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Radioisotope Feces Tagging as a Population Estimator of Black Bear (*Ursus americanus*) Density in the Great Smoky Mountains National Park

Daniel Calhoun Eagar
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To the Graduate Council:

I am submitting herewith a thesis written by Daniel Calhoun Eagar entitled "Radioisotope Feces Tagging as a Population Estimator of Black Bear (*Ursus americanus*) Density in the Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Boyd L. Dearden, Ralph W. Dimmick

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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Vice Chancellor
Graduate Studies and Research

RADIOISOTOPE FECES TAGGING AS A POPULATION ESTIMATOR OF BLACK BEAR (URSUS AMERICANUS) DENSITY IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Daniel Calhoun Eagar

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CHAPTER I

INTRODUCTION

The black bear (*Ursus americanus*) population in the Great Smoky Mountains National Park (GSMNP or Park) is an important renewable natural resource to the Southern Appalachian region. It is valuable as an attraction to Park visitors who annually spend millions of dollars in areas surrounding the Park; it is valuable as a yardstick against which to compare exploited bear populations in adjacent areas, and, perhaps most importantly, it is valuable as a symbol of Eastern wilderness which is being rapidly diminished by human exploitation of the environment. In order to effectively manage this resource, it is necessary to gain a thorough understanding of the population dynamics of the species. Basic to the understanding of any wildlife population is a knowledge of the number of individuals present, and of their distribution within the habitat.

Past studies dealing with density estimates of bear populations have employed a wide range of techniques. These include Lincoln and Schnabel estimates, questionnaires, dump counts, other direct counts, and in many cases simple guesswork (Bray and Barnes, 1967). Many of the techniques used to study bear populations in other areas have been shown to be either generally inadequate, or not applicable in the GSMNP.

Poelker and Hartwell (1973) in Washington, Carpenter (1973) in Virginia, and Spencer (1955) in Maine, in computing statewide estimates of black bears, used methods based on mean annual harvest figures. In Michigan the bear population has been estimated by utilizing harvest information as the recapture segment of a Lincoln Index (Erickson and Petrides, 1964). Neither of these techniques can be utilized in the Park, as the bear population is not subject to legal hunting. Trover and Hensel (1964) and Hornocker (1962) used direct count methods on brown bear (Ursus arctos) populations, and Barnes and Bray (1967) attempted to utilize such a technique with black bears. This approach is not suited to black bears, as they show a decided preference for dense habitat which causes difficulties in observation, especially in the eastern United States. Kemp (1972) working on a smaller and more accessible study area than that of the present study, employed Lincoln and Schnabel indices with capture-recapture data on black bears. It is beyond the capacity of the present study (and perhaps most studies) to trap with the intensity of the study by Kemp. Therefore, sufficient sample sizes cannot be generated in the Park to produce an accurate estimate using his methods.

Robson (1969) stated that the most effective plan for mark-recapture type population estimates consists of a determined effort to obtain a random sample for marking, and then exploiting the habits of the creature to obtain a large, if selective, sample in the recapture stage. A useful means of reducing bias for such a method is to employ different sampling techniques for the two stages of the experiment. Pelton (1972) proposed a method for estimating black bear populations which incorporates both of these principles. He suggested that a radioisotope feces tag be administered to captured bears, and that subsequent collection of scats (feces) along predetermined trails be considered the recapture portion of the formula.

Rongstad (1965) used a related technique in estimating densities of snowshoe hares (Lepus americanus) and 13 lined ground squirrels (Citellus tridecemlineatus). Adult females were given a subcutaneous implant of Calcium-45 prior to the breeding season. The radioisotope tag was passed on to the offspring of those females, and an estimate of the pre-breeding season population of adult females was calculated from the proportion of tagged to untagged young collected in the fall. Rongstad found that this technique gave better estimates with less effort than did traditional mark-recapture methods.

Miller (1957) conducted early work on the use of radioisotopes as feces tags. His studies were of movements in voles, but he noted the potential usefulness of the feces tag in population estimation. Nellis, et al. (1967) worked with penned animals in evaluating the potential of isotopic feces tags in carnivores.

Marcum (1974) developed and evaluated the technique proposed by Pelton (op. cit.) for determining black bear densities in the GSMNP. He believed that the estimates derived with the radioisotope scat tagging method were superior to those utilizing more conventional mark-recapture or mark-observe techniques for the following reasons: (1) biases resulting from loss of or failure to recognize tags were completely removed; (2) bias introduced by animals becoming trap shy or trap prone was removed; (3) since the estimation did not depend on reobservation of bears, bias introduced by animals becoming habituated to the presence of humans, and thus observation prone, was removed; (4) since scat were collected randomly over the study area, bias resulting from non-random recaptures or observations was removed; (5) the technique tends to generate a large sample size; (6) the method probably utilized a greater percentage of the total population in the data collection process; and (7) it is felt that less expenditure of time and resources was required in the collection of data.

On the strength of these reports it was felt that further application and evaluation of the technique of radioisotope scat tagging was warranted. This will lead to a better understanding of black bear population dynamics, and possibly to the development of an easily utilized index to bear density in the GSMNP, based on the collection of accurate density data for a period of several years. In addition, the design of the present study presents the opportunity for the further refinement and evaluation of capture techniques for black bears.

CHAPTER II

DESCRIPTION OF STUDY AREA

Geography and Physiography

This study was conducted within the boundaries of the Great Smoky Mountains National Park. The Park, which comprises a 2,072 km^2 area (207,382 ha), is bisected by the common boundary of Tennessee and North Carolina. It includes sections of Blount, Sevier and Cocke Counties in Tennessee and Swain and Haywood Counties in North Carolina. There are two major highways passing through the Park: U.S. Highway 441, the transmountain road from Gatlinburg, Tennessee to Cherokee, North Carolina and Tennessee State Route 73, which parallels the north Park boundary from Townsend to Gatlinburg. In addition to the improved roads, there is a system of secondary and fire control roads. Most of the Park is accessible only by the 1,048 km of foot trails lacing the area (National Park Service, 1969); this is especially true of the higher elevation areas.

The steep mountains which make up the GSMNP range in elevation from 270.6 m above sea level, at the confluence of Abrams Creek and the Little Tennessee River, to 2,024.7 m at Clingman's Dome. The narrow ridges and steep, V-shaped valleys are drained by approximately 960 km of rocky, fast-flowing streams. The mountains are part of the Unaka Mountain Range section of the Blue Ridge Province in the southern division of the Appalachian Highlands. Most of the underlying rock is of the Ocoee series which dates to the later precambrian, and is made up of quartz, feldspar and slate, with some schist and limestone (King, et al., 1969). The predominant soil classification is the Ramsey soil type, which displays low water storage capacity, moderate natural fertility and medium to high natural acidity (United States Forest Service, 1970).

The study area comprises approximately one-fourth (50,607 ha) of the total area of the Park. This quadrant is bounded by the transmountain road on the East and by the Tennessee-North Carolina boundary on the South. The extremes in elevation already mentioned both occur within the study area, and approximately half of the study area is over 1000 m above sea level. There are four main drainages within this area; the East, Middle and West Prongs of the Little River and Abrams Creek. Access routes include approximately 64 km of improved roads, 88 km of unimproved and deep roads, 400 km of maintained foot trails and over 240 km of abandoned foot trails.

Climate

The climate of the GSMNP is characterized by high precipitation and cool temperatures, with much variability in both factors resulting from the large differences in elevation within the Park. Temperatures at the highest elevations are 6-9° C cooler than those in the lowest areas, with a temperature gradient of 4.07° C per 1000 m rise in elevation. The precipitation at the higher elevations is about 50 percent greater than in the low-lying areas. The highest elevations receive as much as 230 cm per year: more than any other area in the eastern United States. Temperature and precipitation data are presented in Tables 1 and 2, respectively.

Flora

The many microhabitats of the Park support a vast array of flora including more than 1,300 species of flowering plants, approximately 350 mosses and liverworts, 230 lichens and more than 2,000 fungi (Stupka, 1960). Major studies of the vegetation of the Smokies have been conducted by Cain (1935), Shanks (1954), and Whitaker (1956). The most widely utilized classification of vegetation types is that of Shanks (Table 3).

The cove hardwood forests occur at low and middle altitudes, in sheltered situations where there is considerable depth of soil. This forest type comprises about

Table 1. Monthly average temperatures within the Great Smoky Mountains National Park.[a]

Month	Average Temperature 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 (56.5)
November	8.2 (46.7)	8.0 (46.4)	8.0 (46.4)
December	4.6 (40.2)	4.1 (39.4)	3.4 (38.1)

[a]From National Park Service records at Gatlinburg, Tennessee (elevation 445 m).

Table 2. Monthly precipitation within the Great Smoky Mountains National Park.[a]

Month	Avg. 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)	13.43 (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)	3.66 (2.23)
December	10.84 (4.27)	18.36 (7.31)	10.41 (4.10)
Annual	140.48 (55.31)	162.99 (64.17)	136.29 (53.66)

[a]From National Park Service records at 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 (*Oxydendrum arboreum*)
Open oak and pine	Sassafras (*Sassafras albidum*) Scatlet oak (*Quercus coccinea*) Pitch pine (*Pinus rigida*) Virginia pine (*Pinus virginiana*) Mountain laurel (*Kalmia latifolia*)
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, Knoxville, 1954. (Mimeographed).

15 percent of the study area. Hemlock forests are found along streams and lower slopes up to an altitude of 1075-1100 m, and makes up only about 5 percent of the study area. The northern hardwood forest, which occupies 25 percent of the study area, is located in areas above 1400 m. In these higher elevation areas, especially those above 1500 m, one also finds the spruce-fir forest type, which accounts for 10 percent of the study area. On intermediate to dry slopes at the lower and middle elevations the closed oak forest can be found, accounting for 25 percent of the study area. Open oak and pine stands occupy the dry, exposed slopes where the terrain is rocky. This association comprises approximately 20 percent of the study area.

In addition to the above-mentioned forest types, there is a small percentage of the study area occupied by three other vegetation types: grassy balds in some of the higher elevation areas, heath balds on some exposed sites above 1200 m, and pasture land in the Cades Cove area.

Vertebrate Fauna

Linzey and Linzey (1971) report 59 species of mammals are found in the GSMNP. The only large mammals in the Park other than the black bear are the whitetail deer (*Odocoilius virginianus*) and the European wild hog (*Sus scrofa*). There are also reports that the eastern mountain lion (*Felis concolor*) may be present in small numbers, but there is little evidence, as yet, to substantiate these reports. In addition to the mammals, other vertebrates include more than 200 species of birds, 23 species of snakes (two poisonous), more than 72 fish species and one of the richest arrays of salamanders to be found in the world (National Park Service, 1969).

CHAPTER III

METHODS AND MATERIALS

I. TRAPPING

Conditions under which this study was conducted precluded any systematic randomization of trap lines or trap sites. An effort was made to distribute captures as evenly as possible over the study area. This was accomplished by establishing one or two trap lines within each of the four major drainages in the summers of 1974 and 1975. Availability of trails or roads, topography and intensity of visitor use sometimes affected the feasibility of trapping in a given area.

In each year of the study trap lines totaling approximately 80 km were established. Approximately 25 percent of this total consisted of unimproved, limited access roads which could be trapped with the use of vehicles. For the remainder of the trap lines, it was necessary to carry all equipment in backpacks and to check traps on foot. When trapping from a vehicle, it was possible to set many more traps than could be set on foot trails, as the time required to check traps was greatly reduced. Lengths of trap lines ranged from 8 to 24 km.

Once a trap line was selected, the method of prebaiting described by Marcum (1974) was used. A prebait consisted of either three cans of sardines or about 1 kg of cured ham scraps obtained from a local restaurant. Sardines were wrapped in burlap and the ham was tied in a bundle. The baits were then suspended from a tree at a height of approximately 2.5 m. Between 10 and 20 prebaits were usually set out along a prospective trap line.

Prebaits were used more as an indicator of areas of bear activity than as a means of "baiting in" animals as in the study by Barnes and Bray (1967), or of acclimating them to an area or bait type. When a prebait was taken by a bear, a trap was constructed in the immediate vicinity. Prebaits offer the advantages of being established much more easily than a trap, and of not needing to be checked on a daily basis.

The trap used in back country captures was the Aldrich spring activated foot snare. This lightweight and effective trap consists of two parts: a 1/4 inch (0.635 cm) steel spring with a trigger mechanism, and a 3/16 inch (0.476 cm) steel cable approximately 2 m long. One end of the snare cable was anchored to a tree, and the other end positioned, with the spring, as illustrated in Figure 1. Guide logs were then placed against the tree in a wedge shape, and stepping logs positioned around the snare loop causing the bear to step into the center of the loop and onto the trigger. Bait was placed at the back portion of the "V." If ham scraps remained in

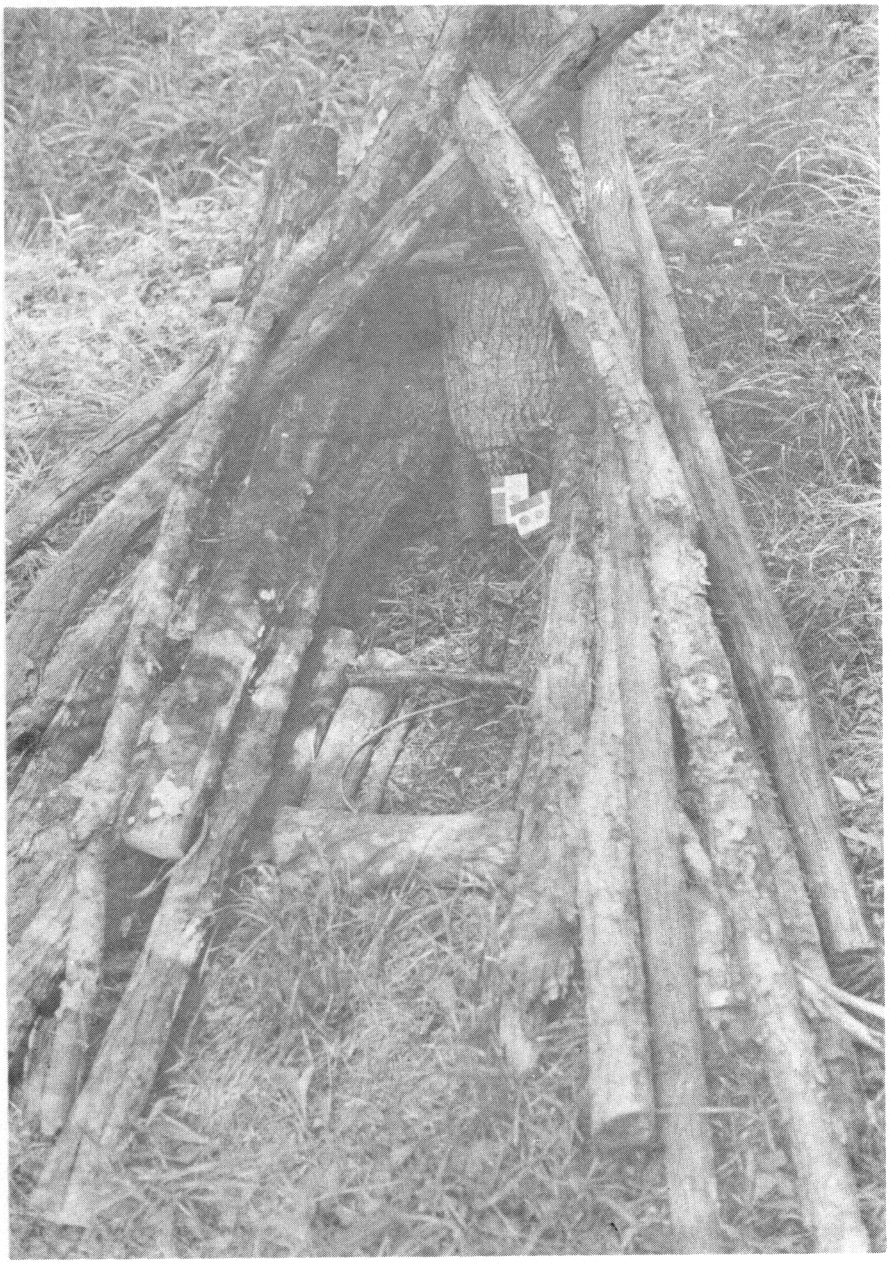

Figure 1. Aldrich spring-activated foot snare set used to capture black bears in the Great Smoky Mountains National Park.

a trap for several days, they were periodically burned with a propane torch to enhance the odor. When sardines were used, baits were periodically freshened by adding one or two cans of sardines when old baits began to putrify. There are some indications that as baits putrify, they become less effective in luring bears to traps (Erickson, 1957).

Once a snare was set, it was checked at least once daily until it was felt that enough bears had been captured in that area, or until trapping on the entire trap line was discontinued. The longest period of time for which an area was trapped was 35 days, and the shortest was 10 days. The maximum number of snares set at one time on any trap line was 13 (Bote Mountain, 1974). The maximum number set at one time on a trap line that required the trapped to be on foot was nine on Defeat Ridge in 1974.

On several occasions, a culvert type trap belonging to the National Park Service was used. This type of trap was employed when a bear was regularly visiting an area which was accessible by vehicle, such as a developed campground. Culvert traps were not used extensively since the emphasis of the study was on the segment of the population living in the back country.

II. IMMOBILIZATION

Bears were immobilized by intramuscular injection of either M-99 (etorphine) or Sernylan (phencyclidine hydrochloride). M50-50 (diprenorphine) was used as an antagonist for M-99. Concentrations of the drug solutions used were as follows: M-99, 1 mg/cc; M50-50, 2 mg/cc; and Sernylan, 100 mg/cc. The immobilizing drugs were administered by means of a projectile syringe system manufactured by Palmer Chemical and Supply Co., Inc. The aluminum syringe was loaded with the desired dosage and fired from either a CO_2-charged pistol or a powder charge syringe rifle.

The use of M-99 in conjunction with the M50-50 antagonist was the more satisfactory of the two drugs used. Average doses of M-99 were 0.013 mg/kg (range, 0.004 to 0.031) with an average induction period of 9.8 minutes (range, 3.75 to 23.5). Induction period is defined as the time from injection of the drug until the animal could be safely handled. These averages are based on 36 different captures. Other captures in which M-99 was used are not included because difficulties with equipment or field conditions prevented a clear determination of dosage or induction period. Once the necessary data were collected from an animal immobilized with M-99, a procedure which usually took from 30 min to 1 hour, the antagonist, M50-50 was administered. Dosages of M50-50 were double the amount of M-99 which had initially been injected. Average dosage of the antagonist was 0.026 mg/kg (range, 0.009 mg/kg to 0.062 mg/kg). Of the 37 captures for which good information is available, 19 were injected intramuscularly and 18 intravenously. Injection of the M50-50 into the femoral vein produced a much shorter recovery time than did intramuscular injection. Recovery time for bears given the drug intravenously ranged from 0.8 min to 20.25 min with an average of 4.3 min, while recovery time for those receiving intramuscular injections averaged 14.5 min with a range of 7.0 to 23.75 min. Recovery time is defined as the interval between the administration of the antidote and the time at which the animal is capable of walking.

During the summer of 1975, Sernylan was used as the immobilizing drug because of increased restrictions on the use of M-99 by the Bureau of Narcotics and Dangerous Drugs, and because of an increase in the price of the drug. Sernylan does not have the advantage of an antidote to speed the recovery of anesthetized animals. For this reason, and because of the long recovery time involved with the use of Sernylan (several hours), immobilized bears had to be left in the woods while other traps were attended. Another drawback in the use of Sernylan is that it sometimes induces convulsions in the animals. No bears died as a result of the use of Sernylan or M-99. The average dosage of Sernylan was 1.52 mg/kg (n=39), with the highest dose being 3.67 mg/kg and the lowest 0.66 mg/kg. Induction time was comparable to that of M-99, with an average time of 10.2 min (n=38), and a range of 3.0 min to 20.0 min. No recovery times were recorded for Sernylan, but recovery usually takes several hours, and is a gradual process during part of which the bear is capable of uncoordinated movements.

III. TAGGING

Once a captured bear was immobilized, a series of basic body measurements were taken (total length, shoulder height, length and width of front and hind feet, skull length and width, and neck, chest and forearm circumference), the bear was examined to determine whether any injuries had resulted from the capture, and it was weighed, using either a 300 or 500 pound capacity spring scale. The bear was then equipped with color coded and numbered plastic ear tags (Nasco Co.). A number was tattooed on the inner surface of the upper lip so that the bear could be identified upon recapture in the event of loss of ear tags. The first upper or lower premolar was extracted from each bear for the purpose of aging. All teeth were processed in a manner similar to the technique described by Willey (1974), which allows the cementum annuli to be counted. Ages of all bears captured are listed in Appendix A. Radio transmitter collars were placed on some bears for use in concurrent research by other workers. Blood samples and rectal swabs were also collected from some bears for analysis by other researchers.

All captured bears to be released within the study area were injected with trace amounts of radioisotopes, which were eliminated in the feces. The two isotopes, Zinc-65 and Manganese-54, were purchased from New England Nuclear Corporation (Boston, Massachusetts), and diluted so that the resulting isotonic saline-isotope solution had an initial activity of 20 microcuries (μc) per ml of solution. The isotope solutions were then stored in locked metal cabinets, and only a small amount (10-15 ml) of each isotope was carried while checking traps.

Zinc-65 and Manganese-54 were found by Pelton and Marcum (1976) to be suitable as feces tags in black bears based on the criteria that: 1) they emit gamma rays in the decay process, which are easily detectable at the necessary low levels by scintillation analysis; 2) the biological half-life is long enough to allow detection in the droppings throughout the summer and early fall; 3) the biological half-life is short enough to alleviate problems resulting from high year-to-year carryover of tags; 4) the physical half-life is long enough to permit detection throughout the study period, but not so long as to cause prolonged contamination of the environment; 5) a major route of elimination of the isotopes is through the feces; 6) a low dosage level can be used which provides ease of handling of radioisotope materials and a lessened danger to injected animals; and 7) the isotopes are resistant to leaching from feces by rainfall. Marcum (1974) offered a thorough discussion of the characteristics of Zinc-65 and Manganese-54, and of the public health aspects involved in their use as a tag in the wild bear population.

Upon capture, bears were injected intramuscularly with 30-60 μc of one or both of the isotopes. The most frequent dosage was 60 μc, with only one bear receiving as little as 30 μc. As a part of another research project in progress at the same time, bears in the watershed drained by the West Prong of the Little River were injected with Manganese-54, those in Laurel Creek drainage were tagged with Zinc-65, and bears captured in any other section of the study area were tagged with both isotopes. During the field seasons of 1974 and 1975, 34 and 47 bears, respectively, received the isotopic tags.

IV. INDEX ROUTES

During the summers of 1974 and 1975 a series of five previously established Index Routes were hiked within the study area at two-week intervals to collect bear scats. Trails were cleared of all scats approximately two weeks prior to 8 June, which marked the beginning of the bi-weekly sampling periods. Collection of scats on Index Routes continued each year until 1 October, so that there were nine sampling periods each summer. In July of 1974, a sixth route was added to the series. This route is situated in the Defeat Ridge-Thunderhead vicinity, and was helpful in increasing the sample size of collected scats. The series of Index Routes inclusive of the Defeat Ridge-Thunderhead loop, totals 144 km (Figure 2).

Bear scats were placed in plastic bags, labeled as to exact location, date of collection, appearance (freshness, contents, etc.) and collector, and stored in a freezer for future analysis.

V. SCINTILLATION ANALYSIS OF SCATS

During, or at the end of, each summer all bear scats were placed in a drying oven for a minimum of two days. A portion of each scat was then finely pulverized, and approximately 3 cm placed in the bottom of a labeled glass sample tube. The weight of the sample to be counted was recorded. The prepared scat samples were taken to Oak Ridge National Laboratories, operated by the Union Carbide Corporation for the Energy Research and Development Administration, and analyzed with an autogamma spectrometer linked with a Nuclear Data dual-channel analyzer. Each sample was counted for 20 minutes. The counter handled

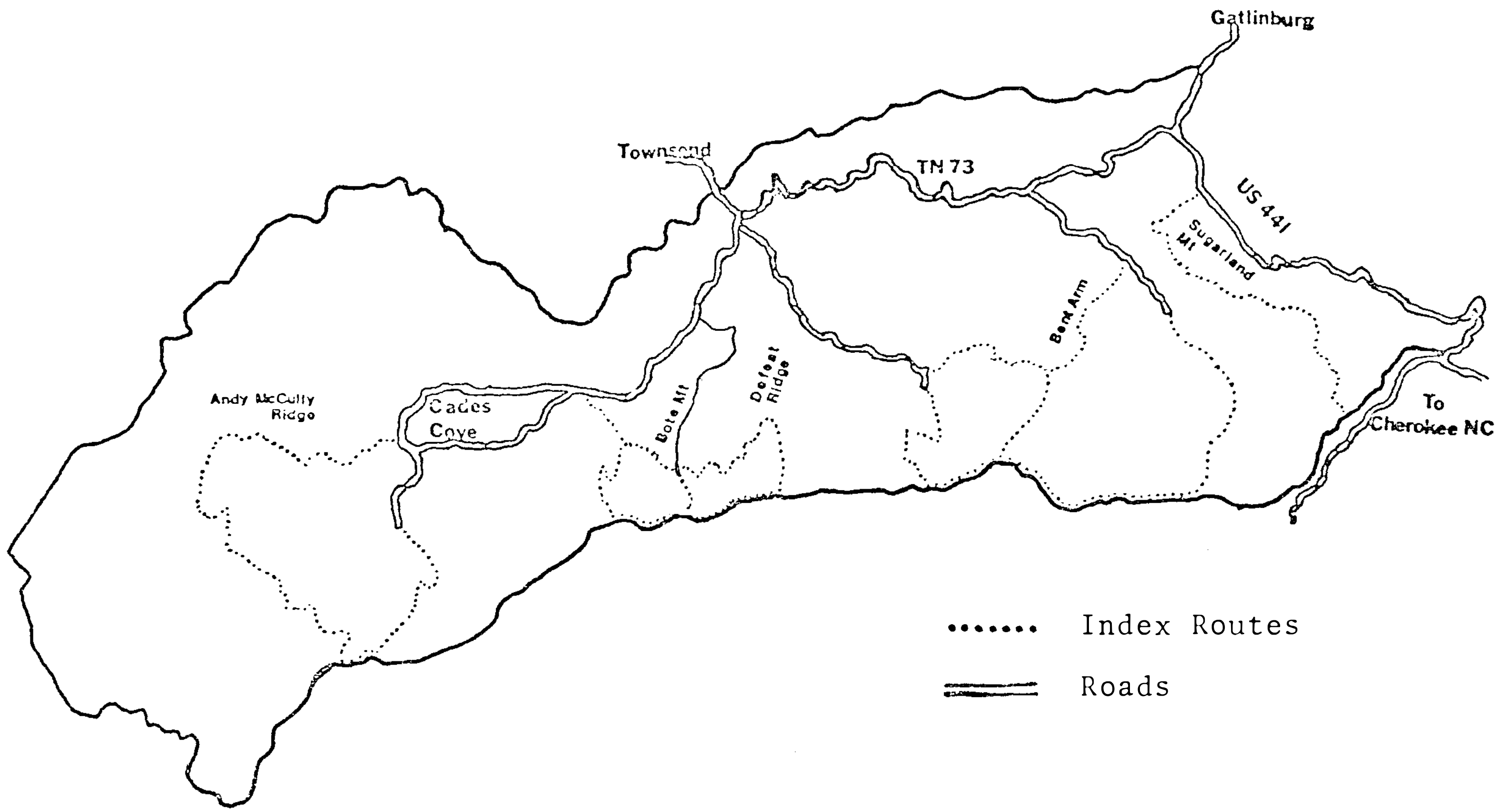

Figure 2. Map of the study area within the Great Smoky Mountains National Park showing Index Routes.

43 scat samples with a single loading and programming, counting each sample for both isotopes simultaneously. The Nuclear Data system printed out disintegrations per minute for each sample after correcting for background radiation. This value was divided by the weight of each sample to yield disintegrations per minute per gram. The value derived in this manner was then compared with values of scats with known histories of isotope tags to determine which were tagged with an isotope.

VI. POPULATION ESTIMATION

Scat Tag--Index Route

The primary method for estimating the bear population was the radioisotope tagging of feces as proposed by Pelton (1972) and evaluated by Marcum (1974). The technique applies the Schnabel method for multiple sampling (Schnabel, 1938) to scat collected along the previously described index trail system. The scat serves as the recapture portion of the estimator. This was done for data collected in both 1974 and 1975. Using the same scat tag--Index Route data, estimates were also calculated for each year with the regression technique of Schumacher-Eschmeyer.

Between Year Estimates

Since black bears were captured and tagged on the study area in 1973 in conjunction with another study, it was possible to compute population estimates using the Petersen, or Lincoln Index mark-recapture method for both 1974 and 1975. This was done by letting one summer's captures serve as the marked portion of the population, and using the next summer's samples as the second sample. Only marked bears which were handled in the previous year were considered to be recaptures in the second sample. It was also possible to calculate an estimate for 1974 from trapping data by using a three-point census method derived from Jolly's (1965) technique.

Back-dating

Due to the availability of exact age information on most bears handled in the Park for research purposes since 1972, it was possible to derive a minimum population estimate for 1972 by a simple tally method. For example, all bears handled in 1974, and known to be 2.5 years old or older were counted as being members of the 1972 population. This technique yields a minimum population density which is helpful in evaluating other estimating techniques.

Comparison of Methods

The statistical estimates were compared by examination of 95 percent confidence intervals to determine whether significant differences existed among them. The Schnabel and between-year Petersen estimates were further compared using the more sensitive test given by Chapman and Overton

(1966) to determine whether there was a significant difference at the 99 percent level of significance.

Where possible, sub-population estimates were calculated. By comparing these estimates to records of bear sign in the areas, it was hoped an index to bear density could be established. This information might also be valuable in assessing habitat requirements of the black bear in the GSMNP, and the impact of such factors as visitor use or illegal hunting.

CHAPTER IV

RESULTS AND DISCUSSION

I. TRAPPING

During the two years of the study, 70 different bears were snared a total of 92 different times (Appendix A). A detailed discussion of trapping techniques along with a tabular breakdown of prebait and trapping data is given in Appendix B. Eubanks (1976) reported capture locations for bears tagged in the GSMNP study area in 1974 and 1975.

II. TAGGING

There is evidence that the colored plastic Nasco ear tags are not adequate for marking black bears. An examination of trapping records for 1974 and 1975 showed that of 35 recaptures of tagged animals, nine had lost or broken one or both of the plastic tags. It was possible to determine if captured bears had lost ear tags by examining the ears for characteristic holes or notches left when ear tags were pulled or broken out. It was also possible to determine past capture history for most of these animals by checking the tattoo on the inner surface of the upper lip. However, most animals trapped prior to 1974 were not tattooed; thus, their history could not be determined if the ear tags had been lost.

The colored tags were originally chosen for the study because it was believed that they would provide an easily recognizable mark when animals were observed in the wild. In most cases the ear tags served this function, but there are indications that untrained observers often fail to notice whether an animal is equipped with ear tags, especially in a brief encounter. The rate of loss of tags is high enough, however, to cast doubt upon the utility of observational information in population estimation for black bears.

It is recommended that in any long-term study of bears involving trapping and marking individuals, animals should be equipped with a permanent mark which is at least individually recognizable upon recapture of a bear. The lip tattoo provided such a mark in this study.

III. SCAT COLLECTION AND ANALYSIS

Scat Collection on Index Routes

Between 9 June and 15 October 1974, Index Routes totaling 1212 km were hiked at biweekly intervals; 146 bear scats were collected (one scat per 8.30 km) (Table 4). In 1975 the same routes were hiked a total of 1296 km, and 207 scats were collected (one scat per 6.26 km) (Table 5). Eubanks (1976) plotted locations of isotopically tagged scats collected during the study.

Table 4. Index Route data, Great Smoky Mountains National Park, 1974.

Trail	Km	June 8	June 22	July 6	July 20	Aug. 3	Aug. 17	Aug. 31	Sept. 14	Sept. 28	Total	Scat/km Total	Km/Scat Total	Total Km
Mt. Collins	17.2	1	1	1	2	2	1	0	1	1	10	0.065	15.48	154.8
Elkmont-Bent Arm	32.8	31	5	7	9	5	9	4	4	2	76	0.257	3.88	295.2
Tremont-Derrick Knob	24.8	5	1	3	2	9	0	0	0	0	20	0.090	11.16	223.2
Spence Field	20.1	0	1	0	1	0	0	2	2	1	7	0.039	25.84	180.9
Gregory Bald-Hannah Mt.	35.1	1	0	0	4	2	0	0	0	0	7	0.022	45.13	315.9
Defeat Ridge-Rocky Top	14.0						21	4	1		26	0.464	2.15	42.0
Total	144.0	38	8	11	18	18	31	10	8	4	146	0.120	8.40	1212.0
Scat/km Total		0.292	0.062	0.085	0.138	0.138	0.215	0.069	0.056	0.031	0.119			
Km/Scat Total		3.42	16.25	11.82	7.22	7.22	4.65	14.40	18.00	32.5	8.30			
Km	144.0	130.0	130.0	130.0	130.0	130.0	144.0	144.0	144.0	130.0				1212.0

Table 5. Index Route data, Great Smoky Mountains National Park, 1975.

Trail	Km	June 8	June 22	July 6	July 20	Aug. 3	Aug. 17	Aug. 31	Sept. 14	Sept. 28	Total	Scat/km Total	Km/Scat Total	Total Km
Mt. Collins	17.2	1	0	5	2	1	0	0	0	1	10	.065	15.48	154.8
Elkmont-Bent Arm	32.8	14	12	10	3	9	5	10	10	6	79	.268	3.737	295.2
Tremont-Derrick Knob	24.8	6	2	0	1	0	0	3	0	1	13	.058	17.169	223.2
Spence Field	20.1	0	0	3	0	2	0	1	0	4	10	.055	18.09	180.9
Gregory-Hannah Mt.	35.1	1	0	0	0	1	0	2	0	1	5	.016	63.18	315.9
Defeat Ridge-Rocky Top	14.0	3	5	18	8	26	14	10	2	4	90	.714	1.40	126.0
Total	144.0	25	19	36	14	39	19	26	12	17	207	.160	6.26	1296.0
Scat/km Total		.174	.132	.250	.097	.271	.132	.181	.083	.118	.160			
Km/Scat Total		5.76	7.58	4.00	10.29	3.69	7.98	5.54	12.00	8.47	6.26			
Km	144	144	144	144	144	144	144	144	144	144				1296.0

Sections of unmaintained trails, which receive very little use by Park visitors, proved to be the most productive Index Routes. Virtually all of the Defeat Ridge-Rocky Top loop is made up of unmaintained trails, and during the two-year period it produced one scat per 1.45 km. The only other Index Route which includes a section of unmaintained trail is Elkmont-Bent Arm, which produced one scat per 3.78 km for the two-year period.

Heavy visitor use of a trail could tend to reduce the number of scats found on the trail in two ways. Bears could be too frightened by the physical presence of, or odor of human beings, to use the trails, and thus they would not defecate on them. The other factor which could reduce the incidence of scats collected on such trails would be the trampling or kicking aside of scats by hikers or horses.

Scintillation Analysis of Scats

Scintillation analysis of scats collected on index trails revealed that 26 and 43 scats, for 1974 and 1975, respectively, were tagged.

Year to year carryover of the feces tag caused some difficulty in data analysis. Nellis, et al. (1967) found that rabbits injected with Zinc-65 eliminated detectable amounts of the isotope in the feces for 400+ days. Marcum (1974) found that penned bears injected with Zinc-65 and Manganese-54 in June exhibited a gradual decline in the concentrations of the isotopes in the feces throughout the summer. However, in November there was an increase in the amount of isotopes in the scats. This trend showed a peak in December, and then began another gradual decline until May, after which no more scats were collected. Marcum attributed this increase in radioactivity of the scats to a change in the physiology of the black bear in the winter.

Since bears were trapped and injected with Zinc-65 and Manganese-54 throughout the summer of 1973 (as a part of another study), 1974 and 1975, one would expect a high degree of year to year carryover of scat tags in bears tagged late in the summer. This carryover in activity would then decrease gradually throughout the following summer.

For the purpose of population estimation it was necessary to determine whether a particular scat which showed radioactivity had been tagged within the same year it was collected. This was done by determining the radioactivity, measured in disintegrations per minute per gram (dpm/gm), of scats from bears with a known isotopic injection history, as when a bear which had been tagged in 1974 was recaptured in 1975 and defecated while in the trap. This information was used as a standard against which to evaluate the activity (dpm/gm) of index trail scats. This approach resulted in the construction of a scale of standards used as a cutoff point, which was gradually lowered as the summer progressed.

Scats collected in June were required to have a higher dpm/gm to be considered tagged in that year than were scats collected in August of the same year. Since the radioactivity is highest in scats immediately after the bear has been tagged, and since no bears were injected before June of either year, it is felt that this higher cutoff standard early in the summer did not result in the discounting of scats which were tagged in that year. The decline in the radioactivity of scats deposited later in the summer by bears injected earlier that summer were compensated for by shifting the cutoff standards downward at monthly intervals as the summer progressed. Subsequent analysis of scats collected in June and early July, 1976 indicated no carryover whatsoever.

IV. POPULATION ESTIMATION

In studying population trends, the more methods of population estimation that can be used and compared the better (Seber, 1973). By employing a variety of techniques based on different sets of assumptions, and evaluating the degree to which each technique meets the stipulated assumptions, the researcher gets a clearer idea of the bias inherent in a given technique. The population estimation techniques used in this study are variations of the basic mark-recapture, or Petersen technique. These techniques fall into two general categories: those assuming a closed population and those assuming the population is open. A closed population is defined as one in which the effects of migration, mortality and recruitment are negligible during the period of investigation. If the population is changing due to one or more of the above processes operating, then the population is said to be open (Seber, 1973). Seber (1973) noted that the assumptions to be met for a technique involving a closed population are:

1) The population is closed so that N is constant;

2) All animals have the same probability of being caught in the first sample;

3) Marking does not affect the catchability of an animal;

4) The second sample is a simple random sample, i.e., each of the possible samples has an equal chance of being chosen;

5) Animals do not lose their marks in the time between the two samples;

6) All marks are reported upon recovery in the second sample.

Those for an open population estimation technique are:

1) Every animal in the population, whether marked or unmarked, has the same probability of being caught in the ith sample, given that it is alive and in the population

when the sample is taken;

2) Every marked animal has the same probability of surviving from the ith to the (i + 1)th sample and of being in the population at the time of the ith sample, given that it is alive and in the population immediately after the ith release;

3) Every animal caught in the ith sample has the same probability of being returned to the population;

4) Marked animals do not lose their marks and all marks are reported on recovery;

5) All samples are instantaneous, i.e., sampling time is negligible.

Estimates Assuming a Closed Population

The principal method of population estimation employed in this study was a modification of the Schnabel (1938) technique. This is a capture, mark and recapture type estimate, which allows continued marking of individuals throughout the sampling period. The formulation:

$$\hat{N} = \Sigma(n_i M_i)/m_i,$$

where

$\hat{N}$ = estimate of total population;

n_i = total sample taken in the ith period;

M_i = total number of marked animals in the population at the start of the ith period;

m_i = number of marked samples in n_i.

Data collected in 1974 and 1975 were used to derive population estimates and 95 percent confidence intervals (Tables 6 and 7). The n_i column in the tables represents total scats collected along Index Routes, and m_i is the number of scats containing radioisotope tags. The estimates are 118 for 1974 and 129 for 1975.

Estimates calculated by applying the Petersen technique to between year trapping data utilized the formula:

$$\hat{N} = M(n+1)/m+1$$

where

$\hat{N}$ = estimate of total population;

M = total tagged and released in the first sample;

n = total number of animals taken in the second sample;

m = total number of animals taken in the second sample which had been marked in the first sample.

Population estimates for 1974 are:

$\hat{N} = 38(42)/9 = 177$, $P(72<N<282) = .95$

and for 1975,

$\hat{N} = 35(51)/10 - 178$, $P(77<N<279) = .95$.

The above methods are maximum likelihood estimates. Seber (1973) states that, where possible, regression estimates should be calculated along with maximum likelihood estimates. The value in this approach is that the regression estimates are more robust. That is, they are less

Table 6. Black bear population estimate for the Great Smoky Mountains National Park study area, using the radioactive scat tag-Schnabel method, 1974.

Sampling Period	M_i	n_i	m_i	n_iM_i
9 June - 16 June	3	38	1	114
22 June - 26 June	12	8	2	96
6 July - 10 July	17	11	2	187
20 July - 24 July	18	18	1	324
3 Aug. - 7 Aug.	27	18	1	486
17 Aug. - 21 Aug.	32	31	15	992
31 Aug. - 8 Sept.	32	10	2	320
14 Sept. - 18 Sept.	34	8	1	272
28 Sept. - 5 Oct.	34	4	1	136
12 Oct. - 15 Oct.	34	4	0	136
			$\Sigma = 26$	$\Sigma = 3063$

$$\hat{N} = \Sigma(n_iM_i)/m_i$$

$$\hat{N} = \frac{3063}{26} = 118$$

$$P(76<N<172) = 0.95$$

Table 7. Black bear population estimate for the Great Smoky Mountains National Park study area, using the radioactive scat tag-Schnabel method, 1975.

Sampling Period	M_i	n_i	m_i	n_iM_i
6 June - 9 June	0	25	0	0
20 June - 22 June	7	19	0	133
4 July - 6 July	16	36	6	576
18 July - 20 July	24	14	5	336
1 Aug. - 3 Aug.	35	39	18	1365
15 Aug. - 17 Aug.	38	19	5	722
29 Aug. - 31 Aug.	41	26	3	1066
12 Sept. - 14 Sept.	47	12	3	564
26 Sept. - 28 Sept.	47	17	3	799
			$\Sigma = 43$	$\Sigma = 5561$

$$\hat{N} = \Sigma(n_iM_i)/m_i$$

$$\hat{N} = \frac{5561}{43} = 129$$

$$P(93<N<174) = 0.95$$

sensitive to departures from the underlying assumptions. However, regression methods are usually not as efficient as the maximum likelihood estimates, meaning the estimate thus derived is less precise. If the two types of estimates agree, one can be more certain of the accuracy of the estimates.

The Schumacher-Eschmeyer estimate is a regression method which is well suited to application to the data contained in Tables 6 and 7. The formula for calculating the Schumacher-Eschmeyer estimate is

$$\hat{N} = (\Sigma n_i M_i^2)/(\Sigma m_i M_i),$$

where the notation is the same as that of the Schnabel formula. This method yields population estimates of 117 [P(75<N<267) = .95] and 138[P(91<N<301) = .95) for 1974 and 1975, respectively. Confidence intervals are calculated as suggested by DeLury (1958).

Estimates Assuming an Open Population

Jolly (1965) presented a population estimation technique which accounts for such factors as natality, morality, immigration and emigration. The three point census, or triple catch method is an adaptation of Jolly's method which utilizes data from three sampling periods to estimate the population size at the start of the second sampling period. The method of data organization, formulas and calculations are presented in Table 8. The sampling

Table 8. Data organization and computations for the triple catch estimate.

i	C_i	Recaptures		F_i
1	C_1	-	-	F_1
2	C_2	R_{12}	-	F_2
3	C_3	R_{13}	R_{23}	

C_i = total number caught in sample i.

R_{hi} = number of marked animals in sample i last caught in sample h.

F_i = number of marked animals released from sample i.

$\hat{a}_2 = R_{12}/C_2$.

$\hat{M}_2 = (F_2 R_{13}/R_{23})\ R_{12}$.

$\hat{N}_2 = \hat{M}_2/\hat{a}_2$ = estimated total population at the time of the second sample.

i	C_i	Recaptures		F_i
1973	38	-	-	38
1974	41	8	-	41
1975	50	4	9	

$\hat{N}_2 = 26.22/0.2 = 131$

periods for this three point census are 1973 (data from Marcum, 1974), 1974 and 1975. The population estimate for 1974 derived with this technique is 131.

Back-dating

Accurate ages are available for most bears captured in the GSMNP since 1972 in conjunction with the ongoing population studies at The University of Tennessee. Using this information, a tally of all bears captured on the study area which were known to be alive in 1972 was compiled. The minimum count thus derived is 115 different bears. This is not a statistical method and is not subject to either set of assumptions previously stated. If the figure is to be taken as an estimate of the 1972 population, two assumptions must be made: 1) every bear which was alive on the study area in 1972 has been captured since, and 2) no bears living off the study area in 1972 have been captured on the study area since that time. It is almost certain that neither of the assumptions has been met. Violating the first assumption would result in an underestimate of the population, while failure to meet the second assumption would bias towards overestimation. The combination of the two effects cannot be expected to balance each other and result in an unbiased estimate. However, this minimum "head count" figure is still of value for evaluating other methods of population estimation.

Comparison of Estimates

One method of testing whether a significant difference exists between two population estimates is to determine whether the confidence intervals at the chosen percentile show any overlap. Application of this method reveals no significant differences at the 95 percent level of confidence between any of the statistical population estimates used in this study. Table 9 lists all population estimates with 95 percent confidence intervals.

A more sensitive method of comparing two estimates is given by Chapman and Overton (1966). This method was used to test for significant differences between the Schnabel estimates for 1974 and 1975 and the between year Petersen estimates for the same years. At the 95 percent level, no significant difference was shown between the estimates derived by the two methods.

Although there is no statistically significant difference in the results of the techniques evaluated, a determination as to which is the best method under the circumstances of the study can be made. Examination of the degree to which underlying assumptions are met by the various techniques, and evaluation of the efficiencies of the various methods are the criteria for this determination.

In evaluating the Schnabel, Petersen and Schumacher-Eschmeyer methods, the assumptions (p. 38) which are open

Table 9. A comparison of population estimation techniques employed in the Great Smoky Mountains National Park, 1974 and 1975.

Technique	Population Estimate 1974	Population Estimate 1975	95 Percent Confidence Interval
<u>Index Route</u>			
Schnabel	118	129	1974 $P(76<N<172) = 0.95$ 1975 $P(93<N<174) = 0.95$
Schumacher-Eschmeyer	117	138	1974 $P(75<N<267) = 0.95$ 1975 $P(91<N<301) = 0.95$
<u>Capture-Recapture</u>			
Between year Petersen	177	178	1974 $P(72<N<282) = 0.95$ 1975 $P(77<N<279) = 0.95$
Triple catch	131	---	---
<u>Other</u>			
Back-dating	115 (1972)	---	---

to question in the present study are the assumption of a closed population (1) and those concerning equal catchability of animals (2,3 and 4).

The shorter the sampling period, the greater the likelihood of meeting the condition of a closed population. The data used in the calculation of the Schnabel and Schumacher-Eschmeyer estimates (feces tag methods) were collected over a four-month period. Each Petersen estimate is based on data collected over a 16-month period. Beeman (1975) reported an average annual mortality rate of 21.7 percent for adult black bears in the GSMNP. Although the sources of this natural mortality remain obscure, he speculated that morality factors may operate more heavily in autumn, when movement patterns of black bears in the Park show a marked increase which is probably related to their search for food. Seber (1973) pointed out that the assumption of a closed population may be met although mortality occurs in the population. This would be the case when mortality is independent of the mark status of an individual. However, Robson and Regier (1968) stated that when both recruitment and mortality occur, mark-recapture methods will overestimate the population. The sampling period for the estimates based on the feces tag method was at a time of year when no natality was occurring in the bear population, while the sampling period for the Petersen estimates included one complete breeding season, and one autumn with its probable higher mortality. For this reason the Petersen estimate for a given year would be expected to be higher than estimates calculated using the feces tagging method. The trend is in that direction, although the difference is not significant.

Immigration and emigration have the same effects on the estimates as do natality and mortality. The action of these factors affects both estimates. However, it is obvious that the methods having the shorter sampling period are less affected by the action of these agencies. The high proportion of untagged bears captured each year indicates that there are transient individuals in the population. Because of this, the Schnabel, Schumacher-Eschmeyer, and Petersen estimates may be inflated.

Eberhardt (1969) outlined three possible causes of failure to meet assumptions concerning equal catchability: 1) a property truly inherent in the individuals (expressed by behavior in the immediate presence of a trap); 2) a property depending on the relative opportunity for capture; and 3) the result of a learning process (animals become "trap-happy" or "trap-shy" with experience). Seber (1965) and Cormack (1966) offer statistical tests of equal catchability. However, both methods require larger sample sizes than were generated.

It is probable that all three factors listed by

Eberhardt affected trapability of bears in this study. The discussion of trapping in this chapter gives evidence that black bears do exhibit differential trap response. Also, all bears probably did not have an equal opportunity for capture, owing to the inaccessibility of many portions of the study area. It was not possible to randomize trapping in the strict sense of the word.

Marten (1972) pointed out that non-recapture sampling techniques offer the advantage of eliminating problems due to low or unequal catchability. The feces tagging method is such a technique. There is less bias resulting from unequal catchability than exists in the between year Petersen estimates.

An important point to consider in the evaluation of population estimation techniques is the effort expended in achieving a certain level of precision. The feces-tag-Index Route method required one field season (four months) to generate a population estimate while the mark-recapture type estimates require at least two trapping seasons in the GSMNP to generate sufficient data for an estimate. The collection of scats along Index Routes involves much less effort per bit of information for the second sample than does a trapping operation. In addition, a much larger sample size was generated for the second sample in the isotope tag technique than in the recapture methods, thus yielding more precise estimates.

Of the methods evaluated, the feces-tag-Index Route technique using the Schnabel and Schumacher-Eschmeyer calculations provides the best estimate of the bear population on the study area. It is more likely that this method meets underlying assumptions, and thus should be more accurate than the other estimates. The Index Route technique also provides a more precise estimate due to the larger sample size involved. There is a potential drawback to the isotope tagging technique which deserves further consideration. It is not known whether all bears exhibit a propensity to use hiker trails as avenues of travel. If they do not, and because trapping is carried out along trails for practical reasons, a bias toward tagging animals which routinely use trails could exist. If this were the case, the estimates thus derived would be lower than the actual population.

Population Density

Because they are the best estimates available, the estimates derived by the Index Route-Schnabel method will be used in calculation of density figures. The total area encompassed by the estimates is 358 km^2. Black bear density in the study area based on these figures was one bear per 3.03 km^2 in 1974, and one bear per 2.77 km^2 in 1975. These figures agree closely with those of Marcum (1974) who calculated the black bear density to be one bear per 2.71 km^2 on the same GSMNP study area in 1973.

Subpopulation Estimates

Sufficient data were collected from two watersheds within the study area to allow computation of population densities within each area. If a significant difference could be established between the densities in the two areas, this would be helpful in the attempt to establish some index to black bear population density in the GSMNP which could be utilized to monitor trends in density without the necessity of trapping. This would be done by correlating the frequency of occurrence of a chosen indicator (tracks, feces, percentage of prebaits taken within five days, etc.) with the population density of that area.

The two areas for which estimates were derived are the Elkmont watershed and the West Prong watershed (Bote Mountain-Defeat Ridge). The feces tagging technique was employed in the derivation of the estimates. The population for Elkmont was determined to be 58 bears [$P(15<N<83) = .95$] or one bear per 1.96 km^2 in 1974, and 84 bears [$P(33<N<181) = .95$] or one bear per 0.89 km^2 in 1975. For the West Prong drainage the figures are 35 bears [$P(20<N<56) = .95$] or one bear per 1.00 km^2 for 1974, and 52 [$P(36<N<71) = .95$] or one bear per 0.67 km^2 for 1975. Application of the Chi-square test to these data yields no significant difference ($.90<P<.70$) in the population densities for the two watersheds.

The greatest difficulty encountered in the attempt to establish an index to density for a species such as black bear is the high amount of effort involved in generating a relatively small sample size. The establishment of such an index will likely involve the pooling of data collected over a long period of time.

Population Density and Habitat Relationships

Black bear density for the entire GSMNP study area compares closely with density estimates from other areas of North America which are considered to be prime black bear habitat (Kemp, 1972; Jonkel and Cowan, 1971; Piekielek and Burton, 1975; and Bray, 1967) (Table 10). The density estimates for smaller areas within the study area are higher than has been reported anywhere in the literature. Such high black bear population densities generally are found in areas of diverse habitat (Beeman, 1975; Jonkel and Cowan, 1971; Kemp, 1970; and Barnes and Bray, 1967). The GSMNP offers extremely diverse vegetation patterns with a high degree of interspersion of the various forest types. This habitat diversity along with the high degree of protection from illegal hunting pressure within the central portion of the study area accounts for the high densities found in the West Prong Little River and Elkmont watersheds.

The high population densities reported from the central portion of the study area do not hold throughout

Table 10. A comparison of black bear density estimates for the Great Smoky Mountains National Park and other areas in North America.

Source	Density Estimate (One Bear Per)	Study Area
Present study, 1974	3.03 km^2	GSMNP
	1.96 km^2	Elkmont
	1.00 km^2	West Prong, Little River
Present study, 1975	2.77 km^2	GSMNP
	0.89 km^2	Elkmont
	0.67 km^2	West Prong, Little River
Marcum (1974) (density for 1973)	2.71 km^2	GSMNP
Kemp (1972)	2.56 km^2	Cold Lake, Alberta
Kemp (1976)	1.19 km^2	Cold Lake, Alberta
Poelker and Hartwell (1973)	2.56 km^2	Washington
Jonkel and Cowan (1971)	2.05 km^2	Whitefish Range, Montana
	4.40 km^2 (post hunting)	
Erickson and Petrides (1964)	8.81 km^2	Michigan
Spencer (1955)	14.34 km^2	Maine
Stickley (1957)	10.10 km^2	Virginia
Piekielek and Burton (1975)	1.30 km^2	Trinity County, California
Bray (1967)	13.47 km^2	Yellowstone National Park
	3.63 km^2 (prime range)	

the Park. Not all sections of the Park offer such a rich variety of food items. Also areas on the periphery of the Park are subject to heavy illegal hunting pressure.

It must be noted that the density figures presented in this study represent the summer distribution of bears. Many areas of the Park which do not offer a rich variety of food items probably support a lower density of resident bears throughout the year, and become important to other bears at a time of year when a particular food item, found in abundance in that area, become available. Beeman (1975) found that most bears in the GSMNP increase their movement patterns in the fall of the year. This movement of bears beyond the limits of their summer home range is probably a response to the ripening of oak mast in areas of lower habitat diversity and higher concentrations of oak species. Piekelek and Burton (1975) found a similar pattern of habitat exploitation in a high density black bear population in California. Thus, although such areas do not support high resident black bear densities, they may play a critical role in survival of bears whose summer home ranges do not encompass these areas.

Jonkel and Cowan (1971) stated that long-term control of black bear population density seems dependent on the habitat and on unique reproductive and behavioral characteristics of the bears. Rogers (1976) offered evidence that nutritional factors are primarily responsible for the adjustment of the adult black bear population to levels that can be sustained through years of scarce food, while Kemp (1976) argued that long-term population regulation is a function of adult-male-induced mortality in the subadult cohort. In Kemp's study the population more than doubled in the two-year period following the removal of 26 large adult males from the population. It remains to be seen, however, whether this density can be sustained through years of scarce food.

Indications are that the black bear population in the GSMNP is stable. The possibility exists, however, that the population could be thrown out of balance with the habitat by changes in either the population itself or in the habitat. Some factors which might have an impact on the quality of black bear habitat in the Smokies are the recent introduction of European wild hog (*Sus scrofa*), whose ultimate impact upon the ecosystem remains to be determined, a failure of the oak mast or berry crop for several years in succession, and the recent increase in intensity of back country use by Park visitors. Factors which might affect bear densities either directly, or by altering the social system are the introduction of a disease, a change in illegal hunting pressure, or an increase in control operations by Park Service personnel.

Probably the most pertinent of the possible perturbing factors from the standpoint of black bear management in the GSMNP is the increased use of back country areas by Park visitors and the ultimate impact of control operations involving the removal of bears from the population. With an increase in visitor density, a concomitant increase in bear-human interactions can be expected. This would then result in an increase in the necessity of control operations. Beeman (1975) found that 87 percent of the panhandler bears captured in the GSMNP were males and that 80 percent of the panhandlers were adult bears. Removal of these individuals from the population will affect the self-regulatory ability of the population (Kemp, 1976). Additional research is needed to determine how many animals in which age and sex classes can be removed from the GSMNP bear population before the social structure is affected. Continued monitoring of black bear densities either through the development of an index to density or by more rigorous estimation techniques is recommended as a tool in evaluating the effects of perturbations on the population.

CHAPTER V

SUMMARY

The study was carried out in 1974 and 1975 on a 50,607 ha portion of the Great Smoky Mountains National Park, which is characterized by high relief, rough terrain and a high degree of interspersion of vegetation types. The primary purpose was to determine the density and distribution of black bears within the Park. It was hoped that an easily utilized index to bear density could also be gleaned from the data.

Bears were captured primarily with Aldrich spring-activated foot snares. During the course of the study 70 different bears were snared a total of 92 different times in 891 trap nights. Basic biological data were collected from all bears, and most were ear tagged, lip tattooed and injected with trace amounts of either Zn-65 or Mn-54, or both. Both isotopes are eliminated gradually in the feces.

During the summers, a series of six Index Routes totaling 144 km were hiked at bi-weekly intervals for the purpose of collecting bear scats. A total of 2508 km were hiked resulting in the collection of 353 scats. Scintillation analysis of bear scats revealed that 26 and 43 scats, for 1974 and 1975, respectively, contained one or both of the radioactive feces tags.

Application of the Schnabel technique to the trapping and Index Route data yields population estimates of 118 for 1974 and 129 for 1975. The use of the Schumacher-Eschmeyer formula with the same data results in estimates of 117 and 138 bears for 1974 and 1975.

Estimates were also calculated from capture-recapture data. Using the Petersen method, estimates of 177 for 1974 and 178 for 1975 were derived. A triple catch technique was also applied to trapping data yielding an estimate of 131 bears for 1974. A direct count method resulted in an estimate for 1972 of 115 bears.

Statistical analysis of population estimates showed no significant difference between any of the estimates. The methods utilizing the capture and Index Route data (Schnabel and Schumacher-Eschmeyer) are superior to the other methods evaluated because they: 1) more likely meet the assumption of closed population and those concerning equal catchability; 2) generate a larger sample size which results in a more precise estimate; and 3) require less time and effort in the collection of data.

The population density for the entire study area was calculated to be one bear per 3.03 km^2 in 1974 and one bear per 2.77 km^2 in 1975. Subpopulation densities were calculated for the Elkmont and West Prong watersheds. The densities for Elkmont were one bear per 1.96 km^2 and 0.89 km^2 for 1974 and 1975, respectively, while the estimates for West Prong for the same years were one bear per 1.00 km^2 and 0.67 km^2. The attempt to establish an index to black bear density in the Smokies was hampered by the small sample sizes.

The relatively high black bear density in the GSMNP is probably a result of high species diversity, and of the good interspersion of the various forest types and other habitat requirements. Bear density is not uniform throughout the Park, but some low density areas may be important in helping to sustain high densities in other areas.

The bear population is apparently stable, but should be monitored to determine the effects of perturbing factors, either natural or human-caused.

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APPENDICES

APPENDIX A

BLACK BEAR TRAPPING RECORDS, 1974-1975

Table 11. Data for black bears captured in the Great Smoky Mountains National Park, 1974 and 1975--Part 1.

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
01	6-14-74	01	01	L-yy52 R-BB53-55	Zn-65 40μC	S	2.5 mi. up Bote Mtn.	1 2	1.4 1.4	5.5	23.0	RF	-	X	-
02	6-15-74	02	02	L-RW76-51 R	Mn-54 60μC	S	2 mi. up Bote Mtn.	1 2	1.3 1.3	8.75	18.75	LF	X	X	-
03	6-15-74	03	03	L R-R67	Zn-65 40μC	S	4 mi. up Bote Mtn.	1 2	0.9 0.9	9.25	13.5	LF	X	X	-
04	6-16-74	04	04	L R-RW52-77	Mn-54 40μC	S	2 mi. up Bote Mtn.	1 2	0.5 0.7	14.25	17.0	RF	X	X	-
05	6-16-74	05	05	L-yy31 R-BB31	Zn-65 40μC	S	2.5 mi. up Bote Mtn.	1 2	1.0 1.0	3.75	11.0	LF	X	X	-
06	6-19-74	Rec 04	04	L R-RW52-77	--	S	2.5 mi. up Bote Mtn.	1 2	1.2 1.2	--	15.0	-	-	-	-
07	6-19-74	06	06	L R-R51	Zn-65 60μC	S	3 mi. up Bote Mtn.	1 2	1.8 -	40.0	10.0	RF	-	-	-
08	6-19-74	07	07	L-RW53-78 R-RW54-79	Zn-65 40μC	S	4 mi. up Bote Mtn.	1 2	0.8 0.8	11.65	10.5	LF	X	-	-
09	6-19-74	08	08	L-OW55-80 R	Zn-65 32μC	S	0.5 mi. down Sugar Cove from Bote Mtn. Rd.	1 2	0.8 0.8	23.5	12.1	LF	X	-	-
10	6-21-74	09	09	L-BB29 R-WW29	Zn-65 40μC	S	1 mi. above turnaround on Bote Mtn. Rd.	1 2	0.8 0.8	8.5	8.0	LF	-	-	-
11	6-22-74	10	10	L R-OW56-81	Zn-65 40μC	S	2.5 mi. up Bote Mtn.	1 2	0.7 0.8	16.0	8.75	LF	X	X	-
12	6-22-74	11	11	L-y64 R-y57	Mn-54 40μC	S	.75 mi. Down Defeat Ridge Trail from Bote Mtn.	1 2	0.8 0.8	--	18.5	RF	-	X	-
13	6-25-74	12	12	L-OW58-83 R-OW57-82	Zn-65 40μC	S	3 mi. up Bote Mtn.	1 2	1.0 1.0	6.5	12.25	RF	X	X	-
14	6-26-74	13	13	L-GW59-84 R	Zn-65 40μC	S	4 mi. up Bote Mtn.	1 2	0.8 0.8	17.5	23.75	RF	X	X	-
15	6-26-74	14	14	L-R53 R-W53	Mn-54 40μC	S	4.5 mi. up Bote Mtn.	1 2	0.6 0.6	12.2	11.0	LF	-	-	-
16	6-27-74	Rec 07	07	L-RW53-78 R-RW54-79	--	S	0.5 mi. down Sugar Cove from Bote Mtn. Rd.	1 2	.85 .85	6.0	20.25	-	-	-	-
17	6-27-74	15	15	L R-GW60-85	Mn-54 50μC	S	Bote Mtn. Rd. turnaround	1 2	1.2 1.2	4.25	7.0	LF	-	-	-

Table 11 (Continued)

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
18	6-28-74	Rec 13	13	L-GW59-84 R	--	S	.75 mi. down Defeat Ridge Trail from Bote Mtn. Rd.	1 2	1.5 -	--	--	--	-	-	-
19	7-2-74	16	16	L-GW61-86 R-GW62-87	Mn-54 40μC	S	Defeat Ridge-Hornet Tree Top	1 2	0.6 0.6	7.5	0.8	RF	X	-	-
20	7-4-74	Rec 11	11	L-y64 R-y57	--	S	Bote Mtn. 0.5 mi. up from turnaround	1 2	0.8 0.6	6.5	2.5	LF IV	-	-	-
21	7-4-74	Rec 02	02	L-RW76-51 R	--	S	Defeat Ridge-Hornet Tree Top	1 2	1.2 1.2	46.1	26	RF	-	-	-
22	7-5-74	17	17	L-y56 R-W56	Mn-54 40μC	S	Defeat Ridge-Hornet Tree Top	1 2	1.0 0.8	18	10	RF	X	-	-
23	7-5-74	Rec 01	01	L-y52 R-B53-55	--	S	5.2 mi. up Bote Mtn.	1 2	0.6 0.6	--	--	LF IV	-	X	-
24	7-10-74	Rec 09	09	L-BB29 R-yy29	--	S	Bote Mtn. Rd. 0.2 mi. below Spence	1 2	- -	--	--	--	-	-	-
25	7-10-74	18	18	L-B54 R-W54	Mn-54 60μC	S	Defeat Ridge Trail 2 mi. from Bote Mtn. Rd.	1 2	0.6 0.6	10.5	1.8	RF IV	X	X	-
26	7-11-74	Rec 05	05	L-B31 R-y31	--	S	0.3 mi. down Defeat Ridge Trail from Bote Mtn.	1 2	1.1 -	--	9	RF	-	-	-
27	7-24-74	25	25	L-GB76 R-GB77	Zn-65 60μC Mn-54 60μC	S	Rabbit Creek Rd. 1.25 mi. from Abrams Ck.	1 2	0.8 0.8	15	1.7	-- IV	X	X	-
28	7-24-74	26	26	L-RB79 R-RB78	Zn-65 60μC Mn-54 60μC	S	1/4 mi. west of Scott Gap	1 2	0.8 0.8	10	2	LF IV	X	X	-
29	7-25-74	27	27	L-OB80 R-OB81	Zn-65 60μC Mn-54 60μC	S	Rabbit Creek Rd. 1-1/2 mi. past Abrams Ck.	1 2	0.8 0.7	10.0	2.0	RF IV	X	X	-
30	7-25-74	28	28	L-RB83 R-GB82	Zn-65 60μC Mn-54 60μC	S	1/4 mi. west of Scott Gap	1 2	0.8 0.7	10.5	1.5	LF IV	X	X	-
31	7-25-74	29	29	L-GB85 R-RB84	Zn-65 60μC Mn-54 60μC	S	Rabbit Creek Rd. 1-1/4 mi. past Abrams Ck.	1 2	0.6 0.6	5.2	3.25	RF IV	X	X	-
32	7-30-74	19	19	L-Ry77 R-Ry78	Zn-65 60μC Mn-54 60uC	S	Sugarland Mtn.	1 2	0.7 0.6	12.5	23	LF IM	X	X	-

Table 11 (Continued)

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
33	7-31-74	20	20	L-yG79 R-yR80	Zn-65 60μC Mn-54 60μC	S	Sugarland Mtn.	1 2	0.8 1.0	8.75	22.8	LF IM	X	X	-
34	8-1-74	21	21	L-Ry81 R-Gy82	--	S	Rough Creek	1	0.6 -	7.5	--	LF	X	X	-
35	8-1-74	22	22	L-Gy83 R-Gy84	Zn-65 30μC Mn-54 30μC	S	Sugarland Mtn.	1 2	0.7 0.6	8.0	2.0	RF IV	X	X	-
36	8-5-74	23	23	L-RB86 R-OB87	Zn-65 60μC Mn-54 60μC	S	Bent Arm, 2 mi. up from Cucumber Gap	1 2	0.5 0.5	5	2.1	RF IV	X	X	-
37	8-8-74	24	24	L-OB88 R-RB89	Zn-65 60μC Mn-54 60μC	S	Bent Arm, .75 mi. up from Cucumber Gap	1 2	0.5 0.5	6.5	20	RF IV	X	X	-
38	8-8-74	30	30	L-GB90 R-OB92	Zn-65 60μC Mn-54 60μC	S	Bent Arm, 3 mi. up from Cucumber Gap	1 2	0.5 0.5	--	3	LF IV	-	X	-
39	8-18-74	31	31	L-OB93 R-RB94	Zn-65 60μC Mn-54 60μC	S	Sam's Gap (near Derrick Knob)	1 2	0.3 0.3	8	2.2	RF IV	X	-	-
40	8-19-74	32	32	L-OB95 R-GB96	Zn-65 60μC Mn-54 60μC	S	Miry Ridge .75 mi. from Dripping Spgs.	1 2	- 0.5	--	1.75	-- IV	-	X	-
41	8-20-74	33	33	L-W60 R-B60	Zn-65 60μC Mn-54 60μC	S	Miry Ridge .5 mi. south of Bent Arm	1 2	0.4 0.4	15	2.5	RF IV	X	X	-
42	8-27-74	34	--	L-B97 R-B98	--	F	Clingman's Dome Rd. 1/2 mi. below parking lot	3	3.4	--	--	RF	-	X	-
43	9-5-74	35	--	L-R6 R-B99	--	F	Clingman's Dome Rd.	5	2.6	--	--	RF	-	X	-
44	9-10-74	36	36	L-GB100 R-Ry85	Zn-65 60μC	S	3 mi. up Bote Mtn.	1 2	0.3 0.3	10	1.0	LF IV	X	X	-
45	9-11-74	Rec 12	12	L-OW82 R-OW58-83	--	S	3 mi. up Bote Mtn.	1 2	0.3 0.2	10	--	RF	-	-	-
46	9-13-74	Rec 09	09	L-BB29 R-WW29	--	S	Spence Field	3	1.0	5	--	LF	-	X	-
47	9-13-74	37	37	L-y86 R-y87	Zn-65 60μC	S	4 mi. up Bote Mtn.	1 2	0.2 0.2	8	7.5	RF	X	X	-

Table 11 (Continued)

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
48	10-20-74	38	38	L-R31 R-y33	--	C	Tremont Center	1 3	0.8 1.0	--	--	LF	-	-	-
49	6-13-75	39	39	L-R82 R-R83	Zn-65 60μC Mn-54 60μC	S	Bent Arm, 4 mi. up from Cucumber Gap	3	0.7	3	--	LF	X	X	-
50	6-15-75	40	40	L-R85 R-R84	Zn-65 60μC Mn-54 60μC	S	Bent Arm, 4 mi. up from Cucumber Gap	3	1.3	--	--	RF	X	X	-
51	6-17-75	41	41	L-y71 R-R86	Zn-65 60μC Mn-54 60μC	S	Bent Arm, 4 mi. up from Cucumber Gap	3	0.9	11.5	--	LF	X	X	-
52	6-17-75	42	42	L-y66 R-R66	Zn-65 60μC Mn-54 60μC	S	Bent Arm, 4.3 mi. up from Cucumber Gap	3	1.8	10	--	RF	X	X	-
53	6-17-75	43	43	L-y54 R-y55	Zn-65 44μC Mn-54 40μC	S	Bent Arm, 4.6 mi. up from Cucumber Gap	3	0.3	--	--	LF	X	X	-
54	6-16-75	46	46	L-y90 R-y91	Mn-54 60μC	S	Defeat Ridge Trail 1.5 mi. from Bote Mtn.	3	1.2	7	--	RF	X	X	-
55	6-17-75	47	47	L-y92 R-y93	Mn-54 60μC	S	Defeat Ridge Trail 3 mi. from Bote Mtn.	3	0.8	9	--	RF	X	X	-
56	6-22-75	48	48	L-y94 R-y95	Mn-54 60μC	S	Defeat Ridge Trail 2.5 mi. from Bote Mtn.	3	0.5	8	--	LF	X	X	-
57	6-22-75	49	49	L-y96 R-y97	Mn-54 60μC	S	Defeat Ridge Trail 3 mi. from Bote Mtn.	3	1.2	15	--	--	X	X	-
58	6-22-75	50	50	L-y88 R-y89	Mn-54 34μC	S	Defeat Ridge Trail 4.5 mi. from Bote Mtn.	3	1.8	12	--	LF	X	X	-
59	6-23-75	51	06	L R-RR51	Mn-54 60μC	S	Defeat Ridge Trail 1.5 mi. from Bote Mtn.	3	1.4	8	--	RF	-	X	-
60	6-28-75	44	44	L-y75 R-y74	Zn-65 60μC Mn-54 60μC	S	Sugarland Mtn. 0.8 mi. N. of Huskey Gap	3	0.5	12	-	RF	X	X	-
61	6-30-75	45	45	L-R87 R-y72	Zn-65 60μC Mn-54 60μC	S	Sugarland Mtn., 0.1 mi. N. of Huskey Gap	3	0.9	15	--	LF	X	X	-
62	7-3-75	52	52	L-B2 R-B1	Zn-65 60μC Mn-54 60μC	F	Hwy. 441 No. 4 Overlook	3	0.5	10	--	LF	X	X	-

Table 11 (Continued)

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
63	7-4-75	56	56	L R-W77-5	Mn-54 60μC	S	2 mi. up Bote Mtn.	3	2.1	--	--	LF	X	X	X
64	7-5-75	57	57	L-W1 R-W2	Zn-65 60μC	S	5.9 mi. up Bote Mtn.	3	0.7	18	--	LF	X	X	X
65	7-5-75	58	--	L R-R67	Mn-54 36μC	S	4.5 mi. up Bote Mtn.	3	0.8	8	--	RF	-	X	X
66	7-7-75	59	59	L-yy52 R-BB53-55	Zn-65 60μC	S	3 mi. up Bote Mtn.	3	0.6	10	--	LF	-	X	X
67	7-8-75	60	60	L-W3 R-W4	Zn-65 60μC	S	4.3 mi. up Bote Mtn.	3	3.2	--	--	RF	X	X	X
68	7-8-75	61	07	L R-W79-54	Zn-65 60μC	S	5.9 mi. up Bote Mtn.	3	2.6	--	--	LF	-	X	X
69	7-8-75	53	53	L-B3 R-y73	Zn-65 60μC Mn-54 60μC	S	.75 mi. up Rough Ck. Trail	3	0.7	6	--	RF	X	X	X
70	7-9-75	54	54	L-R88 R-B4	Zn-65 60μC Mn-54 60μC	S	.75 mi up Rough Ck. Trail	3	1.3	20	--	LF	X	X	X
71	7-10-75	62	62	L-W5 R-W6	Zn-65 60μC	S	2.5 mi. up Bote Mtn.	3	1.2	13	--	LF	X	X	X
72	7-19-75	63	63	L-W7 R-W8	Zn-65 60μC	S	1.5 mi. up Bote Mtn.	3	1.5	--	--	LF	X	X	X
73	7-19-75	64	64	L-W9 R-W10	Mn-54 60μC	S	2.4 mi. up Bote Mtn.	3	1.6	--	--	RF	X	X	X
74	7-21-75	70	70	L-B5 R-R89	Zn-65 60μC Mn-54 60μC	S	3 mi. out Rabbit Creek Rd.	3	0.4	10.5	--	LF	X	X	X
75	7-21-75	71	71	L-R91 R-R90	Zn-65 60μC Mn-54 60μC	S	4 mi. out Rabbit Creek Rd.	3	0.7	23	--	LF	X	X	X
76	7-23-75	55	55	L-W11 R-W12	Zn-65 60μC	S	2.5 mi. up Bote Mtn.	3	0.3	15	--	LF	X	X	X
77	7-23-75	65	05	L-W13 R-W14	Zn-65 60μC	S	3.5 mi. up Bote Mtn.	3	1.6	11.8	--	RF	X	X	X

Table 11 (Continued)

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
78	7-24-75	66	18	L-R100 R-W15	Mn-54 60μC	S	5 mi. up Bote Mtn.	3	1.5	--	--	RF	-	X	X
79	7-24-75	72	72	L-B-7 R-B-6	Zn-65 60μC Mn-54 60μC	S	3 mi. out Rabbit Creek Rd.	3	0.2	15.0	--	RF	X	X	X
80	7-24-75	73	73	L-B-8 R-R-92	Zn-65 60μC Mn-54 60μC	S	3.5 mi. out Rabbit Creek Rd.	3	0.9	7.0	--	RF	X	X	X
81	7-25-75	74	74	L-B-9 R-R-93	Zn-65 60μC Mn-54 60μC	S	3 mi. out Rabbit Creek Rd.	3	0.6	10.0	--	LF	X	-	-
82	7-31-75	75	75	L-y-62 R-R-62	Zn-65 60μC Mn-54 60μC	S	2 mi. out Rabbit Creek Rd.	3	1.0	11.0	--	RF	-	X	X
83	8-1-75	67	12	L-W-83,58 R-R-96	Mn-54 60μC	S	2.4 mi. up Bote Mtn.	3	0.8	8.0	--	RF	-	X	X
84	8-1-75	68	68	L-W-17 R-W-16	Zn-65 60μC	S	3.0 mi up Bote Mtn.	3	1.0	7.0	--	RF	X	X	X
85	8-4-75	69	69	L-W-19 R-W-18	Zn-65 60μC	S	3.0 mi up Bote Mtn.	3	1.0	9.0	--	RF	X	X	X
86	8-15-75	76	76	L-B-10 R-R-94	Zn-65 60μC Mn-54 60μC	S	Ekaneetlee Gap	3	1.0	--	--	RF	X	X	X
87	8-15-75	77	77	L-B-11 R-B-12	Zn-65 60μC Mn-54 60μC	S	0.2 mi. East of Doe Knob	3	0.8	20.0	--	RF	X	X	X
88	8-18-75	78	78	L-B-13 R-B-14	Zn-65 60μC Mn-54 60μC	S	0.2 mi. East of Doe Knob	3	0.6	8.0	--	RF	X	X	X
89	8-18-75	79	79	L-B-15 R-R-95	Zn-65 60μC Mn-54 60μC	S	Ekaneetlee Gap	3	1.3	--	--	LF	X	X	X
90	8-21-75	80	80	L-B-16 R-B-17	--	F	Hwy. 441 North Carolina pulloff no. 3	3	0.8	7.5	--	LF	X	-	-
91	8-22-75	81	81	L-B-18 R-B-19	--	F	Clingman's Dome Rd. 2.5 mi. out	3	1.0	6.0	--	LF	X	-	X
92	8-26-75	82	82	--	--	F	Chimney Picnic area	3	0.8	7.0	--	RF	X	-	-

Table 11 (Continued)

Reference Number	Date	Capture Number	Lip Tattoo	Ear Tags	Isotope Injected	Trap Type[a]	Capture Location	Drug[b]	Amount (cc)	Latency Time (Min.)	Recovery Time (Min.)	Injection Point[c]	Tooth Ext.	Blood	Rectal Swab
93	8-27-75	83	83	L-B-22 R-B-23	Zn-65 60μC Mn-54 60μC	F	Cades Cove Campground	3	2.0	10.0	--	LF	X	X	X
94	8-31-75	84	84	L-B-24 R-G-1	Zn-65 60μC Mn-54 40μC	S	Green Camp Gap	3	1.1	--	--	LF	X	X	X
95	9-3-75	85	85	L-G-3 R-G-2	Zn-65 60μC Mn-54 40μC	S	Green Camp Gap	3	1.0	--	--	LF	-	X	X
96	9-4-75	86	38	L-R-31 R-y-33	Zn-65 60μC Mn-54 40μC	S	.5 mi. East of Green Camp Gap	3	1.0	--	--	RF	X	X	X
97	9-5-75	87	87	L-G-5 R-G-4	Zn-65 60μC Mn-54 40μC	S	.25 mi. West of Green Camp Gap	3	0.6	8.0	--	LF	X	X	X
98	9-10-75	88	88	L-G-6 R-B-25	Zn-65 60μC Mn-54 40μC	S	.5 mi. East of Green Camp Gap	3	1.0	--	--	LF	X	X	X
99	9-12-75	89	89	L-G7 R-G8	Zn-65 60μC Mn-54 60μC	S	Green Camp Gap Trail 2.5 mi. West of Sam's Creek	3	1.4	--	--	RF	X	X	X
100	9-13-75	Rec 07	07	L R-W54-79	--	S	.75 mi. West of Sam's Creek on Green Camp Gap Trail	3	1.0	--	--	LF	-	X	X

[a]S = Snare; C = Culvert; F = Free ranging.

[b]1 = M99; 2 = M50-50; 3 = Sernylan.

[c]RF = Right flank; LF = Left flank.

Table 12. Data for black bears captured in the Great Smoky Mountains National Park, 1974 and 1975--Part 2.

Reference Number	Sex	Wgt.	Total Length	Shoulder Height	Skull Width	Skull Length	Forearm Circumference	Neck Girth	Chest Girth	Hind Foot Length	Hind Foot Width	Front Foot Length	Front Foot Width	Teat Length	Lactating	Comments
01	F	45.5	139.0	74.5	14.0	30.0	25.5	40.5	69.0	12.5	8.0	4.5	9.0	0.5	N	Old transmitter Ch. 10.2 still functioning
02	M	77.2	156.0	88.5	21.0	32.5	36.0	61.5	91.0	14.5	8.5	6.5	10.5	-	-	Transmitter attached Ch. 2.05
03	F	34.0	128.0	69.0	10.0	27.0	24.0	42.5	68.0	12.0	7.5	4.2	9.0	0.5	N	White chest blaze
04	M	52.2	142.0	73.0	12.0	30.5	30.0	47.0	84.0	13.0	10.0	5.5	11.0	-	-	
05	M	54.5	152.0	81.0	13.5	34.5	30.5	50.5	86.0	15.5	10.0	6.0	10.5	-	-	
06	M	--	--	--	--	--	--	--	--	--	--	--	--	-	-	Puncture wound on left thigh
07	M	100.0	170.0	102.0	15.0	35.0	39.0	60.0	101.0	15.0	12.0	6.5	13.0	-	-	Transmitter attached Ch. 1.25 and 10.3
08	M	38.6	127.0	76.5	13.5	31.0	28.0	46.0	74.5	12.0	9.0	4.5	9.5	-	-	
09	F	59.0	138.0	72.0	15.0	30.5	29.0	54.5	84.0	12.5	9.5	4.5	9.0	2	N	Right foreleg badly cut from snare
10	F	est 32.0	125.0	59.0	12.0	27.0	25.0	42.0	76.0	11.0	8.5	4.5	9.5	0.5	N	Skin on top of front left foot torn away
11	M	65.9	140.0	81.0	13.0	31.0	30.0	53.0	85.0	13.5	10.0	6.0	11.0	-	-	Slight cuts on gums and lips
12	M	63.6	134.5	79.0	12.0	30.0	29.0	46.0	75.0	13.0	10.0	5.0	11.5	-	-	Old transmitter removed
13	M	61.3	139.0	80.5	11.0	30.0	30.0	50.5	83.0	12.0	9.0	5.5	9.0	-	-	
14	M	68.1	141.0	83.0	14.0	31.0	30.0	52.0	96.0	15.0	10.0	5.5	11.5	-	-	
15	F	40.9	121.0	68.0	11.0	27.5	27.0	42.0	76.0	11.0	8.0	4.5	9.5	.75	N	
16	M	--	--	--	--	--	--	--	--	--	--	--	--	-	-	Attempted to inject M50-50 intravenously
17	M	est. 77.0	151.0	64.0	10.0	31.0	32.0	48.5	81.0	12.5	9.0	[illegible].0	9.0	-	-	Compound fracture of left foreleg
18	M	--	--	--	--	--	--	--	--	--	--	--	--	-	-	
19	M	est. 45.0	134.0	70.5	13.0	30.5	28.0	45.0	77.0	13.0	10.0	5.5	10.5	-	-	Georgia Game and Fish tags L-M120, R-M119
20	M	--	--	--	--	--	--	--	--	--	--	--	--	-	-	1 cm. cut on right forefoot
21	M	--	--	--	--	--	--	--	--	--	--	--	--	-	-	
22	F	est. 52.0	140.0	79.0	13.0	32.0	28.0	53.0	81.0	11.0	8.0	4.0	9.0		Y	No cubs seen
23	F	--	--	--	--	--	--	--	--	--	--	--	--	-	-	
24	F	--	--	--	--	--	--	--	--	--	--	--	--	-	-	Caught by hind foot. Old injury starting to heal

Table 12 (Continued)

Reference Number	Sex	Wgt.	Total Length	Shoulder Height	Skull Width	Skull Length	Forearm Circum-ference	Neck Girth	Chest Girth	Hind Foot Length	Hind Foot Width	Front Foot Length	Front Foot Width	Teat Length	Lactating	Comments
25	F	--	143.0	71.0	13.0	30.0	27.0	46.0	76.0	13.0	9.0	5.0	9.5	1.5	Y	One cub seen running from trap
26	M	--	--	--	--	--	--	--	--	--	--	--	--	-	-	
27	M	56.8	155.0	77.0	12.0	32.0	30.0	50.5	89.5	14.0	9.0	6.5	10.25	-	-	
28	F	47.7	144.0	73.0	11.5	31.5	27.5	47.5	79.5	13.0	9.0	5.0	10.0	0.5	N	
29	M	77.2	165.0	82.0	15.5	34.5	34.0	60.25	96.0	14.5	11.0	7.0	6.5	-	-	
30	F	63.6	161.5	75.5	12.5	32.5	31.5	49.0	88.0	12.0	9.5	6.0	10.25	2.25	N	1 cm cut of toe of left forefoot
31	F	54.5	141.0	70.0	11.5	31.0	29.5	49.5	81.5	13.5	10.5	6.0	11.0	.6	N	
32	M	est. 86.0	172.0	83.0	13.0	34.0	37.0	72.0	102.0	15.0	11.0	7.0	11.5	-	-	Slight snare cut on right forefoot, small cuts on nose
33	M	75.0	158.0	84.0	15.0	34.0	36.0	64.0	95.0	14.0	10.0	6.5	10.0	-	-	Caught by left hind leg, slight cable cut
34	F	47.7	158.0	80.0	13.0	31.0	28.0	49.0	78.0	12.0	9.0	5.0	9.0	2.5	Y	Two cubs at trap sight, small cut below left ear
35	M	38.6	132.0	75.0	13.0	26.0	26.0	44.0	72.0	12.0	9.0	5.0	10.0	-	-	0.5 cm cut from cable
36	M	75.0	159.0	83.0	13.0	33.0	31.5	54.5	86.0	14.75	11.5	6.5	12.0	-	-	
37	M	77.2	159.0	79.5	13.0	34.0	34.5	57.5	102.5	14.0	10.0	6.5	11.0	-	-	Very slight cable cut
38	M	68.1	153.0	87.0	13.0	34.0	31.0	57.5	92.5	15.0	10.0	6.0	10.5	-	-	Had tangled cable and was hung 30 ft. up tree
39	F	50.0	138.0	68.5	12.5	23.5	28.0	45.0	76.0	11.0	9.0	4.5	10.0	1.5	N	Slight cable cut on right front foot
40	F	59.0	148.0	73.0	12.0	30.0	28.0	51.5	89.0	12.5	8.5	5.0	9.5	1.0	N	Right foreleg apparently separated at wrist
41	F	43.1	139.0	67.0	11.0	29.0	27.5	44.0	74.5	12.5	9.0	5.0	9.5	1.0	N	
42	F	79.5	157.0	83.0	19.0	27.0	35.0	57.0	103.0	13.0	9.0	6.0	10.0	-	Y	Moved with 3 cubs to Little Cataloochee
43	F	90.9	145.0	87.0	14.0	28.0	32.0	62.0	119.0	13.0	8.0	7.0	10.0	1.0	N	Moved to Little Cataloochee
44	M	45.4	132.0	70.0	12.0	30.0	25.5	44.0	75.0	13.0	8.5	5.5	9.0	-	-	Transmitter attached frequency 150.892
45	M	56.8	136.0	69.0	12.0	31.0	27.5	51.5	85.0	13.0	9.0	5.5	10.0	-	-	Transmitter attached frequency 151.025
46	F	27.2	137.0	66.0	13.0	26.0	22.5	37.0	66.0	11.0	8.0	4.5	9.0	-	-	Previously injured foot healed, 2 toes lost

Table 12 (Continued)

Reference Number	Sex	Wgt.	Total Length	Shoulder Height	Skull Width	Skull Length	Forearm Circum-ference	Neck Girth	Chest Girth	Hind Foot Length	Hind Foot Width	Front Foot Length	Front Foot Width	Teat Length	Lactating	Comments
47	F	29.5	128.0	69.0	9.5	30.0	25.0	39.0	69.0	11.5	8.5	5.0	9.0	.5	N	Right front foot amputated below wrist (old) transmitter 151.034
48	M	70.4	154.0	71.0	14.0	33.0	30.5	56.0	95.0	13.5	9.5	6.0	11.5	-	-	Transmitter attached (150.861) released on Bote Mtn.
49	M	34.0	134.0	69.0	14.0	30.0	23.0	39.0	69.5	13.0	9.0	5.5	10.5	-	-	.5 cm cable cut on right forepaw
50	M	72.6	158.0	79.0	15.0	32.0	31.0	57.0	89.0	15.0	10.0	6.0	11.5	-	-	Old wound on right shoulder
51	F	40.8	119.0	70.0	14.0	29.0	26.0	45.0	74.0	11.5	9.0	5.0	9.0	2.5	N	
52	M	113.4	183.0	90.0	18.0	37.0	36.0	69.0	109.0	15.5	13.0	7.0	12.0	-	-	
53	F	45.4	133.0	70.0	14.0	30.0	26.0	44.0	75.0	12.0	8.0	5.0	9.0	1.5	N	Slight 0.5 cm cable cut on right front foot
54	M	45.4	140.0	74.0	14.0	29.0	30.0	48.0	76.0	13.0	8.0	7.0	10.0	-	-	Slight cable cut
55	F	56.7	141.0	66.0	14.0	31.0	28.0	47.0	79.0	14.0	9.0	7.0	10.0	-	N	Last year's cub seen near trap
56	F	36.3	145.0	68.0	15.0	28.0	26.0	44.0	72.0	12.0	9.0	6.0	9.0	-	N	0.5 cm cut on inside of right forefoot
57	M	59.0	148.0	72.0	18.0	32.0	30.0	53.0	84.0	15.0	9.0	6.0	11.0	-	-	
58	M	83.9	168.0	86.0	17.0	34.0	41.0	68.0	102.0	14.0	9.0	6.0	11.0	-	-	
59	M	127.0	176.0	94.0	19.0	35.0	41.0	71.0	128.0	14.5	12.0	7.0	12.0	-	-	Old transmitter removed
60	F	52.2	151.0	77.0	14.5	30.0	28.0	48.0	81.0	13.0	9.5	5.5	10.5	2.5	N	
61	M	79.4	156.0	91.0	19.5	33.0	32.0	56.5	94.5	15.0	10.0	6.0	12.0	-	-	
62	M	49.9	136.0	68.0	14.0	29.0	25.5	45.0	77.5	14.0	9.5	5.5	11.0	-	-	Released at Schoolhouse Gap
63	M	56.7	146.0	80.0	15.5	29.0	33.5	59.0	92.5	13.25	10.0	6.75	10.5	-	-	
64	F	31.8	135.0	72.0	17.0	31.0	30.0	44.0	73.0	13.5	7.5	6.0	9.5	-	N	
65	F	38.6	136.0	71.0	16.0	28.0	33.0	44.0	78.0	13.0	10.0	6.5	10.0	-	N	Slight cable cut on inside of right forefoot
66	F	47.6	148.0	75.0	15.5	30.0	28.0	44.0	80.0	13.0	8.0	5.5	9.0	2.0	Y	No cubs seen; old transmitter removed
67	M	48.1	138.0	76.0	17.0	27.0	29.0	53.0	80.0	12.5	9.5	6.5	10.0	-	-	Transmitter attached frequency 150.883
68	M	59.0	154.0	69.0	15.5	32.0	32.0	55.0	81.0	14.5	10.0	7.5	12.0	-	-	Transmitter attached frequency 150.914

Table 12 (Continued)

Reference Number	Sex	Wgt.	Total Length	Shoulder Height	Skull Width	Skull Length	Forearm Circumference	Neck Girth	Chest Girth	Hind Foot Length	Hind Foot Width	Front Foot Length	Front Foot Width	Teat Length	Lactating	Comments
69	F	38.6	140.0	76.0	11.0	30.0	24.5	44.0	74.0	12.5	9.0	6.0	9.5	1.5	N	Apparently in estrus
70	M	65.8	154.0	81.0	17.0	33.0	31.5	59.0	88.0	15.0	10.5	6.0	11.75	-	-	Left upper lip with slight cut
71	M	38.6	130.0	71.0	13.5	29.0	27.0	46.0	75.0	14.0	10.0	6.5	10.0	-	-	2 in. cable cut on front of right front foot
72	F	59.0	154.0	72.0	17.0	31.0	31.0	52.0	88.0	12.5	8.0	6.0	9.5	-	N	Transmitter attached frequency 150.948
73	F	40.8	131.0	67.0	14.0	27.0	28.0	48.0	78.0	12.0	9.0	5.5	10.5	-	N	Transmitter attached frequency 150.964
74	M	38.6	134.0	68.5	14.0	29.0	36.0	44.0	70.0	14.0	10.5	5.5	12.0	-	-	
75	F	43.1	145.0	74.0	15.0	30.0	28.0	45.0	81.5	13.0	9.5	5.0	10.0	1.75	Y	No cubs seen
76	M	20.4	106.0	53.5	11.0	28.0	20.0	32.0	56.0	11.0	8.0	5.0	8.5	-	-	
77	M	74.8	170.0	76.5	19.0	35.0	28.5	54.0	95.0	16.0	10.0	7.0	13.0	-	-	Transmitter attached frequency 151.068
78	F	54.4	135.0	71.5	17.5	28.0	26.5	49.0	82.0	14.0	10.0	6.0	11.0	3.0	N	Believed to have lactated this year
79	M	27.2	115.0	60.0	12.0	25.5	21.0	34.0	61.0	11.0	7.0	5.0	10.0	-	-	Possible separation or fracture of right wrist
80	M	65.8	165.0	86.5	18.0	34.0	30.0	51.0	83.5	15.5	10.0	6.5	11.5	-	-	2 cm cut on pad of right forefoot
81	F	52.2	143.0	77.0	14.0	29.0	27.5	47.0	80.0	12.0	9.0	5.5	10.0	.5	N	Simple fracture of left radius
82	M	79.4	164.0	87.0	18.0	35.5	32.5	60.0	92.0	16.0	11.0	7.0	12.0	-	-	
83	M	61.2	159.0	81.0	16.0	34.0	29.0	47.0	79.0	13.0	10.0	6.0	10.0	-	-	Transmitter attached frequency 151.046
84	M	65.8	149.0	81.0	16.0	32.0	33.0	53.0	83.0	14.5	10.0	6.0	11.5	-	-	Transmitter attached frequency 151.095
85	M	74.8	170.0	92.0	17.0	33.0	36.0	67.0	95.0	15.5	12.0	8.0	11.5	-	-	Transmitter attached frequency 151.008
86	F	61.2	152.0	72.0	16.5	29.5	27.0	42.0	77.0	13.0	9.5	5.0	10.0	0.5	N	
87	F	65.8	151.0	75.0	14.5	33.0	30.5	48.0	84.0	13.5	9.5	5.0	10.0	1.5	N	Possibly accompanied by last year's cub
88	M	72.6	159.0	84.0	15.0	34.0	32.0	52.5	83.0	15.5	11.0	6.5	12.0	-	-	
89	M	74.8	148.0	78.0	15.0	34.0	32.0	47.5	92.0	15.0	10.5	6.5	12.5	-	-	

Table 12 (Continued)

Reference Number	Sex	Wgt.	Total Length	Shoulder Height	Skull Width	Skull Length	Forearm Circum-ference	Neck Girth	Chest Girth	Hind Foot Length	Hind Foot Width	Front Foot Length	Front Foot Width	Teat Length	Lactating	Comments
90	F	36.3	140.0	70.5	12.0	27.0	27.5	43.0	72.5	13.0	10.0	5.0	10.0	.25	N	Released at Little Cataloochee
91	F	36.3	137.0	68.0	15.0	28.5	24.5	48.0	79.0	12.5	9.0	5.5	10.0	2.0	Y	Released at capture point, couldn't catch cubs
92	M	34.0	133.0	67.0	15.0	30.5	26.5	42.0	73.5	13.0	9.5	6.0	11.5	-	-	Captured by Park personnel; .410 shotgun wound treated
93	M	147.4	179.0	96.0	18.0	36.5	40.0	77.0	121.0	16.0	11.0	8.0	13.0	-	-	Released at Tremont
94	M	79.4	160.0	84.0	15.0	34.0	35.0	59.0	92.5	17.0	11.5	7.0	13.0	-	-	
95	M	74.8	153.0	82.0	18.0	34.0	32.5	55.0	89.0	16.0	11.0	6.5	11.5	-	-	Old transmitter removed
96	M	65.8	161.0	82.0	15.0	36.0	32.5	51.0	94.0	16.0	10.5	7.0	11.5	-	-	Old transmitter removed
97	F	54.4	147.0	74.0	12.0	31.5	26.5	47.0	77.0	14.0	10.0	6.0	11.5	2.5	Y	No cubs seen, one heard nearby
98	M	77.1	171.0	88.0	15.0	35.0	33.0	56.0	90.0	16.0	11.5	7.0	12.5	-	-	Transmitter attached frequency 151.125
99	F	74.8	157.0	78.0	17.0	32.0	31.0	57.0	96.0	13.0	9.5	6.0	10.0	1.5	N	Transmitter attached frequency 150.927
100	M	63.5	--	--	--	--	28.5	--	89.5	--	--	--	--	-	-	

Table 13. Ages of black bears captured in the Great Smoky Mountains National Park, 1974 and 1975.

Reference Number	Age	Reference Number	Age
1	5.5	53	9.5
2	6.5	54	5.5
3	5.5	55	5.5
4	4.5	56	4.5
5	3.5	57	3.5
7	7.5	58	4.5
8	4.5	60	5.5
9	8.5	61	5.5
10	2.5	62	1.5
11	3.5	64	4.5
12	3.5	67	3.5
13	3.5	69	4.5
14	5.5	70	5.5
15	5.5	71	2.5
23	17.5	72	8.5
25	4.5	73	10.5
27	4.5	74	2.5
28	6.5	75	4.5
29	5.5	76	1.5
30	13.5	78	1.5
31	5.5	79	4.5
32	10.5	80	5.5
33	7.5	82	6.5
34	5.5	84	4.5
35	4.5	85	3.5
36	3.5	86	4.5
37	4.5	87	6.5
38	4.5	88	4.5
39	5.5	89	3.5
41	7.5	90	1.5
44	4.5	91	4.5
46	5.5	92	1.5
48	2.5	93	5.5
49	2.5	94	5.5
50	5.5	97	7.5
51	4.5	98	4.5
52	5.5	99	6.5

APPENDIX B

TRAPPING TECHNIQUES

Prebaiting

During the two years of the study, a total of 190 prebait sites were established; 106 in 1974 (Table 14) and 84 in 1975 (Table 15). Given the limited time and resources available for this study, and the relative inaccessibility of many portions of the study area, prebaiting was an invaluable component of the trapping technique. Prebaits were much more quickly and easily established than were traps, and they were apparently effective in indicating areas of high potential trap success. Using prebaiting, as in the present study, Marcum (1974) reported higher trapping success than had previously appeared in the literature for black bears. He stated that differences in densities of the populations concerned may account for some of the differences in trapping success, but that the prebaiting method likely accounted for much of his lower trap night to capture ratio. Data from the present study corroborate these findings.

Trapping

In addition to snare captures, seven bears were captured by means of the projectile syringe gun and one was caught in a culvert trap. In 1974, 65 snare sites were used in amassing 430 trap nights; 45 bears were captured

Table 14. Prebait data for black bears in the Great Smoky Mountains National Park, 1974.

Area (Date)	Number of Prebait Sites	Number of Bear Visits	Number of Non-Bear Visits	Percentage Utilization By Bears	Percentage Utilization Within 5 Days
Bote Mountain (10 May-29 June)	21	16	7	76.2	23.8
Defeat Ridge (1 July-12 July)	29	9	0	31.0	27.6
Rabbit Creek (15 July-25 July)	11	6	0	54.5	27.3
Sugarland Mountain (15 July-1 Aug.)	13	7	0	53.8	38.5
Bent Arm (20 July-8 Aug.)	12	8	0	66.7	33.3
Miry Ridge-Derrick Knob (12 Aug.-22 Aug.)	10	4	0	40.0	40.0
Bote Mountain (2 Sept.-22 Sept.)	10	10	0	100.0	50.0
Total	106	60	4	56.6	28.3

Table 15. Prebait data for black bears in the Great Smoky Mountains National Park, 1975.

Area (Date)	Number of Prebait Sites	Number of Bear Visits	Number of Non-Bear Visits	Percentage Utilization By Bears	Percentage Utilization Within 5 Days
Defeat Ridge (9 June-24 June)	7	7	0	100.0	28.6
Bote Mountain (29 June-4 Aug.)	18	16	0	88.9	72.2
Bent Arm (9 June-19 June)	12	11	0	91.7	58.3
Sugarland Mountain (23 June-9 July)	12	10	0	83.3	33.3
Rabbit Creek Road (17 July-3 Aug.)	10	8	0	80.0	40.0
Ekaneetlee Gap (5 Aug.-19 Aug.)	12	5	0	41.7	33.3
Green Camp Gap (27 Aug.-13 Sept.)	13	10	0	79.9	53.8
Total	84	67	0	79.8	48.8

(Table 16). In 1975, 47 captures were produced by 52 snare sites run for 461 trap nights (Table 17). The average trapping success of one capture per 9.7 trap nights is not as high as was reported by Marcum (1974) (one capture per 4.6 trap nights, using similar methods), but it is more efficient than has been reported by other researchers (Barnes and Bray, 1967; Miller, et al., 1973). At least part of the difference in trapping success between the present study and that of Marcum can be attributed to an attempt in the present study to distribute captures more evenly over the study area. The higher trapping efficiency than is reported by other researchers using spring activated foot snares is partially a result of the higher black bear density in portions of the GSMNP, and partially due to the use of the prebaiting technique.

In evaluating live-trapping techniques for black bears Erickson (1957) found number 4-1/2 steel-spring wolf traps to be the best capture method available at that time. Advantages mentioned for the steel traps are that they are inexpensive, "they are easily handled, can be set in a greater number of places and in a greater variety of situations, work well with a greater range of baits and can be easily cleaned and camouflaged" (p. 542). In the present study the Aldrich spring activated foot snare has been found to offer all these advantages as well as others not present when steel traps were used. With the snares there is no

Table 16. Trapping data for black bears in the Great Smoky Mountains National Park, 1974.

Area (Date)	Number of Snare Sites	Number Snare Nights	Number of Visits	Number of Captures	Number of Misses	Trap Nights Per Visit	Trap Nights Per Capture	Percentage of Sites Visited Within 5 Days	Percentage Success
Bote Mountain (10 May-29 June)	14	195	27	18	9	7.22	10.8	21.4	9.2
Defeat Ridge (1 July-12 July)	7	74	8	8	0	9.25	9.25	--	10.8
Rabbit Creek Road (15 July-25 July)	5	24	10	5	5	2.40	4.80	80.0	20.8
Sugarland Mountain (15 July-1 August)	6	30	8	4	4	3.75	7.50	50.0	13.3
Bent Arm (20 July-8 August)	6	22	9	3	6	2.44	7.33	66.7	13.6
Miry Ridge-Derrick Knob (12 Aug.-22 Aug.)	4	26	4	3	1	6.50	8.67	75.0	11.5
Bote Mountain (2 Sept.-22 Sept.)	7	58	8	4	4	7.25	14.50	26.2	6.9
Total	49	429	74	45	29	5.80	9.53	--	10.5

Table 17. Trapping data for black bears in the Great Smoky Mountains National Park, 1975.

Area (Date)	Number of Snare Sites	Number of Snare Nights	Number of Visits	Number of Captures	Number of Misses	Trap Nights Per Visit	Trap Nights Per Capture	Percentage of Sites Visited Within 5 Days	Percentage Success
Defeat Ridge (9 June-24 June)	5	54	12	6	6	4.50	9.00	80.0	11.1
Bote Mountain (29 June-4 Aug.)	14	172	65	15	50	2.65	11.47	64.3	8.7
Bent Arm (9 June-19 June)	7	35	17	5	12	2.06	7.00	85.7	14.3
Sugarland Mountain (23 June-9 July)	6	48	19	4	15	2.53	12.00	83.3	8.3
Rabbit Creek Road (17 July-3 Aug.)	8	56	6	6	0	9.33	9.33	37.5	10.7
Ekaneetlee Gap (5 Aug.-19 Aug.)	5	37	6	4	2	6.17	9.25	40.0	10.8
Green Camp Gap (27 Aug.-13 Sept.)	7	59	17	7	10	3.47	8.43	85.7	11.8
Total	52	461	142	47	95	3.25	9.81	67.3	10.1

evidence of bias towards capture of bears in a particular size class, and the incidence of injury to bears as a result of trapping is less than reported by Erickson with the use of steel traps.

In 1974 three bears sustained serious injuries as a result of captures with snares, and in 1975 there were two serious injuries. Of these injuries, two were fractures of the ulna and/or radius, two were separations of the wrist joints and one was the tearing of a portion of skin from the top of a snared foot. Subsequent captures of two bears which had sustained broken bones in the foreleg indicated a remarkable ability to heal. In both cases the only remaining evidence of the fractures were calcerous knots on the long bones at the point of the fracture.

Such injuries can likely be eliminated altogether if certain precautions are taken in the setting of the snares. The primary cause of injury was the setting of snares in close proximity to trees other than that used to anchor the cable. When this was done bears either collided with the trees in the course of struggling to free themselves, or used the trees as a means of exerting added pressure on the snared leg. Eveland (1975) felt that the latter was the case in his study. Sites chosen for snare sets should have no trees (other than anchor tree) within a radius which can be reached by a bear while in a trap. It was also helpful to set the snare loop at such a height as to catch bears just above the large pad of the front foot. This section of the foot is tough and resistant to cuts caused by the cable, and there is little chance that the cable, once tightened here, will slip further down the limb. Additional considerations in the selection of snare sites to reduce injuries are the avoidance of sharp staubs on trap logs or in the immediate area, and an avoidance of situations where traps are set on steep slopes.

During the summer of 1975, evaluation of a modification of the Aldrich snare was begun. The modification consisted of the attachment of an automobile hood spring to the snare cable to function as a shock absorber. Most injuries probably resulted from the sudden jolt experienced when a struggling bear reached the end of the cable in a lunge. The spring was attached to the cable by means of "u" bolts, and a loop of the anchor cable was left to act as a safety line in the event the spring was broken or pulled loose (Figure 3). Subsequent observations indicate that the spring functions well in the reduction of serious leg injuries as a result of trapping. Observation of snared bears prior to immobilization showed a different behavior in response to the modified traps. Rather than rushing to the end of the cable and experiencing a sudden jolt, bears spent more time pulling gradually against the cable. Perhaps it was the slight give in the cable caused by the spring which brought about this different behavior pattern.

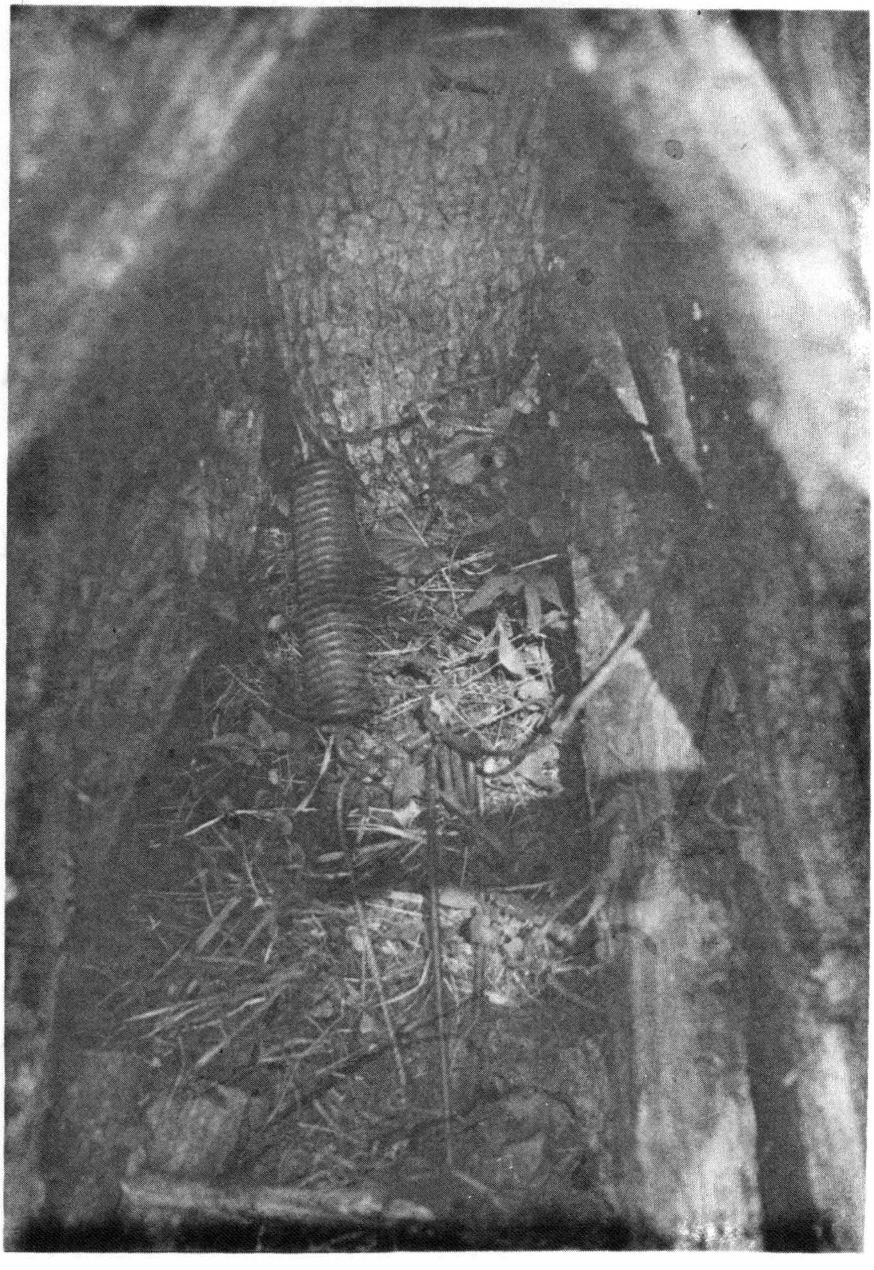

Figure 3. Aldrich spring-activated foot snare showing attachment of spring to prevent injury.

Another experimental modification intended to reduce the possibility of injury was the addition to the snare loop of an approximately 5 cm piece of rubber tubing in such a manner as to pad the portion of the cable which holds the foot. At first, this seemed to be quite successful in reducing minor injuries and swelling of the foot. However, it was found that some bears were able to escape from snares equipped with this apparatus, so its use was discontinued.

In captures where the above-mentioned modifications and precautions were used, there were no serious injuries to the bears. However, there still exists a problem of vulnerability of trapped bears to attack by other bears. This problem can be reduced by checking traps early in the day, or by checking traps more frequently.

When properly set, the Aldrich spring activated foot snare is an extremely efficient capture technique. Upon first encounter with the cubby type set, bears apparently display little wariness. Once captured, bears show a variety of responses to the traps upon subsequent encounters. Most bears are not recaptured after the initial capture despite continued trapping within their probable home range. These bears apparently develop trap shyness, and after initial encounter avoid traps altogether. A few bears display a propensity toward repeated recaptures, either within a given trapping season, or on a year-to-year basis. Still other bears appeared to develop a trap wariness which caused them not to avoid traps altogether, but to approach them more carefully. Erickson (1957) reported that bears develop trap shyness in areas which are intensively trapped. In the present study, the development of a wariness of traps, and a subsequent higher frequency of trap robberies was observed in the Bote Mountain-Defeat Ridge area. This area was the most intensively trapped throughout the study. In 1974 there were twelve robberies in this area. In 1975 the number increased to fifty-six, and subsequent data for 1976 shows yet another increase in misses for this area.

In situations such as the above, where bears learned to acquire baits while avoiding capture, it became necessary to deviate from the standard trapping procedure. When possible the course of the bear's approach to the trap was determined, and a carefully concealed second snare was set to catch the bear as it approached the standard snare set. In most cases this technique proved effective for capturing trap-wary bears.

VITA

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