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Movement ecology of resident raccoons in East Tennessee

Gregory Hamilton Hardy

To the Graduate Council:

I am submitting herewith a thesis written by Gregory Hamilton Hardy entitled "Movement ecology of resident raccoons in East Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Ralph W. Dimmick, Boyd L. Dearden

Accepted for the Council:
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(Original signatures are on file with official student records.)

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Boyd S. Dearden

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MOVEMENT ECOLOGY OF RESIDENT RACCOONS IN EAST TENNESSEE

A Thesis
Presented for the
Master of Science
Degree
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Gregory H. Hardy

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ABSTRACT

A study of the movement patterns of resident raccoons (Procyon lotor) in East Tennessee was conducted during 1976 and 1977. Sufficient data were obtained from 9 raccoons to estimate home range size. Average home range size was 157 ha and ranged from 49 ha to 264 ha. Food availability and other habitat differences were thought to have the greatest influence on home range size. Larger home range sizes in the Ridge and Valley Province of the study area were probably the result of the continual shifting of foraging and denning activities between the cornfields and wooded knobs.

The sex of the raccoon was also thought to influence home range size. The average home range size of male raccoons was 232 ha and was significantly larger ($P < 0.025$) than the average home range size of the female ($\bar{x}$ = 134 ha). Reduction in home range size was observed in 1 female raccoon after parturition. Harassment by dogs was also suggested as a factor influencing movement patterns and home range size.

No indication of territories was observed. The area of home range overlap varied from 36.4 ha to 70.1 ha. Habitat utilization and movement patterns were similar in areas of overlap.

Diel activity was recorded; the greatest period of activity was between 2000 and 2400 hours. Activity was

noted during all periods of the day.

Tree species with highest denning utilization were white oak (Q. alba) and northern red oak (Q. rubra). Average tree den height was 14.7 m and ranged from 7 m to 26 m. Average den tree dbh was 54 cm and ranged from 28 cm to 117 cm. Den cavity measurements that were reported included: height from ground, exposure, external dimensions, internal dimensions, and depth of cavity.

Den site parameters for 30 trees were recorded. The average distance from tree den to water was 138 m. The average distance from tree den to nearest agricultural land was 237 m. The average distance from tree den to human inhabitance was 1,039 m.

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CHAPTER I

INTRODUCTION

The raccoon is an adaptable species and is found throughout continental United States (Goldman 1950). The raccoon usually inhabits rural areas along streams or lakes but high densities have been noted in some large metropolitan areas (Schinner 1969, Cauley 1970). In the South, raccoon hunting and trapping are an important source of recreation and profit. However, due to a decrease in habitat and increasing exploitation by man, some state agencies are faced with an extreme raccoon supply and demand problem.

Throughout the South, raccoon hunting is an established tradition dating back to the pioneers (Redford 1965). Raccoon hunting, without the crutch of modern gadgetry, has retained the "split rail flavor" which Aldo Leopold (1943) described as essential for quality hunting.

In addition to being considered a quality sport, raccoon hunting is also economically important. The raccoon harvest in the United States during the 1975-76 season was 3,232,159 pelts with the total value ($61,411,021) exceeding all other furbearers (Deems and Pursley 1978). In Tennessee some 17,170 hunters harvested an estimated 81,442 raccoons during 1961 while spending over $65,000 on

food and transportation (Legler n.d.). In a more recent study, southwest Virginia hunters individually spent approximately $400 annually on raccoon hunting (Clements 1972).

The price of raccoon pelts has fluctuated greatly. During the 1920's when raccoon coats were stylish, pelts brought high prices (Johnson 1970). For the next 40 years, the price of pelts decreased drastically. During the 1970's a renewed interest in long-haired fur has increased the value of the raccoon with the average pelt selling for $19.00 during the 1975-76 season (Deems and Pursley 1978). These high prices have increased the attractiveness of the raccoon with the annual harvest steadily increasing from 1,089,803 during the 1970-71 season to 3,232,159 during 1975-76.

In East Tennessee the number of raccoon hunters has more than tripled from 1951 to 1969 (Whitehead 1975). The average number of hunting trips has increased from 2.2 trips per season in 1951 to 17.6 trips per season in 1969. Hunter success, during this period, has varied greatly. In East Tennessee hunter success ranged from 13.3% to 76.6% while the combined hunting success for the rest of the state ranged from 51.6% to 74.7%. More recent data from bag checks indicate a further decline in hunter success of raccoons in East Tennessee (0.16 raccoons/hour in 1969 to 0.08 raccoons/hour in 1974) (Whitehead 1975).

The declining success rates and increased interest in raccoon hunting has created a general unrest among raccoon hunters. Many raccoon clubs and hunters have initiated their own raccoon stocking programs. These raccoon importations have not been adequately documented or monitored, and the impact of these introductions on the native (resident) raccoon populations and hunter success is unknown.

It is possible that raccoon stocking may offer a solution to declining hunter success (Clements 1972, Frampton and Webb 1973, Wright 1977). However, to judge the success of such introductions, preliminary investigations of the resident raccoon populations are needed.

It was the objective of this study to examine the home range, movement patterns, intraspecific interaction, and habitat utilization of resident raccoons in East Tennessee.

CHAPTER II

GENERAL STUDY AREA DESCRIPTION

Study Area Selected

The study area, selected by TWRA officials through the recommendations of East Tennessee Coonhunters Association, is representative of typical raccoon habitat in East Tennessee. The selected area was closed to raccoon hunting and dog training with the exception of Loudon County where dog training was legal.

Location and Size of Area

The study area is located in the southeastern portion of Tennessee. The area encompasses 52,084 ha (128,602 ac) and includes portions of Blount, Loudon, and Monroe counties (Warr 1978).

The boundary lies southeast from Maryville along the Foothills Parkway to the Little Tennessee River. The area is bounded on the south and west by the Little Tennessee River. The northern boundary is formed by Fort Loudon Lake and highways 2424 and 2560. The eastern boundary is along highway 2497.

Topography

The study area is divided between two physiographical provinces. The Ridge and Valley Province comprises 90%

of the study area and includes the entire portion of Loudon County and the western half of Blount and Monroe counties (Warr 1978). The Ridge and Valley Province is characterized by low parallel ridges and gently rolling valleys. The eastern portions of Blount and Monroe counties lie in the Unaka Mountain Province (Warr 1978). The topography of the province is characterized by steep mountain slopes with narrow ridge crests. The highest elevations (2600 m) in the study area occur in the Unaka Mountain Province along Chilhowee Mountain with peaks averaging 762 m.

Permanent streams and small creeks are distributed throughout 378 km of the area (Warr 1978). The Little Tennessee River flows along the southern border of the area for 53 km. The shoreline of Fort Loudon Lake forms 9.2 km of the northern boundary.

Soils

Soil fertility differs greatly between the river bottomland and the ridge crest of the Ridge and Valley Province (Elder 1959, 1961). The fertile bottomland soils of the Little Tennessee River produce high yields of corn and hay. The ridges of the Ridge and Valley Province consist primarily of loose limestone fragments interrupted by numerous limestone outcrops. The land is of limited use for agriculture.

The soils of the Unaka Mountain Province are generally low in fertility (Elder 1959). The parent rock is a mixture of sandstone, quartzite, and slate. The soil is shallow with abundant bedrock outcroppings. These steep mountainous areas offer no potential for agriculture.

Climate

The study area has a humid-temperature climate. Winter temperatures are generally moderate with short cold snaps not uncommon. Summers are warm with daily temperatures averaging between 23° C and 32° C (U.S. Weather Bureau 1976, 1977). Temperatures in excess of 35° C are rare. Summer night temperatures vary between 15° C and 21° C. Average annual precipitation in the lower elevations is 136 cm (Blount Co., Tennessee State Planning Commission 1970), including an average snowfall of 16.5 cm. Precipitation is higher in the mountains with snowfall averaging 32 cm.

CHAPTER III

MATERIALS AND METHODS

Trapping

Collapsible (Tomahawk 207) live-traps (25.4 x 30.5 x 81.3 cm) were used to capture raccoons. Each trap was identified with a numbered metal plate and plastic tag stating the project title, phone number, and university address.

Traps were baited with sardines. Scent trails of sardine oil and fish were made in front of the trap entrance. The sardine can was suspended in the back of the trap to act as a curiosity bait. Traps were butted against a tree or fallen log to prevent the raccoon from stealing the bait. To discourage human harassment, traps were concealed as much as practicable.

Additional areas were designated for trapping after interviewing local raccoon hunters. Aerial reconnaissance was also employed in locating remote trapping areas.

The trapline was checked in the morning to minimize the effects of raccoon confinement. Traps were checked on foot except in some areas where a Honda-90 trailbike was used.

Handling and Marking

All raccoons captured in the study area were considered resident individuals unless previously tagged.

Due to the past history of releasing imported raccoons in the area (Pers. comm. Robert Wolfe), it is possible that a raccoon which was considered a resident individual was in reality an imported raccoon.

To permit safe handling, raccoons were anesthetized with Phencyclidine hydrochloride (Sernylan, Parke-Davis Co.) (Bailey 1971, Dean et al. 1973). Injections were made with a 1 cc tuberculin syringe. The dosage of Sernylan administered varied considerably but a standard guide of 0.66 mg/kg was used (Warr 1978).

After immobilization, the weight and standard body measurements of each raccoon were recorded. The general condition and presence of abnormalities were also noted.

Each raccoon was tagged with both metal and plastic ear tags. A 3.5 cm plastic, colored, and numbered tag (cattle Rototags, Nasco Co., Fort Atkinson, Wis.) was attached to one ear. The opposite ear was tagged with a metal Tennessee Wildlife Resources Agency tag (Monel #4, National Band and Tag Co., Newport, Ky.). Females were Rototagged in the left ear and males in the right. The initial raccoons captured were tattooed on the inner surface of both ears. Ear tattooing was discontinued because the tattoo was not legible on later inspection.

Aging and Reproductive Status

The age of adult raccoons was determined by tooth wear, with raccoons over 3.5 months grouped in five age classes (Grau et al. 1970, Johnson 1970). Raccoons of less than 3.5 months were aged using the tooth eruption technique (Montgomery 1964). Sexually mature-immature male raccoons were distinguished by weight classes (Stuewer 1943b, Sanderson 1950, 1961, Johnson 1970). Criteria similar to those adopted in Alabama (Johnson 1970) were used for raccoons in fall; animals 2.7 kg were considered mature. Sexual maturity of female raccoons was determined by the size and coloration of the teats (Stuewer 1943b, Johnson 1970). Fall females with teats longer than 6 mm and blackish in color are at least yearlings; juvenile raccoons have teats measuring 2 mm to 3 mm in length.

Radio Telemetry

Both 12 and 24 channel radio receivers (Wildlife Materials, Inc., Carbondale, Ill.) were used during the study, but several different antennae designs were utilized. Initially, 3 and 4 element Yagi antennae from WMI were utilized. The Yagi style antenna was later replaced with a H-shaped antenna (Telonics, Inc., Mesa, Az.). A ping pong paddle antenna (Telonics, Inc.) was also tested during the study.

The frequency of the transmitting units ranged from 150.850 to 151.450 MHz. Transmitters (Wildlife Materials, Inc.) were equipped with a mercury activity switch and powered by a lithium battery. The weight of each unit varied from 90 to 120 g. A 20 cm external antenna was attached directly to the transmitter and extended above the animal's body.

After determining the correct size for the radio collar, the transmitter was bolted securely around the animal's neck. The raccoon was placed in a cage to recover from the anesthetic. Animals were released at the original capture site. Daily locations of each raccoon were attempted. Locations were taken either on foot or from a vehicle where the road system permitted. Aerial searches were made after continual ground searching failed to locate an animal.

Calculations of home range size were derived using two techniques: the convex polygon (Southwood 1966) and an ellipse based on the covariance matrix of the telemetry locations (Jennrich and Turner 1969, Koppel et al. 1975).

Periods of activity/inactivity were determined by recording the changes in transmitted oscillation during a 1 minute monitoring period. An animal was considered active if changes in oscillations were noted during 50% of the monitoring period. A 24 hour activity pattern was calculated from the sum of all monitoring periods during the entire study (Verts 1963).

Denning Ecology

Tree dens were located by using radio telemetry or by following raccoon tracks left in snow. The height and dbh of each tree den were measured using a clinometer and D-tape. Distances from the tree den to the closest permanent water source, type of agriculture, and house were measured on topographic maps. The cavity dimensions and height from the ground were recorded for 10 tree dens.

Statistical Analysis

Home range sizes (convex polygon) were statistically compared using the Students t-test (Steel and Torrie 1960). The distances moved between consecutive den sites and home range sizes (convex polygon) were compared by linear regression (Steel and Torrie 1960). Tree den comparisons were made with the Students t-test (Steel and Torrie 1960).

CHAPTER IV

RESULTS AND DISCUSSION

Monitoring of Raccoons

Radio transmitters were attached to 19 raccoons during 1976 and 1977 (Appendix A). However, sufficient data were obtained on only 9 raccoons for estimation of home range size (Appendix B). Improper design of the transmitter antenna and the loss of several tagged animals to poachers accounted for insufficient data on 10 animals. The antenna was weakly joined to the transmitter of several animals; reception decreased from 0.5 km to less than 50 m after the antenna separated from the transmitter. Additional reinforcement of the antenna solved this problem. Two radio equipped raccoons were illegally killed. Both poaching and research activities were centered in areas of raccoon concentrations; thus, the chance for conflict was high. Arrests were made following three incidents where illegal hunting or trapping had occurred (Pers. comm. Robert Wolfe). Illegal hunting and trapping probably accounted for the loss of three additional radio equipped raccoons.

Factors Affecting Movements and the Home Range Size

Food availability and habitat differences within the study area were thought to have the greatest influence

on home range size. There was a significant difference between the home range size of raccoons from the Ridge and Valley Province portion of the study area ($\bar{x}$ = 215 ha) and those from the Unaka Mountain Province ($\bar{x}$ = 127 ha) ($P < 0.05$) (Table 1). Components of raccoon habitat (i.e., food sources and den sites) of the Ridge and Valley Province are more diverse and are dispersed over a larger area than in the Unaka Mountain Province (Table 2). The agricultural land of the Ridge and Valley Province provides alternative sources of food (i.e., cornfields, feed lots, gardens) which are not available to raccoons inhabiting the Unaka Mountain Province.

Foraging activities in the Ridge and Valley Province were concentrated either on the wooded knobs or in various cornfields. This alternation of food sources in the Ridge and Valley Province was thought to increase both nightly movements and home range size. Home range sizes were positively correlated ($r^2 = 0.95$, $P < 0.01$) to the average nightly shift between den sites. The average distance between consecutive den sites was significantly larger in the Ridge and Valley Province ($P < 0.01$) (Figure 1) (Table 3). Longer movements in the Ridge and Valley Province were probably the result of the continual shifting of foraging activities between the cornfields and wooded knobs. When foraging in cornfields, raccoons utilized den sites located either close to field openings or in lone

Table 1. Comparison of home range sizes of raccoons monitored in the Ridge and Valley Province and Unaka Mountain Province of East Tennessee.

	Number (n)	Mean[a] (ha)	Standard Deviation	Standard Error	t
Ridge and Valley Province	4	214.75	55.37	27.69	2.778*
Unaka Mountain Province	4	126.75	30.79	15.40	

[a]Convex polygon.

*Significant at 0.05.

Table 2. Habitat components within 1 km radius of the activity center of raccoons monitored in the Ridge and Valley Province and Unaka Mountain Province in East Tennessee.

	Pastures (> 1.0 ha)	Corn-fields (> 1.0 ha)	Old Fields or Power-line	Woodlots (Dis-junct Areas 1-2 ha)	Build-ings
Ridge and Valley Province	7	8	14	4	23
Unaka Mountain Province	0	0	14	0	14

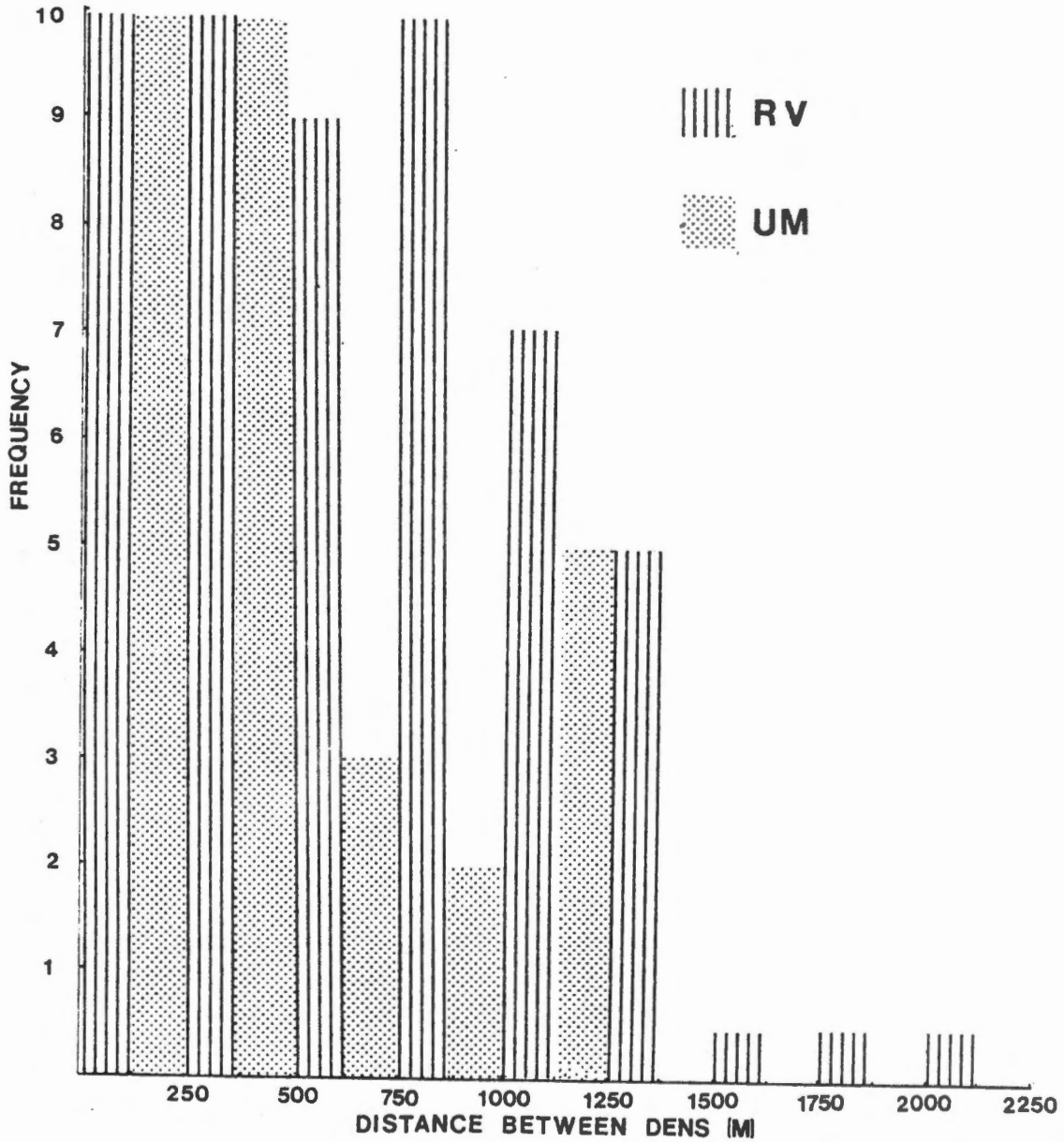

Figure 1. Comparison of distances moved between consecutive den sites for raccoons monitored in the Ridge and Valley Province and the Unaka Mountain Province.

Table 3. Comparison of distances moved between consecutive den sites in the Ridge and Valley Province and the Unaka Mountain Province in East Tennessee.

	Number (n)	Mean (m)	Standard Deviation	Standard Error	t
Ridge and Valley Province	54	758.3	477.3	71.8	2.86*
Unaka Mountain Province	25	467.1	345.4	69.1	

*Significant at 0.01.

isolated trees adjacent to the fields. When foraging activities increased in the wooded knobs, den sites in the more remote portions of the knobs were utilized. Raccoon denning and foraging activities in the Unaka Mountain Province were usually concentrated along the creeks and lower slopes of the ridges thus resulting in smaller home range sizes.

The sex of a raccoon also influences nightly movements and home range size. Adult males had significantly larger home ranges ($\bar{x}$ = 232 ha) than adult females ($\bar{x}$ = 134 ha) ($P < 0.025$) (Table 4). The distance between consecutive den sites was also significantly ($P < 0.05$) larger for males ($\bar{x}$ = 775.7 m) than females ($\bar{x}$ = 557.4 m) (Table 5). In the extreme case, home range size after parturition (16 April 1977) of a female (Raccoon 35) was reduced to approximately

Table 4. Comparison of home range size of male and female raccoons monitored in East Tennessee.

	Number (n)	Mean[a] (ha)	Standard Deviation	Standard Error	t*
Male	3	232.3	52.3	30.2	0.025*
Female	5	133.8	31.1	13.9	

[a]Convex polygon.

*Significant at 0.025.

Table 5. Comparison of distance moved between consecutive den sites of male and female raccoons monitored in East Tennessee.

	Number (n)	Mean (m)	Standard Deviation	Standard Error	t
Male	39	775.7	476.7	76.4	2.19183*
Female	41	557.4	413.5	64.6	

*Significant at 0.05.

one-third the area recorded during the two previous months. Denning activities were restricted primarily to one tree during the first two weeks after parturition. Nocturnal activity was concentrated in the general area of the natal den. A new den was established 17 days after parturition approximately 1.0 km upstream. Denning was confined to this tree for the next 22 days. In May, movements continued to increase with the return of movement patterns similar to those established before parturition.

The degree of dog-raccoon interaction is another factor which may influence the different home range sizes between the two physiographic provinces in the study area. Raccoon dog training was confined to the Loudon County portion of the Ridge and Valley Province in the study area. Dog training during late summer and early fall was often intense. The increase in erratic movement patterns and longer movements between consecutive den sites during the period of heavy dog training suggests that harassment from dogs may be influencing movements and home range size.

Normality of Telemetry Locations

The frequency distributions of the telemetry locations for Raccoons No. 18, No. 21, No. 41, and No. 25 were normally distributed ($P > 0.1$) (Table 6). The distribution of telemetry locations for Raccoon No. 38 was highly leptokurtic ($G2(Y) = 4.5$, $P < 0.001$) along the y (north-south) axis. Telemetry locations were concentrated on an east-west

Table 6. Analysis of the confidence ellipses and frequency distributions of telemetry locations for resident raccoons in East Tennessee.

Raccoon Number	Area of Confidence Ellipse (ha)				Skewness		Kurtosis	
	95%	90%	75%	50%	G1(x)	G1(y)	G2(x)	G2(y)
18	359.91	267.10	153.66	74.04	-0.1994	-0.5519	-0.7592	0.2077
21	591.73	445.60	261.59	123.73	-0.5995	-0.0734	0.5489	-0.8081
38	329.42	247.32	143.44	70.24	0.2999	-0.7315	-1.1940 platykurtic P < 0.01	4.4975 leptokurtic P < 0.001
35	322.06	245.73	146.39	72.88	-0.0500	1.5116	2.5408 leptokurtic P < 0.025	5.6958 leptokurtic P < 0.001
41	600.60	445.33	254.23	122.68	1.1877	0.8206	0.6128	-0.7366
42	359.19	268.33	155.29	75.43	-0.6968	1.2685	3.5228 leptokurtic P < 0.005	2.2236 leptokurtic P < 0.05
26	519.55	382.15	216.12	103.62	2.5914 skewed to right P < 0.001	0.3405	10.2609 leptokurtic P < 0.001	0.2071
25	232.10	173.72	101.45	49.41	-0.2962	0.5366	-1.5273	0.4268

axis (x) along Jackson Bend (Appendix C); this resulted in a clumped distribution of telemetry locations near the mean. The high concentration of locations along Jackson Bend also resulted in a slightly platykurtic ($G2(X) = 1.2$, $P < 0.1$) distribution along the x axis. The highly leptokurtic distribution along the y axis probably resulted in an overestimation (Koeppl et al. 1975) of the confidence ellipses for Raccoon No. 38 (Table 6).

Raccoon No. 35 was highly leptokurtic along the x ($G2(X) = 2.5$, $P < 0.025$) and y ($G2(Y) = 5.7$, $P < 0.001$) axes (Table 6). The clumped distribution was caused by the raccoon concentrating her activities in the vicinity of the natal den (Appendix C). The high degree of leptokurtosis, along the x and y axes, probably resulted in an overestimation (Koeppl et al. 1975) of the actual home range areas obtained from the confidence ellipses (Table 6).

Raccoon No. 42 was leptokurtic along the x ($G2(X) = 3.5$, $P < 0.005$) and y ($G2(Y) = 2.2$, $P < 0.05$) axes (Table 6). Telemetry locations for Raccoon No. 42 were concentrated in an 11 ha area along Cochran Creek resulting in a clumped (leptokurtic) distribution (Appendix C). The high degree of leptokurtosis probably resulted in an overestimation of the actual home range areas obtained from the confidence ellipses.

Raccoon No. 26 was leptokurtic along the x ($G2(X) = 10.7$, $P < 0.001$) axis and skewed to the right ($G1(X) = 2.6$, $P < 0.005$) (Table 6). Telemetry locations during the first month of monitoring were primarily centered in an area of less than 10 ha (Appendix C). During the second month of monitoring, locations were not confined to a specific area. However, the raccoon appeared to shift the majority of foraging activities further upstream. The high concentration of locations during the initial month of monitoring resulted in a skewed leptokurtic distribution along the x axis. The confidence ellipses for Raccoon No. 26 probably slightly overestimated (Koeppl et al. 1975) the actual home range sizes.

Daily Activity

Periods of greatest activity were noted from 1200 to 1800 (Figure 2). However, some activity was noted during all periods of the day. Raccoons usually became more active after sunset and continued through 2400.

Home Range Overlap

Three separate groups (No. 31 and No. 18; No. 35 and No. 36; No. 41, No. 42, and No. 26) of raccoons were tracked simultaneously during the study. Raccoon No. 31 and Raccoon No. 18 were tracked for a 41 day period (10 October 1976 to 11 November 1976) in the Red Knob portion of the study area. Home range size for Raccoon 18

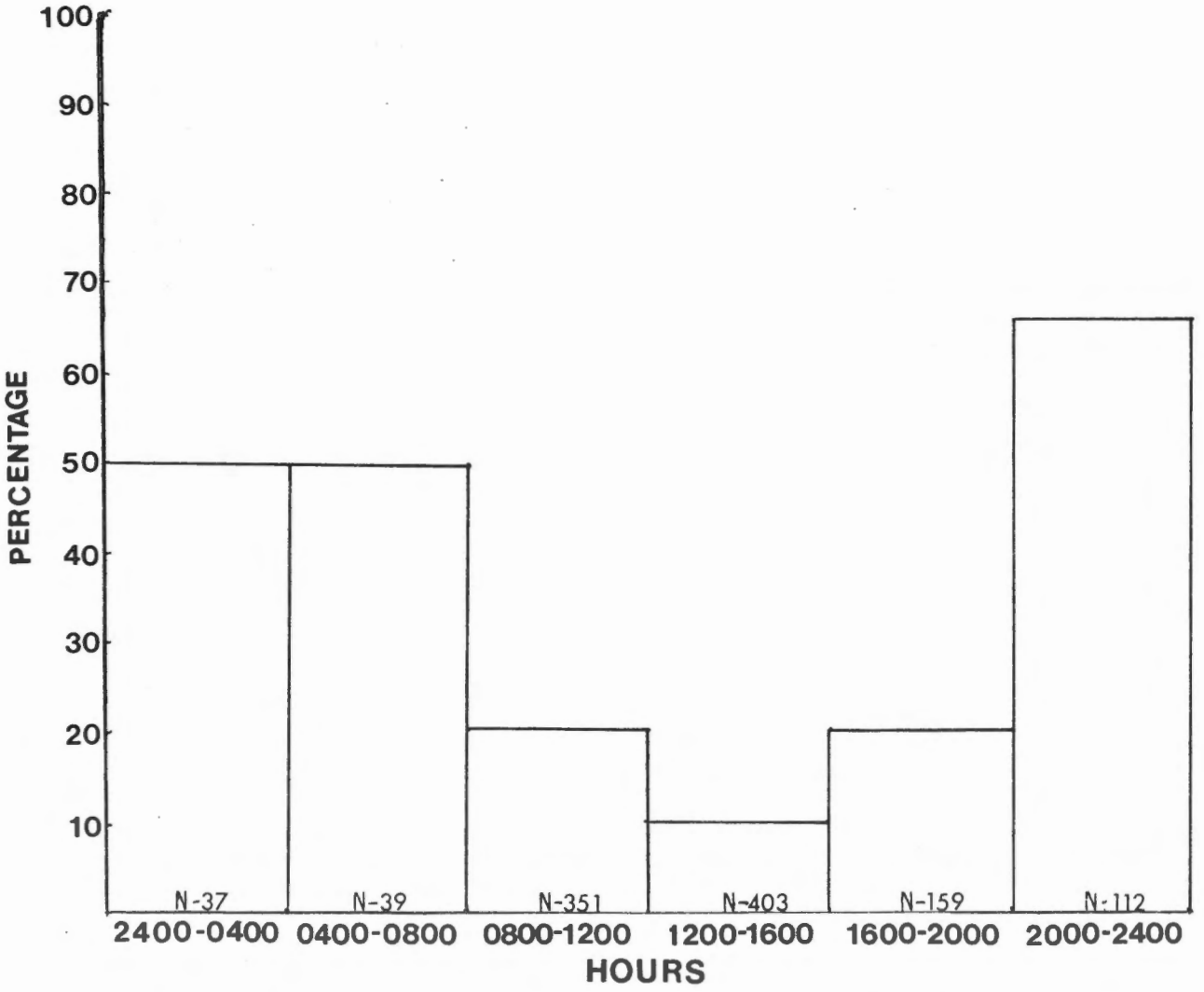

Figure 2. Percentage of daily activity of resident raccoons monitored in East Tennessee.

was 122 ha and 70.4 ha for Raccoon 31. The area of overlap for the two home ranges was 20.8 ha, with the majority of the overlap occurring on the wooded knobs. The area of overlap was used by both raccoons for feeding and denning (Figure 3).

Raccoon No. 35 and Raccoon No. 36 were tracked simultaneously (Figure 4) for 18 days (8 February 1977 to 26 February 1977) along the Little Tennessee River. Home range size for Raccoon No. 35 was 95 ha and 57 ha for Raccoon No. 36. The area of overlap for the two home ranges was 52 ha. The activities of Raccoon 35 were evenly distributed on Calloway Island and along the banks of the Little Tennessee River. The movements of Raccoon 36 were predominantly centered on Calloway Island with little foraging or denning activity off the island. The shortest distance separating the two raccoons was 408 m; the average daily distance of separation was 925 m.

Raccoon No. 41, Raccoon No. 42, and Raccoon No. 26 were monitored simultaneously for a period of 122 days (9 August 1977 to 10 December 1977) along the Cochran Creek drainage of Chilhowee Mountain (Figure 5). Home range size for Raccoon No. 41 was 172 ha, 284 ha for Raccoon No. 42, and 103 ha for Raccoon No. 26. The area of home range overlap of the three raccoons was 24.5 ha. The raccoons were not located sharing a common den although the same dens were utilized by the three raccoons

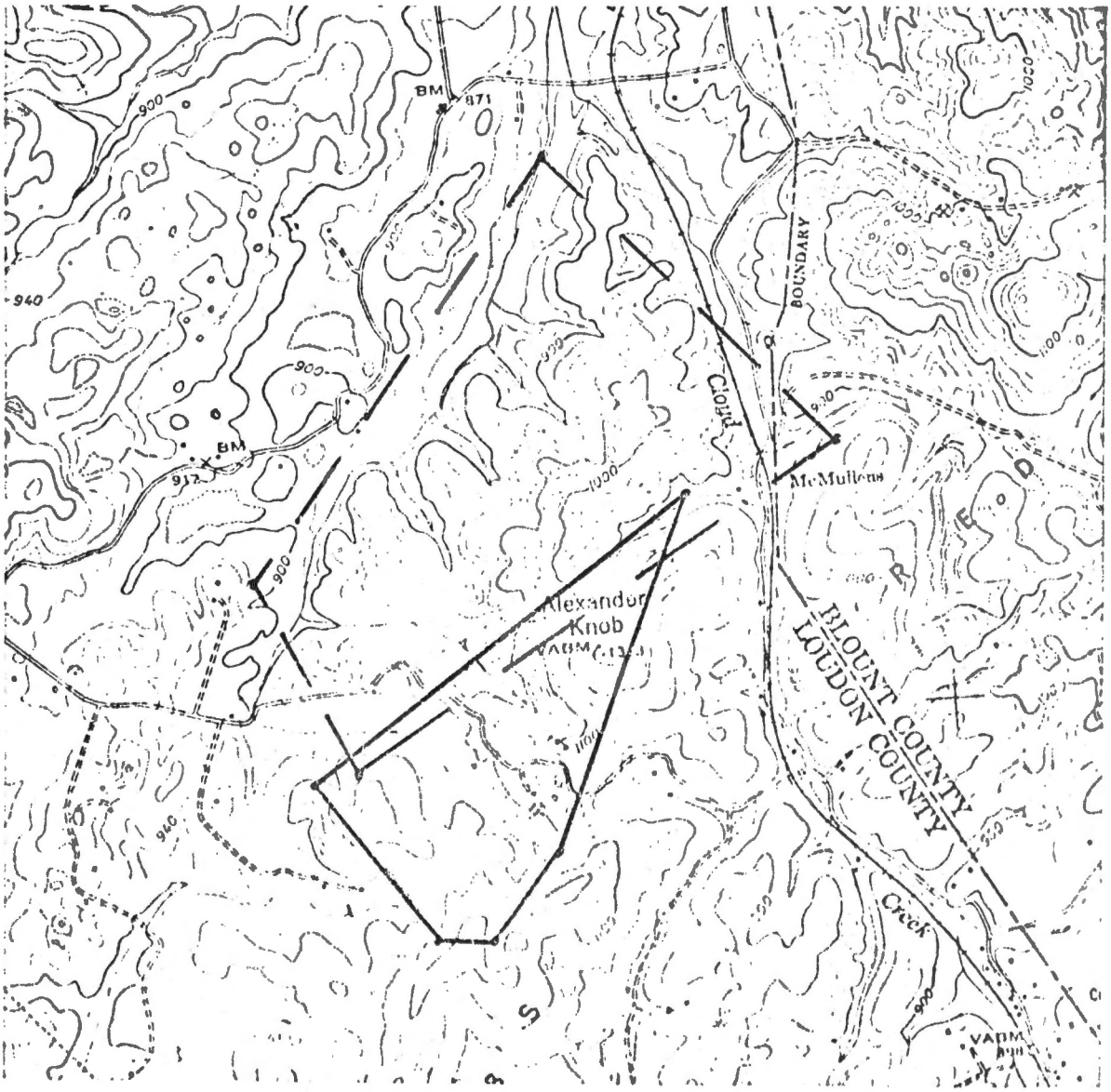

Figure 3. Overlap of fall home ranges of Raccoon No. 18 and Raccoon No. 31 in East Tennessee.

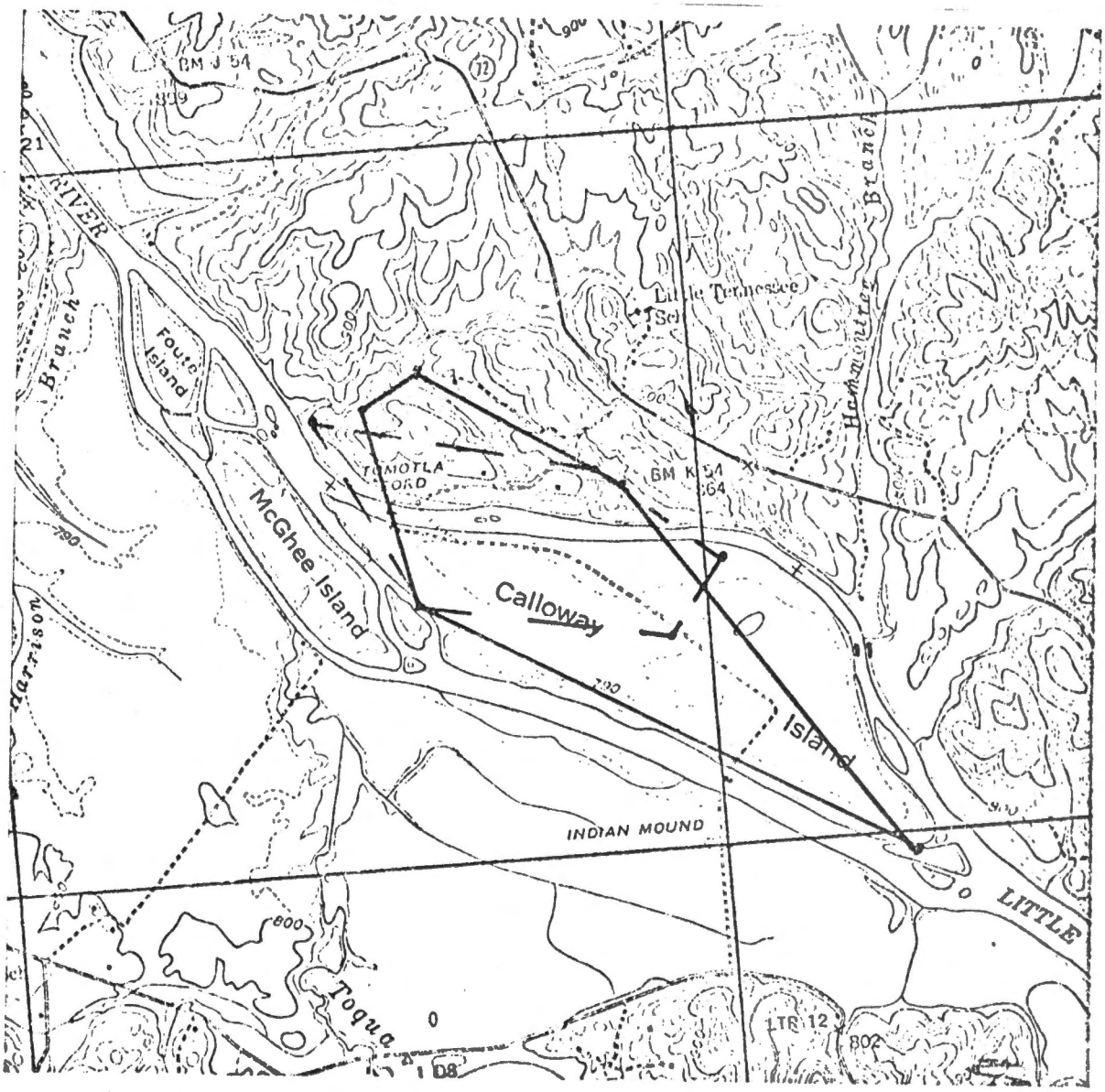

Figure 4. Overlap of winter home ranges of Raccoon No. 35 and Raccoon No. 36 in East Tennessee.

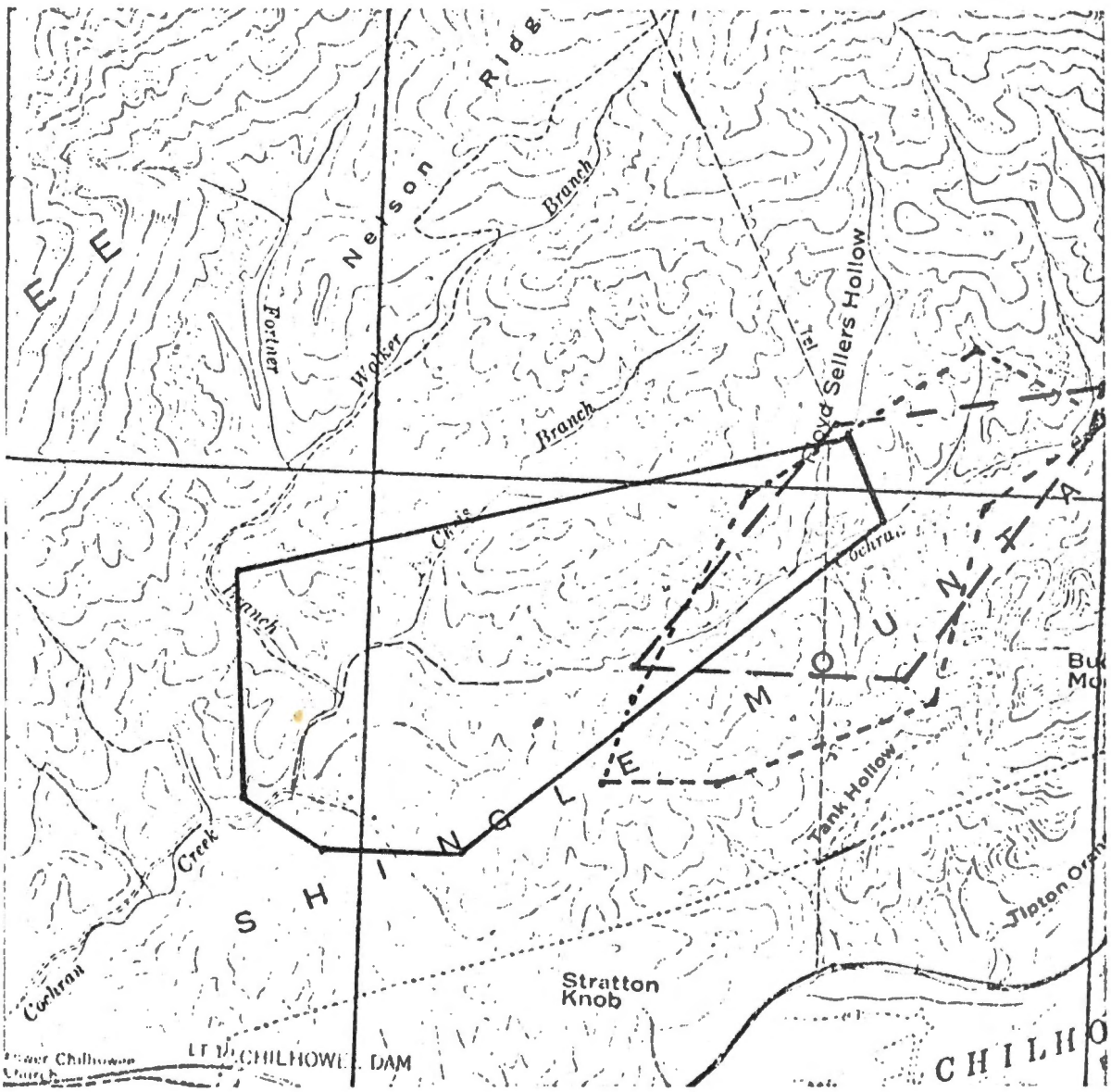

Figure 5. Overlap of summer and fall home ranges of Raccoon No. 41, Raccoon No. 42, and Raccoon No. 26 in East Tennessee.

on different occasions. The denning and nocturnal activities in the area of overlapping home ranges were very similar and were primarily concentrated along Cochran Creek.

Comparison of the movement patterns of the above raccoons illustrates the high degree of individual variation in habitat utilization and activity patterns that can be expected in a raccoon population. The movements of Raccoon No. 41 outside the area of overlapping home ranges were considerably different from the movements of Raccoon No. 26 or Raccoon No. 42. Raccoon No. 41 was constantly shifting from the isolated portions of Cochran Creek to an area within close vicinity of a house. The continual shifting enabled Raccoon No. 41 to utilize the different food sources of the two areas. Foraging and denning activities in the isolated area were concentrated along Cochran Creek and the lower slopes of Chilhowee Mountain. Food sources consisted primarily of mast, muscadines, and aquatic organisms. Foraging activity in the less remote area was primarily in a cornfield. Denning in the less remote area was often close to the forest edge within sight of human activities. By periodically shifting to this area, Raccoon No. 41 was able to supplement his diet by feeding on corn.

The movement patterns of Raccoon No. 26 and Raccoon No. 42 were considerably more sedentary than Raccoon No. 41.

Foraging and denning activities were restricted to the remote mountainous areas along Cochran Creek. The two raccoons did not feed in the cornfield which was highly utilized by Raccoon No. 41. The pattern of nightly movements of Raccoon No. 26 and Raccoon No. 42 were very similar with the distance moved between den sites considerably shorter and more predictable than Raccoon No. 41.

Raccoon No. 26 and Raccoon No. 42 had the largest percentage of home range overlap of raccoons which were tracked simultaneously (Figure 6). The average distance between the dens of Raccoon No. 26 and Raccoon No. 42 was 533 m and was significantly smaller ($P < 0.01$) than the comparative distances of Raccoon No. 41 versus Raccoon No. 26 or Raccoon No. 41 versus Raccoon No. 42 (Figure 7).

Characteristics of Tree Dens

Physical characteristics of 30 tree dens were recorded. Sixteen of the 30 trees (53%) were oaks (Table 7). Oaks with the highest utilization included white oak (*Quercus alba*) (27%) and northern red oak (*Q. rubra*) (17%) with chestnut oak (*Q. prinus*) (6%) and the southern red oak (*Q. falcata*) (3%) also noted. Two species of hickories (*Carya* spp.) were recorded and represented 20% of the trees located. These were equally divided between shagbark hickory (*C. ovata*) and mockernut hickory (*C. tomentosa*).

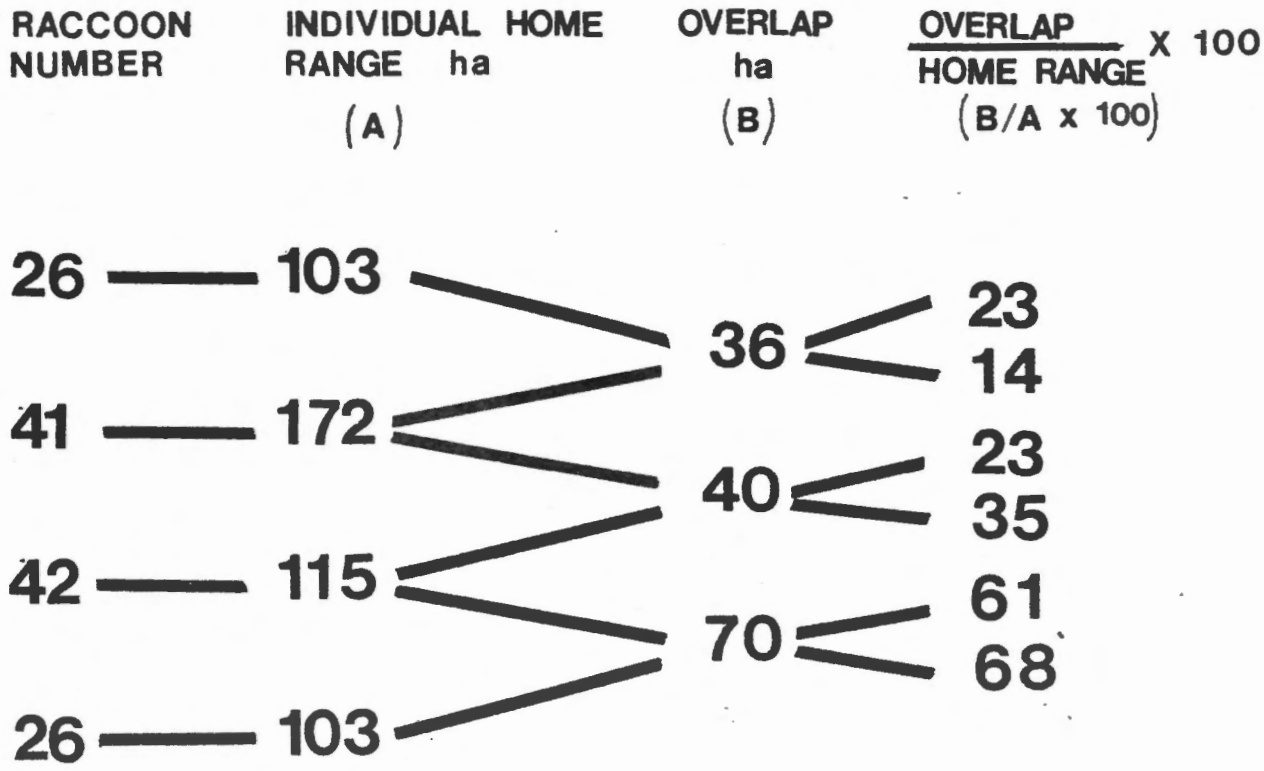

Figure 6. Comparison of area of home range overlap for Raccoon No. 26, Raccoon No. 41, and Raccoon No. 42.

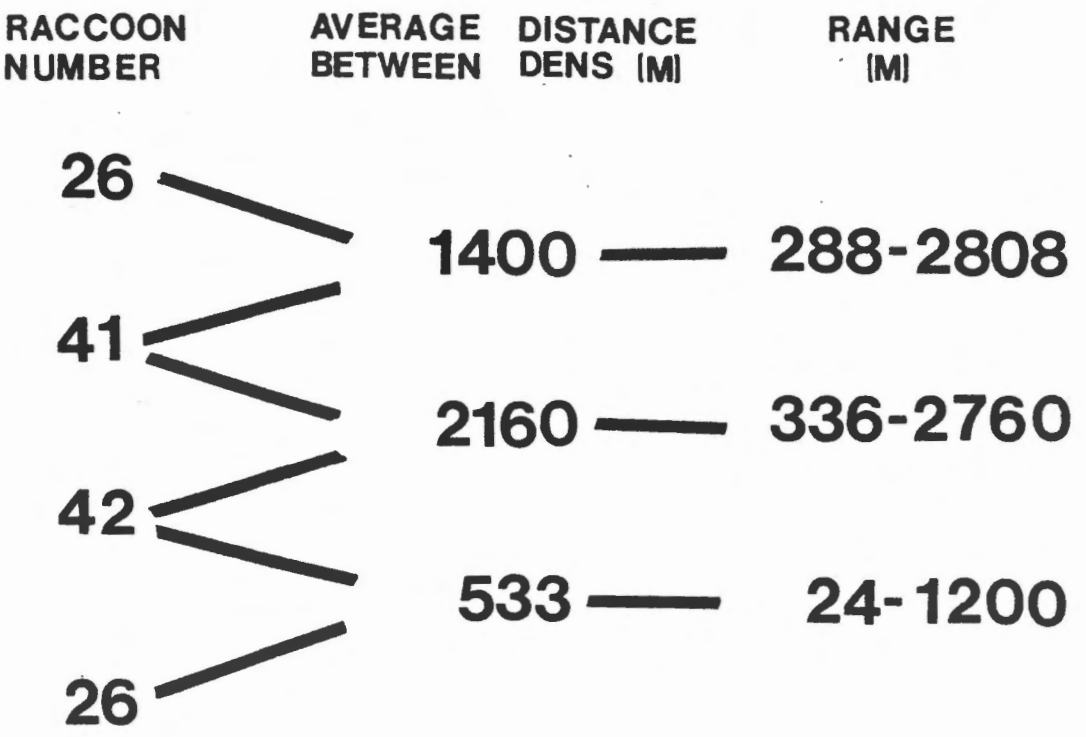

Figure 7. Comparison of the minimum distances separating the den sites of Raccoon No. 26, Raccoon No. 41, and Raccoon No. 42.

Table 7. Tree den and den site characteristics of trees used by raccoons in East Tennessee.

Species	DBH (cm)	Height (m)	Distance from Den Site (m)			
			Water	Agricultural Land	Type of Agriculture	Human Inhabitance
Quercus rubra	56	15	61	76	Corn	1,067
Q. rubra	46	12	23	457	Corn	480
Q. rubra	63	9	238	274	Pasture	1,006
Q. rubra	53	16	137	527	Corn	1,045
Q. rubra	52	18	73	152	Pasture	384
Q. alba	64	18	152	427	Corn	911
Q. alba	38	12	8	244	Corn	503
Q. alba	74	23	122	30	Pasture	384
Q. alba	48	7	76	30	Soybean	1,554
Q. alba	58	16	3	-	-	3,071
Q. alba	41	11	91	168	Pasture	457
Q. alba	91	19	46	259	Corn	427
Q. alba	61	17	143	527	Corn	1,055
Carya tomentosa	58	14	66	73	Corn	1,372
C. tomentosa	46	8	213	381	Corn	229
C. tomentosa	58	19	366	11	Corn	1,128
C. ovata	30	11	46	396	Corn	716
C. ovata	43	12	76	411	Corn	1,585
C. ovata	43	12	335	366	Pasture	1,067
Q. prinus	79	11	244	244	Corn	1,463
Q. prinus	28	12	192	152	Pasture	384
Q. falcata	54	26	5	250	Corn	451
Liriodendron tulipifera	36	17	192	30	Pasture	290
L. tulipifera	52	21	15	274	Corn	274
Fagus grandifolia	38	20	5	96	Pasture	823
Robinia pseudoacacia	51	14	262	366	Corn	1,311

Table 7 (Continued)

Species	DBH (cm)	Height (m)	Distance from Den Site (m)			
			Water	Agricultural Land	Type of Agriculture	Human Inhabitance
Tilia americana	46	8	335	-	-	3,070
Acer saccharum	48	11	168	152	Corn	3,121
Ulmus americana	117	16	9	17	Pasture	1,105
Pinus strobus	48	15	152	244	Corn	427
Total	1,620	440	3,854	6,634		31,160
Mean	54	14.7	128	237		1,039

The height and dbh of the 30 tree dens were measured (Table 7). The average height was 15 m and ranged from 7 m to 26 m. The average dbh was 54 cm and ranged from a 28 cm chestnut oak to a 117 cm elm (Ulmus americana).

Characteristics of Den Cavities

Den cavity characteristics of 10 tree dens were measured (Table 8). The distance from the ground to the cavity entrance varied from 4.6 m to 18.4 m. The average height to the cavity was 9.4 m. Most (60%) of the cavity entrances faced southward. The external dimensions of the cavities averaged 0.27 x 0.22 m. Internal cavity dimensions averaged 0.20 x 0.22 m. The depths of cavities varied greatly with the average depth measuring 4.3 m. The depth ranged from an almost flat vertical shelf to a hollow tree measuring 7.9 m deep.

Characteristics of Den Sites

Den site information was recorded from the 30 trees which were measured for tree den characteristics (Table 8). The average distance from the tree den to a source of water was 128 m and ranged from 3 m to 366 m. The average distance to the closest form of agriculture was 237 m and ranged from 11 m to 527 m. The distance to the nearest house averaged 1039 m and ranged from 229 m to 3121 m.

Table 8. Physical characteristics of tree cavities used by raccoons in East Tennessee.

Species	Height from Ground (m)	Exposure	External Dimensions (m)	Internal Dimensions (m)	Depth of Cavity (m)
Quercus rubra	7.1	N	0.79 x 0.35	0.20 x 0.35	0.45
Quercus rubra	11.4	SE	0.15 x 0.10	0.25 x 0.25	2.40
Quercus alba	4.6	S	0.24 x 0.13	0.21 x 0.15	2.70
Quercus alba	7.4	S	0.25 x 0.15	0.20 x 0.20	3.50
Quercus alba	10.4	NW	0.11 x 0.09	0.11 x 0.09	1.50
Quercus prinus	10.8	SW	0.09 x 0.11	0.09 x 0.11	2.70
Quercus falcata	18.4	W	0.27 x 0.13	0.18 x 0.15	0.03
Acer saccharum	7.9	NW	0.08 x 0.13	0.33 x 0.30	7.90
Liriondendron tulipifera	10.5	SW	0.41 x 0.09	0.15 x 0.18	0.28
Ulmus americana	5.5	S	0.30 x 0.91	0.30 x 0.41	0.15

CHAPTER V

DISCUSSION OF LITERATURE

Interpretation of Home Range

Several difficulties were encountered in comparing the home range size of raccoons in the present study with those of previous studies. The conventional method (before 1964) for estimating the home range of raccoons was derived from trapping data (Stuewer 1943a, Butterfield 1954, Cunningham 1962).

Home ranges were generally circular in shape with the diameter representing the maximum distance between capture locations. Most studies since 1964 have used radio telemetry for determining home range size (Geis 1966, Schneider et al. 1971, Shirer and Fitch 1970, Johnson 1970). Home ranges reported from the above studies were also difficult to compare to the present study due to the different sampling methods used; for example, several studies expressed sizes of home ranges only in linear measurements (Table 9).

In addition, the interrelationship of factors which influence home range size causes problems in interpreting home range data. Factors that influence the movements and home range size of raccoons include: food availability and individual food preference (Schoonover and

Table 9. Comparison of home range sizes for raccoons.

Author	Location	Sex	Home Range (ha)	Major Axis (m)
Hardy	East Tennessee	Male	232	2,475
		Female	134	1,950
Stuewer (1943a)[a]	Michigan	Male	204	--
		Female	108	--
Butterfield (1954)[a]	Ohio	---	---	403[c]
Cunningham (1962)[a]	S. Carolina	Male	---	435
		Female	---	425
Geis (1966)	S. Dakota	Male	65[b]	--
		Female	518[b]	--
Schneider et al. (1971)	Minnesota	Female	---	1,610-4,026
Shirer and Fitch (1970)	Illinois	---	5-110[c]	--
Johnson (1970)	Alabama	Male	122[b]	--
		Male	245[b]	--
		Female	114	--

[a]Data obtained from trapping.

[b]Home range calculated from N = 1.

[c]Average of both sexes.

Marshall 1951, Uhler and Llewellyn 1952, Schneider et al. 1971, Johnson 1970); sex (Stuewer 1943a, Cunningham 1962, Geis 1966); age (Geis 1966); and perhaps population density (Ellis 1964).

Comparison of West Tennessee Home Ranges

Home range sizes from raccoons monitored in West Tennessee were considerably smaller than home ranges in the study area (Table 10). However, the method of data collection was different in the two areas, thus, statistical comparison of the home range size is irrelevant. Raccoons in West Tennessee were intensively monitored over a short period (Pers. comm. D. Alsbrook) while raccoons in the study area were monitored less intensively but over a longer period. It is reasonable to believe that home ranges in West Tennessee are considerably smaller than home ranges in East Tennessee. Factors causing the smaller home range size in West Tennessee are probably a combination of excellent bottomland habitat and low human influence.

Discussion of Factors Affecting Movement and Home Range Size

Food availability and the interspersion of habitat components in the study area had the greatest influence on movement patterns and home range size. Others (Johnson 1970, Schneider et al. 1971) also noted the influence of food availability on movements and home range size.

Table 10. Comparison of home range sizes for resident raccoons monitored in Tennessee.

	95% Confidence Ellipse			90% Confidence Ellipse			75% Confidence Ellipse		
	Mean (ha)	Number (n)	Standard Error	Mean (ha)	Number (n)	Standard Error	Mean (ha)	Number (n)	Standard Error
Hardy									
(E. Tenn.)									
Males	507.25	3	4.15	379.41	3	3.57	219.75	3	2.71
Females	358.56	5	2.04	267.40	5	2.88	154.58	5	1.28
Total	414.32	8	1.47	309.41	8	1.26	179.20	8	0.96
Alsbrook									
(W. Tenn.)									
Males	20.83	8	0.39	15.74	8	0.46	9.30	8	0.27
Females	15.68	6	0.52	11.79	6	0.46	6.92	6	0.35
Total	18.62	14	0.22	14.50	14	0.20	8.35	14	0.15

Johnson (1970) reported that habitat utilization by raccoons in Alabama was strongly related to seasonal food availability and food preferences causing home ranges to be highly variable. Foraging activities in Alabama during the early summer were concentrated in areas where corn and grasshoppers were available. However, foraging activities shifted during late summer to areas providing wild grapes (Vitis spp.). Winter and spring movement patterns of one adult male in Alabama were also highly variable. Foraging areas were continually changing with the raccoon frequently entering areas it had not previously utilized.

The presence of corn was an important factor influencing movement patterns in Minnesota (Schneider et al. 1971). An abrupt change in the movements of one adult female in Minnesota was noted after the harvest of a cornfield located in her home range. When corn was not available the next year, the raccoon made three major shifts in movement that were unlike the movement patterns established the previous year.

Sex of a raccoon influenced nightly movements and home range size (Table 4, page 17). Previous authors have reported that sex influenced movements and home range size (Stuewer 1943a, Cunningham 1962, Ellis 1964, Schneider et al. 1971). Stuewer (1943a) reported the average home range for adult males was 203 ha (range from

18 to 814 ha). The average adult female had a home range of 104 ha and ranged from 5 ha to 376 ha. Stuewer (1943a) considered the larger home range size for adult male raccoons logical since males are not involved in nurturing the young. The average area covered by juveniles was similar to the home range size estimated for adult females. Cunningham (1962) reported male raccoons range slightly farther than females. The average distance between extreme capture locations for male raccoons was 0.40 km while females averaged 0.34 km. Ellis (1964) reported the movements of a female raccoon in Illinois after parturition were greatly reduced; the minimum rate of nocturnal movement decreased from 98 m/hr to 9 m/hr. Movements during the first three nights after parturition were restricted to a hog feeder and watering trough 27 m away from the den. Schneider et al. (1971) reported that gravid females usually den in the natal den for one or two days before parturition. Activity outside the den is not initiated again until two or three days after parturition.

Discussion of Home Range Overlap and Territoriality

No indication of territoriality was observed during the study. The home ranges of all individuals monitored simultaneously overlapped with one another. Areas of high raccoon utilization (i.e., banks along the Little Tennessee River) frequently had tracks of several

individuals foraging in the same area and thus suggest no defense of feeding areas. Overlap of foraging areas was also indicated from trapping data. Different individuals were caught at the same trap site within a period of a few days and thus is another indication of communal foraging area.

Previous authors reported that overlapping of raccoon home ranges is extensive, thus indicating that raccoons do not defend a definite territory (Stuewer 1943a, Geis 1966). Stuewer's (1943a) analysis of trapping data from over 250 raccoons indicated no territoriality in male, female, or juvenile raccoons. Different individual raccoons were captured at the same trap site within the space of a few days indicating large overlapping of ranges. Tracks of several individuals were observed within a short distance of each other on the same day. The short distance between natal dens also indicated that females with young ranged over the same territory.

Raccoons in South Dakota were gergarious in feeding and denning habits (Geis 1966). Observations of more than one raccoon occupying a single den were common.

Mech et al. (1966) reported that although extensive overlap occurred in areas used for day resting sites that raccoons probably had a minimum spacing distance between resting sites. Raccoons utilized rest sites over 122 m apart with 82% of the distance separating individuals over 610 m.

Johnson (1970) reported extensive overlapping of raccoon home ranges with no apparent influence due to the sex or age of an individual. Raccoons in the winter congregated in areas of prime habitat. Definite territories were not defended by raccoons but Johnson (1970) suggested that other forms of territorial defense may exist.

The possibility of a feeding territory as suggested by Tevis (1947) was noted in Alabama (Johnson 1970). No raccoon activity was observed for a period of one week after a lone male raccoon was removed from his former feeding area. If this territory had previously been defended then the period of one week might represent the time necessary for another raccoon to establish a new feeding territory.

Daily Activity Pattern

Previous authors have noted activity patterns similar to those in the present study. Peak foraging activities at a feeding station in Kansas occurred from 2030 to 2100 (Sharp and Sharp 1956). Activity decreased throughout the night but was fairly constant from 2330 to 0030 and between 0130 and 0330. Schneider et al. (1971) in Minnesota noted variation in periods of activity; activity during April and May usually began at sunset. The starting times of raccoon activity in summer months were more

variable and often started before sunset. The period when activity ceased also varied with the seasons. Activity periods in April and May usually ceased after sunrise, while activity stopped before sunrise in the latter summer months. Ellis (1964) in Illinois monitored diel activity for five raccoons; activity was recorded during 74% of the daylight periods.

Comparative Den Studies

The height of a den cavity above the ground is usually less than 12.2 m (Stuewer 1943a, Berner 1962). Stuewer (1943a) reported the average entrance height was 8.4 m with a range of 6-12 m. Den heights in Michigan (Stuewer 1943a) were not significantly different from den trees measured within the study area ($P < 0.10$). Den heights reported by Berner (1965) ($\bar{x} = 3.8$ m) were significantly different from the heights measured in the study area ($P < 0.01$). The lack of human harassment may possibly account for the significantly lower den heights reported by Berner (1965). In areas where hunting is legal, raccoons utilizing dens lower than 5 m would probably increase their chances of being harassed.

The external den cavity dimensions in the present study area were not significantly different from the two Michigan studies ($P < 0.10$). Stuewer (1943a) reported the average entrance dimension for 34 trees was 0.32 x

0.13 m. The entrance dimensions measured by Berner (1965) averaged 0.32 x 0.13 m.

Internal cavity dimensions of dens in the study area were smaller than the cavities measured in the two Michigan studies. The internal cavity dimensions were significantly different for the dens measured by Stuewer (1943a) which averaged 0.35 x 0.30 m ($P < 0.01$). Internal cavity dimensions measured by Berner (1965) averaged 0.36 x 0.30 m and also differed significantly ($P < 0.025$). Berner (1965) reported that the influence of internal cavity dimensions in Michigan on den selection was minimized once the internal dimensions were over 25.4 cm in diameter. The larger inner cavity dimensions reported from Michigan may be necessary to accommodate the larger raccoons which inhabit these regions. The average fall and winter weight of male raccoons in Michigan was 6.8 kg (Stuewer 1943a) compared to 4.1 kg for the study area (Warr 1978).

The average cavity depth Stuewer (1943a) reported was 1.0 m and is significantly less than the cavities on the study area ($P < 0.025$). The average depth of cavities measured by Berner (1965) was 1.2 m and did not differ from the average depth in the study area ($P < 0.01$). Stuewer (1943a) reported that cavity depth did not influence raccoon den selection. Berner (1965) stated that cavities with greater depth probably have greater internal

temperature fluctuation and thus are poor denning sites during the winter.

Discussion of Denning Behavior

The function of a tree den has been classified into three categories: protection from severe weather conditions, secure environment to raise young, and refuge from predators (Preble 1940). Raccoons select different types of tree dens depending on the season. Berner (1965) reported that the type of tree den selected by a raccoon was related to the ambient temperature. Raccoons in Michigan preferred well insulated dens during months of cold temperatures, but frequently chose cavities which had large entrances and little protection from the rain during warm months.

In the summer, raccoons in the study area rarely utilized well insulated dens and were frequently observed lying in dens which opened to the zenith and offered no protection from rain. One raccoon was observed lying on a large limb of a white pine (Pinus strobus). Raccoons were also found utilizing abandoned squirrel (Sciurus carolinensis) nests. This phenomenon is not uncommon (Twichell and Dill 1949, Mech et al. 1966, Shirer and Fitch 1970, Schneider et al. 1971), with the squirrel nest being crushed flat to form a cool, secure resting platform.

Several authors have cited lack of tree dens as a factor limiting raccoon populations (Stuewer 1943a, Whitney and Underwood 1952, Butterfield 1954). The raccoon, however, is a very adaptable species and has been reported denning in a variety of situations other than natural tree cavities (Bergtold 1925, Stuewer 1943a, Whitney and Underwood 1952). Raccoons have been frequently reported denning in artificial nest boxes (Baker and Newman 1942, Stuewer 1943a, Berner 1965). Raccoons, in Iowa, utilized rock outcrops more than 50% of the time in comparison to tree dens (Shirer and Fitch 1970). Raccoons were also noted using hawk (Bueto spp.) and fox squirrel (Sciurus niger) nests as rest sites. Raccoons in South Dakota utilized different resting sites according to the season (Geis 1966). Abandoned farm buildings and tree cavities were used during early spring, winter, and late autumn. Heavy marsh vegetation provided sufficient cover during summer and early autumn (Geis 1966).

Other authors have reported the raccoons' preference for ground beds in grassy fields or marsh habitats (Cabalka et al. 1953, Ellis 1964, Mech et al. 1966). In these habitats dense stands of vegetation provide ample cover. Raccoon utilization of tree dens accounted for only 5% of the denning which occurred on Horicon National Wildlife Refuge in Wisconsin (Dorney 1954). Raccoon denning was primarily (over 90%) on ground beds. Dorney

(1954) concluded that on the area den trees were not essential for maintaining high raccoon densities.

Within the study area there did not appear to be a lack of den sites. Many of the woodlots had diseased or lightning-struck trees which formed excellent den cavities. Raccoon were also found utilizing the dens of red fox (Vulpes vulpes) and woodchuck (Marmota monax) burrows which are plentiful throughout the area. The Red Knobs portion of the study area has several old rock quarries which provide excellent refuge sites for raccoons.

Water in Relation to Den Sites

A permanent source of water has also been reported as an important component of quality raccoon habitat (Stuewer 1943a, Calbalka et al. 1953, Dorney 1954, Stains 1956). The average distance from a tree den to the closest source of water in the study area was 128 m and ranged from 3 m to 366 m. Stuewer (1943a) reported the average distance from a tree den to a source of water was 124 m. The maximum distance to water was 365 m. Berner (1965) found little correlation between the distance of a den to water and the amount of den utilization. Considering the ample water resources of the study area (Warr 1978), water probably has little influence on limiting raccoon densities.

Human Influence

The distance from a den site to a house relates both positive and negative habitat components that influence

raccoon populations. Houses often provide an alternate food source (small gardens and garbage) where food can easily be obtained. The extent which raccoons can adapt to humans and urban surroundings is evident in the high raccoon densities in Cincinnati, Ohio (Shinner 1969, Cauley 1970), and in Memphis, Tennessee (Pers. comm. D. Alsbrook).

Farm and housing developments also have several negative influences on raccoon densities. The distance from a house to the tree den is often a measurement of the distance to the nearest free roaming dog. Warr (1978) observed an average of five dogs per day (1,200 observations) during 14 months of trapping in the area. Dogs were directly confronted on 67 occasions during trapping operations. The continual harassment by dogs throughout the year is possibly one of the major factors limiting raccoons. Preble (1941) in Ohio estimated that predation of raccoons by dogs possibly accounted for 20% of the annual mortality. Surveys of tracks along Ohio streams showed that raccoons were continually harassed by free roaming dogs.

Insight on hunter accessibility (road access) may also be interpreted from the house-to-den tree distance. Roads provide easy access to any portion of the study area. The average distance from a den tree to a house was 1.04 km and ranged from 0.23 km to 3.1 km. The strain on the

raccoon population is probably high when considering the ease or accessibility to hunting areas and the large number of raccoon hunters. Illegal activities (i.e., trapping along stream crossings) can also be very effective where an extensive system of road exists.

CHAPTER VI

CONCLUSION

A study of the movement patterns of resident raccoons in east Tennessee was conducted during 1976 and 1977. Sufficient data were obtained from nine raccoons to estimate home range size, habitat utilization, and movement patterns.

Food availability and habitat differences were thought to have the greatest influence on home range size. There was a significant difference in the home range size between the Ridge and Valley Province ($\bar{x}$ = 215 ha) and the Unaka Mountain Province ($\bar{x}$ = 127 ha) ($P < 0.01$). The larger home range size was attributed to the diversity and juxtaposition of the habitat components in the Ridge and Valley Province. Raccoons inhabiting the Ridge and Valley Province alternated their foraging activities between the wooded knobs and cornfields. Raccoon activity in the Unaka Mountain Province was primarily along small creeks and adjacent slopes where food sources were concentrated, thus movements were limited and home ranges were smaller.

Den site utilization was related to foraging activities. When foraging in cornfields, raccoons utilized den sites along the field edge. When foraging in the more remote wooded knobs area, den sites in the interior of the forest near feeding areas were utilized.

The average distance between consecutive den sites was significantly larger in the Ridge and Valley Province ($P < 0.10$). These larger movements were probably due to the continual shifting of foraging (i.e., cornfields vs. wooded knobs).

The sex of the raccoons also influenced home range size. Male raccoons had an average home range of 232 ha which was significantly larger ($P < 0.025$) than that of female raccoons ($\bar{x}$ = 134 ha). The home range size of one female raccoon after parturition was reduced to approximately one-third of the area utilized during the two previous months.

The high degree of dog-raccoon interaction in portions of the study area probably had an extreme effect on raccoon movement patterns, home range size, and population density. An elimination of dog training activities during the spring and early summer would alleviate the hunter harassment and stress on raccoon production. Additional investigations of the effects of dog training on raccoon populations are needed.

Three separate sets of raccoons were tracked simultaneously during the study. No evidence of territories was observed. The area of home range overlap varied from 36.4 to 70.1 ha. Habitat utilization and movement patterns were similar in areas of overlap. The shortest distance recorded between two denning raccoons was 24 m.

The majority of raccoon activity was recorded between sunset and sunrise but some activity was noted throughout the day. Peak raccoon activity was between 2000 and 2400 hours. Tree species with highest utilization were white oak (Q. alba) and northern red oak (Q. rubra). The average tree den height was 14.7 m and ranged from 7 m to 26 m. The average tree den dbh was 54 cm and ranged from 28 cm to 117 cm.

Within the study area, the availability of den sites did not appear to be a limiting factor. Although den sites were primarily tree cavities, raccoons utilized fox dens, woodchuck burrows, and rock outcrops. Squirrel nests were commonly used for resting sites during the warm months.

The high frequency of corn in close proximity to den sites may indicate that an increase in overall corn production is necessary for higher population densities. Raccoon utilization of pasture was low and suggested that raccoons avoided large open areas.

Insight on hunter accessibility (road access) may be inferred from the short house-to-den distance ($\bar{x}$ = 1.04 km). The resulting strain on the raccoon population is probably high when one considers the ease of hunter access.

CHAPTER VII

MANAGEMENT RECOMMENDATIONS

1. A severe decrease in the length of dog training season is needed. Reduction to a one month training season before the opening day of raccoon hunting season would significantly increase the quality of raccoon hunting in East Tennessee.

2. Increased law enforcement is needed especially during spring and summer when raccoon family groups are particularly vulnerable.

3. The closure of counties to raccoon hunting and dog training in areas of particularly low raccoon densities is necessary for future quality raccoon hunting.

4. In order to protect juvenile raccoons, the hunting season in East Tennessee should not open until the second or third week in November.

5. Increased interaction between TWRA and raccoon hunting clubs is necessary to provide a sound management program.

6. The possibility of utilizing money raised by raccoon hunting clubs in future research and management programs should be investigated.

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APPENDICES

APPENDIX A

Table 11. Movement parameters of 19 East Tennessee resident raccoons.

Raccoon Number	Sex	Physiographic Province	Number of Locations	Home[a] Range (ha)	Major Axis (m)	Minor Axis (m)
15	M	UM[b]	21	-	-	-
16	M	UM	1	-	-	-
17	M	UM	0	-	-	-
18	F	RV[c]	22	173	2,600	1,600
21	M	RV	42	261	2,700	1,500
25	F	UM	30	117	1,400	1,200
29	F	RV	6	-	-	-
31	M	RV	5	-	2,700	1,100
32	M	RV	7	-	-	-
33	F	RV	2	-	-	-
34	M	RV	2	-	-	-
35	F	RV	116	161	2,600	900
36	F	RV	13	49	1,500	600
38	M	RV	34	264	2,200	1,600
39	M	RV	2	-	-	-
40	M	RV	14	-	-	-
41	M	UM	22	172	2,300	700
42	F	UM	39	115	1,900	500
26	F	UM	35	103	1,700	400

[a]Convex polygon.

[b]Unaka Mountain Province.

[c]Ridge and Valley Province.

APPENDIX B

Table 12. Tag number, sex, physiographical province, weight, and telemetry information for resident raccoons monitored in East Tennessee.

Rototag #	Sex	Physiographic Province	Wt. (kg)	Date of Capture	Number of Locations	Number Days Searched for and not Located	Inclusive Monitoring Period (Days)	Home[a] Range (ha)
15	M	UM[b]	2.6	4-1-76	21	8		24
16	M	UM	3.5	4-21-76	1	22	1	-
17	M	UM	2.5	4-29-76	0	14	0	-
18	F	R&V[c]	5.4	9-19-76	22	18	71	173
21	M	R&V	3.4	7-27-76	42	9	94	261
25	F	UM	3.5	9-5-76	30	34	78	117
29	F	R&V	3.7	10-7-76	6	8	12	-
31	M	R&V	4.3	10-15-76	5	19	43	-
32	M	R&V	7.5	11-12-76	7	14	23	-
33	F	R&V	2.6	11-12-76	2	12	4	-
34	M	R&V	3.4	11-15-76	2	12	12	-
35	F	R&V	4.1	1-28-77	116	5	193	161
36	F	R&V	4.2	2-7-77	13	5	13	49
38	M	R&V	4.0	4-12-77	34	17	66	264
39	M	R&V	5.9	4-17-77	2	4	5	-
40	M	R&V	5.0	7-12-77	14	0	13	-
41	M	UM	5.4	8-3-77	22	19	60	172
42	F	UM	2.7	8-5-77	39	9	183	115
26	F	UM	3.1	8-7-77	35	12	180	103

[a]Convex polygon. [b]Unaka Mountain Province. [c]Ridge and Valley Province.

APPENDIX C

INDIVIDUAL NARRATIVES OF RESIDENT RACCOONS MONITORED IN EAST TENNESSEE

Home range maps are included for raccoons with sufficient telemetry information.

Raccoon No. 15

Raccoon No. 15 (adult male) was captured 11 April 1976 in the Cochran Creek Drainage of Shingle Mountain. Technical difficulties prevented calculation of home range size. Signal deflection problems were detected during the third week of monitoring; preceding locations were determined inaccurate. Limited data suggest a home range size of 25 to 50 ha. However, the small home range size can possibly be attributed to concurrent trapping operations. During the monitoring period the raccoon was recaptured five times. The first four recaptures were at the original capture site. After closure of the original trap, the raccoon was recaptured approximately 0.4 km upstream.

Raccoon No. 16

Raccoon No. 16 (adult male) was captured 21 April 1976 in the Cochran Creek Drainage of Shingle Mountain. Due to transmitter malfunction, the raccoon was located only once.

Raccoon No. 17

Raccoon No. 17 (adult male) was captured 29 April 1976 in the Walker Prong Creek Drainage of Chilhowee Mountain. The transmitter was thought to have malfunctioned resulting in no telemetry information.

Raccoon No. 21

Raccoon No. 21 (adult male) was captured 27 July 1976 in the Red Knobs portion of the study area (Figure 8). Extensive foraging in cornfields was recorded during August and September. Denning was concentrated mainly along the forest/field edge. Raccoon 21 shifted activities during late September to the wooded area east of Alexander Knob. Den sites were located several times in abandoned rock quarries. The utilization of den sites in quarries was probably higher than was actually recorded due to limited signal transmission in rocky terrain. The nightly movements of Raccoon No. 21 varied greatly in comparison to the other raccoons monitored during the study. Daily shifts in den sites were large with a maximum shift of over 2100 m. The erratic and fluctuating movements of Raccoon No. 21 were thought to have been influenced by the intensive training of raccoon dogs in the Red Knobs during the late summer months. A shift was noted to the wooded area east of Alexander Knob where the degree of harassment by dogs was lower. Dog training was

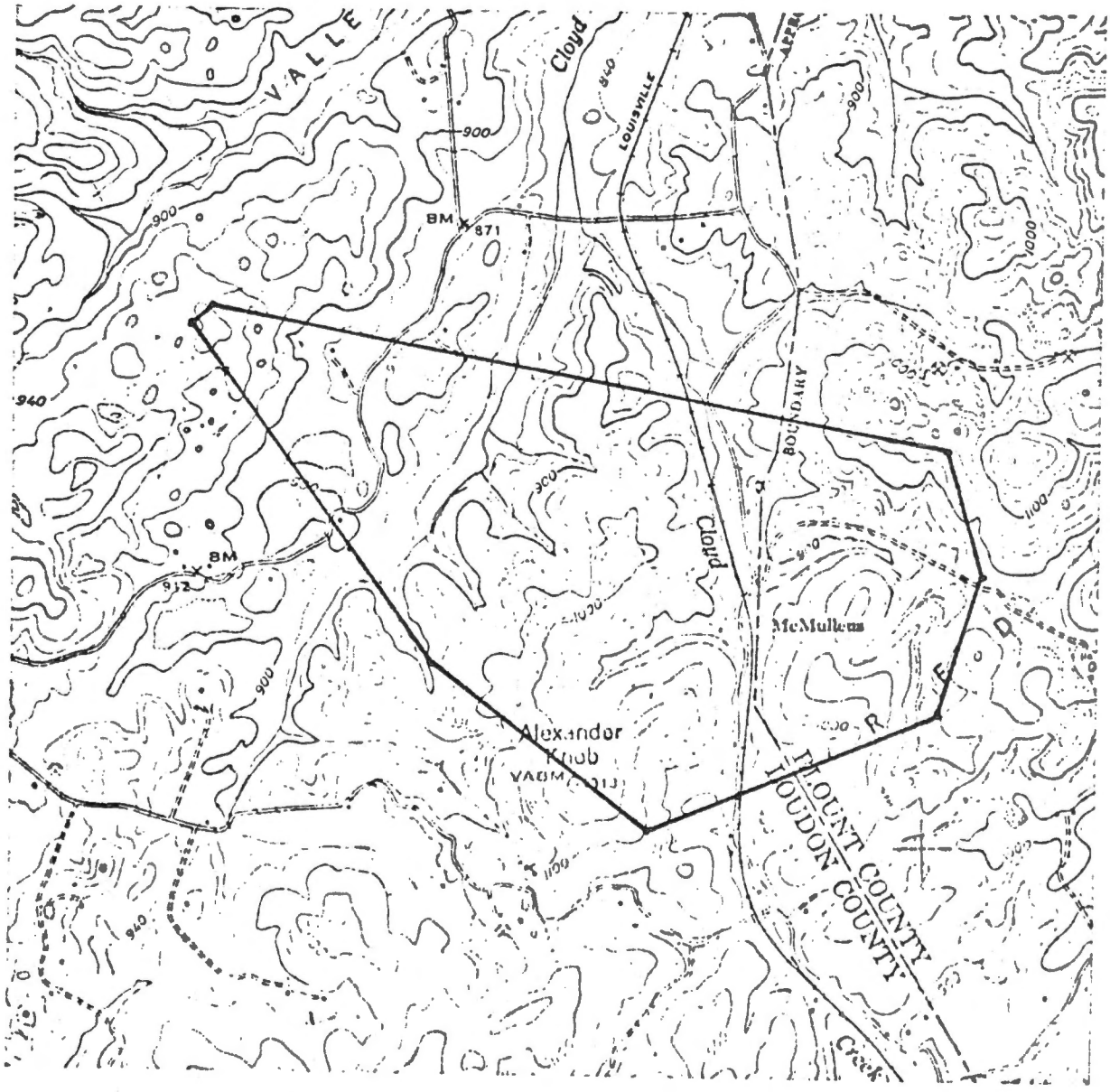

Figure 8. Summer and fall home ranges of Raccoon No. 21 (adult male) in East Tennessee.

illegal in the portion of the raccoon's home range east of Alexander Knob.

Raccoon No. 18

Raccoon No. 18 (adult female) was captured 26 June 1976 in the Red Knobs portion of the study area (Figure 9). The raccoon was lactating and was thought to have a litter. Denning and foraging activities were mainly confined to Alexander Knob during September. A limited amount of foraging activity occurred along the streams and in the cornfields. The activity pattern in October shifted to the cornfields and small adjacent woodlots. Denning was confined to the edge of a woodlot adjacent to the cornfields. Nightly foraging activities were concentrated in the cornfields with movements into the fields along the small creeks. Foraging and denning activities during November were similar to the activity pattern established during October. Raccoon No. 18 was killed in December during a dog training session in a pasture west of Alexander Knob.

Raccoon No. 38

Raccoon No. 38 (adult male) was captured 12 April 1977 on the Jackson Bend portion of the Little Tennessee River (Figure 10). The raccoon was instrumented with a radio transmitter and released on 13 April. This animal was located the following day on the bank of the Little

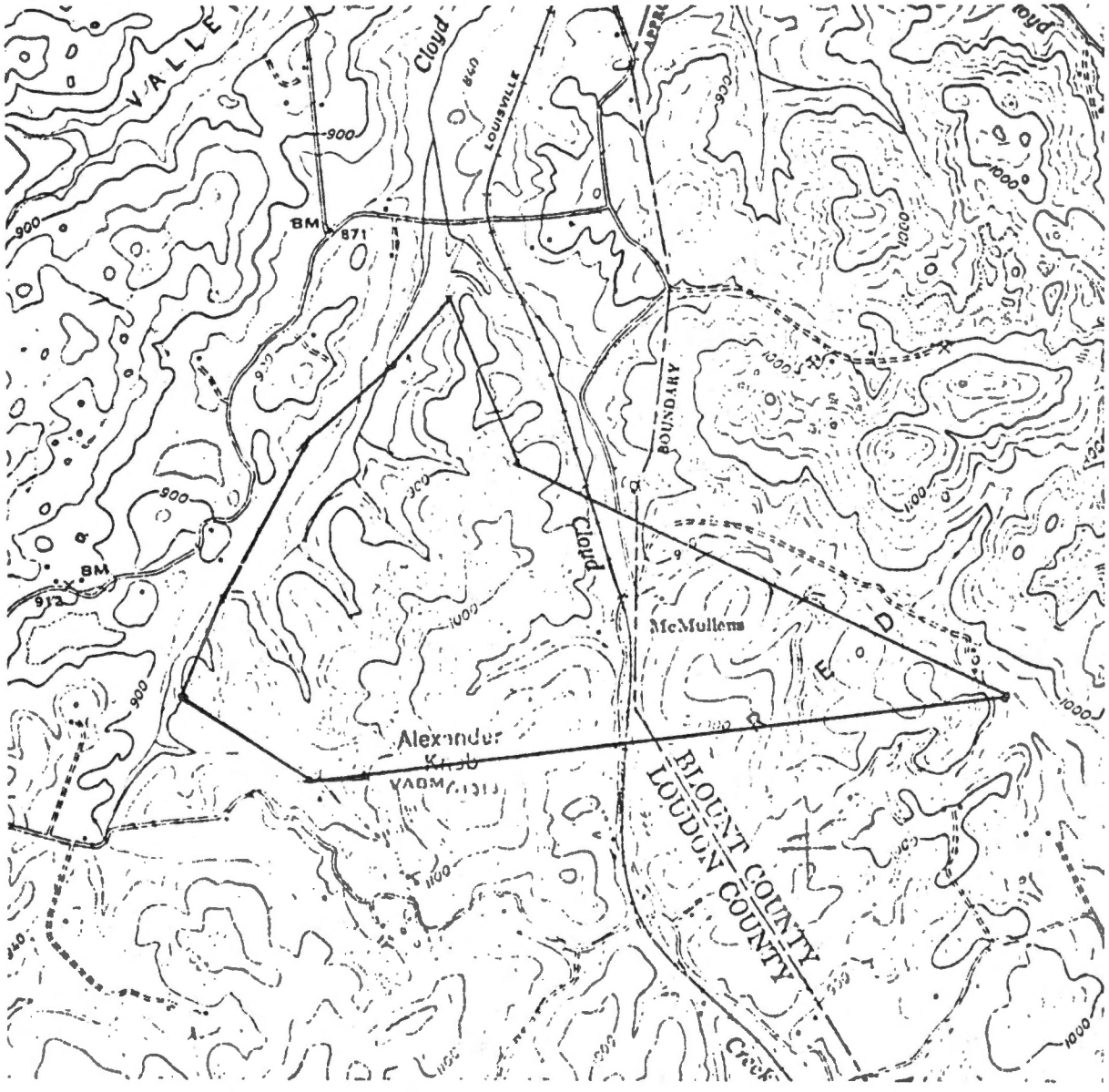

Figure 9. Summer and fall home ranges of Raccoon No. 18 (adult female) in East Tennessee.

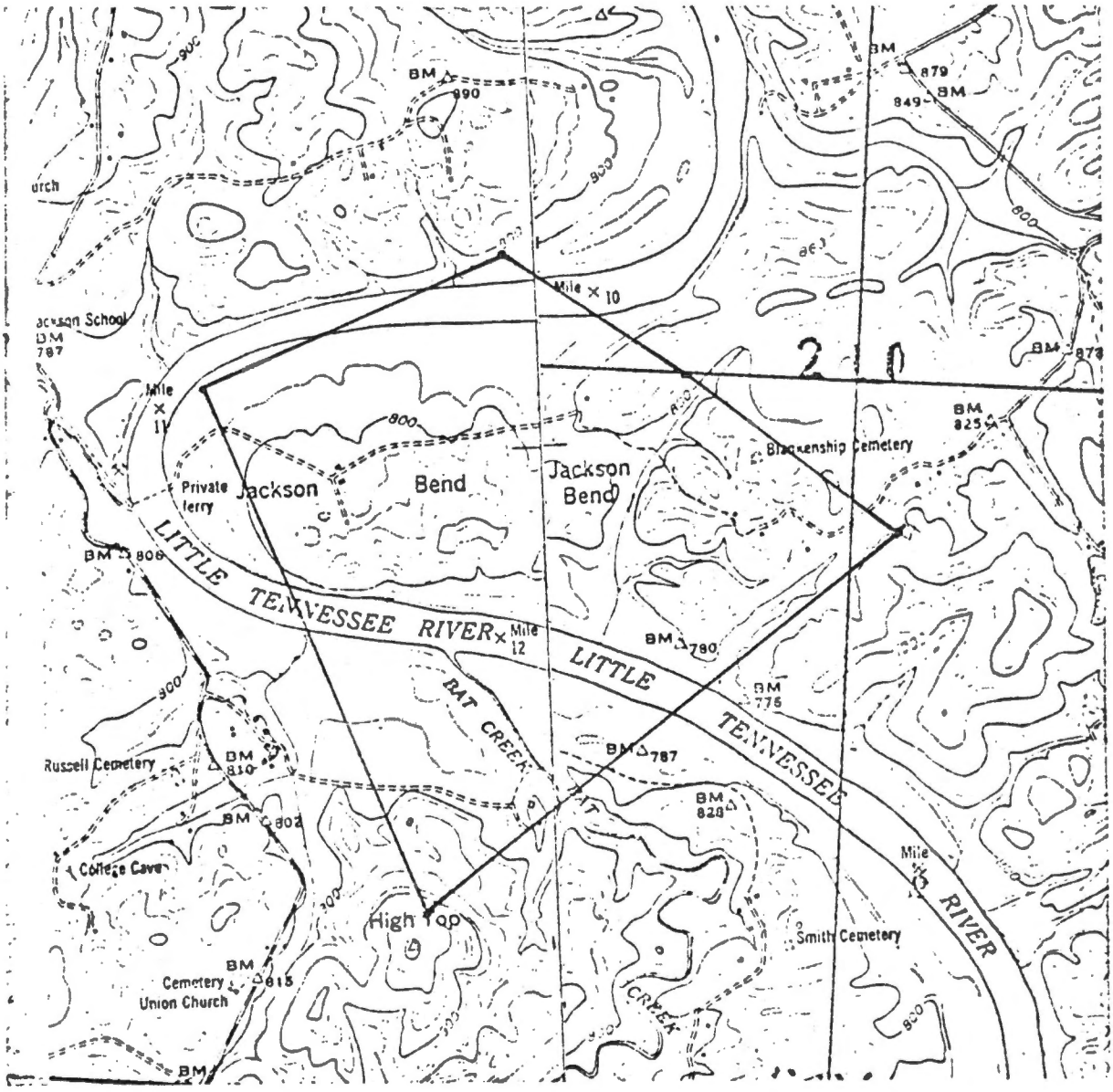

Figure 10. Spring home range of Raccoon No. 38 (adult male) in East Tennessee.

Tennessee River in the vicinity of the release site. The raccoon occupied a den site for the next two days in a small woodlot on Jackson Bend. Activity was concentrated in the woodlot for two more days before moving approximately 1 km to a den on the opposite side of the Little Tennessee River. The following night the raccoon recrossed the Little Tennessee River and moved upstream 1.3 km to a small woodlot which was located east of Jackson Bend. Raccoon No. 38 was recaptured 23 April and was determined to be in excellent condition. Raccoon activity during the remainder of April was recorded primarily in the Jackson Bend woodlot. The movement patterns during May were not as restricted as in the previous month. Den sites were mainly on the wooded knobs east of Jackson Bend with the raccoon continually entering new areas. Limited telemetry data for the month were thought to have been caused by the raccoon denning on the opposite side of the river. A ground search of the area was unsuccessful in determining the specific location of the raccoon. Foraging activities of Raccoon No. 38 during the entire monitoring period were primarily along the banks of small creeks and the Little Tennessee River. High numbers of tracks were observed along these water courses. Raccoon No. 38 was located on several occasions in the middle of an idle soybean field and was thought to be foraging for insects.

Raccoon No. 29

Raccoon No. 29 (adult female) was captured 7 October 1976 in the Negro Hollow section of the study area. The raccoon was blind in one eye and was determined to be in fair physical condition. Telemetry data were limited with insufficient data for an accurate estimation of home range size. Foraging activities were concentrated along the creek in Negro Hollow. Raccoon tracks were observed frequently along a 0.5 km portion of the creek. Den sites were usually near the crest of the ridges. The raccoon was located denning in several large white oaks which had been struck by lightning.

Raccoon No. 31

Raccoon No. 31 (adult male) was captured 15 October 1976 in the Red Knobs portion of the study area. Telemetry data were limited during the 43-day monitoring period with insufficient data for an accurate estimation of home range size. Raccoon 31 utilized the creeks and cornfields surrounding Alexander Knob suggesting that movement patterns were similar to the activities for Raccoon No. 21 and Raccoon No. 18.

Raccoon No. 32

Raccoon No. 32 (adult male) was captured 12 November 1976 along a small creek 1.0 km from Calloway Island on the Little Tennessee River. The animal was located in the

vicinity of the capture site on 18 November. The animal moved down the creek and was located in a woodlot along the Little Tennessee River on 19 November. During the remainder of the monitoring period, the raccoon was found along the bluffs of the Little Tennessee River or on the small islands directly upstream from Foute Island.

Raccoon No. 33

Raccoon No. 33 (adult female) was captured 12 November 1976 along Smoky Branch approximately 1.5 km upstream from the Little Tennessee River. The raccoon was located twice (18 November and 19 November) on a wooded knob within 0.2 km of the original capture site. Raccoon No. 33 was thought to have been illegally trapped; two telemetry locations were obtained.

Raccoon No. 34

Raccoon No. 34 (adult male) was captured 15 November 1976 along Smoky Branch approximately 1.5 km upstream of the Little Tennessee River. Raccoon No. 34 was located (18 November) on a wooded knob approximately 0.5 km from Raccoon No. 33. Raccoon No. 34 was located 20 November in the vicinity of the original capture site. Raccoon No. 34 was also thought to have been illegally trapped.

Raccoon No. 39

Raccoon No. 39 (adult male) was captured 17 April along a small creek approximately 0.1 km upstream from

the 13.0 mile marker on the Little Tennessee River. The raccoon was located 19 April lying on a limb of a 48 cm white pine approximately 0.3 km from the original capture site. Raccoon No. 39 was located (22 April) in a grove of trees on Jackson Bend 2.5 km downstream from the trap site. After 22 April radio contact was lost; ground or aerial searches were unable to locate Raccoon No. 39.

Raccoon No. 35

Raccoon No. 35 (adult female) was captured 27 January 1977 along the Calloway Island portion of the Little Tennessee River (Figure 11). During February and March foraging activities were concentrated along the Little Tennessee River and several small creeks. The raccoon on several occasions crossed the Little Tennessee River and fed in the idle fields of Calloway Island. Movement patterns and home range size were influenced after parturition (see text).

Raccoon No. 36

Raccoon No. 36 (adult female) was captured on the Calloway Island portion of the Little Tennessee River (Figure 12). The activities of Raccoon No. 36 were concentrated on Calloway Island. Telemetry data were limited with insufficient data for an accurate estimation of home range size. Raccoon No. 36 movements were similar to Raccoon No. 35 and suggest that the home range size

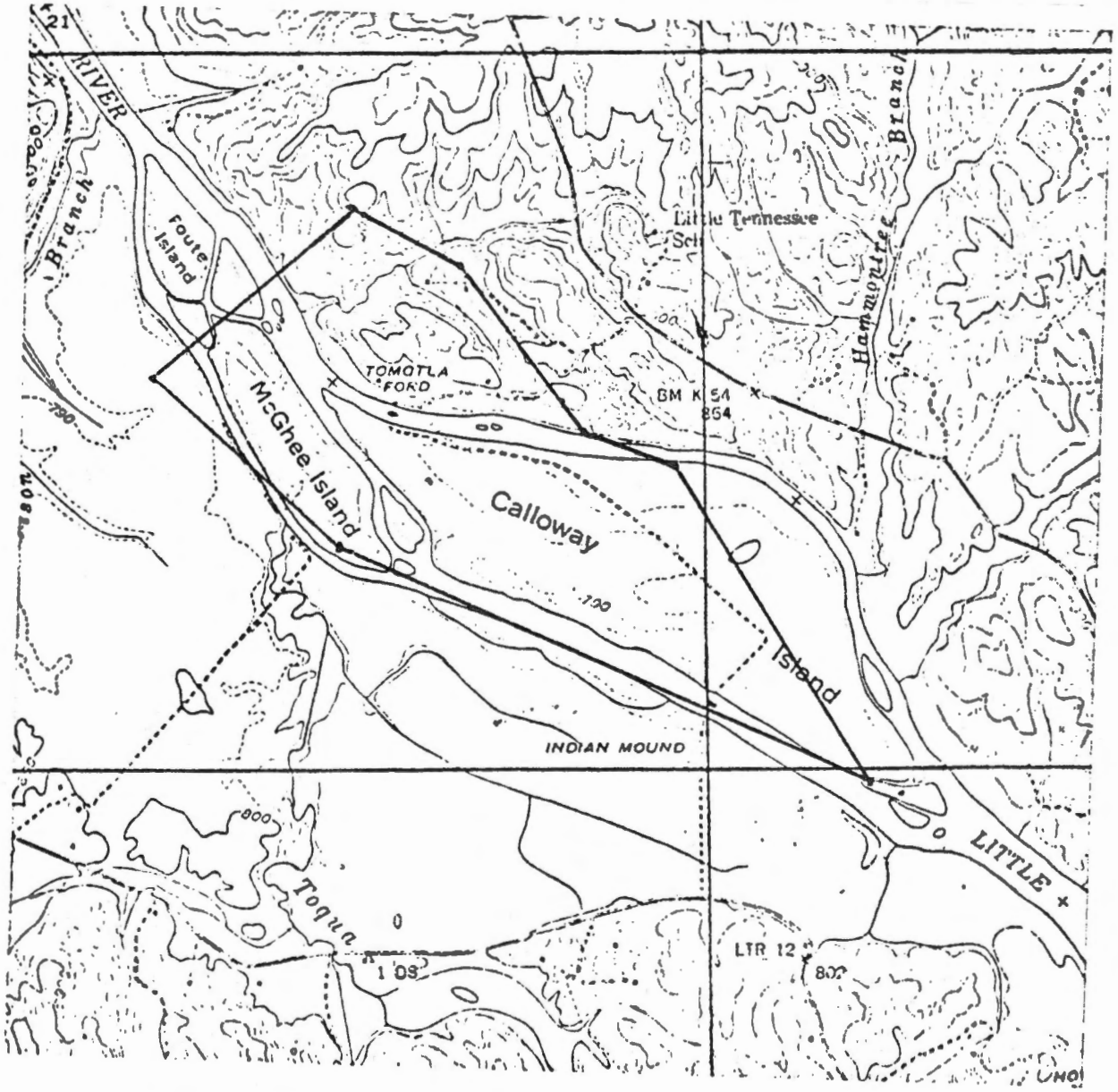

Figure 11. Spring and summer home ranges of Raccoon No. 35 (adult female) in East Tennessee.

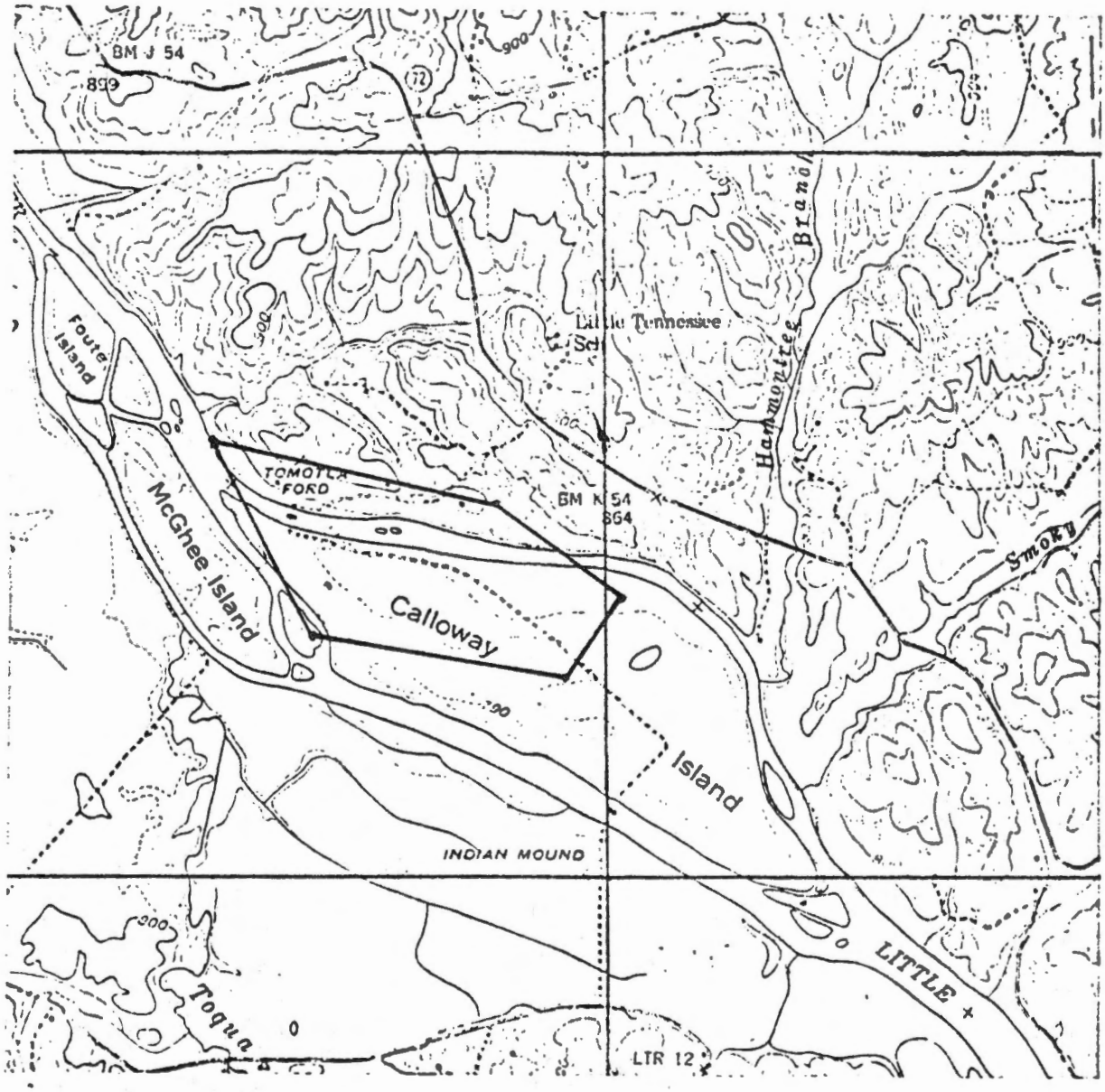

Figure 12. Spring home range of Raccoon No. 36 (adult female) in East Tennessee.

would have been similar. Raccoon No. 36 was illegally killed with the radio collar recovered in a house 8 km from Calloway Island.

Raccoon No. 25

Raccoon No. 25 (adult female) was captured 6 September 1977 on Chilhowee Mountain (Figure 13). Activities during September were concentrated in two areas. The first area of high raccoon utilization was along a small creek, which flowed into Harrison Branch. Raccoon No. 25 was very active along the upper portions of the creek. Denning usually occurred in tree cavities within 200 m of the creek. The raccoon was located on several occasions denning in rock outcrops. The second center of activity was along the ridge crest of Chilhowee Mountain. Denning usually occurred on the portion of the mountain facing the Little Tennessee River. Foraging activities while denning of the ridge crest were along Harrison Branch and the Little Tennessee River. Activities during October were primarily concentrated along the upper portion of the small creek which was utilized in September. Activity shifted for a two-day period along a portion of Harrison Branch north of the small creek and the ridge crests of Chilhowee Mountain. Raccoon No. 25 was recaptured 1 November along the Little Tennessee River approximately 600 m downstream from the junction of Harrison Branch. December activity patterns were similar to the activities in November.

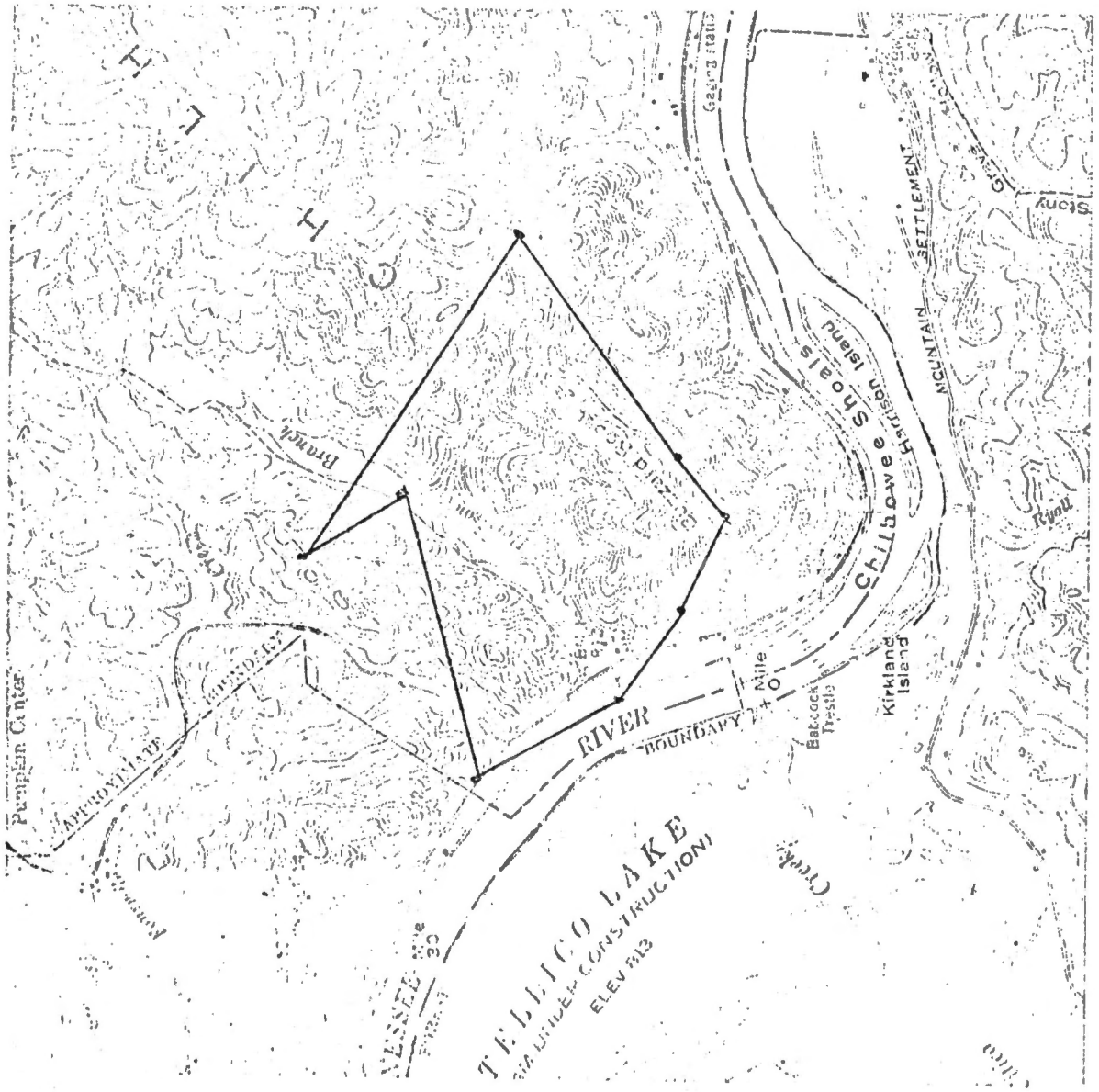

Figure 13. Fall home range of Raccoon No. 25 (adult female) in East Tennessee.

Raccoon No. 25 did not venture from the den during periods of low temperatures. Outside activities usually ceased with temperatures below -4° C, although activity inside the den was recorded.

Raccoon No. 40

Raccoon No. 40 (adult male) was captured 12 July 1977 along Negro Hollow Creek. Following release the raccoon moved 4,200 m from the original capture site and denned in a small woodlot. The next night the raccoon moved approximately 2,100 m and denned in a woodlot along the Little Tennessee River. During the next four days denning activities were confined to this woodlot. Foraging activities were concentrated along Baker Creek and the Little Tennessee River. The final eight days of the monitoring period, the raccoon concentrated denning activities in a woodlot along the Little Tennessee River approximately 900 m from the previous woodlot.

The movements of Raccoon No. 40 were much larger than other raccoons that were monitored during the study. Illegal hunting activities were concentrated in this area (Pers. comm. Robert Wolfe) and could possibly account for the extended movements. However, Raccoon No. 40 was reported to have been killed 13 April 1978 approximately 9.6 km SW of Jasper, Georgia (Pers. comm. K. Kammermeyer). Extensive movements by resident raccoons have not been reported in the literature and this suggested the

possibility that Raccoon No. 40 was an unauthorized stocked raccoon.

Raccoon No. 41

Raccoon No. 41 (adult male) was captured 8 August 1977 in the Cochran Creek Drainage of Shingle Mountain (Figure 14). Foraging activities were primarily on the lower slopes of Shingle Mountain. The raccoon periodically shifted foraging areas from a remote portion of the Cochran Creek to an area within the close vicinity of a house. The raccoon was noted on several occasions in a small cornfield. The movement patterns of Raccoon No. 41 when feeding in the cornfield were very restricted.

Raccoon No. 42

Raccoon No. 42 (adult female) and one offspring, which was lying next to the trap, were captured 5 August 1977 in the Cochran Creek Drainage of Shingle Mountain (Figure 15). The foraging activities of Raccoon No. 42 during August were primarily concentrated along a 1 km portion of Cochran Creek. Den sites were located on the lower slopes of Chilhowee Mountain. The movement patterns during October were less restricted but similar to those of September. The raccoon was located several times on the ridge crests along Shingle Mountain. The raccoon was located in December during an aerial search. The den site was in an area which had been utilized previously

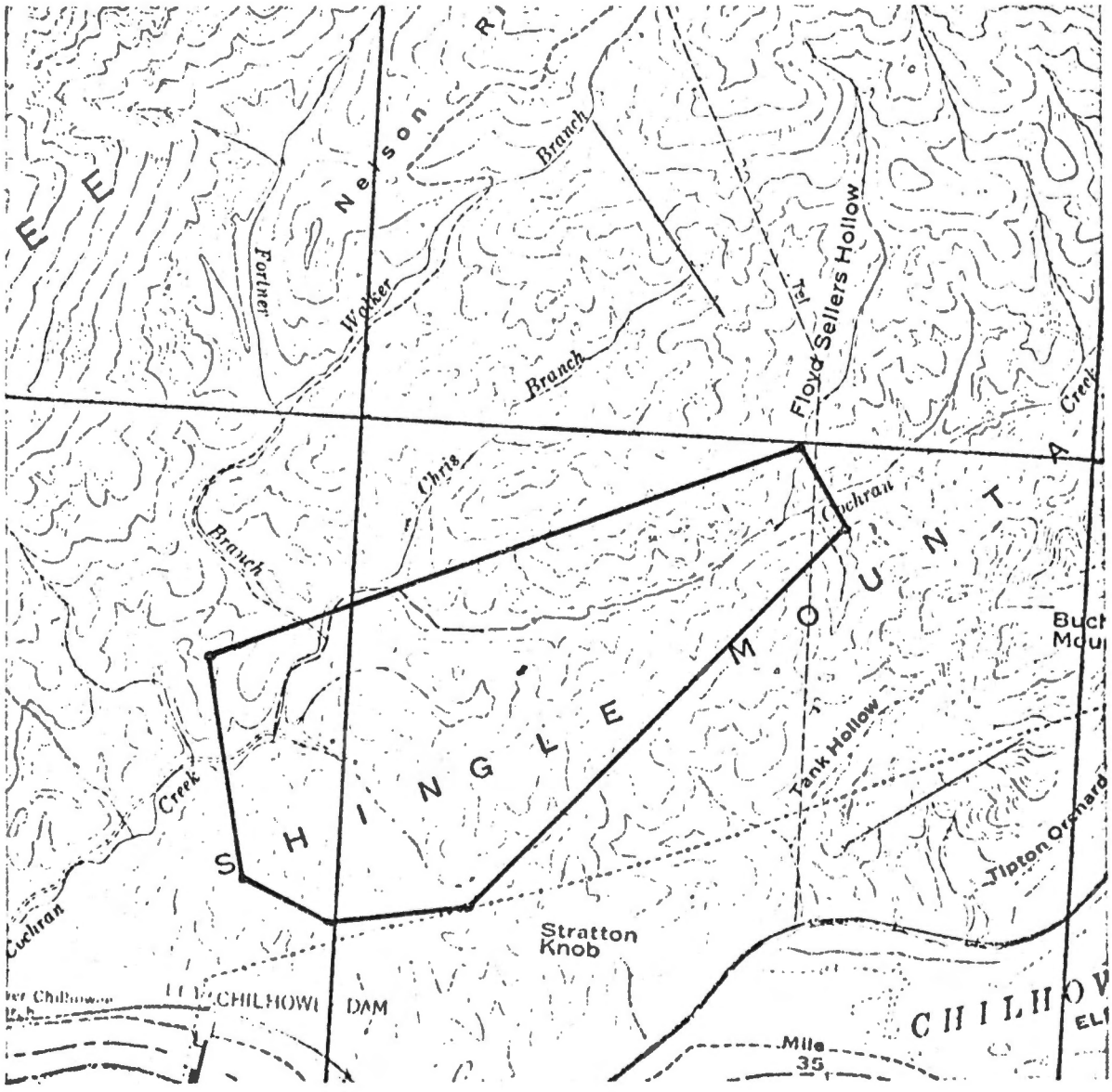

Figure 14. Fall home range of Raccoon No. 41 (adult male) in East Tennessee.

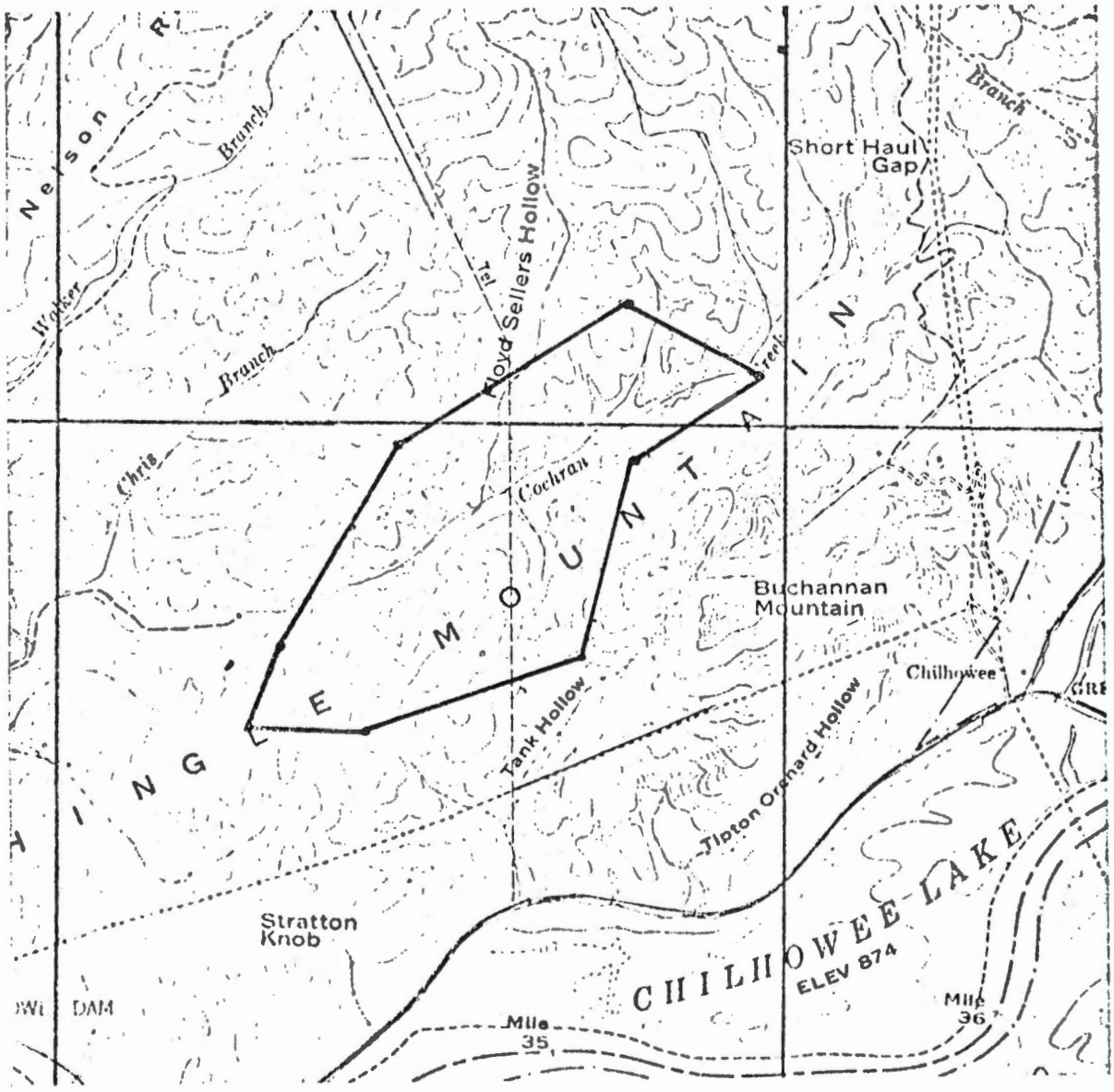

Figure 15. Fall and winter home ranges of Raccoon No. 42 (adult female) in East Tennessee.

during October. Raccoon No. 42 was located twice during January. The locations of the raccoon were in areas of previous activity, thus suggesting no large seasonal shift in habitat utilization.

Raccoon No. 26

Raccoon No. 26 (immature female) was originally captured 21 September 1976 in the Cochran Creek Drainage of Shingle Mountain (Figure 16). The age of the raccoon was estimated at 85.5 days. Raccoon No. 26 was recaptured 9 August 1977 at the original capture site and equipped with a radio transmitter. Foraging and denning activities during August and September were restricted primarily to a large drainage adjacent to a remote portion of Cochran Creek. The raccoon was located on several occasions along a 1 km portion of Cochran Creek. Raccoon No. 26 was located once during November. The den site was in an area where denning had previously occurred during the months of August and September. Raccoon No. 26 during the first week of December was located during an aerial search. The raccoon was denning in an area which had been previously utilized, thus indicating no large seasonal shifts in habitat utilization.

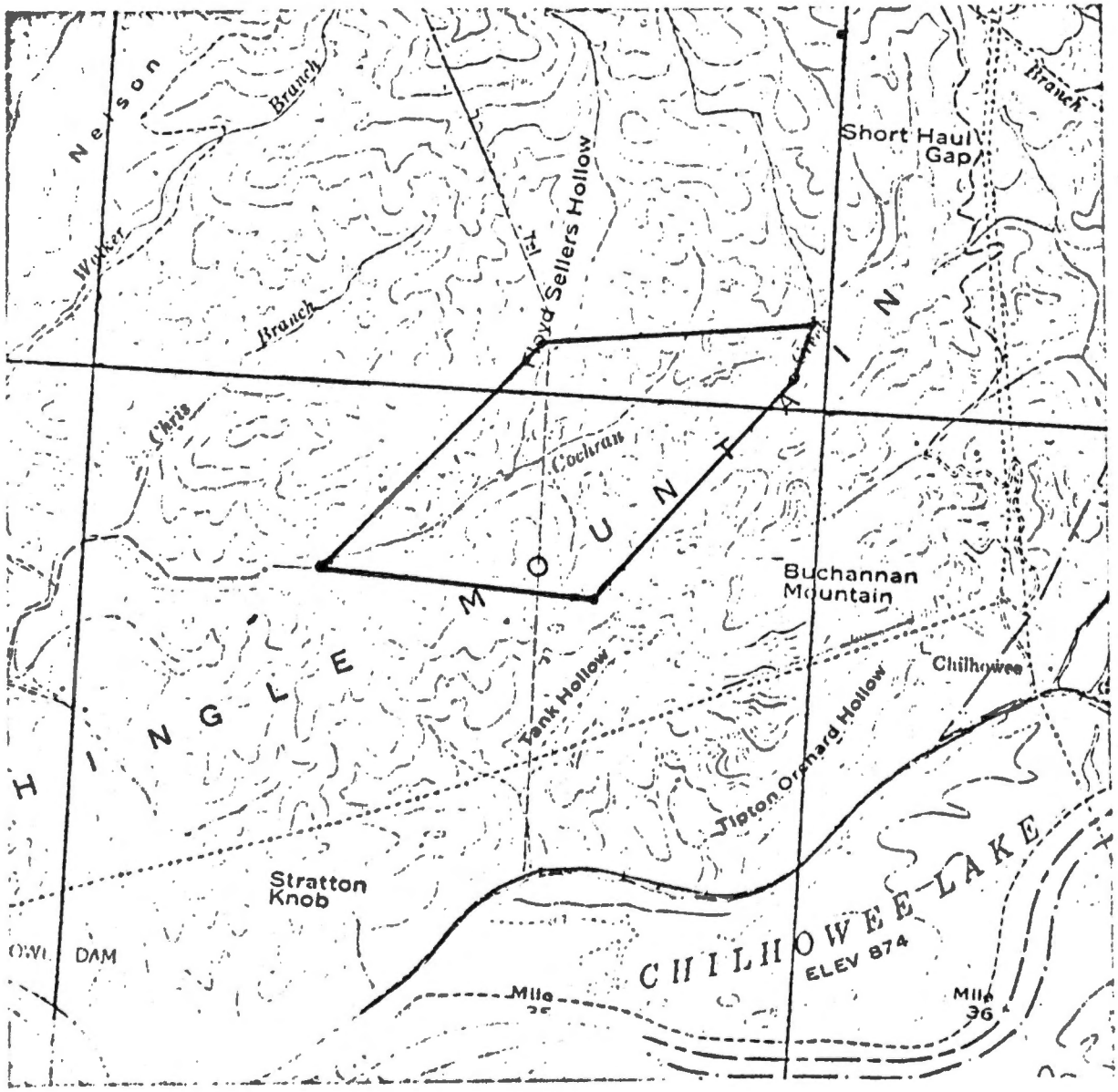

Figure 16. Fall and winter home ranges of Raccoon No. 26 (adult female) in East Tennessee.

VITA

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