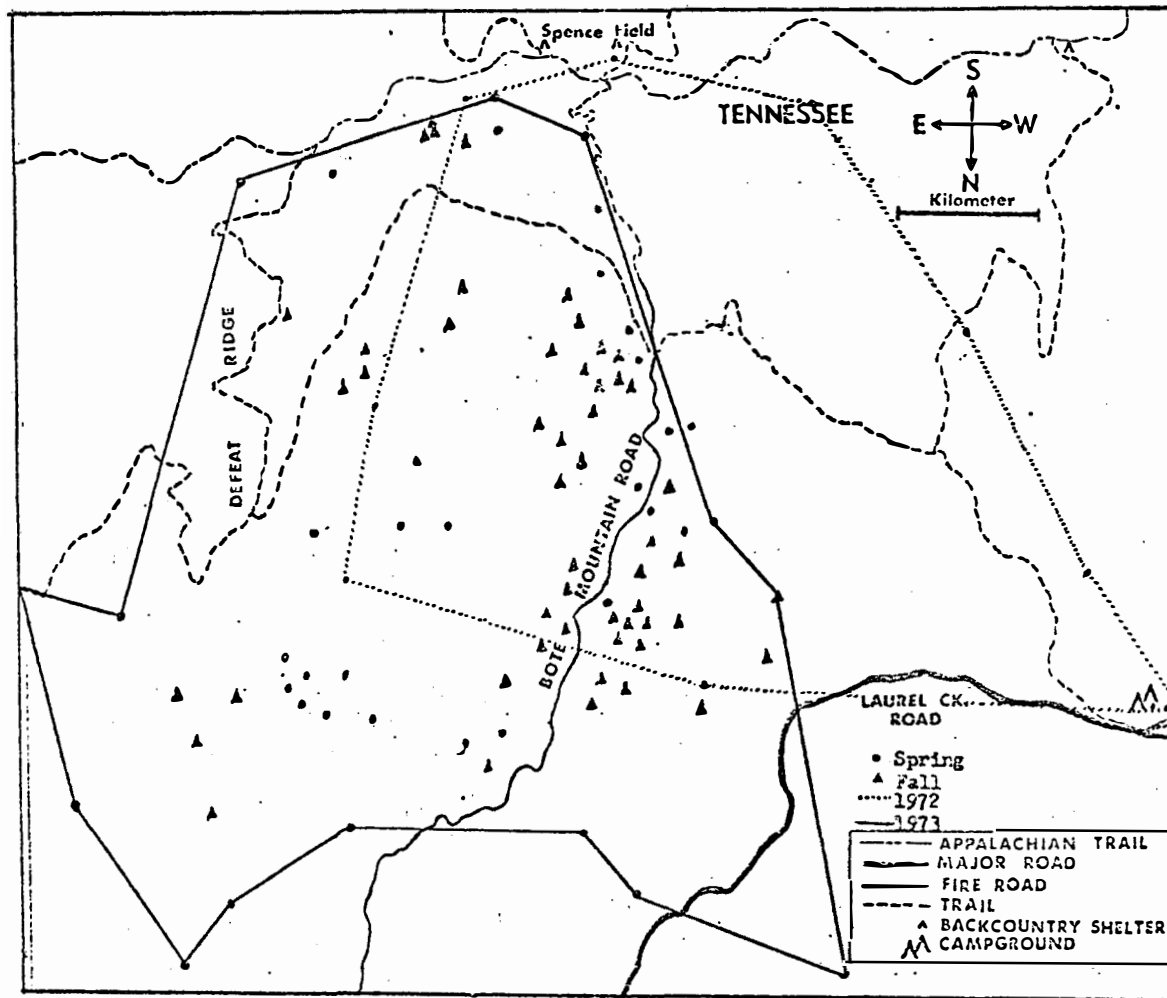


Figure 18. Home range of R26, a 5.5 year old (1972) male, as determined by radiolocations during 1972 and 1973 in the GSMNP.

During 1973, bear B26 covered much of the same area although he appeared to shift his activities more to the western slope of Bote Mountain. His estimated home range was slightly larger than the previous year enclosing a 2242 hectare (5538 acres) area. The home range length and width were 7.3 and 6.0 kilometers, respectively. During the two-year period, R26 ranged from an elevation of 570 to 1650 meters. There were no activity centers detected as R26 appeared to utilize his established home range rather evenly.

Discussion of Home Range

Home range size of black bears appears to be correlated with habitat diversity. The GSMNP provides diverse habitat types and the home range size of bears is concomitantly small. There was variation in home range size among bears of the same age and sex class as well as between different sex and age classes. However, adult females and subadult males generally utilized an area approximately one-third the size of the one adult male radio-tracked.

Home range size of adult females in the GSMNP averaged 721 hectares (1781 acres). In Washington, Poelker and Hartwell (1973) reported an average home range of 500

hectares (1235 acres) for females. Jonkel and Cowan (1971) used a measurement similar to home range length. Their measurement of 2.6 kilometers is less than one-half the home range length calculated in the GSMNP. Ernst (1972) reported two adult females averaged 1537 hectares (3796 acres) in Georgia. In Pennsylvania Kordek (1973), estimated a home range average of 1995 hectares (4928 acres) for two adult females. Part of the large variability between estimated home ranges is likely due to different methods of collecting movement data and calculating home range. However, habitat diversity and the interspersation of these habitats is probably the key factor in determining home range size.

The home range size of subadult males in the GSMNP ranged from 228 to 1080 hectares (563 to 2668 acres) and averaged 650 hectares (1605 acres). Home ranges of two subadult males appeared to be underestimated due to insufficient data and, likewise, the average home range size of all subadults may be underestimated.

Some of the subadult males appeared to have established a home area. Their movements were confined to a well-defined area. In addition, these bears were observed the following year either in or near their previously defined home range. Bear Y60 was captured in the same

watershed in 1974 as radiotracked during 1973. Bear B29 (Appendix B, Ref. Nos. 171-174) was captured in July, 1972, at Spence Field and was frequently observed there. During 1973 and 1974, B29 was located 0.8 and 2.4 kilometers from Spence Field, respectively. Also, B29 was found in a den tree less than 1 kilometer from Spence Field.

Other subadult males appeared to have not established a home area. In searching for a home area, these subadults spent several days in a fairly localized area and suddenly made abrupt shifts to other areas of the Park. This type of movement was especially evident with bear W30 and R55. Another subadult male, R31 (Appendix B, Ref. Nos. 165-166) was captured at Siler's Bald as a cub. Two years later R31 was observed at Tremont, a movement of 15 kilometers. These data suggest bears as old as 3.5 years may not have established a home area.

Other studies of black bears report dispersal of young animals. Jonkel and Cowan (1971) found that 18 bears moved outside their study area; 13 of which were subadults. The greatest distance was a 48 kilometer dispersal by a 2.5 year old male. Erickson et al. (1964) mention two yearlings moving 10 kilometers each. A 145 kilometer movement by a 2.5 year old male was reported by Stickley (1961). Barnes and Bray (1967) reported evidence of dispersal was limited,

but one yearling and one 2.5 year old male made long movements that were dispersal in nature.

Dispersal of young is likely a natural mechanism that is regulating the population in the GSMNP. While aggression between bears may play a role in dispersal, no observations of this behavior were recorded. Pruitt (1974) reported that black bears have evolved a sophisticated means of communication. Very likely, this highly developed communication system reduces the need for physical confrontations between bears.

The home range of R26, an adult male, was approximately three times larger than subadult males and adult females. However, the home range of this bear was relatively small compared to movements of adult males in other studies. Erickson et al. (1964) estimated summer ranges of 1560 hectares (3853 acres) and an annual range of 3400 hectares (8398 acres) for males. They suggested males covered twice the area of females. Jonkel and Cowan (1971) found maximum distances between particular bears to average 6.3 kilometers. This is approximately 2.5 times larger than their same measurement for females. Kordek (1973) reported a much larger area of 14,769 hectares (36,480 acres) for males. This area was approximately seven times larger than the estimated home range for females in his study. Poelker and Hartwell (1973) found males ranged over an average of

5200 hectares (12,844 acres). They estimated the average male home range was nearly 10 times larger than females. These studies show quite variable results but do agree that adult males use a substantially larger area for their annual movements than females.

There were obvious differences between the activities of back-country and panhandler bears. Back-country bears completely avoided people as was evidenced by no field observations of these marked individuals. While back-country bears likely used some areas of their home range more than others, their activities were dispersed and probably related to areas of food availability. Panhandler bears were not afraid of people and freely associated with them at close distances (Appendix H). There was some evidence that a panhandler female with a cub avoided people while the cub was very young but became less inhibited after the cub reached nine months of age. There appeared to be different degrees of nuisance among panhandler bears. Bear Y30 spent nearly all her time during the summer at the trail shelters and along the Appalachian Trail. Bear B50 made frequent treks to Spence Field but did not totally dedicate her time to panhandler activities. Both panhandler females were in good physical condition and had the ability to forage for native foods when human foods were not available. Therefore, their panhandler activities

support the belief that bears are opportunistic feeders and that they can readily adapt their behavior patterns in order to obtain food.

The home ranges of bears in the GSMNP were nearly twice as long as wide. Linearity of home range allow animals to utilize more habitat types by including additional environmental conditions. In the GSMNP where the slopes are steep, elevation changes rapidly. Dates of fruit maturation of particular fruit-bearing species varies according to elevation allowing a longer season for food availability. By having linear home ranges, bears in the GSMNP can more efficiently utilize the food resource.

Diel Movements

Diel movements of bears were recorded for two adult females, two subadult males, and one adult male during 18 different 24-hour periods (Appendix F). These results are cursory since the attempted sequence of one bear location per hour was frequently not achieved. Only data that provided at least two bear locations within a six-hour period were used. Therefore, frequent attempts of recording diel movements were aborted when this criterion was not met.

The greatest distance between any two locations (EDL) and the sum of the distances between sequential locations

(MTDD) of particular bears during a 24-hour period is listed in Table 5 and Figures 19 to 24. The EDL varied from 0.77 to 5.81 kilometers. The average EDL values were relatively consistent and varied from 1.8 to 3.8 kilometers. The MTDD ranged from 2.62 to 21.08 kilometers among all the bears and averaged from 5.38 to 9.29 kilometers for individual bears. These values are less than the actual movements since bears obviously did not move in a straight line from one location to another.

The greatest distance between any two locations during a 24-hour period (EDL) was generally one-third to one-half the estimated home range length; this indicates bears utilize only a portion of their home area during a particular day. There appeared to be a direct relationship between home range size and daily movements. Bear R26, an adult male, had the largest home range and the longest diel movements. As reported earlier, adult females and sub-adult males had approximately equal sized home ranges and their diel movements were also similar.

The total distance bears moved during a 24-hour period was largely dependent upon how frequently bears were located. The most complete data were collected from bears R53, R56, and R26 (Appendix F). During three different diel periods when R53 (adult female) was located 17, 16, and 15 times, she moved a minimum of 10.74, 7.98,

TABLE 5. Minimum distance that radiotracked bears moved during a 24-hour period in the GSMNP during 1972-73

Bear	Sex	Age	Population Parameters ^a			
			EDL (km)	MTDD (km)	Avg. EDL (km)	Avg. MTDD ^b (km)
W30	M	2.5	1.81	3.46	1.96	8.73
			2.10	8.73		
R56	M	2.5	2.26	21.08	2.13	21.08
			2.00	4.43		
		Subavg. =	<u>2.04</u>	<u>9.43</u>	<u>2.05</u>	<u>14.91</u>
R53	F	4.5	1.39	10.74		
			2.16	11.90		
			1.81	10.88		
			1.35	2.92		
			2.16	7.98		
			0.77	2.62		
			3.10	15.75		
Y52	F	4.5	3.23	8.20	2.65	-
			2.48	7.29		
			2.39	6.52		
			2.48	6.19		
		Subavg. =	<u>2.12</u>	<u>8.27</u>	<u>2.24</u>	<u>11.49</u>
R26	M	6.5	2.16	13.09	3.82	12.73
			5.81	14.07		
			3.48	12.36		
		Subavg. =	<u>3.82</u>	<u>13.17</u>		

^aSee methods for description of population parameters.

^bOnly included 24-hour readings with 10 or more readings.

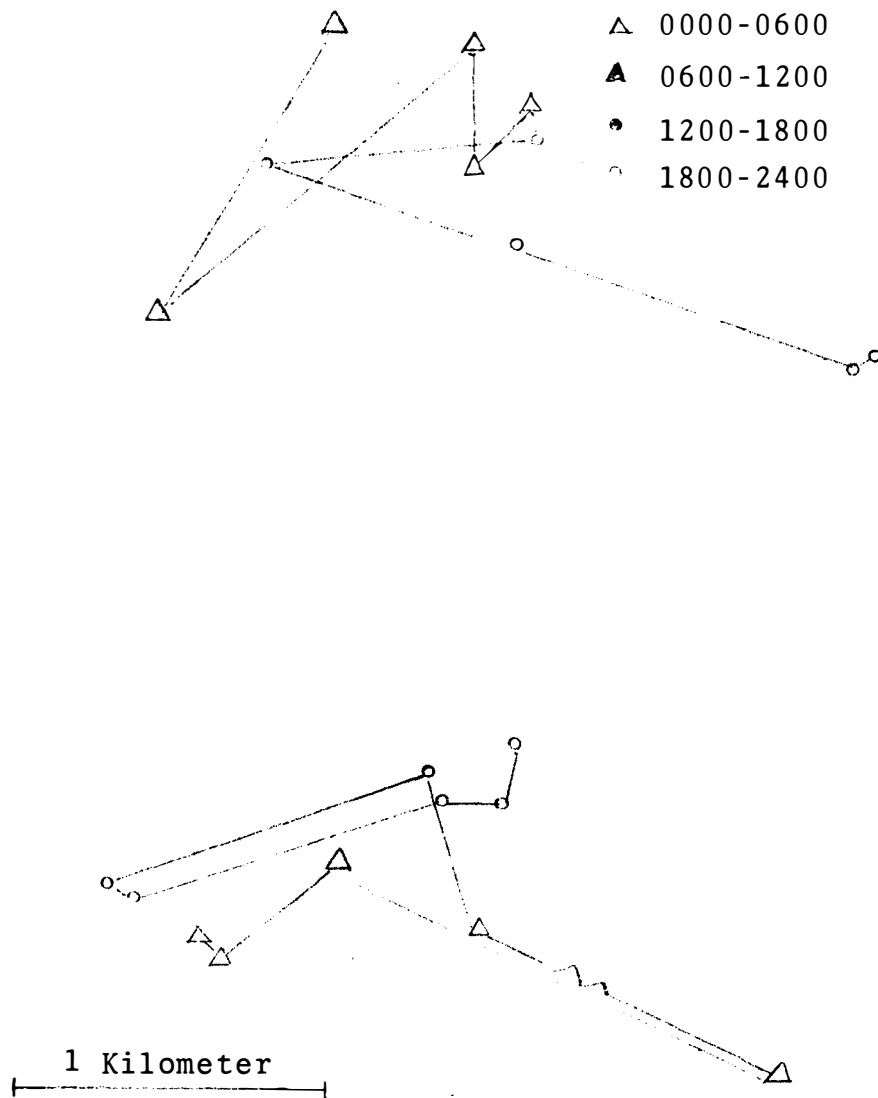


Figure 19. Diel movements of bear W30, a 2.5 year old male, in the GSMNP during 1972.

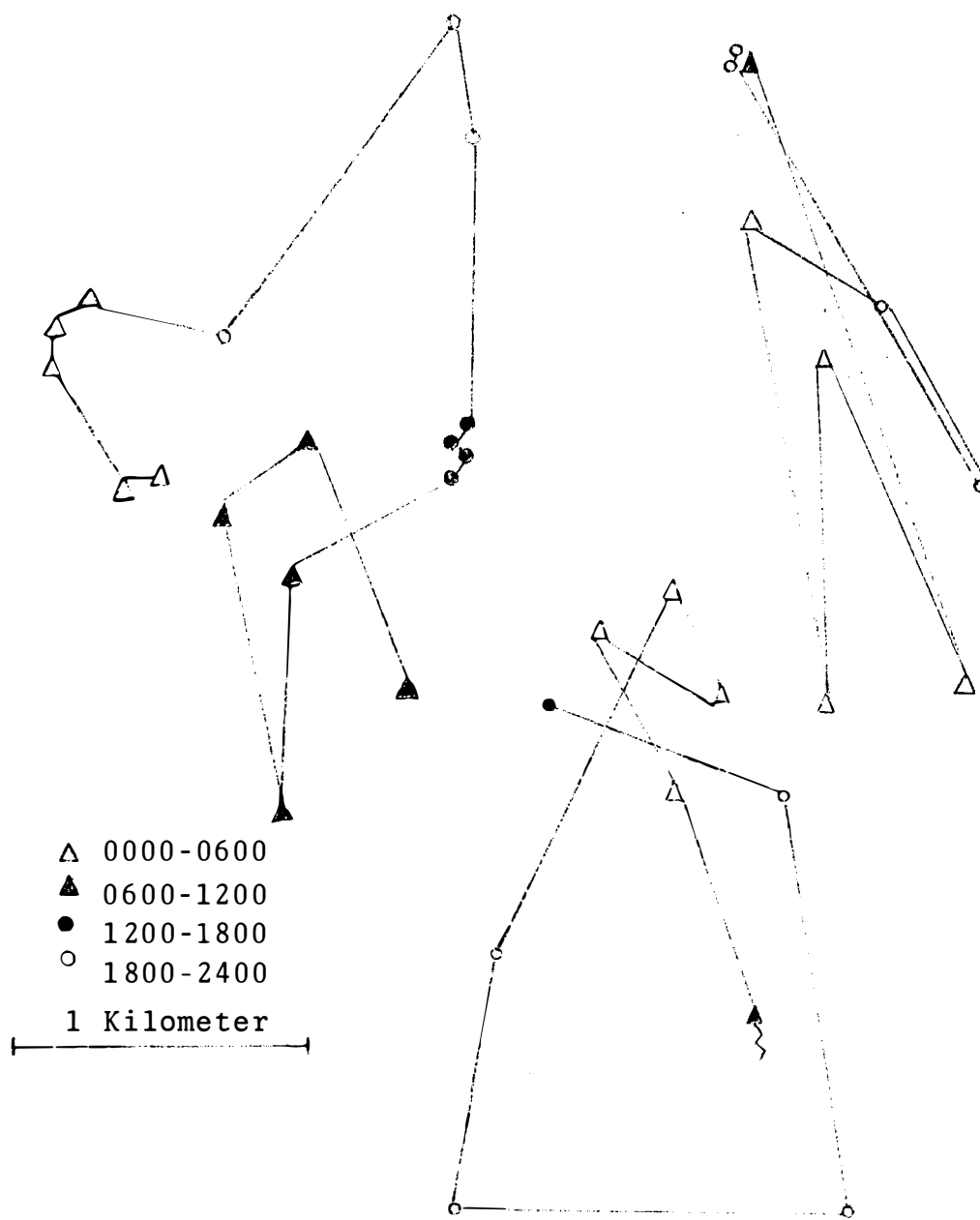


Figure 20. Diel movements of bear R53, an 8.5 year old female, in the GSMNP during 1973.

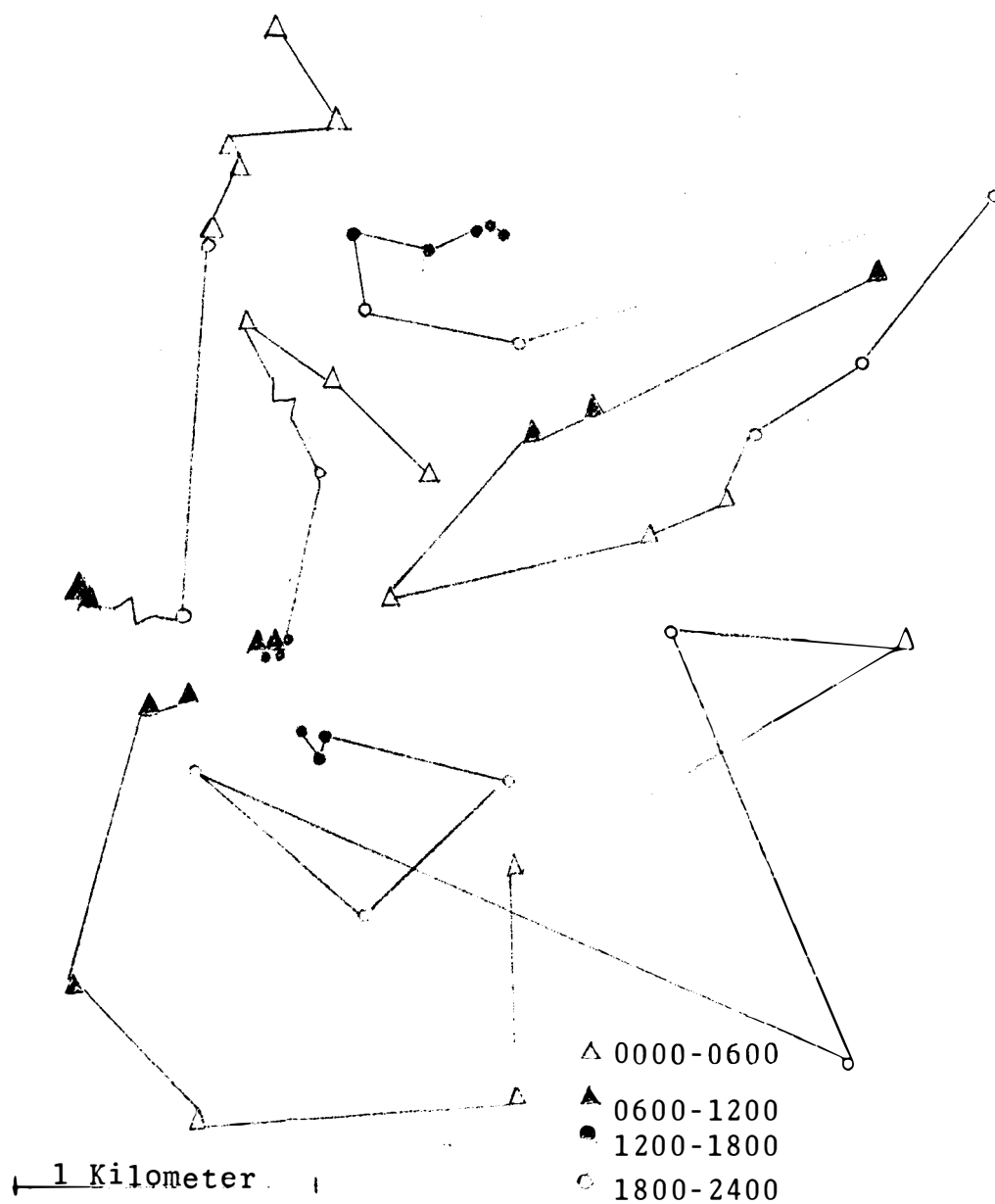


Figure 21. Diel movements of bear R53, an 8.5 year old female, in the GSMNP during 1973.

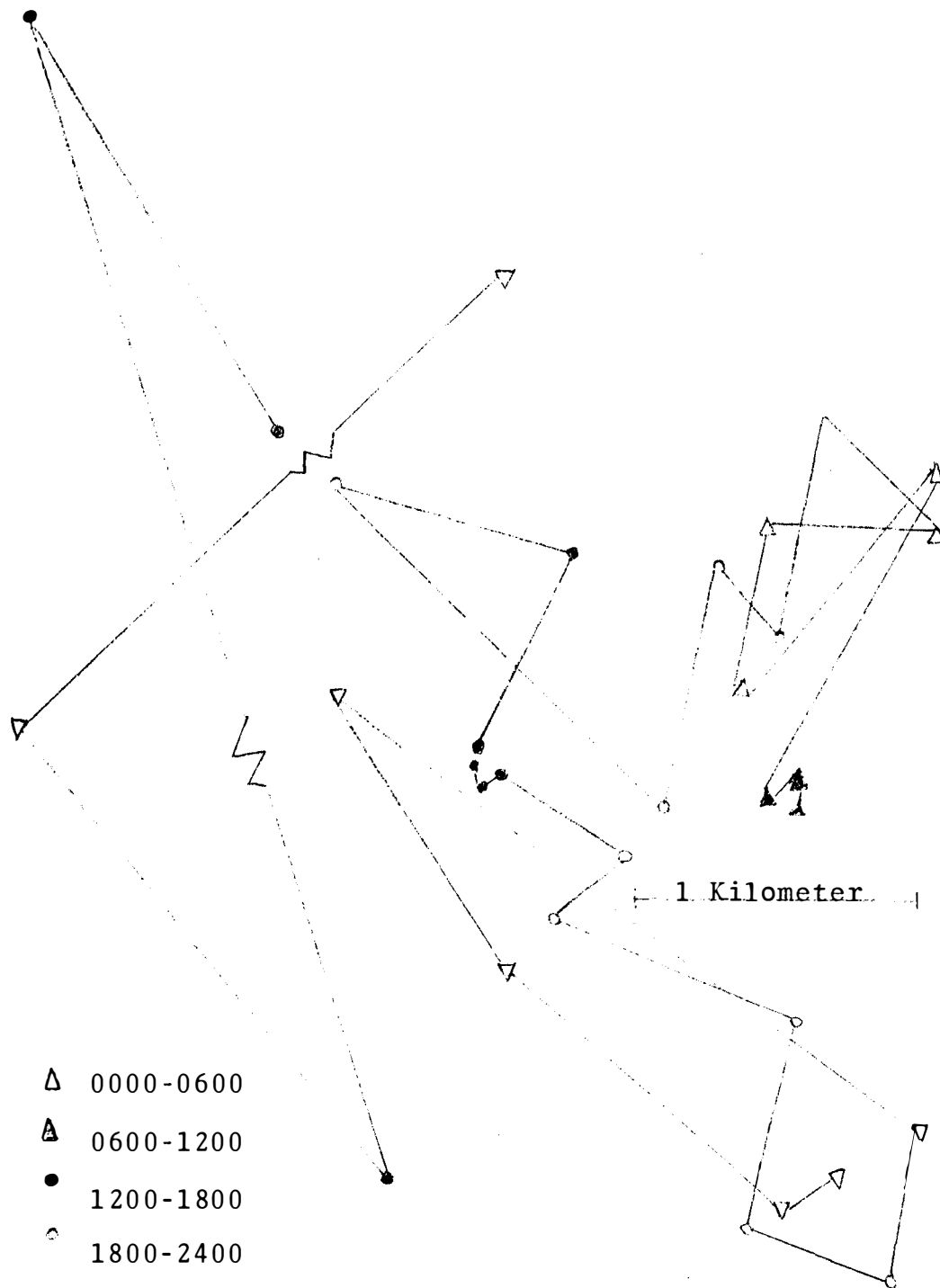


Figure 22. Diel movements of bear R26, a 6.5 year old male, in the GSMNP during 1973.

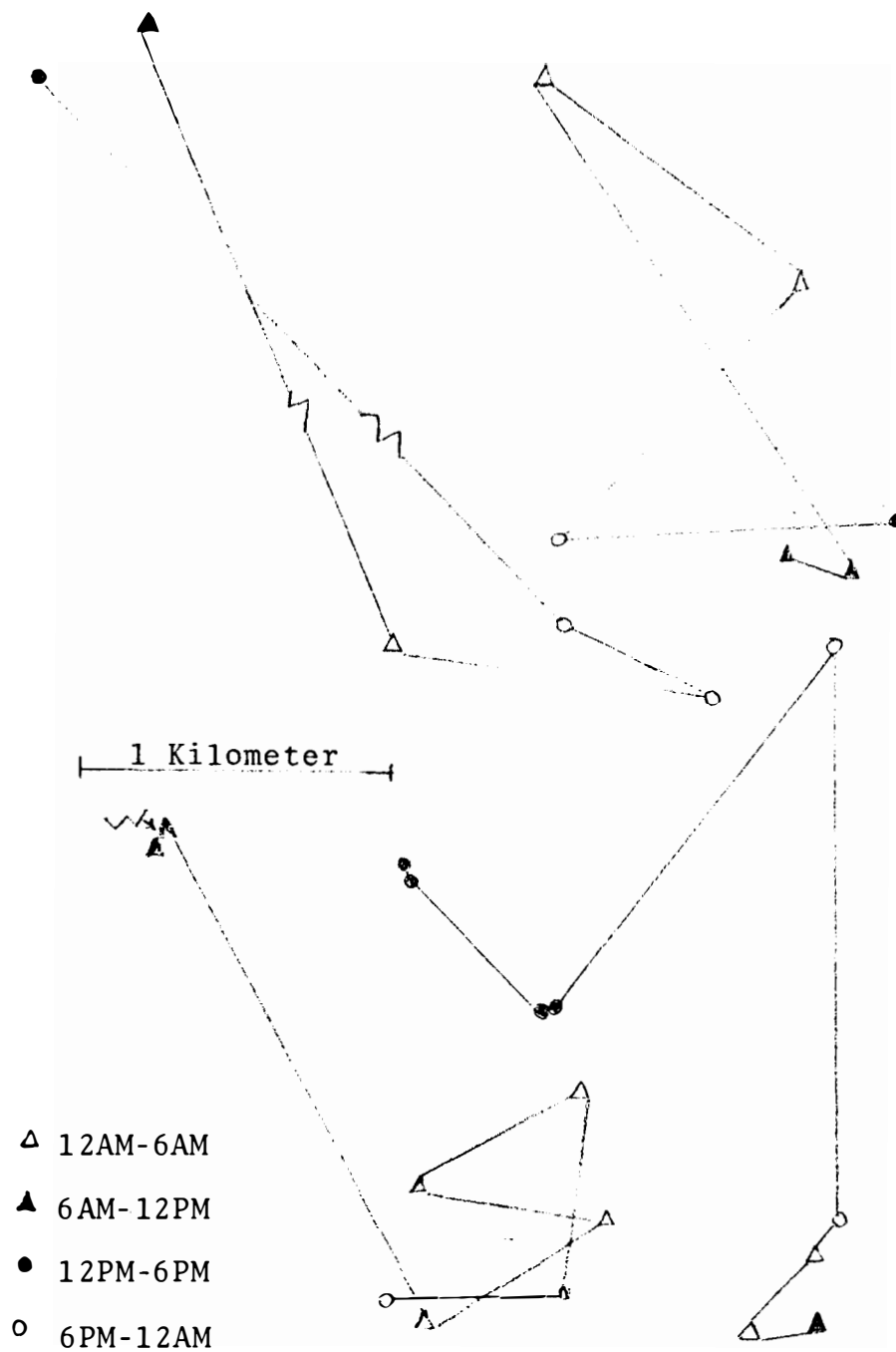


Figure 23. Diel movements of bear Y52, a 4.5 year old female, in the GSMNP during 1973.

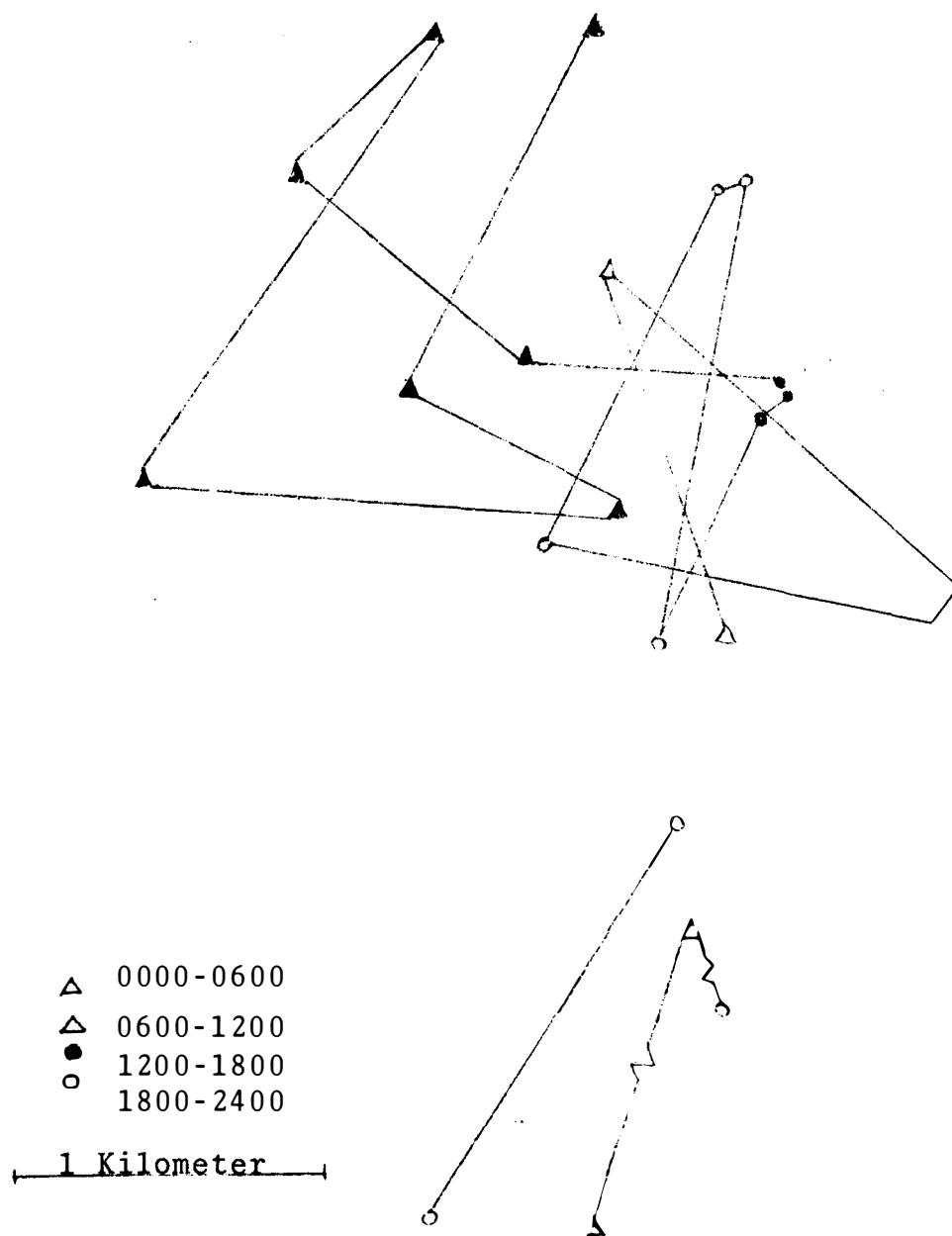


Figure 24. Diel movements of bear R56, a 2.5 year old male, in the GSMNP during 1973.

and 15.75 kilometers, respectively. Bear R26, an adult male, was located 14 times and covered a minimum distance of 13.09 kilometers during a 24-hour period. The longest recorded diel movement was made by R56 (subadult male); 18 locations revealed he moved a minimum distance of 21.08 kilometers. It should be stressed that these estimates of diel movements are cursory since a slight error in radiotracking readings affects their accuracy.

The belief that bears are generally nocturnal animals was partially substantiated during this study. Average movements of bears during various times of a 24-hour period are shown in Table 6 and Figure 25. While bears were frequently found active during any part of the day or night, the most active period was from 1800 to 2400 hours. The least active period was during the afternoon (1200 to 1800 hours). It is interesting to note that from 0 to 600 hours, bears appeared to be relatively inactive. While bears may be less active during this time of day, it could also be related to the method of recording activity. By using radiolocations, bear activity was measured only by movement. However, bears were observed several times spending much time browsing in one small berry patch or in one mast-producing tree. This type of activity would not be detected by using linear movement as an index to activity. Bears might have a general pattern of making crepuscular

TABLE 6. Minimum average distances radiotracked bears moved during 24-hour periods in the GSMNP

Bear	Sex	Age	Kilometers ^b			
			0-600	601-1200	1201-1800	1801-2400
W30	M	2.5	0.40	1.63	0.13	1.29
			0.98	0.32	0.99	1.09
R53	F	4.5	0.40	1.05	0.28	1.19
			1.50	2.87	0	1.52
			0.96	1.10	1.52	a
			0.23	0	1.35	a
			0.63	0.89	0.08	1.13
			0.62	0	0	0.76
			1.36	0.76	0.35	1.74
R26	M	6.5	1.00	0.68	1.06	2.40
			a	3.16	3.64	a
			1.94	1.03	0.13	0.87
Y52	F	4.5	1.42	2.84	a	0.71
			1.82	0.35	a	1.48
			1.43	0	a	0.81
R56	M	2.5	1.30	1.55	0.84	1.58
			0.97	a	0.40	2.00
			<u>0.32</u>	<u>0.32</u>	<u>0.41</u>	<u>2.21</u>
			Avg.		0.83	1.09

^aInadequate data.

^bDistances were calculated from locations made every one to three hours.

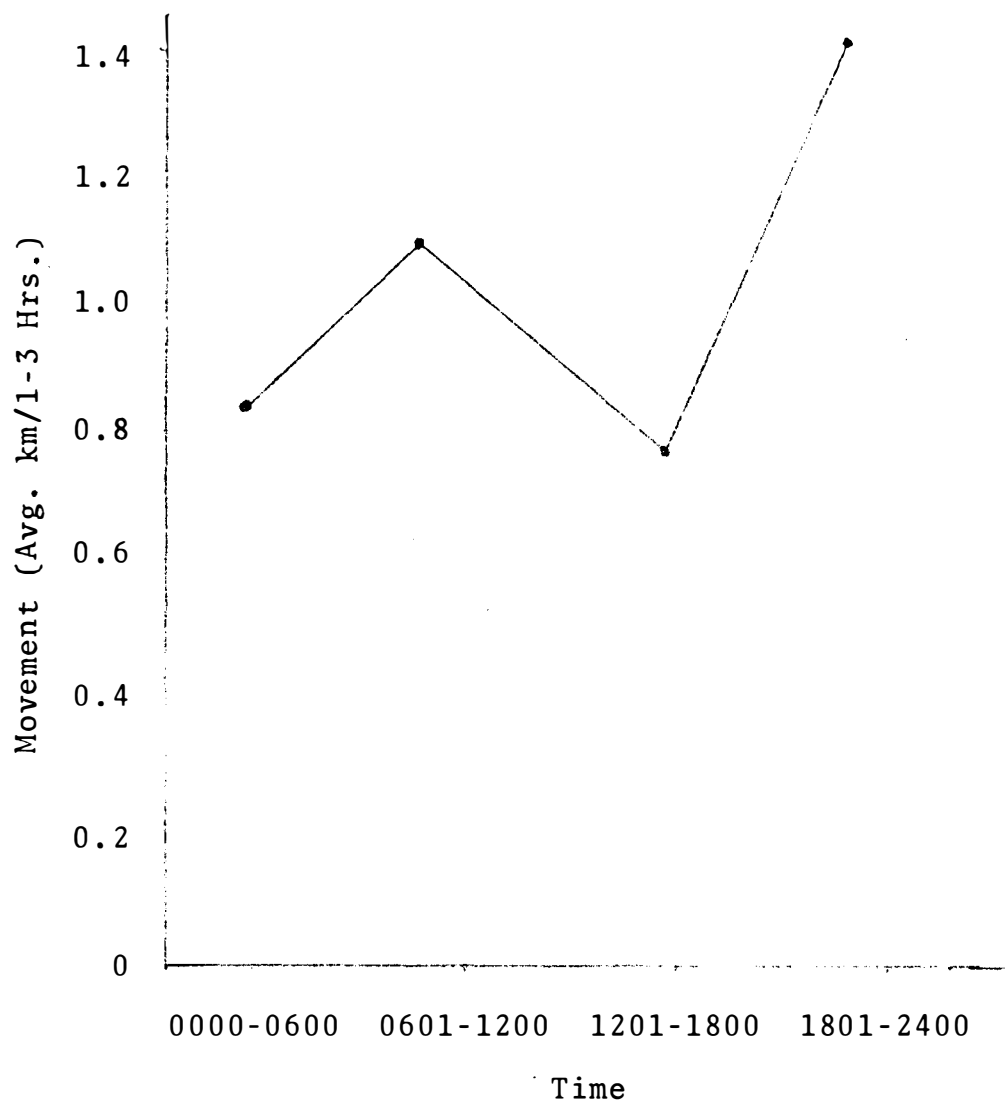


Figure 25. Average diel movements of radiotracked bears in relation to various time periods of the day.

movements to and from favored feeding grounds and spend early morning hours in these feeding grounds.

The normally secretive and solitary habits of black bears, accompanied with their normally associated forested habitat have kept sightings to a minimum in many areas. This undoubtedly has lent support to the hypothesis that bears are nocturnal animals.

Other studies also indicate bears are active during all times of the day and night. Barnes and Bray (1967) found panhandler bears active at all times in Yellowstone National Park. In Washington, Poelker and Hartwell (1973) had 347 radio-locations of bears during the day. During these diurnal locations bears appeared to be active over 90 percent of the time.

Periods used for resting by bears are difficult to measure by using telemetry. The thick vegetation limits visual observations in the GSMNP to very short distances. However, bears appeared to be least active in the afternoon (1200 to 1800 hours) which is likely the peak resting period. Several beds have been located in the GSMNP. These beds are evidently day beds and may be used extensively during the period 1200 to 1800 hours.

No particular pattern of movement over a 24-hour period could be detected from the data collected. Some diel movements were circuitous while others ended far from

the original starting point. Some diel movements were linear in shape while others were a network of crisscrosses.

Forest Type Preference

As was previously mentioned in the description of the study area, there are six basic forest types in the GSMNP (Shanks, 1954b). The spruce-fir forest is not found in the southwest end of the Park and, thus, is not found in the focal point of the radiotracking study. The other five forest types are present within the study area although closed oak, cove hardwood, and northern hardwood make up over 85 percent of the cover type (Figure 2, page 12). Timber harvest during 1900-1935 and the decimation of the chestnut have created various stages of secondary seral growth although most of the forest is a minimum of 40 years old.

Although bears used all five habitat types, 82 percent of all back-country bear locations occurred in two of them. Fifty-six percent of all locations of back-country bears were in the closed oak forest and 26 percent in the cove hardwood forest. Other forest types were used less frequently (northern hardwood, 1 percent; open oak and pine, 7 percent; and hemlock, 2 percent; Table 7).

Back-country bears altered their use intensity of the different forest types between summer (June-August) and

TABLE 7. Number of bear locations during 1973-74 in the various forest types of the GSMNP

Bears	Season ^a	Habitat Type					
		Closed Oak	Cove Hardwood	Northern Hardwood	Open Oak and Pine	Hemlock	Other
Adult females							
R53	summer	19(43) ^b	15(34)	3(7)	2(5)	5(11)	0
	fall	38(58)	22(34)	2(3)	1(2)	2(3)	0
Y52	summer	23(52)	16(36)	0	2(5)	2(5)	1(2)
	fall	19(63)	9(30)	2(7)	0	0	0
Y70	summer	-	-	-	-	-	-
	fall	8(53)	5(33)	1(7)	1(7)	0	0
W52	summer	-	-	-	-	-	-
	fall	16(79)	2(13)	1(9)	0	0	0
Subadult males							
R56	summer	17(20)	3(9)	12(35)	0	0	0
	fall	18(75)	1(4)	4(17)	1(4)	0	0
R55	summer	2(25)	0	0	6(75)	0	0
	fall	10(63)	1(6)	0	5(31)	0	0
Y60	summer	3(50)	1(17)	0	2(33)	0	0
	fall	2(50)	2(50)	0	0	0	0
W67	summer	-	-	-	-	-	-
	fall	11(58)	2(11)	0	6(32)	0	0
Adult males							
R26	summer	10(29)	13(37)	9(26)	3(9)	0	0
	fall	36(69)	14(27)	1(2)	1(2)	0	0
Subtotal	summer	74(44)	48(25)	24(14)	15(9)	5(4)	1(0)
	fall	158(65)	58(23)	11(5)	15(6)	2(1)	0
Panhandler bears							
Y30 ^c	summer	0	3(7)	38(93)	0	0	0
	fall	5(22)	10(43)	8(35)	0	0	0
B50 ^c	summer	-	-	-	-	-	-
	fall	29(49)	5(8)	25(42)	0	0	0
W30 ^d	summer	3(5)	3(8)	31(84)	-	-	-
	fall	11(42)	8(31)	7(27)	-	-	-
Subtotal	summer	3(4)	6(8)	69(88)	0	0	0
	fall	45(42)	23(21)	40(37)	0	0	0

^aSummer-June to August 31; Fall-September 1 to denning.^bPercent.^cAdult female.^dSubadult male.

fall (September-denning). To quantify forest type preferences by bears, index values were derived. Index values were calculated by dividing the actual number of locations by the expected locations of each bear for the different forest types. Expected observations were calculated by multiplying the percent of each forest type found in the study area times the total locations of each bear (Table 8 and Figure 26).

Bears preferred the hemlock and closed oak forests (index values 1.67 and 1.25, respectively). However, the hemlock forest is not an important habitat for bears in the GSMNP since it included only 2 percent of the study area.

Shrubs in the closed oak forest include huckleberry (Gaylussacia ursina) and high bush blueberry (Vaccinium simulatum) that provide important food sources for bears during the summer (Beeman and Pelton, 1975). Also, there is a rich understory in some areas of the closed oak forest that provides herbaceous foods for bears during the spring and early summer.

The open oak and pine forest was utilized by bears during the summer in the same proportion as present in the study area. This forest type is usually found on the more xeric sites. Four species of blueberries plus serviceberry (Amelanchier laevis) are common and are important fruit-bearing foods for bears.

TABLE 8. A summary of habitat preference of bears (includes only radiotracked back-country bears) by comparing the actual and expected locations in the different forest types of the GSMNP, 1972-73

Forest Type	Percent of Area	Season					
		Summer (June-Aug. 31)			Fall (Sept. 1-Denning)		
		Observations		Index ^a Value	Observations		Index Value
		Actual	Expected ^b		Actual	Expected	
Closed Oak	35.2	74	59	1.25	158	76	2.07
Cove Hardwood	31.6	48	53	0.91	58	68	.85
Northern Hardwood	21.7	24	36	0.67	11	47	.23
Open Oak and Pine	8.7	15	15	1.00	15	19	.79
Hemlock	2.0	5	3	1.67	2	4	.50
Other	1.5	1	3	0.33	0	3	0.00

^aIndex Value = $\frac{\text{Actual Observations}}{\text{Expected Observations}}$

^bExpected Observations = Percent of forest type in study area x total observations.

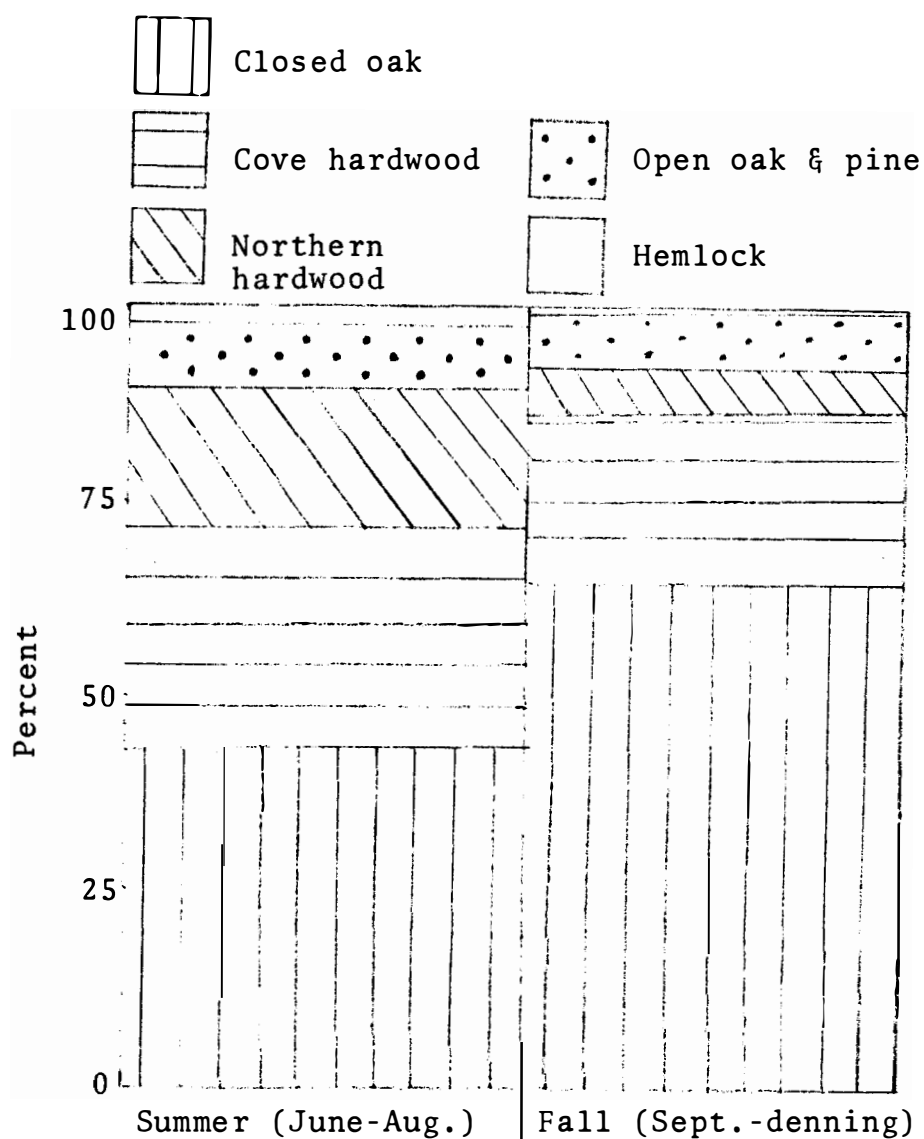


Figure 26. Forest types in which bears were radio-tracked in the GSMNP. The data are based on 411 radio-tracking locations and include only back-country bears (excludes panhandler bears), 1972-73.

Northern hardwood and cove hardwood forests were least preferred by bears during the summer. These two forest types do not support numerous fruit-bearing plants that bears feed on.

During the fall the closed oak forest was heavily utilized by bears and appeared to be the only preferred habitat type. The overstory is dominated by oaks, the major source of food in the fall for bears in the GSMNP (Beeman and Pelton, 1975).

Movements of panhandler bears in the various forest types are shown in Table 7, page 92. These three bears were generally located in the northern hardwood forest in the summer. This was attributed more to their panhandler behavior rather than habitat preference (Spence Field is surrounded by the northern hardwood forest). There was a shift in the fall when the closed oak and cove hardwood forests were utilized more.

There were no abrupt altitudinal shifts between summer and fall (Figure 27). Since the topography and habitat are so diverse, seasonal habitat shifts do not require large altitudinal shifts. The elevation range was more narrow in the fall than during the summer for seven of the ten bears in which movements for both seasons were recorded. This could be explained by bears limiting their movements to areas in the closed oak forest where mast is

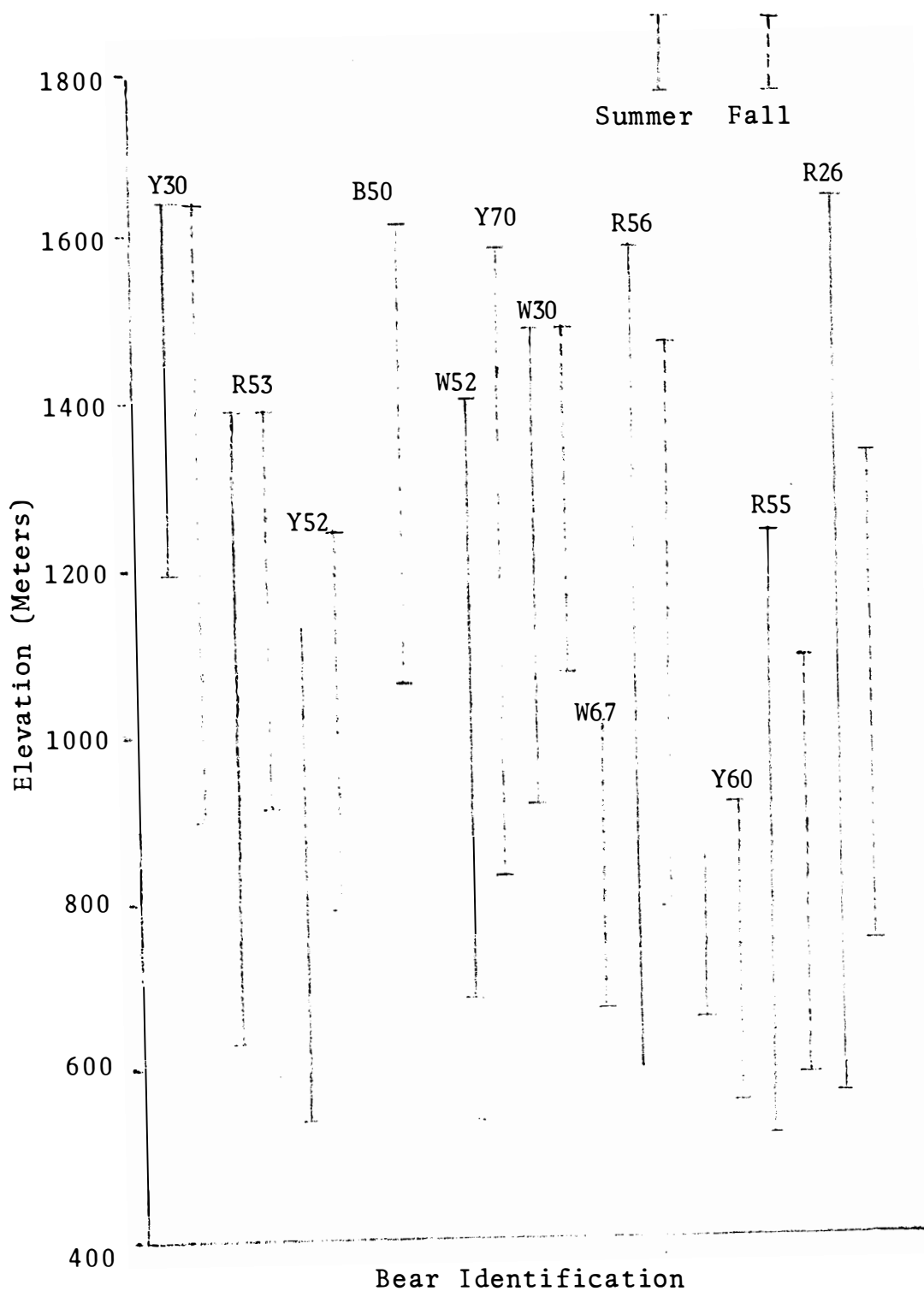


Figure 27. Summer (June 1-Aug. 31) and fall (Sept. 1-denning) elevation extremes within the home range movements of bears radiotracked in the GSMNP, 1972-73.

available. However, this is conjectural with no conclusive evidence available.

While black bears appear to usually limit themselves to a well-defined home range area, there are several documented cases of bears making long movements out of their home range. These movements of bears are in the fall and appear to be related to natural food failures. Schröger (1949) reported periodic mass movements of bears every three to seven years in Wisconsin. Harlow (1961) suggested that bears in eastern North America leave areas where acorns are scarce and move into areas where acorns are plentiful. Drahos (1951) mentions cases where apparently large numbers of bears made long excursions during years of food scarcity. In the GSMNP similar incidents of this fall shuffle have been noted. The last seven years have had two fall mast failures. During 1968, 25 bears (a four-fold increase over the annual mean bear kill) were reported killed from Tennessee counties adjacent to the Park (Richard Conley, personal communications). Bears killed in these counties were originally from the Park since the surrounding counties do not support resident bear populations. The next year of poor mast production occurred in 1972. There was no bear season, and, hence no legal kills reported from the Tennessee counties. However, in Tennessee counties adjacent to the Park, 40 bears were trapped or found dead by the Tennessee

Wildlife Resources Agency (Richard Conley, personal communications) during the fall. Normally, less than five bears are found outside the Park in these counties. Additionally, it was in the fall when three of the bears being radiotracked temporarily vacated their summer home ranges. The increased growth rate of bears during the fall indicates that large quantities of foods are eaten and/or the assimilation of fall foods is high for bears. Therefore, as noted in the GSMNP and reported by other authors, bears apparently do not hesitate to extend fall movements beyond their summer home range in search of food.

During this fall shuffle by bears in the GSMNP, various mortality factors are encountered outside the Park. Since mast failures are periodical, large numbers of bears leaving the Park are likely to be periodical. This suggests that any population regulation of bears by this method comes in waves; large numbers killed in years of mast scarcity and few bears killed in years when natural fall foods are plentiful. The frequency of this phenomenon has probably increased since the decimation of the chestnut. Of the replacement trees, 47 percent produce fruits eaten by bears (Beeman and Pelton, 1975) according to Woods and Shanks (1957) and 74.4 percent according to Keever (1953). Even where the oaks and hickories replaced chestnut

stands, this change cannot be considered compensatory. Unlike the chestnut, oaks are inconsistent mast producers from year to year. Reid and Goodrum (1957) state no definite periodicity in the production of acorns. Baker (1950:192) found that a good acorn crop about once every three years can be expected. Strickland (1972) attributed spring weather conditions as the major environmental factor determining mast production in the Southern Appalachians.

Agonistic Behavior

Closely associated with animal movements and activities is the social behavior between conspecifics. Several aspects of social behavior were both directly observed and implicated from analysis of data from radiotracking.

During the course of the study, bears were occasionally observed in close proximity to each other at campgrounds and trail shelters. In 1972 there were four bears frequently present at Spence Field (Appendix G); two adult females, one yearling female, and one 2.5 year old male. The two adult females were occasionally present at the same time but appeared to mutually avoid close contact. They were never known to come closer than 100 meters of each other. The adult females appeared to tolerate the yearling female at close distances at Spence

field. Observations were made with the adult females within 20 meters of the yearling female. The subadult male was never observed closer than 50 meters from any bear. Similar observations were made at Cades Cove campground. As many as four bears were observed in the campground at one time. These bears moved around the campground from one garbage can to another but always maintained at least a minimum distance (approximately 50 meters) from other bears. These data are not conclusive but do illustrate bears will tolerate conspecifics at relatively close distances in certain areas of food concentration. However, there appear to be individual distances maintained by bears and direct confrontations are avoided.

Similar results have been reported in Montana. Jonkel and Cowan (1971) noted 11 different bears congregated in one small area but maintained a mutual avoidance distance of approximately 50 meters.

Drahos (1951) and Pruitt (1974) concluded that bears communicate by means of facial, body, and occasionally vocal expressions. All field observations of agonistic behavior were directed toward man and have been well defined by Jonkel and Cowan (1971). Basically, they include a sudden lunge combined with a loud "whoof" or air forcefully exhaled out the nose and mouth. This may come suddenly or

be preceded by a low moan and chopping of the teeth. A second type of agonistic behavior was noted on at least three occasions in which the bear suddenly charged in a full gallop toward a person. The threat is ended by the bear suddenly stopping in front of the threatened person and veering off to one side. As previously mentioned, these acts of aggression were directed toward humans. Likely, these behaviors are the same toward other bears and simply redirected toward humans.

Since recent studies on black bear behavior (Bacon, 1973; Pruitt, 1974; and Robert Jordan, personal communications) demonstrate that behavior is more highly developed than earlier believed, bears have likely ritualized threat behavior to a point where actual physical confrontations between bears are relatively uncommon.

Spatial Relationships and Territoriality

The home ranges and spatial relationships of bears Y30 and B50 are illustrated in Figure 28. As was discussed earlier, both of these adult females were frequently located at Spence Field. In addition, these bears had overlapping home ranges that approximately paralleled areas along the Appalachian Trail. Excluding Spence Field, areas used by both bears appeared to be used at different times by each

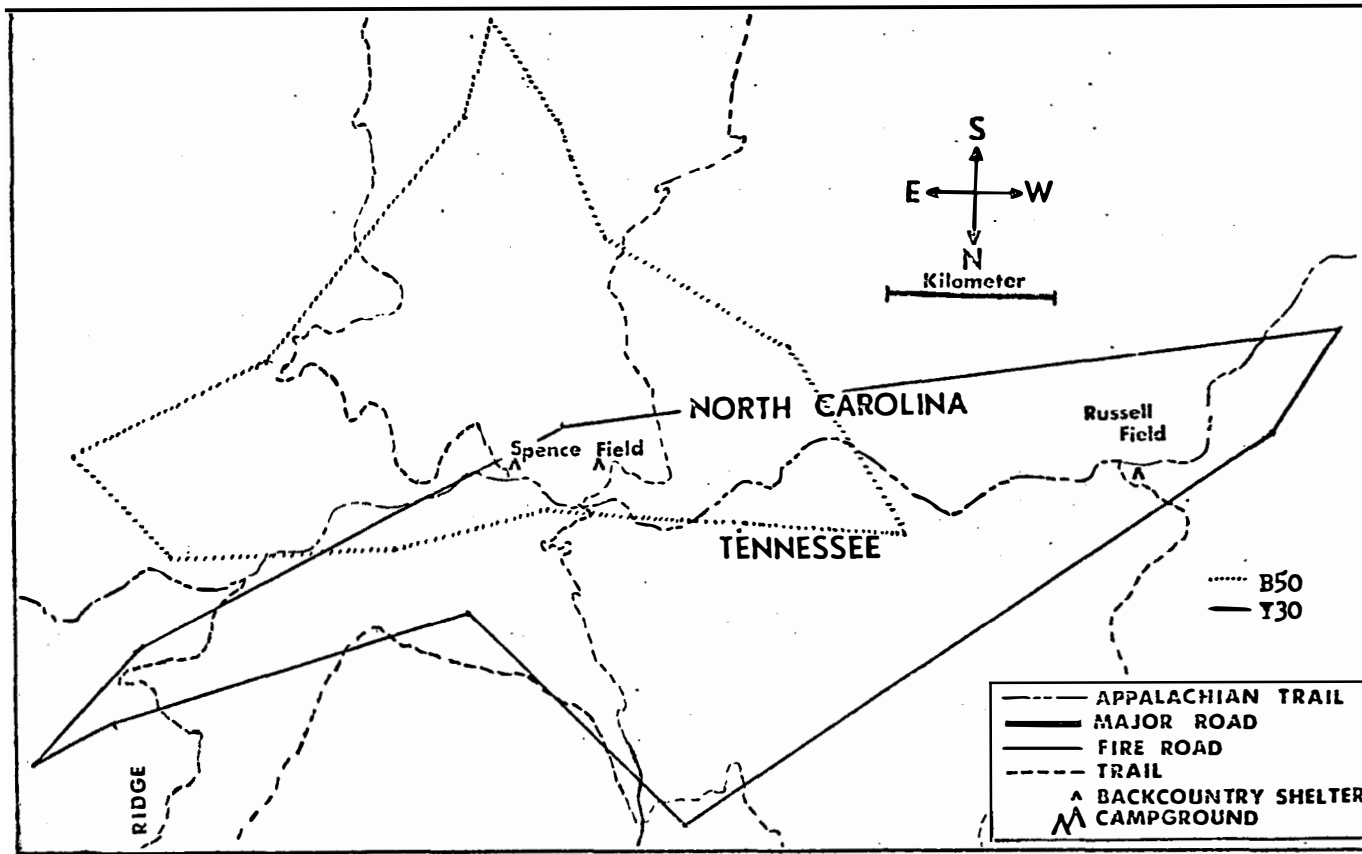


Figure 28. The home range spatial relationship of two adult females (Y30 and B50) radiotracked in the GSMNP during 1972.

bear (Figure 29). These radiotracking data indicate bears B50 and Y30 did not come into close contact away from Spence Field.

During the summer of 1974 three adult females (R53, Y52 and W52) were captured within 5 kilometers along Bote Mountain Road. The radio locations of these bears demonstrate some overlapping of R53's and Y52's home range but a large percentage of their ranges were used exclusively by only one female (Figure 30). During the fall two additional females (B50 and Y70) apparently moved into the Bote Mountain area and were trapped and radiotracked. When all five of these ranges are plotted (Figure 31), there appears to be extensive overlapping of movements and only small areas used exclusively by one bear. However, the two bears trapped in the fall appeared to be only temporary residents and were thought to have moved out in October.

During the summer, females R53 and Y52 were not usually simultaneously found in areas of home range overlap (Figure 32). The two exceptions were bears R53 and Y52 which twice were estimated to be within 0.3 kilometers of each other. However, during the fall this mutual avoidance appeared to be altered. Bears were occasionally found within 0.5 kilometers of each other.

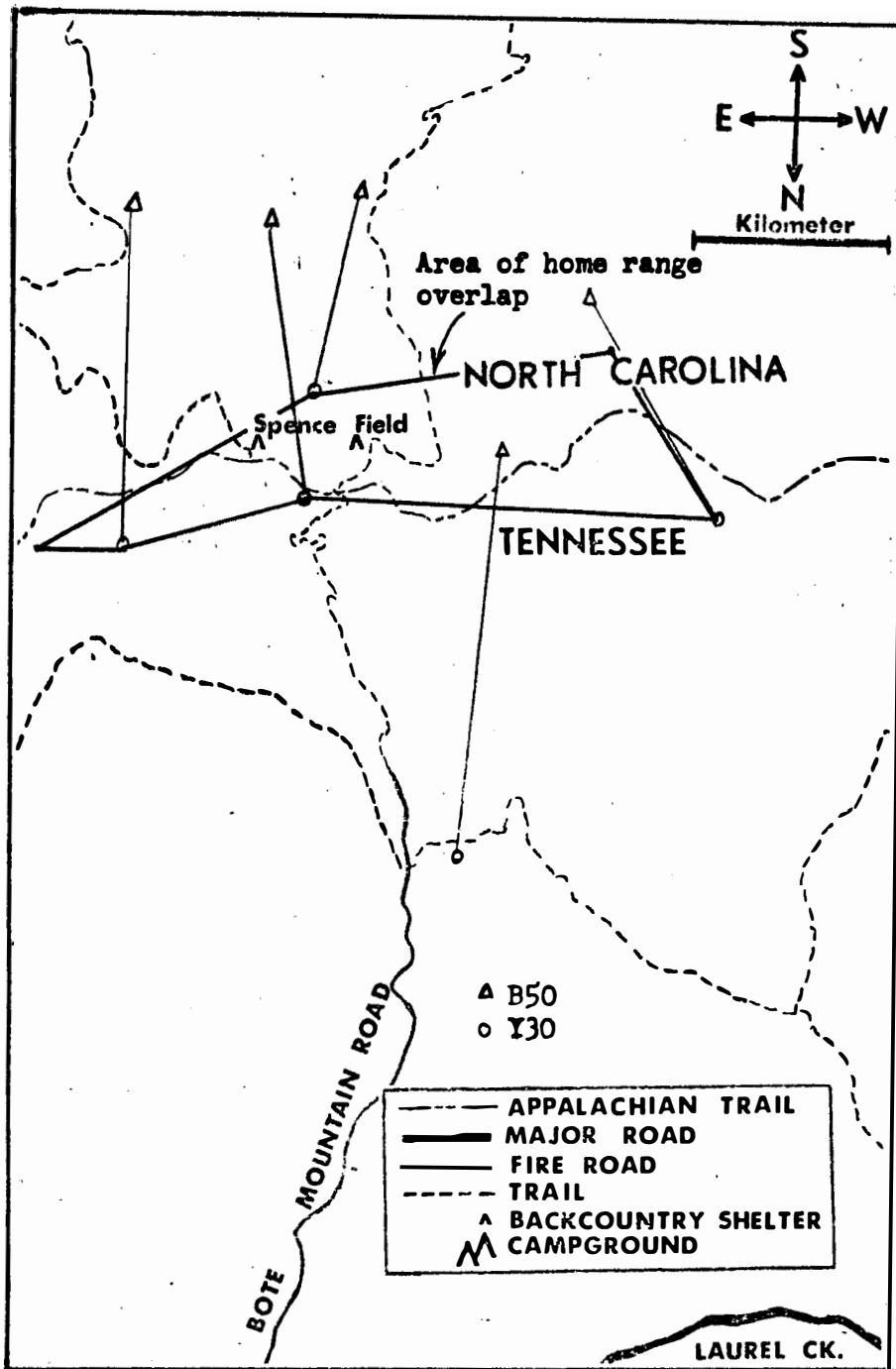


Figure 29. Simultaneous locations of two adult females (Y30 and B50) in the area of home range overlap in the GSMNP during 1972.

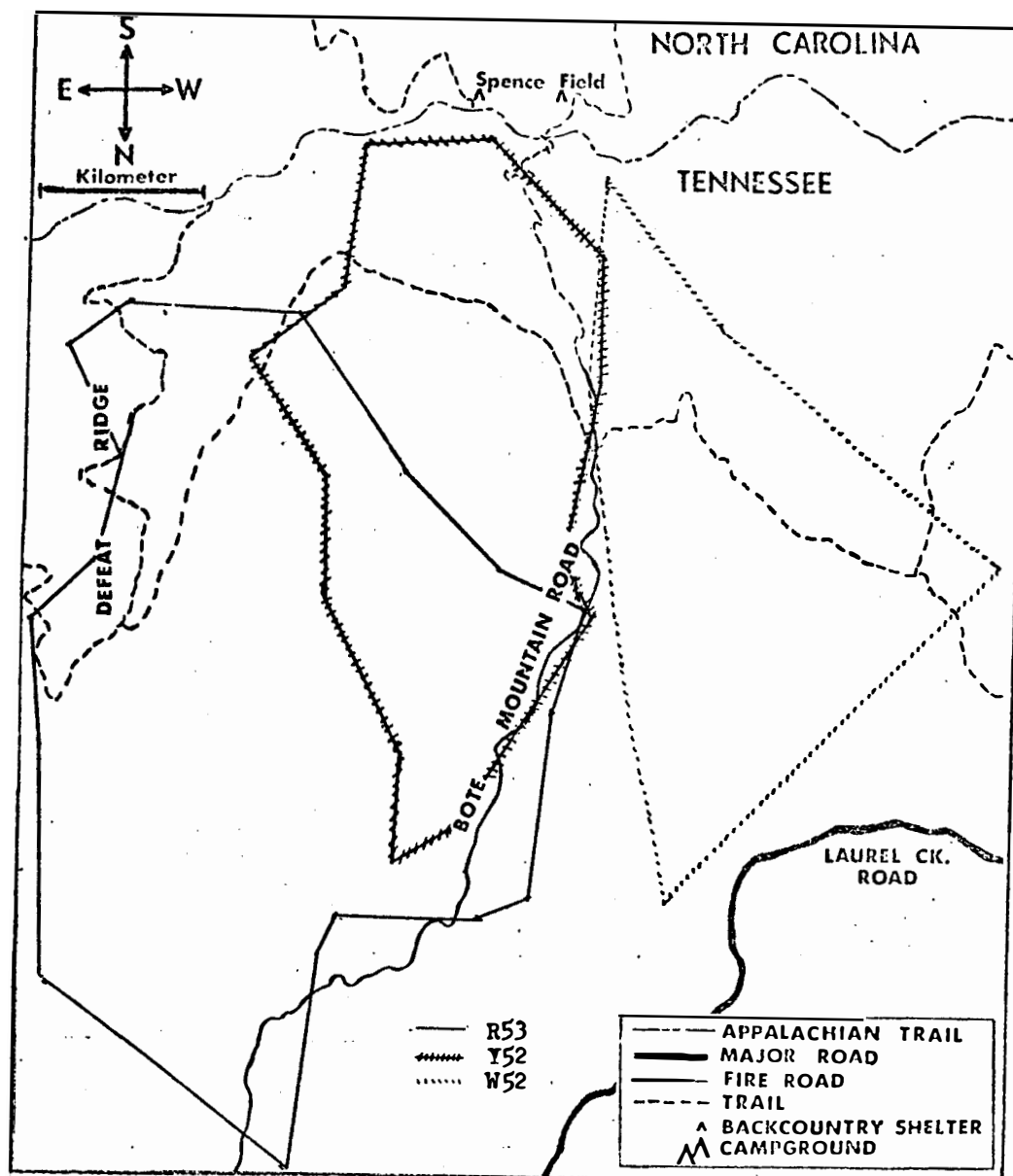


Figure 30. The home range spatial arrangement of three adult females (R53, Y52, and W52) radiotracked in the GSMNP during 1973.

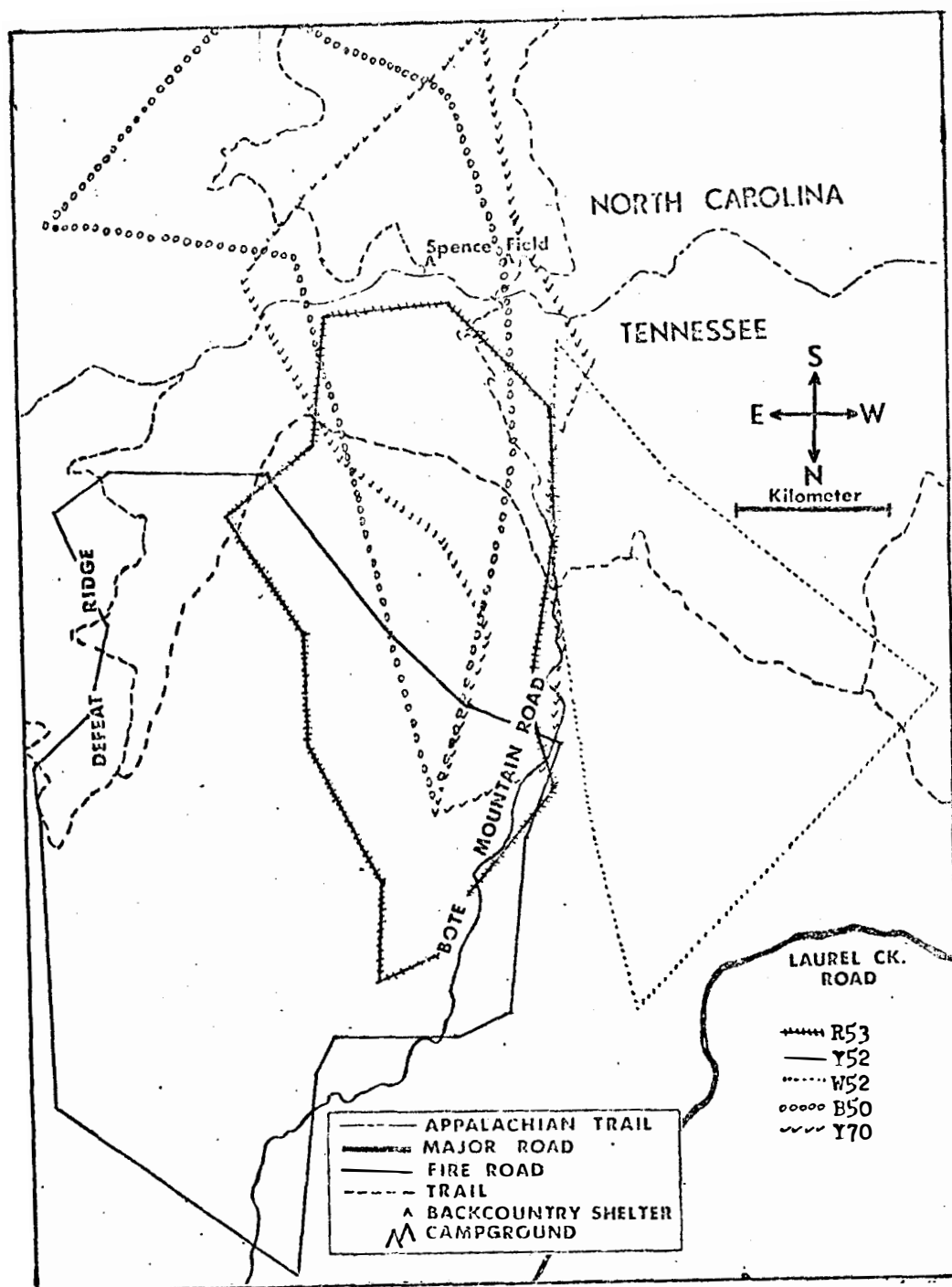


Figure 31. The home range spatial arrangement of five adult females (R53, Y52, W52, B50, and Y70) radio-tracked in the GSMNP during the fall of 1973.

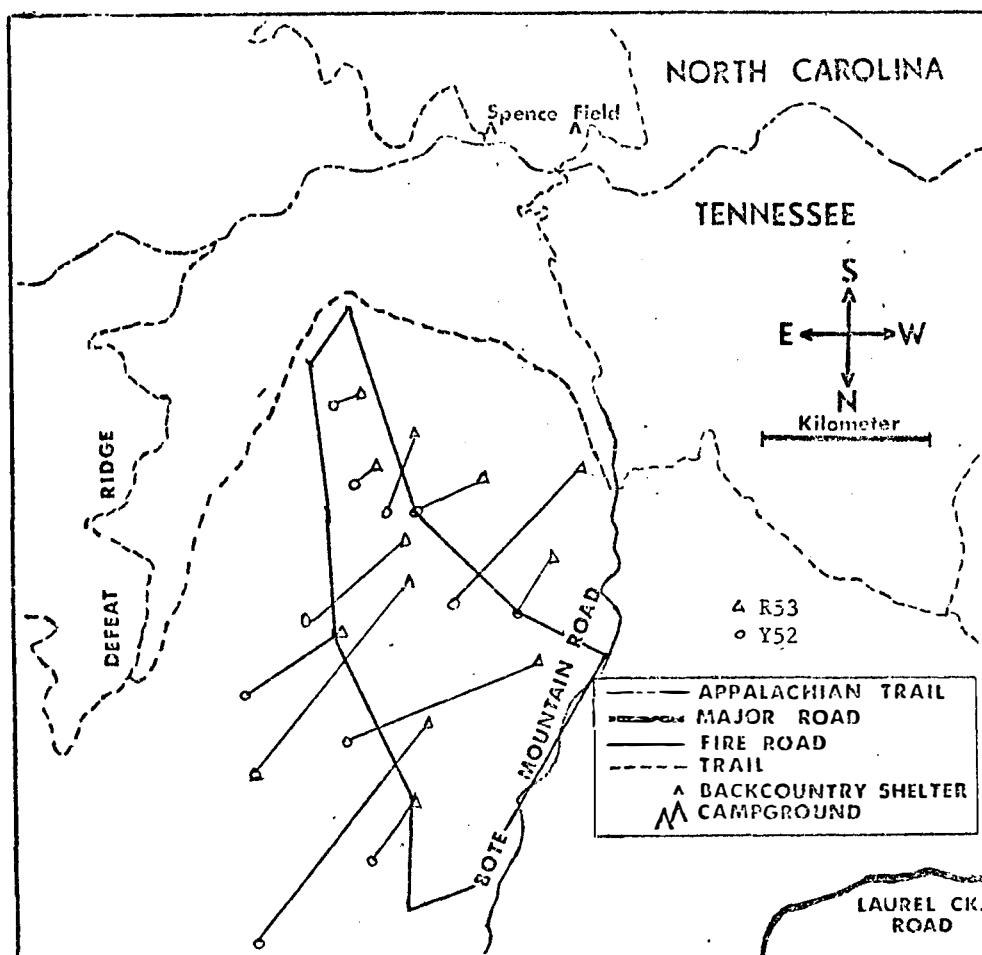


Figure 32. Simultaneous locations of two adult females (R53 and Y52) in the area of home range overlap in the GSMNP during 1973.

These observations are more evidence for the fall shuffle described earlier. Bears appear to concentrate where food is available during the fall. Home range boundaries take on less significance in the fall as bears readily cross the limits set forth during the summer.

In 1973, three subadult males (W67, R56, and Y60) were captured within 5 kilometers of each other along Bote Mountain Road. A fourth male (R55) was trapped at Cades Cove campground. As described earlier, two of these subadults appeared to be wandering extensively. This behavior complicates attempts to describe spatial arrangements of subadult males. However, the spatial relationship of the subadult males shows areas of overlap (Figure 33). Also, like the adult females, at least part of each bear's home range was exclusive to all other subadult males.

Only one adult male (R26) was successfully radio-tracked. Therefore, the spatial relationship of this bear with other adult males was not delineated.

The spatial arrangement of bears in the GSMNP is difficult to interpret without more detailed information. Adult males range wider than adult females and transgress the boundaries of several females. Adult females, on the other hand, limit their movements to smaller areas but still come in contact with bears in surrounding areas.

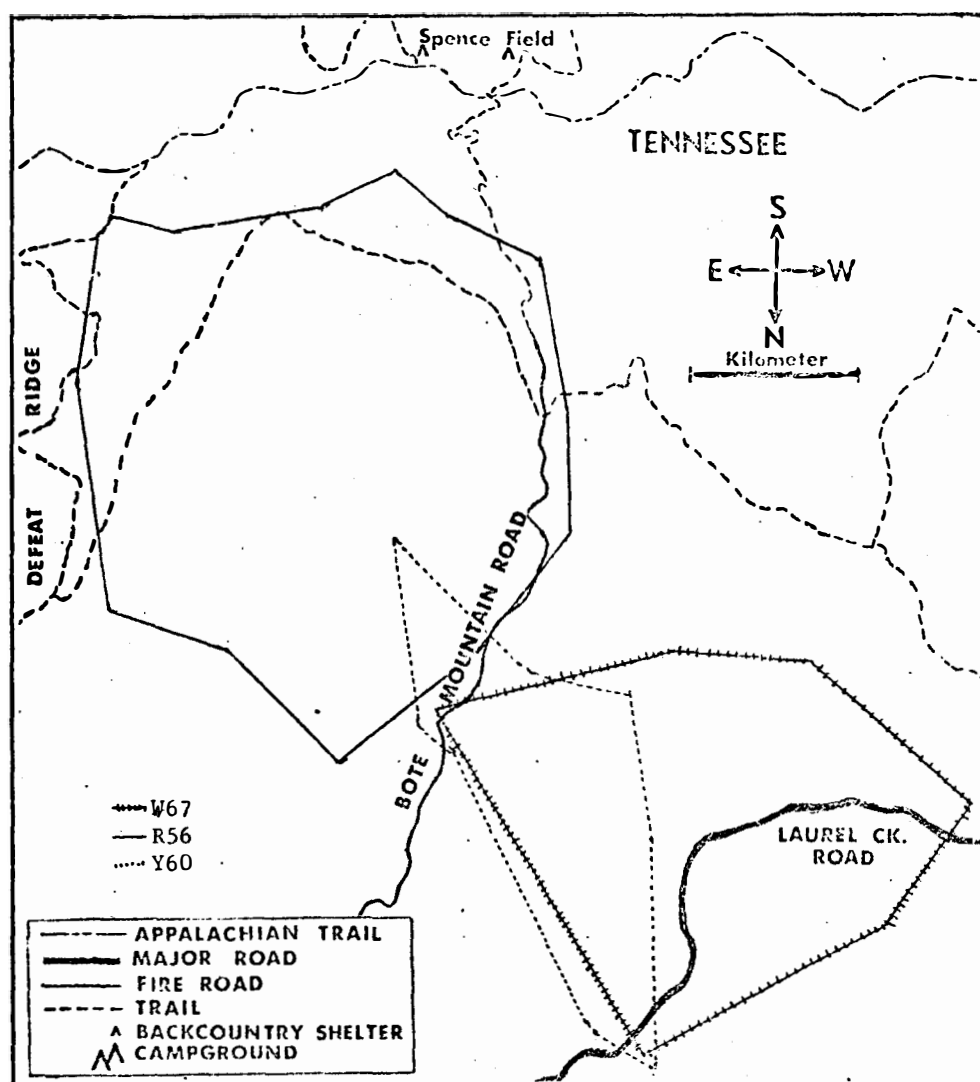


Figure 33. The home range spatial arrangement of three subadult males (W67, R56, and Y60) radiotracked in the GSMNP during 1973.

In the GSMNP, adult females do have considerable areas of home range overlap, giving an increase opportunity for social contact with other bears. There appeared to be areas within each home range that were used only by the holder of that home range during the summer. Home range boundaries appear to be less restrictive in the fall when bears are seeking fall food supplies.

Other studies have found that black bears have overlapping home ranges. Spencer (1955) concluded that in Maine there is a great deal of range overlap with very little conflict. Sauer et al. (1969) indicated from population estimates and range size that bears in New York must have overlapping home ranges. Jonkel and Cowan (1971) also found a great deal of home range overlap among adult males and females but only a small degree of overlapping among bears of the same sex.

The conclusions of this study based on the movements and bear behavior suggest that at least some form of territoriality exists. Generally, bears confine their movements to defined areas, but freely enter areas that are mutually visited by other bears. This serves the purpose of dispersing bears throughout the Park, but yet allows for neighboring bears to take advantage of an especially rich supply of seasonal foods outside their normal range of movements.

II. HOMING BEHAVIOR OF BLACK BEARS

The interactions between panhandler black bears and people create many problems in the GSMNP as well as other areas of North America. Personnel of the NPS have handled panhandler bears by moving them to various areas within the GSMNP, transporting them to state wildlife management areas in North Carolina and Tennessee or in some instances destroying chronically nuisance animals. Generally, bears have been destroyed only when other management procedures failed and the animal was judged as potentially dangerous to Park visitors.

Eliminating the causal factors creating conditions that alter the normally wary black bear into a panhandler animal is the most effective and economical method of reducing bear-people interactions. Since precautionary measures (see Bear Management by the National Park Service in Chapter II, page 22) have alleviated but not eliminated this problem, the NPS has moved bears that have become panhandler animals. This procedure presents problems. With the movement and homing capabilities of the black bear, it is questionable whether the GSMNP is large enough for this management practice. The limited road system within the Park hinders transplant of bears into the more remote areas (Figure 2, page 12).

Capturing panhandler bears and moving them into remote areas is time consuming and limited by the availability of Park personnel. Most of the area surrounding the Park has a high human population density, leaving no buffer zone between the Park and areas inhabited by people.

Since the study area was in the GSMNP where over 7,000,000 people visit annually, relocation of panhandler bears was under the direction of the NPS. This eliminated any experimental design and thus the interpretation is limited to reporting the results rather than testing various hypotheses.

From 1967 to 1974, 66 male and 10 female panhandler bears were captured and released a total of 155 times in the GSMNP (Appendix B). Bears that habitually entered campgrounds or roadsides were considered panhandler animals. A bear was considered to have successfully homed if it returned to within 8 kilometers of the original capture point. In every case except two (2 percent), bears that were known to home in this study returned to within 2 kilometers of the original capture point. Individual bears were identified by members of the research team, employees of the GSMNP, and reports of individually marked bears by Park visitors. For ease of reference, all bears less than 4.5 years old were grouped into a single classification of juveniles. Inexperienced bears

are defined as individuals trapped and transplanted to distant areas for the first time. Experienced individuals are bears trapped two or more times and transplanted. Time of homing was calculated from the date of release to the first time that a particular bear was observed or recaptured a minimum of 8 kilometers from its original capture point. This distance was selected since a bear would be within or, at least, very close to its original home range. The recorded time period is the minimum time of homing since bears could have returned without being trapped or observed until a later date.

Distance between two locations within the Park is given in air-kilometers and, therefore, due to the mountainous terrain is less than the actual minimum distance. Chi-square contingency tables, Fisher Exact Probability Test and Student's t-test were used to test for statistical significance. Probability levels of significance were set at $P < .10$ since tendencies rather than absolute differences between bears were being measured.

Comparison of Males and Females

From 1967 to 1974, 76 panhandler bears were captured and transplanted a total of 155 times. Individual bears were captured one to 13 times and transplanted an

average of 21.7 air-kilometers (range 5.8 to 64.8 kilometers). Males comprised 87 percent of the pan-handler bears and juveniles 20 percent. All females were adults and only one (10 percent) was recorded as having cubs (Tables 9 and 10).

The longest homing distance in the GSMNP was an adult male returning 64 kilometers. Of the three females that homed, 19 kilometers was the longest distance.

There was no statistically significant difference ($P = .22$) between the homing of inexperienced females (30 percent) and inexperienced males (50 percent). Difference between experienced males and females was not tested statistically due to the limited sample size of females.

Approximately 33 percent of the inexperienced juveniles ($n=15$) and 55 percent of the inexperienced adult males ($n=51$) homed. However, these differences were not significant ($P > .10$). As previously mentioned, none of the juveniles were cubs and only one bear was a yearling. Therefore, it would be more precise to state that no statistical difference was found between subadult (2.5 and 3.5 years old) and adult bears.

TABLE 9. Transplant of panhandler female bears
(adults) in the GSMNP, 1967-1974

Date	Bear Number	Displacement (km)	Comments
6/15/67	1	46.4	Never reobserved
7/16/67	2	16.0	Never reobserved
7/27/67	3	Not recorded	Given to North Carolina
8/11/67	4	Not recorded	Given to North Carolina
6/1/68	5	9.6	Homed in 15 days; recaptured 6/16/68
6/16/68	5	Not recorded	Given to North Carolina
7/2/68	6	7.2	Homed in 31 days; recaptured 8/2/68
8/2/68	6	7.2	Never reobserved
9/9/70	7	19.0	Homed the following spring; recapture 5/23/71
5/23/71	7	19.0	Reobserved and captured 8/30/71 at original capture point
8/30/71	7	19.0	Never reobserved
7/28/72	8	24.8	Never reobserved
8/11/72	9	58.0	Never reobserved
11/14/72	10	28.0	Never reobserved

TABLE 10. A summary of the transplants of panhandler male bears in the Great Smoky Mountains National Park from 1967 to 1974.

Bears Transplanted	<July 1 ^a				July 1-August 15				>August 15			
	<4.5 Years Old		>4.5 Years Old		<4.5 Years Old		>4.5 Years Old		<4.5 Years Old		>4.5 Years Old	
	Transplant ^b		Transplant		Transplant		Transplant		Transplant		Transplant	
	<30 km	≥30 km	<30 km	≥30 km	<30 km	≥30 km	<30 km	≥30 km	<30 km	≥30 km	<30 km	≥30 km
Homing												
Inexperienced	4	0	12	0	1	0	11	1	0	0	2	2
Experienced	0	0	16	1	0	0	10	3	0	0	24	3
Not Homing												
Inexperienced	3	1	13	2	3	1	2	1	2	0	3	2
Experienced	0	1	2	3	0	0	6	1	1	0	3	1

^aDate bears were displaced.

^bTransplants of bears from the capture point to the release area in aerial kilometers.

Distance Transplanted and Homing

Females that homed (n=3) were transplanted an average of 11.9 kilometers (range 7.2 to 19 kilometers) and the females not known to home (n=7) were transplanted an average of 34.6 kilometers (range 16 to 58 kilometers) (Table 9).

Approximately 54 percent (n=56) of the inexperienced male bears transplanted less than 30 kilometers homed. Thirty percent (n=10) of the inexperienced males transplanted greater than 30 kilometers homed (Table 10). The probability of distance transplanted causing a difference in homing success ($P = .08$) of males was statistically significant.

The total area in the GSMNP (2273 km²) is relatively small for successfully transplanting animals as mobile and wide-ranging as black bears. However, as described earlier, the Park has rugged topography typified by narrow valleys and steep slopes creating rapid elevation changes ranging from 275 to 2,025 meters. This rough topography combined with dense vegetation may hinder long movements of bears.

Seasonal Effects on Homing

Bears were captured and removed from early May until December with most of the transplants taking place from

June through August. Sixty-five percent of the 20 inexperienced bears transplanted in the summer (July 1 to August 15) homed while only 43 percent of the inexperienced male bears transplanted in the spring (before July 1) and fall (after August 15) homed. However, these differences were not significantly different ($P > .10$).

Experienced Versus Inexperienced Bears

There was a significant difference ($P < .10$) between the homing capabilities of experienced (includes only second capture) and inexperienced male bears ($\chi^2 = 3.23$, 1 d.f.). Fifty percent of the inexperienced males ($n=66$) homed and 70 percent of the experienced male bears ($n=27$) homed after the second capture. Bears transplanted after August 15 were excluded from these analyses since there may have been inadequate time for observation before the denning period.

The average homing rate for experienced males transplanted the second time was 0.51 kilometers/day and averaged 44.4 days. One bear returned 21 kilometers in two days for a rate of 10.5 kilometers/day. Inexperienced male bears that homed averaged 179.5 days to return for an average rate of 0.17 kilometers/day. Nine of these bears were not reobserved at their capture point

until the following summer. There was a statistically significant difference ($P < .05$) between the homing rate of inexperienced and experienced bears homing the second time.

A Comparison of Release Areas

Poaching is an important factor influencing the homing of transplanted bears in the GSMNP. Records of the NPS and Tennessee Wildlife Resources Agency give evidence of heavy hunting along the periphery of the Park. To test the hypothesis that bears released along the periphery are less likely to return than animals released at more centrally located release sites, a comparison was made between two release points. One release point, Tremont, is centrally located within the Park and is not easily accessible to anyone except Park personnel. The other area, Parson's Branch Road, is near the border of the Park and joins U.S. Highway 129. Both areas are approximately 20 kilometers from the common capture point (Cades Cove).

It was found that 86 percent of the inexperienced male bears released at Tremont homed ($n=18$) while only 56 percent of the inexperienced males released at Paron's Branch homed ($n=16$). These differences were significant ($P=.09$). Habitat and terrain differences were not

evaluated but could have affected homing incidence along with poaching. However, it appears that bears transplanted to peripheral areas of the Park are subjected to poaching and frequently killed.

Orientation

The ability of an animal to return to its homesite has been reported in birds (Bellrose, 1958 and Sauer and Sauer, 1960), dogs (Canis domesticus) (Carthy, 1956:138), gray squirrels (Sciurus carolinensis) (Hungerford and Wilder, 1941) and mice (Peromyscus spp.) (Griffo, 1961; Bovet, 1968 and Furrer, 1973).

Wasem (1968) reported on the homing behavior of 13 black bears in Glacier National Park. He attempted to evaluate the effectiveness of transplanting habitually panhandler bears and found that eight individuals (62 percent) homed. In Michigan, Erickson et al. (1964) transplanted 17 bears an average of 64 kilometers from their capture point and considered only two of these bears to later indicate homing. One of these bears was an adult male that was killed within 9.7 kilometers of the capture point after being removed 151.6 kilometers. The second bear was an adult female captured 30.6 kilometers from the original capture point after being separated from her cubs and moved 103.2 kilometers. Of the transplanted

bears, Erickson et al. concluded that males moved farther than females and adults farther than juveniles. Harger (1967) found a definite tendency for relocated bears to move toward the original point of capture. Of the 18 bears furnishing movement records, Harger considered that 12 individuals had homed with cubs exhibiting poorer homing ability than older bears. Sauer et al. (1969) transplanted 52 panhandler bears 13.9 to 106.6 kilometers from their capture point and found 43 percent were able to home. The authors concluded that homing fell off sharply when bears were transplanted greater than 64 kilometers from their capture point. Other than these studies there is little available literature that quantifies the homing ability of black bears.

Recent studies have shown black bears are capable of memory. In testing for color and form discrimination of black bears, Bacon (1973) concluded that black bears can make rapid visual discrimination, and can remember a task for long periods of time. He also stated that their retention ability may be related to their high degree of persistence.

Bears possibly use other means to home than previous association with the terrain. For example, star navigation has been demonstrated in birds (Bellrose, 1958; Sauer and Sauer, 1960). In the case of bear species, polar

bears (Ursus maritimus) have the ability to return to the same areas after drifting on ice which changes form and would carry them elsewhere if they were not able to navigate (Jack Lentfer, personal communications). Means of navigation other than association with the terrain were not tested in the GSMNP.

Besides indicating that experienced bears have a higher probability of homing and home in less time, the data of this study suggest that bears are capable of learning and memory of the terrain outside their home range and/or previous homing experience somehow increases their efficiency of homing. Motivation is another factor that may be an important influence. Griffo (1961) stated that home range may not only satisfy the physical needs which might often be provided equally well or better in other areas, but may also provide a psychic function. This psychic function may allow bears to move about areas with which they are familiar with assurance and to efficiently utilize the resources with which they are intimately attached. Also, whatever intraspecific social relationships were present may be altered when bears are moved into unfamiliar areas. Territoriality, whatever form exists, would also be affected. These factors may motivate bears that have been artificially transplanted to seek their original homesite.

Many of the animals transplanted were released in areas near sources of garbage (campgrounds, shelters, etc.). Of those bears transplanted, only one (1.3 percent) became a panhandler animal in an area other than near the original capture point. This presents additional evidence that bears were not inclined to remain in unfamiliar areas outside their home range and were motivated to return home. The combination of being highly mobile, evidently motivated to return to their homesite, and capable of learning and retention give black bears the capability of being highly successful in returning to their original homesite after being transplanted.

If we accept that bears possess a homing ability and for one reason or another are motivated to return to their established home range, the question arises as to how bears are capable of relocating their home area after being relocated. Griffo (1961), Furrer (1973), and others have postulated that small rodents homed by random wandering in unfamiliar terrain until familiar terrain is encountered and non-random movements in terrain with which the animal had some previous familiarity.

It is reasonable to assume that bears are familiar with their home range. However, it is known that animals occasionally make excursions out of their home range.

In Burt's (1943) classical definition of home range, he includes the idea of an animal's occasional excursion outside its normal home range. Also, it is a well-accepted observation that many young animals disperse from their birthplace to unfamiliar areas to establish a homesite. In the GSMNP there is evidence of extensive wanderings by yearling and subadult bears (see Movements and Activities, page 35). The movements of animals beyond their established home range allow an opportunity for bears to familiarize themselves with terrain beyond their home range. Furrer (1973) and others have employed the term "life range" for the total area an animal has traversed during its lifetime. A life range may have little biological significance for normal day-to-day activities, but could be important in a bear's ability to orient itself after being moved by unnatural circumstances.

Evidence is presented in this study indicating experienced bears were more likely to home and homed in less time than inexperienced bears. It, therefore, appears that learning and memory of the terrain encountered may play a role in homing ability.

Management Implications

Creating conditions that reduce the amount of human food available to bears is probably the most important management tool for reducing panhandler animals. Eliminating all sources of unnatural food is not realistic in the GSMNP (or any other park) so the problem of panhandler bears will not be totally eliminated. Another precautionary step is to move a bear as soon as possible after it enters a campground or roadside and thus reduce the amount (frequency) or reinforcement (food) that a particular animal receives.

Since 50 percent of the male and 70 percent of the female bears transplanted for the first time did not home, the first transplant may be important in eliminating future encounters with a particular animal. Although this study does not provide enough data to evaluate how well inexperienced bears will home from transplants over 50 kilometers ($n=3$), distance could be an important parameter of homing. While it may require much time to move a bear the first time to an appropriate transplant area, it likely reduces the chances of having to handle that particular bear again.

The relatively small area of the Park may prove to be inadequate to successfully transplant bears captured in some areas. There are a limited number of

places within the GSMNP that are less than 10 kilometers from a source of human food (campgrounds, roadsides or back-country shelters). Yet, only one out of 76 (1.5 percent) of the bears transplanted was reported to have caused a nuisance other than at the original capture point. The data indicate that the probability of a bear becoming a chronic panhandler other than in its established home range is quite low; this should be considered when determining possible locations for transplanting bears. Thus, an area for relocating a bear does not necessarily need to be eliminated as a choice because of its proximity to another campground, roadside, etc.

It seems appropriate to consider that poaching may be an important factor when selecting a release site in the GSMNP. While moving bears to a peripheral area of the Park may eliminate a nuisance problem, it may be doing so by eliminating the bear. This problem is magnified by the lack of any buffer zone around much of the Park's periphery and areas of relatively dense populations of people.

As long as human food is available, bears will continually be attracted. When a panhandler bear is successfully moved, the problem of panhandler bears is only solved for that particular bear. Eliminating the

availability of human food to bears is the only long-term solution.

III. DEN ECOLOGY

Den Site Selection

Six active den sites were located for five different bears. All den sites were located after bears carrying radio-transmitters entered them for their winter dormancy period. Bears tracked to their den sites included three adult females and two subadult males.

Characteristics of the den sites selected by black bears in the GSMNP are given in Table 11. All three of the females (four den sites) selected cavities in standing trees. These tree cavities ranged from 6.1 to 17.4 meters from the ground. The cavities were naturally formed from what appeared to be trees struck by lightening and natural decay. Den entrances were formed by limbs falling off in three of these trees. The top of the fourth tree had toppled over leaving the entrance hole at the top of the remaining tree trunk. A 3.5 year old male also denned in a tree cavity that was approximately 10.7 meters from the ground. The last den site, occupied by a 2.5 year old male, was located under a dead stump.

TABLE 11. Black bear den characteristics in the GSMNP, 1972-73

Bear No.	Sex	Age	Date Entered	Date Vacated	Forest Type	Slope Exposure	Elevation (m)	Den Site Type	Tree Circumference	Distance from Ground (m)	Cavity Size (cm)			Entrance Opening (cm)		Bedding Material
											H	W	L	W	L	
Y30	F	4.5	12/12/72 to 12/18/72	1/4/73	Ecotone between cove hardwood & closed oak	SW	1277	Cavity in red maple	290 cm	10.7	69	48	38	30	53	Humus and wood scrapings
Y39	F	4.5	1/4/73 to 1/3/73	After 3/1/73	Cove hardwood	SE	1225	Cavity in eastern hemlock	295 cm	6.1	122	61	61	61	61	Humus and wood scrapings
Y52	F	4.5	12/5/73 to 12/15/73	Unknown	Cove hardwood	SE	1189	Cavity in eastern hemlock	325 cm	15.2	152	46	46	28	33	Unknown (tree had blown over)
P53	F	4.5	12/1/73 to 12/15/73	After 3/1/73	Cove hardwood	E	1207	Cavity in eastern hemlock	340 cm	17.4	183	86	76	33	38	Humus and wood scrapings
Y60	M	2.5	12/15/73 to 12/20/73	1/10/74 to 1/15/74	Closed oak	NE	823	Under dead tree stump	-	-	53	61	71	30	38	Leaves
X56	M	3.5	12/5/73 to 12/15/73	After 2/20/74	Northern hardwood	SW	1341	Cavity in red maple	264 cm	10.7 (Est.)	Unknown			38 (Est.)	46 (Est.)	Unknown

Four den sites were located in the cove hardwood forest type (one den was in the ecotone between cove hardwood and closed oak). The northern hardwood and closed oak forests were the sites of the other two dens. Four of the slope exposures were generally sloping toward the south and the other two sloped toward the Northeast and East. Three of the tree den sites were located in large mature eastern hemlocks and two in red maples ranging in size from 84 to 108 centimeters DBH (Table 11 and Figure 34).

Three of the tree den sites had humus and small splinters of wood for bedding (Figure 35). It appeared as though the humus had been collected from the forest floor and carried up to the den sites. Additional bedding was added by bears clawing and chewing the inside of the tree to produce small wood splinters. This bedding material was approximately 60 centimeters deep in one of the tree cavities. Leaves had been scraped into the ground den site for bedding material.

All except one of the den sites were located in secluded areas relatively free of direct human disturbance. However, bear Y30 denned only 15 meters from Anthony Creek Trail and 1.5 kilometers from Spence Field. This trail is used year round and receives considerable hiking traffic.



Figure 34. Den trees used by bears during 1972-73 in the GSMNP.



Figure 35. Bedding material (humus and splinters of wood) used by bears inside their tree dens in the GSMNP, 1972-73.

Denning Period

Only one den site was located in 1972. This bear (Y30) entered the den between December 12 and December 18. Y30 was frequently located in the denning area the month prior to going into dormancy. On January 4, a researcher climbed the tree to confirm that the radio-transmitter signal was being emitted from this tree. The activity of climbing the tree disturbed the bear enough for her to stick her head out of the cavity entrance. For five minutes the bear noticeably shivered. Finally, she very slowly climbed down the tree and walked off. The next day this bear was found in another tree approximately 100 meters from the first den site. She appeared to remain in this den site the rest of the winter before emerging sometime after March 1.

Of the four den sites located in the fall of 1973, three bears entered their den site between December 1 and 15. Bear Y60 (2.5 year old male) denned between December 15 and 20. The den site of Y60 was approached as quietly as possible on January 5. The bear was found in a curled up position and appeared to have his head tucked under his chest. The bear was touched by the researcher with no apparent reaction. However, five days later (January 10) Y60 had vacated the den site and was never relocated.

Several trips were made to the den tree of bear Y52 (4.5 year old female). As far as is known, none of these trips disturbed the bear enough to cause her to leave. However, a broken trip wire that had been placed around the base of the tree in addition to fresh claw marks on the tree indicated she had left and returned sometime between February 2 and 8. The permanent spring emergence of Y60 was not determined since her transmitter ceased functioning shortly after February 8.

The last signal received from bear R53 (4.5 year old female) was on March 1. The bear appeared to be in or near her den site on this date. Bear R56 (3.5 year old male) was still denning when the last signal was received on February 20. The exact date of spring emergence is unknown but was sometime after radio contact was lost.

Four of the five bears located in their dens were known to survive the winter. All except R56, a 3.5 year old male, were captured the following summer within their previously established home range.

Denning Behavior

Differences in behavior and physiological responses among various animals during winter dormancy have caused researchers to formulate varying definitions of this

phenomenon. Species differ in time and duration of winter dormancy, the degree of drop in body temperature and its relation to the ambient temperature, the accumulation of energy reserves in body fat, depression of metabolic activity, and variations in the functioning of individual organs. A typical mammalian hibernator reduces its body temperature, heart rate, and metabolism, until body temperature is within 1° C of the ambient temperature. A regular awakening every few days to drink, eat, urinate or defecate is also typical for mammalian hibernators (Folk et al., 1970). The dormancy of black bears is described by a slight drop in body temperature, a slow continuous depression of heart rate (from 40 beats/min. to 8 beats/min.), and no urination or defecation during the dormant period. Unlike most mammalian hibernators, bears can readily be aroused after which they can react quickly to a disturbance (Folk et al., 1970). Morrison (1960) stated the bear cannot maintain a body temperature near the ambient temperature because of its large mass and low thermal conductance. Morrison thinks this limited depression of body temperature observed in bears may qualify them as "ecological" hibernators. However, Folk et al. (1970) believes that the extreme reduction in heart rate, digestion and excretion, and a partial reduction in body

temperature and in metabolism, indicate that the bear is at least a semi-hibernator.

The five bears that denned in this study hibernated approximately at the same time (December 1 to December 15). A maximum of 15 days existed between the denning dates. Denning did not appear to be triggered by any particular weather factor as was found for grizzly bears (Ursus horribilis) in Yellowstone National Park when snowstorms immediately preceded denning (Craighead and Craighead, 1972). In 1972 there was a 5 to 9 centimeter snowfall about the time that bear Y30 denned. However, the entering of dens in 1973 was accompanied by exceptionally mild weather.

A common belief is that during years of abundant fall food crops bears fatten quickly and den earlier than in years of poor food crops (Spencer, 1955; Bromlei, 1973). The mast crop was generally poor in 1972 and fair to poor in 1973. No unusual dates for denning were noted during these two years although nothing conclusive can be derived from such a small sample.

Black bears are quite adaptable in utilizing the available physical resources for selecting den sites (Table 12). They have used such simple structures as shallow depressions in forested areas for den sites (Erickson et al., 1964; Smith, 1946; Leopold, 1959).

TABLE 12. Different types of winter dens used by black bears

Den Type	Area	Reference
Open nest or shallow depression	Minnesota Mexico	Morse (1937) Leopold (1959)
Depression under boughs of coniferous trees	Maine	Smith (1946)
Depression under tree roots	Minnesota North Carolina Alaska Pennsylvania	Morse (1937) Aldous (1937) Clodfelter (1943) Hoch (1951) Matson (1946)
Depression under boulders	Montana Mexico New York Pennsylvania	Jonkel and Cowan (1971) Leopold (1959) Schoonmaker (1938) Matson (1946)
Depression under logs	Michigan Montana Pennsylvania	Erickson et al. (1964) Jonkel and Cowan (1971) Matson (1954)
Base of hollow tree	Montana USSR	Jonkel and Cowan (1971) Bromlei (1973)
Drainage culvert	Yellowstone Nat. Pk.	Barnes and Bray (1967)
Under cabin	Montana	Jonkel and Cowan (1971)
Tree cavities high off the ground	Michigan Louisiana GSMNP	Switzenberg (1955) Taylor (1971)

Usually more elaborate den sites have been used such as cavities under logs, roots and stumps (Matson, 1946; Schoonmaker, 1938; Cahalane, 1947). Occasionally den sites have been located where black bears have used man-constructed structures. Barnes and Bray (1967) found two bears denning in drainage culverts. A black bear was also located under a cabin during the denning period (Jonkel and Cowan, 1971). The bears in the GSMNP appear to frequently use large, mature trees that have cavities several meters above the ground. Only a few reports of black bears denning in tree cavities off the ground have been documented. Taylor (1971) and Switzenberg (1955) have reported bears denning in tree cavities high off the ground. Taylor (1971), as in this study, was only able to locate tree den sites by use of radio-tracking equipment. As the use of radio-telemetry expands, it is likely that a larger percentage of black bear den sites will be located in tree cavities.

The physiological state of hibernating black bears as described earlier indicates that, while they are capable of being aroused, they are somewhat defenseless. Additionally, observations of denning bears in this study and others (Taylor, 1971; Matson, 1946) indicate that at least some bears are not easily aroused. However, some disturbances will cause bears to abandon their den sites.

It seems intuitive that bears free of any winter disturbance would have an increased survival value over bears that are somehow disturbed. This might take on additional significance when females with new-born young are involved. Bears denning in tree cavities high off the ground are likely freer from disturbance than ground denning bears. Tree dens found in the GSMNP appeared to remain dry, offered protection against the wind, and were well insulated for conserving body heat. In a study testing the heat transfer of a raccoon (Procyon lotor) in a closed tree den, it was found that the tree den wall plus the air space within the den created a heat resistance of 35 percent (Thorkelson and Maxwell, 1974).

The use of tree dens for such a large mammal seems unusual. However, the black bear has lived and evolved in forested habitat and has used trees for defense mechanisms (Herrero, 1970). Black bears also spend considerable time in trees and are arboreal feeders much of the time (Beeman and Pelton, 1975). With these facts in mind, it seems a short step for a bear to locate and utilize tree cavities for den sites.

The implications from this bear denning study indicate that bears may use tree dens more frequently (83 percent) than all other types of dens in the GSMNP.

If this situation exists in other areas of black bear range in the Southeast, forest practices may play an important role in limiting this type of den site. Established timber practices (i.e., U.S. Forest Service on national forests) may be eliminating potential den trees by either cutting cull trees during timber stand improvement or simply cutting trees before they reach the minimum size necessary for large cavities to form. Even though bears are adaptable in selecting den sites, trees may provide the most suitable den site.

IV. POPULATION CHARACTERISTICS

Population Structure

Information collected by live trapping allows for a preliminary evaluation of the animals living in the GSMNP. An age and sex structure of 114 back-country and panhandler bears trapped in the Park is illustrated in Figures 36 and 37. Animals trapped were unbalanced toward males (65.4 percent) (Appendix B). Of the bears trapped in the back-country, 52 percent were males. Panhandler bears trapped in campgrounds and along roadsides were predominately males (82 percent). This high percentage of panhandler male bears is significantly different from the expected 50:50 sex ratio ($P < .01$).

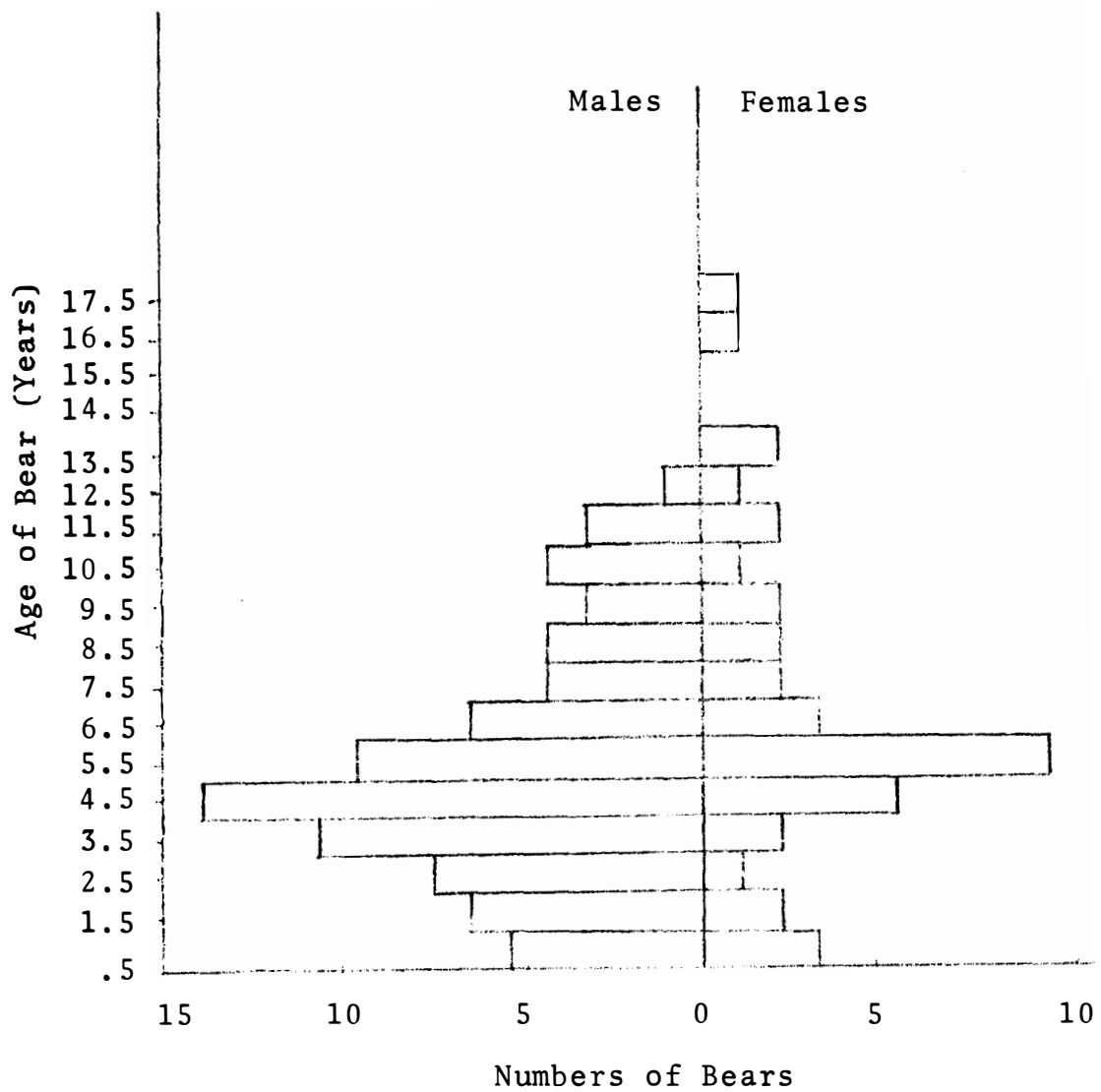


Figure 36. Age and sex structure of 114 bears trapped in the GSMNP during 1972-74.

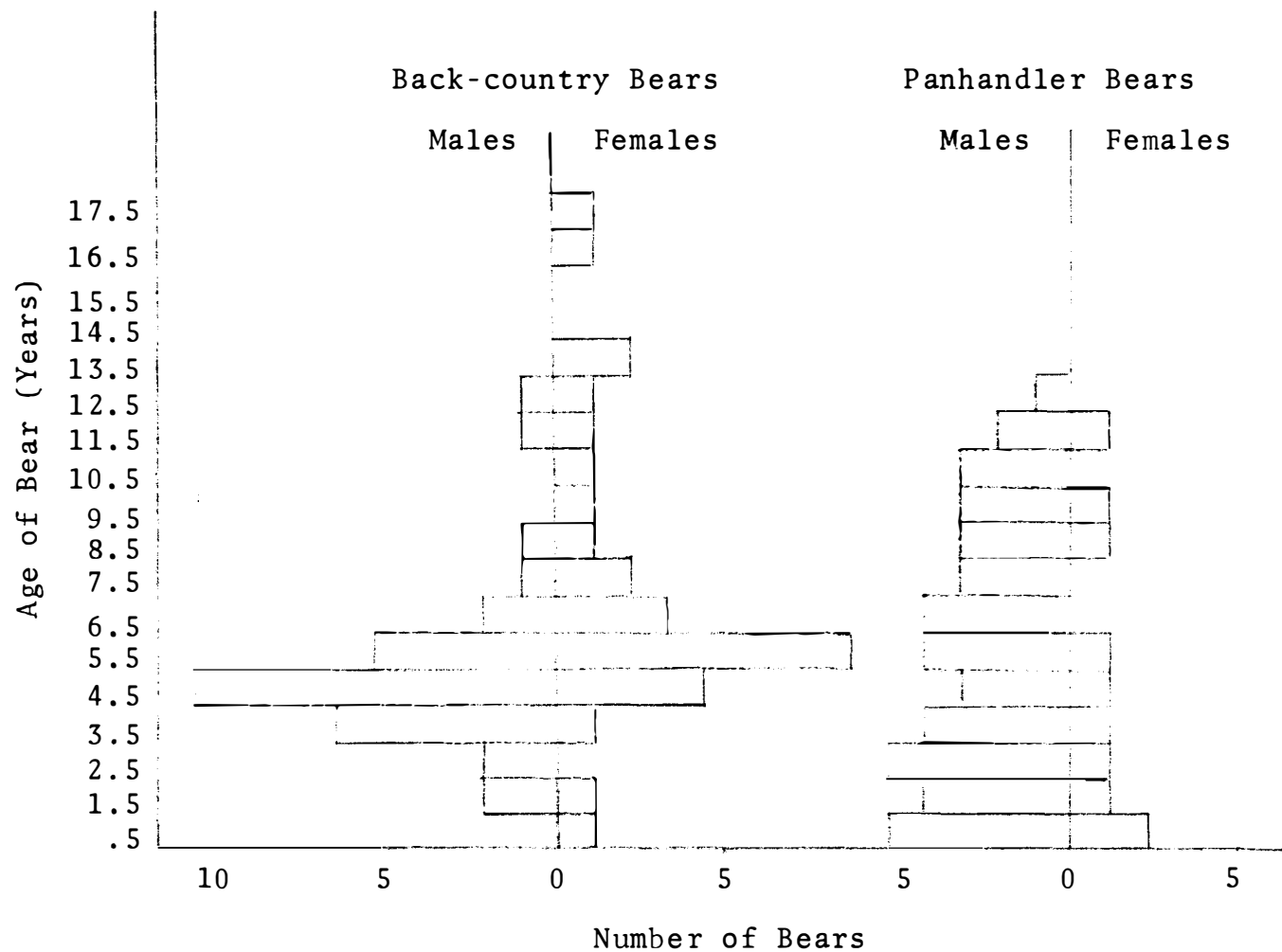


Figure 37. Age and sex structure of 114 panhandler and back-country bears trapped in the GSMNP during 1972-74.

The high ratio of panhandler males indicates males are apparently less inhibited about entering areas of high human activity. The dominance of males classified as panhandler bears generally agrees with results reported by Erickson et al. (1964), Harger (1967), Wasem (1968), Rogers et al. (1974), and Sauer et al. (1969).

Females avoiding contact with humans during the period of rearing young could partially explain the small percent of female panhandler bears. Parental care of young may act as an inhibitory stimulus for adult females to enter areas of concentrated human activity. Since females can potentially breed in alternate years and young bears remain with the female for nearly 1.5 years, much of an adult female's time is potentially involved with parental care. Additionally, females localize their movements to relatively small areas and have less opportunity for contacting people and taking advantage of the available food supply.

Cubs (bears less than 12 months old) and yearlings (bears 13-24 months old) were estimated to total 14 percent of the bear population in the GSMNP. The percentage of subadults (bears 25-51 months old) was estimated to include a comparatively small proportion (18 percent) of the population. Adults, estimated to include 68 percent of the population, were the major

constituent of the population.

The estimated age structure of bears captured in the GSMNP was different than what might be expected. Rather than the youngest age class being the largest as is the general case in a stable or growing population, bears 4.5 and 5.5 years old were the most numerous (Figure 36). The estimated age structure suggests a stable adult bear population and an unstable juvenile population. Some event or events in the last few years has likely caused instability in the population by lowering reproduction and/or cub survival.

Fall is a critical season for bears in the GSMNP (Beeman and Pelton, 1975). Bears are actively engaged in consuming large quantities of food and adding fatty tissue in preparation for winter dormancy. In the GSMNP, acorns, hickory nuts, and beechnuts are major sources of fall foods. These foods are not consistently produced from year to year with near total crop failures occasionally occurring.

A near total mast failure occurred in 1968 with a very poor year following in 1972 (Richard Conley, personal communications). It has been demonstrated with the European wild hog, another species highly dependent on mast in the late fall and winter, that reproduction can drop to virtually zero when a mast failure occurs (Matschke, 1967).

Very likely reproduction of the black bear was adversely affected in 1968. Since bears possess a low biotic potential, it takes several years for the population to stabilize. A second mast failure four years later again adversely affected reproduction with the end result of sustaining instability in the bear population over the past five years.

Further evidence that the black bear population in the GSMNP has been unstable during the course of the study is illustrated by comparisons with black bear populations in other geographical areas (Table 13). Approximately 68 percent of the bears in the GSMNP were estimated as adults while only 41 to 45 percent of the bear populations in Washington (Poelker and Hartwell, 1973), Montana (Jonkel and Cowan, 1971), and North Carolina (Collins, 1973) were estimated as adults.

There were substantial differences between the age structure of back-country and panhandler bears (Figure 37, page 141). Approximately 46 percent of the panhandler bears were estimated as juveniles. This age group was estimated to represent only 22 percent of the back-country population. A detailed analysis of males and females of both panhandler and back-country bears is shown in Figure 38. Ten percent of the back-country females and 32 percent of the males were juveniles (cubs,

TABLE 13. Age structure of the GSMNP bear population compared with black bear populations of other areas

Age Group	Percent						GSMNP
	Washington ^a	Montana ^b	Michigan ^c	Virginia ^d	North Carolina ^e	Yellowstone Nat. Park ^f	
Cub	4.2	12	20	2	5	21	7
Yearling	12.9	17	18	29	29	10	7
Total cub & yearling	<u>17.1</u>	<u>29</u>	<u>46</u>	<u>31</u>	<u>34</u>	<u>31</u>	<u>14</u>
Subadult	40.4	30	-	-	21	-	18
Adult	42.5	41	-	-	45	-	68
Total subadult & adult	<u>82.9</u>	<u>71</u>	<u>54</u>	<u>69</u>	<u>66</u>	<u>69</u>	<u>86</u>

^aPoelker and Hartwell (1973): 5,880 bears (1950-1970).

^bJonkel and Cowan (1971): 155 bears (1960-1965).

^cErickson et al. (1964): 158 bears (1952-1957).

^dStickley (1961): 94 bears (1955-1956).

^eCollins (1973): 151 bears (1969-1971).

^fBarnes and Bray (1967): 52 bears (1965-1966).

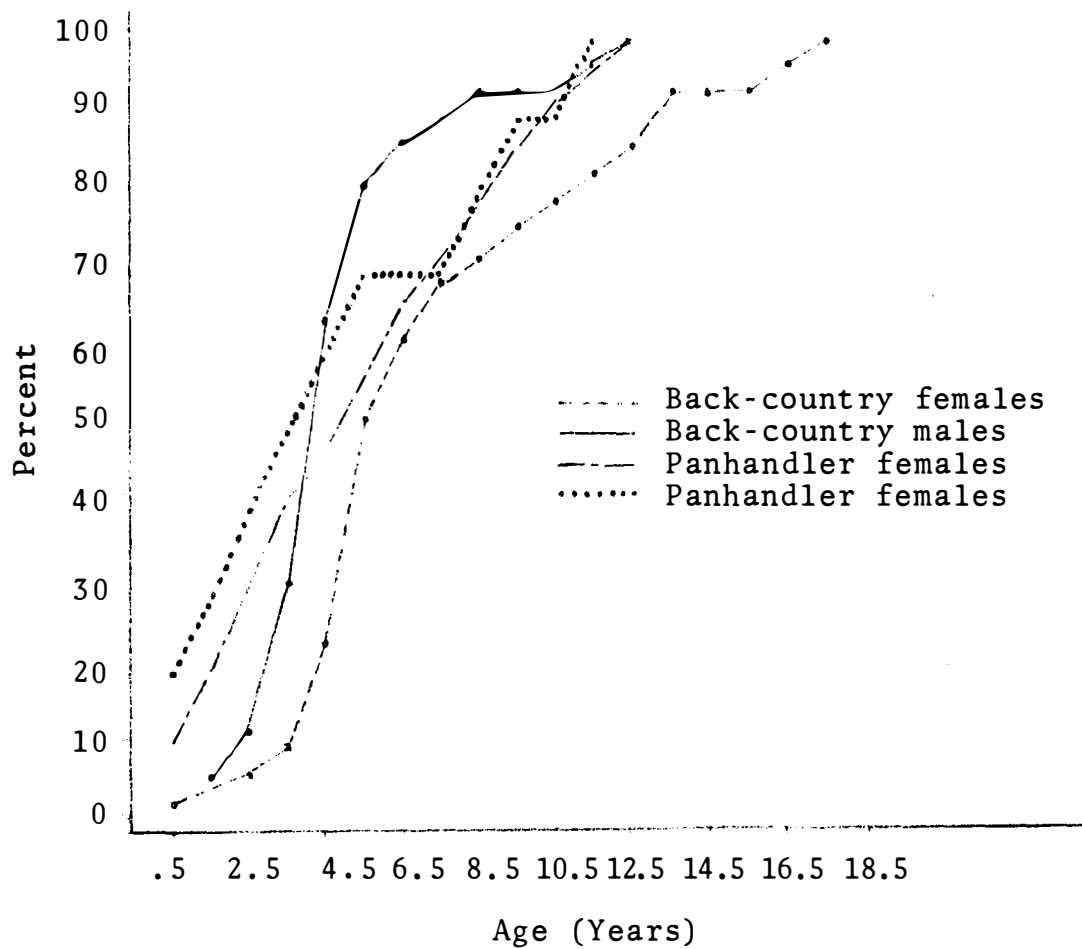


Figure 38. Cumulative percent of males and females in different age groups from panhandler and back-country bears trapped in the GSMNP 1972-74.

yearlings, and subadults). Fifty-eight percent of the panhandler females and 42 percent of the males were juveniles.

In Michigan, Rogers et al. (1974) reported similar results with juveniles constituting 65 percent of the panhandler bear population. The above is evidence of dispersal movements by young bears. In searching for a home area, they likely encounter campgrounds, roadsides, and trail shelters and become habituated to the food source provided by people. Thus, dispersal of young bears could also contribute to the low percentage of juveniles in the GSMNP.

Average Population Survival Rate

The average annual survival rate ($\bar{s}_x$) can be estimated from the age composition if the bear population is relatively free of excessive movements in and out of the Park (see Appendix C for the formula and calculations). The condition of immigration into the Park was likely met due to the lack of bear habitat in much of the surrounding areas. However, emigration out of the Park may be an active phenomenon that could alter the estimated survival rate.

The $\bar{s}_x$ for adult bears was estimated to be 78.3 percent. Inadequate data are presently available to

calculate the survival rate of bears less than 4.5 years old. From the age structure illustrated in Figure 36, page 140, it appears that once a bear reaches 6.5 years of age, the probability of surviving to the next year is very high.

Erickson et al. (1964) reported a mortality of 19 percent for bears (all ages and sex classes) during one year caused by hunting, automobiles and the disposal of panhandler animals. In Washington, Poelker and Hartwell (1973) estimated an annual average mortality rate of 15 to 18 percent; this study included hunting, control operations and natural mortality. A mortality rate of 14 percent was reported by Jonkel and Cowan (1971) for adult bears in Montana; mortality caused by factors other than natural mortality were excluded in this study. The estimated average annual mortality rate of 21.7 percent for adults in the GSMNP is higher but in general agreement with those reported in other studies.

Both intrinsic and extrinsic factors have been mentioned as population regulatory mechanisms. An inadequate supply of fall food may be an effective extrinsic population regulator by lowering reproduction and causing emigration out of the Park. Dispersal of young bears outside the Park, supposedly caused by adult antagonism (although not observed), is a previously-mentioned intrinsic

factor. Although not observed, intraspecific strife between males before, during, and perhaps after breeding is also a possible intrinsic factor regulating the population.

The causes of natural mortality within the GSMNP remain obscure. The dense vegetation and lack of easy accessibility to the back-country combine to make the probability of finding a bear that has died of natural causes very remote. However, there are data related to bear activities and movements that suggest several hypotheses that might explain mortality factors. Bears appear to become more restless in the fall in their quest for food. This "fall shuffle" was documented and discussed earlier in this study. Schroger (1949), Scott (1947), and other biologists have documented massive, long-range movements by bears in the fall. Jonkel and Cowan (1971) reported that only 20 percent of the cubs remained in the population until 2 years of age and only 7 of 31 subadults remained in the population for three years. Dispersal by young bears into areas of unsuitable bear habitat likely adds to bear mortality. Bears moving to roadsides and campgrounds are accidentally killed by vehicles and shot by poachers. Rogers et al. (1974) reported a higher mortality rate for panhandler than back-country bears in Michigan. Finally, transplanting

panhandler bears adds to mortality. In an attempt to find their home area, some bears apparently roam aimlessly and are often poached or otherwise eliminated. For example, one adult male was transplanted 65 kilometers from its capture point and was killed eight days later near Knoxville. Knoxville is located over 100 kilometers from both the capture and the transplant point of this bear.

Age and Growth

The weights of 80 bears throughout the spring, summer, and fall are illustrated in Figure 39. The data indicate males grow faster as well as considerably larger than females. For the inclusive years of 0.5 to 5.5, the annual mean growth rate for the population was estimated to be 18.4 kilograms/year and 8.9 kilograms/year for males and females, respectively. The average age of bears in the GSMNP was 7.7 years for females and 7.2 years for males. The oldest male and female trapped were 12.5 and 17.5 years old, respectively.

The largest male captured during the study weighed 231.9 kilograms. Males attained approximately one-half of their growth potential at sexual maturity and continued to grow until 7 to 10 years of age.

The largest female captured during the study

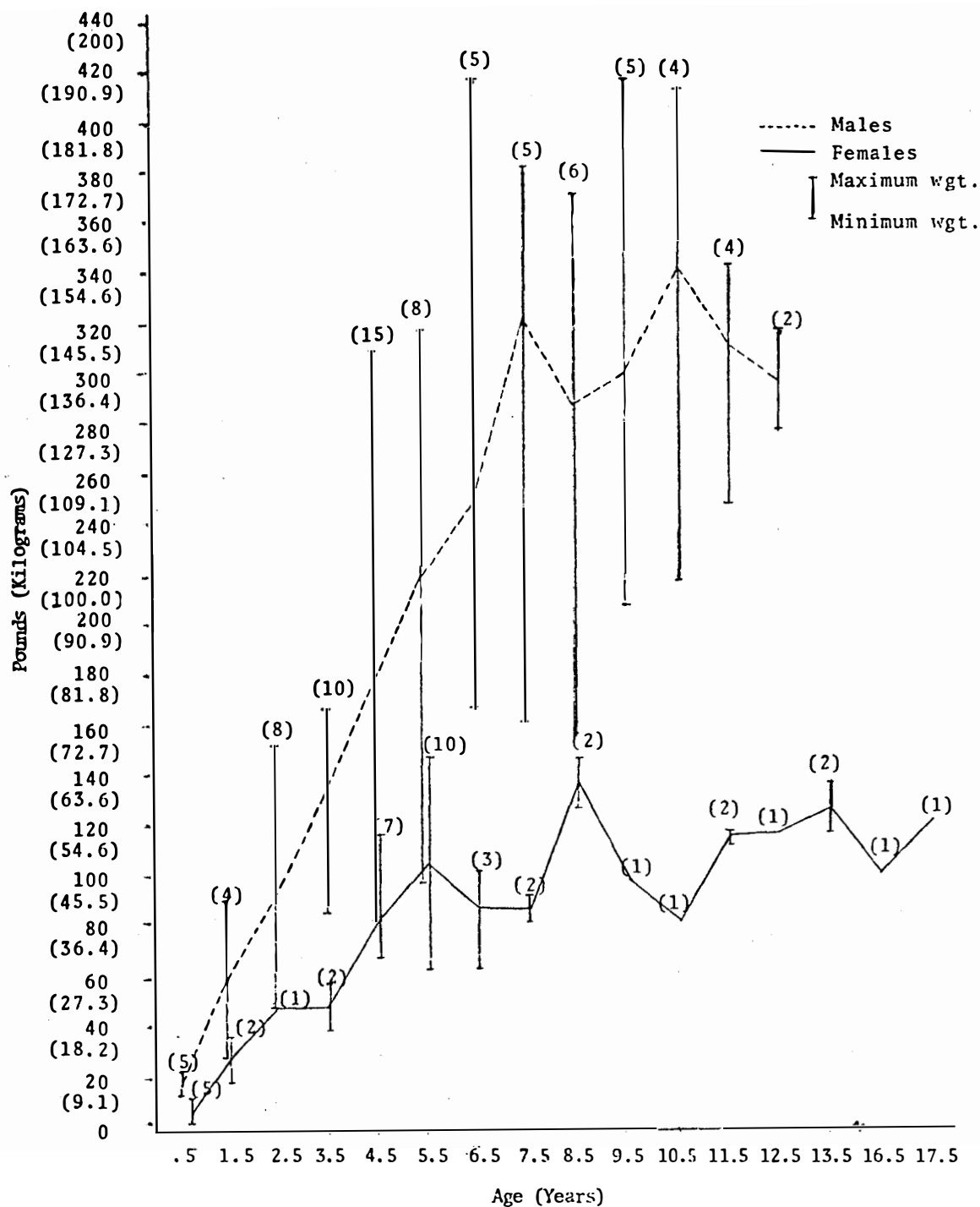


Figure 39. Minimum, maximum and average population weights for males and female bears of different ages in the GSMNP during 1972-74.

weighed 90.9 kilograms. Females were nearly half grown at sexual maturity. Both males and females fluctuated their weight after approaching growth potential. The degree of weight fluctuation depended on the individual, season, and available food supply.

There was large variation between individuals of the same sex and age, especially among males. For example, the weights of males 6.5 years of age varied from 77.3 to 190.9 kilograms, a difference of 247 percent. These results agree that weight is not a reliable character for aging black bears. The variation between females of the same age class was less but still an unreliable characteristic of age; one 47.7 kilogram female was 5.5 years old while another 47.7 kilogram female was 16.5 years old.

Annual weight changes of 12 males and eight females captured within 30 calendar days of different years are shown in Figures 40 and 41 and Table 14. One male increased in weight from 5.9 kilograms as a cub to 70.5 kilograms two years later. One yearling male, weighing 27.3 kilograms, approximately doubled his weight one year later. A 2.5 year old male gained from 32.7 to 63.6 kilograms while another subadult (3.5 years old) increased from 77.3 to 118 kilograms in one year. The estimated

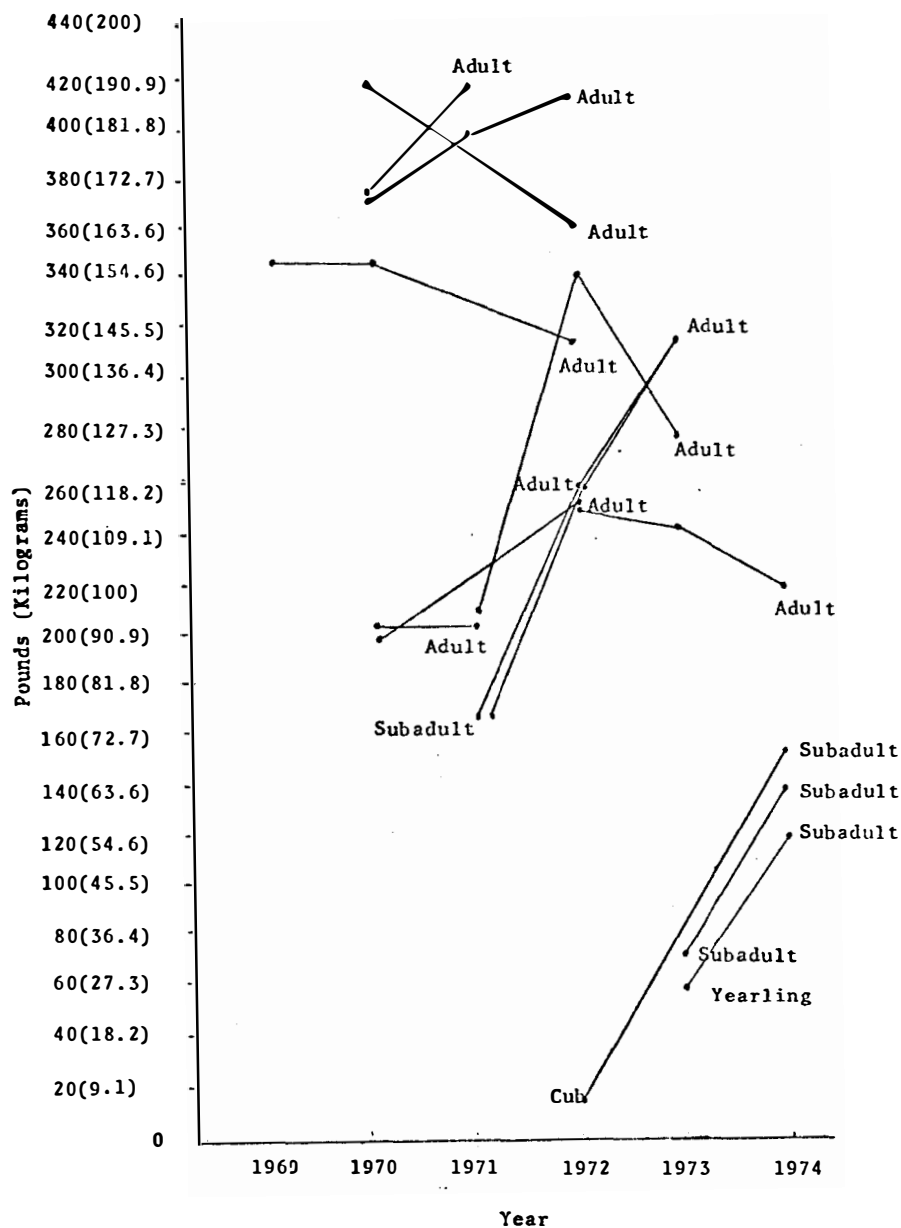


Figure 40. Weight changes of individual males captured within 30 calendar days in different years in the GSMNP.

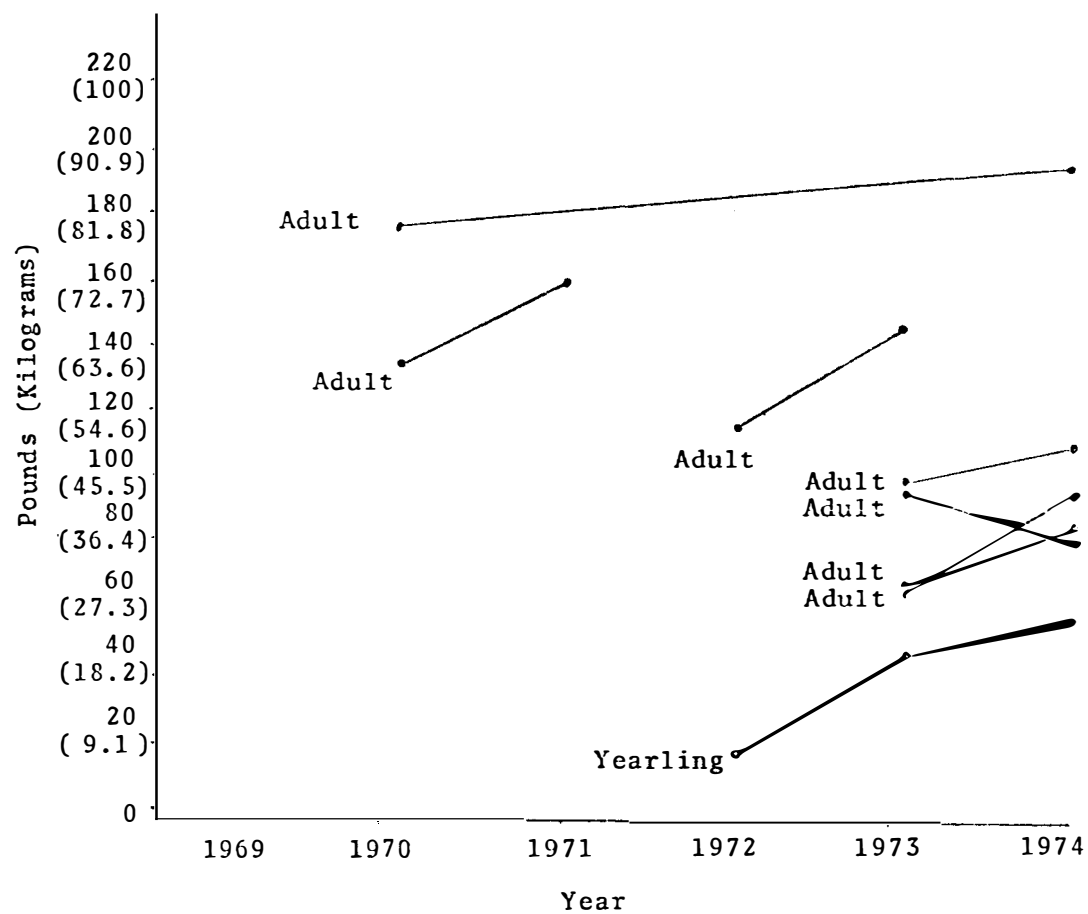


Figure 41. Weight changes of individual females captured in different years in the GSMNP.

TABLE 14. Weight changes of individual bears at various times of the year and between years in the GSMNP.

Bear No.	Sex	Date	First Capture	Age	Subsequent Capture(s)	No. of Days	Weight Loss or Gain (Kilograms)	Percent Weight Change
			Weight (Kilograms)		Date Weight (Kilograms)			
Y30	F	7-6-72	54.4	4.5	7-27-73	386	+13.6	+25
B59	F	7-12-72	9.1	1.5	6-21-73	344	+13.6	+150
					9-13-74	53	+4.5	+20
R53	F	6-19-73	32.7	4.5	9-12-73	54	-10.4	+32
					6-26-74	318	-2.3	-5
Y52	F	7-3-73	32.2	4.5	9-23-73	84	+13.2	+41
					6-16-74	295	0	0
B54	F	7-4-73	45.0	6.5	7-10-74	371	-6.8	-15
Y56	F	7-5-73	46.7	16.5	7-5-74	365	+5.4	+12
W60	F	7-18-73	29.5	6.5	8-20-74	398	+13.6	+46
R67	F	9-4-73	34.0	4.5	6-15-74	284	0	0
B36	M	5-30-69	136.1	9.5	9-1-69	94	+22.7	+17
					5-8-70	250	-14.1	-10
					8-13-70	97	+14.1	+9
					5-24-71	284	0	0
					8-14-72	446	-14.5	-9
Y37	M	8-5-70	90.7	4.5	8-4-72	729	+25.0	+28
Y35	M	8-12-70	190.5	6.5	8-4-72	722	-25.0	-13
R39	M	8-17-70	170.1	8.5	8-17-71	365	+20.4	+12
					8-3-72	351	-9.1	+5
					8-23-72	20	+6.8	+4
Y26	M	6-26-70	95.7	9.5	8-7-70	42	+1.8	+2
					6-6-71	300	+2.3	+2
					6-9-72	368	+57.6	+58
					8-23-72	75	-2.3	-1
					6-11-73	292	-19.1	-12
					8-3-73	53	+18.1	+14
R31	M	7-28-72	5.9	.5	10-20-74	449	+64.4	+1092
R8	M	5-24-72	174.2	6.5	6-13-72	20	-15.4	-9
					7-9-72	30	-5.9	-4
Y27	M	7-1-71	77.1	3.5	6-14-72	349	+40.8	+53
					8-17-72	64	+19.1	+16
Y31	M	7-13-72	27.2	1.5	6-16-74	338	+27.2	+50
R26	M	6-20-72	113.4	4.5	7-11-72	21	-21.5	-19
					6-29-73	353	+18.1	+20
					6-19-74	355	-10.4	-9
Y64	M	7-24-73	33.1	2.5	8-9-73	16	+3.2	+10
					6-22-74	317	+27.2	+75
W58	M	6-25-74	61.2	3.5	9-11-74	78	-4.5	-7
B26	M	7-1-71	77.1	3.5	6-14-72	349	+40.8	+53
					6-17-73	368	+27.2	+25

average weight gain for adult males was only 3.7 kilograms/year but is rather meaningless when discussing individual bears due to the high variability. However, it does illustrate that while weights of individual adult males do fluctuate, the net weight change of the adult male cohort is relatively small and may, in fact, be negative.

The extreme weight variation among bears of the same age and sex is likely due to a combination of factors. Many bears are likely smaller or larger than other individuals due simply to genetic variability. However, environmental stresses and food scarcity may also be responsible for individual variations. To test the hypothesis that environmental stresses limit growth, a comparison was made between free-roaming and two penned female bears in the GSMNP. The penned bears were captured as cubs in the back-country of the GSMNP and were, therefore, from the same population gene pool. There was a substantial difference between the pen-reared and free-roaming bears; free-roaming bears weighed only 23 percent as much as the pen-reared bears at 1.5 years of age and 29 percent at 2.5 years (Figure 42). These data are inconclusive due to such a small sample, but suggest environmental stresses of food scarcity, nutrition, food searching, etc., may substantially limit growth.

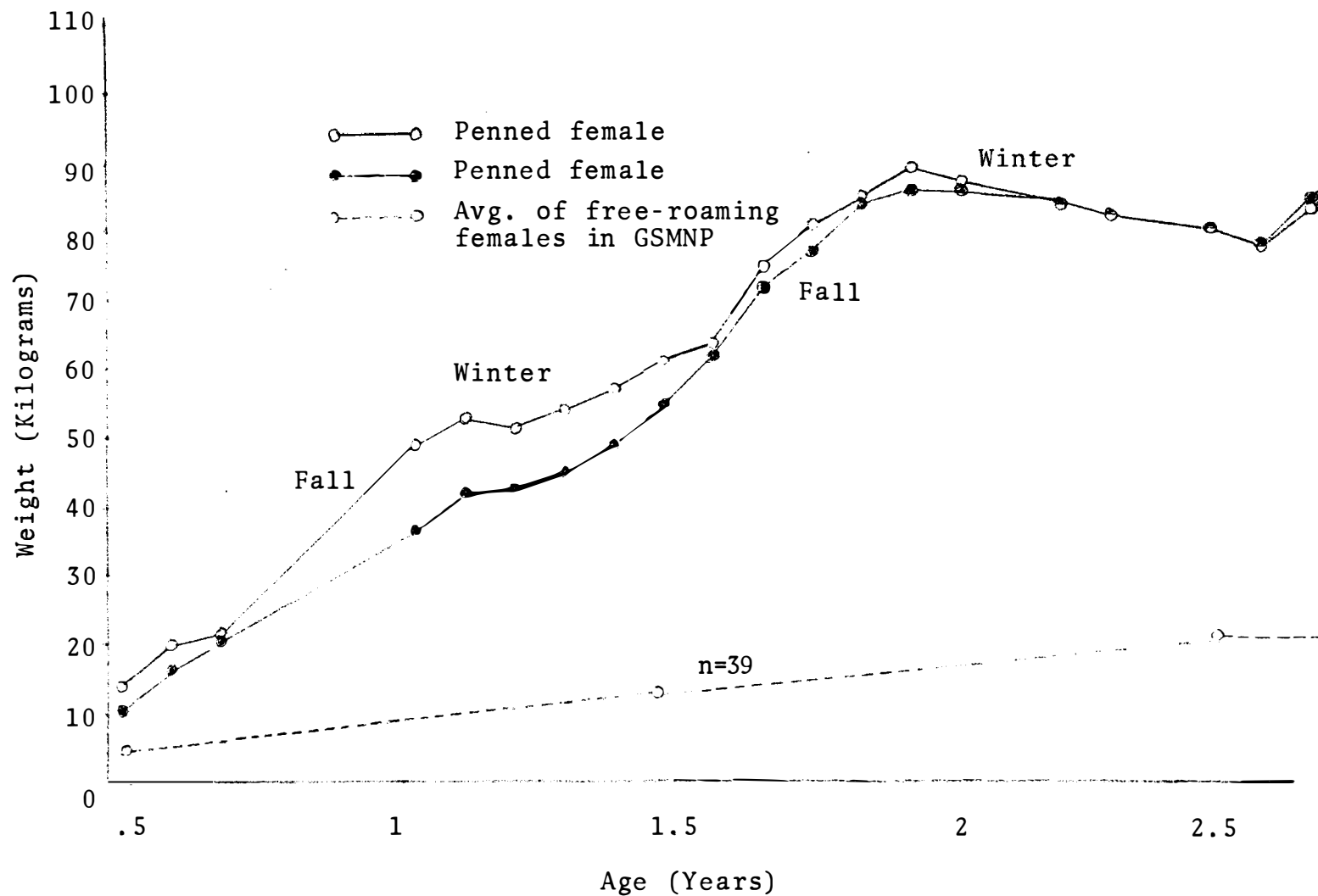


Figure 42. Average weights of free-roaming females and two penned female black bears in the GSMNP.

The penned bears gained weight most rapidly in the fall and then went through a period of weight reduction during the winter. Food was available at all seasons and so any change in food consumption was initiated by the bear; bears voluntarily increased food consumption in the fall and fasted during the winter. Seasonal alterations of feeding behavior in these bears appeared to be an innate behavioral response and support the hypothesis that fall is a critical time for food consumption, and, therefore, foods available in the fall are critical. It also supports the hypothesis that denning may be controlled more by food satiety rather than directly by other environmental conditions such as weather.

Seasonal Weight Changes

Captured bears were weighed a total of 134 times throughout the spring, summer, and fall. These weights yielded information on the population as a whole but offered only pieces of information concerning the seasonal fluctuations of individual bears. The weight changes of bears which were weighed more than one time are presented in Table 14, page 154 (only bears of known age are included). There was a general trend for bears to gain weight from summer to fall. For example, bear R53, a 4.5 year old female, gained from 33 to 43 kilograms

(32 percent increase) during the period from June 19 to September 12. The largest percentage gain for males (17 percent) was an 8.5 year old (bear B36) increasing from 136 to 159 kilograms during the period from July 30 to September 1.

Average monthly weights of adult males showed a 19 percent drop from June to July and a general trend of weight increase the remaining summer and fall (Figure 43). Adult females showed the same general trend except weight fluctuation was less and no weight loss was recorded in the spring.

The weight loss of males from June to July may be attributed to two factors. Adult males likely spend little time eating during the mating season. Evidence for this behavioral phenomenon is partially substantiated by the drop in the number of scat found on predetermined index trails (Table 15).

Nutrition during the spring and early summer may also be partially responsible for bears not gaining weight during the spring. A low nutritional level may be causing a "negative foraging period" when bears are feeding but still losing weight. Bears, coming from an evolutionary line of carnivores, have a relatively shorter digestive tract than most mammalian herbivores (Hatler, 1967). This appears to limit the digestibility of herbaceous stems

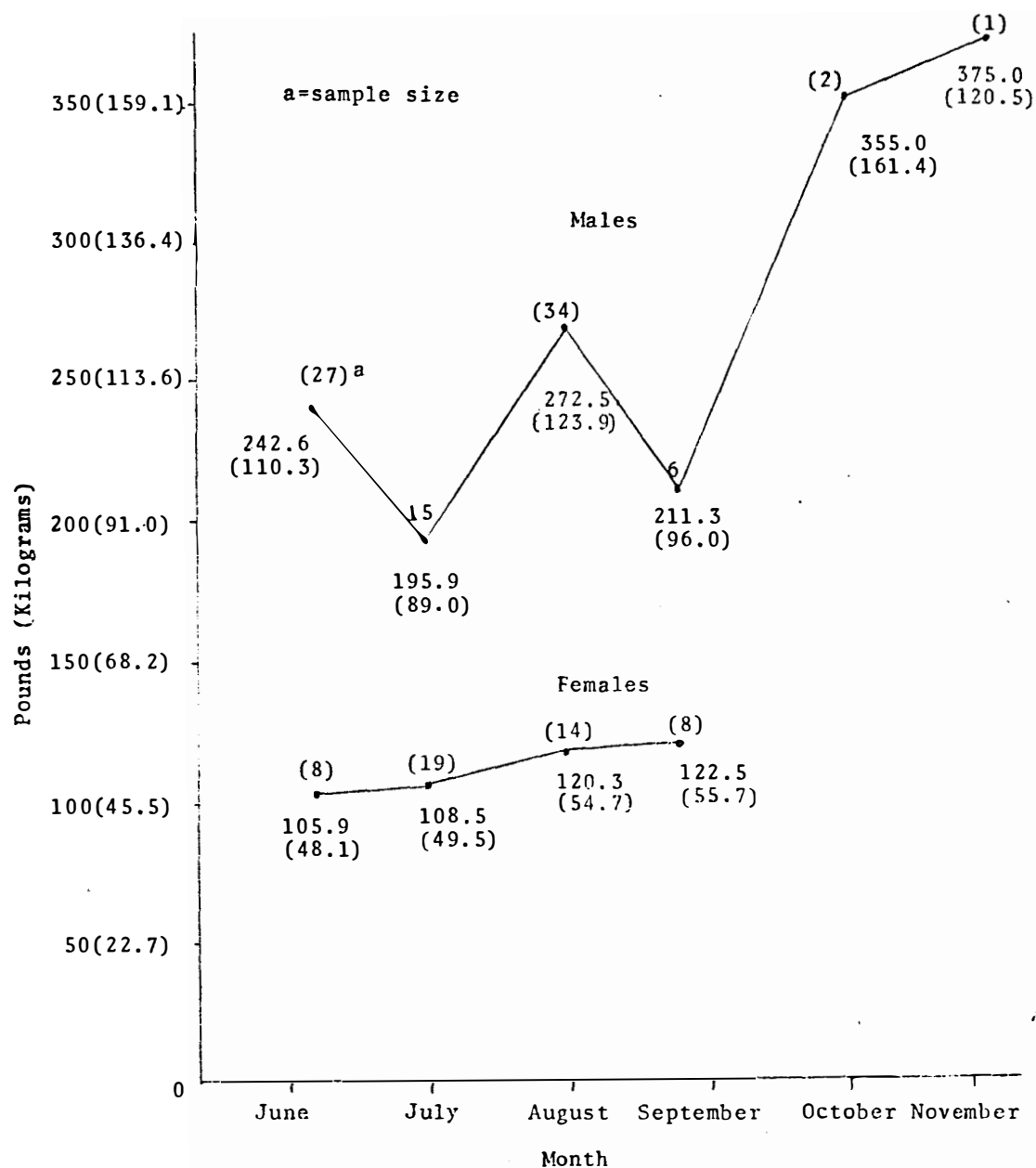


Figure 43. Seasonal weight changes of adult males and females in the GSMNP during 1970-1974.

TABLE 15. Hiking dates and numbers of scat located along trails in the GSMNP

Date	Number of Routes Taken	Number of Trails Taken	Miles Covered	Number of Scat Located	Scat/Mile	Miles/Scat
Apr. 4	4	8	75	0	0	0
Apr. 18	3	6	51	4	0.078	12.75
May 2	9	17	160	5	0.031	32.0
May 16	9	18	167	4	0.024	41.8
May 30	10	19	180	23	0.127	7.8
June 13	9	17	163	17	0.104	9.59
June 27	10	19	180	15	0.083	12.0
July 11	7	13	123	27	0.219	4.5
July 25	10	19	180	17	0.094	10.6
Aug. 8	7	14	126	11	0.087	11.45
Aug. 22	10	19	180	41	0.227	4.4
Sept. 5	9	17	166	29	0.174	5.7
Sept. 19	8	15	133	28	0.210	4.7
Oct. 3	10	19	180	40	0.220	4.5
Oct. 17	10	19	180	7	0.038	25.7
Oct. 31	7	14	119	4	0.033	29.8
Total or Average	132	263	2,363	272	0.115	8.69

and leaves. The general herbaceous feeding behavior of bear (Beeman and Pelton, 1975) is evolutionarily more advanced than evolution of the digestive system; many foods appear unaltered after the digestive process. This is especially prevalent in the spring when the foods are largely grass and other herbaceous stems and leaves. During the summer and fall, bears in the GSMNP alter their food habits to the more nutritious fruits and nuts.

Adult females gained an estimated average of 3 percent from June to July. They are likely eating in the same nutritional plane as males but may not be altering their feeding behavior during the mating season. This may explain the slight weight change of females from June to July.

Reproduction

The female black bear has seasonal constant estrus and has the potential to breed in alternate years after reaching sexual maturity (Erickson et al., 1964). There is substantial evidence that bears breed in late June or early July (Wimsatt, 1963). However, some studies have indicated reproduction may extend into August (Knudsen, 1961; Jonkel and Cowan, 1971). In the GSMNP the earliest

and latest record of breeding activity was June 17 and August 17, respectively.

While breeding likely does peak in July, future studies may show the breeding season extending into August. Since the bear is a seasonal breeder and under no conditions can a second litter be propagated nor can remating occur if pregnancy fails, the length of the breeding season has little significance in determining reproductive rate.

From 1970 through 1974, 81 different black bear litters were observed in the GSMNP. These field observations totaled 170 cubs (Appendix D) for an estimated average litter size of 2.1 cubs (Table 16). Twins were the most frequent litter size (52 percent) followed by triplets (23 percent), singletons (21 percent) and quadruplets (4 percent). One litter of five was reported but not documented by a member of the research team and was not included in the calculations.

It is interesting to note that the estimated litter size from corpora lutea counts in areas adjacent to the Park from North Carolina during the same time period was 2.2 (Collins, 1973). This is nearly the same as in the GSMNP based on field observations of cubs. Equal counts of corpora lutea and cubs (5 to 10 months old) possibly indicate either complete survival or complete

TABLE 16. Different black bear litters observed in the GSMNP from 1970 through 1974

Year	Litter Size				Total Number of Litters	Total Number of Cubs	Average Litter Size
	1	2	3	4			
1970	5	8	4	2	19	41	2.2
1971	2	8	5	0	15	33	2.2
1972	5	14	2	0	21	39	1.9
1973	5	6	2	0	13	23	1.8
1974	<u>0</u>	<u>6</u>	<u>6</u>	<u>1</u>	<u>13</u>	<u>34</u>	<u>2.6</u>
Total	17	42	19	3	81	170	2.1

mortality (pre- or postnatality) of a litter. In other words, it appears uncommon for only part of a litter to be lost.

A comparison of the litter sizes between various geographical areas includes a range from 1.8 to 2.6 (Table 17). At first glance this appears to be a narrow range. However, in animals with a low biotic potential, Craighead et al. (1974) have mathematically illustrated that a very small reproductive change can greatly alter the stability of populations with low biotic potential. Thus, the range of 1.8 to 2.6 (144 percent increase) can be significant.

The GSMNP has a relatively dense bear population and females a relatively small average litter size. By comparing studies where both average litter size and population density are known, there appeared to be an inverse relationship between these two factors (Figure 44). However, the techniques of estimating both litter size and population density varied from study to study and may influence this comparison.

Reproductive status was determined on 46 different females. Thirty-eight of these bears (82.6 percent) were barren and the other 17.4 percent had cubs during June to September. The reproductive histories of 10 adult female bears captured in two or more years is presented in

TABLE 17. A comparison of black bear litter size between various geographical areas of North America

Study	Geographical Location	Average Litter Size	Method of Determining Litter Size
Hatler (1967)	Alaska	1.73	Field count
Spencer (1955)	Maine	2.4	Field count
Poelker and Hartwell (1973)	Washington	1.9	Corpora lutea
Jonkel and Cowan (1971)	Montana	1.8	Field count
Erickson et al. (1964)	Michigan	2.15	Field count
Stickley (1961)	Virginia	2.6	Corpora albicantia
Collins (1973)	North Carolina	2.2	Corpora lutea
Harlow (1961)	Florida	2.2	Field count
Beeman	Great Smoky Mountains National Park	2.1	Field count

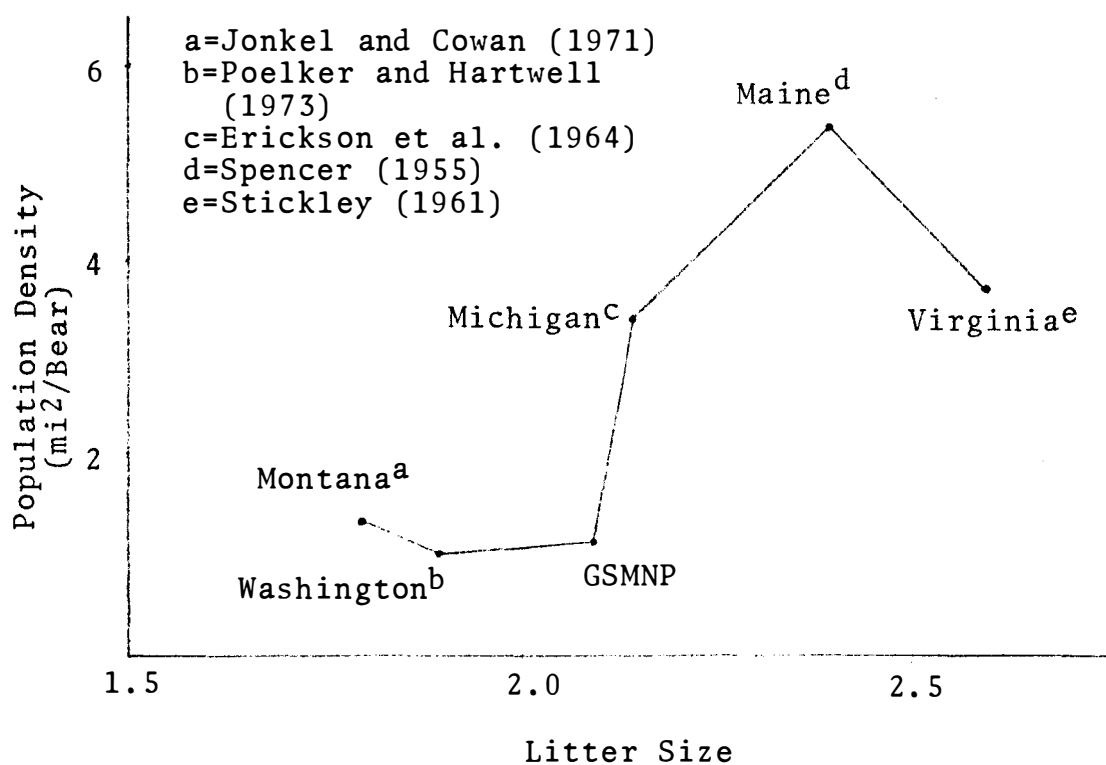


Figure 44. Relationship of litter size and population density in black bear studies conducted in various geographical areas.

Table 18. Bear R6 complies with the belief that black bears produce a litter in alternate years; five years of data show this bear produced two litters. Six other adult females of known age with two years' capture data were barren both years. In addition, two more females that were thought (although not documented by the cementum-annuli technique) to be adults, were barren for two consecutive years. These data suggest frequency of litter bearing in the GSMNP is far below the biotic potential.

Discussion of Population Characteristics

While the final population estimates of sex ratio, age distribution, survival rate, growth, and reproduction in this study may not withstand critical analysis, they are the best information available and are the only description of the bear population in the GSMNP. As research continues in the GSMNP and more data are accumulated, the results will be improved upon and a more critical review of idea and hypothesis can be made.

By using a radioactive tagged feces method, Marcum (1974) was able to estimate the black bear population in a 36,437 hectares (140 mi²) area of the Park at 1 bear/275 hectares (1.06 mi²). Within one 4405 hectare (40 mi²) area, Marcum found one subpopulation of 1 bear/109 hectares

TABLE 18. Reproductive history of adult female bears in the GSMNP during 1970 through 1974

Bear Number	Year	Age	Cubs
R56	1970	Unknown	0
	1971	Unknown	2
	1972	Unknown	0
	1973	Unknown	2
	1974	Unknown	0
W1	1970	Unknown	0
	1971	Unknown	0
W42	1972	Unknown	1
	1973	Unknown	0
R67	1973	4.5	0
	1974	5.5	0
W60	1973	6.5	0
	1974	7.5	0
Y56	1973	16.5	0
	1974	17.5	0
B54	1973	6.5	0
	1974	7.5	0
R53	1973	4.5	0
	1974	5.5	0
B50	1972	8.5	1
	1973	9.5	0
Y30	1972	4.5	0
	1973	5.5	0

(0.42 mi²). This density is higher than estimated densities in Michigan (Erickson et al., 1964), Yellowstone National Park (Barnes and Bray, 1967), Maine (Spencer, 1955), and Virginia (Stickley, 1961) (Table 19). Jonkel and Cowan (1971) estimated a black bear density of 1 bear per 207 hectares (0.8 mi²) in Montana that declined to 1 bear per 518 hectares (2 mi²) in five years. Also, Kemp (1970) estimated a bear population in Alberta of 1 bear per 259 hectares (1 mi²). The Alberta bear population, like the bear population of the GSMNP, is not exploited by hunting. The Montana population has only light hunting exploitation.

Comparisons of bear densities from one area to another are not conclusive unless the census techniques and other environmental components are discussed. For example, a subjective judgment of bear density by using bear sign may yield very different results from using a marked/unmarked ratio technique. Also, as shown by Marcum (1974), concentrations of bears within a population may vary within an area due to habitat variations.

The estimates of most wildlife populations are subject to bias. Estimates using trapping results are biased by "trap proneness" or "trap shyness" of certain individual animals. Estimates using field observations can be distorted by some individuals (i.e., female with

TABLE 19. Population density of the black bear population in the GSMNP compared with that of other geographical areas

Area	Density of Bears	Census Method
Yellowstone Nat. Park ^a	1/20.7 mi ² to 1/1.4 mi ²	Field observations of tagged and untagged bears
Washington ^b	1/mi ²	Trapping per unit area
Maine ^c	1/5-6 mi ²	Various methods
Virginia ^d	1/3.9 mi ²	Questionnaires to game wardens
Montana ^e	1/0.8 mi ² to 1/2 mi ²	Spot census
GSMNP	1/1.06 mi ² (entire study area) 1/0.42 mi ² (area of radio- tracking)	Radio-active tagged feces

^aBarnes and Bray (1967).

^bPoelker and Hartwell (1973).

^cSpencer (1955).

^dStickley (1957).

^eJonkel and Cowan (1971).

cubs) being more easily seen than other individuals of the population. Any bias caused by visual observations in this study were eliminated by using radio-isotope tagged feces for determining ratios of marked and unmarked animals.

High bear population densities are usually associated with diverse habitat (Jonkel and Cowan, 1971; Kemp, 1970; Barnes and Bray, 1967). A diverse habitat gives a variety of food items to select and reduces the bear's dependence on a few food types. As described earlier, the GSMNP offers an extremely diverse vegetation pattern. With the steep slopes, narrow valleys and different exposures of the Park, an interspersed of the various forest types is found.

Bear densities and their fluctuations have interested hunters and biologists for a long time. Scott (1947) stated that bear populations are not unlike other game species and fluctuate regularly. Schroger (1949) discusses bear irruptions in the earlier part of this century in the upper Mississippi drainages. During these irruptive years, Schroger noted gray squirrels (Sciurus carolineus) were also migrating during the fall of the year. He concluded bear irruptions were emigrations that were correlated with a lack of fall food. Troyer and Hensel (1961) suggested that food is the most important

factor regulating bear populations. Spencer (1955) found food abundance affected black bear abundance in Maine.

In the GSMNP there is a wide variety of food items available to the black bear except in the late fall (Beeman and Pelton, 1975). Acorns, hickory nuts and beechnuts are the staple food items during this season. These three mast producers are inconsistent from year to year (Baker, 1950: 192-193). During these periods of mast scarcity, the number of bears entering communities and private residences surrounding the Park greatly increases (Beeman and Pelton, 1975). These bears are usually killed or captured and removed to a wildlife management area outside the GSMNP. Undoubtedly, this periodic emigration and loss of the bears coming originally from the Park is one means by which the population is regulated.

The periodic mast failures mentioned above may have other effects on the population besides emigration. A few bears were captured in the spring that were extremely thin and appeared to be malnourished. These bears were possibly more vulnerable to decimating factors during the spring. Very likely, the decimating factors are more pronounced in the spring than during the denning period. While the denning period causes a substantial

drain on a bear's energy reserves, the records show that male bears are still losing weight during the spring (inadequate data are available for females). The spring foods of grass and other herbaceous plants (Beeman and Pelton, 1975) are less adequate than summer and fall foods for fulfilling the energy requirements of a bear's movements and activities. This annual pattern of body condition suggests that the amount of energy reserves stored in the fall is important in the winter but perhaps even more critical during the spring. The body condition of bears in the spring is probably predetermined in the fall when more nutritious foods are available.

Penned bears that are maintained on a high nutritional plane grow much more rapidly and mature sexually sooner than most bears in the wild. The two female cubs abandoned in the GSMNP when only two months old and maintained in pens came in estrus at 2.5 years. Additionally, some of the females maintained in pens in North Carolina bred at 2.5 years of age (A. E. Ammons, personal communications). Potentially, bears can breed in alternate years; one bear (R6) in the GSMNP did, but many others did not.

Besides the quality of the habitat being important, the annual growing season also determines sexual maturity. Jonkel and Cowan (1971) reported good bear habitat in

Montana but a short growing season. These authors found no bears in estrus younger than 4.5 years old and no successful litters produced by bears younger than 6.5 years old. In Washington one-third of the 3.5 year old females bred (Poelker and Hartwell, 1973). These data were collected by corpora lutea counts; therefore, the success of parturition and rearing young was unknown. In North Carolina, 80 percent of the 3.5 year old females had active corpora lutea (Collins, 1973). These results suggest that female bears in the more southern latitudes mature sexually sooner than in the more northern latitudes. This is likely a reflection of a longer growing season in the southern latitudes rather than inferior habitat of the northern latitudes.

From the preliminary data available there appears to be a large discrepancy between the percentage of females with active corpora lutea in the fall and the percentage of females with cubs the following summer. For example, in Washington 26 percent of the females captured over a three-year period were found in an estrus condition (Poelker and Hartwell, 1973). However, only 16 percent of the adult females during the same period were lactating. This suggests that somewhere in the reproductive process between estrus and post-natal care of the cubs five to nine months, a loss of 38 percent was

incurred. In similar terrain adjacent to the GSMNP, Collins (1973) used corpora lutea counts to estimate that 66 percent of the adult females were pregnant in North Carolina over a three-year period. However, in the GSMNP 17.6 percent of the adult females were observed bearing young. This is similar to the findings of Jonkel and Cowan (1971) who used field counts to estimate that only 16 percent of the adult females were bearing cubs. Although these data are preliminary at best, they suggest that a critical time exists sometime during implantation, parturition and/or post-natal care of the young. It was mentioned earlier that it appears many adult females are either totally successful or totally unsuccessful in rearing cubs through the first summer.

CHAPTER V

CONCLUSIONS AND SUMMARY

1. There are two cohorts of bears in the GSMNP that have distinct population characteristics; panhandler and back-country bears. Back-country bears had a high proportion of adult bears and a nearly balanced male:female sex ratio. Panhandler bears had a lower proportion of adult bears and a higher proportion of males than back-country bears.

2. Adult males averaged 7.2 years old and adult females 7.8 years. Adults made up 68 percent of the total population and had an average survival rate of 78.3 percent. The oldest male and female captured were 12.5 and 17.5 years old, respectively.

3. The proportion of cubs and yearlings in the GSMNP bear population was lower than that reported by other studies. This small proportion is accounted for by a low reproductive rate plus dispersal of young bears out of the GSMNP.

4. Male bears grow at a faster rate as well as considerably larger than females. The average weight of adult males and females was 113.2 and 47.2 kilograms, respectively. The largest male and female captured

weighed 231.9 and 90.9, respectively. Males obtained approximately one-half of their growth potential at sexual maturity and continued to grow until 7 to 10 years of age. Females were nearly full grown at sexual maturity. Weights of individual bears fluctuated up and down depending on the season and the available food supply. Nutrition and food scarcity appear to greatly retard growth of bears in the GSMNP. The weight changes of individual bears vary considerably between years, but the net weight change of the population is relatively stable.

5. There was a general trend for bears to be at their optimum weight in the late fall, slowly lose weight during the winter and spring, and add weight during the late summer and fall. Males continue to lose weight during the spring and early summer due to breeding behavior and scarcity of nutritious foods. Adult females maintain their weight during the spring and accelerate their weight gain during the summer and fall.

6. Intrinsic and extrinsic factors appear to be regulating the GSMNP black bear population. An inadequate supply of fall food may be an effective extrinsic population regulatory and is probably the cause of population instability during the last few years. Dispersal of young bears and intraspecific strife between bears of the

same sex are also likely helping to regulate the population.

7. Breeding activity for black bears in the GSMNP continues over a longer period of time than some other studies have indicated. Although breeding probably peaks in July, it extends from June until late August.

8. The reproductive rate of bears in the GSMNP is quite low. Average litter size was 2.1 and only 17.4 percent of the adult females had cubs. Potentially, bears can have young in alternate years; at least one female did. However, most adult females went successive years without successfully rearing young. During the five years that field observations were recorded, the smallest average litter size was recorded during a year following a mast failure. However, the data are inadequate to directly correlate fall food shortages and low reproductive success.

9. There appears to be a substantial loss of cubs from the time of fertilization until the cubs are five to nine months old. These losses appear to be entire litters rather than partial litters. Little information on the causes of failure to implant, prenatal mortality or early postnatal mortality was found.

10. Nutrition and the availability of foods in the GSMNP retard growth and maturity of bears. This in turn

lowers reproduction by delaying the initial time that females successfully raise young.

11. Due to the diverse habitat, home ranges of GSMNP bears were small compared with some estimates made in other geographical areas. Adult females limited their movements to a 721 hectare (1780 acres) area. Home ranges of subadult males were difficult to assess due to their dispersal movements but averaged 650 hectares (1606 acres). One adult male restricted its movements to 1901 hectares (4695 acres) and slightly expanded the range to 2242 hectares (5538 acres) the following year.

12. Three bears made a sudden shift out of their home area in October for a three-week period and then returned to den. It was suspected these bears went to a feeding ground where mast was abundant, although this was not confirmed.

13. Panhandler bears spend considerable time around trail shelters, although this varies with individual bears. Panhandler animals appear to obtain only small amounts of food from backpackers. These animals forage for native foods and only supplement their diet with food from backpackers. Also, when food brought in by backpackers was reduced in the fall, panhandler bears readily adapted to only native foods. All panhandler

bears radiotracked in this study appeared to be in good physical condition.

14. There is some evidence that panhandler females with cubs avoid people when cubs are young (less than seven months old). However, when cubs become older, females appear less inhibited to enter areas with people.

15. Back-country bears completely avoided people. Their activities and movements were largely related to areas where seasonal foods were available.

16. There was both direct and circumstantial evidence that subadult males are not a stable part of the population and are somehow forced out of their place of birth to find a home area. Dispersal of many bears appears not to be complete until near adulthood.

17. The home range of the one adult male radio-tracked was approximately three times larger than the adult females' and included areas of several different adult females.

18. Bears in the GSMNP vary considerably in range of their movements during a 24-hour period. The minimum distance moved during a diel movement ranged from 2.62 to 21.08 kilometers and averaged 13.17 kilometers. The belief that bears are nocturnal was only partially substantiated during this study. Bears were found active

during any time of the day or night, but were most active during 1800 to 2400 hours and least active during 1200 to 1800 hours.

19. There are six basic forest types in the GSMNP although only five are present in the area of radiotracking. Bears used all the habitat types but over 80 percent of the locations were in the closed oak and cove hardwood forests. During the summer, the closed oak and open oak and pine forests were the most preferred habitat types due to their abundance of berry-producing shrubs. Bears concentrated in the closed oak forest during the fall to take advantage of acorns and hickory nuts. The northern hardwood forest was the least preferred forest type.

20. Due to juxtaposition of various habitat types caused by various exposures, steep slopes, and narrow valleys, diverse habitats are found at varying elevations. Therefore, there did not appear to be any elevation shifts of bears from summer to winter.

21. There is a great deal of home range overlap between members of the same sex. Nevertheless, there did appear to be some form of territoriality. Certain areas were mutually exclusive of other bears of the same kind. Bears in the GSMNP scratch, bite, and rub trees that may be some form of marking. Also, urine and feces could serve

to advertise a bear's presence and serve to bring bears together or to maintain distance.

22. Under certain conditions bears will tolerate each other at relatively close distances (campgrounds, trail shelters, and areas of native food concentrations). In these situations bears will freely enter areas that are mutually visited by other bears. This allows for neighboring bears to take advantage of an especially rich supply of seasonal food in areas outside their home range.

23. Moving panhandler bears to various areas inside the Park has been only partially successful due to the homing ability of black bears. Within the limits that bears were transplanted there was only a weak relationship between the percent of bears homing and the distance they were transplanted. Bears with previous homing experience were more likely to home than inexperienced bears. There is circumstantial evidence that many bears moved to the Park periphery are poached.

24. Since bears are capable of making visual discriminations and have long-term retention, it is suspected that GSMNP bears home by recognition of physical features of the terrain. However, other means of navigation were not tested.

25. GSMNP bears entered their dens in early December and emerged some time after early March. Two bears abandoned their den sites and a third temporarily left and then returned during mid-winter.

26. Five of the six dens located were in tree cavities far off the ground. The other den was under a stump on the ground. The tree dens were in over-mature hemlock and red maple trees. These dens remained dry, offered protection against the wind, and were well insulated for conserving body heat.

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APPENDIXES

APPENDIX A

TABLE 20. Results of attempted captures of free-roaming black bears by using the projectile syringe gun

Bear No.	Date	Sex	Weight (kg.)	Location	Comments
None	5/18/72	M	130	Cades Cove Cpgd.	Overdosed by the Park with (sucostin) ^a
B8	5/24/72	M	175	Cades Cove Cpgd.	Did not run after being shot (M99)
B8	6/13/72	M	159	Cades Cove Cpgd.	Did not run after being shot (M99)
B28	7/7/72	M	14	Spence Field	Ran a short distance before stopping (M99)
B29	7/12/72	M	9	Spence Field	Ran up a tree and fell after becoming immobile (M99)
B30	7/19/72	M	153	Cades Cove Cpgd.	Did not run after being shot
None	7/20/72	M	-	Cades Cove Cpgd.	Ran after being shot and was never found (M99)
W31	7/20/72	M	116	Hwy. 441	Ran a short distance before stopping (M99)
R30	7/27/72	F	68	Siler's Bald	Ran a short distance before stopping (M99)
None	7/28/72	-	-	Siler's Bald	Ran off and never located (M99)
R31	7/28/72	M	7	Siler's Bald	Ran up a tree but came back down before becoming immobilized (M99)
R35	7/28/72	F	6	Siler's Bald	Ran off but came back before becoming immobilized (M99)
R33	7/28/72	F	65	Hwy. 441	Ran off short distance before stopping (Sernylan)
None	7/28/72	M	-	Hwy. 441	Ran off and was never located (M99)

TABLE 20 (continued)

Bear No.	Date	Sex	Weight (kg.)	Location	Comments
Y37	8/4/72	M	116	Cades Cove Cpgd.	Ran a short distance before stopping (M99)
R39	8/3/72	M	182	Cades Cove Cpgd.	Did not run after being shot (Sernylan)
Y35	8/4/72	M	175	Cades Cove Cpgd.	Did not run after being shot (M99)
W31	8/9/72	M	122	Hwy. 441	Ran a short distance before stopping (M99)
R36	8/14/72	M	146	Cades Cove Cpgd.	Did not run after being shot (M99)
R26	8/17/72	M	142	Cades Cove Cpgd.	Ran a short distance before stopping (M99)
R39	8/23/72	M	187	Cades Cove Cpgd.	Did not run after being shot (M99)
Y26	8/23/72	M	155	Cades Cove Cpgd.	Ran after being shot (M99)
B50	8/25/72	F	68	Spence Field	Ran a short distance after being shot (M99)
B50	8/28/72	F	68	Spence Field	Ran a short distance after being shot (M99)
W33	9/8/72	M	82	Hwy. 441	Required 5 doses of sernylan
W48	9/14/72	M	23	Thomas Ridge	Ran short distance after being shot (M99)
B46	11/14/72	M	11	Newfound Gap	Ran short distance after being shot (Sernylan)

^aDrug used.

APPENDIX B

TABLE 21. Black bear capture data in the Great Smoky Mountains National Park

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
1	B36	6/6/68	M	7.5	-	Cades Cove	Tremont
2		5/30/69		8.5	300	Cades Cove	Hwy. 129
3		6/6/69		8.5	-	Cades Cove	Parson's Branch
4		9/1/69		8.5	350	Cades Cove	Hwy. 129
5		5/8/70		9.5	319	Cades Cove	Tremont
6		6/26/70		9.5	-	Cades Cove	Tremont
7		8/8/70		9.5	-	Cades Cove	Tremont
8		8/13/70		9.5	350	Cades Cove	Tremont
9		8/21/70		9.5	-	Cades Cove	Cooper Creek
10		5/23/70		9.5	-	Cades Cove	Bunker Hill
11		5/24/71		10.5	-	Cades Cove	Hwy. 129
12		8/14/72		11.5	318	Cades Cove	Cooper Road
13		8/18/72		11.5	-	Cades Cove	Bunker Hill
14	146	10/27/67	M	-	510	Elkmont	Pisgah Nat'l Forest
15	176	6/13/72	M	-	100	Cosby	Davenport Gap
16		8/27/68		-	125	Cosby	Noisy Creek
17	108	5/24/67	M	-	350	Elkmont	Ramsey Cascades
18		5/25/68		-	400	Elkmont	Given to state
19	3	6/2/67	M	-	-	Cades Cove	Parson's Branch
20		6/14/68		-	500	Cades Cove	Given to state
21	1	5/20/67	M	-	250	Cades Cove	Hwy. 129
22		8/2/68		-	300	Cades Cove	Given to state
23	122	6/17/66	M	-	150	Hwy. 441	Tremont
24		5/4/68		-	-	Hwy. 441	Killed
25	102	5/16/67	M	-	250	Elkmont	Ramsey Cascades
26	5	6/3/67	M	-	-	Cades Cove	Hwy. 129
27	103	5/20/67	M	-	225	Chimneys	Ramsey Cascades
28	106	5/23/67	M	-	400	Chimneys	Ramsey Cascades
29	118	6/15/67	F	-	-	Big Walnut	Hwy. 129
30	110	5/26/67	M	-	300	Chimneys	Ramsey Cascades
31	128	7/9/67	M	-	50	Twin Creeks	Tremont
32	130	7/15/67	M	-	60	Big Walnut	Tremont
33	132	7/16/67	F	-	-	Hwy. 441	Tremont
34	136	7/16/67	M	-	-	Hwy. 441	Given to state

TABLE 21 (continued)

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
35	138	7/27/67	F	-	-	Hwy. 441	Given to state
36	140	8/11/67	F	-	190	Hwy. 441	Deals Gap
37	18	6/6/68	M	-	300	Cades Cove	Hwy. 129
38	20	6/11/68	M	-	300	Cades Cove	Hwy. 129
39	22	6/13/68	M	-	175	Cades Cove	Hwy. 129
40	24	7/26/68	M	-	250	Cades Cove	Hesse Creek
41	30	7/30/68	M	-	100	Cades Cove	Deals Gap
42	32	7/31/68	M	-	400	Cades Cove	Deals Gap
43	38	8/14/68	M	-	200	Cades Cove	Deals Gap
44	150	5/16/68	M	-	250	Chimneys	Mt. Sterling
45	156	6/5/68	M	-	350	Cosby	Tremont
46	154	6/4/68	M	-	100	Chimneys	Mt. Sterling
47	161	9/6/68	M	-	200	Elkmont	Mt. Sterling
48	175	6/13/68	M	-	100	Cosby	Davenport Gap
49	203	5/21/68	M	-	250	Cosby	Noisy Creek
50	304	8/4/68	M	-	125	Cosby	Mt. Sterling
51	309	8/29/68	M	-	250	Cosby	Noisy Creek
52	311	8/29/68	M	-	125	Cosby	Noisy Creek
53	314	6/26/69	M	-	300	Cosby	Copeland Creek
54		6/10/69			300	Cades Cove	Tremont
55	16	6/7/68	M	-	200	Cades Cove	Tremont
56		8/3/68			-	Cades Cove	Deals Gap
57	26	7/26/68	M	-	300	Cades Cove	Deals Gap
58		8/10/68			-	Cades Cove	Hwy. 129
59		8/22/68			-	Cades Cove	Hwy. 129
60	34	8/4/68	M	-	250	Cades Cove	Hesse Creek
61		8/13/68			-	Cades Cove	Hwy. 129
62	36	8/8/68	M	-	-	Cades Cove	Unknown
63		8/16/68			-	Cades Cove	Killed
64	12	5/9/68	M	-	475	Cades Cove	Parson's Branch
65		8/5/68			-	Cades Cove	Mt. Sterling
66	28	7/2/68	F	-	60	Cades Cove	School House Gap
67		8/2/68			100	Cades Cove	Hesse Creek
68	G3	8/11/70	F	-	150	Cosby	Tremont
69	W1	9/9/70	F	-	140	Cades Cove	Tremont
70		5/23/71			145	Cades Cove	Tremont
71		8/30/71			165	Cades Cove	Tremont
72	R6	9/13/70	F	-	185	Collins Gap	Same
73		9/5/74			200	Collins Gap	Little Cataloochee
74	P2	8/29/70	M	-	228	Cosby	Same ^a

TABLE 21 (continued)

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
75	R1	6/12/70	M	-	150	Cosby	Killed
76	W6	9/10/70	M	-	200	Collins Gap	Same
77	G4	9/18/70	M	-	235	Thomas Ridge	Same
78	G7	8/4/70	M	-	220	Cades Cove	Tremont
79	Y16	7/16/70	M	-	205	Cades Cove	Tremont
80		6/20/71			205	Cades Cove	Tremont
81		6/3/71			-	Cades Cove	Bible Creek
82		6/5/71			-	Cades Cove	Bunker Hill
83		6/7/71			-	Cades Cove	Hesse Creek
84	R4	8/22/70	M	-	209	Cades Cove	Indian Camp
85		6/5/71			210	Cades Cove	Sam's Gap
86		6/7/71			-	Cades Cove	Hesse Creek
87		6/24/71			-	Cades Cove	Tremont
88		7/4/71			-	Cades Cove	Davenport Gap
89	W22	7/14/70	M	-	142	Bote Mtn.	Same
90	B11	8/15/70	M	-	300	Cades Cove	Tremont
91		8/23/70			-	Cades Cove	Bunker Hill
92		7/9/71			-	Cades Cove	Tremont
93		8/27/71			-	Cades Cove	Ramsey Cascades
94		7/27/72			-	Cades Cove	Tremont
95	P5	10/10/70	M	-	200	Sugarlands	Tremont
96	W11	7/31/70	M	-	236	Cades Cove	Tremont
97		8/8/70			-	Cades Cove	Tremont
98		9/3/70			-	Cades Cove	Tremont
99	Y2	4/21/70	M	-	500+	Cades Cove	Tremont
100		8/22/70			-	Cades Cove	Bunker Hill
101		9/4/70			-	Cades Cove	Hesse Creek
102		9/7/70			-	Cades Cove	Bunker Hill
103		6/24/71			500+	Cades Cove	Twenty-mile Station
104		9/9/71			-	Cades Cove	Greenbriar
105	P3	8/17/70	M	-	375	Cades Cove	Tremont
106		8/17/71			420	Cades Cove	Tremont
107		8/20/71			-	Cades Cove	Bunker Hill
108		8/25/71			-	Cades Cove	Tremont
109	Y37	8/5/70	M	4.5	200	Cades Cove	Tremont
110		8/30/71		5.5	-	Cades Cove	Tremont
111		8/4/72		6.5	255	Cades Cove	Tremont
112		8/14/72			-	Cades Cove	Bunker Hill
113	Y35	8/14/70	M	6.5	365	Cades Cove	Indian Camp Road

TABLE 21 (continued)

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
114		8/4/72		8.5	420	Cades Cove	Bunker Hill
115	R39	8/17/70	M	8.5	375	Cades Cove	Cooper Creek
116		8/17/71		9.5	420	Cades Cove	Tremont
117		8/20/71			-	Cades Cove	Bunker Hill
118		8/25/71			400	Cades Cove	Tremont
119		8/3/72		10.5	-	Cades Cove	Bunker Hill
120		8/23/72			415	Cades Cove	Bunker Hill
121	Y26	6/26/70	M	9.5	211	Cades Cove	Forge Creek
122		7/14/70			-	Cades Cove	Cooper Creek
123		8/7/70			215	Cades Cove	Sam's Gap
124		6/6/71		10.5	220	Cades Cove	Sam's Gap
125		6/9/72		11.5	347	Cades Cove	Sam's Gap
126		8/23/72			342	Cades Cove	Sam's Gap
127		6/11/73		12.5	280	Cades Cove	Bunker Hill
128		8/3/73			320	Cades Cove	Tremont
129	P20	9/11/70	M	.5	20	Thomas Ridge	Same
130	R20	8/29/71	F	-	90	Grouse Creek	Same
131	W16	7/26/71	F	-	140	Spence Field	Same
132	W24	8/6/71	F	-	90	Cosby	Same
133	G8	9/13/71	M	-	220	Spence Field	Same
134	P8	7/17/71	M	-	200	Defeat Ridge	Same
135	B8	5/24/72	M	6.5	384	Cades Cove	Parson's Branch
136		6/13/72			350	Cades Cove	Indian Camp Road
137		7/19/72			-	Cades Cove	Indian Camp Road
138	B52	7/1/71	M	3.5	170	Cades Cove	Tremont
139		6/14/72		4.5	260	Cades Cove	Cooper Road
140		6/17/73		5.5	320	Cades Cove	Tremont
141	B10	7/1/71	M	3.5	170	Cades Cove	Tremont
142		9/10/71			-	Cades Cove	Sam's Gap
143		6/14/72		4.5	260	Cades Cove	Cooper Road
144		8/17/72			312	Cades Cove	Hatcher Mtn.
145	R22	7/7/71	M	-	80	Tricorner Knob	Same
146	W42	11/7/72	F	-	102	Sugarlands	Hwy. 441
147	R33	7/28/72	F	5.5	142	Hwy. 441	Tremont
148	R26	6/20/72	M	5.5	250	Bote Mtn.	Same
149		7/11/72			203	Bote Mtn.	Same
150		6/29/73		6.5	243	Bote Mtn.	Same
151		6/19/74		7.5	220	Bote Mtn.	Same
152	B50	8/25/72	F	8.5	150	Spence Field	Same
153		8/16/73		9.5	173	Bote Mtn.	Same

TABLE 21 (continued)

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
154	Y30	7/6/72	F	4.5	120	Spence Field	Same
155		7/27/73		5.5	150	Little Bald	Same
156	R30	7/27/72	F	-	150	Siler's Bald	Same
157	None	5/18/72	M	-	286	Cades Cove	Killed
158	W33	9/8/72	M	-	180	Hwy. 441	Chimneys
159	W31	7/20/72	M	-	255	Hwy. 441	Tremont
160		8/9/72			268	Hwy. 441	Sam's Gap
161		8/21/72			275	Hwy. 441	Hatcher Mtn.
162	W27	6/23/72	M	5.5	260	Forge Creek	Same
163	R43	9/8/72	M	5.5	163	Walnut Bottoms	Tremont
164	R46	8/16/72	M	7.5	385	Elkmont	Hatcher Mtn.
165	R31	7/28/72	M	.5	15	Siler's Bald	Same
166		10/20/74		2.5	155	Tremont	Bote Mtn.
167	Y31	7/13/72	M	1.5	60	Bote Mtn.	Same
168		6/16/74		3.5	120	Bote Mtn.	Same
169		7/11/74			-	Bote Mtn.	Same
170	B28	7/7/72	M	1.5	30	Spence Field	Same
171	B29	7/12/72	F	1.5	20	Spence Field	Same
172		6/21/73		2.5	50	Bote Mtn.	Same
173		7/10/74		3.5	-	Bote Mtn.	Same
174		9/13/74			60	Spence Field	Same
175	W40	11/7/72	M	.5	22	Sugarlands	Hwy. 441
176	W37	7/3/72	M	1.5	50	Forge Creek	Tremont
177	B35	8/15/72	M	2.5	125	Cades Cove	Tremont
178	B46	11/14/72	M	.5	25	Newfound Gap	Tremont
179	W48	9/14/72	M	1.5	93	Thomas Ridge	Same
180	W41	11/17/72	M	.5	15	Seymour, Tn.	Tellico WMA
181	R45	9/6/72	F	.5	12	Tremont	Same
182	B39	11/14/72	F	.5	12	Newfound Gap	Tremont
183	R35	7/28/72	F	.5	13	Siler's Bald	Same
184	W30	7/13/72	M	2.5	60	Spence Field	Same
185	Y29	7/6/72	M	6.5	190	Bote Mtn.	Same
186		7/17/72			-	Bote Mtn.	Same
187	B57	7/18/73	F	-	110	Miry Ridge	Same
188	None	6/19/73	F	-	120	Bote Mtn.	Killed
189	W52	6/17/73	F	11.5	115	Bote Mtn.	Same
190	Y67	8/23/73	F	10.5	85	Sam's Gap	Same
191	B63	8/8/73	F	12.5	119	Forge Creek	Same
192	Y58	7/21/73	F	13.5	120	Jake's Gap	Same
193	Y54	7/17/73	F	4.5	70	Bent Arm	Same

TABLE 21 (continued)

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
194	R54	7/5/73	F	9.5	100	Defeat Ridge	Same
195	W60	7/18/73	F	6.5	65	Miry Ridge	Same
196		8/20/74		7.5	95	Miry Ridge	Same
197	Y56	7/7/73	F	16.5	103	Defeat Ridge	Same
						Abandoned Trail	
198		7/5/74		17.5	115	Defeat Ridge	Same
						Abandoned Trail	
199	Y70	9/7/73	F	11.5	120	Spence Field	Same
200	R53	6/19/73	F	4.5	72	Bote Mtn.	Same
201		9/12/73			95	Bote Mtn.	Same
202		6/26/74		5.5	90	Bote Mtn.	Same
203	Y52	7/3/73	F	4.5	71	Bote Mtn.	Same
204		9/25/73			100	Bote Mtn.	Same
205		6/16/74		5.5	100	Bote Mtn.	Same
206		7/5/74			-	Bote Mtn.	Same
207	B54	7/4/73	F	6.5	100	Defeat Ridge	Same
						Abandoned Trail	
208		7/10/74		7.5	85	Defeat Ridge	Same
						Abandoned Trail	
209	R67	9/4/73	F	4.5	75	Bote Mtn.	Same
210		6/15/74		5.5	75	Bote Mtn.	Same
211	Y61	8/9/73	F	5.5	120	Forge Creek	Same
212	Y66	8/16/73	M	11.5	250	Sugarlands	Same
						Trail	
213		8/8/73			-	Sugarlands	Same
						Trail	
214	Y63	8/8/73	M	8.5	158	Scott's Gap	Same
215	B61	7/31/73	M	5.5	100	Derrick Knob	Same
216	W64	8/9/73	M	5.5	145	Scott's Gap	Same
217	Y62	8/7/73	M	4.5	110	Rabbit Creek	Same
						Road	
218	W10	11/27/73	M	-	375	Tremont	Same
219	W58	7/24/73	M	2.5	105	Little Bald	Same
220	Y60	7/24/73	M	2.5	73	Bote Mtn.	Same
221		8/9/73			80	Bote Mtn.	Same
222		6/22/74		3.5	140	Bote Mtn.	Same
223		7/4/74			-	Bote Mtn.	Same
224	Y68	8/28/73	M	1.5	55	Bote Mtn.	Same
225	Y65	7/28/73	M	3.5	185	Little Bald	Same
226	W59	7/19/73	F	3.5	40	Jake's Gap	Same
						Trail	

TABLE 21 (continued)

Ref. No.	Bear No.	Date	Sex	Age	Weight (Lbs.)	Capture Point	Release Point
227	B51	7/4/73	F	1.5	38	Defeat Ridge Abandoned Trail	Same
228	W67	9/27/73	M	2.5	100	Bote Mtn.	Same
229	R56	7/12/73	M	3.5	93	Bote Mtn.	Same
230	R55	6/17/73	M	3.5	87	Cades Cove	Same
231	B83	7/25/74	F	13.5	140	Scott's Gap	Same
232	B85	7/25/74	F	5.5	120	Bote Mtn.	Same
233	B95	8/19/74	F	-	130	Buckeye Gap	Same
234	B79	7/24/74	F	6.5	105	Scott's Gap	Same
235	W55	6/19/74	F	8.5	130	Bote Mtn.	Same
236	B97	8/27/74	F	-	175	Thomas Ridge	Little Cataloochee
237	Y81	8/1/74	F	5.5	105	Sugarlands Trail	Same
238	B93	8/18/74	F	5.5	110	Sam's Gap	Same
239	Y86	9/13/74	F	5.5	65	Bote Mtn.	Same
240	W56	6/22/74	M	3.5	145	Bote Mtn.	Same
241	B56	8/5/74	M	3.5	165	Bent Arm	Same
242	W60	6/27/74	M	-	170	Bote Mtn.	Same
243	G61	7/2/74	M	-	120	Defeat Ridge	Same
244	W76	6/15/74	M	6.5	170	Bote Mtn.	Same
245		7/4/74			-	Defeat Ridge	Same
246	Y79	7/31/74	M	7.5	165	Sugarlands Trail	Same
247	Y77	7/30/74	M	10.5	190	Sugarlands Trail	Same
248	G100	9/10/74	M	4.5	100	Bote Mtn.	Same
249	W59	6/26/74	M	5.5	150	Bote Mtn.	Same
250		6/28/74			-	Bote Mtn.	Same
251	B80	7/25/74	M	5.5	170	Rabbit Creek Road	Same
252	Y83	8/1/74	M	4.5	85	Sugarlands Trail	Same
253	B88	8/8/74	M	4.5	170	Bent Arm	Same
254	B70	8/8/74	M	4.5	150	Cucumber Gap	Same
255	W58	6/25/74	M	3.5	135	Bote Mtn.	Same
256		9/11/74	M		125	Bote Mtn.	Same
257	W52	6/16/74	M	4.5	115	Bote Mtn.	Same
258		6/19/74			-	Bote Mtn.	Same
259	W53	6/19/74	M	4.5	85	Bote Mtn.	Same
260		6/27/74			-	Bote Mtn.	Same
261	B76	7/24/74	M	4.5	125	Rabbit Creek Road	Same

^aSame as capture point.

APPENDIX C

CALCULATION OF THE AVERAGE POPULATION SURVIVAL RATE ($\bar{s}_x$) OF BEARS IN THE GSMNP (1972-1974)

$$\bar{s}_x = \frac{\sum (L_x + 1)y}{\sum L_x y}$$

where L_x = bears surviving of the same age (cohort)
 y = number of cohorts

Entire bear population: $\bar{s}_x = \frac{\sum (18+9+6+6+5+5+5+2+2)}{\sum (18+18+9+6+6+5+5+5+2)} = \frac{58}{74} = .78$

Back-country bears: $\bar{s}_x = \frac{\sum (13+5+3+2+1+1+2+2+2)}{\sum (14+13+5+3+2+1+1+2+2)} = \frac{31}{43} = .72$

Panhandler bears: $\bar{s}_x = \frac{\sum (5+4+3+4+4+3+3+1)}{\sum (4+5+4+3+4+4+3+3)} = \frac{27}{30} = .90$

APPENDIX D

TABLE 22. Different bear litters observed from 1970 through 1974 in the GSMNP.

Year	Location	Litter Size
1970	Spence Field	3
	Noland Ridge	2
	Noland Ridge	1
	Mt. LeConte	2
	Siler's Bald	2
	Cosby Knob	2
	Boulevard Trail	1
	Mt. Collins	2
	Mt. Kephart	4
	Gregery Bald	2
	Parson's Branch	1
	Spence Field	1
	Round Bottom	3
	Chimney's Picnic Area	1
	Anthony Ridge	2
	Parson's Branch	3
	Rainbow Falls	3
	Beech Gap	2
	Birch Spring Gap	4
1971	Tricorner Knob	1
	LeConte Lodge	3
	Icewater Springs	2
	Spence Field	2
	Alum Cave	3
	Russell Field	2
	LeConte Lodge	3
	Collin's Gap	2
	Smokemont	2
	Route 441, N.C.	2
	Peck's Corner	3
	Cosby Knob	1
	Boulevard Trail	2
	Noland Ridge	3
	Noland Ridge	2
1972	Peck's Corner	2
	Greenbriar	3
	Giant Poplar	1
	Siler's Bald	3

TABLE 22 (continued)

Year	Location	Litter Size
1973	Spence Field	1
	Smokemont	2
	Spence Field	2
	Cosby	1
	Russell Field	2
	Andrew's Bald	2
	Icewater Springs	2
	Pine Mt.	2
	Seymour	1
	School House Gap	2
	Laurel Creek Tunnel	2
	Cades Cove	2
	Gregery Bald	2
	Miller's Cove	2
	Cosby	2
	Cosby	1
	Noland Ridge	2
	Laurel Creek Tunnel	1
	Noland Ridge	3
	Chota Route 129	2
	Chimney Tops	1
	Cades Cove	2
	Cades Cove	3
	Cades Cove	2
	Route 441-Tenn.	1
	Mt. LeConte	2
	Smokemont	1
	Abrams Creek	2
	Abrams Creek	2
	North Exit Road	1
1974	Noland Ridge	2
	Sugarlands	3
	Mt. LeConte	2
	Mt. LeConte	4
	Noland Ridge	3
	Peck's Corner	2
	Route 441-N.C.	3
	Rough Creek	2
	Bent Arm	3
	Noland Ridge	3
	Cades Cove	3
	Cades Cove	2
	Abrams Creek	2

APPENDIX E

TABLE 23. Field observations of bears made by backpackers and members of the research team during 1972 and 1973

Bear Number	Date	Location
Y30	7/6/72	Spence Field
	7/6/72	0.5 mi. below Spence Field on Anthony Creek Trail
	7/10/72	Spence Field
	7/12/72	Spence Field
		Jct. Bote Mtn. and Anthony Creek Trail
	7/13/72	Spence Field
	7/19/72	Spence Field
	7/20/72	Spence Field
	7/26/72	0.5 mi. from Spence Field toward Russell Field
	8/1/72	Spence Field
	8/4/72	0.75 mi. below Spence Field on Anthony Creek Trail
	8/7/72	Spence Field
	8/2/72	Thunderhead
		Russell Field
		Spence Field
	8/21/72	Russell Field
		Spence Field
	8/22/72	Spence Field
	8/24/72	Spence Field
	8/25/72	Thunderhead
		Russell Field
		Spence Field
	8/27/72	Spence Field
	8/28/72	Spence Field
	5/2/73	Thunderhead
	5/29/73	Spence Field
	6/12/73	Spence Field
	6/13/73	Spence Field
	6/14/73	Spence Field
	6/16/73	Thunderhead
	6/18/73	Spence Field

TABLE 23 (continued)

Bear Number	Date	Location
B50	6/25/73	Spence Field
		Russell Field
	6/26/73	Little Bald
	6/27/73	Little Bald
	7/3/73	Spence Field
	7/5/73	Spence Field
	7/13/73	Russell Field
	8/24/72	Spence Field
	8/25/72	Spence Field
	8/28/72	Spence Field
	9/9/72	Spence Field
	9/10/72	Spence Field
	9/23/72	Spence Field
	10/23/72	Spence Field
	10/27/72	Spence Field
	6/12/72	Spence Field
	6/13/72	Spence Field
	6/20/73	Spence Field
	7/4/73	Spence Field
	7/6/73	Spence Field
	7/8/73	Spence Field
	7/10/73	Spence Field
	7/11/73	Spence Field
	8/7/73	Spence Field
	8/21/73	Spence Field
	8/30/73	Spence Field
	9/20/73	Spence Field
	8/19/74	Spence Field
	8/20/74	Spence Field
	8/21/74	Spence Field
	8/22/74	Spence Field
	8/24/74	Spence Field
W30	7/13/72	Spence Field
	7/25/72	Spence Field
	8/3/72	Spence Field
	8/4/72	Spence Field
	8/28/72	Spence Field
	9/14/72	Moore's Spring Shelter
	9/15/72	Moore's Spring Shelter
	10/21/72	Moore's Spring Shelter

TABLE 23 (continued)

Bear Number	Date	Location
R26	6/20/72	Bote Mtn. turnaround
	7/11/72	Jct. Bote Mtn. and Anthony Creek Trail
	7/14/72	Cades Cove
	10/23/72	Spence Field
	6/30/73	Hickory Tree Gap
B28	7/1/72	Spence Field
B8	5/24/72	Cades Cove
	6/12/72	Cades Cove
	6/13/72	Cades Cove
	7/18/72	Cades Cove
	7/19/72	Cades Cove
	7/24/72	Gatlinburg
	7/28/72	Gatlinburg
	8/4/72	Cades Cove
P7	7/20/72	Cades Cove
Y39	8/14/72	Cades Cove
	8/23/72	Cades Cove
	8/25/72	Cades Cove
	10/18/72	Cades Cove
	10/21/72	Cades Cove
	10/27/72	Cades Cove
W48	8/15/72	2.5 mi. out Thomas Ridge
	8/23/72	2.5 mi. out Thomas Ridge
Y37	8/4/72	Cades Cove
	8/14/72	Cades Cove
Y29	7/6/72	Jct. Anthony Creek Trail and Bote Mtn.
	7/17/72	2.1 mi. below Jct. Anthony Creek Trail and Bote Mtn.
W31	7/20/72	0.5 mi. above Walter Prong
	7/29/72	0.5 mi. above Walter Prong
	8/9/72	0.5 mi. above Walter Prong
	8/21/72	0.5 mi. above Walter Prong
B29	6/22/72	Spence Field
	7/7/72	Spence Field
	7/9/72	Spence Field
	7/10/72	Spence Field
	7/13/72	Spence Field

TABLE 23 (continued)

Bear Number	Date	Location
R30, R31, R35 (sow and cubs)	7/25/72	Spence Field
	8/1/72	Spence Field
	8/20/72	Spence Field
	8/25/72	Spence Field
R30	7/27/72	Siler's Bald
	7/28/72	Siler's Bald
	8/1/72	Siler's Bald
	8/8/72	Siler's Bald
R31	8/28/72	Siler's Bald
	9/9/72	Siler's Bald
	9/11/72	Siler's Bald
	9/1/73	Siler's Bald
R6	10/20/74	Termont
Y27	7/11/72	Collins Gap
	8/10/72	Thomas Ridge
	8/12/72	4.3 mi. out Thomas Ridge
	11/10/72	2 mi. out Thomas Ridge
B36	6/14/72	Cades Cove
	6/24/72	Cades Cove
	8/14/72	Cades Cove
	8/18/72	Cades Cove
B37	8/23/72	Tremont
	8/14/72	Cades Cove
	8/18/72	Cades Cove
	6/9/72	Cades Cove
Y26	6/10/72	Forge Creek
	6/11/72	Cades Cove

APPENDIX F

TABLE 24. Distances (km) bears moved during various time periods of a 24-hour period

Bear No.	Time	Distance Moved (km)	Bear No.	Time	Distance Moved (km)
W30	1500			0330	0.26
	1700	0.13		0430	0.65
	1950	1.55		0530	0.19
	2150	1.15			
	2345	1.16	R53	1500	
	0130	0.19		1600	0
	0230	0.42		2200	2.13
	0330	0.60		2300	0.90
	0730	1.81		0100	0.71
	0830	1.45		0200	2.16
W30	0700			0300	1.55
	0800	0.32		0530	1.58
	0900	0.32		0700	2.87
	1300	1.37	R53	1600	
	1400	0.16		1830	1.13
	1500	1.45		1930	1.90
	1950	0.72		2030	1.77
	2050	1.45		2150	1.16
	0030	2.10		0030	0.65
	0.30	0.68		0130	0.55
	0330	0.16		0330	0.65
R53	0700			0500	0.81
	0800	1.21		0700	1.10
	0930	0.52	R53	0800	
	1030	1.39		0930	0
	1130	1.06		1700	0.42
	1245	0.81		1800	1.35
	1345	0.16		0100	0
	1500	0		0200	0.32
	1750	0.16		0330	0
	1850	1.29		0430	0.35
	2000	0.55		0600	0.48
	2300	1.74	R53	1300	
	0100	0.65		1400	0
	0200	0.26			

TABLE 24 (continued)

Bear No.	Time	Distance Moved (km)	Bear No.	Time	Distance Moved (km)
	1530	0	R56	0600	
	1700	0		0700	1.77
	1750	0.26		0800	1.06
	1930	0.35		0900	2.10
	2030	0.35		1000	2.26
	2130	0.70		1100	0.84
	2230	2.16		1150	1.26
	2330	0.97		1350	1.10
	0130	0.58		1500	0
	0330	0.32		1700	0.16
	0530	1.0		1900	1.08
	0730	0.97		2000	2.00
	0930	0.32		2150	0.16
	1030	1.39		2250	1.68
				2350	1.71
R53	1000			0100	0.16
	1100	0		0300	2.06
	1230	0		0500	1.68
	1330	0			
	1430	0	R56	2100	
	1900	0.76		2300	2.00
	0300	0.77		0.00	0.74
	0400	0.48		0500	1.19
	0500	0.61		1300	0.40
R53	1400		R26	1500	
	1500	0.16		1700	1.06
	1630	0.08		1900	1.16
	1730	0.81		2100	2.16
	1900	0.87		2200	1.19
	2000	0.97		2350	0.48
	2200	3.10		0100	1.13
	2300	2.02		0200	0.81
	0100	1.03		0300	0.81
	0230	2.00		0400	0.84
	0330	1.03		0530	1.42
	0500	1.39		0800	1.74
	0700	0.81		0930	0.19
	0900	1.29		1100	0.10
	1000	0.19			

TABLE 24 (continued)

Bear No.	Time	Distance Moved (km)	Bear No.	Time	Distance Moved (km)
R26	0300			0550	2.39
	0800	3.16		0900	0
	1300	2.81			
	1530	5.81	Y52	1300	
	1730	2.29		1400	0
R26	1400			1600	0.81
	1500	0.13		1700	0
	1700	0.13		2000	1.94
	1900	0.74		2300	2.48
	2000	0.48		0200	0.19
	2100	1.23		0400	0.45
	2200	1.03		0700	0.32
	2350	0.73			
	0130	0.77			
	0300	3.48			
	0430	1.58			
	0700	1.74			
	0800	0.32			
Y52	1400				
	1900	3.23			
	2200	6.71			
	0100	1.42			
	0700	2.84			
Y52	1800				
	2100	1.48			
	0000	1.53			
	0200	1.45			
	0400	2.48			
	0700	0.35			
Y52	2100				
	2300	0.81			
	0100	0.74			
	0200	0.84			
	0300	0.84			
	0400	0.90			

APPENDIX G

TABLE 25. Field notes of bears^a simultaneously present at Spence Field

Date	Notes
7/10/72	Y30 at new shelter. W30 at old shelter. B29 at new shelter. Y30 and W30 never closer than 800 meters. B29 and Y30 were within 15 meters of each other.
7/12/72	Y30 and B29 within 20 meters. No aggressive behavior noted.
7/13/72	Y30, B29 and W30 present. W30 was at least 100 meters from other bears. B29 and Y30 were within 20 meters. No aggressive behavior but B29 did climb a tree.
7/25/72	W30 and B29 were within 50 meters of each other (B29 was up a tree). No aggression noted.
8/1/72	Y30 and B29 within 20 meters of each other. No aggression noted.
8/4/72	Y30 and B50 present (200 meters apart).
8/25/72	Y30, B50, and B29 present. B29 was 20 meters from B50, never close to Y30. Y30 and B50 were at least 100 meters apart.
8/28/72	Y30, B50, and W30 all present at same time. Never closer than 200 meters to each other.
6/12/73	Y30 and B50 present (200 meters apart).
6/13/73	Y30 and B50 present (800 meters apart).

^aY30 = adult female; W30 = subadult male; B50 = adult female with cub; B29 = yearling female.

APPENDIX H

TABLE 26. Summary of backpacker response of observing bears at the three trail shelters in the central area of the radiotracking study (1972-1974)

Backpacker Card Reports	Spence Field	Russell Field	Moore's Spring	Total
May 1-Sept. 15.				
No. of visits	41	11	11	63
Times bears were observed	36	5	3	44
Percent time bears were observed	88	45	27	$\bar{X}=70$
Sept. 16-Dec. 31				
No. of visits	6	5	4	15
Times bears were observed	3	1	0	4
Percent time bears were observed	50	20	0	$\bar{X}=27$
Avg. percent for both time periods	83	38	20	$\bar{X}=61$

APPENDIX I

BEAR DESCRIPTION FORMS USED TO RECORD DATA OF CAPTURED BEARS

Bear Description Report

Previous markings _____
Date _____ Time _____ Trap Type _____
Capture point _____
Release: Location _____ Time _____ Date _____

Drug

Kind _____ Dosage _____ Injection Point _____
Latency Time _____ Recovery Time _____ Antidote _____
Description and comments: _____

Measurements

Sex _____ Wgt. _____ Tot. Lgt. _____ Shoulder Hgt. _____
Skull: Wdt. _____ Lgt. _____ Forearm Circum. _____ Neck _____
Chest Girth _____
Rectal Temp. _____ Hind Ft.: Lgt. _____ Wdt. _____
Front Ft.: Lgt. _____ Wdt. _____

Condition

Teeth: Loss _____ Wear _____
Parasites _____ Est. Age _____
Female: Lactating _____ Cubs _____ Teat No. _____
Teat Lgt. _____
General Condition: _____

Marking

Ear: Left _____ Right _____ Tatoo _____ Transmitter _____
Isotope: Kind and Sodage _____ Tooth Extraction _____

General Comments:

POSTCARD AND EXPLANATION SHEET GIVEN TO BACKPACKERS BY
THE NATIONAL PARK SERVICE, 1972-74

Date (1)	Exact Time (PM,AM) and Location in Park (2)	Number of Bears Ob- served (2)	Distinguishing Marks: Tags, (ear, collar) and Color (4)

The University of Tennessee is presently conducting research on the black bear in the Great Smoky Mountains National Park. Records of overnight bear observations by campers is an integral part of this research. We would appreciate your time in filling out the attached form with the following information and dropping postcard in mail at your earliest convenience.

Information needed on postcard:

- (1) Date - list the date of each overnight stay.
- (2) Location - name of shelter or specific campsite.
- (3) Number - number of bears observed at each location.
- (4) Identifying Marks - Some of the bears have been tagged with ear markers and/or collars around the neck. Note the color of any identifying mark: ear tags and/or collar. In the case of ear tags note the color of the tag in both the left and right ear. If the bear has no tags, note this also.

NOTE: IF NO BEARS ARE OBSERVED ON A PARTICULAR DATE AND OVERNIGHT LOCATION, PLEASE RECORD 0 FOR THAT OVERNIGHT LOCATION.

PLEASE RETURN POSTCARD WHETHER YOU SEE ANY BEARS OR NOT.
WE ARE AS INTERESTED IN WHERE BEARS ARE NOT SEEN AS WE ARE
WHERE THEY ARE SEEN.

THANK YOU.

VITA

Larry Eugene Beeman was born in Alexandria, Indiana, on February 13, 1944. He attended elementary school in that city and was graduated from Alexandria High School in 1962. In September, 1963, he entered Purdue University, and in June 1967, received a Bachelor of Science in wildlife management. From 1967 to 1969, he taught school in Alexandria, Indiana.

In the fall of 1969, he accepted a teaching assistantship at The University of Tennessee and began study toward a Master's degree. He received this degree in August, 1971, and began graduate studies for the Doctor of Philosophy in September, 1971.

In 1972, he was married to the former Jennifer Leigh Jones. Presently, he is employed by Tennessee Valley Authority in Norris, Tennessee, as a wildlife biologist.