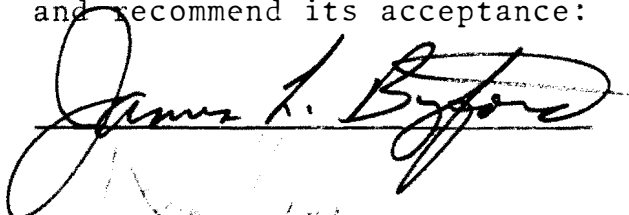
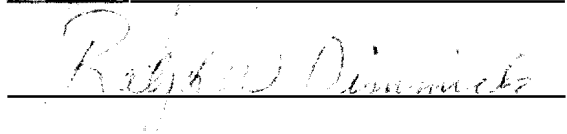


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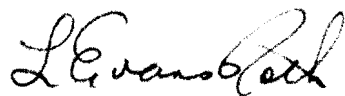
I am submitting herewith a thesis written by William Eugene Keeler entitled "Some Aspects of the Natural History of the Raccoon (Procyon lotor) in Cades Cove, The Great Smoky Mountains National Park." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

  
Michael R. Pelton, Major Professor

We have read this thesis  
and recommend its acceptance:

Accepted for the Council:

  
Vice Chancellor  
Graduate Studies and Research

## ACKNOWLEDGMENTS

I am grateful to Dr. Michael R. Pelton, Associate Professor of Forestry, Wildlife, and Fisheries, The University of Tennessee, who served as director of research.

I would like to express appreciation to Dr. James L. Byford, Extension Wildlife Specialist, Dr. J. Larry Wilson and Dr. Ralph W. Dimmick, Associate Professors of Forestry, Wildlife, and Fisheries, who served on my committee.

Appreciation is extended to the personnel of The Great Smoky Mountains National Park for permitting the research.

Necessary equipment and expenses for the research were provided by the Department of Forestry, Wildlife, and Fisheries and McIntire Stennis Project No. 12 of the Agricultural Experiment Station and The Great Smoky Mountains Natural History Association.

## ABSTRACT

A study was conducted from January 1973 to April 1974 to determine the density and distribution of the raccoon (Procyon lotor) population in the Cades Cove area of The Great Smoky Mountains National Park. Raccoons were live-trapped, anesthetized with Sernylan, ear-tagged, aged, weighed and measured. Beginning in April 1973 an epizootic of canine distemper occurred in the raccoon population in Cades Cove, enabling this study to demonstrate the impact of an epizootic on a raccoon population.

During 2870 trap nights, 217 raccoons were captured, of which 106 were recaptures. The 111 individual raccoons captured consisted of 48 males and 63 females (0.76 male per 1 female). Data indicated a change in sex ratio from 0.53 male per 1 female for the pre-epizootic period to 2.03 males per 1 female for the post-epizootic period. Data also indicated a change in the age structure of the population resulting in a greater proportion of juveniles and a decline in the 15-38 month age class after the epizootic. Raccoon weights changed seasonally, and body measurements varied widely among individuals of each age class. Limited data indicated home ranges for male raccoons in Cades Cove to be three times greater than those of females.

Five methods of population estimation were used and compared. They indicated the average raccoon density in

Cades Cove to be 1 raccoon per 17.5 ha before the epizootic in 1973, and 1 raccoon per 51.8 ha in 1974. The pre-epizootic raccoon population in Cades Cove was estimated to be 251, which declined 75.0 percent after the epizootic, using the Frequency of Capture method of population estimation which was judged preferable for estimating number of raccoons, while it was necessary to use the Jolly method to demonstrate population trends.

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## INTRODUCTION

The raccoon, Procyon lotor, is an omnivorous, nocturnal mammal found throughout most of the United States (Johnson 1970). This species is an adaptable animal which can thrive in the presence of man (Cauley and Schinner 1973), is expanding its natural range (Sutton 1964), and has been successfully transplanted and established in other areas of the world (Goldushko 1964, Aliev and Sanderson 1966, Scheffer 1947).

The raccoon is also an important furbearer. In the period 1960-64, \$7.3 million worth of raccoon furs were exported from the United States (U. S. Department of Commerce 1966).

Raccoon hunting is a popular sport in many states. Sanderson (1960) estimated the annual Illinois harvest at 100,000 raccoons. In Tennessee in 1961 an estimated 17,170 hunters harvested 81,442 raccoons, while spending \$65,712 on food and lodging on hunting trips (Legler 1961).

Beginning with the classic study of Stuewer (1943a), an extensive literature is now available on various aspects of the life history of the raccoon. Included are such topics as aging techniques (Grau, Sanderson, and Rogers 1970; Montgomery 1963, 1964; Sanderson 1961a, 1961b), behavior (Johnson and Michels 1958; Lyall-Watson 1963; Sharp and Sharp 1956; Shell and Riopelle 1957; Thorgersen 1958; and

Thackray 1956), parasites and diseases (Cappucci 1970; Kappus, Bigler, McLean, and Trevino 1970; Crook and McNutt 1958; Gorham 1966; Habermann, Herman and Williams 1958; Helmboldt and Jungherr 1955; Kilham 1956; Menges, Habermann, and Stains 1955; Robinson, Newberne, and Brooks 1957; Cauley and Schinner 1973; Friend 1968; Bigler 1971; Gifford and Jungherr 1947; Osebold, Schultz, and Jameson 1957; Reilly 1954; Weller 1940; Clark and Herman 1959; Harkema and Miller 1964; Herman and Price 1965; and Jordan and Hayes 1959), food habits (Baker, Newman, and Wilke 1945; Giles 1939, 1940; Hamilton 1936, 1951; Schoonover and Marshall 1951; Tester 1953; Tyson 1950; Yeager and Rennels 1943; and Yeager and Elder 1945), movements (Giles 1943; Lynch 1967; Montgomery, Lang, and Sunquist 1970; and Sunquist, Montgomery, and Storm 1969), reproduction (Creed and Biggers 1963; Heidt 1969; Lehman 1968; Llewellyn 1952, 1953; Llewellyn and Enders 1954a, 1954b; McKeever 1958; Sanderson 1951; Stuewer 1943b; and Wood 1955), and predation (Urban 1970; Eaton 1966; Kadler 1971; Llewellyn and Webster 1960; and Wilson 1953, 1956).

The status of the raccoon in Tennessee was reviewed by Schultz (1956). cursory surveys by Komarek and Komarek (1938) and Linzey and Linzey (1968) briefly discuss the raccoon in The Great Smoky Mountains National Park.

The lack of available information on this animal in Tennessee and also the apparent scarcity of raccoons in many

areas of East Tennessee indicate that a need exists for research on this species in the state. East Tennessee hunter groups participate in annual restocking programs in an attempt to increase the number of raccoons available to the hunter in the area.

Cades Cove, in The Great Smoky Mountains National Park, is an area which has been protected from legal hunting for more than 35 years. Much of this area has also been managed as a pastoral environment for beef cattle similar to many East Tennessee counties outside the Park, but without the various influences of permanent residents. Therefore, Cades Cove offers an unusual opportunity to establish baseline data on a raccoon population relatively protected from the disturbances of man, with the exception of habitat alteration in the form of beef cattle pastures and haying operations. Thus, a "yardstick" can be established with which to compare populations outside the park.

The present study of the raccoon population in Cades Cove began on 27 January 1973 and terminated on 16 April 1974. The main goals of the research were to determine the density and distribution of this raccoon population. However, during the study, beginning in April 1973, an epizootic of canine distemper occurred in the raccoon population. Since the study began before the epizootic and continued for 11 months after the epizootic ended, it was possible also to demonstrate the impact of the epizootic on the raccoon population.

## CHAPTER I

### THE STUDY AREA

#### A. THE PARK

The Great Smoky Mountains National Park was established in 1934; it consists of 207,301 ha within the states of North Carolina and Tennessee. The Park is a densely forested area of rugged topography; its elevation ranges from 275.3 m to 2059 m. Annual precipitation ranges from 114.3 cm at the lower elevations to greater than 241.3 cm at the higher elevations. Monthly average temperatures range from 23.9° C during July and August to 3.3° C during January. Temperatures at the highest elevations average approximately 8.25° C less than temperatures at the lowest elevations.

#### B. CADES COVE

Cades Cove is a unique area within The Great Smoky Mountains National Park. In 1941 Cades Cove was established as "an area of living mountain culture" by the National Park Service; it was maintained "to force back the wilderness for a show of history and folk culture" (Frome 1966). For this reason, some cultural practices not found within the remainder of the Park are practiced here in order to perpetuate

aspects of early pioneer life. The area is maintained in a pastoral setting of 976.6 ha, approximately 8 km long and 3.2 km wide (Figure 1).

#### C. MANAGEMENT

Land management is carried out by three permittee operations under the supervision of the National Park Service. Of the 976.6 ha under management, 747.1 ha (76.5 percent) are devoted to pasture and hay. The remaining 229.5 ha (23.5 percent) comprise small woodlots. Habitat management consists of mowing, periodic plowing, fertilization, and seeding of the pastured areas. No row cropping is undertaken.

#### D. ROADS

Over 24 km of roads permit access throughout the area. The main road, known as the Cades Cove Loop Road, is a one-way, single lane, paved, motor nature trail of 17.7 km around the perimeter of the Cove. Along this road Park visitors may tour five log cabin sites, visit a water-powered grain mill and country store complex, and observe wildlife.

#### E. TOPOGRAPHY AND PHYSIOGRAPHY

Cades Cove can best be described as a gently rolling, pastoral setting isolated by high mountains. Elevations within the area range from 527 m to 558 m. The valley is

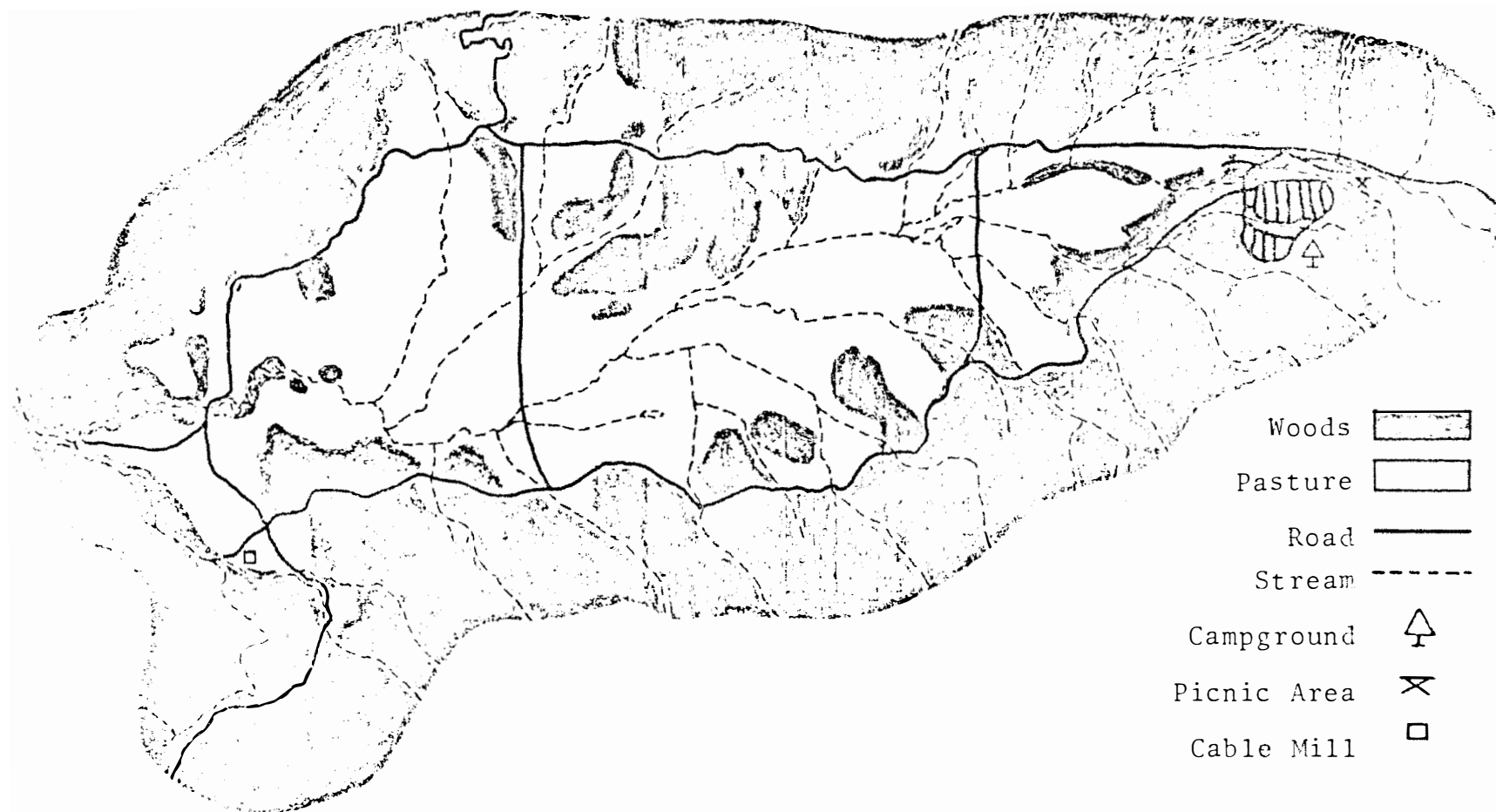


Figure 1. The Cades Cove raccoon study area in The Great Smoky Mountains National Park, 1973-1974.

underlain by dolomite and limestone, while the surrounding rim is composed of older metamorphic rock. Most of the valley consists of alluvial deposits. It is drained by Abrams Creek and its tributaries which make up 37.03 km of streams. Abrams Creek enters Cades Cove as a fast-flowing mountain stream, but its flow rate decreases as it meanders throughout much of the pasture area. During August 1973, sections of the main stream within Cades Cove dried up. Many small swampy areas are found along this stream, and two sink holes, located in the woods away from Abrams Creek (Figure 1) form swamps during the spring.

#### F. VEGETATION

Vegetation within the pasture areas consists primarily of fescue (Festuca sp.), orchardgrass (Dactylis sp.), timothy (Phleum sp.), redtop grasses (Agrostis sp.), and red and ladino clovers (Trifolium sp.). When the Park was created in 1934, approximately 100 families lived in Cades Cove. After they were relocated outside the Park, their houses and barns were torn down and many of their pastures and fields were permitted to undergo natural succession. Today many areas of the Cove consist of almost pure even-age stands of white pine (Pinus strobus) or shortleaf pine (P. echinata). The understory in these pine stands often contain hemlock (Tsuga canadensis). There are also mixed deciduous woodlots consisting of tulip poplar (Liriodendron tulipifera),

and various species of oak (Quercus sp.), maple (Acer sp.), and hickory (Carya sp.).

#### G. WILDLIFE

A diversity of mammalian and avian wildlife, including the following species, are found within Cades Cove: black bear (Ursus americanus), white-tailed deer (Odocoileus virginianus), European wild hog (Sus scrofa), raccoon (Procyon lotor), striped skunk (Mephitis mephitis), spotted skunk (Spilogale putorius), gray fox (Urocyon cinereoargenteus), red fox (Vulpes vulpes), cottontail rabbit (Sylvilagus floridanus), opossum (Didelphus marsupialis), gray squirrel (Sciuris carolinensis), red squirrel (Tamiasciuris hudsonicus), woodchuck (Marmota monax), wild turkey (Meleagris gallopavo), ruffed grouse (Bonasa umbellus), and the eastern bluebird (Sialia sialis).

In addition to the wildlife in Cades Cove, approximately 1,300 domestic cattle and about 40 horses are permitted to graze throughout the year.

## CHAPTER II

### MATERIALS AND METHODS

#### A. TRAPPING AREA

To identify trap sites, a topographic map of the Cades Cove study area was divided into numbered squares, each representing an area 400 m on a side (Figure 2). Square 136 was not trapped because the large number of Park visitors in the area might have endangered captured animals. Also, squares consisting primarily of pasture were not trapped due to lack of cover for trap placement and because traps could be disturbed by cattle. The perimeter of the study area was approximately 400 m out from the loop road. At that point, in most areas of the Cove, the elevation increases rapidly. Thus, the study was restricted primarily to the valley floor.

#### B. SELECTION OF TRAP SITES

When the study began on 27 January 1973, the initial purpose of trapping was to tag as many raccoons as possible. Forty trap sites were chosen, primarily along streams and stream junctions, according to the criteria established by Butterfield (1954). In addition, sites were selected to provide adequate cover in which to conceal traps from Park visitors. Traps were set at these sites on 12 nights during

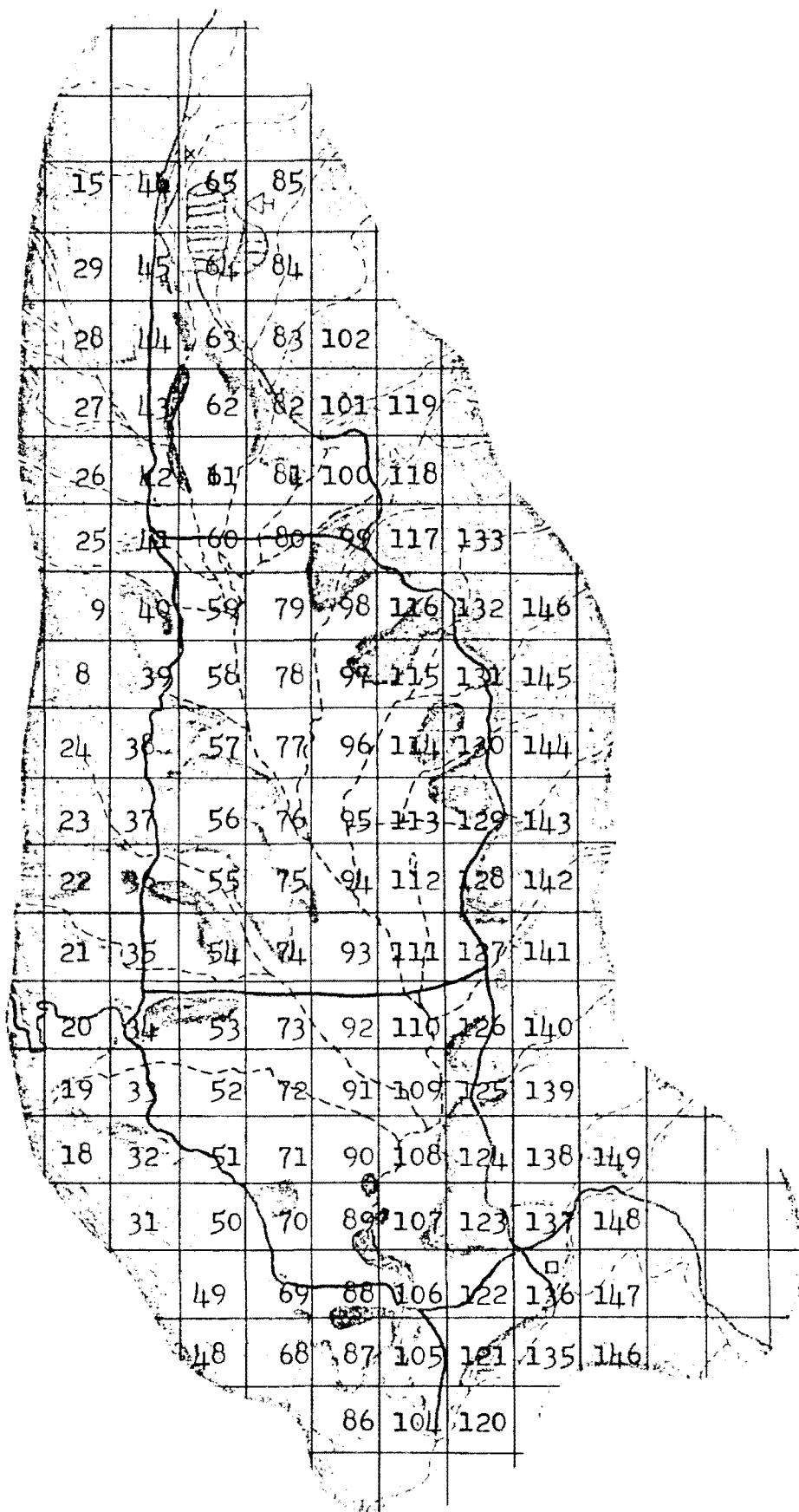


Figure 2. Grid square trapping pattern for raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

the period of 27 January to 4 March.

On 28 March 1973, a new method of trap site selection was initiated. Numbered cards corresponding to the numbered squares on the map were drawn from a container to obtain a random selection of trap sites. Traps were placed within the square according to the following criteria: (1) along a stream if a stream were present, (2) if no stream were present, the trap was placed in a ditch, near a swamp, or along a fallen log in a woods (Stuewer 1943a), (3) if none of the above were present, then the site was an open field and was not used. Twenty sites were selected for each trapping session, which usually lasted for three nights. However, there were occasions when more trap sites were used and the trapping period was extended. Variations were made to continually reevaluate the trapping techniques in order to determine the best method.

### C. TRAPS

The traps used were collapsible welded-wire live-traps, 60.96 cm long, 25.4 cm high, 25.4 cm wide, and weighed 2.5 kg. On several occasions raccoons escaped from traps by forcing apart the rear and side panels. However, it was felt that ease of transportation and storage outweighed this disadvantage of collapsible traps.

#### D. BAIT

Bait was whole kernel yellow corn obtained from a local feed store in 22.7 kg bags. This bait was easy to use, clean, and could be stored for long periods. It proved to be very species-specific when compared to sardines, which were added several times. Numbers of skunk and opossum captured increased when sardines were used. Stuewer (1943a), using smoked herring and an ear of corn, observed that raccoons failed to eat the herring, but always ate the corn. He considered the odor of herring useful in luring raccoons to traps.

#### E. IMMOBILIZATION OF RACCOONS WITH SERNYLAN

Raccoons captured for the first time were immobilized with Sernylan (Phencyclidine Hydrochloride) in order to facilitate handling, and to prevent stress or injury to raccoon or handler (Montgomery 1964, Seal and Erikson 1969, Bailey 1971, Harthoorn 1965, and Dean, et al. 1973).

Preparation for injection and handling followed the same sequence for all raccoons. First the weight of the captured raccoon was estimated by weighing the trap with the raccoon in it and then subtracting the weight of the trap. Occasionally raccoons gathered soil and leaves into the trap: one female raccoon weighing 3.2 kg pulled 5.9 kg of such debris into the trap. The injection was based on a 4.5 kg

weight resulting in an overdose and convulsions. In order to prevent such overdoses it was necessary to remove debris from the trap, although with some more aggressive animals this could not be done.

Sernylan is available in 10 cc vials of 100 mg/cc concentration. For use with raccoons the concentration was diluted to 20 mg/cc with sterile water. The drug was administered with a 1cc tuberculin syringe of the plastic disposable type. Dosages could be accurately measured to .01 cc.

In order to inject the drug it was necessary to restrain the raccoon against the side of the trap. A simple tool, "the plunger," facilitated this restraint. It consisted of a 1.55 m long broom handle attached to the center of a 20.32 cm by 20.32 cm square of 1.27 cm plywood. The trap was stood on end with the door at the top. The raccoon was then distracted to the bottom of the trap, which permitted the door to be opened and the plunger inserted. A rapid firm push on the handle held the raccoon between the plunger and the bottom of the trap. Sernylan was then injected intramuscularly.

#### Immobilization and Recovery Behavior

It was often difficult to determine when a raccoon was sufficiently anesthetized to permit safe handling, because small doses of 1.32 mg/kg did not produce complete paralysis. Raccoons were able to move head and legs but

could not or would not bite. Raccoons that were unable to right themselves when the trap was rolled over were considered safe to handle.

Recovery from Sernylan was quite variable, ranging from 1-1/2 to 8 hours. The ability to walk preceded the ability to recognize or respond to danger. Thus, when raccoons were able to support themselves on their front legs and walk, they were susceptible to human harassment, since they were disoriented, walked in a drunken manner, were unable to defend themselves, and were unable to swim if they fell or were thrown into water. Tranquilized raccoons staggering around in the woods and across roads were not only in danger, but would have caused public relations problems if seen in a busy area of Cades Cove. Safe recovery was best assured by replacing the drugged raccoon in the trap to be released later in the day.

#### Various Dosage Levels

When the study began Sernylan was injected at dosages of 2.2 mg/kg (Montgomery 1964). This dosage later was raised to 3.3 mg/kg and then to 4.4 mg/kg to decrease the immobilization time. However, all three of the above dosages resulted in severe convulsions. Dosages were subsequently reduced in an attempt to find a dosage level sufficient to make raccoons tractable for handling without causing convulsions (Table 1).

Dosages of 1.65 mg/kg and 1.32 mg/kg were used. Although 1.65 mg/kg was quite satisfactory, 1.32 mg/kg

Table 1. Average immobilization times for raccoons injected with Sernylan (Phencyclidine Hydrochloride) in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

| Dosage<br>mg/kg=cc/kg |     | Sample<br>Size | Time<br>Min.* | Range<br>Min. | Std.<br>Dev. | Percentage<br>Convulsions |
|-----------------------|-----|----------------|---------------|---------------|--------------|---------------------------|
| 1.32                  | .07 | 31             | 6.1           | 2-16          | 16.2         | 0                         |
| 1.65                  | .09 | 34             | 5.2           | 3-10          | 9.6          | 0                         |
| 2.20                  | .11 | 10             | 5.5           | 2-12          | 9.6          | 50                        |
| 3.30                  | .18 | 15             | 4.2           | 1-11          | 9.4          | 26.6                      |
| 4.40                  | .22 | 4              | 3.3           | 3-4           | .27          | 50                        |

\*These data are based on a Sernylan concentration of 20 mg/cc for use in a 1 cc tuberculin syringe, which can be read accurately to .01 cc.

permitted a greater margin of error in weight estimation. Thus, errors in weight estimates of 0.454 kg did not result in convulsions (Table 1).

Sernylan was found to be a satisfactory immobilizing agent for raccoons. Dosages of 1.32 mg/kg took effect fairly rapidly with a mean of 6.1 minutes, and with a minimum risk of convulsions. With this small dosage it was not necessary to use other drugs such as Promazine (Seal and Erickson 1969) and Atropine (Dean, et al. 1973) to prevent side effects. The standard deviation of 16.2 minutes for reaction time demonstrated the high variability of the effect of Sernylan on different raccoons.

#### F. AGING TECHNIQUE

Raccoons were aged by the tooth wear method described by Grau, et al. (1970). This involved the placing of raccoons into five age classes based on the amount of wear of the teeth. A photocopy of the above author's diagram was carried in the field kit, and the raccoons' teeth were matched with the drawing--a subjective technique but one which did facilitate the placing of raccoons into general age groups. Grau, et al. (1970) found this technique to be 82.7 percent accurate. In the present study juvenile raccoons captured in the fall could be classified in Class I without doubt, due to the presence of deciduous teeth or very small, sharp, and white permanent teeth.

## G. MEASUREMENTS

Raccoons were weighed on a spring balance and weights were measured to the nearest half pound and later converted to metric equivalents.

Front and hind feet were measured in millimeters. Total length was measured from the tip of the nose along the dorsal side to the last caudal vertebra. Tail length was measured from the sacral vertebrae to the last caudal vertebra.

## H. TAGGING

Raccoons were tagged with numbered red or blue plastic sheep tags distributed by NASCO Company, Fort Atkinson, Wisconsin. A red tag was placed in the right ear of males, and a blue tag placed in the left ear of females. Optimum placement of tags was found to be at the base at the front of the ear, where cartilage was sufficiently thick to prevent the tag from pulling out, and where drainage from the wound was slight. Tags which had been on raccoons for over a year could still be identified as to number and color. These tags were found to be, on the whole, quite satisfactory in ease of application and permanence.

## I. RECAPTURES

Recaptured raccoons were identified and weighed, after which they were released. The capture site was

noted for possible home range determination.

#### J. POPULATION ESTIMATION

Various methods of population estimation were compared in order to determine how they would respond to a massive die-off as occurred in the Cades Cove raccoon population. The following closed population estimators: Schnabel, modified Schnabel, Schumacher-Eschmeyer (Ricker 1955), and Frequency of Capture (Eberhardt 1969, Edwards and Eberhardt 1967), were compared with an open population estimator--Jolly (1965, Krebs 1973).

Closed population estimators assume no mortality or natality and, therefore, were not able to show the population crash which occurred. However, by breaking the study into two separate periods--pre- and post-epizootic--it was possible to use the closed population estimators for populations which were "closed" for the study period.

Data from the entire study period were used in the open population estimator--Jolly, which demonstrated the observed reduction in population.

#### K. HOME RANGE DETERMINATION

An estimation of the home range of those raccoons with sufficient numbers of recaptures was obtained by plotting the points of capture on a map of the study area, and then connecting the outside points of capture to form a

polygon representing the minimum home range. This is one of the methods described by Hayne (1949) who states that lines connecting the "outside points of capture enclose an area within which the animal was known without doubt to have been present."

## CHAPTER III

### RESULTS AND DISCUSSION

#### A. TRAPPING

Traps were set on 114 different nights during the period 27 January 1973 through 16 April 1974, for a total of 2,870 trap nights. The total number of animal captures was 553, of which 217 were raccoon captures. The overall rate of capture success was 1 raccoon per 13.23 trap nights, or 7.56 percent. There were 106 raccoons recaptured. The 111 individual raccoons captured consisted of 48 males and 63 females. Trapping success seemed to reflect seasonal food availability (Figure 3).

There were 60 striped skunks and 2 spotted skunks captured during the study. The sex of 7 skunks was determined to be 3 males and 4 females. A total of 54 opossums were captured; the sex of 28 was determined to be 15 males and 13 females. Other species captured included 11 gray fox, 29 groundhogs, gray and red squirrels, cottontail rabbits, cotton rats (Sigmodon hispidus), crows (Corvus brachyrhynchos), and blue jays (Cyanocitta cristata).

Live trapping began during January, a time of year when food availability was very low. During the fall of 1972 there was a mast failure in The Great Smoky Mountains National Park, which further reduced the winter food supply.

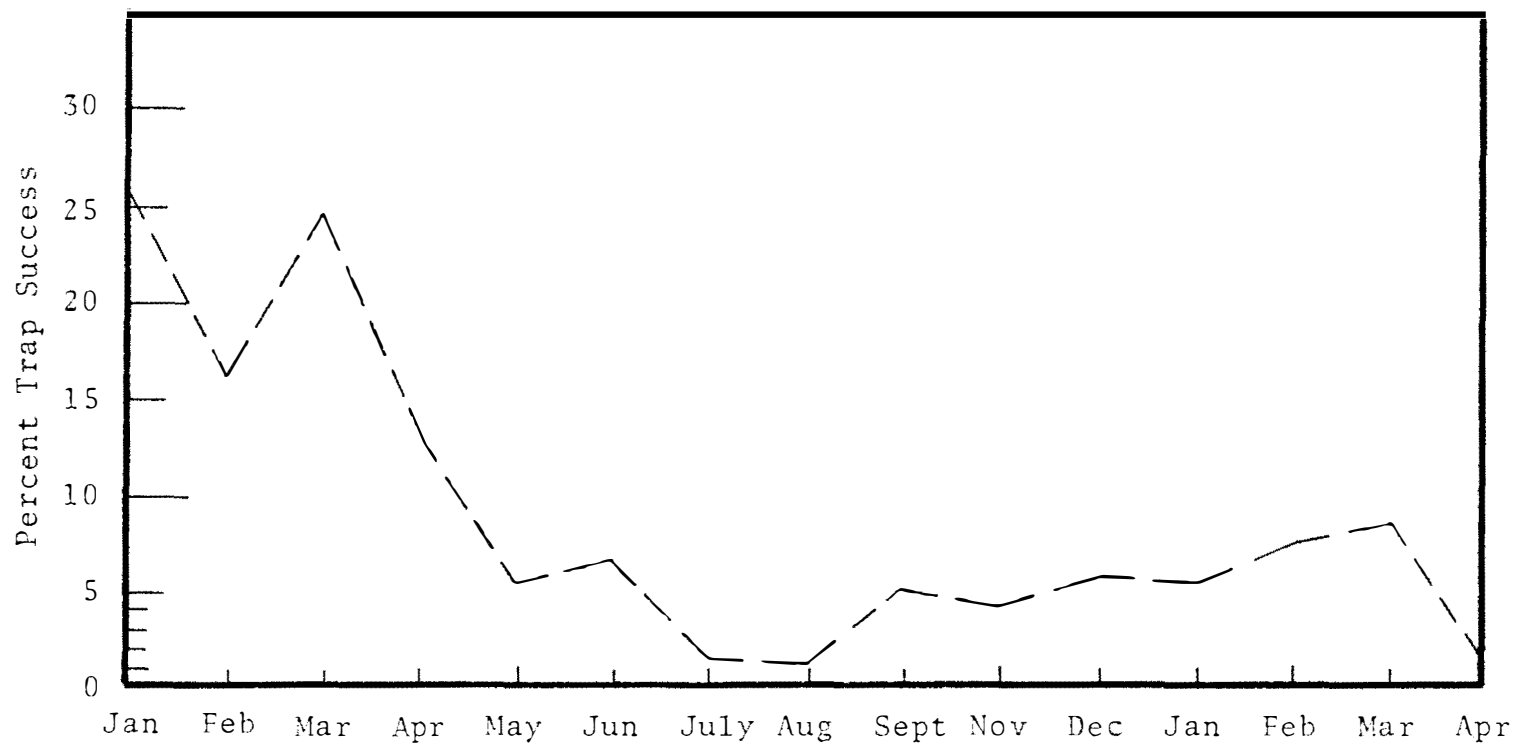


Figure 3. Average monthly percent trap success for raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

Many black bears had been captured that fall (in a separate study) in areas outside the Park where they had apparently moved in search of food.

Perhaps this scarcity of food contributed to the high capture success obtained during the first few months of this study. The percentage of raccoons captured (of the number of traps set) each trapping night went as high as 38 percent in February 1973, and averaged 25 percent for March 1973. Capture success declined drastically during spring and summer 1973; the decline is attributed to the spring distemper epizootic and probably to some extent to the greater availability of natural foods.

Cauley and Schinner (1973) reported a high capture success of 25 percent, which declined to 2 percent due to a distemper epizootic among the raccoon population that they were studying in Cincinnati.

Capture of raccoons increased in the fall of 1973, a time when juvenile raccoons first begin to emigrate from the areas in which they were born (Stuewer 1943a). In the fall raccoons begin to build fat reserves by eating large amounts of food (Stuewer 1943a). This physiological need may have been a cause of the increased capture success for adults as well as juveniles.

#### B. SEX RATIO

The sex ratio for the 111 individual raccoons captured was 48 males to 63 females (0.76 male:1 female).

The number of male and female raccoons captured each month was variable (Figure 4). Prior to the epizootic in April, the number of females captured each month exceeded the number of males captured. However, after the epizootic, beginning in May, the number of males captured each month exceeded the number of females captured.

Although Stuewer (1943a) reported that "raccoon populations are about equally divided as to sex," other studies have reported one-sided sex-ratios but with no consistent pattern. Twichell and Bill (1949), in Missouri, found 67 males:100 females while Wood and Odum (1964), working in South Carolina, reported 170 males:100 females. Johnson (1970) attempted to explain the preponderance of 161 males to 100 females for Alabama raccoons by attributing it in part to the males' movements over larger areas which would make them more subject to capture. However, although males in Cades Cove moved over a larger area, there appeared to be a preponderance of females in the pre-epizootic population.

The data indicate that a change in sex ratio occurred during April 1973, at the time an epizootic of canine distemper occurred in the Cades Cove raccoon population.

A sex ratio of 0.53 males per female was calculated for the pre-epizootic period (27 January 1973 to 31 March 1973), and a sex ratio of 2.03 males per female was calculated for the post-epizootic period (1 May 1973 to 16 April 1974).

Although Gorham (1966) reported that "the sex of the

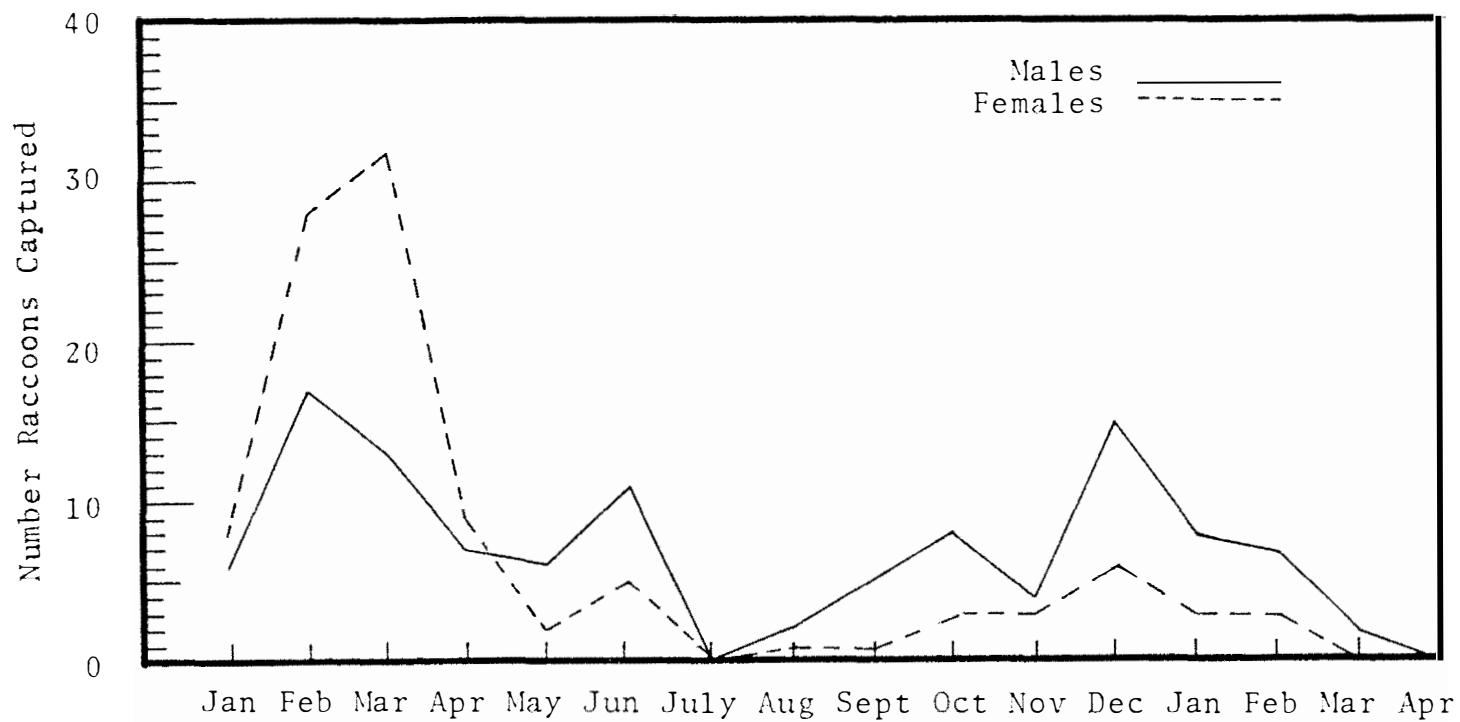


Figure 4. The number of male and female raccoons captured each month in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

host does not seem to have any effect on the prevalence of distemper," data from the present study indicate that the distemper epizootic did alter the sex ratio of the Cades Cove raccoon population, since the post-epizootic sex ratio never approached that of the pre-epizootic period. Further study would be necessary to determine if females in the later stages of gestation are more vulnerable to the disease, or if there are behavioral changes during gestation which bring females into contact with each other, facilitating the transmission of disease.

### C. AGE STRUCTURE

A sex and age pyramid for all raccoons captured during the entire study is shown in Figure 5.

The sex and age pyramid for the Cades Cove raccoon population, shown in Figure 6, for the pre-epizootic period (27 January 1973 to 31 March 1973) appears to represent a population which is declining (Dasmann 1964). Numbers of yearlings present in the population did not approach the number expected from the size of the adult population.

The post-epizootic age structure, shown in Figure 7, had changed from that shown in Figure 6. The greatest change was in class II which dropped from 33.8 percent of the population to 15.4 percent after the epizootic. Age class V remained approximately the same, changing from 14.1 percent to 17.9 percent after the epizootic.

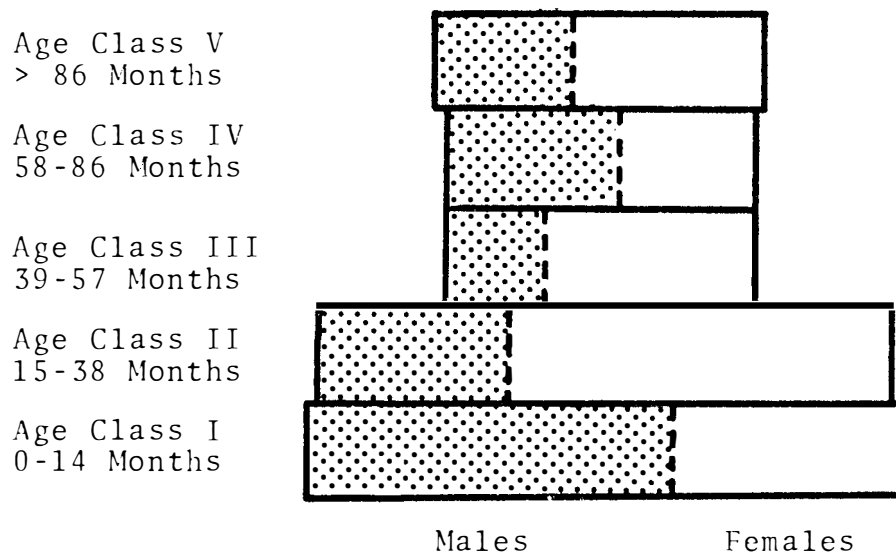


Figure 5. Age structure of the raccoon population in Cades Cove, The Great Smoky Mountains National Park, 27 January 1973 to 16 April 1974.

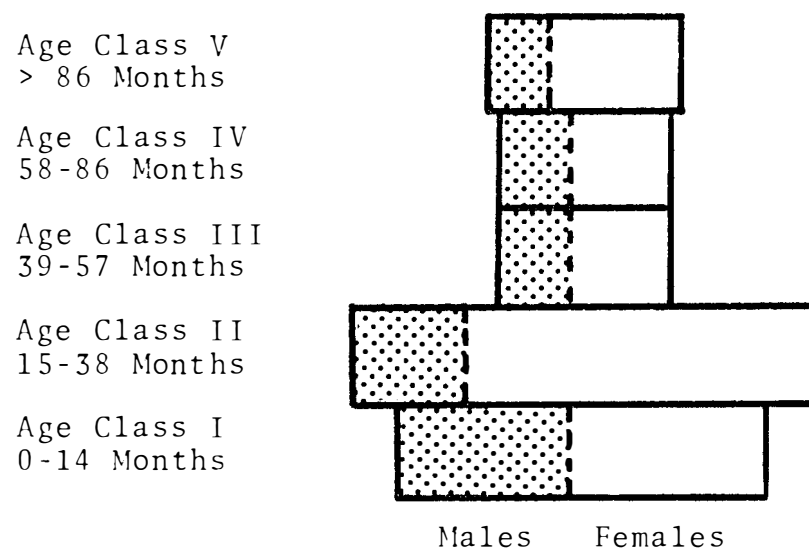


Figure 6. Age structure of the raccoon population in Cades Cove, The Great Smoky Mountains National Park, 27 January 1973 to 31 March 1973.

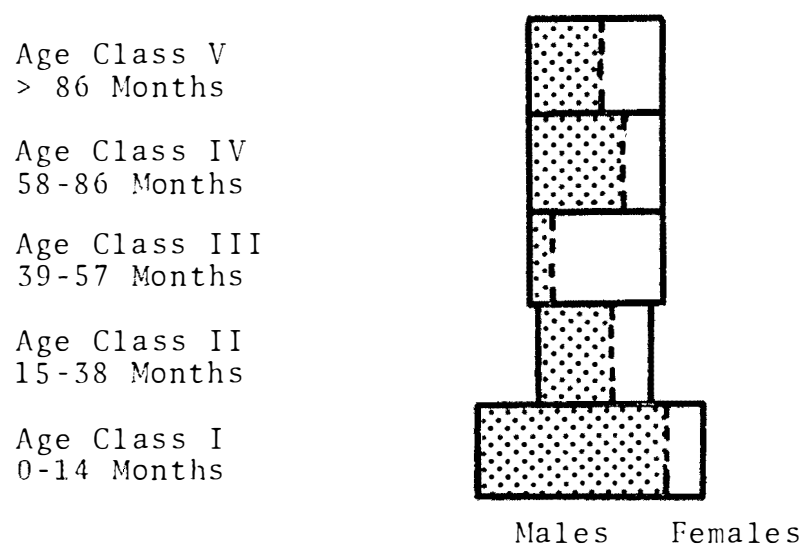


Figure 7. Age structure of the raccoon population in Cades Cove, The Great Smoky Mountains National Park, 8 May 1973 to 16 April 1974.

The small proportion of juveniles present in the Cades Cove raccoon population during the first three months of 1973 may have been due to the mast failures which occurred in the Park in the fall of 1972. According to Stuewer (1943a), "while older raccoons are storing most of the food they take in fall as fat reserve, juveniles are still utilizing much of theirs for growth, and consequently may not be able to acquire as much fat." Without this fat reserve, which sustains the raccoon over the winter, juveniles may be more vulnerable to starvation during periods of lower than normal food supply.

#### D. PHYSICAL PARAMETERS

Raccoons were grouped into three weight classes: adult male, adult female, and juvenile. Average weights for each class were calculated for each month and then plotted on graphs with 95 percent confidence limits (Figures 8, 9, and 10). Data for each class indicated that raccoons gained weight during the fall and lost weight during the winter and spring. Adult male raccoons in Cades Cove weighed more than females throughout the year, while juvenile raccoons weighed noticeably less than adults.

Seasonal weight variations are consistent with those reported by Stuewer (1943a) and by Johnson (1970). Mean fall weights were somewhat greater than those demonstrated by Johnson (1970) in Alabama and were somewhat less than

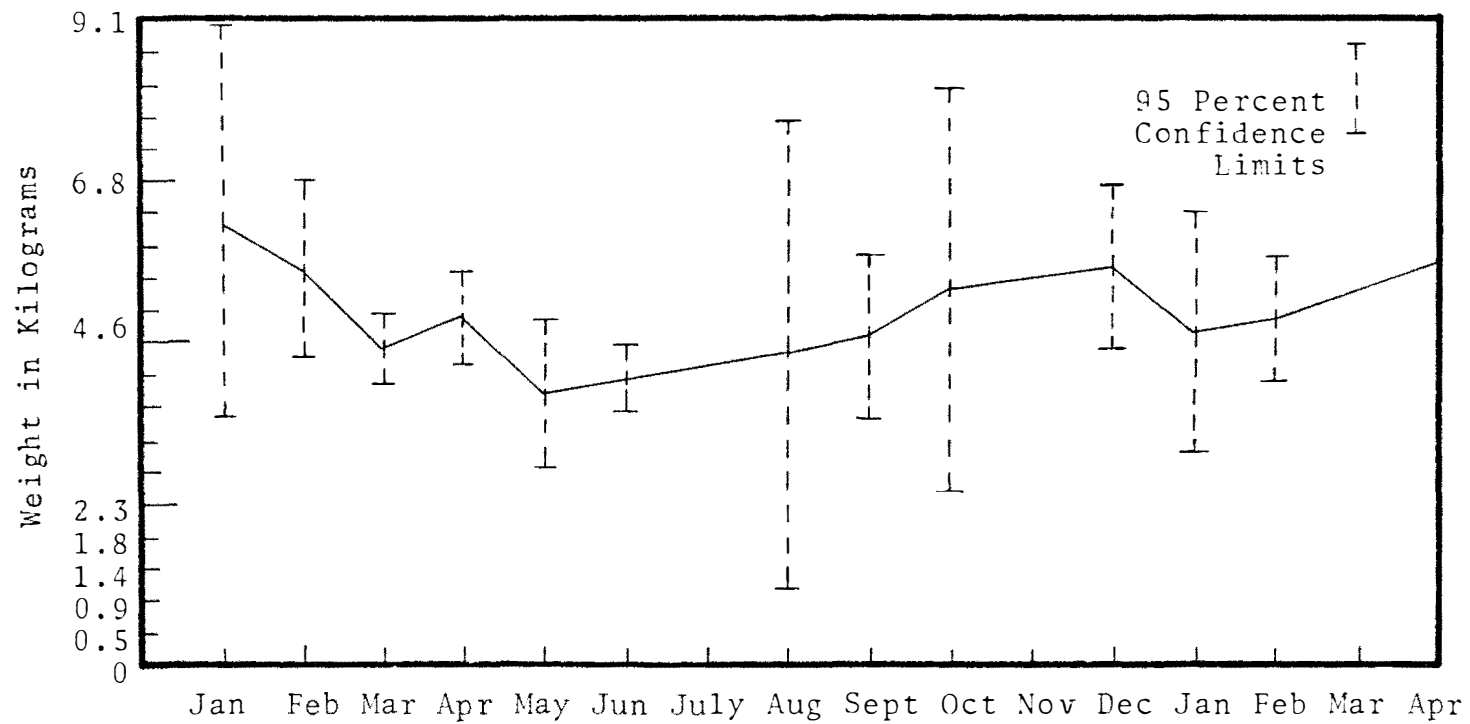


Figure 8. Monthly weight changes of adult male raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

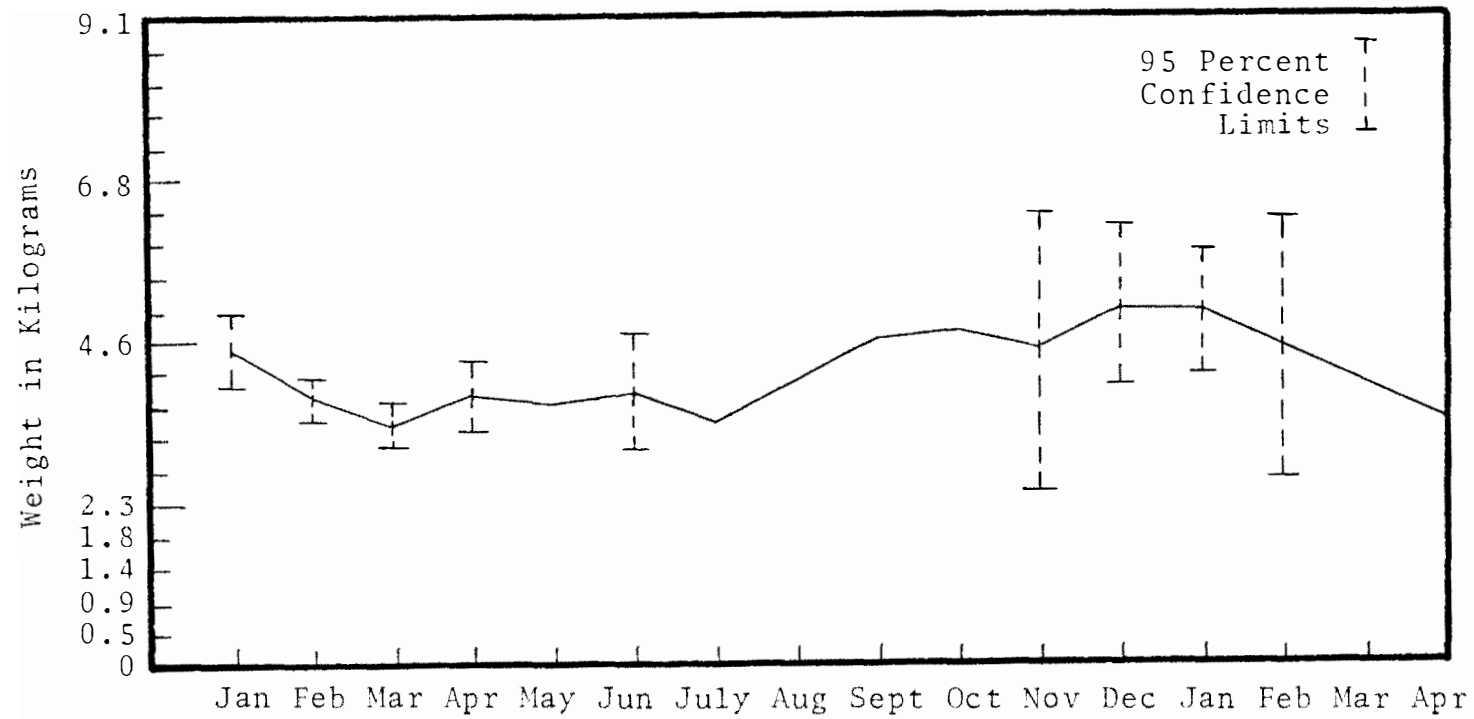


Figure 9. Average monthly weight changes of adult female raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

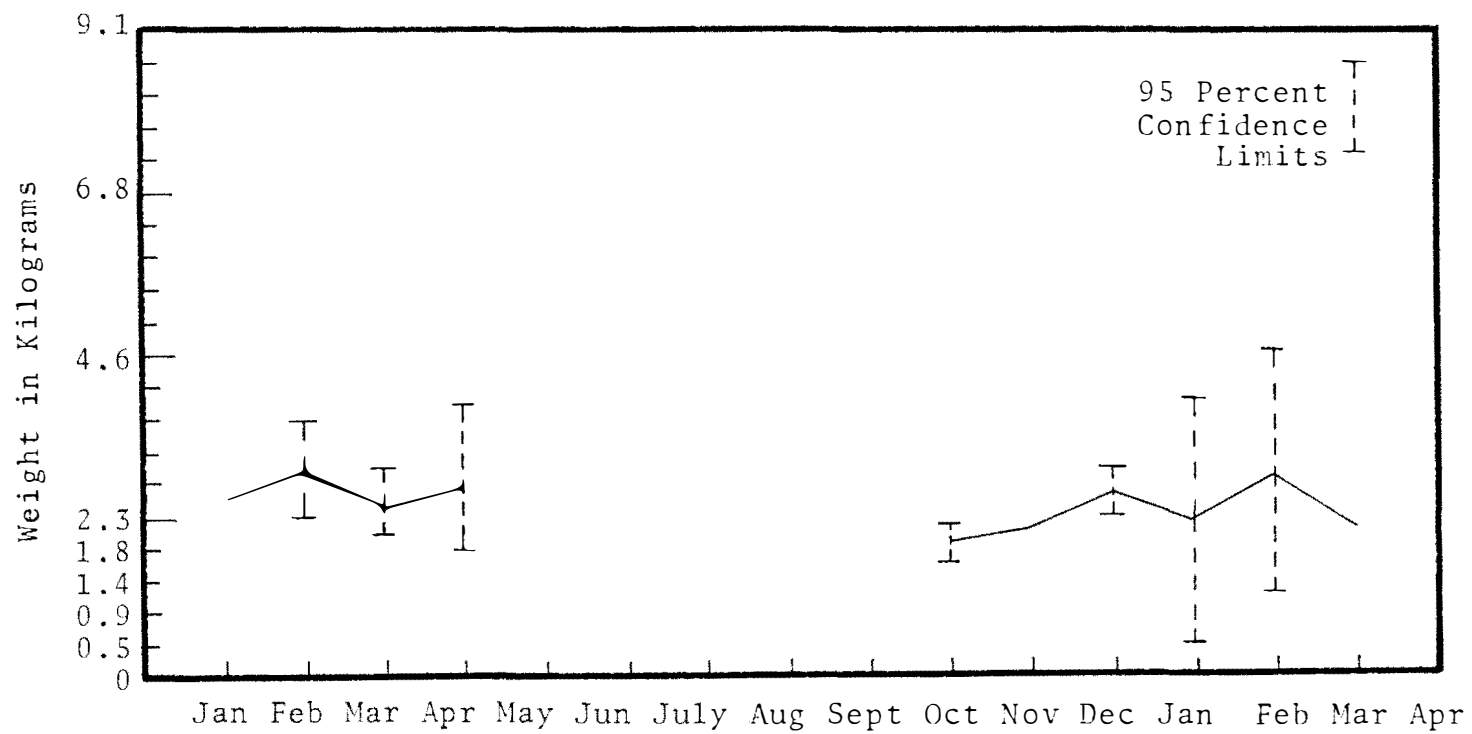


Figure 10. Average monthly weight changes of juvenile raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

those demonstrated by Stuewer (1943a) in Michigan. These results are consistent with Johnson's (1970) statement "that there is a general tendency for average weights of adult raccoons to increase with increasing latitude in the northern hemisphere."

Adult raccoons did not demonstrate significant weight differences in the pre- and post-epizootic periods. Raccoons are very susceptible to distemper (Robinson, et al. 1957, observed that 100 percent of inoculated raccoons developed the disease), and their proximity to the virus--not their physical condition--determines the spread of the disease. Budd (1970) pointed out that although weak and emaciated raccoons have been reported with distemper, "other affected animals appeared to be in good nutritional condition." The present study also found that raccoons which appeared to be in excellent physical condition contracted the disease and died.

Although the mortality rate among those individuals that contracted the disease could not be determined, only one animal survived of those exhibiting distemper symptoms and subsequently captured. This raccoon was given intensive care for over three months before it was able to support itself on its front legs. It, therefore, seems improbable that many raccoons could have survived this epizootic. The distemper epizootic seemed to affect the raccoon population in Cades Cove without regard to weight or condition, and, therefore,

the weight differences in the pre- and post-epizootic periods were probably not related to the epizootic.

Raccoon body measurements are summarized in Table 2. These results indicate a great variation in total length and tail length of individual raccoons. Adult raccoons have a greater tail length, total length, hind foot length, and front foot length than do juveniles, but the differences are too small to be of much value in aging raccoons in the field; however, when there is doubt as to whether or not a raccoon is a juvenile or an adult, body measurements and weight may assist in determining the correct age.

#### E. HOME RANGE

Approximate home ranges for eight raccoons (five male and three female) are depicted in Figures 11 and 12. These figures represent an approximate home range based upon limited numbers of captures. A line was drawn on a map connecting points of capture to represent the perimeter of the animal's range. The estimated areas of these home ranges are the actual areas bounded by the perimeter lines shown in Figures 11 and 12. Home range data are summarized in Table 3.

In Cades Cove the home ranges of male raccoons studied were greater than those of females (Table 3). These results are consistent with those reported by Stuewer (1943a) and by Johnson (1970).

Table 2. Body measurements of raccoons in Cades Cove,  
The Great Smoky Mountains National Park,  
1973-1974.

|                         | Sex-Age<br>Group | Sample<br>Size | Mean<br>Cm. | Std.<br>Dev. | 95% (t Test)<br>Confidence Limits |
|-------------------------|------------------|----------------|-------------|--------------|-----------------------------------|
| Ear<br>Length           | A male           | 29             | 5.5         | .46          | 5.4 to 5.7                        |
|                         | A female         | 49             | 5.4         | .36          | 5.3 to 5.5                        |
|                         | J male           | 18             | 5.2         | .50          | 4.9 to 5.4                        |
|                         | J female         | 13             | 5.3         | .33          | 5.1 to 5.5                        |
| Front<br>Foot<br>Length | A male           | 30             | 6.5         | .59          | 6.3 to 6.7                        |
|                         | A female         | 49             | 6.1         | .68          | 5.9 to 6.3                        |
|                         | J male           | 18             | 6.0         | .44          | 5.8 to 6.2                        |
|                         | J female         | 13             | 6.0         | .61          | 5.6 to 6.4                        |
| Hind<br>Foot<br>Length  | A male           | 30             | 10.1        | .45          | 9.2 to 10.3                       |
|                         | A female         | 50             | 9.7         | .50          | 9.6 to 9.8                        |
|                         | J male           | 18             | 9.5         | .49          | 9.2 to 9.7                        |
|                         | J female         | 14             | 9.0         | .87          | 8.5 to 9.6                        |
| Tail<br>Length          | A male           | 29             | 23.1        | 2.5          | 22.2 to 24.1                      |
|                         | A female         | 50             | 22.8        | 2.5          | 22.1 to 23.5                      |
|                         | J male           | 18             | 20.1        | 3.9          | 18.2 to 22.0                      |
|                         | J female         | 14             | 20.6        | 3.9          | 18.4 to 22.9                      |
| Total<br>Length         | A male           | 30             | 75.5        | 5.0          | 73.6 to 77.3                      |
|                         | A female         | 50             | 72.1        | 3.4          | 71.2 to 73.1                      |
|                         | J male           | 18             | 60.7        | 7.7          | 56.9 to 64.5                      |
|                         | J female         | 14             | 67.2        | 8.7          | 62.2 to 72.2                      |

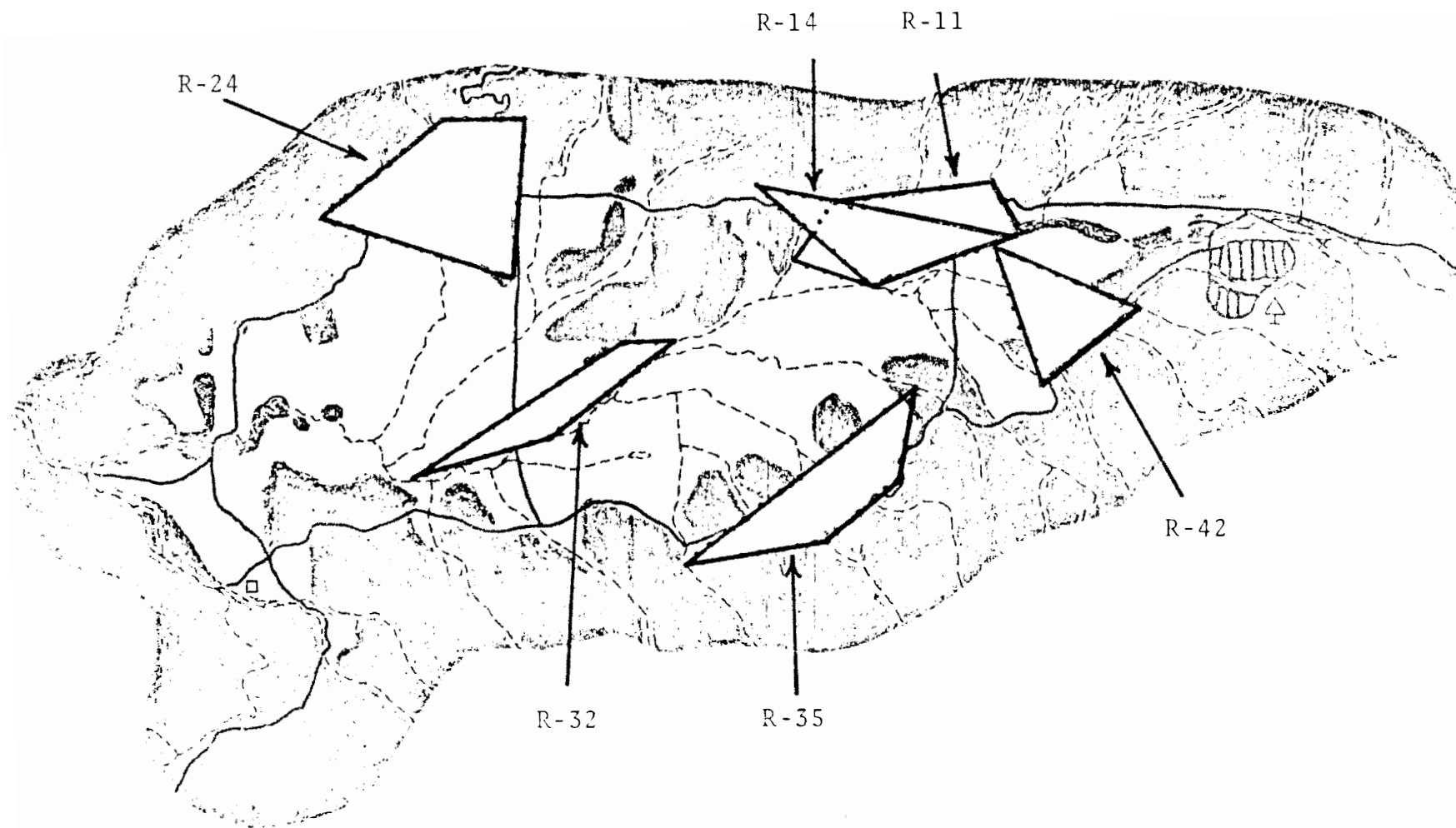


Figure 11. Home ranges of six male raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

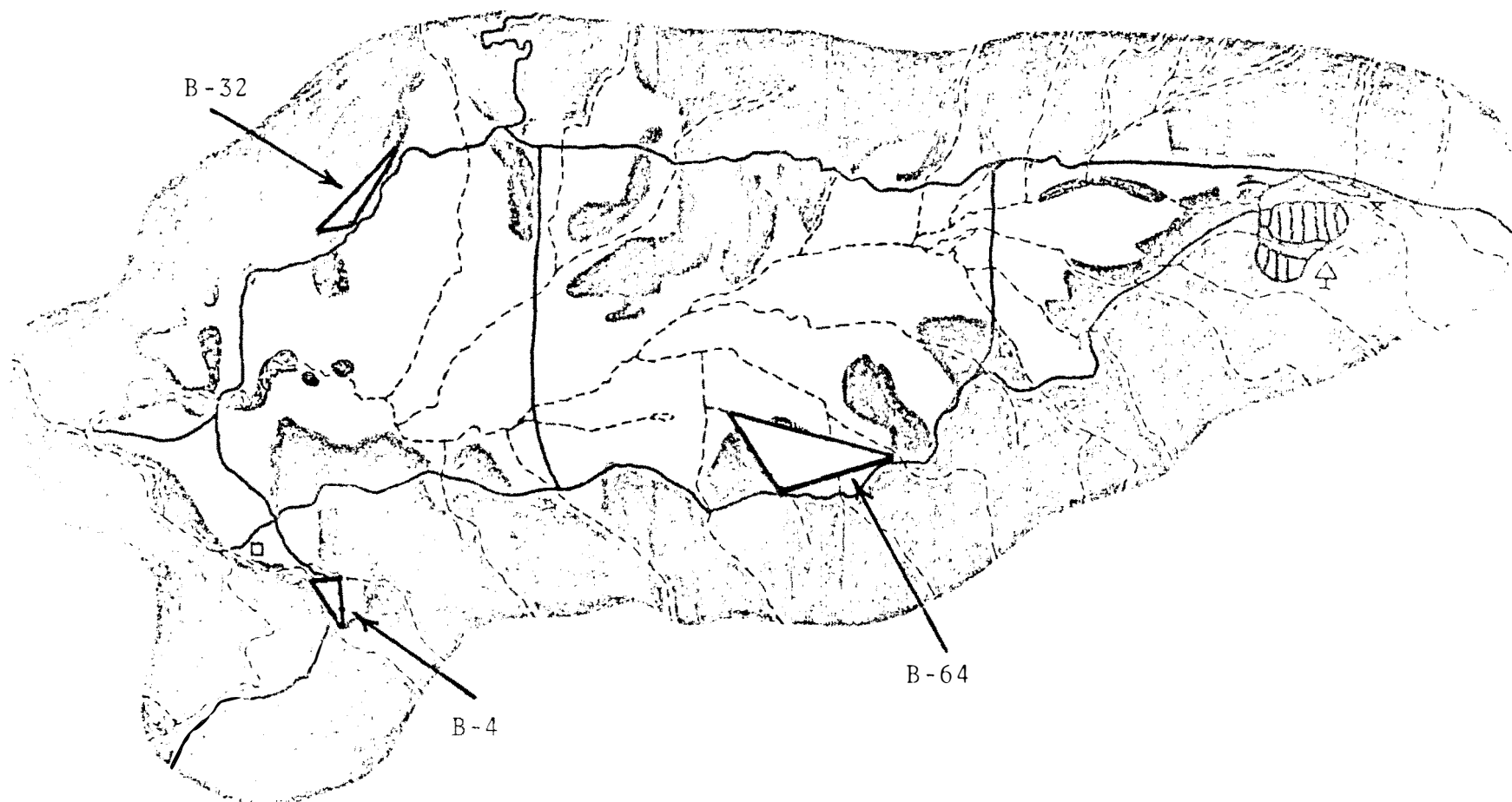


Figure 12. Home ranges of three female raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

Table 3. Home range data for raccoons in Cades Cove,  
The Great Smoky Mountains National Park,  
1973-1974.

| Sex    | Raccoon           | Number of<br>Captures | Estimated<br>Age (Years) | Estimated Home<br>Range Ha* |
|--------|-------------------|-----------------------|--------------------------|-----------------------------|
| Male   | R-35              | 6                     | 7                        | 21.9                        |
|        | R-42              | 7                     | 1                        | 22.8                        |
|        | R-14              | 6                     | 4                        | 22.8                        |
|        | R-24              | 6                     | 4                        | 50.0                        |
|        | R-32              | 4                     | 7                        | 37.5                        |
|        | Average 5 males   | 5.8 captures          | 4.6 years                | 31.0 ha                     |
| Female | B-4               | 6                     | 4                        | 4.0                         |
|        | B-32              | 4                     | 2                        | 7.5                         |
|        | B-64              | 5                     | 3                        | 22.5                        |
|        | Average 3 females | 5 captures            | 3 years                  | 11.3 ha                     |

\*Data represent approximate area within a range whose perimeter is a line connecting outside points of capture.

Stuewer (1943a) calculated home range by assuming the straight line between the two most distant points of capture to be the "range diameter." The area of home range was calculated as a circle. Stuewer reported the average home range area for 46 male raccoons was 155.8 ha and 76.9 ha for 41 female raccoons. Using Stuewer's method of calculating home range, the data for the present study show the average home range of five male raccoons to be 184 ha, and for three females, 41.9 ha.

Johnson (1970) used telemetry to observe raccoon movements. He reported a male raccoon as having a home range of 99 ha and a female as 46.1 ha. In the present study the average home range for males was 31 ha and for females 11.3 ha, which would seem to indicate a smaller home range for raccoons in Cades Cove than for those in Johnson's Alabama study.

Cauley and Schinner (1973) used radio-telemetry to study the raccoon population in Clifton, a suburb of Cincinnati. The average home range for raccoons in that urban area was 8.3 ha which is considerably less than that reported for non-urban areas.

The data reported in the above-mentioned studies indicated that the size of raccoon home ranges depended upon available food supply. As food became scarce, home range increased in size. Variations may also be due to differences in habitat or in methods used to determine home range,

The home range data reported here are conservative estimates, since more captures or observations are needed to describe the actual home range accurately. A radio-telemetry study of the Cades Cove raccoon population should result in a more accurate delineation of home range.

#### F. POPULATION ESTIMATION

Capture-recapture data for the Cades Cove raccoon population were obtained for the period 17 January 1973 to 16 April 1974. An epizootic of canine distemper among the raccoon population occurred in April and May 1973, evidenced by sick or dead raccoons observed in the study area and by disease verification by the Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens. The average rate of capture declined 72.8 percent from the pre-epizootic period to the post-epizootic period. The average monthly percentage capture dropped during the epizootic and never again approached the levels obtained in March 1973 (Figure 3, page 21). Average capture rate for February 1974 was 47.2 percent lower than for February 1973. Juveniles accounted for the slight increase in capture success beginning in September 1973. During the period from September 1973 through March 1974 a total of 66 raccoons were captured, of which 25 (71.3 percent) were juveniles.

Population density estimates for the raccoon population in Cades Cove are summarized in Table 4. Average monthly population estimates, using various population estimation techniques are indicated in Figures 13 and 14.

As is shown in Table 4, data indicated an average density estimate of 1 raccoon per 17.2 ha before the epizootic in 1973, and a density of 1 raccoon per 51.8 ha in 1974. Cauley and Schinner (1973) reported urban population densities of 1 raccoon per 0.89 ha before an epizootic and 1 raccoon per 2.6 ha the following year. Stuewer (1943a) reported densities of 1 raccoon per 20.2 ha at the Swan Creek Wildlife Experiment Station in Michigan. Dorney (1954) reported a density of 1 raccoon per 44.5 ha in a marsh area; he counted active den trees and assumed two raccoons per den. Johnson (1970) reported raccoon densities for two areas in Alabama at 1 raccoon per 8.09 ha and 1 raccoon per 2.02 ha. The latter density was for a 35.6 ha beaver swamp. Twichell and Dill (1949) reported the highest density for a raccoon population--that of 100 raccoons on 102 acres, or 1 raccoon per 0.41 ha in an area of mixed timber along a creek in Missouri. Twichell and Dill attributed this high density to the fact that the area was good raccoon habitat and had been closed to hunting for 10 years.

The distemper epizootic among the Cades Cove raccoon population reduced the population estimate an average of 67.9 percent from March 1973 to March 1974. Cauley and

Table 4. Raccoon population density in Cades Cove,\* The Great Smoky Mountains National Park, during two census periods: February and March, 1973; January, February, and March, 1974.

| Census Period | Estimation Technique | No. Est. | Mean | 95 Percent Confidence Limits | Hectares Per Raccoon |
|---------------|----------------------|----------|------|------------------------------|----------------------|
| 1973          | Schumacher-Eschmeyer | 13       | 121  | --                           | 17.7                 |
|               | Schnabel             | 13       | 127  | 83 to 276                    | 16.8                 |
|               | Modified Schnabel    | 13       | 109  | 75 to 203                    | 19.6                 |
|               | Jolly                | 9        | 130  | --                           | 16.4                 |
|               | Average of Above 4   | 48       | 122  | --                           | 17.5                 |
|               | Frequency of Capture | 12       | 251  | --                           | 8.5                  |
| 1974          | Schumacher-Eschmeyer | 13       | 45   | --                           | 47.5                 |
|               | Schnabel             | 24       | 40   | 31 to 55                     | 53.4                 |
|               | Modified Schnabel    | 24       | 39   | 30 to 53                     | 54.8                 |
|               | Average of Above 3   | 39       | 41.3 | --                           | 51.8                 |
|               | Frequency of Capture | 13       | 82   | --                           | 26.1                 |

\*The study area consisted of 2136.8 ha. Due to a lack of future capture data, Jolly estimates for 1974 were not used.

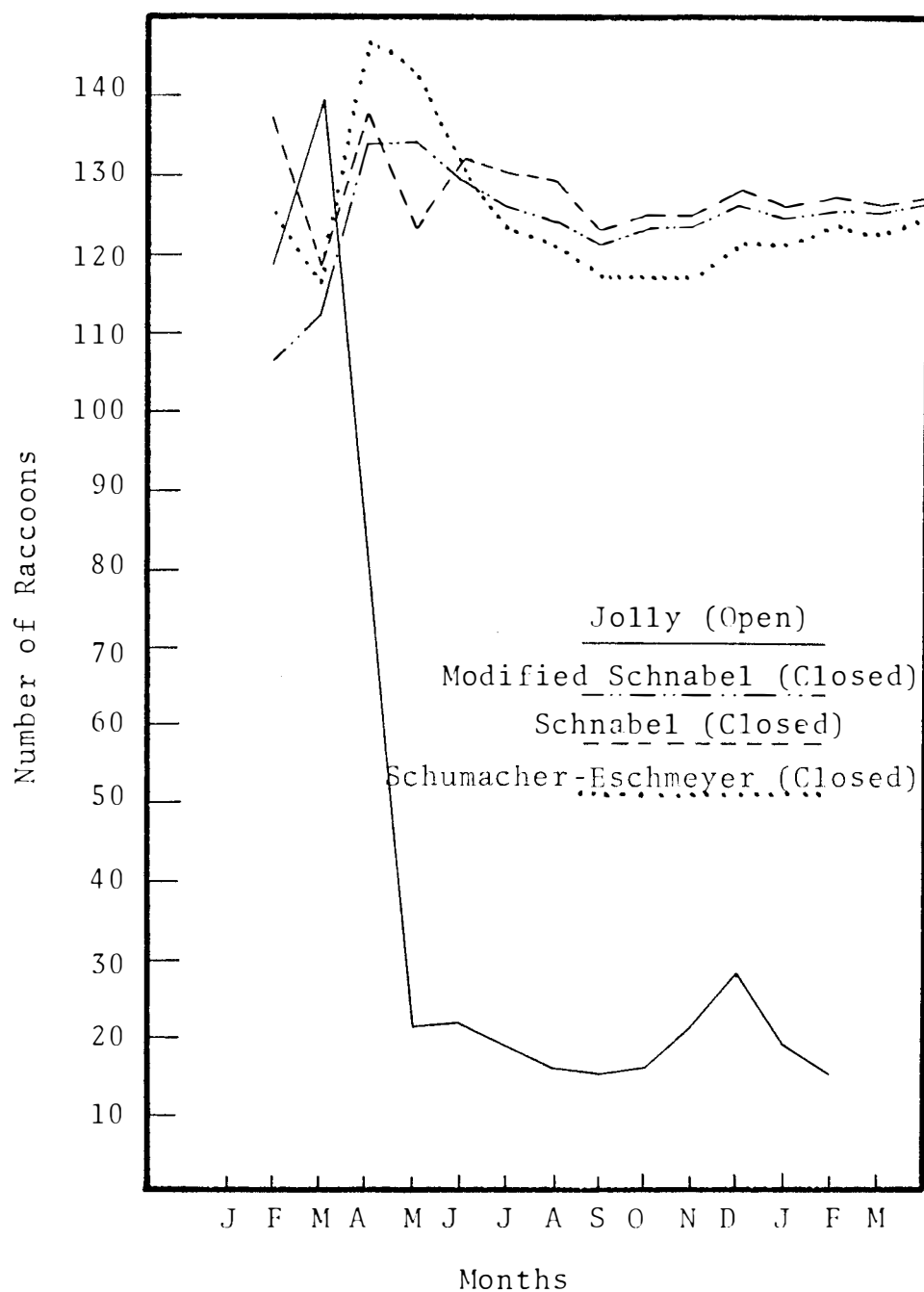


Figure 13. Average monthly population estimates for raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974, using open and closed population estimators, which assume one continuous sample period.

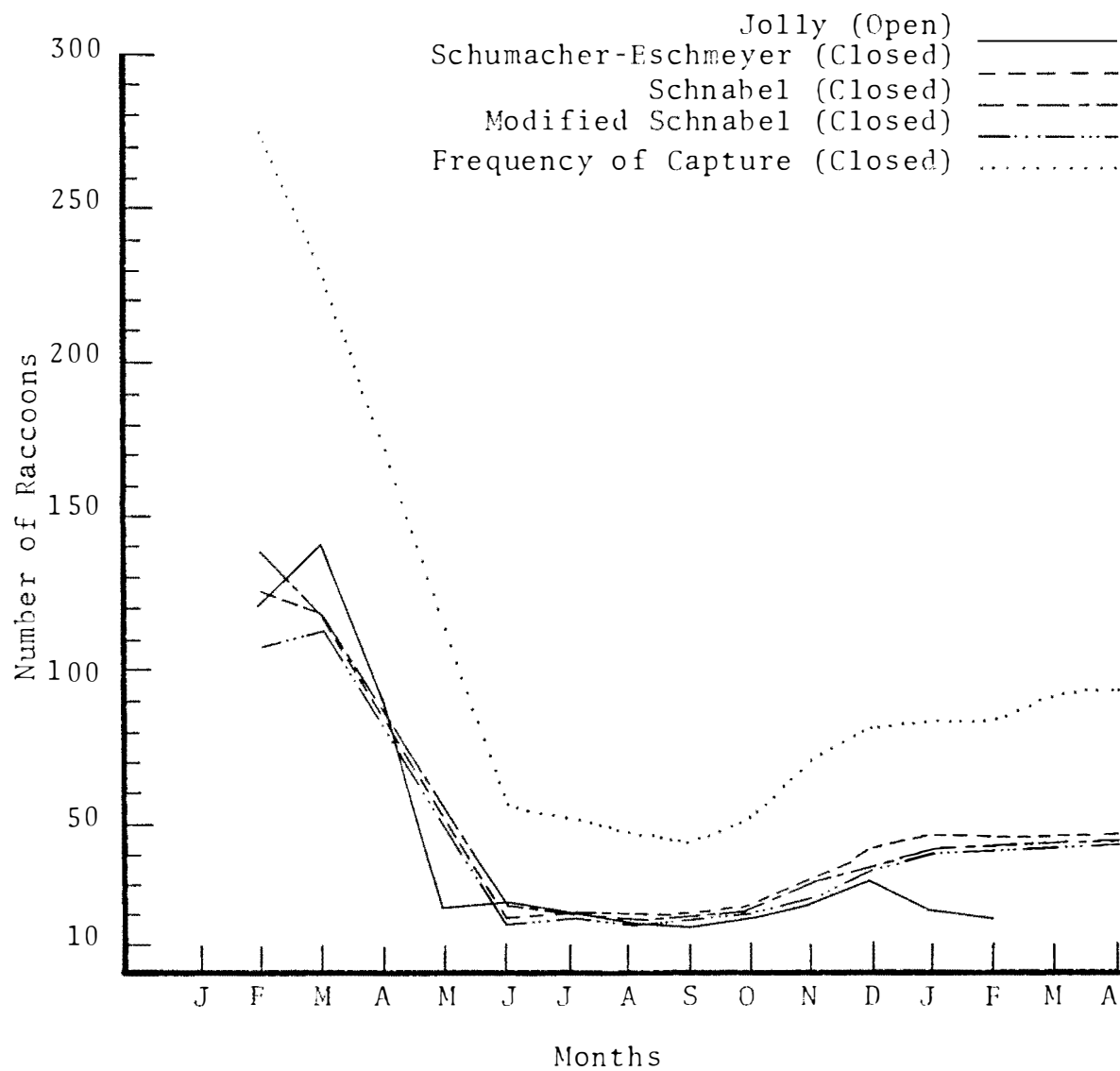


Figure 14. Average monthly population estimates for raccoons in Cades Cove, The Great Smoky Mountains National Park, 1973-1974, using an open population estimator, which assumes one continuous sample period, compared with four closed estimators, which assume two separate sample periods.

Schinner (1973) noted a decline from 145 raccoons in March 1968 to 51 raccoons in March 1969 (64.8 percent) after a distemper outbreak.

The sudden distemper epizootic in Cades Cove offered an excellent opportunity to compare results of various population estimation techniques using data for a population that has experienced a massive loss of marked individuals. Although distemper epizootics had been observed in raccoon populations (Crook and McNutt 1958; Habermann, et al. 1958; Johnson 1970; Menges, Habermann, and Stains 1955; Robinson, et al. 1957), it was not until 1968-1969, when Cauley and Schinner (1973) were studying a Cincinnati raccoon population with radio-telemetry and live-trapping, that the actual impact of an epizootic could be determined. Since live-trapping, capture-recapture data were obtained before, during, and after the Cades Cove epizootic, its impact on the raccoon population there also could be determined.

Closed population estimation techniques--Frequency of Capture, Schnabel, Modified Schnabel, and Schumacher-Eschmeyer--and an open population estimation technique--Jolly--were used to determine the number of raccoons in the population. Only the Jolly method was capable of demonstrating the epizootic which had occurred in the population (Figure 13). The closed population estimators did not have provision for loss of marked individuals from the population and, therefore, their population estimates did not indicate

that an epizootic had occurred. But, by considering capture data during the pre-epizootic period and post-epizootic period as capture data from two separate closed populations, it was possible for the closed population estimators--Schnabel, Schumacher-Eschmeyer, and Frequency of Capture--to demonstrate the drop in numbers of raccoons expected from the epizootic (Figure 14).

The estimates obtained by the Schnabel, Modified Schnabel, Schumacher-Eschmeyer, and Jolly methods were considerably lower than those obtained by the Frequency of Capture method. The average estimate for all five methods for March 1973 was 142.2, and the average for June 1973 was 26.6, a decline of 82.3 percent from the March estimate. The average estimate for all five methods for March 1974 was 47, a drop of 67.9 percent from the March 1973 estimate.

Although there were differences in population estimates among the various methods as shown in Figure 14, the percentage decline in numbers from March 1973 to June 1973 and from March 1973 to March 1974 demonstrated by the various methods was quite close, as is shown in Table 5.

After comparing these five methods of population estimation and observing how they reflect actual changes in a population, it would seem that the Jolly method is the most desirable for showing population trends although its estimates are low. The Frequency of Capture method probably provides the best estimate of the actual numbers in a

Table 5. Percentage decline in numbers of raccoons as demonstrated by five methods of population estimation, in Cades Cove, The Great Smoky Mountains National Park, 1973-1974.

| Estimation<br>Method | Percentage Decline            |                                     |
|----------------------|-------------------------------|-------------------------------------|
|                      | March 1973<br>to<br>June 1972 | March 1973<br>to<br>March 1974      |
| Schnabel             | 81.0                          | 64.7                                |
| Modified Schnabel    | 86.6                          | 64.3                                |
| Schumacher-Eschmeyer | 85.3                          | 61.2                                |
| Jolly                | 83.6                          | 88.6*                               |
| Frequency of Capture | 75.0                          | 60.5                                |
| Average Decline      | 82.3                          | 67.9                                |
| Standard Deviation   | 10.3                          | 26.3<br>or Without<br>Jolly<br>4.27 |

\*Jolly estimates for 1974 were very low due to a lack of future capture data, since study ended in April.

population; however, the population must be assumed closed. If both these methods are used, each may compensate for the shortcomings of the other.

#### G. CANINE DISTEMPER

##### The Cades Cove Epizootic

During the last week of March 1973 a raccoon (R-1) was observed sitting in the yard of the Cades Cove Ranger Station for several hours during the day. This raccoon was judged by the park ranger to be exhibiting abnormal behavior, but the animal disappeared before it could be captured and taken for diagnosis.

On 3 April a vulture was observed feeding on a dead untagged female raccoon. It was not possible to determine cause of death due to destruction by scavengers. The location was in a field 50 m from the loop road in square number 35 (Figure 2, page 10).

On 4 April raccoon number R-18, an adult male, was observed in the Cades Cove Campground having convulsions. Mr. Dwight McCarter, a park employee, described the raccoon's behavior in this manner: "He drew up, stretched his feet out and had spasmodic contractions; he kicked his feet in the air; he stayed contracted for about an hour." This raccoon was easily placed into a trash can; the next day it was transferred to a cage and removed from the Park. At that time the raccoon was observed to bite the air in a

chewing motion. It was taken to Dr. W. H. Montgomery (D.V.M.), Knoxville, Tennessee for diagnosis on 9 April. From a fecal smear it was determined that the raccoon had a high parasite infection. Its behavior was thought to be a result of chronic distemper lesions. The raccoon was kept in a cage for observation. On 15 April it began having a heavy nasal discharge, and by 19 April it could no longer rise from the floor of the cage. The animal died on 20 April.

On 14 April, while night-lighting in Cades Cove, an tagged raccoon was observed and was approached. The animal did not run away or show fear and only slowly moved when nudged with a foot.

On 20 April, at 11:30 A.M., a Park visitor reported having seen a sick raccoon with a blue tag in its ear. For an hour beginning at 12:30 P.M. the area was thoroughly searched, but the sick raccoon was not located. Later in the afternoon the area was searched again. In a barn, about 400 m from the Cades Cove Loop Road, two dead untagged raccoons were found lying about 6 m apart on the ground. The male did not appear to have been dead for long, but the female was infested with fly larvae (Figure 2, page 10, square 81).

On 26 April 1973, a necropsy was performed on the male raccoon by Dr. V. Nettles (D.V.M.) of the Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens, Georgia. The results of the examination are as follows:

The necropsy examination revealed a severe broncho-pneumonia with large areas of the lungs being consolidated. Dissection of the lungs produced few lungworms (approximately six). The liver was swollen and congested. Kidneys and spleen were also mildly congested. Intestinal contents were scarce and consisted of mucus and loose feces in the lower bowel. A few Acanthocephala were seen. Numerous flukes were present in the ducts of the pancreas. The testicles appear smaller than normal.

The histological findings were:

Lungs: large patches of necrosis with a serofibrinous exudate present. Also present are areas of intestinal pneumonia in which there are eosinophilic intranuclear inclusions present in the cells. In one section a lungworm is present. Testicle: complete absence of sperm production. Numerous spermatocytes have eosinophilic intranuclear inclusions. Liver: atrophy of hepatocytes, bile duct epithelium denuded. Brain, stomach, bladder, kidney: no significant lesions seen. Pneumonia and testicular degeneration. Etiologic agent viral. . . .

On 23 April a park ranger captured raccoon R-2, an adult male, who had been seen in the campground having convulsions. R-2 was held for observation. The animal's eyes were full of mucus and its disposition was docile. R-2 was first captured on 27 January 1973. At that time it weighed 9.08 kilograms (the largest raccoon captured during the Cades Cove study). In January this animal had been very aggressive and in excellent condition. When captured on 23 April, it weighed 5.221 kg. This raccoon was necropsied by Dr. V. Nettles on 26 April. The examination results are below:

During examination the raccoon exhibited a nervous twitch of the muscles of the head and neck. An abraded area was seen on the midportion of the tail.

The animal was euthanized with chloroform and a blood sample obtained. In the thoracic cavity the lungs had a few areas of consolidation. Dissection of the lungs revealed approximately 35 lungworms. The kidneys were swollen and one focal area of necrosis was found near the pelvis of the right kidney. A moderate amount of fibrosis was present in the liver along with the presence of two nematodes encysted in the capsule. A full gall bladder was noted. Inside the stomach there was a small amount of mucus and a few stomach worms (Gnathostoma). Intestinal contents were apparently normal. Several Acanthocephala were found in the small intestine. In the pancreatic ducts there were numerous flukes.

Tentative diagnosis: Neurologic disease, possibly due to canine distemper.

On 24 April an untagged female raccoon was observed sitting in the Cades Cove Campground area during the day. The animal was captured without resistance and held for observation. The raccoon was contained in a cage and fed Purina Cat Chow, which contains 30 percent protein, and a mixture of honey and mashed vitamin C (ascorbic acid) tablets. Although it developed severe symptoms of distemper, it survived. It is doubtful that a raccoon in the wild could have lived through the long period of disability brought on by the disease.

This raccoon was kept until August 1974; thus it was possible to observe the long-term effects of distemper on this raccoon. The animal seemed to suffer from chronic distemper lesions in the central nervous system. Its hind legs contracted approximately every two seconds and were observed to do so for over a year. The raccoon was very

docile with no evidence of aggressiveness. It had periodic "epileptic" type fits in which its body became hard as all muscles contracted, and during which it shook, salivated, and urinated. After one of these fits the raccoon appeared to be exhausted and to lack the strength and aggressiveness necessary to survive in the wild; thus it was not released.

On 25 April a sick, blue-tagged (female) raccoon was reported in the Cades Cove Campground. This animal was not located. However, on this date a very sick untagged raccoon was found in a trash can in the area. Its eyes were white with a discharge, and its nose was crusted with dried mucus. This animal disappeared before a cage was obtained in which to contain it.

On 27 April a "tame" raccoon was reported by a park visitor on the main road into Cades Cove at the turn-off to White Oak Sinks (about 6 km from the Cove). This raccoon was reported to have eaten a ham sandwich; it was untagged.

On 28 April a female raccoon, B-56, was found dead near Crooked Arm Branch (Figure 3, page 21, square 28). The body was decomposed and was buried by a park employee.

On 4 May female raccoon B-36 was found having convulsions on the Cades Cove Loop Road. She was killed at that time, and the body was not recovered (Figure 2, page 10, square 34).

On 6 May a sick raccoon B-60 was captured in a cattle permittee's barn at 9:30 A.M. While in captivity the

raccoon aborted young and later was observed eating a fetus. This raccoon was submitted to the Kord Diagnostic Laboratory, Tennessee Department of Public Health, Ellington Agricultural Center, Nashville, Tennessee. No conclusive results were obtained.

On 6 May at 12:00 noon a "tame" untagged raccoon was reported in the Cades Cove Picnic Area. The animal was shot with a syringe gun and captured. It was obviously sick and emaciated; its weight was less than 2.3 kg, and it had a severe tick infestation. This raccoon was also submitted to the Kord Diagnostic Laboratory. The results were inconclusive.

On 11 May female raccoon B-49 was found in the Horse Camp at the end of the Cades Cove Picnic Area. The animal was sick and was killed by park rangers.

On 15 May a dead untagged raccoon was observed near Tater Branch in Cades Cove (Figure 2, page 10, square 33).

Recovery of sick or dead raccoons would indicate the epizootic began the last week of March and ended in the middle of May 1973. A total of 13 sick or abnormal-behaving raccoons and 5 dead raccoons were observed (Figure 15). It was possible to determine the sex of 13 of the 18 raccoons observed--4 were males and 9 were females.

#### Canine Distemper: The Disease

Canine distemper "is a specific, infectious, communicable disease caused by a filterable virus. It is

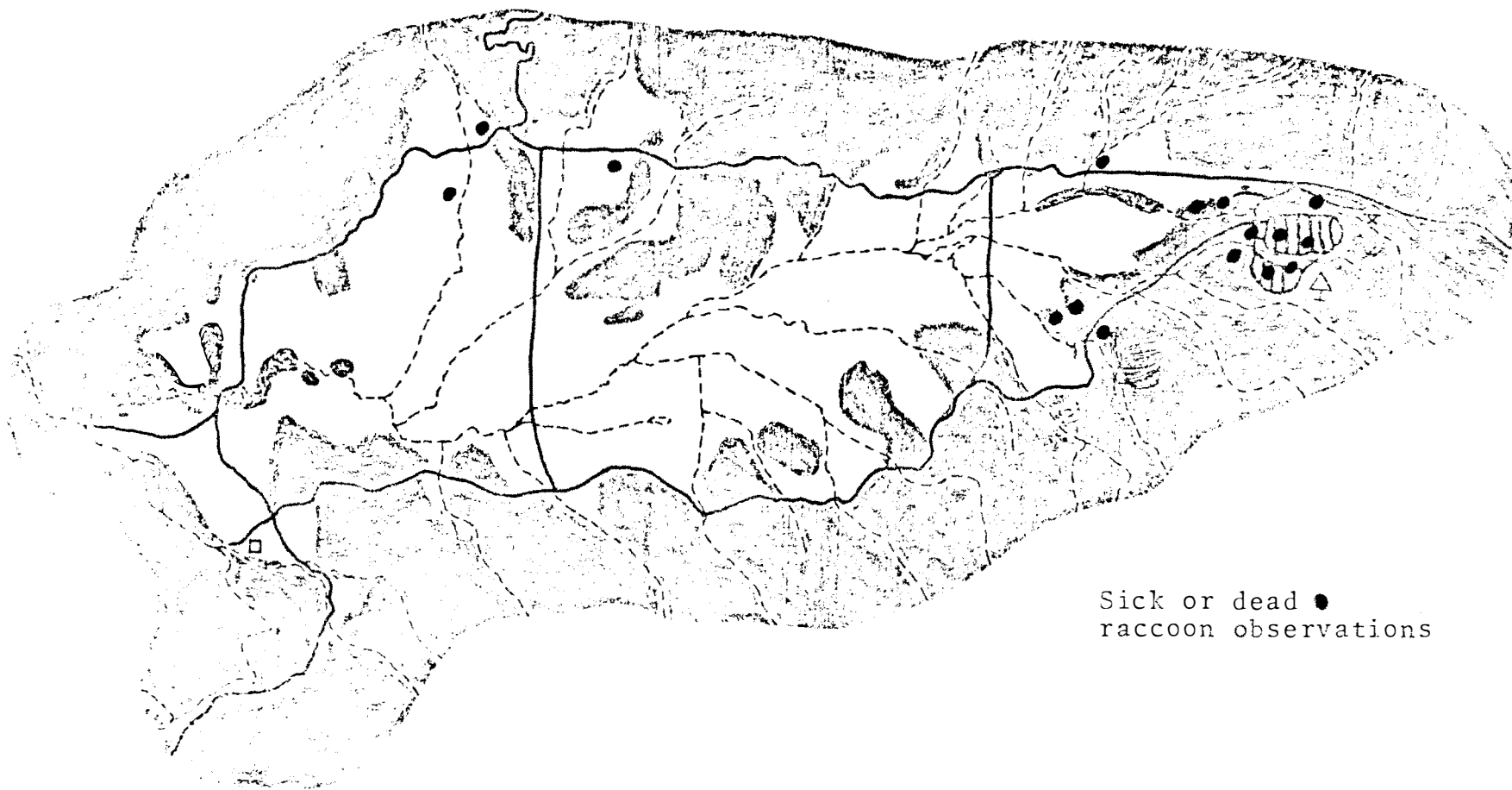


Figure 15. Locations of sick or dead raccoons observed in Cades Cove, The Great Smoky Mountains National Park, during the distemper epizootic in April and May, 1973.

characterized by febrile signs, nasal and conjunctival exudate, and occasionally by signs indicating central nervous system damage" (Menges, et al. 1955). The nasal exudate and saliva of infected animals are highly contagious, resulting in the spread of the virus by direct contact or by air-borne dust particles (Gorham 1966). Budd (1970) reports that "infection of ferrets could be accomplished over a distance of 5 feet."

Symptoms of distemper in raccoons include: "purulent conjunctivitis and nasal discharge; neurological disturbances such as aggressiveness, disorientation, or lack of alertness; chorea; convulsive movements of the head and jaws; and aimless wandering" (Budd 1970).

Budd (1970) lists 36 species of animals which are reported to be susceptible to distemper. The following are species in Tennessee which can serve as hosts for the distemper virus: the dog (Canis domesticus), coyote (Canis latrans), red fox, gray fox, mink (Mustela vison), striped skunk, and raccoon.

The behavioral changes caused by distemper often have been mistaken for symptoms of rabies. Habermann, et al. (1958), working in Maryland, performed necropsies on 21 raccoons and 3 foxes suspected of having rabies. They found that none were rabid and that 14 of the 21 raccoons and 2 of the 3 foxes had distemper. They concluded that "distemper may be a frequent cause of death in raccoons and foxes, in

epizootics which simulate rabies"; and that "distemper in raccoons and foxes has occurred more frequently than suspected or is becoming more prevalent."

#### Distemper Epizootics in Raccoons

Menges, et al. (1955) reported an epizootic among raccoons in Douglas County, Kansas beginning in October 1952. Some of the symptoms reported were emaciation, diarrhea, docile behavior, walking in circles, champing of the jaws, and eye and nasal discharge. Menges, et al. (1955) performed necropsies on five raccoons. They concluded "that the epizootic in Kansas was an outbreak of distemper. The disease was widespread in Kansas, and the history, symptoms and presence of inclusion bodies were consistent with distemper." They made no attempt to determine the effect that this epizootic had upon the Kansas raccoon population.

Robinson, Newberne, and Brooks (1957) reported an epizootic of canine distemper among raccoons in Indiana in 1955. They obtained specimens of sick raccoons from 18 counties. Prior to the epizootic there had been a large population of raccoons in the state, permitting the harvest of 115,000 in 1955. After the epizootic, the raccoon population was reduced. Symptoms exhibited by the 32 raccoons examined were "abnormal social habits, emaciation, ocular and nasal discharge, chorea, blindness, paralysis, and other

nonspecific neurological disturbances." Of the 32 raccoons examined, 24 (75 percent) were diagnosed as having distemper. Although the epizootic was widespread over Indiana, these writers made no attempt to demonstrate the actual impact of the epizootic upon the raccoon population of the state.

Friend (1968) made a general comment concerning raccoons in New York, stating that:

. . . high densities of raccoons have frequently occurred in the state, and just as commonly outbreaks of disease have reduced these populations to lower levels. Diseases such as rabies, leptospirosis, and mange have been involved, but distemper appears to have been the most important disease controlling raccoon density.

Gorham (1966) stated that "when populations of such susceptible species as the raccoon . . . become sufficiently dense to effect ready transmission, distemper appears to be one of the factors regulating the population." According to Budd (1970) "control in free-living distemper-susceptible wild animals is achieved naturally when the opportunity for transmission of the virus is limited. This may occur during an epizootic when the lethal effect of the virus results in a lowered population density."

Cauley and Schinner (1973) demonstrated the impact of canine distemper on a raccoon population. In 1968-1969 they captured 167 different raccoons in a 129.5 ha residential area of Cincinnati, Ohio. Their study involved radio-telemetry to study raccoon movements. They first observed

sick raccoons in October and November, 1968. In a personal letter Cauley described the symptoms as "mucus in the eyes, nasal discharge, twitching and jerking, uncoordinated movement, lack of aggressiveness. . . ."

#### Impact of Distemper on the Cades Cove Raccoon Population

The impact of the canine distemper epizootic in Cades Cove is reflected in the decline in percent capture success from an average of 22.17 for January, February, and March, 1973, to 5.83 for the same period in 1974 (Figure 3, page 21). From March 1973 to March 1974 the population declined 63 percent (Figure 14, page 44).

Canine distemper has been recognized in raccoons for over 20 years. Although it can operate to drastically reduce populations of raccoons, its impact on free-ranging wild populations only recently has begun to be understood. The results obtained by Cauley and Schinner (1973) are similar to those obtained in the Cades Cove study. Further study is necessary to determine the time required for raccoon populations to return to pre-epizootic levels.

## CHAPTER IV

### SUMMARY AND CONCLUSION

A capture-recapture study of the raccoon population in Cades Cove, The Great Smoky Mountains National Park, was conducted during the period 27 January, 1973 through 16 April, 1974. Traps were set a total of 2870 trap nights resulting in 217 raccoon captures, 106 of which were recaptures. The overall trapping success rate was 7.56 percent, although at one time it was as high as 38 percent. A canine distemper epizootic occurred during the spring of 1973 which reduced the population an estimated 82.3 percent.

Newly captured raccoons were anesthetized with Sernylan, ear-tagged, and their body measurements obtained. The overall sex ratio of the population was found to be 0.76 males to 1 female, while data indicated a change in sex ratio from a pre-epizootic value of 0.53 males per 1 female, to a post-epizootic value of 2.03 males per female. Raccoons were divided into age classes based on tooth wear. Results indicated a smaller proportion of juveniles in the population during the winter of 1973 than had been expected. Raccoon weights were observed to change seasonally, and weight alone could not be used to determine age class. Body measurements exhibited much variation among individuals

of each age class. Juvenile measurements were smaller than those of adults, but were not so different as to be used for aging raccoons.

Home ranges were estimated by determining the area enclosed by the outside points of capture. Home ranges for male raccoons were observed to be almost three times as large as home ranges of females.

Five methods of population estimation were compared. The average estimated raccoon population density was 1 raccoon per 17.5 ha before the epizootic in 1973, and 1 raccoon per 51.8 ha in 1974. The average pre-epizootic raccoon population in Cades Cove was 142.2, which declined 82.3 percent after the epizootic. The Frequency of Capture method of population estimation had been shown to most closely approximate populations of known size (Edwards and Eberhardt 1967), and therefore its estimate of 251 was considered the most accurate. However, this method can not show the decline in numbers caused by an epizootic, so it was necessary also to use the Jolly method to demonstrate population trends.

This study demonstrated the impact disease can have on a wildlife population. Although distemper has been observed within raccoon populations, only this study and that of Cauley and Schinner (1973) have measured the actual population change.

Further study of raccoons in Cades Cove is needed to determine the rate of recovery of this population from the epizootic, as well as changes in sex ratio and age structure. Such a study could be combined with a radio telemetry study to provide more information on raccoon home range behavior.

This study has shown that East Tennessee can support sizable raccoon populations. The presence of farms, towns, and rural residents in areas outside the Park is not sufficient to explain the lack of raccoons in these areas, since other studies (Cauley and Schinner 1973) have shown the raccoon to be an opportunist well able to adapt to conditions brought about by man's presence. Why then the "raccoon problem" in East Tennessee, which brings hunter groups to stock raccoons into the area annually? Perhaps excessive hunting is the explanation. Johnson (1970) summarizes the data on detrimental effects of hunting on raccoon populations and points out that "Hunting is obviously a limiting factor on raccoon populations in some areas. In such areas hunters should be encouraged not to kill all raccoons they tree but to allow some to go unharmed after the chase has ended."

Maintenance of family groups into the fall is important for juvenile survival--for this reason Johnson (1970) recommended that the Alabama hunting season not begin until 1 December. A radio-telemetry study might provide valuable information about the behavior of raccoon family groups in East Tennessee.

The management implications of the effects of disease need to be considered as well: control of free ranging dogs which serve as carriers of distemper would seem to be indicated, while distemper-reduced populations may need greater protection from hunter depredation while returning to normal levels.

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## APPENDIX

# APPENDIX

## RACCOON CAPTURE AND RECAPTURE DATA

Table 6. Summary of original male capture data.

| Tag No. | Date Capt. | Trap Site | Age Class | Weight Kgms. | Length Cms. | Front Foot | Rear Foot | Tail Length | Ear Length |
|---------|------------|-----------|-----------|--------------|-------------|------------|-----------|-------------|------------|
| R-1     | 1/27       | 63        | 5         | 3.6          | 73.5        | 7.0        | 10.0      | 23.5        | 6.0        |
| R-2     | 1/27       | 84        | 2         | 9.1          | 76.0        | 6.0        | 10.0      | 25.0        | 5.0        |
| R-3     | 1/27       | 40        | 2         | 8.2          | 82.5        | 6.0        | 10.5      | 20.5        | 5.7        |
| R-4     | 1/27       | 106       | 1         | 3.6          | 55.5        | 6.5        | 9.5       | 7.5         | 4.6        |
| R-5     | 1/28       | 42        | 3         | 5.5          | 78.0        | 6.3        | 10.0      | 23.0        | 6.5        |
| R-6     | 1/28       | 129       | 2         | 4.5          | 77.0        | 6.5        | 10.0      | 25.0        | 5.5        |
| R-7     | 2/2        | 46        | 1         | 3.2          | 59.0        | 5.2        | 9.5       | 16.0        | 5.5        |
| R-8     | 2/2        | 83        | 2         | 3.6          | 75.0        | 5.7        | 10.5      | 25.0        | 5.5        |
| R-48    | 2/2        | 84        | 4         | 5.5          | 79.0        | 6.5        | 10.0      | 20.0        | 5.5        |
| R-10    | 2/2        | 40        | 3         | 7.7          | 73.5        | 5.5        | 10.0      | 22.5        | 5.0        |
| R-11    | 2/2        | 39        | 1         | 2.3          | 63.5        | 5.2        | 9.5       | 20.0        | 5.0        |
| R-12    | 2/2        | 106       | 1         | 3.2          | 45.0        | 6.0        | 9.3       | 20.0        | 5.0        |
| R-13    | 2/2        | 82        | 1         | 3.6          | 66.5        | 6.2        | 10.0      | 22.0        | 4.5        |
| R-14    | 2/3        | 40        | ?         | 8.0          | ?           | ?          | ?         | ?           | ?          |
| R-15    | 2/3        | 130       | 1         | 3.4          | 67.0        | 6.2        | 10.3      | 25.0        | 5.3        |
| R-16    | 2/3        | 99        | 2         | 5.0          | 74.0        | 6.0        | 10.0      | 21.0        | 5.0        |
| R-17    | 2/16       | 51        | 4         | 4.8          | 71.0        | 8.0        | 10.0      | 18.5        | 5.0        |
| R-18    | 2/24       | 63        | 2         | 4.3          | 73.5        | 6.7        | 10.4      | 20.0        | ?          |
| R-20    | 3/2        | 40        | 3         | 4.1          | 76.0        | 7.3        | 10.2      | 23.5        | 5.9        |
| R-22    | 3/2        | 63        | 4         | 4.1          | 77.0        | 6.0        | 9.6       | 24.0        | 6.0        |
| R-23    | 3/4        | 60        | 4         | 5.0          | 79.0        | 6.4        | 10.5      | 24.0        | 6.1        |
| R-24    | 3/4        | 53        | 3         | 4.1          | 68.0        | 6.0        | 9.5       | 21.5        | 5.3        |
| R-25    | 3/4        | 33        | 1         | 2.1          | 67.5        | 6.5        | 9.5       | 21.0        | 5.0        |
| R-26    | 3/4        | 121       | 5         | 5.5          | 78.0        | 6.2        | 10.5      | 24.0        | 5.0        |
| R-27    | 3/28       | 81        | 1         | 2.7          | 69.5        | 6.2        | 9.9       | 23.0        | 6.0        |
| R-28    | 3/29       | 20        | 4         | 5.0          | 75.0        | 6.0        | 11.5      | 23.0        | 6.0        |
| R-29    | 3/30       | 70        | 1         | 2.5          | 61.5        | 5.9        | 9.0       | 19.0        | 5.0        |
| R-30    | 4/18       | 70        | 1         | 3.0          | 69.5        | 6.9        | 9.7       | 21.5        | 5.2        |
| R-31    | 4/5        | 20        | 4         | 5.7          | 80.0        | 7.5        | 10.1      | 25.0        | 6.0        |
| R-32    | 4/20       | 76        | 5         | 5.2          | 76.0        | 6.5        | 9.7       | 24.0        | 6.2        |
| R-33    | 5/8        | 15        | 2         | 3.9          | 76.0        | 6.0        | 10.2      | 26.0        | 6.0        |
| R-34    | 5/25       | 130       | 5         | 3.6          | 60.0        | 7.0        | 9.8       | 3.0         | 5.5        |
| R-35    | 6/14       | 98        | 5         | 3.9          | 75.0        | 6.6        | 9.2       | 22.0        | 5.0        |
| R-36    | 4/5        | 44        | 3         | 4.1          | 68.0        | 7.0        | 9.8       | 20.5        | 5.3        |

Table 6. (continued)

| Tag No. | Date Capt. | Trap Site | Age Class | Weight Kgms. | Length Cms. | Front Foot | Rear Foot | Tail Length | Ear Length |
|---------|------------|-----------|-----------|--------------|-------------|------------|-----------|-------------|------------|
| R-37    | 6/28       | 50        | 2         | 3.6          | 72.5        | 6.1        | 10.2      | 22.5        | 6.0        |
| R-38    | 10/5       | 101       | 1         | 1.8          | 57.5        | 6.0        | 9.5       | 20.0        | 5.4        |
| R-39    | 10/12      | 105       | 1         | 4.1          | 80.0        | 7.0        | 10.0      | 28.0        | 5.8        |
| R-40    | 10/13      | 46        | 5         | 6.4          | 77.0        | 6.7        | 10.3      | 24.0        | 5.6        |
| R-41    | 10/13      | 100       | juv       | 1.8          | 63.0        | 6.0        | 9.0       | 22.5        | 4.8        |
| R-42    | 10/26      | 32        | juv       | 2.2          | 65.0        | 6.0        | 9.5       | 20.0        | 5.8        |
| R-43    | 11/15      | 82        | juv       | 1.1          | 41.5        | 5.4        | 8.5       | 18.0        | 4.5        |
| R-44    | 11/16      | 80        | 1         | 2.5          | 65.5        | 5.8        | 9.6       | 21.0        | 5.3        |
| R-45    | 12/10      | 129       | 2         | 5.0          | 80.0        | 6.0        | 10.5      | 27.0        | 6.0        |
| R-46    | 12/11      | 63        | juv       | 2.5          | 63.0        | 6.3        | 9.6       | 21.5        | 5.7        |
| R-47    | 12/14      | 61        | juv       | 2.3          | 63.0        | 6.0        | 9.5       | 23.5        | 6.0        |
| R-49    | 12/16      | 63        | juv       | 1.8          | 53.0        | 6.0        | 8.6       | 18.0        | 4.4        |
| R-50    | 1/21       | 60        | juv       | 3.2          | 64.0        | 6.6        | 10.3      | 23.5        | 5.5        |
| R-51    | 4/6        | 64        | 4         | 5.7          | 85.0        | 7.5        | 10.8      | 27.5        | 5.3        |

Table 7. Summary of original female capture data.

| Tag No. | Date Capt. | Trap Site | Age Class | Weight Kgms. | Length Cms. | Front Foot | Rear Foot | Tail Length | Ear Length |
|---------|------------|-----------|-----------|--------------|-------------|------------|-----------|-------------|------------|
| B-49    | 1/27       | 46        | 2         | 4.5          | 71.0        | 6.3        | 10.0      | 22.0        | 5.0        |
| B-2     | 1/27       | 60        | ?         | 4.1          | 72.0        | 5.0        | 9.2       | 22.0        | 5.3        |
| B-3     | 1/27       | 121       | 2         | 4.5          | 85.0        | ?          | 9.5       | 28.0        | 5.5        |
| B-4     | 1/27       | 148       | 3         | 4.1          | 72.5        | 7.0        | 9.5       | 21.5        | ?          |
| B-9     | 1/28       | 84        | 2         | 4.5          | 70.5        | 5.3        | 9.0       | 19.0        | 5.2        |
| B-6     | 1/28       | 38        | 3         | 5.5          | 71.5        | 6.0        | 9.5       | 21.5        | 5.3        |
| B-18    | 1/28       | 106       | 5         | 3.6          | 73.0        | 6.0        | 9.0       | 22.0        | 5.7        |
| B-8     | 1/28       | 123       | 1         | 2.7          | 65.0        | 5.3        | 9.0       | 23.0        | 5.0        |
| B-10    | 2/2        | 38        | 2         | 4.1          | 73.5        | 5.2        | 9.0       | 20.0        | 5.0        |
| B-11    | 2/2        | 106       | 4         | 3.6          | 73.0        | 5.0        | 8.0       | 23.0        | 4.5        |
| B-12    | 2/2        | 106       | 2         | 4.1          | 74.0        | 5.8        | 9.2       | 25.0        | 5.0        |
| B-13    | 2/2        | 121       | 2         | 6.8          | 74.0        | 6.0        | 9.8       | 23.0        | 5.2        |
| B-14    | 2/2        | 123       | 4         | 4.5          | 69.5        | 6.0        | 10.0      | 22.0        | 5.0        |
| B-15    | 2/2        | 110       | 2         | 4.5          | 74.0        | 6.0        | 9.5       | 23.0        | 5.5        |
| B-16    | 2/3        | 46        | 1         | 3.2          | 55.0        | 5.5        | 9.0       | 17.0        | 9.0        |
| B-17    | 2/3        | 38        | 1         | 4.1          | 69.0        | ?          | 9.0       | 9.2         | 5.5        |
| B-19    | 2/3        | 121       | 4         | 4.5          | 77.5        | 7.5        | 10.5      | 25.5        | 5.2        |
| B-20    | 2/3        | 137       | 1         | 2.3          | 61.0        | 7.5        | 9.7       | 20.0        | ?          |
| B-21    | 2/3        | 124       | 2         | 3.2          | 70.0        | 6.0        | 9.5       | 25.0        | 5.2        |
| B-22    | 2/3        | 123       | 1         | 2.7          | 61.0        | 6.5        | 9.0       | 21.0        | 5.2        |
| B-23    | 2/3        | 124       | 2         | 4.5          | 71.0        | 6.5        | 10.3      | 24.5        | 6.0        |
| B-24    | 2/4        | 123       | 4         | 3.6          | 71.0        | 5.7        | 10.0      | 26.5        | 5.4        |
| B-25    | 2/24       | 37        | 2         | 2.7          | 70.0        | 5.5        | 9.5       | 23.5        | 5.7        |
| B-26    | 2/24       | 33        | 2         | 3.2          | 69.0        | 5.5        | 10.3      | 22.0        | 6.0        |
| B-28    | 2/24       | 82        | 3         | 4.5          | 72.5        | 6.7        | 10.2      | 16.0        | 5.5        |
| B-30    | 2/24       | 118       | 3         | 4.3          | 67.0        | 6.5        | 9.1       | 25.0        | 5.9        |
| B-37    | 2/25       | 53        | 5         | 3.0          | 69.0        | 5.8        | 9.5       | 21.0        | 5.6        |
| B-32    | 2/25       | 51        | 2         | 3.2          | 73.0        | 5.4        | 10.3      | 22.0        | 5.5        |
| B-33    | 2/25       | 101       | 2         | 3.2          | 71.0        | 5.5        | 10.2      | 24.5        | 5.8        |
| B-34    | 3/2        | 44        | 5         | 4.3          | 66.0        | 6.5        | 9.9       | 19.0        | 5.4        |
| B-36    | 3/2        | 37        | 1         | 3.0          | 89.0        | 5.1        | 9.8       | 25.0        | 5.9        |
| B-39    | 3/2        | 106       | 2         | 3.4          | 69.0        | 6.0        | 10.2      | 23.0        | 5.7        |
| B-40    | 3/2        | 132       | 3         | 4.5          | 73.5        | 5.4        | 10.1      | 26.5        | 5.5        |
| B-41    | 3/2        | 43        | 5         | 4.3          | 70.0        | 5.7        | 9.5       | 20.0        | 5.7        |
| B-43    | 3/3        | 84        | 2         | 4.1          | 72.0        | 9.0        | 9.6       | 24.0        | 5.0        |
| B-45    | 3/3        | 40        | 1         | 3.2          | 71.0        | 6.0        | 9.5       | 23.2        | 5.5        |
| B-46    | 3/3        | 56        | 3         | 3.0          | 73.0        | 5.5        | 9.6       | 23.5        | 5.5        |
| B-47    | 3/3        | 106       | 2         | 3.4          | 71.0        | 5.6        | 9.7       | 25.0        | 5.1        |
| B-48    | 3/3        | 132       | 5         | 5.5          | 81.0        | 7.1        | 10.5      | 26.0        | 5.0        |
| B-50    | 3/4        | 39        | 2         | 3.0          | 71.0        | 6.0        | 9.2       | 19.5        | 5.5        |
| B-51    | 3/4        | 38        | 5         | 3.2          | 71.0        | 6.5        | 10.0      | 22.0        | 5.0        |
| B-52    | 3/4        | 101       | 5         | 3.2          | 75.0        | 6.5        | 9.5       | 22.0        | 5.5        |

Table 7. (continued)

| Tag No. | Date Capt. | Trap Site | Age Class | Weight Kgms. | Length Cms. | Front Foot | Rear Foot | Tail Length | Ear Length |
|---------|------------|-----------|-----------|--------------|-------------|------------|-----------|-------------|------------|
| B-53    | 3/28       | 20        | 4         | 3.6          | 73.0        | 6.1        | 8.5       | 23.0        | 5.8        |
| B-54    | 3/29       | 57        | 1         | 1.9          | 66.0        | 5.9        | 9.1       | 20.5        | 5.5        |
| B-55    | 3/30       | 45        | 2         | 3.2          | 69.5        | 5.4        | 9.6       | 24.0        | 4.5        |
| B-56    | 3/30       | 27        | 1         | 2.7          | 66.0        | 5.8        | 9.0       | 21.5        | 5.1        |
| B-57    | 4/4        | 33        | 5         | 3.2          | 69.0        | 6.5        | 9.7       | 22.5        | 5.2        |
| B-58    | 4/4        | 130       | 4         | 3.6          | 68.0        | 6.0        | 9.5       | 26.0        | 6.0        |
| B-59    | 4/5        | 58        | 1         | 2.7          | 65.0        | 5.8        | 6.2       | 20.0        | 5.8        |
| B-60    | 4/6        | 45        | ?         | 3.6          | 71.0        | 6.1        | 9.6       | 20.0        | 5.1        |
| B-61    | 4/6        | 58        | 3         | 4.3          | 79.0        | 6.2        | 10.1      | 25.0        | 5.7        |
| B-62    | 4/6        | 20        | 4         | 4.5          | 75.0        | 6.5        | 10.7      | 25.0        | 5.7        |
| B-63    | 4/6        | 70        | 3         | 4.1          | 71.0        | 6.0        | 10.0      | 19.0        | 5.3        |
| B-64    | 6/22       | 115       | 3         | 3.2          | 68.0        | 6.5        | 9.7       | 24.0        | 5.8        |
| B-65    | 7/18       | 31        | 4         | 3.4          | 70.0        | 6.5        | 10.0      | 21.5        | 5.0        |
| B-66    | 10/20      | 83        | juv       | 1.8          | 60.0        | 6.0        | 9.1       | 21.0        | 5.0        |
| B-67    | 11/17      | 82        | 5         | 4.3          | 71.5        | 6.0        | 9.7       | 17.0        | 5.0        |
| B-68    | 12/9       | 137       | juv       | 2.7          | 68.0        | 6.6        | 9.5       | 22.5        | 5.5        |
| B-70    | 12/14      | 137       | 3         | 5.0          | 73.0        | 6.5        | 10.0      | 24.0        | 5.7        |
| B-71    | 1/28       | 104       | 3         | 4.5          | 74.0        | 6.5        | 9.7       | 25.0        | 5.0        |
| B-72    | 2/16       | 123       | 3         | 4.1          | 72.0        | 5.6        | 9.8       | 23.0        | 5.0        |
| B-73    | 2/17       | 130       | 3         | 5.2          | 70.5        | 6.1        | 10.0      | 23.0        | 4.9        |
| B-74    | 2/17       | 63        | 5         | 3.9          | 73.0        | 6.5        | 10.0      | 20.0        | 5.2        |

Table 8. Male raccoon recapture record.

| Tag No. | Capture No. | Date     | Trap Site  | Weight (Kgm) |
|---------|-------------|----------|------------|--------------|
| R-1     | original    | 1/27/73  | 63         | 3.6          |
|         | recapture 1 | 2/3/73   | 63         | 4.8          |
| R-2     | original    | 1/27/73  | 84         | 9.1          |
|         | recapture 1 | 2/3/73   | 84         | 9.1          |
|         | 2           | 2/24/73  | 101        | 6.6          |
|         | 3           | 4/23/73  | campground | 5.2 sick     |
| R-4     | original    | 1/27/73  | 106        | 3.6          |
|         | recapture 1 | 2/4/73   | 106        | 2.5          |
| R-7     | original    | 2/2/73   | 46         | 3.2          |
|         | recapture 1 | 4/19/73  | 65         | 2.3          |
| R-9     | original    | 2/2/73   | 84         | 5.5          |
|         | recapture 1 | 12/16/73 | 83         | 7.5          |
| R-11    | original    | 2/2/73   | 39         | 2.3          |
|         | recapture 1 | 3/30/73  | 59         | 2.5          |
|         | 2           | 4/4/73   | 58         | 3.0          |
|         | 3           | 5/9/73   | 60         | 3.2          |
|         | 4           | 6/14/73  | 42         | 3.2          |
|         | 5           | 6/20/73  | 61         | 5.2          |
| R-14    | 6           | 11/9/73  | 42         | 8.0          |
|         | original    | 2/3/73   | 40         | 8.0          |
|         | recapture 1 | 2/25/73  | 60         | 5.0          |
|         | 2           | 4/20/73  | 59         | 4.3          |
|         | 3           | 5/25/73  | 61         | 5.0          |
|         | 4           | 8/17/73  | 38         | 5.9          |
| R-16    | 5           | 9/19/73  | 39         | 6.1          |
|         | original    | 2/3/73   | 99         | 5.0          |
| R-17    | recapture 1 | 3/4/73   | 99         | 4.1          |
|         | original    | 2/16/73  | 51         | 4.8          |
| R-18    | recapture 1 | 12/15/73 | 50         | 5.7          |
|         | 2           | 2/18/74  | 32         | 4.1          |
| R-22    | original    | 2/24/73  | 63         | 4.3          |
|         | recapture 1 | 3/4/73   | 63         | 4.8          |
|         | 2           | 4/4/73   | campground | sick         |
| R-24    | original    | 3/2/73   | 63         | 4.1          |
|         | recapture 1 | 9/14/73  | 43         | 4.1          |
|         | 2           | 9/19/73  | 61         | 4.3          |
| R-24    | original    | 3/4/73   | 53         | 4.1          |
|         | recapture 1 | 3/30/73  | 20         | 3.4          |
|         | 2           | 6/27/73  | 31         | 4.1          |
|         | 3           | 8/2/73   | 31         | 3.6          |
|         | 4           | 1/26/73  | 20         | 5.0          |
|         | 5           | 2/17/74  | 19         | 5.2          |

Table 8. (continued)

| Tag No. | Capture No. | Date     | Trap Site | Weight (Kgm) |
|---------|-------------|----------|-----------|--------------|
| R-28    | original    | 3/29/73  | 20        | 5.0          |
|         | recapture 1 | 6/29/73  | 31        | 4.5          |
|         | 2           | 9/13/73  | 54        | 4.8          |
| R-29    | original    | 3/30/73  | 70        | 2.5          |
|         | recapture 1 | 5/23/73  | 68        | 2.3          |
| R-32    | original    | 4/20/73  | 76        | 5.6          |
|         | recapture 1 | 5/8/73   | 75        | 5.0          |
|         | 2           | 6/7/73   | 109       | 4.5          |
|         | 3           | 6/21/73  | 111       | 4.8          |
| R-33    | original    | 5/8/73   | 15        | 3.9          |
|         | recapture 1 | 1/28/74  | 101       | 5.5          |
| R-34    | original    | 5/25/73  | 130       | 3.6          |
|         | recapture 1 | 6/15/73  | 131       | 3.6          |
|         | 2           | 9/19/73  | 131       | 3.9          |
| R-35    | original    | 6/14/73  | 98        | 3.9          |
|         | recapture 1 | 6/21/73  | 38        | 3.9          |
|         | 2           | 6/28/73  | 98        | 3.4          |
|         | 3           | 10/26/73 | 116       | 5.5          |
|         | 4           | 11/10/73 | 131       | 5.5          |
|         | 5           | 2/16/74  | 129       | 5.2          |
| R-37    | original    | 6/28/73  | 50        | 3.6          |
|         | recapture 1 | 2/17/74  | 32        | 5.0          |
| R-38    | original    | 10/5/73  | 101       | 1.8          |
|         | recapture 1 | 10/27/73 | 32        | 1.8          |
| R-39    | original    | 10/12/73 | 105       | 4.1          |
|         | recapture 1 | 12/11/73 | 105       | 4.5          |
|         | 2           | 1/26/74  | 104       | 4.8          |
| R-40    | original    | 10/13/73 | 46        | 6.4          |
|         | recapture 1 | 12/13/73 | 83        | 7.3          |
|         | 2           | 1/19/74  | 118       | 5.7          |
| R-41    | original    | 10/13/73 | 100       | 1.8          |
|         | recapture 1 | 10/19/73 | 33        | 1.8          |
| R-42    | original    | 10/26/73 | 32        | 2.2          |
|         | recapture 1 | 12/10/73 | 61        | 2.3          |
|         | 2           | 12/12/73 | 100       | 2.5          |
|         | 3           | 12/15/73 | 61        | 2.3          |
|         | 4           | 12/17/73 | 100       | 2.5          |
|         | 5           | 1/20/73  | 83        | 2.3          |
|         | 6           | 1/21/74  | 82        | 2.7          |
| R-43    | original    | 11/15/73 | 82        | 1.1          |
|         | recapture 1 | 1/28/74  | 63        | 1.4          |

Table 8. (continued)

| Tag No. | Capture No. | Date     | Trap Site | Weight (Kgm) |
|---------|-------------|----------|-----------|--------------|
| R-45    | original    | 12/10/73 | 129       | 5.0          |
|         | recapture 1 | 12/13/73 | 130       | ?            |
|         | 2           | 12/14/73 | 129       | 4.5          |
| R-46    | original    | 12/11/73 | 63        | 2.5          |
|         | recapture 1 | 2/17/74  | 59        | 3.0          |
|         | 2           | 2/18/74  | 42        | 3.2          |
| R-49    | original    | 12/16/73 | 63        | 1.8          |
|         | recapture 1 | 2/18/73  | 63        | 2.3          |
|         | 2           | 3/3/74   | 64        | 2.1          |

Table 9. Female raccoon recapture record.

| Tag No. | Capture No. | Date    | Trap Site        | Weight (Kgm) |
|---------|-------------|---------|------------------|--------------|
| B-49    | original    | 1/27/73 | 46               | 4.5          |
|         | recapture 1 | 3/4/73  | 46               | 3.4          |
|         | 2           | 5/11/73 | horse concession | sick         |
| B-2     | original    | 1/27/73 | 60               | 4.1          |
|         | recapture 1 | 2/25/73 | 43               | 2.7          |
| B-4     | original    | 1/27/73 | 148              | 4.1          |
|         | recapture 1 | 2/3/73  | 137              | 2.7          |
|         | 2           | 3/2/73  | 148              | 2.3          |
|         | 3           | 3/3/73  | 148              | 2.3          |
|         | 4           | 3/4/73  | 148              | 2.3          |
|         | 5           | 5/9/73  | 137              | drowned      |
| B-5     | original    | 1/28/73 | 84               | 4.5          |
|         | recapture 1 | 2/2/73  | 47               | 3.6          |
| B-7     | original    | 1/28/73 | 106              | 3.6          |
|         | recapture 1 | 2/3/73  | 106              | 4.1          |
| B-12    | original    | 2/2/73  | 106              | 4.1          |
|         | recapture 1 | 2/25/73 | 106              | 3.6          |
|         | 2           | 3/2/73  | 106              | 3.6          |
| B-13    | original    | 2/2/73  | 121              | 6.8          |
|         | recapture 1 | 3/2/73  | 121              | 3.0          |
|         | 2           | 4/5/73  | 121              | 3.0          |
| B-14    | original    | 2/2/73  | 123              | 4.5          |
|         | recapture 1 | 2/25/73 | 123              | 3.9          |
| B-17    | original    | 2/3/73  | 38               | 4.1          |
|         | recapture 1 | 3/2/73  | 38               | 2.7          |
| B-22    | original    | 2/3/73  | 123              | 2.7          |
|         | recapture 1 | 2/24/73 | 123              | 2.1          |
|         | 2           | 3/4/73  | 123              | 2.1          |
| B-23    | original    | 2/3/73  | 124              | 4.5          |
|         | recapture 1 | 9/19/73 | 149              | 4.5          |
| B-24    | original    | 2/4/73  | 123              | 3.6          |
|         | recapture 1 | 3/2/73  | 123              | 3.9          |
| B-25    | original    | 2/24/73 | 37               | 2.7          |
|         | recapture 1 | 3/4/73  | 37               | 2.7          |
| B-26    | original    | 2/24/73 | 33               | 3.2          |
|         | recapture 1 | 3/2/73  | 33               | 3.2          |
| B-28    | original    | 2/24/73 | 82               | 4.5          |
|         | recapture 1 | 3/4/73  | 82               | ?            |
| B-37    | original    | 2/25/73 | 53               | 3.0          |
|         | recapture 1 | 2/2/73  | 53               | 2.7          |

Table 9. (continued)

| Tag No. | Capture No. | Date     | Trap Site  | Weight (Kgm) |
|---------|-------------|----------|------------|--------------|
| B-32    | original    | 2/25/73  | 118        | 4.3          |
|         | recapture 1 | 11/8/73  | 32         | 5.2          |
|         | 2           | 12/13/73 | 50         | 5.5          |
|         | 3           | 12/15/73 | 32         | 5.0          |
| B-36    | original    | 2/2/73   | 37         | 3.0          |
|         | recapture 1 | 5/4/73   | 34         | sick-killed  |
| B-40    | original    | 3/2/73   | 132        | 4.5          |
|         | recapture 1 | 3/30/73  | 145        | 4.3          |
| B-45    | original    | 3/3/73   | 40         | 3.2          |
|         | recapture 1 | 3/4/73   | 40         | 3.2          |
| B-52    | original    | 3/4/73   | 101        | 3.2          |
|         | recapture 1 | 10/26/73 | 62         | 4.3          |
|         | 2           | 11/10/73 | 100        | 3.6          |
| B-56    | original    | 3/30/73  | 27         | 2.7          |
|         | recapture 1 | 4/28/73  | 43         | dead         |
| B-58    | original    | 4/4/73   | 130        | 3.6          |
|         | recapture 1 | 4/20/73  | 144        | 3.4          |
| B-60    | original    | 4/6/73   | 45         | ?            |
|         | recapture 1 | 5/4/73   | found sick | -            |
| B-61    | original    | 4/6/73   | 58         | 4.3          |
|         | recapture 1 | 6/13/73  | 37         | 3.6          |
|         | 2           | 6/21/73  | 58         | 4.1          |
|         | 3           | 6/22/73  | 58         | 4.3          |
| B-62    | original    | 4/6/73   | 33         | 3.6          |
|         | recapture 1 | 5/24/73  | 33         | 3.6          |
|         | 2           | 1/28/74  | 115        | 3.2          |
| B-64    | original    | 6/22/73  | 115        | 3.2          |
|         | recapture 1 | 6/28/73  | 116        | ?            |
|         | 2           | 8/17/73  | 116        | 3.6          |
|         | 3           | 10/26/73 | 113        | 5.0          |
|         | 4           | 1/20/74  | 130        | 5.0          |
| B-65    | original    | 7/18/73  | 31         | 3.4          |
|         | recapture 1 | 12/16/73 | 50         | 3.4          |
| B-67    | original    | 11/17/73 | 82         | 4.3          |
|         | recapture 1 | 4/15/73  | 63         | 3.4          |
| B-68    | original    | 12/9/73  | 137        | 2.7          |
|         | recapture 1 | 12/13/73 | 137        | 2.7          |

## VITA

William Eugene Keeler was born in Canonsburg, Pennsylvania in 1946. He attended elementary and junior high school in St. Petersburg, Florida, and graduated from Chartiers-Houston High School, Houston, Pennsylvania in 1964. In 1968 he received the B.A. degree in History from Maryville College, Maryville, Tennessee. From November 1968 until September 1971 he served as a cartographer in the U. S. Army, stationed in Hawaii. He attended The University of Tennessee, Department of Forestry, Wildlife and Fisheries, from September 1971 through September 1974 and received the degree of Master of Science in Wildlife and Fisheries Science in March 1978. Mr. Keeler married Margaret A. Haggart in 1967. They live in Lake City, Florida, where he is employed as an Environmental Specialist with the Florida Department of Transportation.