To the Graduate Council:

I am submitting herewith a thesis written by Alton Louis Eubanks entitled "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 Master of Science, with a major in Ecology.

Michael R. Pelton, Major Professor

We have read this thesis
and recommend its acceptance:

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Graduate Studies and Research

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MOVEMENTS AND ACTIVITIES OF THE BLACK BEAR (*Ursus americanus*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Alton Louis Eubanks

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ABSTRACT

This study was conducted on the Tennessee side of the Great Smoky Mountains National Park west of U.S. 441. The region is mountainous, with diverse habitats and considerable variation in temperature and precipitation. The major objectives were to describe bear movements and activities using radioisotopes and radiotelemetry, to determine diel activity patterns, and to evaluate selected radioisotopes as possible feces tags.

In September of 1974, two penned bears were injected with ^{60}Co or ^{134}Cs. Results of an earlier study using ^{109}Cd and ^{144}Ce were evaluated. All isotopes appear unsatisfactory as suitable feces tags.

From June through September of 1974 and 1975, 82 bears were captured and injected with ^{54}Mn, ^{65}Zn, or equal amounts of both isotopes. A total of 907 scats were collected from the study area; 83 of these scats were radioactive. The closed oak forest was the most productive association for collecting scats per hour of effort. Nonmaintained trails and the west-facing slope of a major ridge accounted for most radioactively-tagged scats. All tagged scats, except four, were located within 3.5 air-km of a possible bear capture site.

Radiotransmitters were attached to 8 bears in 1975. Three adult male bears were located too infrequently to describe their home range. Summer home range size of adult females averaged 499 ha (1233 a). Two adult males had an average summer home range of 614 ha (1515 a). Home range size of one subadult male was 517 ha (1276 a). The home of each bear overlapped with the home range of at least one other bear.

Extended movements of two subadult males were recorded during the study. One transplanted panhandler bear was later killed 67 air-km from the release point. Another bear, initially captured in Georgia, was recaptured in 1974 in the study area. Movement of this bear was over 72 air-km.

Bears were most active during diurnal periods. Activity peaked between 0600 to 1000 hr and again between 1500 to 1900 hr. Activity was lowest between 2300 to 0400 hr.

Bears appear to use depressions as bedding sites. In most instances these depressions were created by uprooted trees. These beds are probably used during periods of low activity in the afternoon and at night.

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CHAPTER I

INTRODUCTION

Movements and activities of the black bear (*Ursus americanus*) are especially important ecological components of the animal's life history. Movements and the establishment of home ranges determine the spatial relationships of individual bears and interactions of population cohorts. The home range size needed to satisfy the needs of an animal affects the population density of an animal species. The first step in a study of animal movements is to accurately determine the location of an animal at intervals. A second step is to determine why the animal is at a particular location. A final step is to delineate the influences of individual and population cohort interactions on the population dynamics of the species.

The objectives of the present study were: 1) to describe bear movements and areas of concentrated activity using radioisotopes, 2) to delineate the home range of radiocollared bears and determine the extent of home range overlap, 3) to accurately determine periods of activity and inactivity of bears in the Great Smoky Mountains National Park, and 4) to evaluate selected radioisotopes for use as radioactive feces tags.

Early methods for determining movements and activities of animals relied largely on the capture, marking, and recapture of individuals. Movements of large animals, like movements of small animals, may be influenced by baits, handling, and trap proneness or shyness (Ambrose 1969, Brown and Conaway 1961). Direct observations of typically shy

and secretive animals like black bears is impractical in the densely forested Southern Appalachians. Re-observation of bears with identifying ear tags is biased towards bears habituated to trail shelters and campgrounds in the Park (Marcum 1974). This bias limits data collection to only a few animals whose movements and activities do not reflect those of wild bears.

Locations of animals determined by radiotelemetry have been used to describe the spatial relationship of bears in the mountainous Southern Appalachians. Beeman (1975) successfully radiotracked 12 bears in the region during a two year period. However, radiotelemetry as a technique is both costly and time-consuming. The wide-ranging nature of certain bears limits the number of recorded locations. Additionally, movement of the radiocollared bear behind a major ridgecrest interferes, or prevents radiocontact. Movements of animals based on the location of radioactive feces has advantages over other methods. The technique requires that the animal be captured only once. Subsequent locations can be conducted without interference to the animal from an observer. Locations of tagged scats show exactly where an animal has been.

The use of radioisotopes to study animal movements is a recent innovation. The technique has increased our understanding of several small animal species. Miller (1957) collected radioactive feces deposited on dropping boards to trace meadow vole (*Microtus pennsylvanicus*) movements. Gentry et al. (1971) administered radioisotopes at bait stations to determine small mammal movements patterns. Gerrand (1969) provides an excellent review of radioisotopes in small animal ecology. No data

are available, however, regarding the use of radioisotopes for describing movements of large mammals.

The technique of radioactive feces-tagging has been used previously to estimate population density of black bear populations in the Park (Eager 1976, Marcum 1974). One objective of the present study was to use the feces-tagging technique to delineate subpopulation movements and/or mixing as well as areas of concentrated bear activity. The location of radioactively-tagges scats may also reveal movements of animals into and out of selected areas. New (1958) suggested a similar technique with fecal dyes could illustrate emigration, immigration, and interchange between areas.

Recent studies have demonstrated that black bears prefer to establish a home area and generally limit their movements to this area (Beeman 1975, Ernest 1973, Hardy 1974, Jonkel and Cowan 1971, Kordek 1973, Matula et al. 1974, Poekler and Hartwell 1973). However, few data are available regarding specific activities of bears within their home ranges. The advent of telemetry and activity monitors on transmitters has greatly increased our ability to determine more specific activity patterns. Bear movements may be exploratory, or simply movements between major sources of food. Activity may be centered around a preferred feeding site such as berry patches or seasonally ripe fruits. Earlier studies indicate bears are primarily diurnal (Amstrup and Beecham 1976, Poekler and Hartwell 1973). Other researchers report bears are frequently active at night (Beeman 1975, Erickson 1965, Rogers 1970). When artificial foods are available, bears may exhibit nocturnal activities (Barnes and Bray 1967).

The literature describing black bear bedding sites is limited. Ernest (1973) observed a bear using a small depression as a bed. However, no detailed literature is available describing this aspect of bear ecology.

CHAPTER II

DESCRIPTION OF STUDY AREA

A. LOCATION AND PHYSIOGRAPHY

The Great Smoky Mountains National Park (GSMNP or Park) is located along the common boundary of Tennessee and North Carolina. The Park encompasses 2072 km^2 (512,000 a) of mountainous terrain located in parts of Blount, Cocke, and Sevier counties in Tennessee, and Haywood and Swain counties in North Carolina. One transmountain road (U. S. 441) bisects the Park from Gatlinburg, Tennessee to Cherokee, North Carolina. The only other major road (Tennessee State Route 73) parallels the northern boundary of the Park from Gatlinburg to Townsend, Tennessee, and continues as Laurel Creek Road to Cades Cove.

The GSMNP is part of the Unaka Mountain Range section of the Blue Ridge Province, located in the southern division of the Appalachian Highlands (Fenneman 1938). The dominant feature of the region is the uninterrupted mountain chain extending northeast to southwest. Deep-cut, V-shaped valleys, steep slopes, and narrow ridges characterize the topography of the area. In the Park more than 90 percent of the surface is on slopes greater than 10 percent (Beeman 1975). Numerous small, swift-flowing streams drain the Park. The two major tributaries in the study area are the east, middle, and west prongs of the Little River, and Abrams Creek. Elevations in the GSMNP range from 271 m where Abrams Creek flows into Chilhowee Lake to 2025 m at Clingman's Dome.

The study was restricted to the Tennessee portion of the Park west of U.S. 441 encompassing approximately 520 km^2 (125,000 a). Most of the area is accessible only by foot trails. Approximately 400 km (250 m) of maintained foot trails and most than 240 km (150 m) of abandoned trails exist in the study area (Marcum 1974). One restricted jeep road, Bote Mountain Road, provided access to the higher elevations within the central study area where most of the black bear studies were conducted (Fig. 1).

B. GEOLOGY AND SOILS

The rocks underlying the GSMNP belong to the Great Smoky formation of the late Precambrium age Ocoee series. These greatly metamorphosed rocks are composed primarily of quartz, feldspar, and slate, with lesser amounts of schist and limestone (King et al. 1969).

Soils in the Park are upland soils, having been derived from the underlying bedrock. Most are Ramsey soil types characterized by moderate neutral fertility and low water storage capacity. Soils range from pH of 2.8 to 8.2 with the soils of high elevations generally more acid than soils of lower elevations (Cain 1931, Scott, 1973).

C. CLIMATE

Due to the high relief, the climate of the Park is characterized by cool temperatures and high amounts of precipitation in relation to the surrounding areas. Whittaker (1956) reported the higher elevations average 9.5 to 12.3°C cooler than the base of mountains during the warmer months. Mean temperatures decrease at an average rate of 4.07°C per

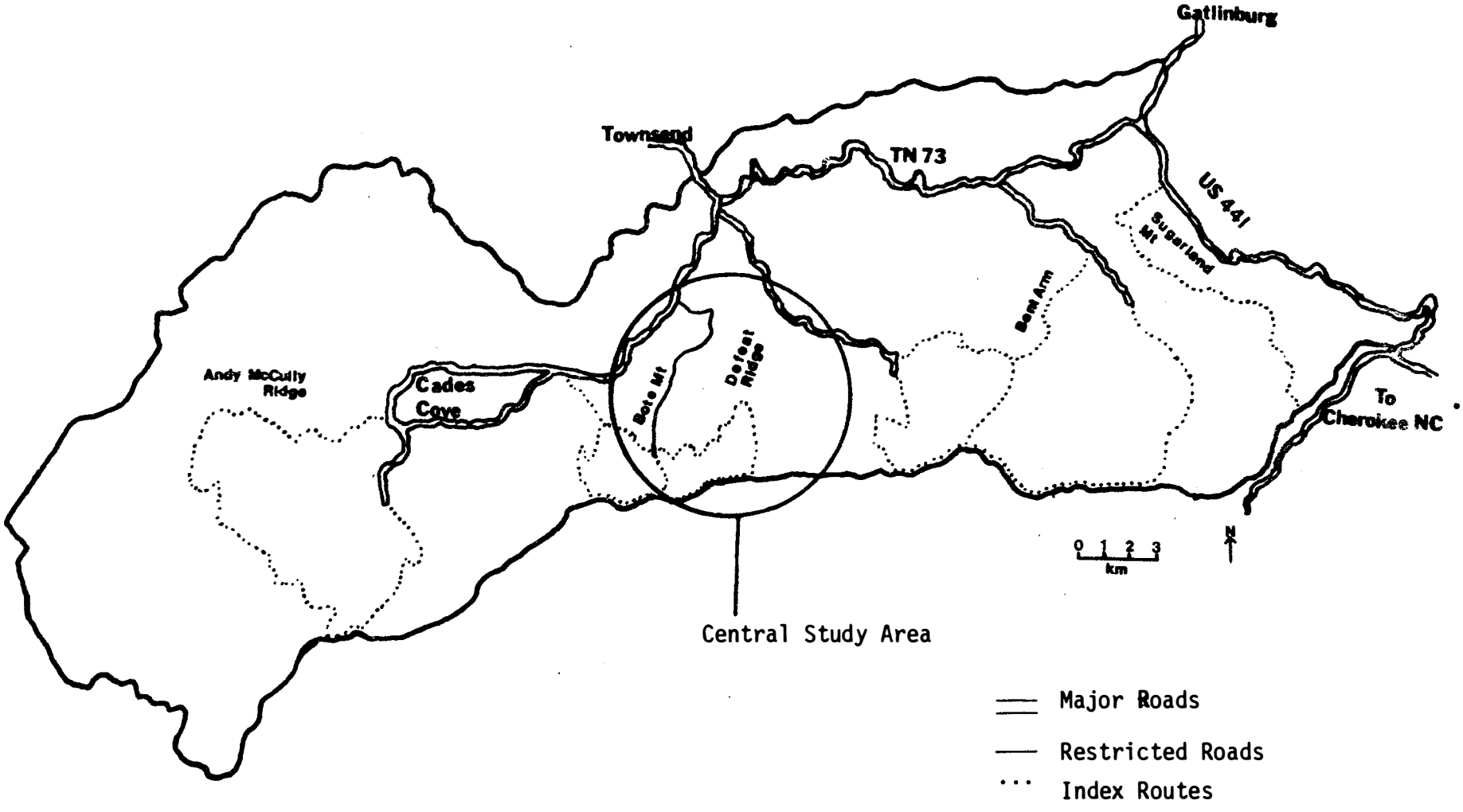


Figure 1. Map of the black bear study area within the Great Smoky Mountains National Park.

1000 meter increase in elevation. In general, there is a rapid warming period between April and May and sharp cooling between October and November. Precipitation in the Park increases rapidly with altitude, and may increase by 50 percent at the 1500 meter elevation (Shanks 1954a). Generally summer is the season of greatest rainfall, while fall is the driest. Precipitation and temperature data for Gatlinburg are presented in Tables 1 and 2.

D. FLORA

The GSMNP is a densely forested area with complex vegetation patterns. There is a diversity of plant species and community types. Within the Park there are 1200 varieties of flowering plants, 350 mosses and liverworts, 230 lichens, and more than 2000 fungi (Stupka 1960).

Whittaker (1956) divided the vegetation into 15 types based on moisture and temperature gradients. Shanks (1954b) classified the forest vegetation into the following six broad physiognomic forest types: cove hardwood, hemlock, northern hardwood, closed oak, open oak and pine, and spruce-fir. The important tree species making up each type are shown in Table 3.

The cove hardwood forest type occurs in sheltered, deep-soiled coves below 1370 m. These forests are generally broader and extend to higher elevations on the Tennessee side of the Park, due to a more northerly exposure. Soils in the cove hardwood forest are deep, rich, and well aerated. In some localities, the understory is dominated by impenetrable thickets of rhododendron (*Rhododendron maximum*), mountain

Table 1. Average monthly precipitation within the Great Smoky Mountains National Park[a]

Month	Average precipitation in centimeters (inches) 1923-1972	1974	1975
January	11.60 (4.57)	20.11 (7.92)	14.83 (5.84)
February	12.49 (4.92)	14.57 (5.74)	11.55 (4.55)
March	14.07 (5.54)	13.48 (5.31)	28.75 (11.32)
April	11.93 (4.70)	13.48 (5.31)	7.03 (2.77)
May	10.79 (4.25)	19.86 (7.82)	10.84 (4.27)
June	13.25 (5.22)	10.31 (4.06)	7.89 (3.11)
July	16.17 (6.37)	11.02 (4.34)	8.10 (3.19)
August	13.51 (5.32)	14.14 (5.57)	8.28 (3.26)
September	7.89 (3.11)	11.25 (4.43)	12.49 (4.92)
October	7.69 (3.03)	4.11 (1.62)	10.41 (4.10)
November	10.18 (4.01)	12.03 (4.74)	5.66 (2.23)
December	10.84 (4.27)	18.56 (7.31)	10.41 (4.10)
Annual	140.48 (55.31)	162.99 (64.17)	136.29 (53.66)

[a]From records maintained by the Great Smoky Mountains National Park, Gatlinburg, Tennessee (Elevation - 445 m).

Table 2. Average monthly temperatures within the Great Smoky Mountains National Park[a]

Month	Average temperatures in °C (°F) 1923-1967	1974	1975
January	4.0 (39.3)	8.9 (48.0)	4.8 (40.6)
February	5.5 (41.9)	5.8 (42.5)	6.3 (43.3)
March	8.8 (47.8)	11.4 (52.5)	7.0 (44.6)
April	13.8 (56.8)	12.7 (54.9)	11.4 (52.5)
May	18.2 (64.8)	17.5 (63.5)	18.1 (64.6)
June	22.2 (72.0)	18.8 (65.9)	20.1 (68.2)
July	23.1 (73.6)	22.0 (71.7)	21.8 (71.3)
August	23.2 (73.7)	21.5 (70.7)	22.3 (72.2)
September	20.2 (68.9)	17.8 (64.0)	17.6 (63.6)
October	14.4 (57.9)	11.6 (52.8)	13.7 (56.7)
November	8.2 (46.7)	8.0 (46.4)	8.0 (46.6)
December	4.6 (40.2)	4.1 (39.4)	3.4 (38.1)

[a]From records maintained by the Great Smoky Mountains National Park, Gatlinburg, Tennessee (Elevation - 445 m).

Table 3. Forest associations and their important tree species in the Great Smoky Mountains National Park

Forest association type	Important species
Cove hardwood	Eastern hemlock (*Tsuga canadensis*) Silverbell (*Halesia monticola*) Yellow buckeye (*Aesculus octandra*) Tulip poplar (*Liriodendron tulipifera*) Beech (*Fagus grandifolia*) Yellow birch (*Betula alleghaniensis*) Black cherry (*Prunus serotina*) Rhododendron (*Rhododendron* spp.)
Hemlock	Eastern hemlock (*Tsuga canadensis*) Yellow birch (*Betula alleghaniensis*) Silverbell (*Halesia monticola*) Fraser magnolia (*Magnolia fraseri*)
Northern hardwood	Beech (*Fagus grandifolia*) Sugar maple (*Acer saccharum*) Yellow buckeye (*Aesculus octandra*) Yellow birch (*Betula alleghaniensis*)
Closed oak	Chestnut oak (*Quercus prinus*) White oak (*Quercus alba*) Black oak (*Quercus velutina*) Northern red oak (*Quercus rubra*) Pignut hickory (*Carya glabra*) Mockernut hickory (*Carya tomentosa*) Sourwood (*Oxygendrum arboreum*)
Open oak and pine	Sassafras (*Sassafras albidum*) Scarlet oak (*Quercus coccinea*) Pitch pine (*Pinus rigida*) Virginia pine (*Pinus virginiana*) Mountain laurel (*Kalmia latiflora*)
Spruce-fir	Red spruce (*Picea rubens*) Fraser fir (*Albies fraseri*)

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

laurel (*Kalmia latifolia*) and dog hobble (*Leucothoe editorum*). Cove hardwoods occupy 31.6 percent (1182 ha) of the central study area (Beeman 1975, National Park Service 1969).

The hemlock forest type is found on sheltered topography along streams up to 1000 m, and to a lesser extent on exposed slopes and ridges up to 1500 m. The sites are generally less mesic than those of the cove hardwood forest. A greater density of herb coverage, more hardwoods, and less heath are characteristic of hemlock stands at lower elevations. The hemlock forest type occupies only 2.0 percent (180 ha) of the central study area (Beeman 1975, National Park Service 1969, Shanks 1954b).

The northern hardwood forest usually occurs at the head of coves, in gaps, and other mesic sites above 1500 m. Dominate tree species include American beech (*Fagus grandifolia*), yellow buckeye (*Aesculus octandra*), and yellow birch (*Betula allegheniensis*). The understory is typically dominated by sedges, ferns, and other herbs. Shrub coverage is limited to less than 10 percent of the stratum. Over 21 percent (787 ha) of the central study area is occupied by northern hardwoods (Beeman 1975, Shanks 1954b).

The closed oak forest is the most common association in the central part of the study area. This forest type, occupying 35.2 percent (1315 ha) of the central study area is found on intermediate to dry slopes, at low and middle elevations. These sites have sufficient moisture to maintain a high and continuous canopy. Various species of oaks (*Quercus* spp.) and hickories (*Carya* spp.) make up a large proportion of the canopy. Understory coverage of heath and saplings varies from

50 to 80 percent at middle elevations to 20 to 50 percent at lower elevations (Beeman 1975, National Park Service 1969).

The open oak-pine forest occurs on steep, south- and southwest facing slopes with shallow, rocky soils. A continuous tall shrub stratum dominated by mountain laurel is usually present. Scarlet oak (*Quercus coccinea*) is the dominant hardwood. More xeric sites below 1000 meters support Virginia pine (*Pinus virginiana*), pitch pine (*P. rigida*), and table mountain pine (*P. pungens*). Open oak and pine stands occupy 8.7 percent (324 ha) of the central study area (Beeman 1975, National Park Service 1969).

Cades Cove (1012 ha), maintained in a pre-Park condition, comprises the remaining portion of the study area. Agricultural practices include cattle and horse grazing as well as pasture and hay production.

CHAPTER III

MATERIALS AND METHODS

A. CAPTURE OF BLACK BEARS

Baits

Cured ham scraps, obtained from a local restaurant in Townsend, Tennessee, were the primary type of bait used in the study. The cured ham could be stored or used for long periods without becoming rancid. Ham scraps were heated using a small propane torch to disperse the odor. Sardines were occasionally used, especially when baiting traps in the backcountry. Sardines had the disadvantage of being costly and becoming rancid after 3 or 4 days. Erickson (1957) noted rancid bait was unattractive to bears.

Prebaiting techniques were used to determine the feasibility of setting a trap. This practice reduced the number of man-hours expended per bear capture. Prebaiting consisted of hanging 2 to 3 kg of ham or 3 to 4 cans of sardines approximately 2 m above ground. Removal of the prebait and claw marks on the tree indicated a bear visit. Prebaits were generally placed in the upper reaches of small drainages, or in gaps along ridges. After a prebait was visited by a bear, a trap was set within a few meters of the site.

Traps

The Aldrich spring-activated snare was used almost exclusively, since this study required the capture of back-country wild bears. The

relatively easy transport of the snare sets enabled research personnel to backpack several sets when checking prebait or trap lines.

The snare consisted of two parts: a 1/4 in steel spring and a 3/16 in diameter cable. A wedge was constructed using logs to encourage the bear to enter the trap from the proper direction. Some traps were covered with branches, but this practice seemed to have no noticeable effect on trapping success. Marcum et al. (1974) describe the snare sets used in the study.

Saplings were cleared around trapsites to prevent entanglement of captured bears. Kordek (1973) stated captured bears may be injured when nearby trees were used as a fulcrum. Traps were not constructed on rocky sites or extremely steep slopes in an effort to further minimize injuries. Snare sets were checked at least once a day. It was felt the longer the animal remained captured, the greater the risk of injury.

During the 1975 capture period, numerous traps were torn down by bears. Logs forming one side of the wedge were raked aside, the snare occasionally sprung, and the bait taken. Certain trapsites were disturbed in this manner for several consecutive days. These regular visits suggested the same bear was probably responsible for this behavior. If a bear was caught at one of these sites, trap destruction generally ceased.

Efforts to solve this problem were only partially successful. One approach was to discontinue use of the trapsite for a few days, hoping the nuisance bear would no longer be attracted to the site. Another approach was to rotate the trap approximately 180° with the

trap entrance on the downhill side of the slope. Particularly frustrating situations called for the construction of an additional trap set approximately 10 m from the original trap. The double trap set proved successful in the majority of cases.

Culvert traps were only used for a total of 8 trapnights in the backcountry. Culvert traps were discontinued because of their impracticality for trapping in remote areas, lack of initial success, and interference from hikers.

Two free-roaming captures occurred during summer, 1975. Both animals were accustomed to the presence of people. Capture involved approaching relatively close to the animal and immobilizing it using a drug delivered by a CO_2 powered pistol.

Immobilization

Bears were immobilized using either M-99 (Etorphine hydrochloride, American Cyanamid Co.) or Sernylan (Phencyclidine hydrochloride, Parke, Davis and Co.). Drugs were delivered using a projectile syringe powered by a CO_2 pistol. The M-99 and Sernylan were administered in solution at concentrations of 1 mg/cc and 100 mg/cc respectively. Needle length ranged from 1.9 cm to 3.2 cm depending on the size and condition of the animal. After estimating the weight of the animal, a dosage was calculated and administered intramuscularly in the posterior portion of the hip, taking care to avoid the femur.

Average administration of M-99 was 1.32 mg/100 kg of animal weight (Appendix Table 9). Dosages as low as 0.65 mg/100 kg were adequate for handling some animals. Immobilization took place within an average of

11 minutes (range 4-40 minutes). The antagonistic drug M50-50 (diprenorphine) was administered at double the dosage (2 mg/cc) of the immobilizing drug. Recovery time using M50-50 averaged 2.2 minutes (range 1-8 minutes) when administered into the femoral vein and 15 minutes (range 7-24 minutes) when administered intramuscularly. Beeman et al. (1974) describe the use of M-99 for immobilizing black bears.

Recaptured animals required slightly greater dosages of M-99 (average 1.86 mg/100 kg animal weight). A 68.1 kg male recaptured within two days required a 1.5 mg (2.2 mg/100 kg) dosage before immobilization. The antagonistic drug M50-50 administered after the initial capture probably interfered with M-99 administered when the animal was recaptured.

Administration of Sernylan was similar to that of M-99. Average dose rate was 1.63 mg/kg of animal weight (Appendix Table 9). Average latency time was 17 minutes (range 3-95 minutes). Average dosage of Sernylan was slightly greater than dosages reported by Kordek (1973). Elevated dosages of Sernylan needed to immobilize bears in this study can be attributed to two factors. First, an effort was made to administer a minimum dosage of Sernylan to each bear. In some cases bears had to be given multiple dosages before immobilization. Secondly, Sernylan at least one year old was used throughout the study period. This period of time probably caused some chemical decomposition of the drug.

A 38.6 kg male and a 65.9 kg male immobilized with Sernylan experienced severe convulsions lasting approximately eight minutes. Dosage for these bears was well within the tolerance limits. Eveland (1973)

corrected this problem by applying ether on a cone placed over the animal's muzzle until the convulsions ceases.

Generally good results were obtained from both drugs. Both have a wide safety margin. The M-99 had the advantage of having an antagonistic drug M50-50 which could be used to effect a faster recovery. No antagonist is available for Sernylan.

Post Immobilization Procedures

After immobilization each bear was released from the snare and closely examined. Various body and skull measurements were taken and the animal weighed using a portable spring scale. External examinations were made for parasites, injuries, and bone or dental malformations. The most common injury was a 3.5 cm abrasion on the snared paw caused by the angle iron on the steel cable. Colored plastic ear tags 3.8 cm in length were placed in each ear for future identification. A number was tattooed on the smooth inner surface of the upper lip for additional identification in case the ear tags were lost. A premolar was extracted and later used to age the animal following the method outlined by Willey (1974). A 27 ml blood sample was collected from the femoral vein of selected bears for hematological study. In 1975, rectal swabs were taken from bears as part of a bacteriological study. All bears captured in the backcountry were released at the site of capture.

B. RADIOTRACKING AND ACTIVITY MONITORING EQUIPMENT

Selected bears were outfitted with radiotransmitters in 1975 to supplement movement and dispersal information gained from radioisotopes.

Radiotracking equipment consisted of a transmitting unit attached to a collar, a 24-channel radio-receiver, and a portable 3-element Yagi antenna. The receiver and transmitters were manufactured by Wildlife Materials, Inc., Carbondale, Illinois. Each lithium-powered transmitter, weighing approximately 400 g, emitted pulsating signals ranging from 150.800 to 151.400 Mhz.

Most compass azimuths for locating bears were recorded from seven telemetry stations (Fig. 2). One permanent antenna attached to a five m boom located on Bote Mountain Road overlooked the central radiotracking area. Directional readings were obtained from two stations and the bears' estimated location was determined by the intersection of the directional lines. Beeman (1975) previously evaluated the accuracy and feasibility of radiotracking bears in the GSMNP.

Each transmitter had an additional component which created a signal disruption when the animal moved. This activity-monitoring device allowed research personnel to determine the activity or inactivity (resting) of radio-collared bears. A penned bear located at Tremont Environmental Education Center within the Park was outfitted with a transmitter and observed at various times during the study. This experience greatly facilitated the interpretation of active or inactive signals. Most activity readings were taken when recording the compass azimuth for bear locations. Additional activity readings were recorded continuously (one reading per hour) for 12 to 15 hr periods.

Radiotracking was limited to the central part of the study area. Bote Mountain Road not only followed a major ridgecrest overlooking two

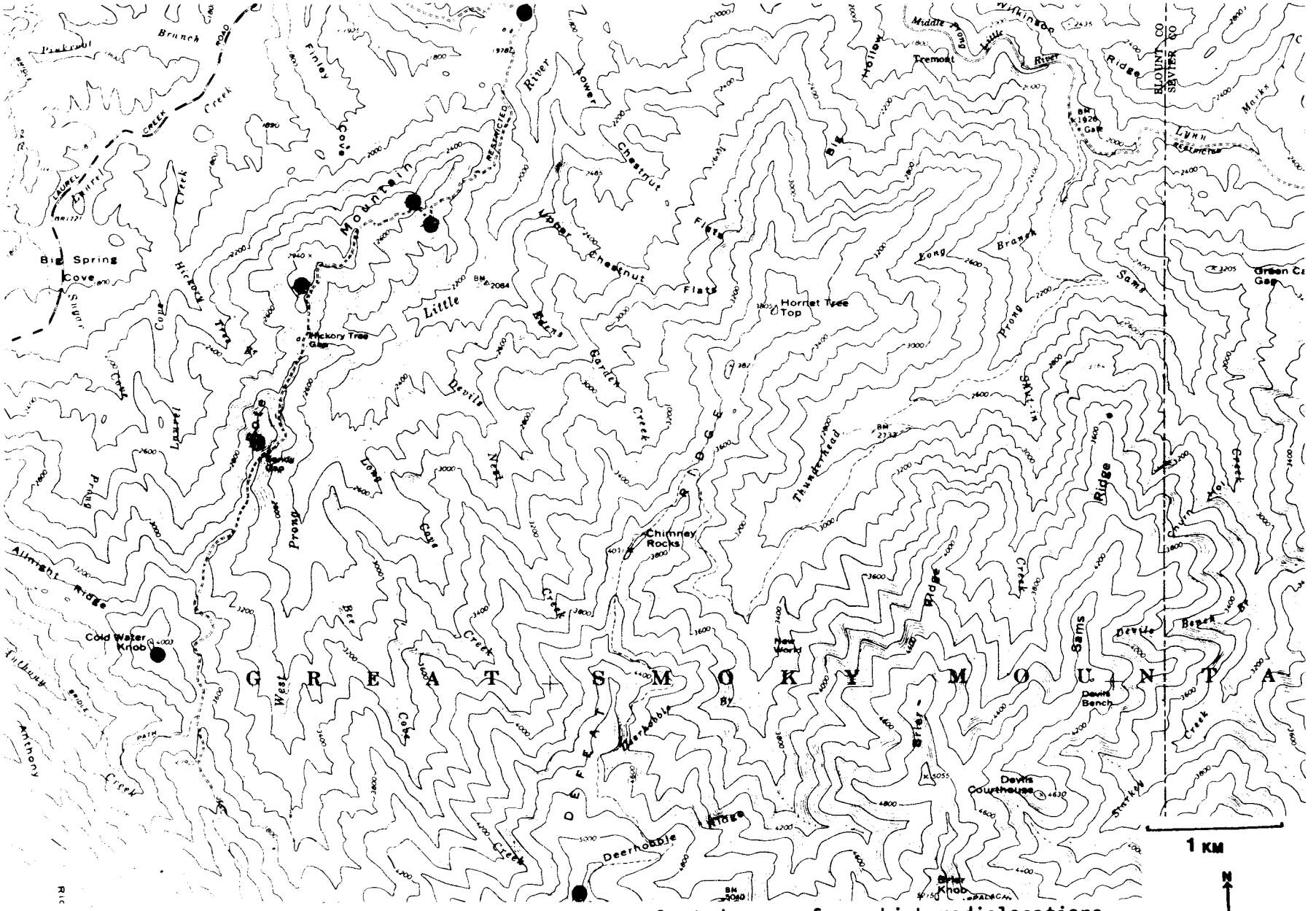


Figure 2. Location of telemetry stations in the central study area from which radiolocations were recorded during summer 1975 in the Great Smoky Mountains National Park.

watersheds but also provided relatively easy access to the higher elevations in the central study area.

Due to the wide-ranging nature of certain bears and the rugged topography within the Park, it was often impossible to continuously locate all bears. Two airplane trips over the study area were helpful in locating elusive bears.

All locations for each bear were compiled to describe movement patterns. The following movement patterns, similar to those used by Marchinton (1968) and Matula et al. (1974), were used to describe bear activities:

1) *minimum home range*--the area enclosed by a line which connects the outermost radiolocations during the entire study period.

2) *home range length*--a line segment formed by connecting the two bear locations that are the greatest distance apart.

3) *home range width*--a line segment perpendicular to the home range length at the widest point.

4) *mean*--mean distance between all sequential observations regardless of time-lapse.

5) *range*--the minimum and maximum distance between sequential locations.

C. RADIOISOTOPE INJECTION

Two radioisotopes, ^{65}Zn and ^{54}Mn, had been previously evaluated as feces-tags by Marcum (1974) and Nellis et al. (1967). Before selection the isotopes had to meet the following criterion: 1) the isotopes had to emit gamma rays in the decay process, since gamma rays are

detectable using scintillation analysis, 2) the isotopes had to have a biological and physical half-life long enough to allow detection of the radioisotopes in the scats through the time of the study, and 3) the major route of elimination of the radioactive materials and to be through the feces (Marcum 1974).

One millicurie of both ^{65}Zn and ^{54}Mn was obtained from the New England Nuclear Corporation (Boston, Massachusetts). The isotopes were diluted using an isotonic saline solution (0.9 percent) so the final solution of isotope and saline was equal to 50 ml in volume for each isotope; this dilution resulted in an initial activity of 20 uc (microcuries) per ml of solution.

Isotopes were administered using a 2 1/2 cc disposable syringe with a 3.1 cm, 18 ga needle. Injections were administered intramuscularly in the hip. The amount of isotopes injected ranged from 40 to 60 uc in most instances. The lowest injection was 30 μc of both isotopes.

All bears captured in the Laurel Creek watershed were injected with ^{65}Zn; bears captured in the West Prong of the Little River (WPLR) watershed were injected with ^{54}Mn. Bote Mountain Road followed the main ridgecrest which separated the two watersheds. By capturing bears along the ridgecrest it was possible to show the extent of bear movements between the two watersheds. Bears captured outside the central study area were injected with equal amounts of both isotopes (dual-tagged). This method made it possible to monitor bear movements into and out of the central study area.

In addition to tagging wild bears with radioisotopes, penned bears were injected with selected radioisotopes to evaluate the isotopes

as possible feces-tags for later use. In 1974 two penned bears, located at the Tremont Environmental Education Center, were injected with 100 μc of ^{60}Co or ^{134}Cs. Additionally, Marcum (1974) injected 50 μc each of both ^{109}Cd and ^{144}Ce into an adult penned bear at Tremont. Scats from these bears were collected on a daily basis for one week, every other day for another week, and then on a weekly basis for the duration of the study. Counts for these scat samples were corrected for decay which occurred between the time of sample collection and counting.

D. COLLECTION AND PREPARATION OF SCATS

Black bear scats were collected from June to October of each year. In 1974 scats were collected from five previously established Index Routes on a bi-weekly basis. An Index Route is defined as one or more maintained or nonmaintained trails. Another Index Route through the central study area was added in 1975. Off-trail (non-Index Route) scat samples in the central study area were collected using a variety of methods. Maintained trails, nonmaintained trails, and game trails were productive for locating off-trail scats. Another method of collecting off-trail scats was to search a 0.2 to 0.4 km radius around certain productive trapsites. This procedure was employed until the scats became increasingly more difficult to find or dense understory vegetation such as rhododendron or mountain laurel prevented a thorough search. In 1975 additional off-trail scat samples were collected by searching each of the major forest associations in the central study area. Scats collected using this method were computed on a scat per hour of effort basis.

Each scat was placed in a 1/2 gal (2 L) plastic bag and labeled with the date and exact location of collection. Approximately 100 g of each scat were dried in a drying oven at 90°C for two days. Approximately 5 g of each dried sample was pulverized, then placed in a 25 mm x 150 mm glass culture tube. Cotton was placed over the samples in the tubes to prevent spillage and moisture absorption.

E. LABORATORY ANALYSIS OF SCATS

Counting equipment used to analyze bear scats collected during the study was made available by the Ecological Sciences Division of the Oak Ridge National Laboratory at Oak Ridge, Tennessee. Equipment included a Packard-Auto-Gamma, 3 x 3 NaI well detector spectrometer coupled to a Nuclear Data ND812 Computer with a hard copy provided by a standard Teletype. Counting standards for each isotope were provided by Oak Ridge National Laboratory. All scats were counted twenty minutes. After counting, each sample was dried for one day at 50°C then weighed to the nearest 1/10 gram.

CHAPTER IV

RESULTS AND DISCUSSION

A. CAPTURE AND TAGGING OF BEARS

In 1974, 34 bears were captured a total of 44 times; 8 animals were injected with ^{54}Mn, 12 with ^{65}Zn, and 14 were dual-tagged with equal amounts of both isotopes (Appendix Table 9). In 1975, 48 bears were captured a total of 49 times; 11 were tagged with ^{54}Mn, 10 with ^{65}Zn, and 27 were dual-tagged (Appendix Table 9). All bears except two panhandler animals were released at the capture site. Eagar (1976) provides more details of capture results throughout the study period. Capture points of bears in 1974 and 1975 are illustrated in Figs. 3 and 4. The concentration of captures in the central study area was the result of a high bear density (Marcum, 1974) and a more intensive trapping effort in this area. Intensive trapping and radioisotope-tagging of bears in this area increased the chances for collecting radioactively-tagged off-trail scats.

B. COLLECTION OF SCAT

In 1974, a total of 114 scats were collected from 1170 Index-Route-km, or 10.3 km per scat (.097 scat per km). The nonmaintained Bent Arm Trail was the most productive trail-section, producing over 68 percent of all Index Route scats for 1974. In 1975 a total of 207 scats were collected from 1296 Index-Route-km (6.26 km per scat or

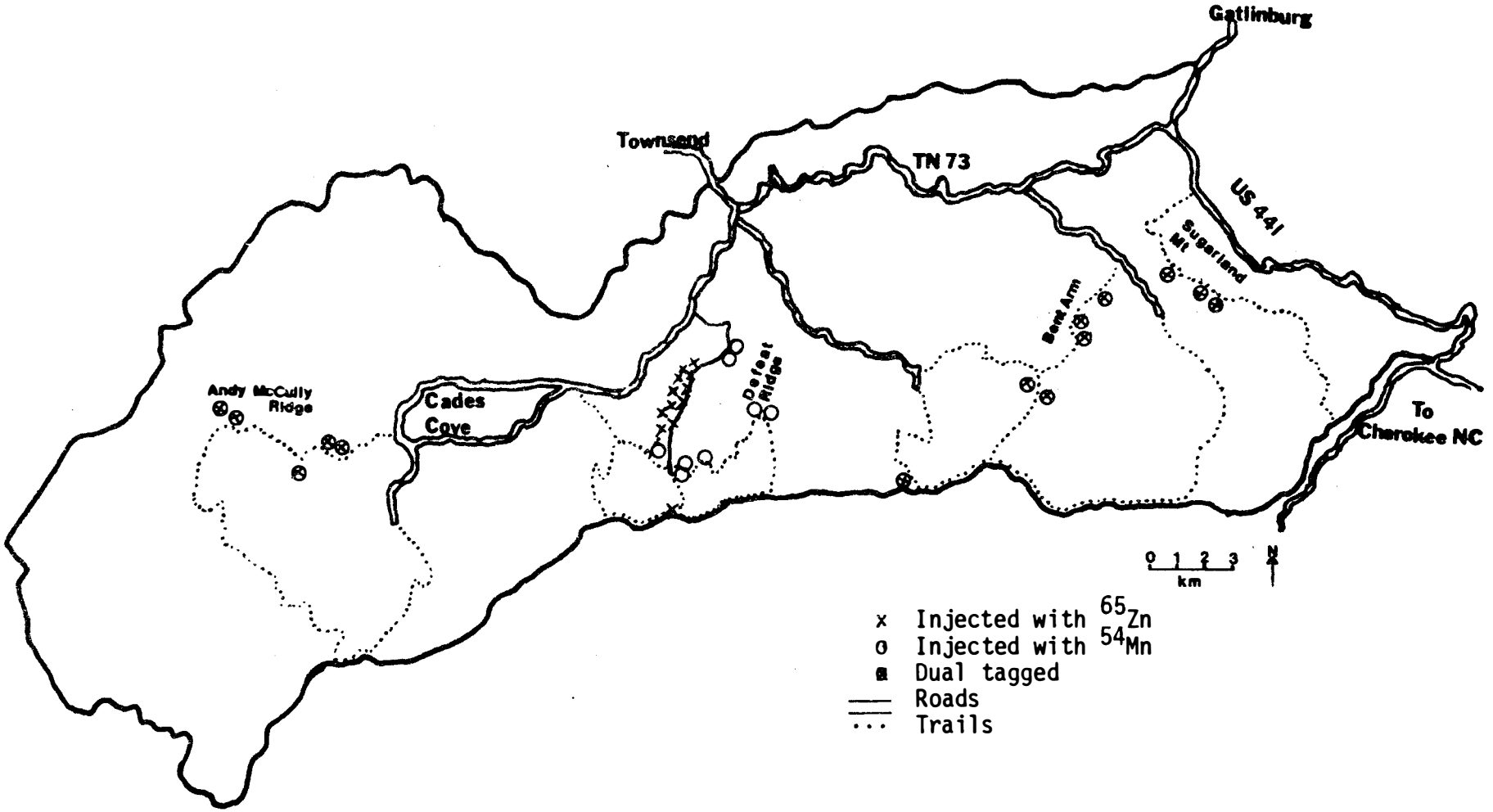


Figure 3. Location of bears captured and injected with radioisotopes during 1974 in the Great Smoky Mountains National Park.

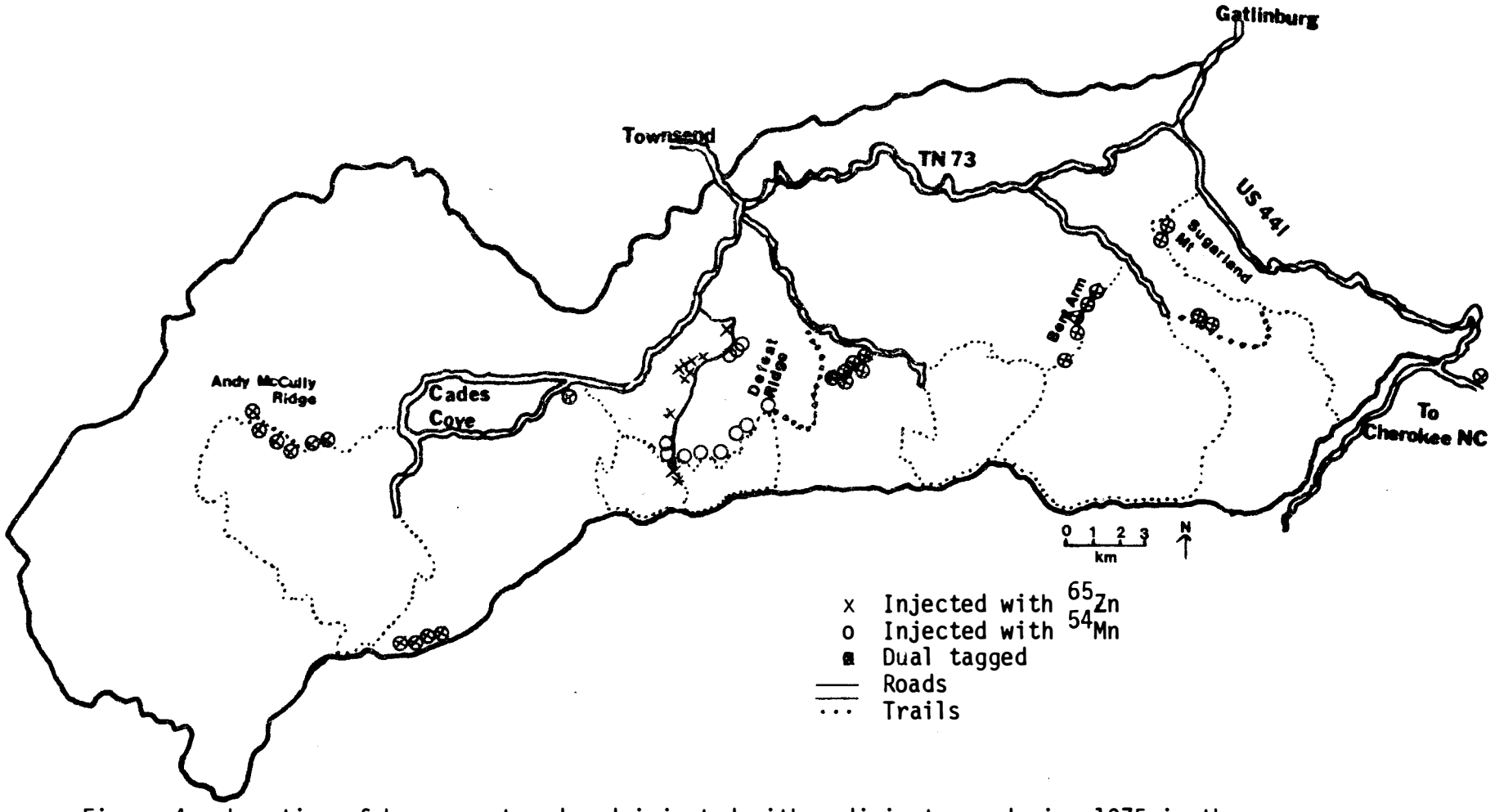


Figure 4. Location of bears captured and injected with radioisotopes during 1975 in the Great Smoky Mountains National Park.

.160 scat per km). The addition of the 14 km Defeat Ridge-Thunderhead Route accounted for 90 scats in 1975.

In 1974, 360 off-trail (non-Index Route) scats were collected in approximately 114 hours of field searching, or an average of slightly more than three scats per hour of effort. Most off-trail scats were collected in the central study area; eight off-trail scats were collected in the Andy McCully and Sugarland Mountain sections of the study area.

Off-trail scats collected in 1975 are presented in Table 4. Ninety-four of the 226 total scats collected were found by searching the four major forest associations in the central study area. No scats were collected in the hemlock association; this forest type occupies only 2 percent of the central study area. Although unequal time was spent in the four forest associations, each type received a maximum effort to locate scats. Scats collected by forest type were computed on a scats per hour of effort basis.

The number of scats collected in an area per unit effort of searching can be a useful index of bear activity (Pelton 1972) and habitat preference. The high number of bear scats collected per hour of searching in the closed oak and open oak-pine indicate intensive bear utilization of these areas in summer. Both associations are rich in blueberry (*Vaccinium* spp.) and huckleberry (*Gaylussacia ursina*), two important summer foods of bears in the Park. The cove hardwood and northern hardwood forest types produced fewer scats per hour of searching. These two forest types support few plants bears feed on in the summer (Beeman 1971). Results of scats collected by forest association in

Table 4. Collection of off-trail bear scats in the Great Smoky Mountains National Park, 1975

Source	No. scats	Percent total	Scats/hr
Non-index routes	64	28.3	
Captured bears	23	10.2	
Vicinity of trap sites	26	11.5	
Miscellaneous[a]	19	8.4	
Northern hardwood	2	0.9	0.2
Cove hardwood	8	3.5	1.0
Open oak and pine	12	5.3	2.4
Closed oak	72	31.8	6.0
Total	226	99.9	

[a]Collected near telemetry stations.

this study agree with summer black bear habitat preference determined by radiotelemetry (Beeman 1975).

C. ANALYSIS OF SCATS COLLECTED FROM PENNED BEARS

From September 1974 through February 1975, a total of 36 scats were collected from two penned bears at the Environmental Education Center at Tremont in the GSMNP. Each animal had been injected with 100 μc of ^{60}Co or ^{134}Cs. Fig. 5 illustrates a rapid fecal loss of non-assimilated ^{60}Co followed by the more gradual decrease in elimination of the radioactive material.

The elimination route of ^{60}Co depends largely on the method of administration. Orally administered ^{60}Co is excreted primarily via the feces; injected dosages are eliminated mainly via the urine (Reed 1971, Smith et al. 1972). Greenburg et al. (1943) reported over 65 percent of an injected dose of ^{58}Co was eliminated via the kidney, while only 8 percent appeared in the feces.

The rapid elimination of ^{60}Co via the feces suggests this radioisotope would be unacceptable as a long-term feces tag. The extremely low levels of radioactivity present after 25 days post-dosing would make the identification and quantification of this radioisotope difficult.

Counts from scat samples also showed rapid elimination of non-assimilated ^{134}Cs, although the rate of decline was not as rapid nor as long as ^{60}Co (Fig. 5). Radioactivity could still be detected approximately 125 days post-injection. This isotope initially appeared to meet the criteria for feces-tagging. However, several complex

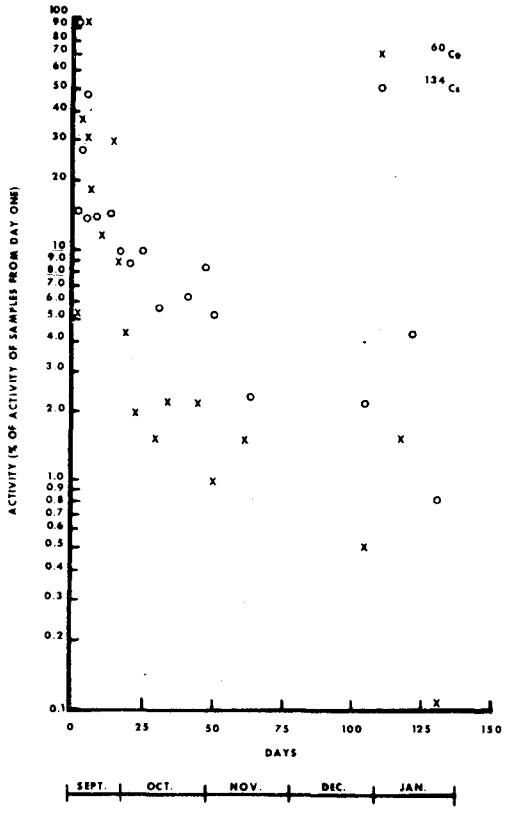


Figure 5. Activity of scats collected from two penned black bears injected with 100 μc of ^{60}Co or ^{134}Cs at Tremont Environmental Education Center.

biological and/or environmental factors may influence ^{134}Cs retention half-life. Lengemann (1970a), working with ^{134}Cs retention in rats, showed a complex interaction of sex, age, and temperature caused large variations in whole body retention.

Any radioisotope used as a feces-tag in the GSMNP must be stable to weathering. Summer climate in the Park is characterized by frequent and intense thundershowers. Radioactively-tagged scats may remain on Index Routes up to two weeks. Since ^{134}Cs is watersoluble and leachable (Meyer et al. 1962, Patten and Witkamp 1965), the isotope was considered unacceptable as a feces-tag in the study area.

D. EVALUATION OF ^{109}Cd AND ^{144}Ce

In 1972, Marcum (1974) injected 50 μc each of ^{109}Cd and ^{144}Ce into an adult penned bear at Tremont Environmental Education Center. Both gamma-emitting isotopes appeared to meet the criteria for use as feces-tags. Following intravenous dosing, the major route of elimination of the radioactive material is via the feces. Inconsequential amounts are lost through the urine (Ekman and Aberg 1961, Miller et al. 1968, Miller and Byrne 1970).

Results of the radioactive analysis of scat samples are illustrated in Fig. 6. Radioactivity was still detectable in the scat material approximately 150 days post-injection. Although retention and elimination of the two isotopes appear favorable, both were abandoned as feces-tags. The major problem in the identification of these isotopes was due to a region in the energy scale known as backscatter. The intensity of the backscatter region was dependent on several factors,

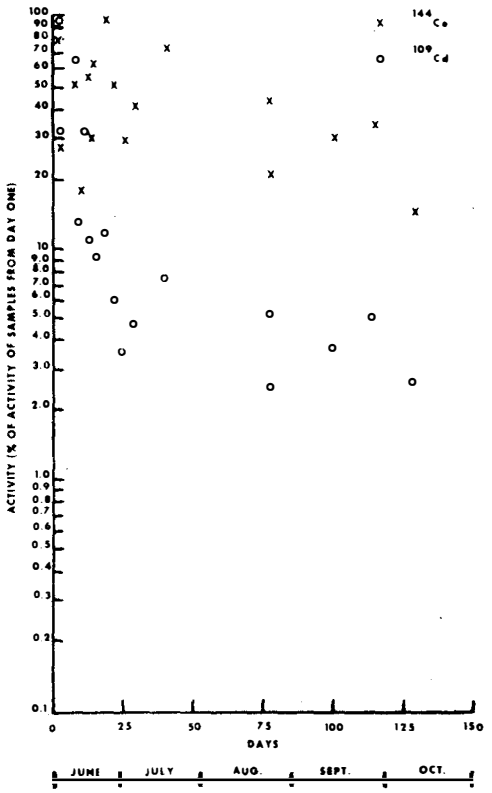


Figure 6. Activity of scats collected from a penned black bear injected with 50 μc each of ^{109}Cd and ^{144}Ce at Tremont Environmental Education Center.

including the type and amount of radioactivity present in the samples (Marcum 1974).

E. LOCATIONS OF RADIOACTIVELY-TAGGED SCATS

A total of 83 radioactively-tagged scats were collected during the study (Appendix Table 10); 25 were tagged with ^{54}Mn, 45 with ^{65}Zn, and 13 were dual-tagged. Figs. 7 and 8 show the location of tagged scats collected in 1974 and 1975 respectively. The greater number of tagged scats collected in 1975 was the result of more bears captured and injected with radioisotopes.

Table 5 presents the minimum and maximum distances of tagged scats from possible bear capture sites. The table represents bear movement determined by the location of tagged scats. All scats, except 4, were located within 3.5 air-km of the nearest possible bear capture site. One single-tagged scat was located 4.7 km from the nearest possible capture site. Three dual-tagged scats, collected in the central study area, represent the greatest minimum distance from a possible capture site. These scats were located a minimum of 7.5 km from the nearest possible capture site.

Maximum bear movement determined by the location of single-tagged scats was generally between 2.5 to 6.0 air-km. However, three single-tagged scats collected on Green Camp Gap Trail represent possible bear movement of 7.0 to 8.0 air-km. Maximum bear movement determined by the location of 13 dual-tagged scats is relatively large. For example, there was the possibility a dual-tagged scat collected on Sugarland Mountain Trail could have been dropped by a bear initially captured in

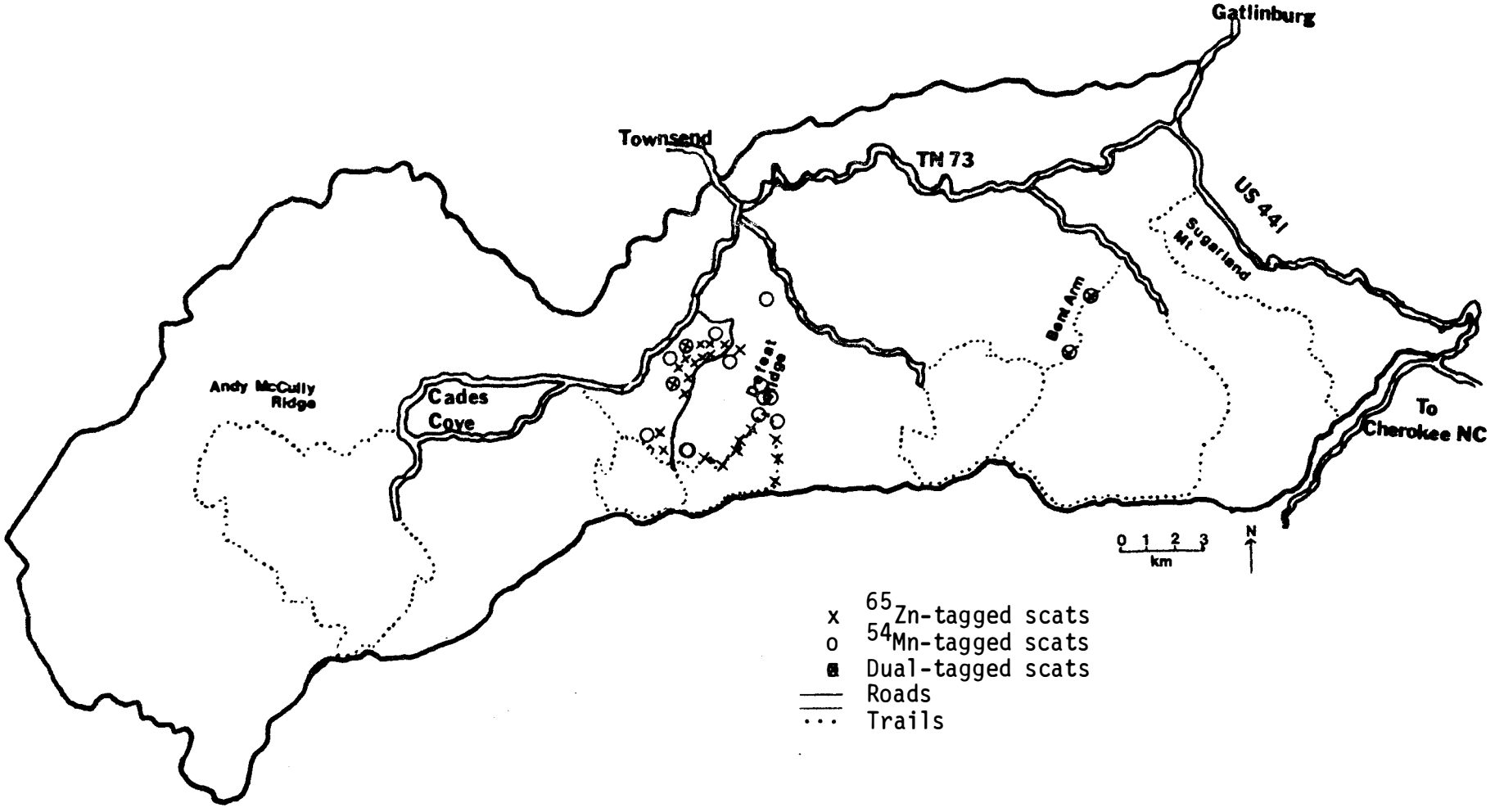


Figure 7. Location of radioactively-tagged scats collected in the Great Smoky Mountains National Park during 1974.

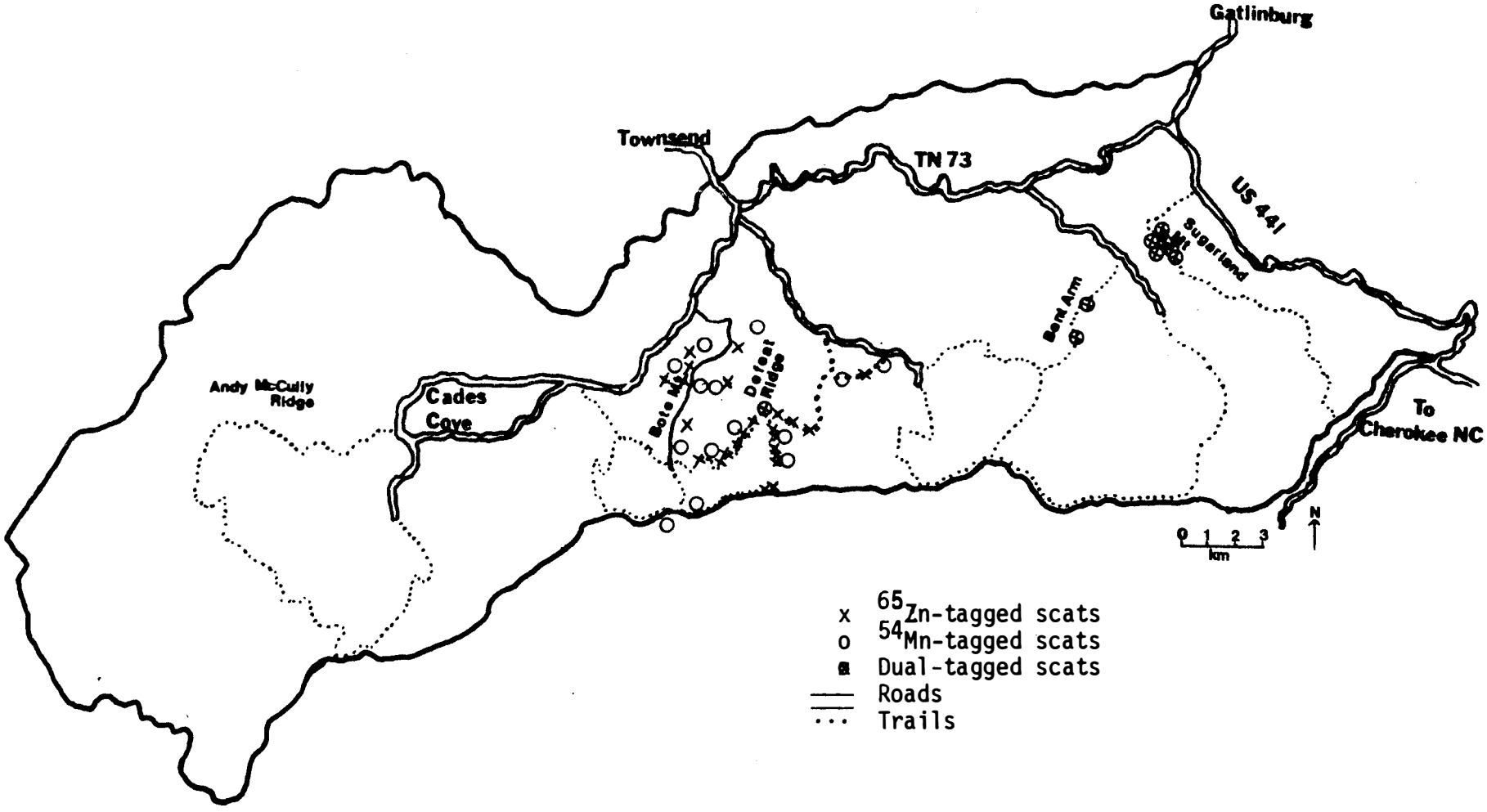


Figure 8. Location of radioactively-tagged scats collected in the Great Smoky Mountains National Park during 1975.

Table 5. Distance of radioactively-tagged scat from closest (minimum) and most distant (maximum) capture sites

Air-kilometers	Minimum distance	Maximum distance
0.1-0.5	25[a]	
0.5-1.0	15	
1.0-1.5	8	
1.5-2.0	4	1
2.0-2.5	8	
2.5-3.0	11	6
3.0-3.5	8	21
2.5-4.0		19
4.0-4.5		9
4.5-5.0	1	7
5.0-5.5		2
5.5-6.0		2
6.0-6.5		
6.5-7.0		
7.0-7.5		2
7.5-8.0	1	1
8.0-8.5		
8.5-9.0		
9.0-9.5	2	
16 - 32		13

[a]Number of scats.

the Andy McCully Ridge section of the Park. The distance between these locations is over 30 air-km.

Scats tagged with ^{54}Mn were generally located in the WPLR watershed. Scats tagged with ^{54}Mn located in the Laurel Creek watershed were primarily restricted to the west slope of Bote Mountain. Understory species in the above area include blueberries, huckleberries, and the parasitic squawroot plant (*Conopholis americana*), all early summer foods of bears in the Park (Beeman 1971). A total of 14 individual bears captured along this section of Bote Mountain suggest bears utilize the area intensively.

Scats tagged with ^{65}Zn were located in both the WPLR and Laurel Creek watersheds. The west slope of Bote Mountain, described above, accounted for 14 ^{65}Zn-tagged scats. Two of these scats were found at a recently used bed. The major source of ^{65}Zn-tagged scat was the 14 km Defeat Ridge-Thunderhead Route, accounting for 21 ^{65}Zn-tagged scats collected from mid-July to September. Locations of these scats ranged from approximately 1200 to 1700 m elevation. Bears may use these abandoned trails when moving to higher elevations to take advantage of seasonally ripening foods such as cherry (*Prunus* spp.) and serviceberry (*Amelanchier arborea*).

The location of radioactive feces and recapture results (Table 6) suggest bears do move freely between West Prong Little River and Laurel Creek watersheds. Some movement across Bote Mountain, determined by recapture, may be influenced by the attraction of baited traps. Locations of animals determined by radiotelemetry suggest Bote Mountain may be a geographical boundary setting movement limits in some bear

Table 6. Movement of bears between WPLR and Laurel Creek watersheds determined by capture-recapture, 1974-1975

Bear no.	Captured		Recaptured		Distance (Air-km)
	Date	Watershed	Date	Watershed	
04	16 June 1974	WPLR	19 June 1974	Laurel Ck	0.7
07	19 June 1974	Laurel Ck	27 June 1974	Laurel Ck	0.6
13	26 June 1974	Laurel Ck	28 June 1974	WPLR	1.6
11	22 June 1974	WPLR	4 July 1974	Laurel Ck	0.5
02	15 June 1974	WPLR	4 July 1974	WPLR	2.5
01	14 June 1974	Laurel Ck	5 July 1974	WPLR	3.4
09	21 June 1974	Laurel Ck	10 July 1974	Laurel Ck	0.3
05	16 June 1974	Laurel Ck	11 July 1974	WPLR	3.4
12	25 June 1974	Laurel Ck	11 Sept 1974	Laurel Ck	0
09	21 June 1974	Laurel Ck	13 Sept 1974	North Carolina	0.8
61	8 July 1975	Laurel Ck	13 Sept 1975	Green Camp Gap	7.8

home ranges. Although bears may make occasional short-term movements across Bote Mountain, generally the home range is restricted to one side of the mountain. Beeman (1975) reported only one bear, excluding trail shelter animals, had a home range which included large areas in both watersheds. The restricted movement of bears in the Laurel Creek watershed may be influenced by vehicular traffic along Laurel Creek Road (approximately 4 air-km to the southwest), and heavy visitor pressure associated with the Cades Cove section of the Park.

No Index Route scats collected outside the central study area were single-tagged. This suggests restricted movement of bears in the central study area. Because of the good bear habitat in this section of the Park and the interspersion of those habitats, bears do not have to travel far to meet their summer food requirements. Three single-tagged scats were collected in September on the abandoned Green Camp Gap Trail, approximately 6 air-km northeast of the central study area. Bear No. 61, tagged with ^{65}Zn, was recaptured on Green Camp Gap. This animal was the only bear which was initially captured within the central study area and receptured later outside the area. The single-tagged scats on Green Camp Gap could represent seasonally changing bear home range movements, or exploratory movements.

Ten of 13 dual-tagged scats collected during the study were located along Sugarland Mountain and Bent Arm trails. The scats were probably dropped by bears captured along these trails. However, since it was not possible to identify individual bears, the scats

could have been dropped by dual-tagged bears captured in other sections. One dual-tagged scat was collected on the Defeat Ridge-Thunderhead Route in early August, 1975. The nearest dual-tagged bear was captured on the Bent Arm Trail approximately 12 air-km to the northeast. The two other dual-tagged scats collected in the central study area were located on the west slope of Bote Mountain. Although these scats were collected in the middle of September, it was impossible to determine when they were deposited. These scats could represent bear immigration into the central study area from more outlying sections.

The location of radioactively-tagged scats provides a unique method for studying the movement of bears in the Park. The technique of radioactive feces-tagging requires that an animal be captured only once. Additionally, locations determined by the collection of tagged scats can be carried out with minimum interference to the animal.

F. EVALUATION OF MOVEMENTS DETERMINED BY RADIOACTIVE TAGGING TECHNIQUE

Several factors limited movement and dispersal information gleaned from this study. The availability of only two radioisotopes as suitable feces tags made it impossible to identify individual bears. Movement patterns could be described only in general terms. Therefore, locations of tagged scats were presented as the minimum and maximum distance a bear moved from a possible capture site. Marcum (1974) attempted to individualize bears by varying the amount of isotopes administered. Results were unsuccessful due to the individual variation

in excretion rates, changes in excretion due to daily metabolic changes, and changes in the ratios of dual-injected isotopes due to time. Other studies (Lengemann 1970b, Mishima and Odum 1963, Pulliam et al. 1969), report a complex interaction of environmental and/or biological factors such as age, sex, ambient temperature, or body size may affect the assimilation, retention, and excretion rates of isotopes.

Analysis of scat samples collected from recaptured animals, or from Index Routes prior to each trapping season revealed detectable amounts of ^{65}Zn from bears injected the previous year. Nellis et al. (1967) determined that rabbits injected with ^{65}Zn excreted detectable amounts of radioactive materials for 400+ days. Counts of radioactivity (disintegrations per minute) were kept conservative in this study to eliminate the year to year "carry-over" problem. Since ^{54}Mn has a much shorter biological half-life than ^{65}Zn, it appeared to be eliminated much more quickly and was undetectable in scats of recaptured animals the following year.

Scats collected on Index Routes represent utilization of the trail during the previous two week period. On the other hand, most off-trail scats were collected in August and September. Collection in this manner gave no accurate indication when the animal was present. For example, two dual-tagged scats collected on the west slope of Bote Mountain in September were composed primarily of squawroot and berries. Since squawroot and berries are generally early summer food of bears, these scats could represent movement into the area in early summer. To adequately describe movement patterns and home range shifts using

radioisotopes, there must be a sufficient number of finds (i.e., tagged feces) within a period of time.

G. MOVEMENT PATTERNS DETERMINED BY RADIOTELEMETRY

Transmitters were attached to 8 bears in 1975 to delineate summer home ranges and to monitor bear mixing between the two watersheds in the central study area (Table 7). Radiocollared animals continued to be radiotracked by another researcher to determine fall movements, den ecology, and spring movements following den emergence. During the study some readings were obtained for all radiocollared animals. Locations of 3 adult males were too infrequent to adequately describe these animals' home ranges. Bear No. 37, outfitted with a radiotransmitter in September 1974 for a den site study, was relocated within the central study area in summer 1975, and also radiotracked. The movement parameters of bears are summarized in Table 7.

Bear No. 37 was a 6.5 year old adult female captured on 13 September 1974 along Bote Mountain Road; the bear's right paw was missing. The animal weighed only 29.5 kg and was thin. She denned during the winter on the west slope of Bote Mountain approximately 1.2 km from the capture site. The summer home range, which included the den site from the previous winter, encompassed only 188 ha (465 a) and was the smallest recorded for any bear. The home range was 2.1 km long and 1.4 km wide (Fig. 9). Bear No. 37 was not captured in 1975 although her home range included an area that was intensively trapped. All locations except one were in the Laurel Creek watershed. By the

Table 7. Movement parameters of bears radiotracked in the Great Smoky Mountains National Park during Summer 1975

Bear no.	Study period	Sex	Age (years)	No. of bear locations	Min. home range (ha)	Home range length (km)	Home range width (km)	Mean (km)	Range (km)
37	8/ 9/75-9/10/75	F	6.5	13	188	2.1	1.4	0.93	0.2-2.1
60	7/10/75-9/10/75	M	3.5	28	517	4.1	2.3	1.29	0.2-2.5
61	7/11/75-8/26/75	M	5.5	11[a]	953	7.5	2.1	1.78	0.6-2.6
63	8/ 1/75-8/30/75	F	9.5	19	540	4.7	2.3	1.51	0.2-4.8
64	7/28/75-9/10/75	F	11.5	27	620	5.0	2.3	1.40	0.4-2.8
65	8/16/75-9/30/75	M	4.5	6	--[b]	---	---	---	---
67	8/11/75-8/29/75	M	4.5	12	274	3.9	1.5	0.90	0.3-2.8
68	8/ 9/75-8/30/75	M	5.5	5	---	---	---	---	---
69	8/15/75-8/29/75	M	5.5	7	---	---	---	---	---

[a] Includes one recapture.

[b] Insufficient data.

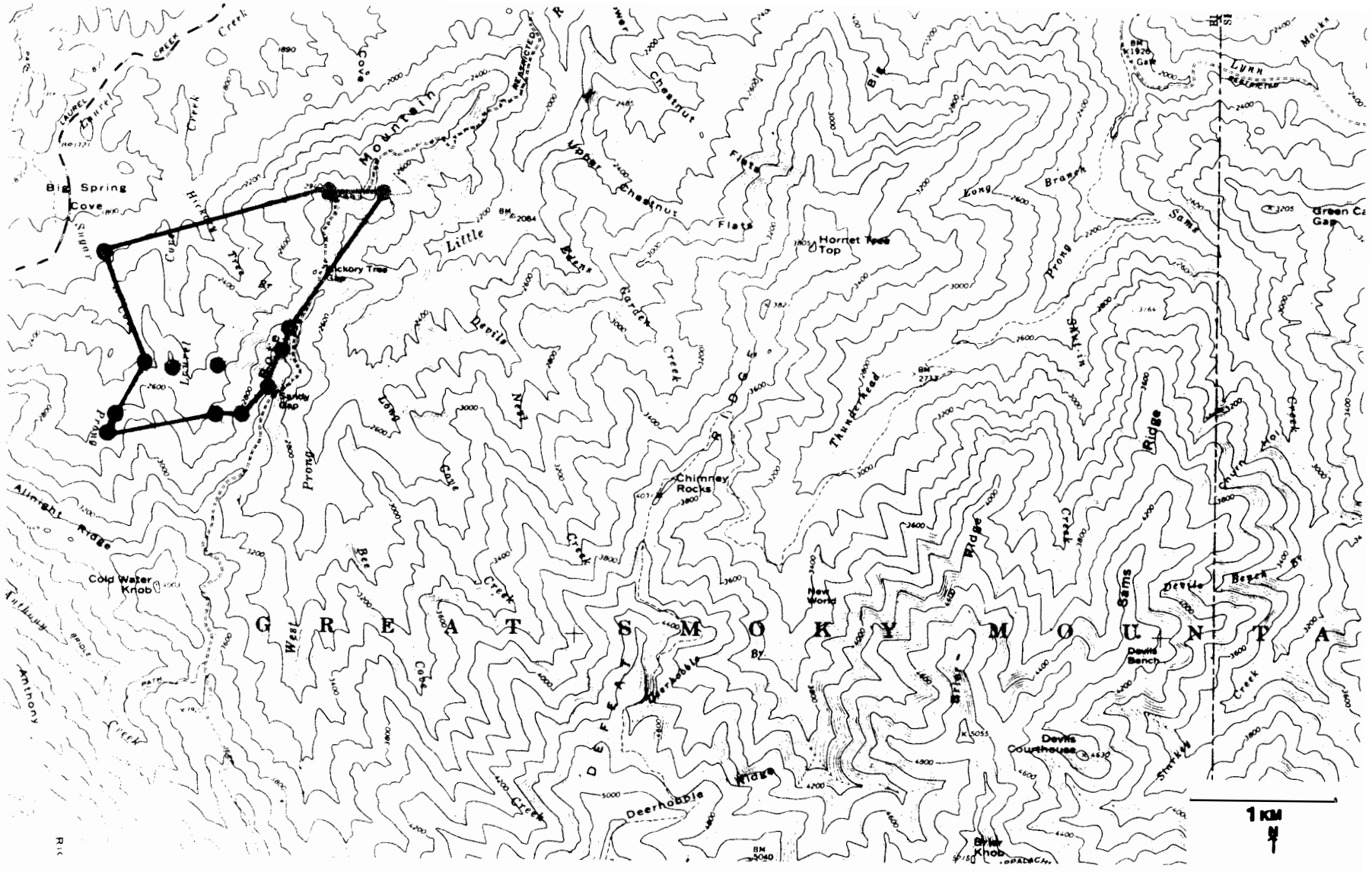


Figure 9. Home range of No. 37, an adult female bear, radiotracked during summer 1975 in the Great Smoky Mountains National Park.

middle of September the transmitting signal had become weak and difficult to identify.

Bear No. 60 was a 3.5 year old subadult male captured in the Laurel Creek watershed on 8 July 1975. The animal required several injections of Sernylan before he was properly immobilized. No. 60 weighed 47.7 kg and appeared in good physical condition. The summer home range included a 517 ha (1276 a) area, 4.1 km long and 2.3 km wide (Fig. 10). No. 60 exhibited no distinct center of activity, but appeared to utilize his home area somewhat evenly. Movements ranged from 671 m to 1097 m elevations. In July No. 60's movements were restricted to the west slope of Bote Mountain in the Laurel Creek watershed. In August No. 60 was located in the WPLR watershed. Several locations in late August placed the animal in the vicinity of Defeat Ridge Trail.

Bear No. 61 was a 5.5 year old adult male captured on 8 July 1975 in the Laurel Creek watershed. He was captured at 1280 m elevation, the highest capture site of radiocollared bears. No. 61 weighed 59.1 kg and appeared in good physical condition. This bear had been captured twice the previous summer during which time he gained 20.5 kg. Summer movements based on 11 locations included a 953 ha (2355 a) area. Home range length was 7.5 km and home range width was 2.1 km (Fig. 11).

After being captured, No. 61 was never located in the Laurel Creek watershed again. Most movements were within the WPLR watershed at middle elevations. Like No. 60, bear No. 61 appeared to have no distinct center of activity. In the middle of August No. 61 apparently left the central study area. In late August, No. 61 was located in

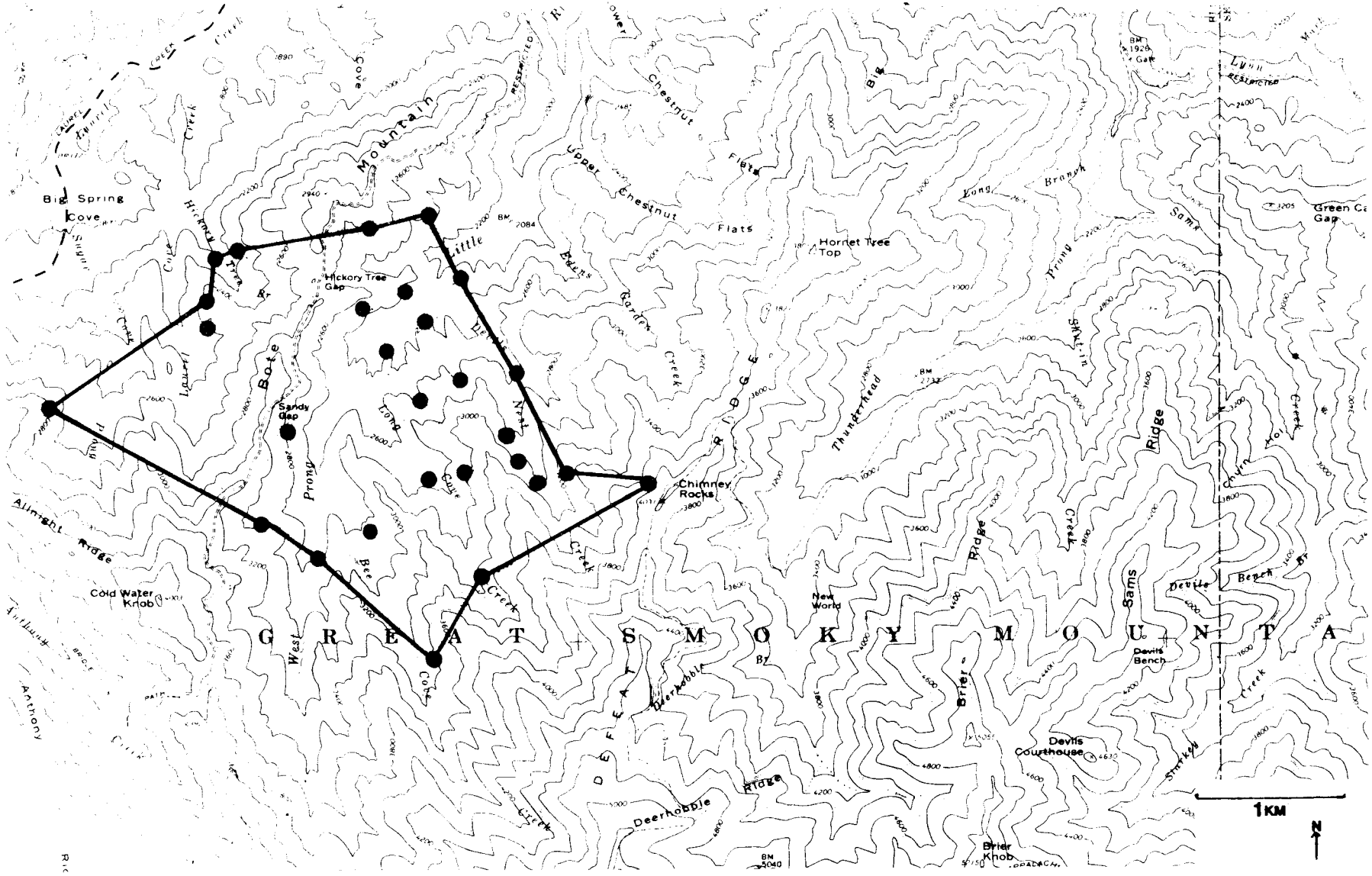


Figure 10. Home range of No. 60, a subadult male bear, radiotracked during summer 1975 in the Great Smoky Mountains National Park.

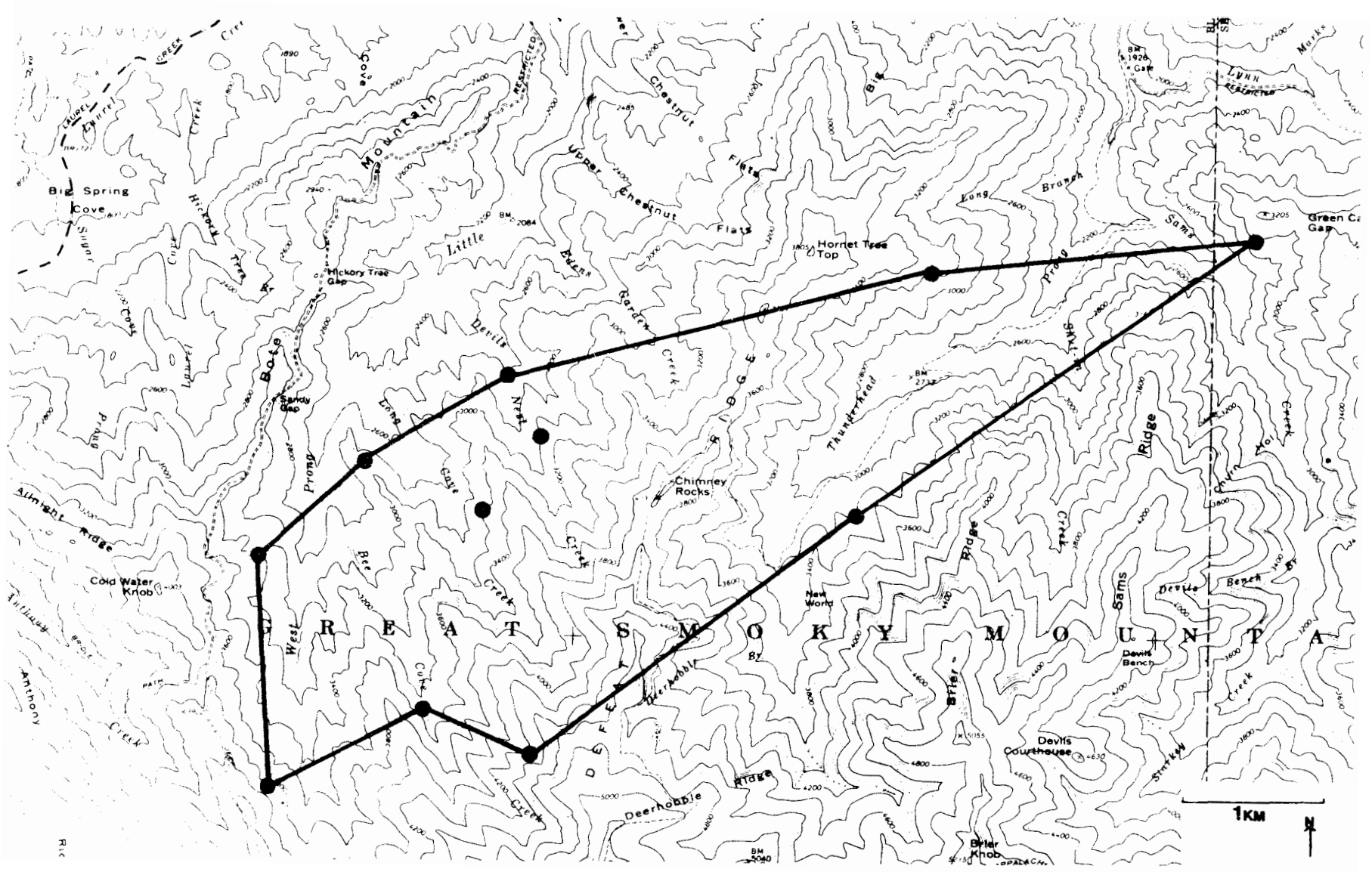


Figure 11. Home range of No. 61, an adult male bear, radiotracked during summer 1975 in the Great Smoky Mountains National Park.

the adjacent watershed, the Middle Prong of the Little River. No. 61 was recaptured near Green Camp Gap on 13 September 1975. This recapture site was over 7 km from the original capture site.

No. 63, a 9.5 year old female, was captured on 19 July 1975. She was captured in the Laurel Creek watershed at 580 m elevation, the lowest elevation of a capture in the central study area. This bear weighed 59.1 kg and was relatively fat for this time of year. Her movements encompassed an area 4.7 km long, 2.3 km wide, and an area of 540 ha (1333 a) (Fig. 12). The home range was generally outlined on three sides by Laurel Creek Road, Tremont Road, and Bote Mountain Road. No. 63's range included the lower elevations in the central study area. She appeared to have a center of activity around Fodderstack Mountain (elevation 732 m). No. 63 made a long movement on 11 August, covering 3.4 km in a 24 hour period. No. 63 denned during the winter on the north slope of Fodderstack Mountain. This den was located within her summer home range.

Bear No. 64 was an 11.5 year old female weighing 40.9 kg when captured in the WPLR watershed on 19 July 1975. She appeared in good physical condition although relatively small for an adult bear. This bear was located 27 times between 28 July and 10 September. Her summer home range included 620 ha (1532 a). Home range length was 5.0 km and home range width was 2.3 km (Fig. 13). Except for one long movement west near Laurel Creek Road, this bear's summer range was limited to the WPLR watershed. No. 64's center of activity appeared to be the valley between Bote Mountain and Defeat Ridge. Occasional movements

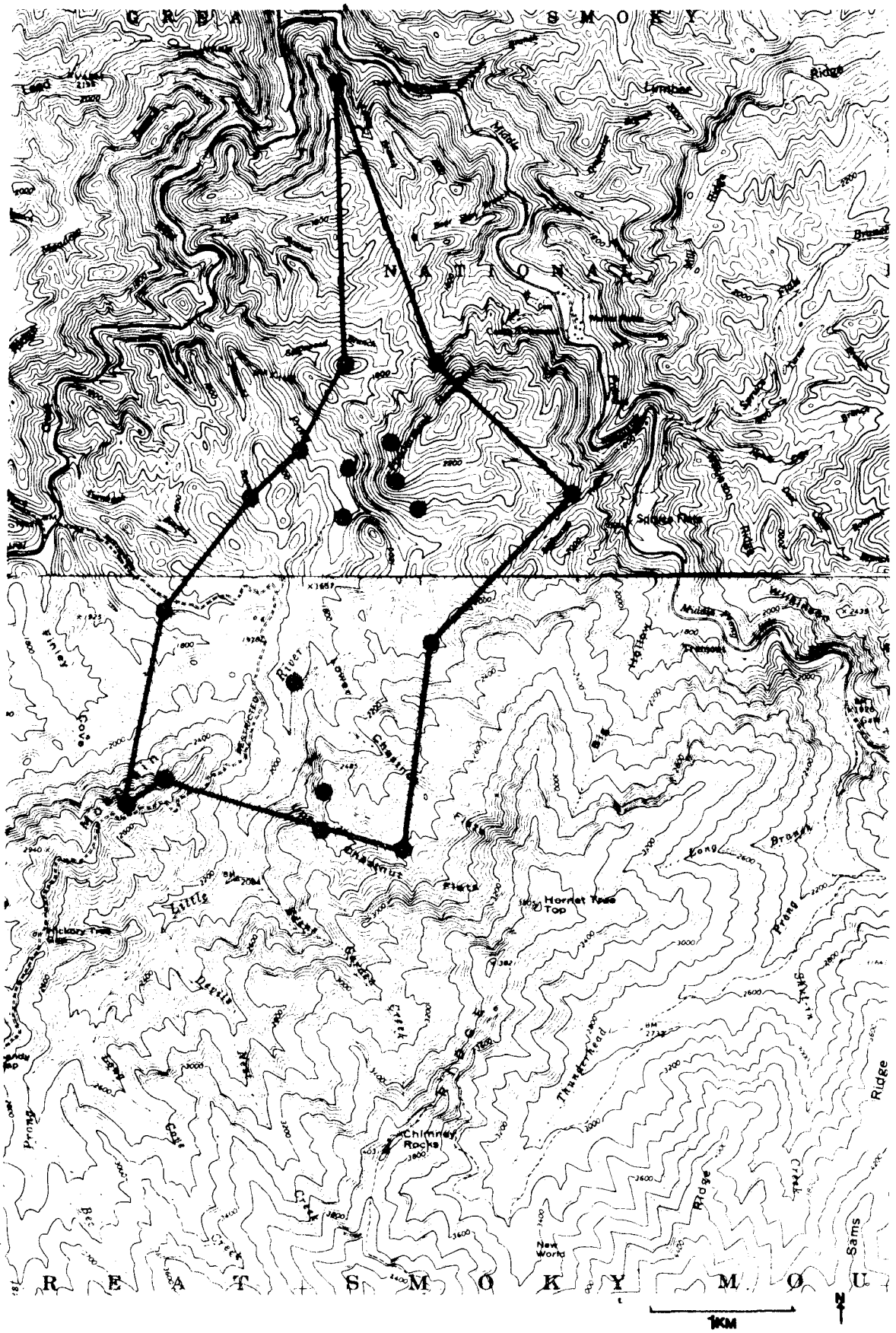


Figure 12. Home range of No. 63, an adult female bear, radiotracked during summer 1975 in the Great Smoky Mountains National Park.

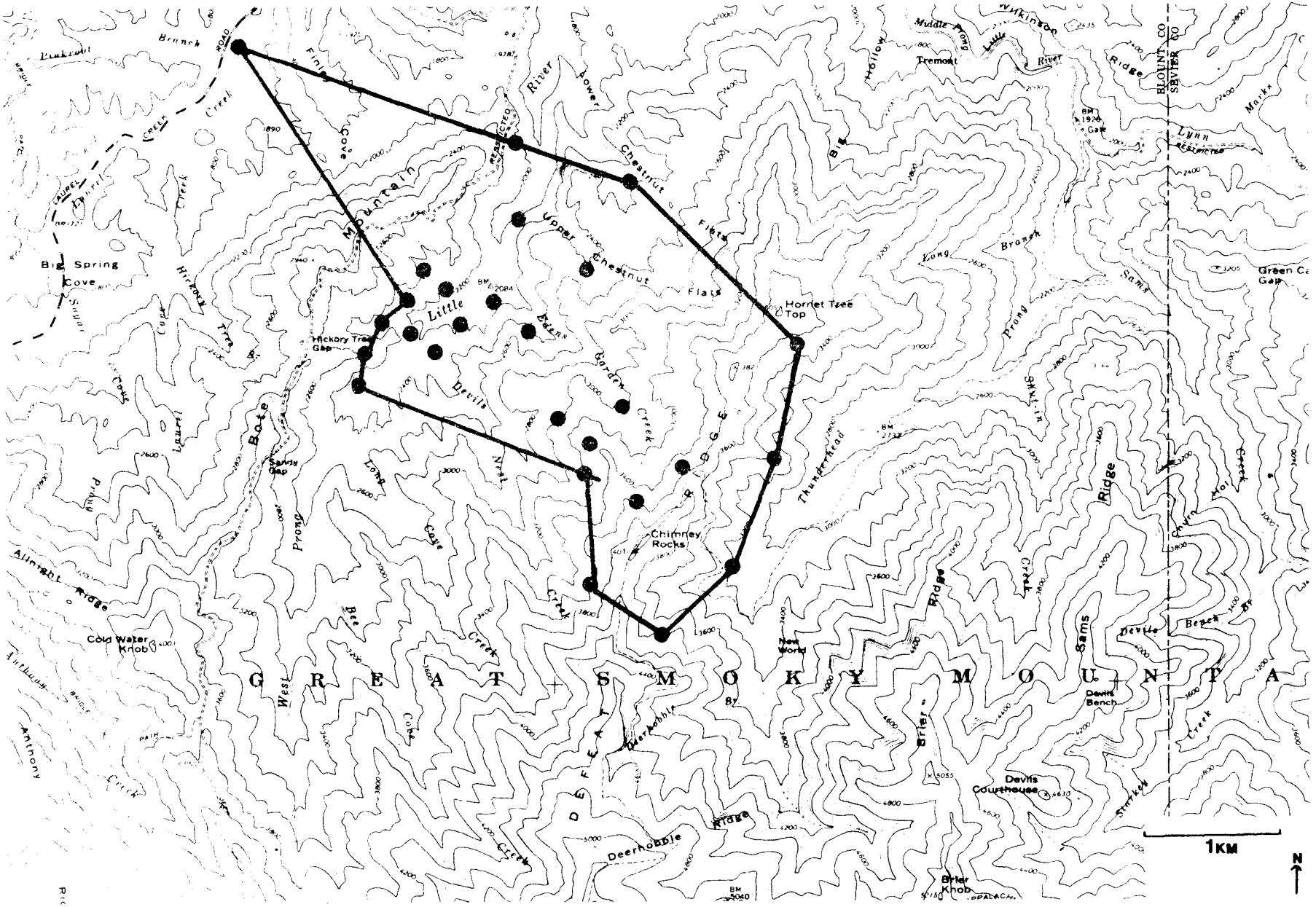


Figure 13. Home range of No. 64, an adult female bear, radiotracked during summer 1975 in the Great Smoky Mountains National Park.

up the east slope of Defeat Ridge were also recorded. No. 64 denned on the west slope of Defeat Ridge within her summer home range.

Bear No. 67, a 4.5 year old adult male, was captured on 1 August 1975 in the WPLR watershed. He weighed 61.4 km and appeared in good physical condition. This bear had been captured in September, 1974 at which time a radiotransmitter was attached to the animal. When captured in 1975, 0.9 km for the 1974 capture site, the transmitter collar was still attached but the battery unit had been knocked off.

The 12 recorded movements of No. 67 were limited to a 274 ha (677 a) area. The home range measured 3.9 km long and 1.5 km wide (Fig. 14). This summer range included both east and west slopes of Bote Mountain with no apparent geographical features of the terrain acting as a boundary. On 28 August, No. 67 made a 2.4 km movement west toward Cades Cove. After 29 August, the bear was never located in the central study area.

Three adult males, Nos. 65, 68, and 69, were located too infrequently to estimate home ranges. All these animals were captured on Bote Mountain within 1.2 km of one another. Bear No. 65 was a large animal for his age and appeared to have a wide range. Five locations of this bear were on Bote Mountain. Another location placed the bear across Laurel Creek Road near Turkeypen Ridge. The maximum distance between locations was 5.4 km.

Bears No. 68 and 69, both 5.5 years old, were only located a total of 12 times. After capture, neither animal returned near its capture site. Both animals appeared to occupy the lower portion of Defeat Ridge between 540 and 850 m elevation. It was often possible

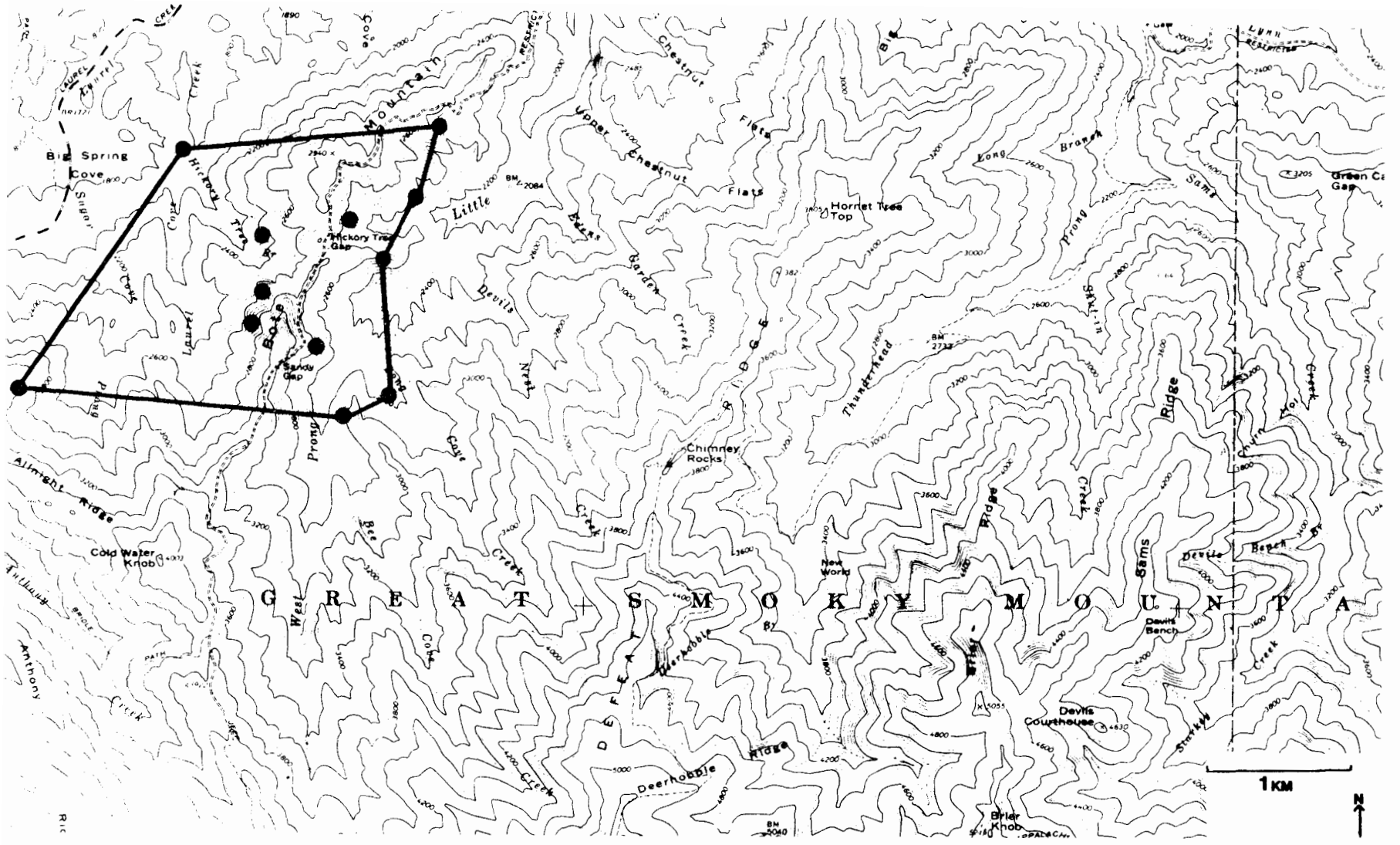


Figure 14. Home range of No. 67, an adult male bear, radiotracked during summer 1975 in the Great Smoky Mountains National Park.

to obtain one azimuth reading on these bears, but attempts to obtain a second reading were generally negative.

Summer home range size of adult females in the GSMNP averaged 499 ha (1233 a). One female had a small home range of only 188 ha (465 a). The small size of this home range may have been a result of the animal's physical condition. Home ranges of adult female bears agree favorably with results obtained by Beeman (1975) in the same study area. He reported an average home range size of 721 ha (1781 a) for 7 adult females in the Park. In Washington, Poekler and Hartwell (1973) estimated an average summer home range of 484 ha (1196 a) for females. Ernest (1973) reported two adult females averaged 1537 ha (3796 a) in Georgia. In Pennsylvania, Kordek (1973) estimated an average home range of 1994 ha (4926 a) for 2 adult females.

Average home range length of 4.6 km is less than reported by Beeman (1975), but greater than a similar measurement used by Jonkel and Cowan (1971) in the spruce-fir biome of Montana. The mean distance between sequential locations for adult females agrees with results obtained by Matula et al. (1974) in Pennsylvania.

The calculation of home range is an approximation and the size shifts with season and conditions. Comparisons of home range show a large variation in size. Part of this variability between estimated home ranges is likely due to differences in methodology. In any bear habitat, the quality, quantity, and distribution of food probably determines the minimum home range size. There is considerable habitat diversity in the GSMNP. Habitat diversity, and its interspersion, are probably the key factors in determining home range size; home ranges

are small because all the animal's requirements can be met in a relatively small area.

The home range size of the only subadult male radiotracked was 517 ha (1276 a). This bear appeared to have established a home range since his movements were confined to a well-defined area. Beeman (1975) found the home range of 5 subadult males exhibited wide variations in size. Home range size ranged from 228 to 1080 ha (563 to 2668 a) and averaged 650 ha (1606 a). In Pennsylvania, Matula et al. (1974) also reported large variations in subadult male home range sizes. The average home range size of 3 subadult males was 5618 ha (13,876 a).

Two adult males successfully radiotracked had an average summer home range of 614 ha (1515 a). Three adult males were located too infrequently to determine their home ranges. The home range size of adult males is relatively small compared to other studies. In the Park Beeman (1975) estimated one adult male averaged 2072 ha (5118 a). Hardy (1974) reported an adult male in eastern North Carolina covered 17,500 ha (43,225 a). Kordek (1973) estimated the home range of males in Pennsylvania averaged 14,763 ha (36,464 a).

All radiocollared bears displayed some home range overlap with at least one other radiocollared bear. The northern boundary of No. 64's home range overlapped with the southern boundary of No. 63's home range (Fig. 15). Although the home range of the two females overlapped, they were not usually simultaneously found in the area of overlap. On one occasion the animals were estimated to be within 0.6 air-km of one another. Each bear's center of activity was approximately 3 to 3.5 km

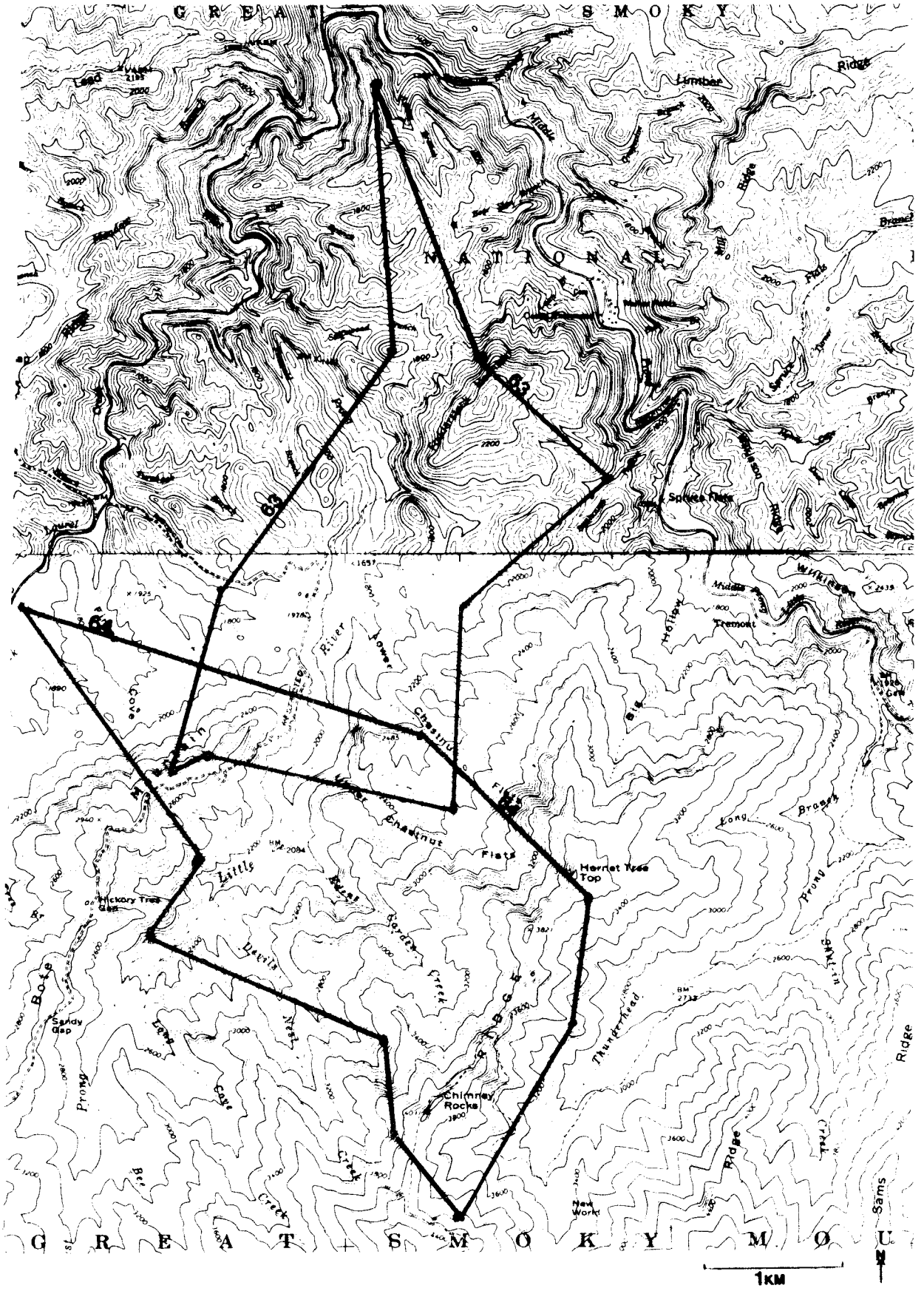


Figure 15. Home range overlap of two adult female bears radiotracked in the Great Smoky Mountains National Park during summer 1975.

apart. Large portions of their home range appeared to be used exclusively by only one female. Bear No. 37's home range showed no overlap with either No. 63 or No. 64.

Home ranges of male bears overlapped with other males and with females. Fig. 16 illustrates the spatial relationship of male bears radiotracked in the GSMNP. The home range of No. 61 and No. 67, both adult males, displayed no areas of overlap. The home range of No. 60, a subadult male, was overlapped on the east by No. 61 and on the west by No. 67. Bear No. 60 appeared to have only a small area that was used exclusive to other males.

Other studies have found that bears have overlapping home ranges. Jonkel and Cowan (1971) reported considerable home range overlap between adult males and females but minimal overlap between adults of the same sex. In Maine, Spencer (1955) suggested that there was a great deal of range overlap among bears. Beeman (1975) found that males range wider than females and the home range of adult males may cross the boundaries of several females.

The extent of bear interchange between the two watersheds depended on the behavior of individual bears. Three female bears radiotracked in this study showed little interchange between the watersheds. Beeman (1975) suggested Bote Mountain may be a geographical boundary setting movement limits in some bear home range. Generally the bears' movements were confined to one watershed. In this study when females did cross Bote Mountain, they quickly returned closer to the activity center of their home range. These movements across Bote Mountain probably reflect exploratory movements of the bears. Bear

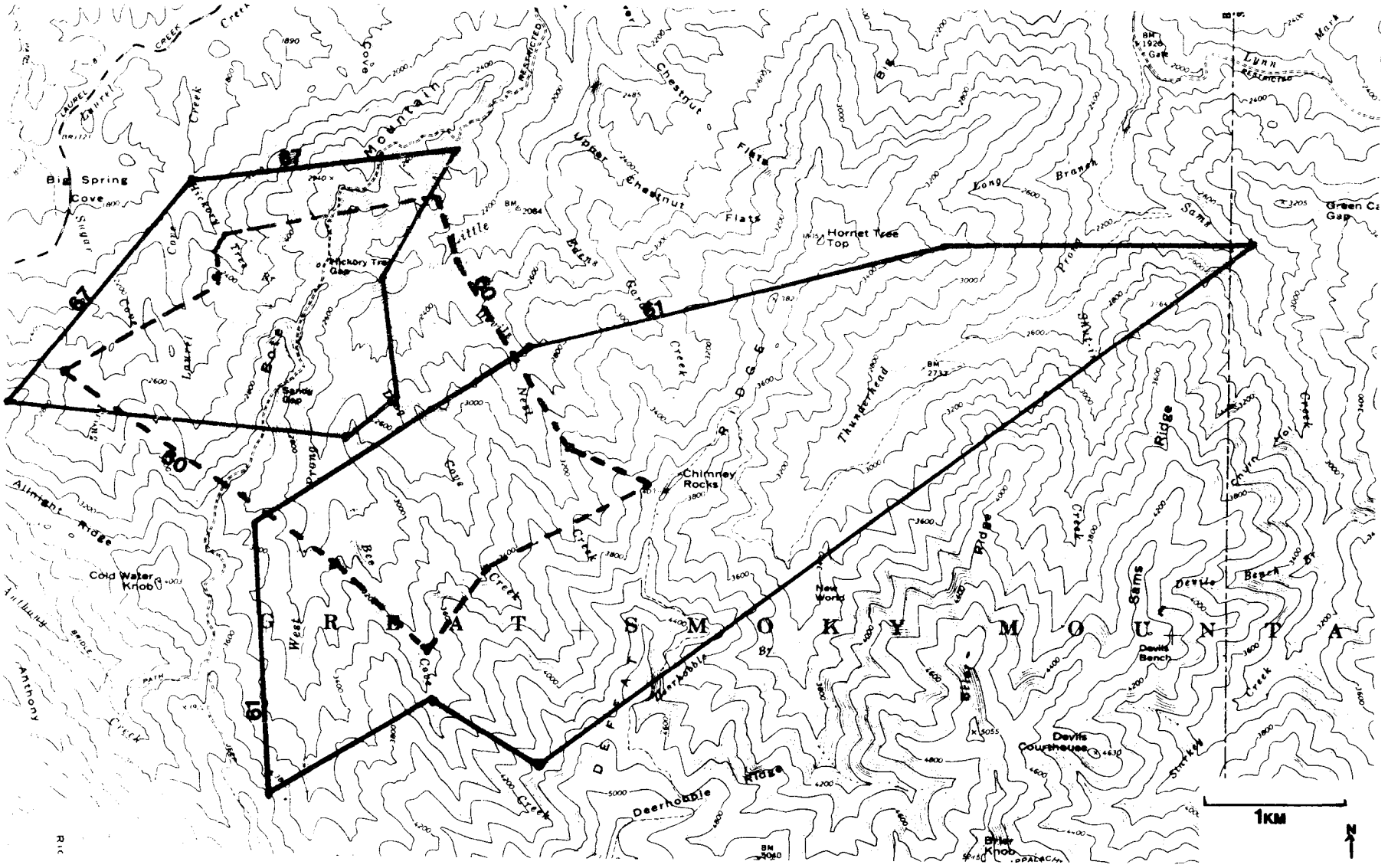


Figure 16. Home range overlap of three male bears radiotracked in the Great Smoky Mountains National Park during summer 1975.

No. 61, an adult male, was never located in Laurel Creek watershed after his capture. The animal eventually left WPLR watershed and was located in the adjacent watershed to the east. Bears No. 60 and No. 67 appeared to utilize areas in both watersheds. In the middle of August No. 60 restricted his movements to the higher elevations on the west slope of Defeat Ridge. Bears No. 68 and No. 69 were never located near Bote Mountain after they had been captured. Their movements appeared to be limited to a remote section of the central study area.

Home ranges of bears determined by radiotelemetry may explain some of the distribution of tagged scats. Eighteen single-tagged scats (4--^{54}Mn and 14--^{65}Zn) were collected on the west slope of Bote Mountain between Hickory Tree Gap and Sandy Gap. The home range of No. 37 (^{65}Zn-tagged), No. 60 (^{65}Zn-tagged), and No. 67 (^{54}Mn-tagged) included this section of Bote Mountain (Figs. 9, 10, and 14). Additionally, 14 individual bears were captured and tagged within 1.0 km of Hickory Tree Gap during the study. The high incidence of tagged scats, capture results, and the inclusion of this area in 3 bears' home range indicate high utilization in summer. It has been previously suggested that the availability of preferred early summer foods is probably the attraction to the area.

Twenty-one ^{65}Zn-tagged scats and 6 ^{54}Mn-tagged scats were collected on the Defeat Ridge-Thunderhead Index Route. Approximately 75 percent of these scats were collected in August and September. Bear No. 60 was located near Defeat Ridge Trail in late August on several occasions. The home range of No. 61 (^{65}Zn-tagged) included almost the entire length of Defeat Ridge Trail (Fig. 11, p. 48). Bear No. 64 (^{54}Mn-tagged) was also

located several times near Chimney Rocks, at the eastern end of Defeat Ridge Trail (Fig. 13, p. 51). Since both radiolocations and tagged scats were generally obtained in August and September, they may represent shifting home ranges in response to seasonally ripening foods.

H. EXTENDED SUBADULT MOVEMENTS

Extended movements of two subadult males were recorded during the study period. Bear No. 16, a 2.5 year old male, was initially captured on 11 November 1972 by the Georgia Game and Fish Division. The animal weighed 35.5 kg when released in the Collman River Wildlife Management Area. The release location was approximately 1.2 km from the Georgia-North Carolina boundary. Bear No. 16 was recaptured along Defeat Ridge on 2 July 1974. His weight was estimated to be 45.4 kg and the animal appeared thin. The minimum distance between the release point in Georgia and the capture site in the GSMNP was approximately 45 air-miles (72 air-km). The Nantahala and Cherokee National Forests occupy large areas between the release and capture locations. These areas would afford some protection to the animal. Since most of the probable travel route is mountainous terrain, the actual distance between the two locations is greater than the figure given above.

Bear No. 52 was a 2.5 year old male captured along U.S. 441 on the North Carolina side of the Park. The animal was captured on 3 July 1975 and weighed 50.0 kg. National Park Service personnel released the bear at Schoolhouse Gap along the Park periphery. This location was over 33 air-km from the capture site. On 2 August 1975, No. 52 was killed by law enforcement officers in Newport, Tennessee. This location

was approximately 42 air-miles (67 air-km) northeast of the release site. The animal moved an average of 2.3 km per day during this 30-day period. Any route the animal traveled involved moving through areas of high human population density. At some time the bear crossed heavily-travelled Interstate 40.

Beeman (1975) evaluated homing ability of bears in the GSMNP. In his study distance transplanted and inexperience of the bear influenced homing success. Seventy percent of the inexperienced males transplanted over 30 km did not home.

I. DIEL ACTIVITY

A total of 455 activity readings were recorded for the 8 bears outfitted with radiotransmitters. Activity was recorded for all animals when possible; however, most readings were taken from two adult females, one adult male, and one subadult male. Diurnal activity readings were recorded in conjunction with azimuth readings for bear locations. Additional daytime readings were taken hourly for 10 to 12 hour periods. Nocturnal readings were usually taken hourly from a single telemetry station where several animals could be monitored simultaneously.

Radiocollared bears were significantly more active during diurnal than nocturnal periods (χ = 82.81, $P \leq .05$). Peaks of activity indicate crepuscular habits of black bears in the GSMNP (Fig. 17). Activity increased shortly before sunrise, and peaked between 0600 to 1000 hr and 1500 to 1900 hr. Activity levels declined after dark and reached a low between 2300 to 0400 hr. The low number of observations taken between

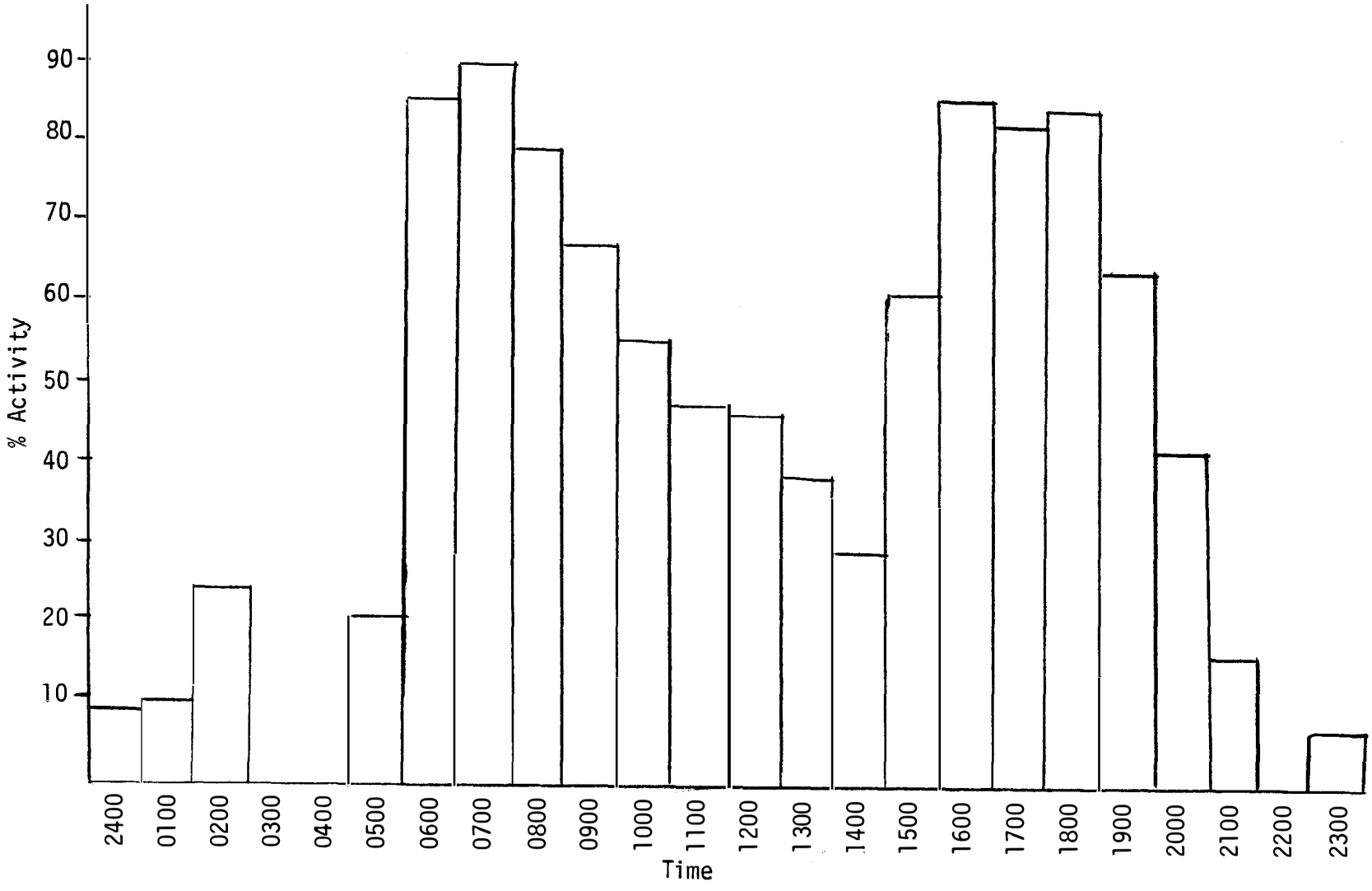


Figure 17. Diel Activity of Black Bears in the Great Smoky Mountains National Park.

0100 to 0500 hr cause the activity during this time to appear relatively high. Recorded nocturnal activity generally occurred during one clear night with a full moon.

Activity levels increased shortly before dawn, probably when a sufficient amount of light enabled bears to begin feeding. Armstrup and Beecham (1976) suggested black bear foraging periods were largely determined by the animal's perceptual abilities. Consequently, foraging activities peak during daytime. Additionally, activity patterns centered around early morning and evening feeding periods enable bears to avoid high summer temperatures in the Park. Linderman (1974) suggested Alaska grizzly bears (*Ursus arctos*) may reduce activities in response to high summer temperatures. Black bear activity in this study appears to decrease in the middle of the afternoon. During this time bears probably utilize bedding sites (described later).

Results of other studies present conflicting descriptions of black bear activity patterns. Poekler and Hartwell (1973) found bears in western Washington to be active 90 percent of the time during the day. Additionally, they suggest bears are inactive for long periods at night. In Idaho, Amstrup and Beecham (1976) reported peaks of activity occurred at 0800 and 2100 hr. Activity reached its lowest level between 0100 to 1400 hr. However, Erickson (1965) suggests Alaska black bears are nocturnal. Similarly, Rogers (1970) attributed nocturnal activity patterns to bears in Minnesota. In the GSMNP, Beeman (1975) found bears to frequently be active during any part of the day or night.

Part of the variability in activity patterns may be attributed to different methods of data collection. The studies mentioned above

relied on visual observation, integrity of the radio signal, or a sequence of radiolocations at specific time intervals. Visual observations may be biased toward a few animals which take advantage of artificial food sources. For example, in Yellowstone National Park, campground bears exhibited a nocturnal feeding pattern (Barnes and Bray 1967). Visual observation of wild bears in the densely forested GSMNP is uncommon; when the animals are observed, visibility is limited to only a few meters.

Observations of bear activity based on the integrity of radio signals is largely subjective. In mountainous terrain, radio contact is often intermittent, and "bouncing" signals require skillful interpretation. Interpretation of bear activity based on a sequence of locations is often impossible to obtain. In the GSMNP, Beeman (1975) reported the attempted sequence of one bear location per hour was frequently not achieved. Additionally, this method measures bear activity only when the animal moves. Restricted bear movement associated with feeding in a small berry patch or around mast-producing trees would be interpreted as inactive.

The advent of activity-monitoring devices on radiotransmitters greatly facilitates the interpretation of activity patterns. As long as the radio signal can be heard, however weak that signal may be, an activity reading can be recorded. This device requires only one reading need be obtained. Activity based on movement requires at least two azimuth readings. Additionally, by placing oneself in a strategic place, activity readings on several animals can be recorded from one location. Signal disruption (change), interpreted as an active reading,

is achieved when the animal moves its head vertically. This allows activity around a restricted feeding site to be interpreted as such.

J. BEDDING SITES

Thirteen black bear bedding sites were located while searching for off-trail scats (Table 8). Beds were generally identified by the presence of two or more scats on the edge of a depression. Other bear signs such as game trails or diggings were also observed near most beds.

Eight depressions used as beds were created by uprooted chestnut trees (*Castanea dentata*). Two beds were located beside rock-outcrops. Another depression was located on the uphill side of a large tulip poplar (*Liriodendron tulipifera*). Most beds were located in thickly forested, remote sections of the central study area. Two beds, however, were in relatively open situations; one on the nonmaintained Bent Arm Trail and another approximately 15 m from Bote Mountain Road. This bed, in the middle of a berry patch, was utilized by a bear within four days of its discovery. Two fresh scats around the bed consisted of berries. The description of a single day bed in the Southern Appalachians of northern Georgia is similar to beds located in the GSMNP (Ernest 1973). This bed was an oval-shaped depression, 1.2 m long and 0.6 m wide, on the uphill side of a stump. Bedding sites used by other species have been described. Taylor (1956) briefly described white-tailed deer (*Odocoileus virginianus*) summer bedding sites. These beds were generally on dry, smooth ground and often had several trees around the site. In some instances deer droppings were located nearby.

Table 8. Description of black bear bedding sites located within the Great Smoky Mountains National Park

Date located	Location	Measurements length x width x depth (m)	Contents	No. scats near bed	Forest type	Other bear signs
8/ 7/1974	Bote Mtn	2.4x0.5x0.3	leaves	3	Closed oak	---
8/10/1974	Bote Mtn	4.6x1.2x0.5	leaves	2	Closed oak	game trails in area
8/22/1974	Bote Mtn	0.9x0.6x0.2	leaves	3	Cove hardwood	game trail through bed
8/22/1974	Bote Mtn	0.9x0.6x0.2	leaves	3	Cove hardwood	---
9/ 9/1974	Bote Mtn	1.8x0.9x0.3	leaves	4	Closed oak	game trail through bed
6/12/1975	Bent Arm Tr	1.2x1.2x0	grass	4	Closed oak and northern hardwood ecotone	---
8/11/1975	Bote Mtn	0.9x0.9x0	berry plants	2	Open oak-pine	---
9/ 8/1975	Bote Mtn	1.8x0.9x0.2	leaves	3	Closed oak	game trail through bed
9/ 8/1975	Bote Mtn	0.9x0.6x0	bare soil	4	Closed oak	game trail through bed
9/ 8/1975	Bote Mtn	2.4x0.9x0.5	leaves	3	Closed oak	game trail through bed
9/ 9/1975	Bote Mtn	1.2x1.2x0.2	pine needles	3	Open oak-pine	several diggings within 15 m of bed
9/10/1975	Bote Mtn	2.1x0.9x0.9	leaves	3	Closed oak	game trail through bed
9/10/1975	Bote Mtn	2.3x0.9x0.6	leaves	3	Closed oak-cove hardwood ecotone	---

Bedding material in most cases consisted of leaves or pine needles. However, there was no evidence of bears raking material into the beds. Leaf content and depth in the depression appeared no deeper than the surrounding forest floor.

Bears may use several different bedding sites located throughout the home range. On the other hand, one bed may be used for several consecutive days, particularly if the bed is near a favorite food source.

Bears probably use these beds at night when the animal's activity is lowest and as resting sites during the daytime. Daytime activity decreases during mid-afternoon. During this time bears may use the site as a resting place to avoid high daytime temperatures.

CHAPTER V

SUMMARY

A study to determine the movements, dispersal, and activities of the black bear using radioisotopes and radiotelemetry was conducted in the GSMNP from June through September of 1974 and 1975. The major objectives of the study were: (1) to describe bear movements and areas of concentrated activity using radioisotopes, (2) to delineate the home range of radiocollared bears and determine the extent of home range overlap, (3) to accurately determine active and inactive periods of bears, (4) to evaluate selected radioisotopes for use as radioactive feces tags.

The GSMNP consists of 2072 square km of mountainous terrain characterized by a diversity of habitats. There is considerable variation in both precipitation and temperature between areas of low elevation and areas of high elevation. The study area consisted of 520 square km within the Tennessee portion of the Park lying west of U.S. 441. Radiotelemetry and the collection of off-trail scats were conducted in two watersheds separated by a major ridgecrest.

During the two-year study a total of 82 individual bears were captured and injected with radioisotopes. Eight radiocollared bears were monitored from July to the middle of September, 1975.

Two penned bears were injected with 100 μc of either ^{60}Co or ^{134}Cs. Both isotopes appear unacceptable as feces tags. The rapid elimination of ^{60}Co made the identification difficult after two weeks post-injection. The elimination of ^{134}Cs was slower than ^{60}Co but the

leachable nature of the isotope reduces its effectiveness as a long-term feces tag. Two additional isotopes, ^{109}Cd and ^{144}Ce, evaluated from a previous study, initially appeared satisfactory as feces tags. However, difficulty in the counting process interfered with the identification and quantification of these isotopes.

Previously established Index Routes accounted for 114 and 207 bear scats in 1974 and 1975 respectively. Additionally, 360 and 226 off-trail scats were collected in 1974 and 1975 respectively. The closed oak and open oak-pine forest types were the most productive associations for collecting off-trail scats. Eighty-three of the total scat samples collected were radioactive. Most scats were located within 3.5 km of a possible capture site. Location of three scats revealed movements of at least 7.5 km. Based on the location of radioactively tagged scats, bears moved freely between two watersheds. Two portions of the central study area showed high utilization by bears.

Average summer home range size of adult females was 499 ha (1233 a). One subadult male had a home range of 517 ha (1276 a). Summar home range of two adult males averaged 614 ha (1515 a). Home range of three adult males was difficult to assess due to their wide-ranging movements.

Extended movements were recorded for two subadult males. One bear released in Georgia on 11 November 1972 was captured in the central study area on 2 July 1974. Another bear, released along the Park periphery, was shot 30 days later in Newport, Tennessee.

Bears were significantly more active during diurnal than nocturnal periods. Activity peaked after sunrise and in late evening.

Activity was lowest during the night. This crepuscular pattern enables bears to avoid high daytime temperatures.

Thirteen bear bedding sites were located during the study. Depressions created by uprooted chestnut trees were most commonly used as bedding sites. Contents of the beds were generally leaves or pine needles. Bears probably use these beds at night and as resting sites to avoid high daytime temperatures.

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APPENDIX

Table 9. Maximum and minimum distance of radioactively tagged scat from capture sites in the Great Smoky Mountains National Park

Date	Location	Minimum distance	Maximum distance	Tagged
6/21/74	Bote Mountain	0.1	1.7	Zn
7/01/74	Defeat Ridge Trail	2.6	3.0	Mn
7/10/74	Defeat Ridge	0.5	4.4	Mn
7/12/74	Defeat Ridge	0.4	4.3	Mn
7/12/74	Defeat Ridge	0.4	4.3	Mn
7/28/74	Defeat Ridge Trail	2.4	3.1	Zn
7/28/74	Defeat Ridge Trail	2.8	3.4	Zn
7/28/74	Defeat Ridge Trail	1.6	3.2	Zn
8/06/74	Bote Mountain	0.8	3.8	Mn
8/10/74	Bote Mountain	0.6	4.9	Zn
8/19/74	Defeat Ridge Trail	2.5	3.2	Zn
8/19/74	Thunderhead Trail	3.2	3.8	Zn
8/19/74	Defeat Ridge Trail	2.1	3.0	Zn
8/19/74	Thunderhead Trail	3.1	3.7	Zn
8/21/74	Bent Arm Trail	0.2	31.6	Mn,Zn
8/23/74	Defeat Ridge	1.2	5.0	Mn
8/24/74	Bote Mountain	0.3	3.6	Zn
8/24/74	Bote Mountain	0.3	3.7	Zn
8/24/74	Bote Mountain	0.2	3.7	Zn
8/24/74	Bote Mountain	0.3	3.6	Zn
8/24/74	Bote Mountain	0.2	3.6	Zn
8/26/74	Bote Mountain	0.2	3.8	Zn
8/26/74	Bote Mountain	0.3	3.7	Zn
9/08/74	Thunderhead Trail	3.0	3.8	Zn
9/12/74	Bote Mountain	0.4	3.5	Zn
9/12/74	Bote Mountain	0.4	3.6	Zn
9/12/74	Bote Mountain	9.5	19.9	Mn,Zn
9/12/74	Bote Mountain	1.4	3.0	Mn
9/16/74	Bote Mountain	0.8	4.4	Mn
9/19/74	Bote Mountain	0.7	3.5	Mn
9/19/74	Defeat Ridge	0.8	3.4	Mn
9/20/74	Bote Mountain	0.2	3.6	Zn
9/20/74	Bote Mountain	1.2	3.1	Mn
9/20/74	Bote Mountain	9.2	18.6	Mn,Zn
9/25/74	Bote Mountain	1.1	3.2	Zn
0/05/74	Bent Arm Trail	1.7	30.4	Mn,Zn
7/06/75	Sugarland Mt. Trail	0.4	18.8	Mn,Zn
7/06/75	Sugarland Mt. Trail	0.3	18.5	Mn,Zn
7/19/75	Defeat Ridge Trail	2.5	3.2	Zn
7/19/75	Thunderhead Trail	2.8	3.3	Zn
7/19/75	Thunderhead Trail	2.9	3.9	Zn
7/19/75	Sugarland Mt. Trail	1.2	19.2	Mn,Zn
8/01/75	Sugarland Mt. Trail	1.7	19.3	Mn,Zn

Table 9 (continued)

Date	Location	Minimum distance	Maximum distance	Tagged
8/02/75	Defeat Ridge Trail	0.8	5.6	Zn
8/02/75	Defeat Ridge Trail	7.8	16.8	Mn,Zn
8/02/75	Defeat Ridge Trail	2.5	4.8	Zn
8/02/75	Defeat Ridge Trail	2.6	4.8	Zn
8/02/75	Defeat Ridge Trail	2.7	4.9	Zn
8/02/75	Thunderhead Trail	2.6	3.5	Zn
8/02/75	Thunderhead Trail	2.6	3.5	Zn
8/02/75	Thunderhead Trail	2.7	3.6	Zn
8/02/75	Thunderhead Trail	2.7	3.6	Zn
8/15/75	Bent Arm Trail	1.0	29.2	Mn,Zn
8/17/75	Thunderhead Trail	0.6	3.0	Mn
8/17/75	Thunderhead Trail	0.9	3.2	Mn
8/30/75	Defeat Ridge Trail	0.2	3.0	Mn
8/30/75	Thunderhead Trail	3.2	4.8	Zn
8/30/75	Thunderhead Trail	3.3	5.2	Zn
9/13/75	Defeat Ridge Trail	0.6	4.2	Mn
9/14/75	Bent Arm Trail	2.2	31.1	Mn,Zn
9/28/75	Spence Field Shelter	2.3	5.8	Mn
7/08/75	Sugarland Mountain	0.1	18.2	Mn,Zn
7/08/75	Sugarland Mountain	0.1	18.5	Mn,Zn
8/11/75	Bote Mountain	0.4	3.6	Zn
8/11/75	Bote Mountain	0.1	3.4	Zn
8/11/75	Bote Mountain	0.1	3.4	Zn
9/01/75	Defeat Ridge	3.0	4.4	Zn
9/01/75	Defeat Ridge	3.1	4.5	Zn
9/01/75	Defeat Ridge	3.2	4.5	Zn
9/03/75	Green Camp Gap	3.2	7.1	Mn
9/03/75	Bote Mountain	1.9	5.4	Mn
9/04/75	Green Camp Gap	3.4	7.5	Mn
9/06/75	Bote Mountain	0.9	4.1	Zn
9/07/75	Defeat Ridge	0.6	3.2	Mn
9/08/75	Bote Mountain	0.2	3.3	Zn
9/09/75	Bote Mountain	1.4	2.9	Mn
9/09/75	Bote Mountain	1.5	2.8	Mn
9/09/75	Bote Mountain	0.5	3.8	Zn
9/10/75	Green Camp Gap	4.8	7.6	Zn
9/10/75	Bote Mountain	1.0	3.5	Mn
9/10/75	Bote Mountain	1.1	3.4	Mn
9/11/75	Bote Mountain	0.9	4.6	Zn
9/14/75	Bote Mountain	0.6	3.8	Mn

Table 10. Black bears captured and injected with radioisotopes in the Great Smoky Mountains National Park, 1974 and 1975

Date	Bear no.	Sex	Weight kg (lbs)	Age (years)	Immobilizing dosage (cc)[a]	Capture and release location	Amount of isotope administered (μc)
6/14/74	01	F	45.4 (100)	5.5	1.4	Bote Mtn	40Zn
6/15/74	02	M	77.3 (170)	6.5	1.3	Bote Mtn	60Mn
6/15/74	03	F	34.1 (75)	5.5	0.9	Bote Mtn	40Zn
6/16/74	04	M	52.3 (115)	4.5	0.5	Bote Mtn	60Mn
6/16/74	05	M	54.6 (120)	3.5	1.0	Bote Mtn	40Zn
6/19/74	06	M	100.0 (220)	6.5	1.5	Bote Mtn	60Zn
6/19/74	07	M	38.6 (85)	4.5	0.8	Bote Mtn	40Zn
6/19/74	08	F	59.1 (130)	8.5	0.8	Bote Mtn	32Zn
6/21/74	09	F	31.8 (70)	3.5	0.8	Bote Mtn	40Zn
6/22/74	10	M	65.9 (145)	3.5	0.7	Bote Mtn	40Zn
6/22/74	11	M	63.6 (140)	3.5	0.8	Bote Mtn	40Mn
6/25/74	12	M	61.6 (135)	3.5	1.0	Bote Mtn	40Zn
6/26/74	13	M	68.2 (150)	5.5	0.8	Bote Mtn	40Zn
6/26/74	14	F	40.9 (90)	5.5	0.6	Bote Mtn	40Mn
6/27/74	15	M	77.3 (170)(est.)	---	1.2	Bote Mtn	50Mn
7/02/74	16	M	45.4 (100)(est.)	4.5	0.6	Defeat Ridge	40Mn
7/05/74	17	F	52.3 (115)(est.)	17.5	1.0	Defeat Ridge	40Mn
7/10/74	18	F	38.6 (85)	7.5	0.6	Defeat Ridge	60Mn
7/24/74	25	M	56.8 (125)	4.5	0.8	Rabbit Creek	60Zn,60Mn
7/24/74	26	F	47.7 (105)	6.5	0.8	Rabbit Creek	60Zn,60Mn
7/25/74	27	M	77.3 (170)	5.5	0.8	Rabbit Creek	60Zn,60Mn
7/25/74	28	F	63.6 (140)	13.5	0.8	Rabbit Creek	60Zn,60Mn
7/25/74	29	F	54.6 (120)	5.5	0.6	Rabbit Creek	60Zn,60Mn
7/30/74	19	M	86.4 (190)	10.5	0.7	Sugarland Mtn	60Zn,60Mn
7/31/74	20	M	75.0 (165)	7.5	0.8	Sugarland Mtn	60Zn,60Mn
8/01/74	22	M	38.6 (85)	4.5	0.7	Sugarland Mtn	30Zn,30Mn
8/05/74	23	M	75.0 (165)	3.5	0.5	Bent Arm	60Zn,60Mn

Table 10 (continued)

Date	Bear no.	Sex	Weight kg (lbs)	Age (years)	Immobilizing dosage (cc)[a]	Capture and release location	Amount of isotope administered (μc)
8/08/74	24	M	77.3 (170)	4.5	0.5	Bent Arm	60Zn,60Mn
8/08/74	30	M	68.2 (150)	4.5	0.5	Bent Arm	60Zn,60Mn
8/18/74	31	F	50.0 (110)	5.5	0.3	Sam's Gap	60Zn,60Mn
8/19/74	32	F	59.1 (130)	---	0.5	Miry Ridge	60Zn,60Mn
8/20/74	33	F	43.2 (95)	7.5	0.4	Miry Ridge	60Zn,60Mn
9/10/74	36	M	45.4 (100)	4.5	0.3	Bote Mtn	60Zn
9/13/74	37	F	29.6 (65)	5.5	0.2	Bote Mtn	60Zn
6/13/75	39	M	34.1 (75)	3.5	0.7	Bent Arm	60Zn,60Mn
6/15/75	40	M	45.4 (100)	4.5	1.3	Bent Arm	60Zn,60Mn
6/16/75	46	M	45.4 (100)	3.5	1.2	Defeat Ridge	60Mn
6/17/75	47	F	56.8 (125)	6.5	0.8	Defeat Ridge	60Mn
6/17/75	41	F	40.9 (90)	10.5	0.9	Bent Arm	60Zn,60Mn
6/17/75	42	M	113.6 (250)	5.5	1.8	Bent Arm	60Zn,60Mn
6/17/75	43	F	45.4 (100)	6.5	0.3	Bent Arm	44Zn,40Mn
6/22/75	48	F	36.4 (80)	4.5	0.5	Defeat Ridge	60Mn
6/22/75	49	M	59.1 (130)	4.5	1.2	Defeat Ridge	60Mn
6/22/75	50	M	84.1 (185)	4.5	1.8	Defeat Ridge	36Mn
6/23/75	51	M	127.3 (280)	7.5	1.4	Defeat Ridge	60Mn
6/28/75	44	F	52.3 (115)	7.5	0.5	Sugarland Mtn	60Zn,60Mn
6/30/75	45	M	79.6 (175)	5.5	0.9	Sugarland Mtn	60Zn,60Mn
7/03/75	52	M	50.0 (110)	2.5	0.5	U.S. 441[b]	60Zn,60Mn
7/04/75	56	M	56.8 (125)	5.5	2.1	Bote Mtn	60Mn
7/05/75	57	F	31.8 (70)	5.5	0.7	Bote Mtn	60Zn
7/05/75	58	F	38.6 (85)	6.5	0.8	Bote Mtn	36Mn
7/07/75	59	F	47.7 (105)	6.5	0.6	Bote Mtn	60Zn
7/08/75	60	M	47.7 (105)	3.5	0.9	Bote Mtn	60Zn
7/08/75	61	M	59.1 (130)	5.5	2.0	Bote Mtn	60Zn

Table 10 (continued)

Date	Bear no.	Sex	Weight kg (lbs)	Age (years)	Immobilizing dosage (cc)[a]	Capture and release location	Amount of isotope administered (μc)
7/09/75	53	F	38.6 (85)	5.5	0.7	Rough Creek	60Zn,60Mn
7/09/75	54	M	65.9 (145)	7.5	1.3	Rough Creek	60Zn,60Mn
7/10/75	62	M	38.6 (85)	3.5	1.2	Bote Mtn	60Zn
7/19/75	63	F	59.1 (130)	9.5	1.2	Bote Mtn	60Zn
7/19/75	64	F	40.9 (90)	11.5	1.6	Bote Mtn	60Mn
7/21/75	70	M	38.6 (85)	3.5	0.4	Rabbit Creek	60Zn,60Mn
7/21/75	71	F	43.2 (95)	5.5	0.7	Rabbit Creek	60Zn,60Mn
7/23/75	55	M	20.4 (45)	2.5	0.3	Bote Mtn	40Zn
7/23/75	65	M	75.0 (165)	4.5	1.6	Bote Mtn	60Zn
7/24/75	72	M	27.3 (60)	2.5	0.2	Rabbit Creek	60Zn,60Mn
7/24/75	73	M	68.9 (145)	5.5	0.9	Rabbit Creek	60Zn,60Mn
7/25/75	74	F	52.3 (115)(est.)	6.5	0.6	Rabbit Creek	60Zn,60Mn
7/25/75	66	F	54.6 (120)	8.5	1.5	Bote Mtn	60Mn
7/31/75	75	M	79.6 (175)	---	1.0	Rabbit Creek	60Zn,60Mn
8/01/75	67	M	61.4 (135)	4.5	0.8	Bote Mtn	60Mn
8/01/75	68	M	65.9 (145)	5.5	1.0	Bote Mtn	60Zn
8/04/75	69	M	75.0 (165)	5.5	1.0	Bote Mtn	60Zn
8/15/75	76	F	61.4 (135)	4.5	1.0	Ekaneetlee Gap	60Zn,60Mn
8/15/75	77	F	63.9 (145)	7.5	0.8	Doe Knob	60Zn,60Mn
8/18/75	78	M	72.7 (160)	5.5	0.6	Doe Knob	60Zn,60Mn
8/18/75	79	M	75.0 (165)	4.5	1.3	Ekaneetlee Gap	60Zn,60Mn
8/27/75	83	M	147.7 (325)	5.5	2.0	Cades Cove Campgr[c]	60Zn,60Mn
8/31/75	84	M	79.6 (175)	6.5	1.1	Green Camp Gap	60Zn,40Mn
9/03/75	85	M	75.0 (165)	---	1.0	Green Camp Gap	60Zn,40Mn
9/04/75	86	M	65.9 (145)	3.5	0.8	Green Camp Gap	60Zn,60Mn
9/05/75	87	F	54.6 (120)	8.5	0.6	Green Camp Gap	60Zn,60Mn

Table 10 (continued)

Date	Bear no.	Sex	Weight kg (lbs)	Age (years)	Immobilizing dosage (cc)[a]	Capture and release location	Amount of isotope administered (μc)
9/10/75	88	M	66,3 (170)	5.5	1.0	Green Camp Gap	60Zn,40Mn
9/12/75	89	F	75.0 (165)	7.5	1.1	Green Camp Gap	60Zn,40Mn

[a]Bears captured in 1974 were immobilized with M-99; bears captured in 1975 were immobilized with Sernylan.

[b]Released at Schoolhouse Gap.

[c]Released on Tremont Road.

VITA

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