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Date November 25, 1987

AN EVALUATION OF POPULATION ESTIMATORS, DENSITIES, AND SCENT-STATION INDICES OF A RACCOON POPULATION IN EAST TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

David M. Kocka

December 1987

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DEDICATION

This thesis is dedicated to my father, the late R. Peter Kocka, who had the wisdom of Solomon. His achievements during 50 years often served as a catalyst for me to pursue and complete a Master's degree.

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ABSTRACT

Population estimates and visitation rates of raccoons to scent-stations were compared for 2 study areas (control = 2588 ha; experimental = 2545 ha) on Chuck Swan Wildlife Management Area (CSWMA), Tennessee. Live trapping and scent-station data were collected from 5 July 1983 to 29 July 1985, during which time 3 nights (November - December, 1984) of managed raccoon hunting were conducted throughout the 9872 ha CSWMA peninsula, exclusive of the control area. Data also were collected during the 3-night, 1985 CSWMA raccoon hunting season.

In 6400 trapnights, 825 raccoon captures represented 328 individuals (1 raccoon/7.76 trapnights). Trapping success was significantly greater in the control area (17.39%) than in the experimental area (12.83%) ($P<0.001$). Seventy-nine raccoons were harvested in 1984 from all hunted compartments at a party success rate of 74%. Hunters harvested 39 raccoons in the experimental area in 1984 and 29 in 1985. The success of hunting parties was not related to the trapping success by compartment ($P=0.20$); however, there was a relationship between the average number of hectares available to a hunting party and their success ($P<0.003$).

The Jolly-Seber (J-S) and Petersen-II estimators were both influenced by heterogeneity of capture. Generally, higher estimates of raccoon density were produced for the control area than for the experimental area by all estimators. J-S estimates, which allow for recruitment, were the most robust for the fall raccoon population on CSWMA; CAPTURE's model M_h produced more robust spring estimates. Fall

density estimates, pooled across both areas, ranged from 1 raccoon/19.4 ha (1983) to 1 raccoon/11.6 ha (1984). Spring densities ranged from 1 raccoon/17.9 ha (1984) to 1 raccoon/14.3 ha (1985). In the experimental area the 1984 raccoon harvest comprised 15-24% of the Fall 1984 population.

During 25 months from 1983-85, 13 (52%) scent-station surveys were completed. Scent-station visitation by raccoons in the control area (5.02%) was not significantly higher than in the experimental area (4.07%) ($P>0.50$). After the 1984 raccoon harvest monthly visitation to scent-stations was 92% higher in the experimental than had occurred prior to these hunts. Maximum and minimum visitation in both areas occurred during summer and winter, respectively. However, neither season nor year were related to visitation rates. Within the control area higher visitation occurred in regions which experienced more raccoon captures/recaptures. This relationship did not occur in the experimental area. Population estimates were not related to visitation rates of raccoons to scent-stations in either the control area ($P=0.62$) or the experimental area ($P=0.58$).

Impact of a harvest on the CSWMA raccoon population was minimized through a reduced season length and use of a controlled harvest strategy. The role of hunter density on harvest success should be investigated through further research. Limited visitation to scent-stations rendered these surveys ineffective as a raccoon index for east Tennessee.

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CHAPTER I

INTRODUCTION

The raccoon (Procyon lotor) is Tennessee's state animal, and has been pursued for recreation and profit since pioneer days. There has been a resurgence in the popularity of raccoon hunting in the eastern region of the state. Since the 1950's, the number of raccoon hunters in Tennessee has declined slightly, while the number in east Tennessee has more than tripled from an estimated 2630 in 1951 to 9637 in 1969 (Whitehead 1975). In 1951 only 7% of Tennessee's raccoon hunters (37,569) were in the eastern region of the state; however, in 1986 25% of all the state's raccoon hunters (24,648) were in east Tennessee (C. Whitehead, Tennessee Wildlife Resources Agency (TWRA), pers. comm.). Statewide, over 23,800 raccoon hunters sold approximately 75,000 pelts in 1978 valued at $1,575,000 (TWRA 1979). Raccoons are one of the many furbearing species which historically have been considered abundant by State agencies in the southeastern U.S. (Sumner and Hill 1980). However, raccoons in many areas of east Tennessee were considered scarce as early as 1940 (Wing 1940, Minser and Pelton 1982).

Despite similar habitat capabilities, privately owned lands support fewer raccoons than parks or wildlife management areas where they are relatively dense for east Tennessee (Minser and Pelton 1982). Rabinowitz (1981) estimated the raccoon density in Cades Cove, Great Smoky Mountains National Park (GSMNP) to be 1 raccoon/17 ha. The raccoon density on CSWMA has been as high as 1 raccoon/14.7 ha

(Nottingham 1985). Hall (1978) and Warr (1978) found raccoon densities on privately owned lands too low to estimate. Even though relatively dense on wildlife management areas in east Tennessee, raccoons have been subject to periodic overharvest on these areas because of an increase in harvest pressure and a lack of harvest management. On CSWMA, during a 9-night season in 1976, 136 raccoons or 32% of the estimated population, were harvested by 638 parties (Woods 1978). This harvest level was too high to maintain sustained yields as indicated by a decline in success for the next 2 years, resulting in a closed season (Nottingham et al. 1982). A similar season closure also occurred from 1965-70 on CSWMA. When trapping was ineffective, night hunting successfully reduced a dense raccoon population on the Wheeler National Wildlife Refuge (WNWR), Alabama. No limit was placed on the number of dogs, number of hunters, or the number of raccoons allowed to be taken per party. Guns and axes were barred so raccoons were shaken out of trees (Atkeson and Hulse 1953). Raccoon hunting has the potential to deplete densities even in areas of optimum habitat such as WNWR. In areas of less than optimum habitat, such as east Tennessee's upland hardwoods, the impact of hunting on raccoon densities is believed more severe.

Although the biology of the raccoon is well documented, there is a scarcity of information on which to base sound management practices (Whitehead 1975). The percentage of raccoons which can be harvested on a sustained basis in east Tennessee is not presently known (Minser and Pelton 1982); without knowledge of this surplus, populations cannot be fully exploited without risking overharvest (Johnson 1982). Concurrent controlled raccoon hunting and population monitoring on an area, over a

given period of time, would provide data to determine such a surplus. Controlled hunting is defined by Scott (1948) as "the orderly harvesting of wildlife through an equitable and pre-determined distribution of hunter pressure." As early as 1948, at least 30 states had attempted a controlled harvest on either big or small game. Intensive management of white-tailed deer hunting has been conducted where hunters were assigned to specific stands from which to hunt (Roseberry et al. 1969). Similar harvest strategies for raccoons have not been documented.

Mark-recapture methods are perhaps the most widely used technique for assessing trends in furbearer populations (Clark and Andrews 1982). Mark-recapture is becoming less feasible due to the intensity and expense involved. Presently, the use of an index of relative abundance is becoming more common; this involves the counting of some animal sign believed to be related to the number of animals present (Davis and Winstead 1980). Scent-station surveys, which record animal tracks, have been conducted for furbearers in 10 (63%) southeastern states (Johnson and Pelton 1981). Scent-stations were initially conducted for foxes (Wood 1959). However, scent-stations were not used extensively until the U.S. Fish and Wildlife Service adopted the survey as a means to index coyote (Canis latrans) populations in the western U.S. (Linhart and Knowlton 1975). Subsequently, the technique has been used by many southern states to assess the relative abundance of furbearers (Johnson and Pelton 1981, Linscombe et al. 1983). In addition to their use for raccoons, scent-station surveys have been conducted for bobcats (Lynx rufus) (Brady 1979, Hon 1979) and opossums (Didelphis virginiana) (Leberg et al. 1983). Several states have conducted surveys for

assessing the abundance of several species (Sumner and Hill 1980, Morrison et al. 1981, Conner et al. 1983).

Despite the wide use of scent-station surveys to monitor population trends, data are lacking for comparing scent-station indices to known densities (Johnson and Pelton 1981, Clark and Andrews 1982, Conner et al. 1983). The assumption that scent-station visitation is consistently related to the density of a species has not been proven (Roughton 1979). Both Conner et al. (1983) and Linscombe et al. (1983) failed to provide population trend data from which an accurate calibration of the scent-station index could be obtained. Nottingham (1985) compared raccoon scent-station visitation and natural population trends, based on concurrent mark-recapture data, from 1981-83 on CSWMA. He concluded that there was no significant relationship between either raccoon population estimates or capture success and scent-station visitation rates.

It was the purpose of this study to determine whether scent-station surveys were able to detect a population reduction resulting from a controlled raccoon harvest on CSWMA. The following objectives were established: (1) to estimate the density of raccoons for spring (pre-recruitment) and fall (post-recruitment) based on mark-recapture techniques for 2 areas in CSWMA, (2) to evaluate the relationship between density and visitation rates to scent-stations for a harvested and an unharvested raccoon population.

CHAPTER II

STUDY AREA

Study Area Description

CSWMA is located approximately 40 km north of Knoxville, Tennessee in Union and Campbell counties. Access to the 9872 ha area is by secondary road west of State Highway 33, 16 km north of Maynardville, Tennessee, in Union County.

Lying within the Great Valley of east Tennessee, CSWMA is thereby part of the Ridge and Valley Province of the Appalachians (Fenneman 1938). This area is characterized by numerous elongated ridges which are steep-sided (Minckler 1946). The study area is bisected by a main central ridge, oriented in a northeast to southwest direction, with smaller ridges extending from it at right angles. Elevations range from 305 m along the reservoir shoreline to 512 m at Weaver's Knob. CSWMA is underlain by cherty and sandy dolomitic limestone of the Knox formation (U.S. Dept. Agriculture 1953). These soils are generally low in fertility, low in organic matter and strongly acidic. Drainage in the area is rapid due to quick subterranean drainage (lowlands) or steep slopes in combination with porous topsoils (uplands) (Rothacher 1953).

Three perennial surface streams and 4 springs are located on the area; other surface streams exist temporarily but generally they are dry during fall. Limestone sinks are common throughout the area, especially on the Clinch River side of the peninsula (Safley 1974). Eight major

caves exist on CSWMA; 2 minor ones were discovered recently by Nottingham (1985).

Climate of the area is temperate and continental. Data collected over a 15-year period indicated 117.4 cm of mean annual precipitation for the CSWMA (Summers 1968). The greatest precipitation occurs during winter (December-March) and mid-summer (July), while the driest period is from late summer to early fall (August-October). Union County weather data collected over 28 years indicated an average growing season of 174 days (Minckler 1946). Mean temperature is 3.3 C in winter and 23.8 C in summer (Rothacher 1953). Infrequent snowfalls remain on the ground only a few days.

A southern pine beetle (Dendroctonus frontalis) infestation during the mid-1970's changed the predominately southern pine (Pinus spp.) forest to one in which hardwoods are dominant. The forest cover on CSWMA is also a result of influences such as slope, exposure, and steepness of the topography (Minckler 1946). Yellow poplar (Liriodendron tulipfera) and yellow poplar-shortleaf pine (Pinus echinata) associations are found on northerly slopes whereas oak (Quercus spp.) and oak-pine (Pinus spp.) occur on the southerly slopes. Oak-hickory (Carya spp.) complexes are found on both slopes. A greater diversity of hardwoods, such as American beech (Fagus grandifolia), maple (Acer spp.), sycamore (Platanus occidentalis) and yellow poplar, is found in bottomlands. Presently, approximately 93% of the study area is forested, of which 85% is hardwoods (Nottingham 1985).

The area now recognized as CSWMA was first settled in the late 1770's or early 1780's (Safley 1974). Corn, wheat, and livestock

farming provided subsistence living. Remnants of buildings, cisterns, cemeteries, and former roads exist throughout the area. To complete its construction of Norris Dam, the Tennessee Valley Authority (TVA) purchased most of the land making up the management area in 1935 and 1936. Approximately 2400 persons resided on the 531 tracts of land at the time of the purchase (Lewis and Safley 1967). To develop the area's forest and wildlife resources, TVA transferred this land to the State of Tennessee in 1952. As late as 1981, 8 non-residing families still owned a total of 164 ha of land within the management area. TWRA and the Tennessee Department of Conservation, Division of Forestry condemned these parcels in 1981 and sold all permanent structures through a public auction in 1984 (P. Bledsoe, TWRA, pers. comm.).

The Division of Forestry is responsible for the management of the forest resource on CSWMA. Early management of the forest lacked continuity. However, long term planning, with even aged management for both hard and softwoods, is among the present objectives (Nottingham 1985). The area is managed by compartment. Presently there are 18 compartments. Additionally, the Division of Forestry maintains 144 km of developed roads on the area.

Management of Chuck Swan's wildlife resource is administered through TWRA. Management practices which favor white-tailed deer (Odocoileus virginianus) and wild turkey (Meleagris gallopavo) populations include controlled hunting. Adaptive species such as raccoons may take advantage of management practices designed for other species (Safley 1974). Fields, which comprise 7% of CSWMA, are leased to local farmers for corn or clover/orchardgrass production. Leasing

agreements were established to help control the presence of fescue in fields on CSWMA. Under most leasing agreements, 20% of each crop is left in the field. Generally, fields are rotated into the production of farm crops every 2-3 years to help remove fescue from the fields (P. Bledsoe, TWRA, pers. comm.).

Raccoon populations on CSWMA were probably limited and did not increase until protection was provided by TVA's acquisition of the land in the 1930's (Safley 1974). Hunting produced annual harvests ranging from 66 to 158 raccoons until harvest success decreased in the early 1960's. The season was closed from 1965-70 to allow the population to recover from a possible overharvest. Hunting was permitted from 1971-78 until an apparent overharvest resulted in another season closure (Nottingham et at. 1982). The raccoon season on CSWMA remained closed until 1984. Trapping of any furbearers was not allowed on CSWMA until a limited season was initiated in January 1986, at which time all furbearers could legally be trapped except raccoons. A single entrance road and a resident TWRA manager/law enforcement officer, reduce the likelihood of illegal raccoon hunting, thereby enhancing the area's research capabilities.

Study Area Choice

Two study areas of comparable size (control = 2588 ha; experimental = 2545 ha), adjacent to one another for logistical considerations, were established on CSWMA (Figure 1). Live-trapping of raccoons and scent-station surveys were conducted in both areas from

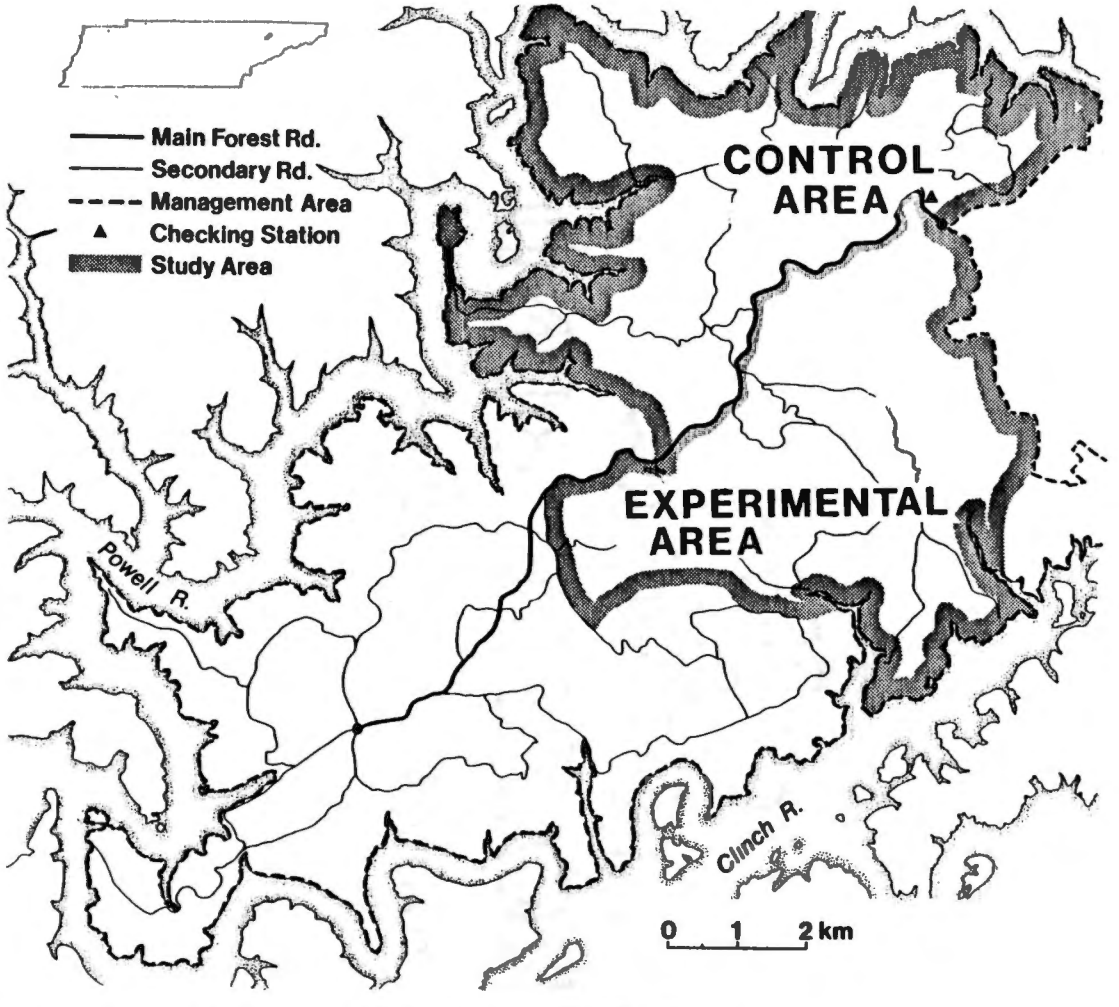


Figure 1. Map of the 2 study areas on CSWMA, Tennessee.

1983-85. In addition, controlled raccoon hunting was conducted throughout CSWMA, in 1984 and 1985, except in the control area. Butterfield (1944) found that raccoons are usually confined to 1 watershed and that ridges may constitute a physical barrier. Therefore, we assumed that the dividing ridge between the 2 areas restricted raccoon movements between them (Nottingham 1985).

CHAPTER III

MATERIALS AND METHODS

Population Estimation

Data Collection

Trapping. From 5 July 1983 through 29 July 1985, 40 collapsible live traps (Tomahawk Live Trap Co., Tomahawk, WI) were baited with sardines during 4 trapping periods. Each trapping period consisted of 20 independent nights of trapping in the control area followed by 20 nights in the experimental area. Trap sites were located in the center of circular plots with a radius of 0.8-km (0.5-mi), which were uniformly distributed throughout each study area. Trap spacing was based on estimated home range size of adult raccoons from east Tennessee (Hardy 1979). The radius of each circular plot was less than the average linear distance (1.6-km) traveled from original capture sites by raccoons on CSWMA in 1976 (Woods 1978). Road access influenced final positioning of traps in the field. Trap sites were re-used for the duration of the study. Seventy-four of the 80 trap sites were the same as those used by Nottingham (1985). Occasionally raccoons were able to reach into the baited end of a trap to steal the bait without being captured. Rocks and sticks, too dense to be moved by raccoons, were placed around the baited ends of the traps to eliminate bait theft. An increasing amount of materials were placed around traps until bait theft

was no longer recorded at that particular site. Sardine packing oil was poured in and around the trap to help disperse the bait scent.

Live traps were checked and re-baited daily. Captured raccoons and foxes were immobilized by injecting with Ketamine hydrochloride (Bristol-Myers Co., Syracuse, NY), at a dosage of 0.2 cc/kg of estimated body weight (Bigler and Hoff 1974). An aluminum jab stick, with a syringe on the end, was used to administer the drug. Once sedated, animals were sexed, aged, weighed, and standard morphological measures were taken. Adult raccoons were aged according to tooth wear (Grau et al. 1970) which allows the placement of raccoons into 1 of 5 relative age groups: 0-14 months, Class 1; 15-38 months, Class 2; 39-57 months, Class 3; 58-86 months, Class 4; and over 86 months, Class 5. This method proved to be 82.7% accurate in a known age sample. Preweaned raccoons were aged according to eruption of deciduous and permanent teeth (Montgomery 1964); accurate ages of raccoons up to 111 days old can be obtained. Foxes were aged as either adult or juvenile. Reproductive condition, ectoparasites, and overall body condition of raccoons and foxes were also noted. Raccoons and foxes were tagged with a plastic, enumerated Rototag (Nasco, Ft. Atkinson, WI) in the base of each ear. Tags were color coded according to the sex of the raccoon; males received red tags and females received yellow tags. Recaptured individuals were identified and released if both ear tags were legible and intact. Illegible or lost ear tags were promptly replaced. All captured animals were released at capture sites.

Data sheets utilizing a computer format for efficient entry of data into data files were completed for each capture or recapture of a

raccoon or fox. Minimum and maximum temperature, overnight weather conditions (overcast, fog, clear) and the occurrence or absence of rainfall was also recorded for each trapping date.

Hunting. Controlled raccoon hunting was conducted on 12 November, 14 November, and 10 December, 1984. Additional data were collected during the 1985 raccoon hunts conducted on 18 November, 20 November, and 2 December. Regulations specifying a maximum hunting party size of 3 persons, assigned hunting areas (compartments), and an 0200 hour maximum check out time, were made available to the public. Additional rules included a 1 dog/hunter limit and a bag limit of 1 raccoon/party/night. Applicants were required to submit names and hunting license numbers of party members to receive a 1-night hunting permit. Forty-four permits were issued for each hunt on a first come basis by TWRA. Each permit allowed 1 party (1-3 persons) to hunt.

CSWMA comprises 18 management compartments, 5 of which are located in the control area which was not hunted (Figure 2). Five compartments are located within the boundaries of the experimental study area; 8 compartments comprise an additional area of 4739 ha. This area was designated the remaining hunted area (RHA). On the night of each hunt, persons possessing the proper permit were required to wait at the CSWMA checking station until approximately 1800 hours. At 1800 hours, the rules were read aloud to the group, the assignment process was described, and a list of registered party leaders was read aloud. Party attendance was recorded and each party received a map of the areas which could be hunted (Figure 2). The parties were assigned to a compartment

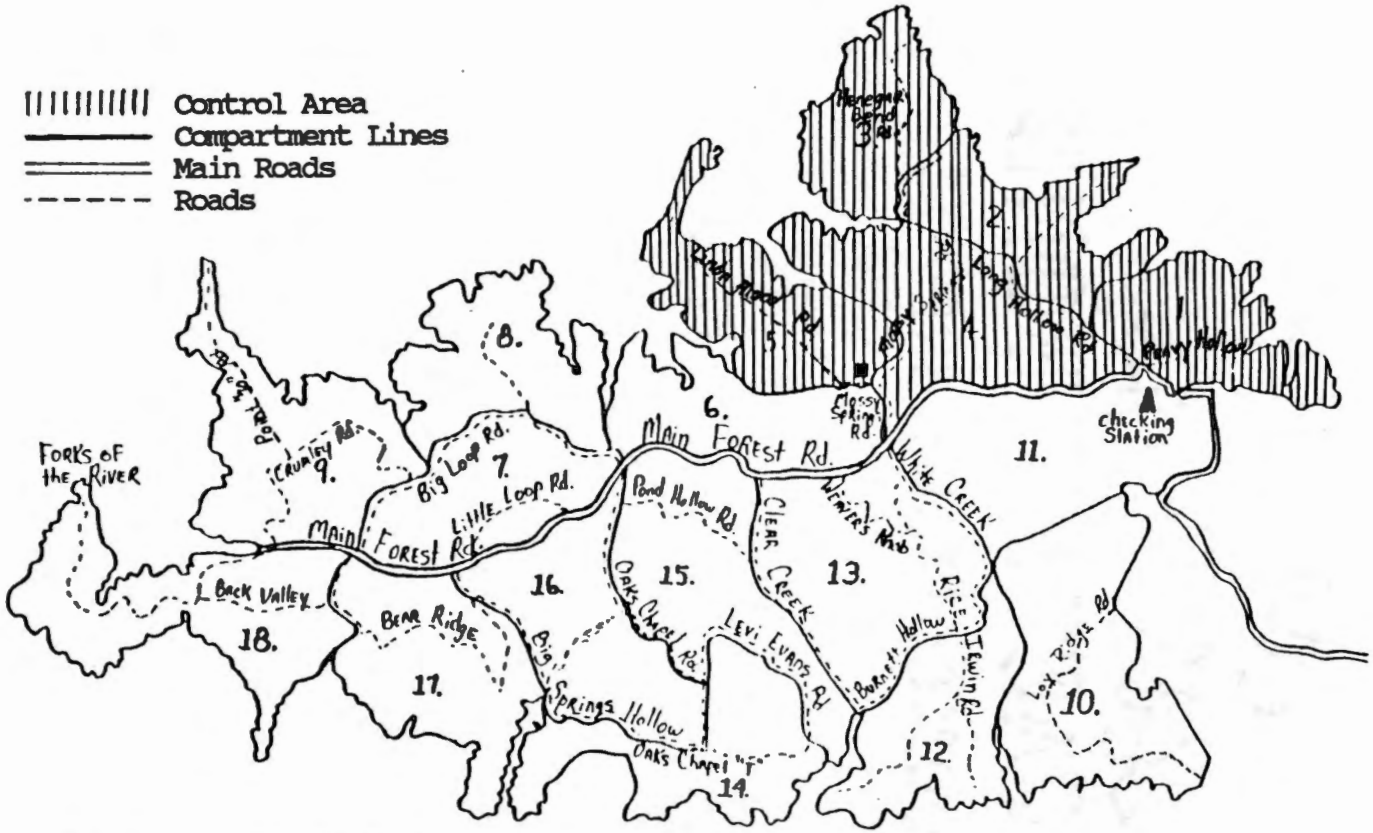


Figure 2. Map of the management compartments on CSWMA.

by a lottery. The first 20 parties drawn were assigned to a compartment of their choice (if possible) within the experimental study area, at a density of 4 parties per compartment. The RHA was assigned parties (after the experimental area was filled) at a density of 3 parties per compartment, or until each party was assigned to a compartment. A list of party assignments was maintained for each night to insure that no more than the correct number of parties was assigned to any one compartment.

Once assigned to a compartment, a party received a card with their compartment number and party assignment number. Therefore if they were the first party assigned to compartment 10 then they received the card with 10-1 printed on it. This card was to be left in their vehicle's windshield so TWRA personnel could verify that parties were in the correct management compartment. After a party received its windshield card it was allowed to begin hunting.

Harvested raccoons were brought intact to the checking station. After data were collected on external features hunters were allowed to skin their raccoon. Once skinned, an internal examination was performed. Data collected on harvested raccoons were the same as that for trapped individuals. Reproductive tracts of females were also collected. Reproductive tracts were examined for the presence of placental scars (Sanderson 1950) in order to estimate average raccoon litter size.

Data Analysis

Study Statistics. Data files containing capture, trap activity, and harvesting or raccoons were created, edited, and stored on the DEC-system-10 (DEC) Computer, U T Computing Center (UTCC). The Statistical Analysis System (SAS) (SAS 1979) was invoked through the DEC-IBM interface at UTCC to edit, compile, subset, summarize, and perform statistical analysis on capture and harvest data. Chi-square tests were conducted on sex ratio data to determine goodness-of-fit to a 1:1 ratio. The effects of month and year on capture success of raccoons were tested through the use of a least-squares analysis of variance (ANOVA).

Capture success was adjusted to minimize the effect of traps sprung by either target or non-target species, thereby providing a more appropriate measure of animal abundance (Nelson and Clark 1973). The adjusted proportion was calculated as follows:

$$CE = \frac{A \times 100}{(TU - IS / 2)}$$, where

CE is catch per effort presented as a percentage, a is the number of animals of the target species trapped, TU is the number of trap units, I is the length of trapping interval (always 1 night), and S is the total number of traps sprung by all causes.

POPulation ANalysis (POPAN), described below, calculated survival estimates and associated variance estimates. Standardizing of survival estimates (Nottingham 1985) was not necessary since sampling periods were generally completed within 2 months time. The following test statistic:

$$Z = \frac{\hat{s}_1 - \hat{s}_2}{[\text{var}(\hat{s}_1) + \text{var}(\hat{s}_2)]^{\frac{1}{2}}}$$

was used to compare survival estimates for the 2 study areas. The survival estimate for the control area was designated by $\hat{s}_1$ while the estimate for the experimental area was $\hat{s}_2$.

The recapture rates of tagged raccoons were examined through a chi-square contingency table. This test was conducted to evaluate age as a source of heterogeneity which could bias population estimates. Heterogeneity is any source of variation which results in capture probabilities that vary among animals (White et al. 1982). Only data from the second and third trapping periods were used, therefore sample sizes should be minimally influenced by mortality. Period 2 was the marking period and period 3 the recovery period. The 3 age categories utilized were Class 1, Classes 2 and 3, and Classes 4 and 5. A 3x2 contingency table was comprised of the totals of tagged raccoons recovered versus those not recovered in period 3.

Throughout this project the grouping of months into seasons was treated as : winter, December - February; spring, March - May; summer, June - August; fall, September - November. The significance level for all testing was P=0.05.

Open Model Estimator. Open and closed population estimators were used throughout this study. Closed population models assume demographic (no births or deaths) and geographic closure. Open models only assume geographic closure (White et al. 1982). Analyzing appropriate data in

both open and closed models can provide comparative estimates for evaluating model robustness (Pollock 1982).

Open population estimates were computed through the use of the POPAN (Arnason and Baniuk 1980) computer program. This program uses a range of variations of the J-S model (Jolly 1965, Seber 1965) to calculate population estimates; the present study design probably satisfied most of the J-S model's assumptions (Nottingham 1985). The full J-S model which allows for immigration, emigration, recruitment, and mortality over a sample period, was used to calculate population size and variance estimates. The J-S model assumes that capture probabilities vary only by night.

Within each sample period, data were pooled so only an individual's first capture was recorded for evaluation by POPAN (Arnason and Baniuk 1980, Pollock 1982, Nottingham 1985). Pooling is suggested since we are only interested in whether an individual was captured at least once during the trapping period. This approach allows the population to be considered approximately closed over the 20-night period and increases precision among all J-S estimates (Nottingham 1985).

Raccoons with capture histories indicating they utilized both areas were excluded from the population analysis. Individuals that were captured more than twice in both areas were omitted. Nottingham (1985) omitted 13 individuals from the analysis of 1981-83 population data because they had exhibited such movements. Several of these individuals eventually maintained consistent capture histories (2 sample periods in 1 study area) during the present study, and therefore, were included in this analysis. Seven (2.1%) of the 328 individuals captured, roughly

half the number omitted by Nottingham (1985), were omitted from this analysis.

Four 20-night trapping periods provided data used in the J-S analysis. Under general J-S model constraints, estimates are not produced for the first and last sampling periods. However, an estimate was produced for Fall 1983 because the initial marking period was conducted by Nottingham (1985). Likewise, a follow-up sample period (Fall 1985) provided the data necessary to produce a J-S estimate for Spring 1985.

Closed Model Estimators. Two estimators provided closed population estimates. Trapping data from Spring 1984 and 1985 were analyzed by the program CAPTURE (Otis et al. 1978); spring trapping was conducted in a relatively short time frame prior to reproductive recruitment, thereby meeting the assumption of closure. CAPTURE tests for closure, selects the appropriate model, and estimates the population size. Goodness-of-fit tests of trapping data determine which is the best model (of 8 possibilities) for calculating population size. CAPTURE's models were developed to relax the equal-catchability assumption (Otis et al. 1978). Animal capture probabilities varying by time, behavior, individual and combinations thereof, are the basis for the 8 models (Otis et al. 1978). For the CAPTURE analysis all raccoons which were previously-marked by myself or Nottingham were treated as newly captured individuals (K. Pollock, S.E. Coop. Wildl. and Fish Stat. Proj., pers. comm.).

The second closed population estimator used was Chapman's modification of the Petersen estimator (Seber 1982). The Petersen-I

estimates, which were generated from the 1984 and 1985 harvest data, considered the previous sample period as the marking period. To produce an estimate from the harvest data for Fall 1984 (resample period), then the Fall 1984 trapping period was considered the marking period. The second format used to produce Petersen estimates (Petersen-II) followed Nottingham's (1985) approach in which each 20-night trapping period was divided into a 10-night marking period and a 10-night resampling period. Animals marked prior to the specified marking period were considered newly captured for both Petersen formats. All Petersen estimates were calculated by utilizing the following formula:

$$\hat{N} = \frac{(M + 1)\ (n + 1)}{(m + 1)} - 1 \quad \text{, where}$$

$\hat{N}$ is the estimated population; M is the number of animals caught in the first sample (marking period); n is the number of marked and unmarked animals caught in the second sample (resampling period); and m is the number of marked animals in the second sample. The variance formula for this estimator is:

$$\text{Var}\ (\hat{N}) = \frac{(M + 1)\ (n + 1)\ (M - m)\ (n - m)}{(m + 1)^2\ (m + 2)}$$

Standard error of the estimate, divided by the estimate itself, produced coefficients of variation (CV) for all population estimates. Coefficients of variation allow comparisons of relative precision between open and closed estimates (Lefebvre et al. 1982). Furthermore, 95% confidence intervals (C.I.) (Otis et al. 1978) were calculated for each estimate.

Scent-Station Surveys

Data Collection

Four scent-station transects, consisting of 10 stations each, were established in each study area (Figure 3) (Nottingham 1985). Both study areas were comparable in size, so that sampling intensity was equivalent between the control and experimental areas. Located within 12-m of the road's edge, scent-stations were generally on alternating sides of a continuous 2.9-km (1.8-mi) route at 0.32-km (0.2-mi) intervals. However, scent-stations were not placed to maximize the likelihood of a raccoon visit, as has been developed in west Tennessee (Leberg and Kennedy In press).

Each scent-station was activated by 2 persons (with a box sifter) sifting topsoil over the 0.91 m cleared, circular plot. A cottonball saturated with synthetic fatty acid scent (FAS) (Roughton 1979) was placed in the center of the station on a wooden tongue depressor. FAS (Pocatello Supply Depot, Pocatello, ID) was chosen because of its attractability to several species and quality control (Morrison et al. 1981, Nottingham 1985). A thumb print was left in the sifted surface to serve as an indicator of the "readability" of the track surface.

The 8 lines were run concurrently and were activated by 2 field teams of 2 persons; each team prepared 4 lines. Each field team, working out of a truck loaded with topsoil, had a map detailing scent-station location. The day following activation, all animal tracks were recorded and the tongue depressors (with cottonballs) were removed. All

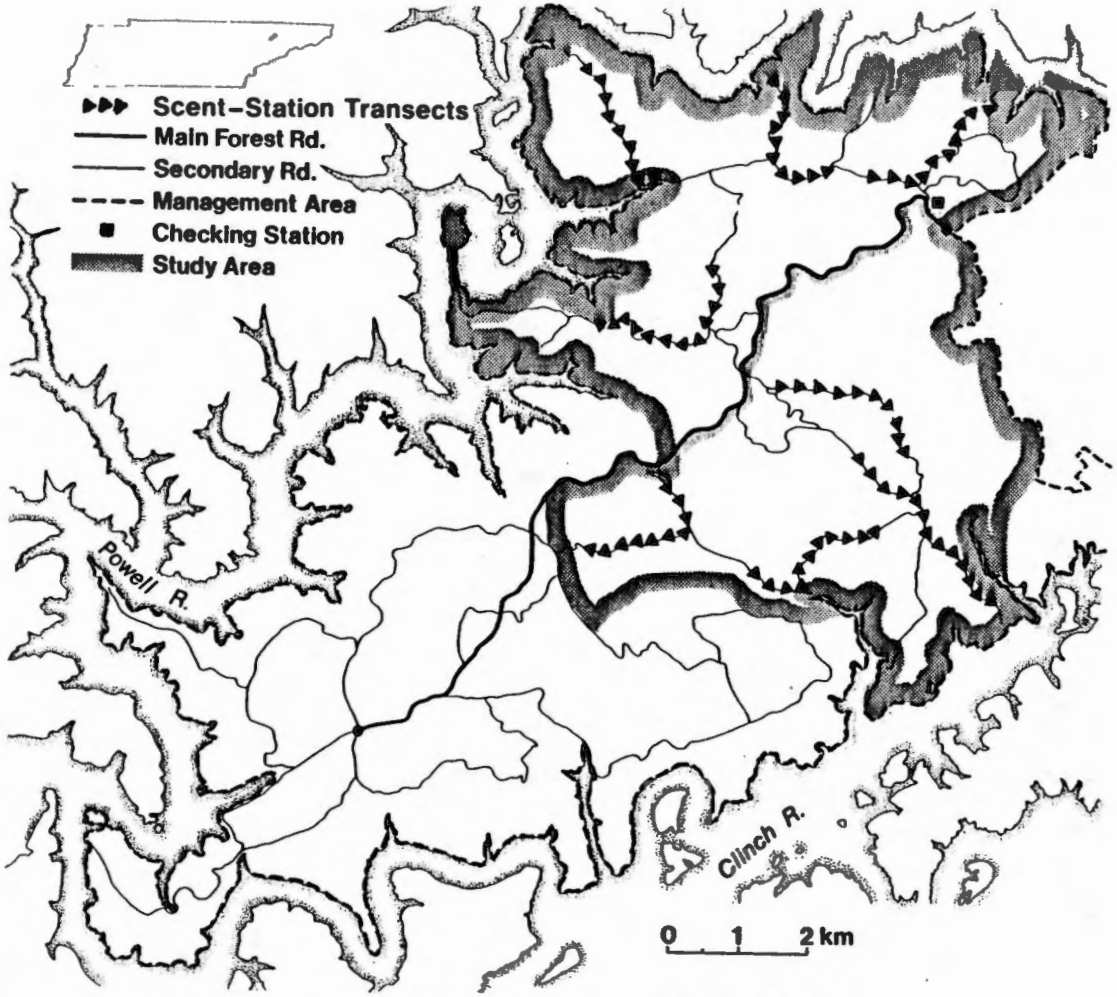


Figure 3. Map of scent-station survey transects on CSWMA.

stations were considered operable unless they were destroyed by weather (Roughton 1979). This was done to standardize the technique and to reduce investigator subjectivity. Data recorded for each survey included station number, line number, track surface condition, precipitation 24 hours prior to survey, wind condition, and maximum and minimum temperatures. When surveys were conducted during trapping periods, traps were closed to prevent inhibiting raccoon movements.

Data Analysis

Species visitation rates (%) were calculated by dividing the total number of visits of a species by the total number of operable stations per line. Data were arcsine transformed because experimental errors were not likely independent or normally distributed with a common variance (Steel and Torrie 1960, Nottingham 1985). If the average visitation rate of raccoons to a line was zero prior to the transformation, this zero value was substituted with 1/4(n) to improve the equality or variance in the angles (Steel and Torrie 1960). Each sample unit or line consists of 10 stations, therefore n=10.

Relationships between visitation rates and survey lines, seasons, and years were performed through the use of least squares analysis of variance (ANOVA). Linear regression was used to analyze the relationship of visitation to survey replication. A mean visitation rate for each survey was considered the dependent variable. Visitation rates of raccoons to scent-stations were calculated for each of the 4 trapping periods. The relationship between visitation rates and population estimates was evaluated by Spearman correlation analysis.

CHAPTER IV

RESULTS AND DISCUSSION

Population Estimation

Study Statistics

Trapping. From 5 July 1983 to 29 July 1985, 4 20-night trapping periods were conducted resulting in 6400 trapnights. Each trapnight consisted of 1 night that 1 trap was open. Therefore, each trapping period represented 800 trapnights (20 x 40) in each area. The 2 study areas produced 825 total captures representing 328 individual raccoons (1 raccoon/7.76 trapnights). In the control area 470 captures consisted of 182 individuals. The mean number of captures per individual was 2.58 in the control area. The experimental area produced 355 captures of 158 individuals with a mean of 2.25 captures per individual. The total for each area included 12 individuals that were captured in both areas. A complete capture history for each raccoon is provided in Appendix B. Eleven non-target species were captured 627 times (Appendix C). The mean adjusted raccoon trapping success for this study was 15.05% (Table 1). Trapping success was significantly greater in the control area (17.39%) than in the experimental area (12.83%) ($t=64.14$, $P<0.001$).

Monthly and seasonal trapping success varied considerably (Figures 4 and 5). The highest trapping success occurred during spring (27.9%) in both areas, followed by summer (10.4%) and fall (7.0%). Nottingham

Table 1. Adjusted trap success (%) for the 2 study areas, CSWMA, 1983-85.

Sample Period	Control Area	Experimental Area	Mean
Fall 1983	9.49	3.56	6.52
Spring 1984	22.86	19.37	21.11
Fall 1984	12.83	13.34	13.08
Spring 1985	24.38	15.06	19.72
Mean =	17.39	12.83	15.05

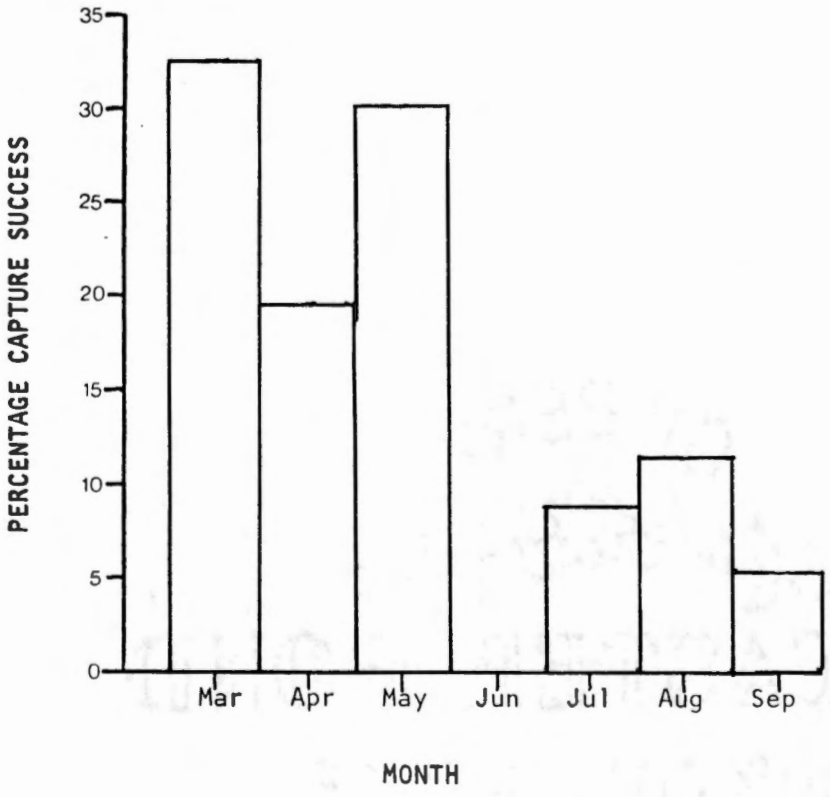


Figure 4. Monthly capture success of raccoons caught in the control area, CSWMA, 1983-85.

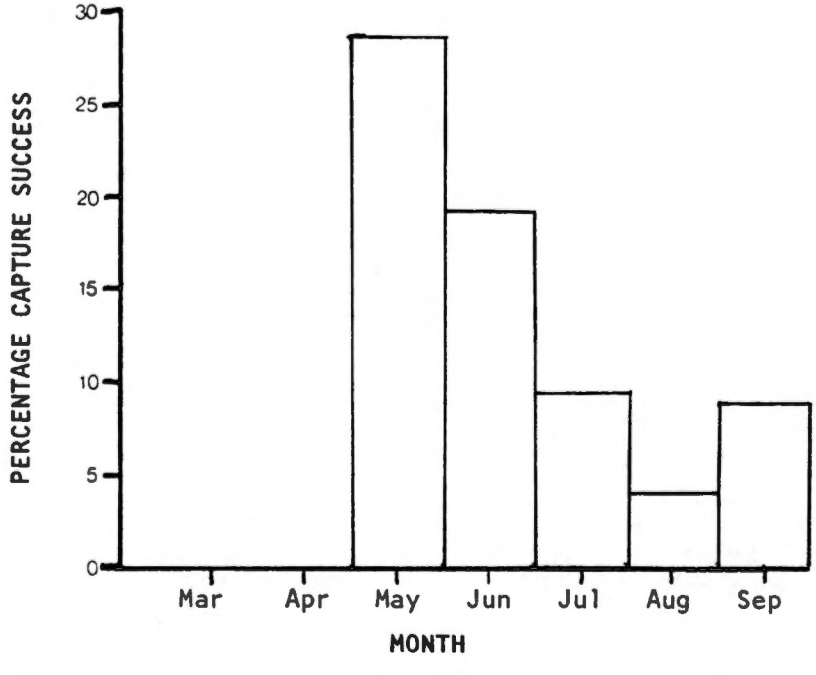


Figure 5. Monthly capture success of raccoons caught in the experimental area, CSWMA, 1983-85.

(1985) reported higher trap success for summer than in spring for these same 2 study areas. Peak breeding activity (Appendix A) occurred in April which does not correspond to the peaks in monthly trapping success. Movements of raccoons are related to the availability and preference of foods (Johnson 1970). Trapping on CSWMA was probably influenced by food availability (Keeler 1978, Moore 1983) because most natural foods, as well as the planted crops on CSWMA, are not available until mid- to late-summer.

Trapping success in the control area was significantly influenced by month ($F=36.40$, $P=0.03$) and season ($F=9.10$, $P=0.02$), whereas the experimental area was not influenced by either ($F=1.58$, $P=0.42$; $F=3.09$, $P=0.15$, respectively). To maintain trapping success traps were only run 5-6 consecutive nights and then closed for 3-5 nights. Therefore, it would require 30-40 nights to conduct a 20-night sample period. In both spring and fall, the control area was trapped before the experimental area. Furthermore, fall trapping was initiated as late as possible to insure the capture of young-of-the-year raccoons. However, once the fall trapping was begun each 20-night period was conducted in as close to 20 nights as possible. Subsequently, the period in which trapping was not conducted (i.e. the time between the spring and fall trapping periods) was longer in the control area than in the experimental area. This difference, and a possible difference in the level of natural foods available, may have influenced trapping success in the control area by month and season. Trapping success did not differ significantly between years in either the control area ($F=1.49$, $P=0.31$) nor in the experimental area ($F=1.91$, $P=0.26$).

With data from both areas combined, trapping success was not influenced by maximum daily temperature ($F=1.02$, $P=0.32$). However, success was significantly influenced by minimum overnight temperature ($F=41.16$, $P<0.0001$) and the difference between minimum and maximum daily temperatures ($F=8.59$, $P=0.0039$). Trapping success was highest during spring on CSWMA. Warm days with cool evenings were optimum for raccoon movements. Minimum overnight temperature is the greatest influence on nightly movements of raccoons (Johnson 1970, Rabinowitz 1981), which might need to be considered when conducting population indices, such as scent-station surveys.

Hunting. During November and December 1984, a total of 107 hunting parties participated in 3-nights of raccoon hunting on CSWMA. A total of 110 parties hunted the 3-night 1985 season. A survey of hunters who participated in the 1984 hunts indicated that 76% liked the way the hunt was managed and 98% would return to hunt CSWMA the following year (Kocka and Pelton, Univ. of TN., unpubl. data). Data gathered from hunter permit applications indicated a mean party size of 2.68 persons for 1984, although the actual mean party size was probably lower because some party members were unable to attend. Similar data for 1985 were not available. In 1984, 79 raccoons were harvested from all hunted compartments (7284 ha) for a party success rate of 74% or 1 raccoon/276 ha. Sixty-seven raccoons were harvested during 1985 for a success rate of 61% or 1 raccoon/326 ha. Data on harvested individuals is provided in Appendices D and E. Under less stringent guidelines during the 1976 season, 638 hunting parties harvested 136 raccoons from the entire

management area over 9 nights, resulting in a party success rate of 21.3% or 1 raccoon/653 ha (Woods 1978).

Within the experimental study area, 39 raccoons were harvested in 1984 at a party success rate of 65% for the 3 nights (range = 55 to 85%) (Table 2). Mean hunting party success in the experimental area decreased by 26% from 1984 to 1985 (Table 3). Twenty-one tagged individuals were harvested in 1984, and 17 in 1985. One tagged individual each year was harvested outside the experimental area. Success of raccoon hunting parties differed significantly between the experimental area ($\bar{X}$=57%) and RHA ($\bar{X}$=80%) when data were averaged across years ($F=56.29$, $P<0.0001$). Hunting success in the experimental area for the first and third hunts in 1984 was the same (55%); likewise hunting success in the RHA for these 2 nights varied by only 3% (Figure 6). On 14 November 1984, the experimental area experienced a 55% increase in hunting party success while a 23% decrease in success occurred in the RHA. During 1985, hunting success in the RHA varied little between nights, whereas success in the experimental area declined constantly, as evidenced by a 42% decrease from 18 November to 2 December. When analyzed by area, hunting party success differed significantly between years in the experimental area ($F=20.99$, $P<0.0001$) but not in the RHA ($F=0.30$, $P=0.59$). Although several investigators have reported a relationship between temperature and hunting party success (Johnson 1970, Woods 1978, Holman 1983), no such relationship was found for the combined 1984 and 1985 CSWMA data ($F=0.99$, $P=0.32$). Likewise, neither cumulative harvest (both areas) ($F=0.30$, $P=0.58$) nor trapping success by compartment (experimental area) ($F=1.68$, $P=0.20$) was related to hunting

Table 2. Harvest data from 3 nights of raccoon hunting for the Experimental area and Remaining hunted area, CSWMA, November - December, 1984.

Date	No. Parties in Experimental Area	No. Raccoons Harvested	Experimental Area Party Success, %	No. Parties in Remaining Hunted Area	No. Raccoons Harvested	Remaining Hunted Area Party Success, %
12 Nov.	20	11	55	20	18	90
14 Nov.	20	17	85	13	9	69
10 Dec.	20	11	55	14	13	93
Total / Mean	60	39	65	47	40	85

Table 3. Harvest data from 3 nights of raccoon hunting for the experimental area and remaining hunted area, CSWMA, November - December, 1985.

Date	No. Parties in Experimental Area	No. Raccoons Harvested	Experimental Area Party Success, %	No. Parties in Remaining Hunted Area	No. Raccoons Harvested	Remaining Hunted Area Party Success, %
18 Nov.	20	12	60	21	16	76
20 Nov.	20	10	50	17	13	76
02 Dec.	20	7	35	12	9	75
Total / Mean	60	29	48	50	38	76

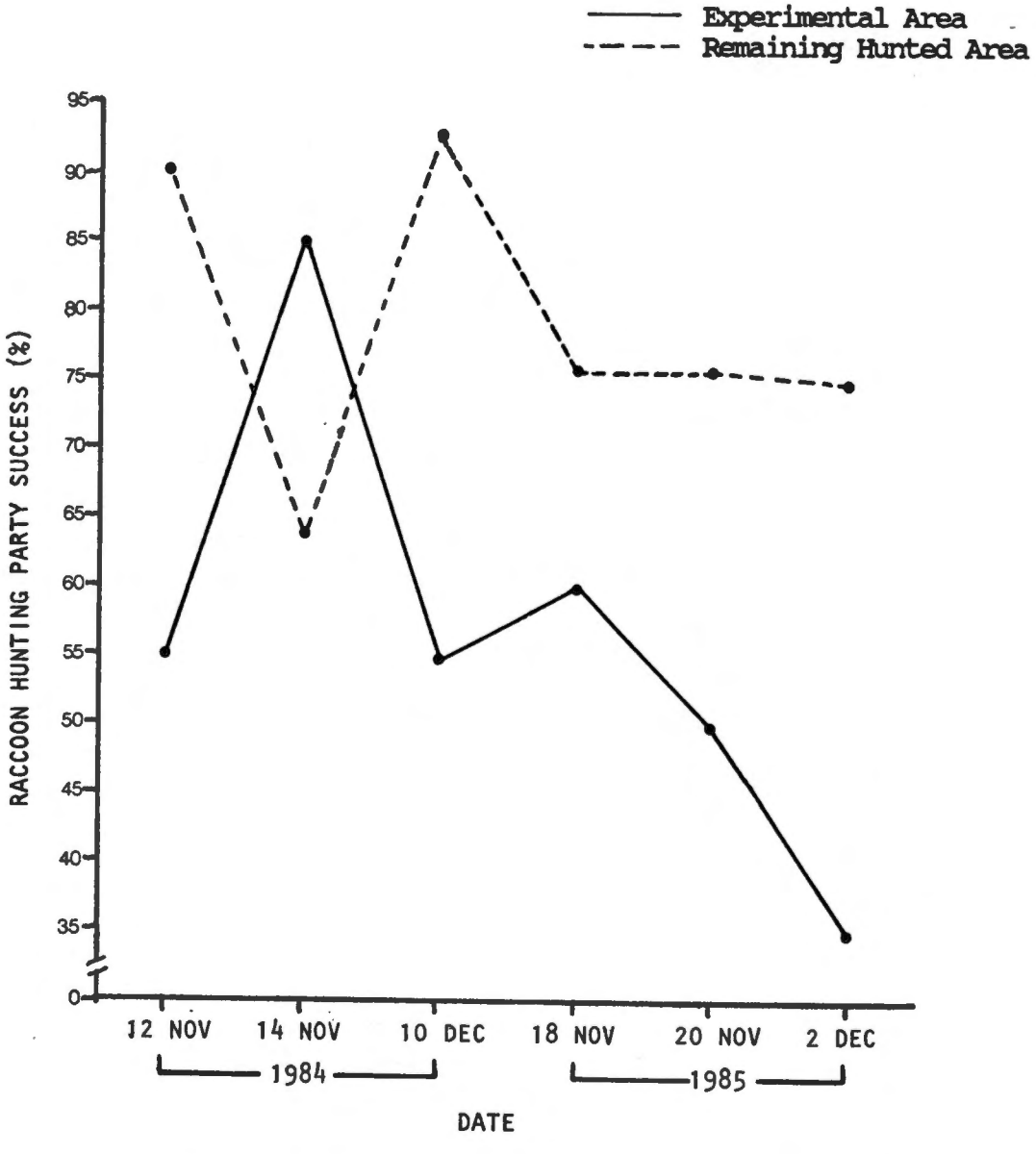


Figure 6. Success of raccoon hunting parties in the experimental and remaining hunted areas, CSWMA, November - December, 1984 and 1985.

party success. Hunting success in the experimental area and RHA for each night was compared to the average number of hectares available to each party. Compartments on CSWMA range in size from 397 ha to 674 ha ($\bar{X}$=545 ha). The number of hectares within a compartment was divided by the number of parties assigned to that compartment to determine the average number of hectares available to each party. The average number of hectares available to parties in the experimental area was 149 for both 1984 and 1985. Each hunting party in the RHA had an average of 292 hectares in which to hunt during both years. A significant relationship was found between the density of hunting parties and their success ($F=9.27$, $F<0.003$).

Results from 2 years of managed raccoon harvests on CSWMA indicated that hunting party success generally decreased when the density of hunting parties increased. The experimental area was assigned 4 hunting parties per compartment (both years); it experienced a lower harvest success than the RHA in 1984. The experimental area showed a continuous decline in success from hunt to hunt during the 1985 season. In contrast, the RHA was assigned 3 parties per compartment and maintained a higher success rate per party than did the experimental area, with no difference in success between the 2 years. The number of raccoons in the RHA was not estimated; therefore, higher success may have been due in part to the existence of more raccoons in this area. However, trapping success, generally an indicator of animal abundance,was not related to hunting success in the experimental area (see Relationship of Indicators of Abundance to Population Estimates). Therefore, it is

unlikely that higher party success in the RHA was attributable to a greater density of raccoons.

Open Model Estimator

Open model estimators relax the assumption of demographic closure but still assume geographic closure. A limited number of individuals moved between the 2 study areas suggesting that geographic closure was generally met during the present study (Appendix A). J-S estimates and corresponding confidence intervals were produced for each sample period from Fall 1983 to Spring 1985 (Table 4). The control area experienced a 30% increase in raccoon numbers from Fall 1983 to Fall 1984, while the difference between the Spring 1984 and 1985 estimates reflected only a 10% increase. The 1984 estimates reflected an annual recruitment of only 13%.

The control area estimates indicated a 15% increase from Fall 1983 (N=142) to Spring 1984 (N=163), instead of showing any over winter decline. However, several factors must be considered when interpreting these estimates. The lowest capture success ($\bar{X}$=6.47%) in this study occurred in Fall 1983. Trapping during this period in the control area was characterized by (1) the capture of few unmarked raccoons (n=14), (2) the capture of only 2 young-of-the-year raccoons, and (3) the highest ratio of marked to unmarked animals (1:2.4) of any control area trapping period. These results reflect heterogeneity of capture due to age (juveniles versus adults) and marking (marked versus unmarked).

Open model estimators assume that equal catchability is present within the population. Because this assumption is not often met,

Table 4. Population estimates of raccoons on the 2 study areas, CSWMA, 1983-85[a].

Estimator	Fall 1983	Spring 1984	Fall 1984	Fall 1984 Harvest	Spring 1985	Fall 1985 Harvest
			Control			
J-S[b]	142±32 (11%)	163±30 (9%)	184±42 (12%)	N/A	180±46 (13%)	N/A
Petersen-I[c]	N/A	N/A	N/A	N/A	N/A	N/A
Petersen-II[c]	128±75 (30%)	123±29 (12%)	142±56 (20%)	N/A	135±48 (18%)	N/A
Jackknife[d]	N/A	173±39 (11%)	N/A	N/A	205±46 (12%)	N/A
			Experimental			
J-S	123±52 (21%)	99±18 (9%)	259±114 (22%)	N/A	106±34 (16%)	N/A
Petersen-I	N/A	N/A	N/A	196±71 (18%)	N/A	230±55 (24%)
Petersen-II	83±78 (48%)	99±37 (12%)	152±83 (28%)	N/A	116±30 (13%)	N/A
Jackknife	N/A	113±23 (10%)	N/A	N/A	154±43 (14%)	N/A

[a] Ninety-five percent confidence intervals and coefficients of variation (in parenthesis) accompany each estimate.

[b] Jolly-Seber model.

[c] Chapman's modification of the Petersen Model (Seber 1982). Petersen-I = marking period is previous 20 night sample period. Petersen-II = marking period is first 10 nights of existing sample period.

[d] CAPTURE's model M_h (Otis et al. 1978).

accurate estimation usually requires population models which allow for unequal probabilities of capture (White et al. 1982). When compared to populations of known size, the J-S estimator has been shown to underestimate animal numbers when capture rates were heterogeneous (Carothers 1973). The J-S estimator was not robust to the assumption of equal catchability, consequently it underestimated the number of raccoons for Fall 1983 in the control area. In comparison to Fall 1983 trapping conducted in the control area during Spring 1984 yielded a much lower ratio of marked to unmarked raccoons (1:1.56). The ratio for Spring 1984 was lower because many (n=8) of the captures were young-of-the-year raccoons which had not been marked during Fall 1983. Despite these differences between the Fall 1983 and Spring 1984 trapping periods, the J-S estimate for Spring 1984 had a lower bound (N=133) which was below the Fall 1983 estimate of 142 raccoons, reflecting the possibility of some animal losses.

The 2% over winter decline from Fall 1984 to Spring 1985 in the control area sharply contrasts with the 45% over winter decline (pooled across areas) from Fall 1982 to Summer 1983 on CSWMA (Nottingham 1985). In a marsh habitat, Urban (1970) documented an over winter decline of 38% for a population subject to mortality from steel trapping.

J-S estimates for the experimental area reflect high post-recruitment estimates followed by lower pre-recruitment figures. Raccoon density increased 111% from Fall 1983 to Fall 1984, and 7% between Spring 1984 and 1985. Like the control area estimate, and for the similar reasons, the Fall 1983 estimate for the experimental area is probably an underestimate. Trapping success in both areas was lower

during fall periods, therefore estimates for both fall periods (mean C.V.=21%) exhibited greater variation than those for both spring periods (mean C.V.=13%).

The 162% increase that occurred from Spring - Fall 1984 in the experimental area, compares favorably to a 171% increase documented for the same area for 1982 (Nottingham 1985). Raccoon populations are subject to irruptive fluctuations (Sanderson 1951, Dasmann 1961, Lotze and Anderson 1979), but these have generally been documented in northern latitudes.

An over winter decline of 46% averaged from 1983-85 in the experimental area is similar to the 45% rate for both areas from Fall 1982 - Summer 1983 (Nottingham 1985). From Fall 1983 to Spring 1984, the decline was 20%, whereas from Fall 1984 to Spring 1985, the rate was 60%. This difference between years in over winter decline for the experimental area may be directly related to the managed hunts conducted in Fall 1984 on CSWMA. The legal harvest of 15-24% of the raccoons in the experimental area plus an unknown percentage which were captured on the ground by dogs probably accounts for this greater rate of decline during the second year (see Impact of Harvest on Raccoon Population).

During Fall 1984, the estimate of raccoons on the experimental area was 41% (N=259) higher than that of the control area (N=184). On the average, control area estimates were 48% higher than those for the experimental for the remaining 3 sample periods. Four estimates made between Spring 1982 and Summer 1983 on CSWMA consistently reflected a greater density of raccoons in the control area (Nottingham 1985). Although data from the present study reflect increased numbers of

raccoons in Fall 1984 for each area, the J-S estimate for the experimental area is probably inflated. This estimate displayed the highest C.V. (22%) and corresponding C.I. (± 114) of any J-S estimate. White et al. (1982) listed a C.V. of 10% or less as one characteristic of a good estimator in biological studies. Although few estimates produced during this study met this criteria several were within 6 percent of this ideal C.V.. The Spring 1984 estimate of 99 individuals (C.V.=9%) is accurate. Data from raccoons harvested on CSWMA indicated the following conditions:

1. 50% are females (Appendix A)
2. 66% of the females are breeding annually (Appendix A)
3. 2.0 young/breeding female is the mean litter size (Appendix A)

These characteristics and a J-S estimate for Spring 1984 of 99 individuals provided a hypothetical estimate of 163 ± 30 for Fall 1984 in the experimental area. However, the Petersen-I estimate derived from the Fall 1984 harvest data indicates that an accurate Fall 1984 estimate probably lies between the J-S estimate (N=259) and the hypothetical estimate (N=163). The J-S estimate for Fall 1984 was probably inflated (1) a low ratio of marked to unmarked raccoons (1:0.75), and (2) 13 young-of-the-year captures.

Closed Model Estimators

Trapping. The CAPTURE program was used to analyze trapping data for Spring 1984 and Spring 1985. Trapping data from each study area during these 2 periods met the hypothesis for demographic closure (range of $z = -.95$ to .60, $P \geq 0.17$). Spring estimates were probably robust to

the assumption of closure since mortality and movements were minimal, and recruitment did not occur (Appendix A).

CAPTURE selected model M_h (capture probabilities vary by individual animal) as the most appropriate model for Spring 1985 in the control area and Spring 1984 in the experimental area. Model M_b (capture probabilities vary by behavioral response to capture) was indicated as most appropriate for the control area in Spring 1984. CAPTURE selected model M_{tb} (capture probabilities vary by time and behavioral response to capture) for the experimental area in Spring 1985. However, no estimator is available to meet the assumptions of model M_{tb} (Otis et al. 1978). Data from the experimental area in Spring 1985 showed too few "newly captured" individuals in the last third of the 20-night sample period to provide a reliable estimate (K. Pollock, S.E. Coop. Wildl. and Fish Stat. Proj., pers. comm.). Therefore, this data set was reanalyzed with only the first 12 nights as the complete resample period. Model M_{tb} was again selected, so the resample period was reduced to 7 nights, at which time model M_o (capture probabilities are constant) was selected by CAPTURE as the most appropriate model.

Each of the 4 trapping periods experienced heterogeneity of capture due to sex (Appendix A). Previous research on CSWMA documented sex (Woods 1978, Nottingham 1985) and age (Nottingham 1985) as sources of heterogeneity in raccoon trapping. Model M_h, the Jackknife estimator, assumes various sources of heterogeneity such as age, sex, social status, and trap accessibility, and is the most robust of CAPTURE's 8 models (Otis et al. 1978). Therefore, the Jackknife estimator was considered to be the most robust and consistent estimator of the CAPTURE

models for the raccoon data from CSWMA (K. Pollock, S.E. Coop. Wildl. and Fish Stat. Proj., pers. comm.). Leberg (1985) and Moore and Kennedy (1985) reported model M_h as CAPTURE's most robust estimator for 2 raccoon population studies in west Tennessee.

Jackknife estimates in the control area reflected a 19% increase from Spring 1984 to Spring 1985. Despite the Fall 1984 harvest of raccoons (n=39), a 36% increase from Spring 1984 to Spring 1985 was indicated in the CAPTURE estimates for the experimental area. Closer inspection of all estimates for the experimental area explain this occurrence. Recruitment and a limited harvest impact could explain why the Spring 1985 estimates for the experimental area were higher than those for Spring 1984.

Petersen-II estimates of raccoons in the control area indicated a mean over winter decline (Fall 1983 - Spring 1984;Fall 1984 - Spring 1985 of 4.5% and a recruitment increase of 10.5% for 1984 (Table 4). By contrast, the experimental area estimates reflected an increase of 19% from Fall 1983 to Spring 1984; the Fall 1983 estimate had a C.V. of 48%, indicating poor precision. Based on the Petersen-II estimates recruitment in the experimental area was 54% for 1984. The Fall 1984 estimate for the experimental area reflected the highest imprecision (C.V.=28%) of any estimate for this same area and time period.

In the present study, as in most population studies, the assumption of equal catchability was found to be invalid. Most traditional methods of population estimation (Lincoln, Petersen) are not robust to the failure of this assumption (White et al. 1982). During fall periods recruitment was observed and throughout this study survival rates varied

(Appendix A). Closed models assume that the survival rate is 100% and recruitment is nonexistent (White et al. 1982). Therefore, not all Petersen-II estimates were robust to these assumptions. Moore and Kennedy (1985) reported that Lincoln estimates were only slightly larger than the actual number of tagged animals when unequal catchability was present. The Petersen-II estimates appeared to underestimate raccoon numbers and had the highest mean C.V. (22%) of all the open and closed estimators used.

Hunting. Produced from the 1984 raccoon harvest data, the Petersen-I estimate for the experimental area was 196 $\pm$ 71 individuals. This estimate is based on the harvest of 39 raccoons in the experimental study area, 13 of which had been captured during the Fall 1984 trapping period (thus considered recaptures by the Petersen-I estimator). The 1985 harvest data produced a Petersen-I estimate of 230 $\pm$ 55 raccoons. The 29 raccoons harvested in the experimental area during 1985 included 7 individuals which had been captured during Fall 1985. Coefficients of variation of 18% (1984) and 24% (1985) indicated that the harvest estimates had low precision.

However, Petersen-I estimates were probably more robust than the Petersen-II estimates for Fall 1984. Dimmick et al. (1982) negated the bias due to trap response in 3 bobwhite quail (Colinus virginianus) populations by systematically shooting rather than live-trapping to resample each population. Composition of the 1984 raccoon harvest from CSWMA showed no heterogeneity of capture as experienced by live-trapping. Therefore, the Petersen-I model was less affected by the

assumption of equal catchability because the resampling was done by harvesting raccoons. Average trapping success during Fall 1984 also increased the likelihood of marking a large proportion of the population, including young-of-the-year raccoons, thereby minimizing heterogeneity from age. Therefore, a Petersen-I estimate that was higher than the Petersen-II estimate for Fall 1984 further showed that the Petersen-II model underestimated raccoon numbers on CSWMA.

Comparison of Open and Closed Estimates

In general, all 3 estimators indicated a greater density of raccoons in the control area than in the experimental area. The only exception to this was for Fall 1984 (J-S and Petersen-II). Consistently higher densities were found in the control area from 1981-83 on CSWMA (Nottingham 1985).

Jackknife estimates for spring periods were consistently higher ($\bar{X}$ = 18%, range = 6 to 45%) than corresponding J-S estimates and maintained precision comparable to the J-S estimates as indicated by the C.V.'s. Jackknife estimates that were consistently higher than J-S estimates supported the presence of heterogeneity of capture (Pollock 1982) and J-S's lack of robustness to this assumption. Sex ratio data also demonstrated that captures were heterogeneous (Appendix A). Nottingham (1985) reported similar results for CSWMA from 1981-83. Petersen-II estimates had the highest C.V.s, especially in the experimental area.

Whether to use an open or closed estimator is a difficult decision which will probably remain so indefinitely (White et al. 1982). Open models which allow for recruitment, mortality, and migration are not

robust to heterogeneity of capture. However, closed models, including those which are robust to heterogeneity, probably aren't robust when recruitment is taking place (White et al. 1982). Generally, closed models should be used for short term studies or when recruitment is not occurring. Open models are suggested for long-term studies. The J-S estimator performed well when recruitment was occurring, therefore it is the better estimator for the fall data sets. Keeler (1978) compared 5 estimators and generally found that the J-S model was the best for showing trends in a raccoon population. CAPTURE's model M_h, however, is more robust for estimating raccoon numbers during spring, because recruitment does not occur and the model assumes heterogeneity of capture. Because of their respective performances to model assumptions during specific periods, fall J-S estimates and spring CAPTURE estimates were used to evaluate scent-station surveys.

Density Estimation

Density estimates were derived for the purpose of comparison to other studies. If not considered, edge effect can cause bias in density estimation. To minimize this phenomenon, the effective area of trapping, based on previous research (Woods 1978, Hardy 1979), was incorporated in the initial study design for CSWMA (Nottingham 1985). Likewise, the relatively large size of the study areas helped minimize the importance of the boundary strip (Otis et al. 1978). However, documented movements of raccoons between study areas led Nottingham (1985) to believe that from 1981-83 the effective area of raccoon trapping on CSWMA was larger than that delineated by the study area

borders. During the present study, only 1.5% of all tagged individuals (n=328) consistently moved between the 2 study areas (Appendix A). Even with the addition of the 2 individuals harvested outside the experimental study area during the 6 nights of hunting on CSWMA, the total remains below 2%. This appears minimal, especially since raccoons which moved between areas were deleted from the data set which derived J-S population estimates. Therefore, the following density estimates are believed to be relatively free of any bias due to edge effect.

Absolute density estimates were derived from fall (post-recruitment) and spring (pre-recruitment) population estimates. The 2 study areas differed with respect to population fluctuations, the amount of over winter decline, and whether or not raccoon hunting had taken place. Density estimates were derived only for comparison to other areas of the United States; therefore, estimates were pooled across both areas. Trapping data provided estimates of densities for fall which ranged from 1 raccoon/19.4 ha (1983) to 1 raccoon/11.6 ha (1984); spring estimates ranged from 1 raccoon/17.9 ha (1984) to 1 raccoon/14.3 ha (1985).

Density estimates for raccoons were compared to estimates from other areas (Table 5). Comparisons among areas must be made with caution because of differences in sampling techniques and time of year. Generally, the highest densities were documented in swamp and marsh areas, while lowest densities were exhibited in upland forests. Excluding spring estimates for this and Nottingham's (1985) study, all estimates include recruitment gains. The estimates derived for Fall 1984 and Spring 1985 were the highest reported for an upland hardwood

Table 5. Raccoon densities reported from different areas of the United States (mark-recapture estimates only).

State	Density (Raccoon/ha)	Habitat Type	Source
Alabama	1/8.5	Bottomland hardwood	Johnson (1970)
Indiana	1/.45-1/2.8	Swampland	Lehman (1977)
Ohio	1/10.9-1/42.9	Upland hardwood	Butterfield (1944)
Florida	1/8.7	Bottomland hardwood, pine-oak	Conner et al. (1983)
Illinois	1/5.7	Marshland	Urban (1970)
South Carolina	1/4.0	Swampland	Cunningham (1962)
Tennessee			
CSWMA (1983)	1/19.4[a]	Upland hardwood	This study
CSWMA (1984)	1/17.9[b]	Upland hardwood	This study
CSWMA (1984)	1/11.6[a]	Upland hardwood	This study
CSWMA (1985)	1/14.3[b]	Upland hardwood	This study
CSWMA (1983)	1/22.1[b]	Upland hardwood	Nottingham (1985)
CSWMA (1982)	1/14.7[a]	Upland hardwood	Nottingham (1985)
CSWMA (1976)	1/27.5	Upland hardwood	Woods (1978)
Cades Cove	1/17	Upland hardwood	Rabinowitz (1981)
Shelby Forest	1/7.2	Bottomland hardwood	Moore (1983)
Virginia	1/5.7	Upland hardwood	Sonenshine and Winslow (1972)

[a] Mean estimate of both study areas for fall (inclusive of recruitment).

[b] Mean estimate of both study areas for early summer.

habitat in east Tennessee. Raccoons on CSWMA have recovered from an apparent overharvest (Nottingham et al. 1982) in 1978. The differences between the Fall 1984 and Fall 1985 density estimates were minimal, which indicates that the population growth is leveling off.

Impact of the Harvest on the Raccoon Population

Thirty-nine raccoons were harvested from the experimental area during the 1984 harvest season. As discussed above the raccoon density for this area was estimated to be between the J-S estimate (N=259) and the hypothetical estimate (N=163) for Fall 1984. It is estimated that 15-24% of the raccoons in this area were harvested in 1984. This removal rate was calculated from the J-S and hypothetical estimates. Nottingham et al. (1982) reported that the 1976 CSWMA raccoon harvest was 31.2-37.2% of the estimated density and was apparently too high to permit sustained yields. The estimated rate of harvest of 15-24% compares favorably to the 40% increase in over winter decline (see Population Estimation) which the experienced by the experimental area during this 2 year study.

Sex ratios of harvested raccoons (77 males:100 females) did not differ significantly from 1:1, therefore the 1984 CSWMA raccoon hunts were not biased toward females (Appendix A). Johnson (1970) found raccoon hunting to be biased towards females (possibly with young). Only 13% of the 1984 harvest were juvenile raccoons whereas Woods (1978) reported that juveniles comprised 75% of the 1976 harvest. A raccoon harvest that was not biased towards females or juveniles would not magnify the effect of a 29% reduction in the average litter size (1976

to 1984) experienced by the raccoons on CSWMA (Appendix A). Despite a mean litter size of 2.0 young/female, the estimated number of raccoons (N=154) in the experimental area during Spring 1985 would have the potential to produce 100 young animals. Considering the above conditions, the 1984 harvest was only 39% of the estimated recruitment for 1985 in the experimental area. This estimate of recruitment does not consider juvenile mortality. Data from the 1984 harvest indicated that the CSWMA raccoon population experienced minimal impact from the managed hunts. The 1984 raccoon hunts appeared to be an improvement, with respect to hunting format and impact, over previous years at CSWMA (Minser and Pelton 1982, Nottingham et al. 1982).

Relationship of Indicators of Abundance to Population Estimates

Although the number of individuals captured on traplines has been used as an index of abundance for furbearers few studies have actually compared trapline indices to estimates of population size (Smith et al. 1984). Without first evaluating the above relationship a comparison of trapline and scent-station indices would do little to improve the confidence in either index (Hatcher and Shaw 1981, Clark and Andrews 1982). For each study area and trapping period a population estimate was compared to trapping success and the number of individuals captured. Estimates of raccoons derived for the control area were not related to trap success ($R=0.80$, $P=0.20$) nor the number of individuals captured each period ($R=0.80$, $P=0.20$). Likewise estimates in the experimental area were not related to trapping success ($R=-0.40$, $P=0.60$) nor the number of individuals captured each period ($R=0.40$, $P=0.60$). Smith et

al. (1984) reported that population trends of opossum, raccoon, and gray fox could not be determined by the number of animals live trapped along traplines. They compared capture probabilities to population estimates. Since trap success was influenced by season in both areas (see Study Statistics), it may be an indicator of raccoon movements rather than population abundance. Holman (1983) indicated that trapping success reflected the susceptibility of a raccoon population to be trapped, rather than its density.

Scent-Station Surveys

Factors Afffecting Raccoon Visitation to Scent-Stations

General. Scent-station surveys were completed during 13 (52%) of the 25 months from 5 July 1983 to 29 July 1985 on CSWMA. Raccoons were harvested during November and December, 1984. A survey was not attempted for November 1984 because it would have occurred in the middle of the raccoon hunting season. Four (16%) surveys were attempted but cancelled due to personnel/vehicle problems or on account of the weather. Surveys were not attempted during the 7 (28%) remaining months due to weather or conflicts with managed hunts on CSWMA.

The 13 surveys produced 1036 (99%) operable scent-stations; 4 stations were not activated. Tracks of 9 mammalian species were recorded in each study area. These species were raccoon, red and gray foxes, opossum, white-tailed deer, cottontail rabbit (Sylvilagus floridanus), striped skunk (Mephitis mephitis), woodchuck (Marmota

monax), and domestic dog (Canis domesticus). The total number of visits and overall visitation rates for each species is summarized in Appendix F.

A total of 52 raccoon visits were recorded for the 2 study areas with a mean monthly visitation rate of 5.02%. Visitation rates were erratic (Figures 7 and 8). Likewise, Nottingham (1985) reported similar variation in visitation to scent-stations by raccoons on CSWMA from 1981-83. Mean raccoon visitation rates in the control area (5.96%) and in the experimental area (4.07%) were not significantly different ($X^2=0.35$, $P>0.50$).

Temporal Factors. The control area experienced its highest visitation rate in August 1984 and the lowest in February 1985. Visitation rates during September and October 1984 were 150% higher than for September and October 1983. During February and June 1985 visitation was 83% lower than from February and June 1984. The greatest 1 month difference occurred from August to September 1984, with visitation rates dropping from 20% to 5%.

Five (38%) scent-station surveys in the experimental area lacked visitation by raccoons. Each of the 4 seasons experienced atleast one of the scent-station surveys which lacked raccoon visitation. Three of these surveys occurred during months (November 1983, February and August 1984) when the control area experienced visitation rates above the mean for that area. The highest visitation rate recorded for this area was 14% and occurred after (June 1985) the 1984 CSWMA raccoon hunts. Prior to this, the highest visitation had occurred in September 1983 (10%).

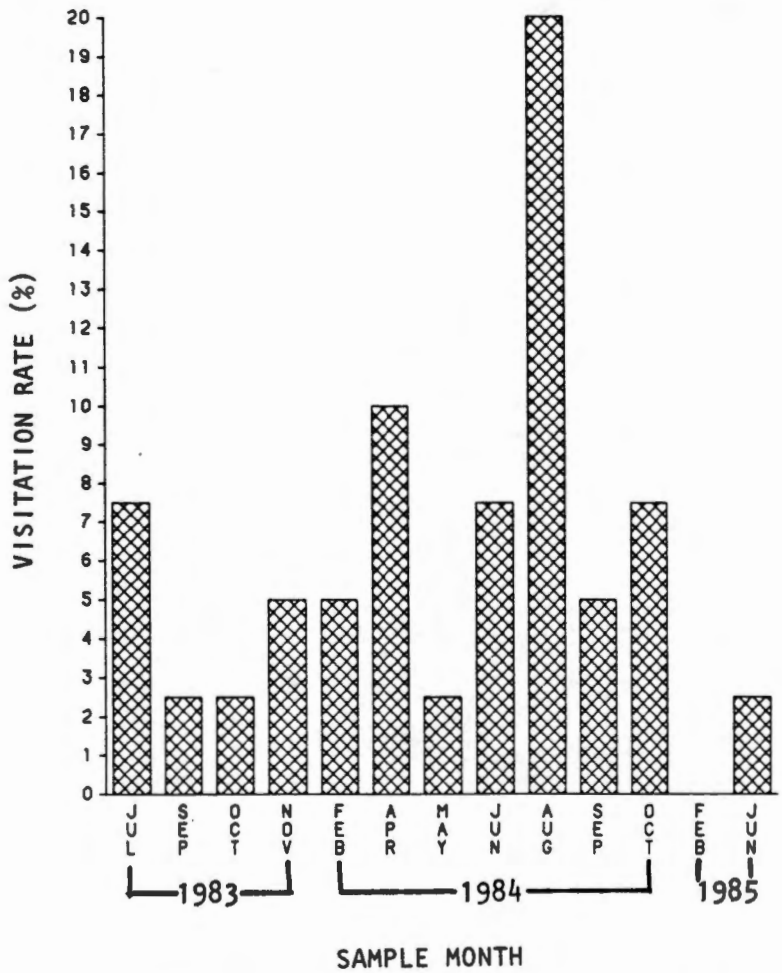


Figure 7. Monthly visitation rates of raccoons to scent-stations in the control area, CSWMA, 1983-85.

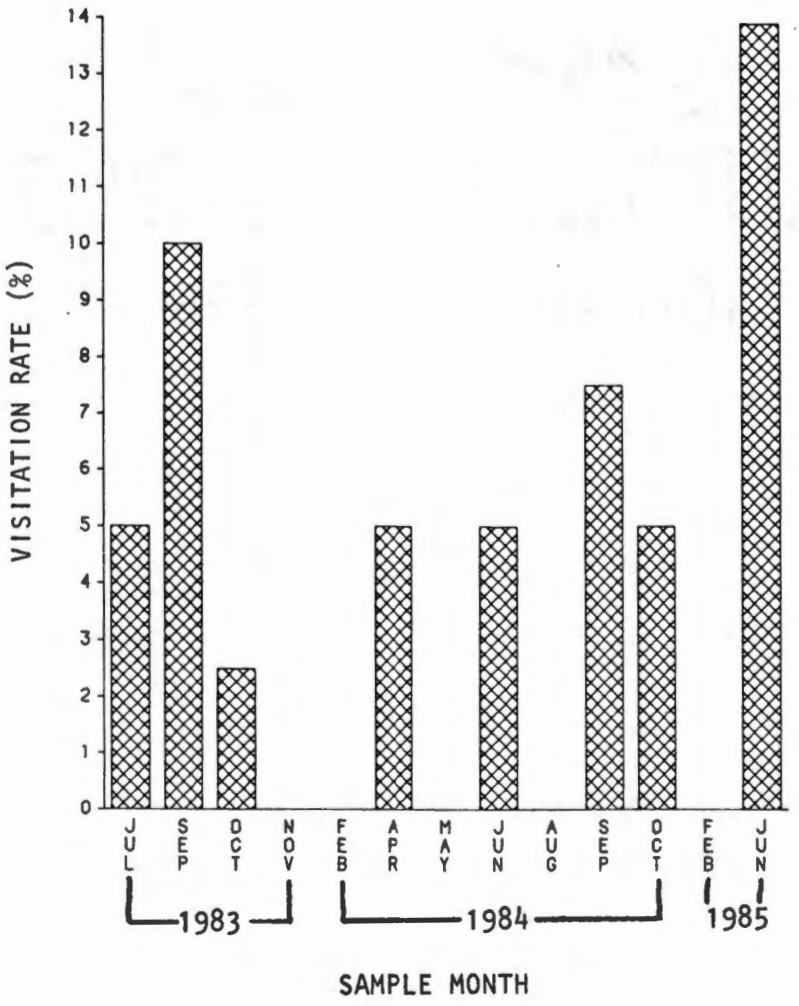


Figure 8. Monthly visitation rates of raccoons to scent-stations in the experimental area, CSWMA, 1983-85.

The October 1984 visitation rate was 100% higher than October 1983; visitation to the June 1985 scent-station survey was 180% higher than for June 1984. For the month of September a 25% decrease in visitation occurred from 1983 to 1984. Both February surveys, 1984 and 1985, lacked visitation by raccoons.

The highest monthly visitation occurred during summer in both areas. In 1984 the greatest number of juveniles were captured during September (n=13) (Appendix A). This peak in juvenile movements did not correspond to a peak in scent-station visitation which occurred during August 1984 in the control area. Yearlings were most active in 1984 during March, a month lacking a scent-station survey. These results are based on the percentage of Class 1 individuals in the monthly capture totals. In the control area a smaller peak in scent-station visitation in April 1984 (10%) was followed by a lower visitation rate in May 1984 (2.5%). This decline in scent-station visitation from April to May 1984 corresponds to the dispersal of yearlings which peaked in March 1984. The June 1985 peak in scent-station visitation did not correspond to the dispersal of yearlings in the experimental area, which peaked in July.

A comparison of the average visitation rate from before and after the 1984 harvest season was conducted. Scent-station visitation by raccoons declined by 82% in the control area while the experimental area experienced a 92% increase. The change was significant in the control area but not in the experimental area (control, $X^2=3.92$, $P<0.05$; experimental, $X^2=1.09$, $P>0.25$).

Visitation rates to scent-stations were analyzed by season (Table 6). Both areas received maximum visitation during summer and minimum

Table 6. Seasonal visitation rates (%) of raccoons to scent-stations, CSWMA, 1983-85.

	Season[a]			
	Fall	Winter	Spring	Summer
Control Area	4.5 (.06)[b]	2.5 (.07)	6.2 (.07)	9.4 (.11)
Experimental Area	5.0 (.08)	0 (0)	2.5 (.07)	6.0 (.07)
Areas Combined	4.8 (.07)	1.2 (.05)	4.4 (.07)	7.7 (.09)

[a] Fall = Sept. - Nov., Winter = Dec. - Feb., Spring = March - May, Summer = June - August

[b] Standard deviation of visitation rate

visitation during winter. The 2 areas differed with respect to seasons which experienced intermediate visitation; the season with the second highest visitation occurred in spring in the control area, but during fall in the experimental area. Standard deviations were relatively the same except for summer in the control area (.11) and winter in the experimental area (no visitation). Peak seasonal visitation did not correspond to trapping success which was highest during spring in both areas.

No relationship between season and raccoon visitation to scent-stations was found (control, $F=1.71$, $P=0.18$; experimental, $F=1.72$, $P=0.18$). Since young raccoons did not move from dens until September (Appendix A) in 1984, this was considered to be the first month in the second biological year. In each area visitation was not related to year (control, $F=1.74$, $P=0.19$; experimental, $F=3.33$, $P=0.07$). Nottingham (1985) reported similar results; the present results are probably attributable to the unreliability of the scent-station technique.

Scent-station surveys have been conducted monthly on CSWMA from 1981-85. Data from 1983-85 were analyzed to determine whether the raccoons were becoming conditioned to the monthly surveys. Survey repetition had no apparent influence on visitation rates ($F=1.28$, $P=0.24$); these results compared favorably to Nottingham (1985) which indicates that behavioral conditioning has not resulted from the replication of monthly surveys from 1983-85.

Spatial Factors. Visitation rates of raccoons along scent-station lines ranged from 1.5% to 10% (Table 7). The control area displayed a

Table 7. Raccoon visitation rates (%) by scent-station line on the 2 study areas, CSWMA, 1983-85.

Control Area		Experimental Area	
Line Number	Visitation Rate (%)	Line Number	Visitation Rate (%)
1	1.5 (.04)[a]	5	3.1 (.05)
2	3.8 (.07)	6	3.1 (.09)
3	8.5 (.11)	7	3.9 (.07)
4	10.0 (.08)	8	6.2 (.08)
Mean =	5.96 (.08)		4.07 (.07)

[a] Standard deviation of rate in parentheses.

wider range of scent-station visitation by line (8.5 %) than that of the experimental area (3.1%). These ranges differ by a factor of 2.7. Nottingham (1985) indicated the range of visitation in the control area for 1981-83 was greater than that of the experimental area by a factor of 2.2 (6.1% vs. 3.0%). Visitation rates by line were significantly different in the control area (F=3.75, P=0.02) but not in the experimental area (F=0.62, P=0.60). These differences between areas reflect the greater range in visitation which occurred in the control area then in the experimental area.

The Henegar Bend (line 3) and Mossy Springs - Lindamood (line 4) regions of the control area received the highest visitation to scent-stations by raccoons. The White Creek (line 8) region recorded the highest visitation in the experimental area. The Henegar Bend and Mossy Springs - Lindamood regions also produced the greatest number of trapped individuals in the present study (Table 8). A post-hoc contrast determined that lines 3 and 4 recorded significantly higher visitation than all other lines combined (F=9.72 vs Scheffe F=6.6, P=0.05) (Neter et al. 1985). Likewise, Nottingham (1985) found these 2 regions to have higher densities and to have recorded higher visitation by raccoons. A second post-hoc contrast determined that White Creek's (line 8) higher scent-station visitation was not significantly different from the other 3 lines in the experimental area (F=0.31 vs Scheffe F=4.5, P=0.05) (Neter et al. 1985). Based on the number of trapped individuals, White Creek has a density comparable to the Pond - Pole Hollow (line 5) region. Higher visitation corresponded to regions of higher raccoon densities within the control area, but not within the experimental area.

Table 8. Total number of visits and captures of raccoons along scent-station lines in the 2 study areas, CSWMA, 1983-85.

Control Area			Experimental Area		
Line Number	Number Visits	Number Raccoon Captures[a]	Line Number	Number Visits	Number Raccoon Captures[a]
1	2	51	5	4	76
2	5	76	6	4	51
3	11	109	7	5	40
4	13	97	8	8	75
Totals	31	333		21	242

a Does not include recaptures of individuals on a given line but animals were captured more than once among the different lines.

Relationship of Scent-Station Visitation to Population Size

Comparisons of population estimates (fall J-S, spring CAPTURE) and visitation rates were made for each study area. Population estimates were produced for each trapping period. Therefore, only scent-station data which corresponded to trapping periods was used in this analysis. Visible relationships were generally lacking between the 2 measures for both the control and experimental areas (Figures 9 and 10).

Although visitation rates in the control area generally paralleled increases in raccoon numbers for the first 3 sample periods, an inverse relationship occurred during the last period. From Fall 1984 to Spring 1985, an 11% increase in raccoon density corresponded to a 61% decrease in scent-station visitation. Likewise, an overall increase in raccoons of 44% from Fall 1983 to Spring 1985 coincided with a 36% decrease in visitation.

There was no relationship between scent-station visitation and the density of raccoons in the experimental area. From Fall 1983 to Spring 1984 the numbers of raccoons in the experimental area declined by 8% . From Spring 1984 to Fall 1984 the raccoon density increased by an estimated 65-129%. These population fluctuations corresponded to an overall decline in scent-station visitation of 7%. The most apparent difference between scent-station visitation and density occurred during Fall 1984 in the experimental area. During this period scent-station visitation (4.1%) by raccoons was lower than all other periods except Spring 1984. However, raccoon density in the experimental area was estimated to be at its densest level of any period from 1983-85. The

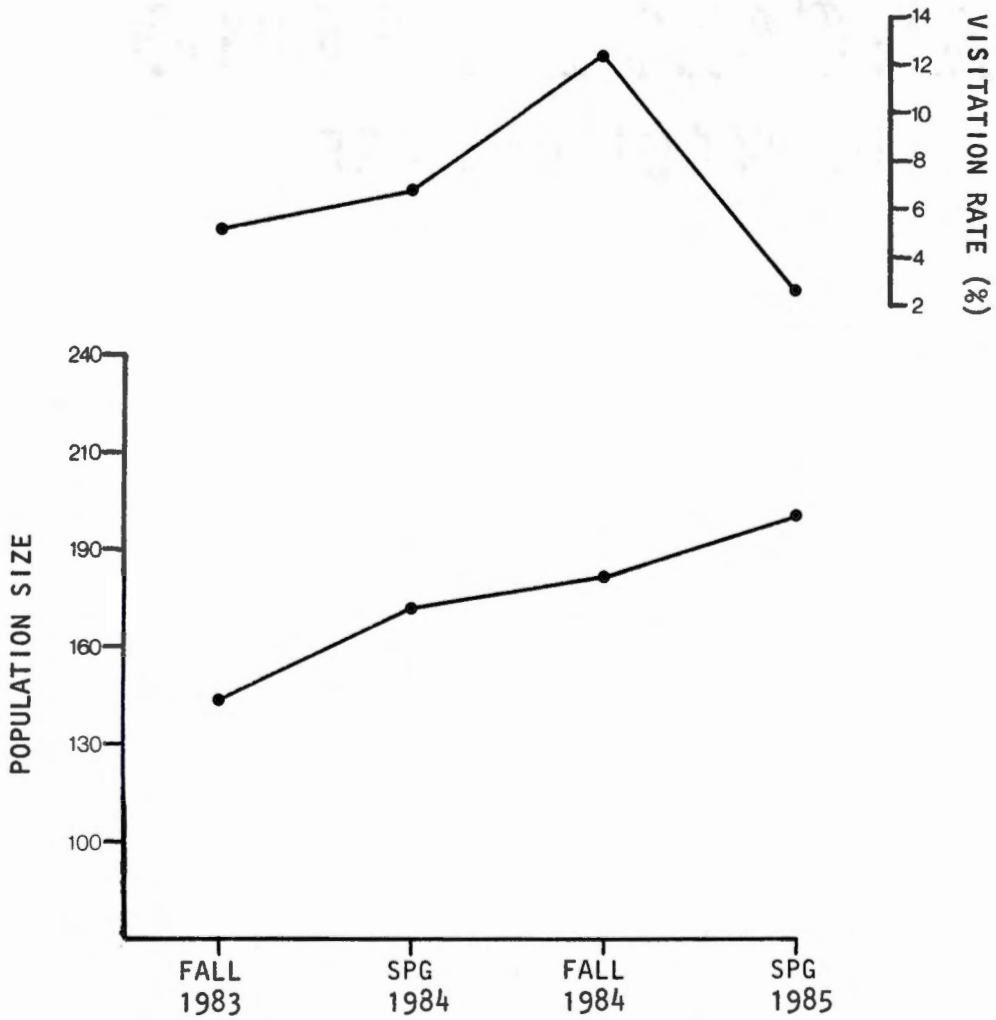


Figure 9. Comparison of seasonal estimates of population size and visitation rates of raccoons in the control area, CSWMA, 1983-85.

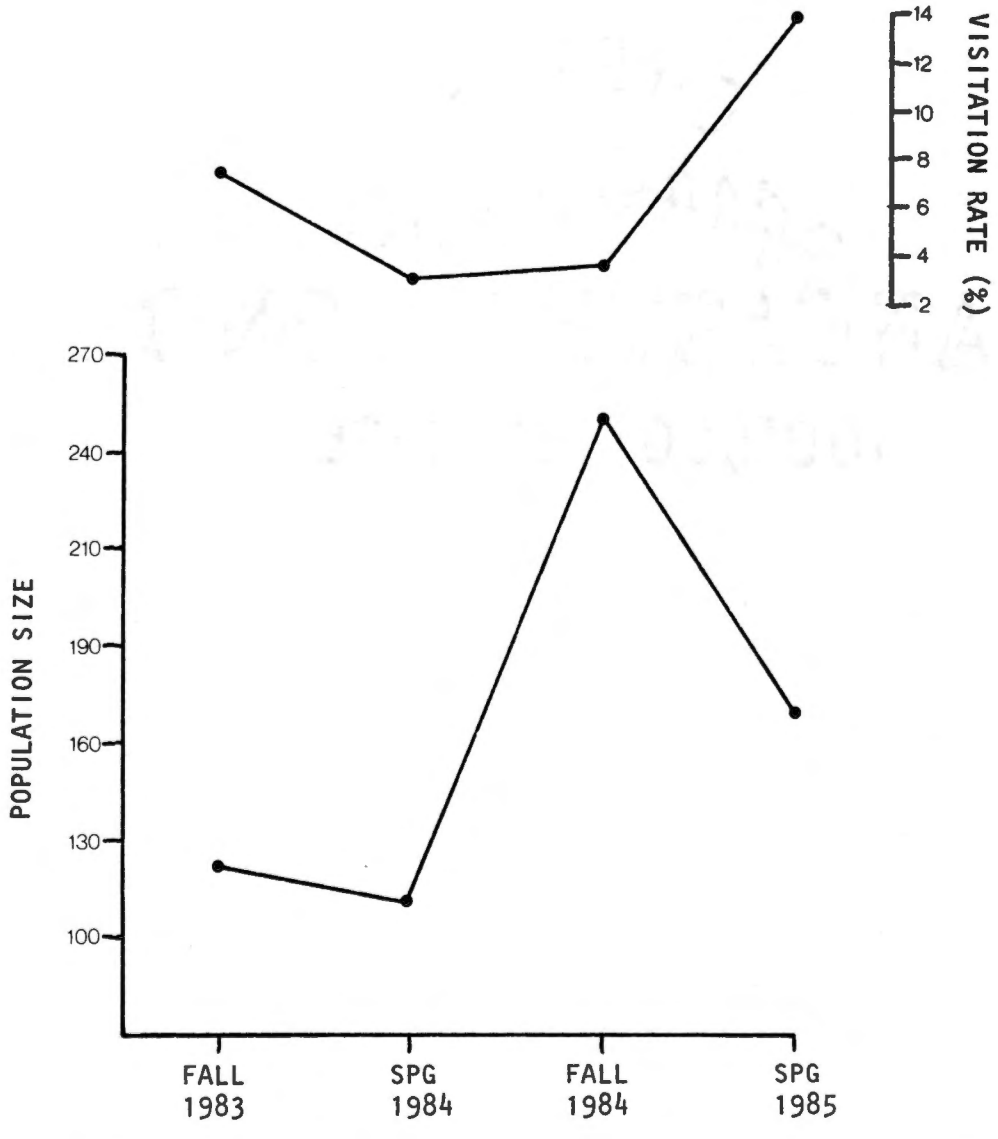


Figure 10. Comparison of seasonal estimates of population size and visitation rates of raccoons in the experimental area, CSWMA, 1983-85.

harvest season of 3 nights contributed to a population decline of 41% from Fall 1984 to Spring 1985. Despite this decrease, scent-station visitation increased by a factor of 3.4 to 14% for Spring 1985. Visitation rates of raccoons to scent-stations were not correlated to population estimates in either the control area (R=0.07, P=0.62) or in the experimental area (R=0.07, P=0.58).

Summary and Assessment of Relationship Between Visitation Rates and Population Abundance

A primary objective of this study was to evaluate the sensitivity with which the scent-station technique reflected a density change caused by hunting. The results indicated that a poor relationship existed between raccoon abundance and their visitation to scent-stations on CSWMA. Raccoons in the control area increased by 44% from Fall 1983 to Spring 1985. The experimental area experienced an increase of 129% from Spring 1984 to Fall 1984 followed by a 41% decrease from Fall 1984 to Spring 1985. Despite these results, no significant difference between visitation rates in the 2 study areas was found; likewise there was no difference in visitation before and after the 1984 raccoon hunts. Additionally, visitation rates and population estimates were not correlated (R=0.03, P=0.77).

A relationship between visitation and one measure of abundance did occur. Two regions recording the highest numbers of individual captures corresponded to 2 scent-station lines which received significantly higher visitation by raccoons. Nottingham (1985) reported significantly higher visitation and individual captures for these same 2 regions.

These results suggest that the technique might be sensitive to population abundance when raccoon densities are high. However, visitation rates (1983-85) sharply contrast these findings. Throughout this study, whenever raccoon density increased visitation did not increase comparatively, and often decreased. This was clearly evident in Fall 1984 when the raccoons in the experimental area increased to an estimated 163-259 (1 raccoon/9.8 - 15.6 ha) individuals during which time scent-station visitation decreased by 7%. Similar results have been reported in other scent-station research. In Iowa, areas reporting the highest incidences of coyote related sheep losses documented little or no visitation to scent-stations by coyotes (Andrews 1979).

Leberg and Kennedy (In press) working in west Tennessee used a similar scent-station methodology (i.e. station size, interval between stations) as the present study except that each station was placed within the 0.32-km interval where it would most likely receive a raccoon visit. They found that scent-station visitation correlated positively with densities of 1 raccoon/17.4 - 34.4 ha. However, higher densities (1 raccoon/5.2 - 17.4 ha) and lower densities (1 raccoon/34.4 - 127.8 ha) were not correlated to visitation rates of raccoons. Visitation rates from 3 of the west Tennessee habitats ranged from 0-71% ($\bar{X}$=28%) (Leberg and Kennedy In press). Several of the densities for CSWMA reported in the present study compare to the density range (1 raccoon/17.4 - 34.4 ha) which correlated to visitation rates in west Tennessee. However, difference in station placement and the higher visitation reported for west Tennessee make comparisons between the 2 studies unreliable.

The present results also support the hypothesis that the technique's ability to detect variations in population size improves with moderate to high visitation (Nottingham 1985). At CSWMA, low visitation may be the largest factor in the technique's inability to detect differences in raccoon population size. Monthly visitation rates ranged from 0-20%, with a mean of 5.02% (areas combined). From 1981-83, Nottingham (1985) reported visitation rates varying from 0-13% ($\bar{X}$=5.25%). The rates reported for the present study, as well as Nottingham's (1985), are in sharp contrast to the 40-60% suggested as optimal for statistical evaluation of scent-station data (Roughton and Sweeny 1982).

Management Implications

Hunting

The 1984 and 1985 managed raccoon hunts on CSWMA successfully incorporated 2 changes suggested by Woods (1978). The first change was a reduction in the season length from 9 nights to 3 nights. Furthermore, hunting parties were only allowed to harvest 1 raccoon from the management compartment in which they were assigned. Parties were assigned at a density of either 3 or 4 per compartment. These two factors reduced the harvest's impact on the population.

Assignment of hunting parties to compartments eliminated intense hunting pressure from any 1 region within CSWMA. Reduction of localized hunting pressure, along with a denser raccoon population, resulted in higher hunting party success as compared to a monitored harvest in 1976

(Woods 1978). Additionally, these conditions provided hunters with a more enjoyable experience (Kocka and Pelton, Univ. of TN., unpubl. data). More importantly, these hunts were less biased towards females and young-of-the-year than previously documented on CSWMA. Since hunters apparently supported this revised harvest format (Kocka and Pelton, Univ. of TN., unpubl. data), similar strategies could be developed for other areas in east Tennessee controlled by TWRA.

Research should continue on CSWMA to provide data on the long-term effects of the current harvest strategy on the raccoon population. Data from 1984 and 1985 indicate that raccoon hunting success is directly attributable to hunter density. After 2 or 3 years of baseline data, an examination of the effects of varying hunter densities (within compartments) should be conducted. These results would document the specific impact of hunter density on success. Additionally, this data base would better indicate the harvestable surplus of raccoons on CSWMA, and possibly for east Tennessee in general.

Scent-Station Surveys

A distinct relationship between raccoon density and scent-station visitation was lacking. Nottingham (1985) documented the scent-station technique's lack of sensitivity in reflecting natural population trends in raccoons. Likewise, the present study found the technique to be inadequate in reflecting the change in density which resulted from a managed harvest. The scent-station technique lacked sensitivity on CSWMA where raccoons are relatively dense for east Tennessee. Unlike parks and wildlife management areas (Minser and Pelton 1982) raccoon

densities are very low throughout most of east Tennessee (Hall 1978, Warr 1978). Since scent-stations were not sensitive to dense raccoon populations their overall effectiveness in east Tennessee is doubtful.

The single greatest problem with the technique as conducted during this study is the low percentage of stations that are visited by raccoons. Optimal visitation for statistical purposes is considered to be 40-60%. The highest visitation rate recorded from 1983-85 in either study area on CSWMA was 20%; this was higher than any rate recorded by Nottingham (1985) for the same 2 areas. Nottingham (1985) suggested refining the technique more specifically towards the raccoon. The refined technique would be based more directly on the ecology of the raccoon rather than the present multi-species survey. However, it is highly unlikely that developments would increase visitation by a factor of at least 2. Therefore, it is the opinion of this author that the scent-station technique is not a valid index for raccoons in east Tennessee.

CHAPTER V

SUMMARY AND CONCLUSIONS

1. An investigation of the relationship between visitation rates of raccoons to scent-stations and raccoon density on 2 study areas was conducted from 5 July 1983 through 29 July 1985 on the Chuck Swan Wildlife Management Area, Tennessee.

2. Raccoons were live trapped to provide mark-recapture data from which population estimates were derived for both study areas. Open (Jolly-Seber Model) and closed (Models in Program CAPTURE, Petersen Model) population estimators were utilized to make model comparisons for evaluating model robustness and bias.

3. Six nights of managed raccoon hunting were conducted on the whole CSWMA peninsula except for the control study area. Three nights of hunting were held on 12 November, 14 November, and 10 December 1984 while 3 nights were held on 18 November, 20 November, and 2 December 1985. During all 6 nights of hunting, 4 parties were assigned to each of 5 management compartments in the experimental area, while 3 parties were assigned to each of 8 compartments in the RHA.

4. Monthly scent-station surveys were operated as weather permitted for the duration of the study. Both study areas contained 4 scent-station transects, each consisting of 10 stations spaced at 0.32 km intervals.

5. During 6400 trapnights, 825 raccoon captures (1 raccoon/7.76 trapnights) were comprised of 328 individuals. More individuals were

captured in the control (n=182) than in the experimental (n=158) area; 12 individuals were captured in both areas.

6. Trapping success was adjusted to allow for traps sprung by any source, thereby providing a more appropriate measure of animal abundance. Once adjusted, the mean rate of trapping success was 14.9% for the study. Trapping success was significantly greater in the control area ($\bar{X}$=17.39%) than in the experimental area ($\bar{X}$=12.83%) (t=64.14, P<0.001). Trapping success was highest in the spring (27.9%) and lowest in the fall (7.0%) and was probably influenced by food availability.

7. Trapping success did not differ significantly between years in either the control (F=1.49, P=0.31) or the experimental area (F=1.91, P=0.26). With both areas combined, trap success was not influenced by maximum daily temperature (F=1.02, P=0.32), but was influenced by minimum overnight temperature (F=41.16, P<0.0001) and the difference between these two temperatures (F=8.59, P=0.0039).

8. During the 3 nights of hunting in 1984, a total of 107 hunting parties harvested 79 raccoons for a success rate per hunting party of 73.8% (1 raccoon/92 ha) for all hunted compartments. Thirty-nine raccoons were harvested by parties in the experimental area for a mean success of 65%. During 14 November 1984 party success in the experimental area increased by 55% while the RHA experienced a 23% decrease. Hunting success for these two areas was not influenced by temperature nor cumulative harvest ($F \leq 0.99$, $P \geq 0.32$), likewise, no relationship existed between trapping success in each compartment and experimental hunting success (F=1.68, P=0.20). However, hunter density

influenced harvest success ($F=9.27$, $P<0.003$). Twenty-one ear tagged raccoons were harvested, one of which was outside the study area.

9. During 1985, 110 parties harvested 67 raccoons for a party success rate of 61% for all hunted compartments. Twenty-nine raccoons were harvested in the experimental area during 1985 for a mean party success rate of 48%, whereas the RHA's mean party success rate was 76%. One ear tagged raccoon was harvested outside the experimental area during 1985 and 16 were harvested within the experimental area. With the data from both years combined the hunting success differed significantly between the experimental area and RHA ($F=56.29$, $P<0.0001$).

10. J-S estimates for the control area indicated a 30% increase in density from Fall 1983 to Fall 1984 with a general lack of any significant over winter decline. The experimental area estimates reflected a 111% increase from Fall 1983 to Fall 1984, with an over winter decline of 46%. Except for Fall 1984, control area estimates were an average of 48% higher than those for the experimental.

11. Heterogeneity of capture was documented during all 4 trapping periods. Therefore, CAPTURE's model M_h was used to produce Spring 1984 and 1985 estimates. These estimates indicated increases in the number of raccoons from 1984 to 1985 of 19% in the control area and 36% in the experimental.

12. The Petersen-II estimates appeared to underestimate the number of raccoons and had the highest mean C.V. (22%) of all the open and closed estimators used. Petersen-II estimates were not robust to the assumption of equal catchability or the assumption of demographic closure. Petersen-I estimates based on raccoon harvests from 1984 and

1985, were 196 (± 71) and 230 (± 55) individuals, respectively. This model was less affected by the assumption of equal catchability because resampling was conducted through a harvest.

13. CAPTURE estimates were consistently higher ($\bar{X}$=18%, range = 6 to 45%) than J-S estimates for each spring trapping period; this supports the presence of heterogeneity of capture and J-S's lack of robustness to this assumption. However, the J-S estimator performed well when recruitment occurred (fall). Because they performed well to model assumptions during specific periods, fall J-S estimates and spring CAPTURE estimates were used to evaluate scent-station surveys. Pooled across areas, density estimates for fall ranged from 1 raccoon/19.3 ha (1983) to 1 raccoon/11.6 ha (1984); spring estimates ranged from 1 raccoon/17.9 ha (1984) to 1 raccoon/14.3 ha (1985). Fall density estimates compared favorably with those from other upland habitats in Tennessee.

14. Based on J-S estimates and reproductive data, 15-24% of the raccoon population in the experimental area was removed during the 1984 harvest season. The CSWMA raccoon population experienced minimal impact from the managed hunts.

15. Population estimates were not related to trap success (control,R=0.80, P=0.20; experimental,R=-0.40, P=0.60) nor the number of individuals captured during each period (control,R=0.80, P=0.20; experimental R=0.40, P=0.60). Since trap success was influenced by season in both areas it probably reflected raccoon movements or their susceptibility to trapping, rather than their density.

16. Thirteen scent-station surveys were conducted from 5 July 1983 to 29 July 1985 resulting in 1036 operable stations that recorded visits of 9 mammalian species. A total of 52 raccoon visits were recorded for both study areas with a mean monthly visitation rate of 5.02%.

17. Visitation rates in both areas were erratic; Visitation rates between study areas did not differ significantly (X^2=0.35, P>0.50). Highest visitation was recorded during the summer in both areas, which did not correspond to the spring peak in trapping success. Average visitation rate before and after the 1984 harvest season reflected an 82% decrease in the control area (X^2=3.92, P<0.05) and a 92% increase in the experimental area (X^2=1.09, P>0.25).

18. Mean raccoon visitation by scent-station line ranged from 1.5% to 10%. The Henegar Bend and Mossy Springs - Lindamood regions recorded significantly higher visitation than all other lines (F=9.72 vs Scheffe F=6.6, P=0.05), and produced the greatest number of trapped individuals. This relationship was previously reported for CSWMA.

19. Relationships were generally lacking between visitation rates and density estimates for both areas. The densest estimate (N=259) corresponded with the second lowest (4.1%) visitation rate for either area. Visitation increased by a factor of 3.4 in the experimental area after the 1984 harvest. Visitation rates of raccoons to scent-stations were not correlated to population estimates in either the control area (R=0.07, P=0.62) or in the experimental area (R=.07, P=.58).

20. Results from the Henegar Bend and Mossy Springs - Lindamood regions suggest that scent-station surveys may be sensitive to raccoon abundance where densities are high. However, when raccoon densities

increased in the 2 study areas, visitation did not increase, and often decreased. Low visitation was the largest factor in the technique's ability to detect changes in population size.

21. Reduction of the season length and the assignment of hunting parties to compartments provided a popular hunt with minimal impact to the raccoon population. A similar hunting strategy may be applicable to other areas in east Tennessee.

22. The scent-station technique lacked sensitivity in accurately reflecting population trends; therefore, it is not considered to be a viable management technique in east Tennessee. It is unlikely that future refinements in the technique, based on raccoon biology, would increase visitation to an optimal level.

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APPENDICES

APPENDIX A

POPULATION CHARACTERISTICS

Materials And Methods For Analyzing Blood

Approximately 1 cc of blood was drawn from the cephalic vein of raccoons and placed in an untreated vacutube. Additional 1 cc samples drawn for microfilarial testing were placed in EDTA vacutubes. Whenever possible blood samples were collected from both live trapped and harvested individuals. Once blood samples had clotted, they were refrigerated for no more than 3 days from date of collection. Within the 3 days, samples were packed in ice and brought to either the Clinical Pathobiology Laboratory (untreated vacutubes) or the Parasitology Laboratory (EDTA vacutubes) of the U.T. Veterinary Hospital.

The Pathobiology Laboratory centrifuged the samples (10 minutes at 1500 rpm), removed the clots, and froze the sera until the assays could be performed. Blood samples were tested for antibodies of canine distemper virus (CDV), canine parvovirus (CP), and rabies virus (RV) through use of the indirect fluorescent antibodies test (Hsiung 1973). Titers were tested at a dilution ratio of 1:10. Serum samples which tested positive were quantified to an exact ratio.

The Parasitology Laboratory processed 1 cc samples which had been collected in EDTA vacutubes within 96 hours of being drawn. Each sample

was examined for the presence of microfilariae using the modified Knott's test (Sloss and Kemp 1978).

Results And Discussion

Sex Ratio

Trapping. Of the 182 raccoons captured in the control area 102 were males (128 males:100 females); these results did not differ significantly from a 1:1 ratio (X^2=2.63, P>0.1). Ninety-four of the 158 individuals captured in the experimental area were males (147 males:100 females); the resulting sex ratio differed from a 1:1 ratio (X^2=5.69, P<0.025). Nottingham (1985) reported a ratio of 121 males per 100 females for 248 individuals captured on CSWMA. Investigators have documented raccoon populations with sex ratios favoring males (Johnson 1970, Urban 1970) and other populations favoring females (Stuewer 1943a, Keeler 1978, Rabinowitz 1981). The variability in raccoon sex ratios is often difficult to explain; no consistent relationship between collection method or type of area and the resulting sex ratios appears to exist (Johnson 1970).

With both study areas combined, monthly sex ratios reflect a general decline from March through September (Table 9). Examined in this manner, ratios ranged from 277 (March) to 85 (August) males per 100 females. Reproductive data indicated that the breeding season occurs from February to May on CSWMA (see Breeding and Reproduction). The proportion of males was significantly lower from June - September than

Table 9. Monthly sex ratios of raccoons captured from March - September, 1983-85 on CSWMA.

Month	Sex Ratio (# M:100 F)[a]
March	277
April	165
May	214
June	150
July	100
August	85
September	103
Mean	156

[a] M=males, F=females.

was exhibited during the breeding season (X^2=36.12, P<0.001). Seasonal sex ratios of raccoons often reflect the greater movements of males versus females (Johnson 1970, Holman 1983). Rabinowitz (1981) documented the sex ratio of raccoons in Cades Cove, GSMNP as favoring females. He plotted the proportion of females to males sampled by month. From March - September, the 2 months with the lowest proportions of females from Cades Cove correspond to the 2 months with the highest proportions of males (March and May) in the present study. The breeding season for raccoons on CSWMA occurred from February - May with a peak in April (see Breeding and Reproduction). A greater proportion of males trapped from March - May is a reflection of the greater movements of males seeking sexually active females (Johnson 1970). Sex ratios reflect the differing activity patterns of males and females in response to the breeding season rather than the actual composition of the population.

Male raccoons exhibited a significantly higher mean number of captures per individual ($\bar{X}$=3.1) than did females ($\bar{X}$=1.8) (t=4.47, P<0.001). The greater mean number of captures per male implies that a live-trapping bias, favoring males, did exist. Two previous researchers on CSWMA (Woods 1978, Nottingham 1985) both indicated that trapping was biased toward males.

Hunting. Sex ratios from the 1984 CSWMA harvest data did not differ significantly from a 1:1 ratio on the experimental area (X^2=0.64, P>0.25) or all the hunted compartments (X^2=1.03, P>0.25). Likewise, no significant deviation from a 1:1 sex ratio in the experimental area

(X^2=0.03, P>0.75) or all hunted compartments (X^2=0.007, P>0.90) existed for the 1985 harvest season on CSWMA. Raccoon hunting probably provides sex ratio data more representative of the population than trapping (Cunningham 1962), although at times it may be biased towards females (with young) (Johnson 1970, Woods 1978). The present results may have been influenced by the closure of raccoon hunting the previous 5 years or less pressure on hunters to harvest treed raccoons immediately, as discussed later (see Age Structure).

Age Structure

Trapping. Pre- and post-hunt age pyramids were constructed for both the control area (Figure 11) and experimental area (Figure 12). Age data were based on the initial capture of individuals. Although both pre-hunt pyramids show a previously large group of Class 1 individuals now becoming sexually mature (presently Class 2), the 2 pyramids differed significantly (X^2=12.57, P<0.025). The control area had relatively fewer Class 3 individuals than Class 4, whereas the experimental area had the opposite. These results may reflect the actual age structure of the 2 study areas, in which the experimental area had more Class 4 raccoons, or this may represent the subjectivity of the aging technique employed. The experimental area also appears to have more Class 5 individuals; however, both areas seem to have more females than males in the older age classes. Higher numbers of Class 5 females may suggest differential mortality (Keeler 1978, Rabinowitz 1981, Nottingham 1985). The post-hunt pyramids more closely resemble

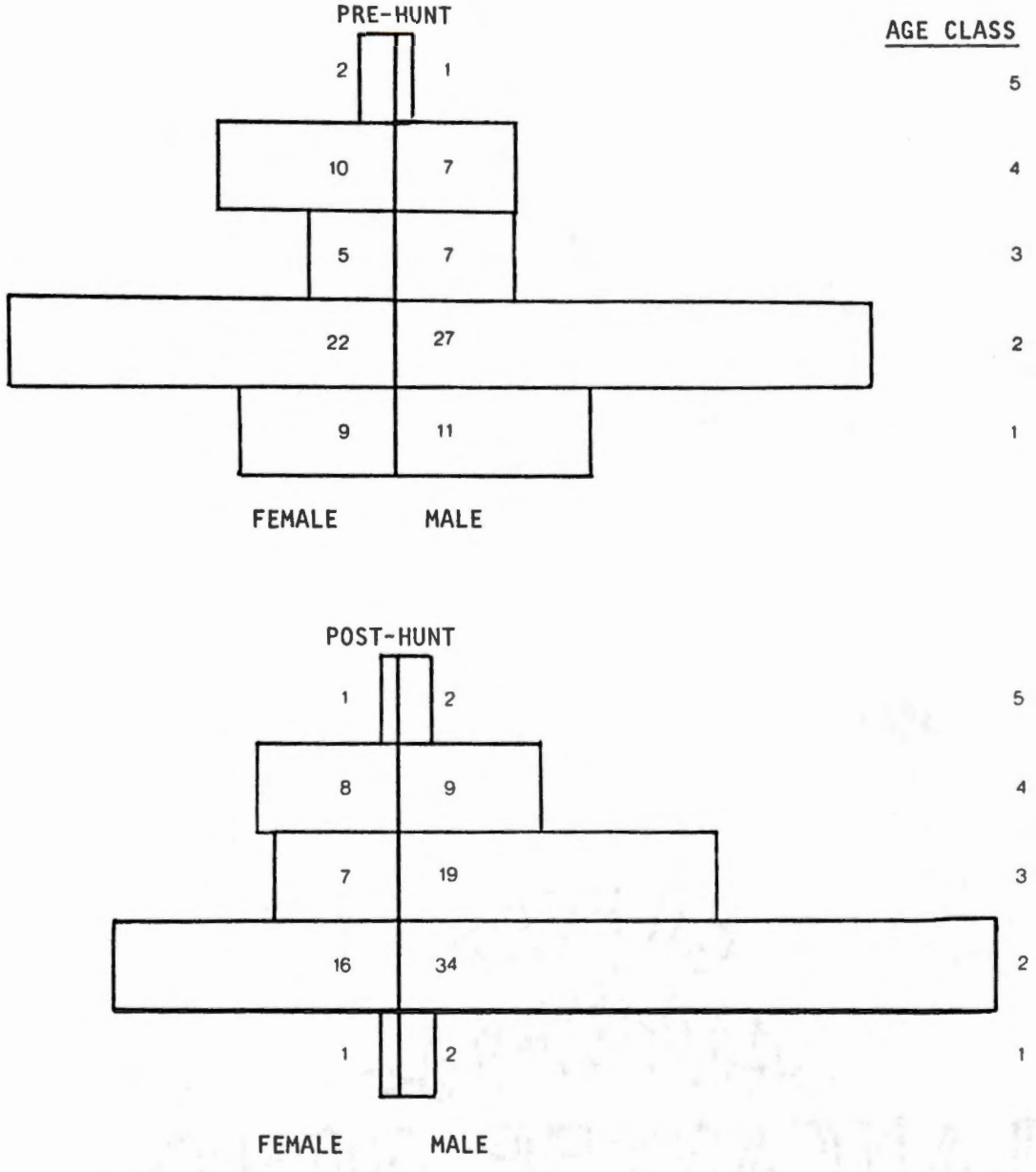


Figure 11. Pre- and post-hunt age pyramids for raccoons captured (initial captures only) in the control area, CSWMA, 1983-85.

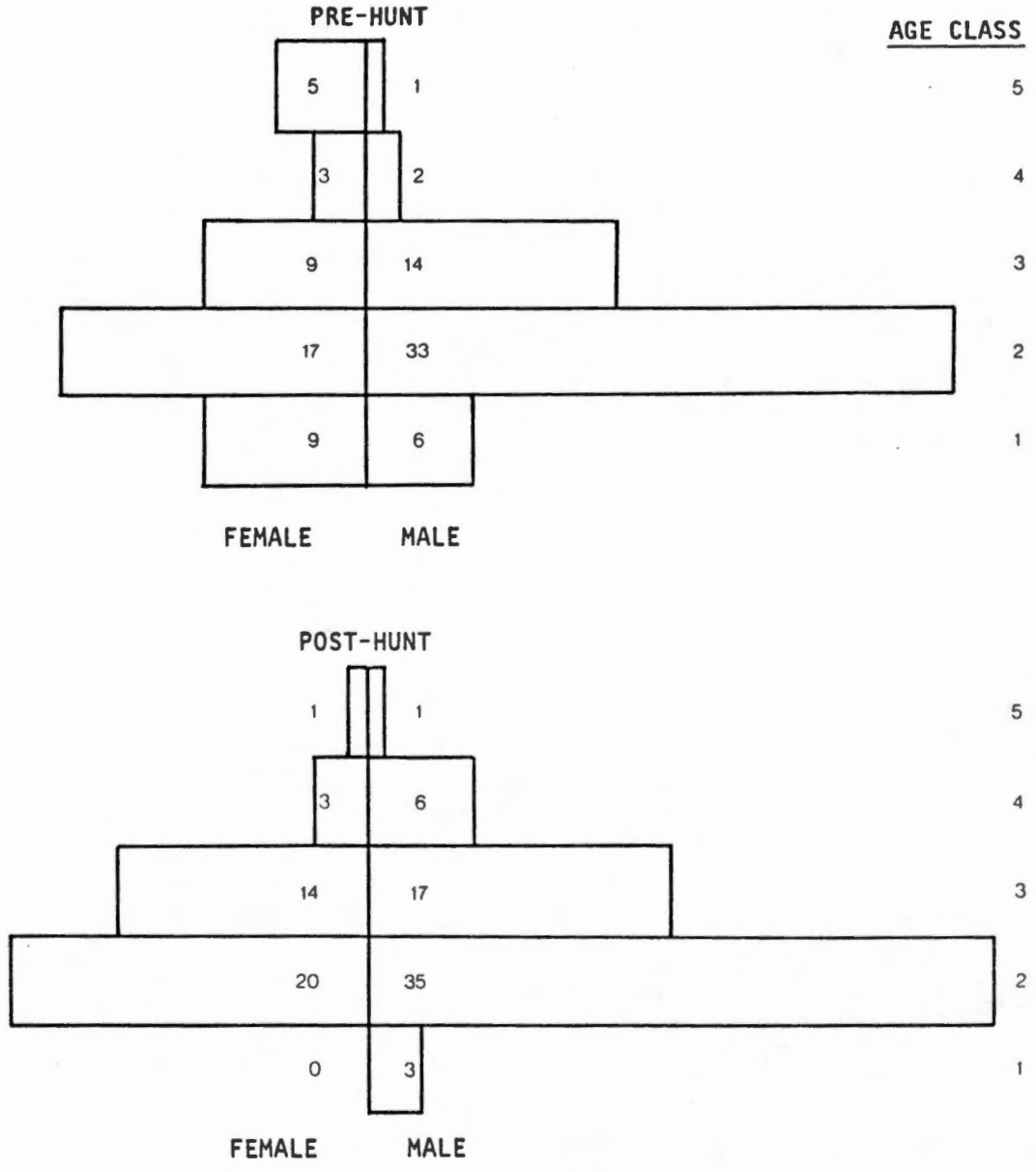


Figure 12. Pre- and post-hunt age pyramids for raccoons captured (initial captures only) in the experimental area, CSWMA, 1983-85.

one another and were not significantly different (X^2=3.08, P>0.5). These 2 pyramids do depict drastic reductions in the number of juvenile individuals (Class 1) and an equal number of Class 5 individuals of both sexes. These results indicate significant mortality of juveniles, which was not a result of the 1984 raccoon hunts because both study areas experienced a reduction in the percentage of juvenile individuals.

To reduce the likelihood of biasing juvenile:adult (J:A) ratios because of the aging technique employed, Age Classes 1 and 2 were considered juveniles and Classes 3, 4, and 5 were grouped as adults (Rabinowitz 1981, Nottingham 1985) (Table 10). The J:A ratios for the first sample period may be exaggerated by low trap success, therefore they were deleted from later analyses. The ratios declined gradually in both areas until the Fall 1984 hunt. The Spring 1985 J:A ratios showed a mean increase between areas of 20% over the preceding sample period. These increases can not be attributed directly to the managed hunts because the control area was not hunted. The mean J:A ratios for the control (1.5:1) and experimental (1.6:1) areas were somewhat higher than the 1.4:1 reported by Nottingham (1985) for the same 2 areas combined from 1981-83. Woods (1978) reported a J:A ratio of 1.2:1 for CSWMA when the raccoon hunting season was 9 nights. Rabinowitz (1981) documented a ratio of 2:1 for the relatively dense, protected raccoons of Cades Cove. These data indicate that the current J:A ratios for raccoons on CSWMA are not atypical for a raccoon population, hunted or unhunted, in east Tennessee. However, age ratios often provide ambiguous information which can lead to management blunders (Caughley 1974). Massive increases or decreases may go undetected by age ratios; different trends

Table 10. Live-trapping Juvenile:Adult ratios for raccoons captured on the 2 study areas, CSWMA, 1983-85.[a]

Trapping Period	Control Area	Experimental Area
Fall 1983	4.75:1[b]	10.1:1[b]
Spring 1984	2.32:1	2.05:1
Fall 1984	0.94:1	1.14:1
Spring 1985	1.15:1	1.36:1
MEAN	1.47:1	1.55:1

[a]Juvenile = Classes I and II; Adult = Classes III, IV, V.

[b]Excluded from calculation of mean.

in age ratios may be interpreted from the same change in the rate of increase.

The mean annual percentage of Class 1 individuals was 14% for the control area and 10% for the experimental area; these are substantially lower than the 23.5% found by Nottingham (1985) from 1981-83 on CSWMA. The above findings may reflect a possible reduction in the reproductive success of raccoon on CSWMA since 1983. The recapture rates among 3 age categories (Class 1, Classes 2 and 3, Classes 4 and 5) were not different for trapping periods 2 and 3 (X^2=2.28, P>0.25). This indicates that age was not a source of heterogeneity in the capture of raccoons.

Hunting. An age pyramid based on the raccoons harvested from the experimental area during 1984 depicted the greatest mortality in Classes 2, 3, and 4 (Figure 13). Age pyramids based on trapping data indicated that 49-55% of the raccoons are Class 2 individuals. Hunting data indicate that only 25% of the harvested raccoons were Age Class 2. In addition, J:A ratios computed for the 1984 hunt data were low for both the experimental area (0.63:1) and the total CSWMA harvest (0.61:1). These results differ from the 1976 season on CSWMA which produced a J:A ratio of 3:1 (Woods 1978).

The J:A ratios for the 1984 harvest probably reflect a greater number of raccoons treed and a greater overall density than those present during the 1976 CSWMA season. Many of the 1984 raccoon hunters hunted as long as possible and treed several raccoons until it was time to check out (0200 hours). Sharp and Sharp (1956), studying raccoon

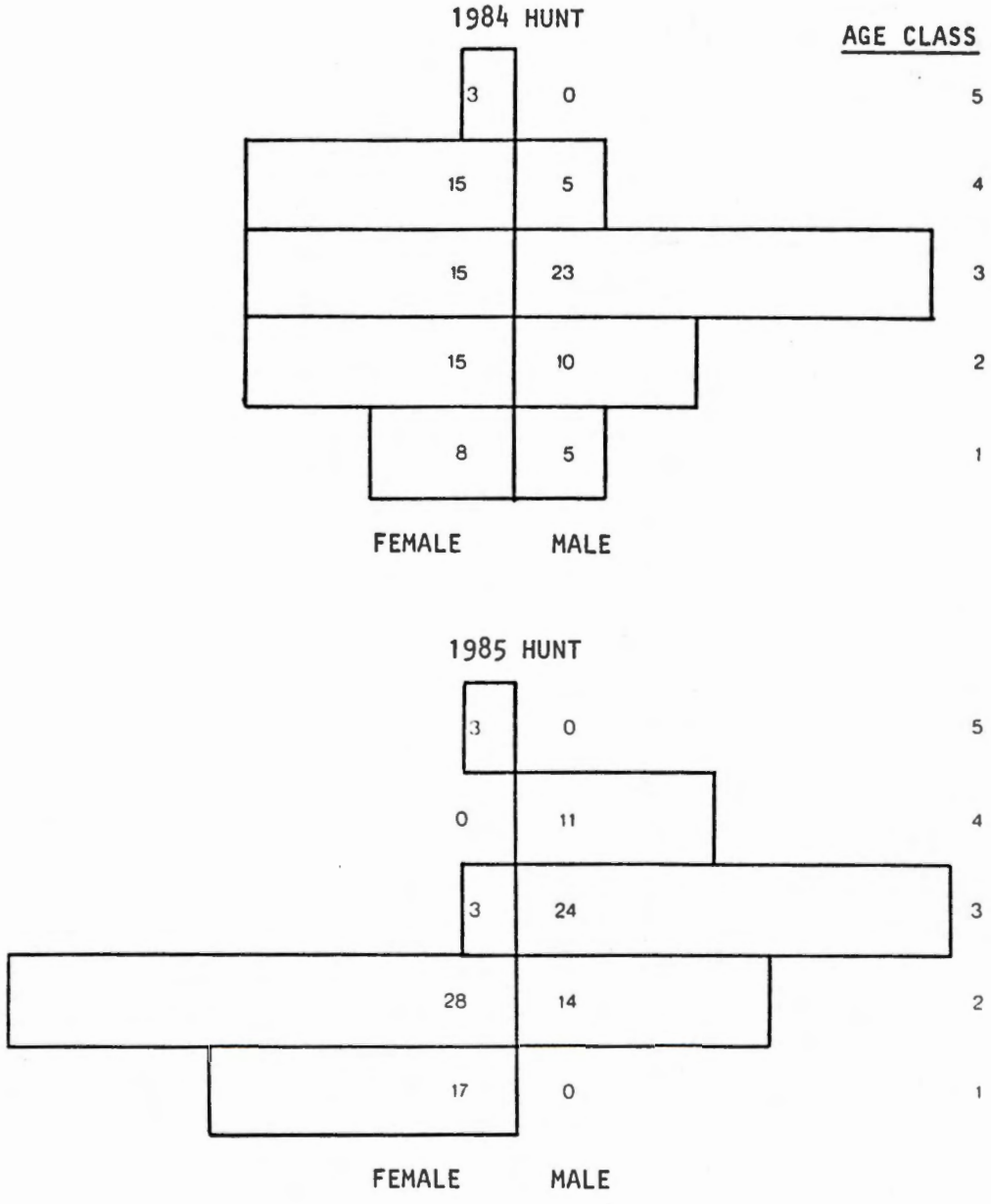


Figure 13. Age pyramids for raccoons harvested in the experimental area, CSWMA, November - December, 1984 and 1985.

behavior for 3 years at an artificial feeding station, noted that older individuals were more alert and became active later at night than young animals. Johnson (1970) and Woods (1978) believed that hunting may be biased towards young raccoons when hunts are conducted early in the night. We suggest that CSWMA hunters treed progressively older raccoons as they hunted later into the night. Therefore, when the hunters decided to harvest a treed raccoon late in the night, because they were ready to quit, it was an older individual. This appears to be substantiated by the 1984 harvest of all hunted compartments, in which 61% of the raccoons were Class 3, 4, and 5 individuals.

Additionally, raccoons were considerably more abundant on CSWMA from 1983-85 (see Density Estimation) than the 1 raccoon/27.5 ha documented for 1976 (Woods 1978). During 1984, CSWMA raccoon hunters hunted at a maximum density of 1 party/149 ha; hunting pressure on CSWMA from 1973-79 was as high as 1 hunter/26 ha (67 acres) (Minser and Pelton 1982). Because raccoon densities were higher and hunting party densities were lower than previous hunting on CSWMA, hunters were less pressured to harvest a raccoon early in the evening, thereby producing an older aged harvest. An age pyramid based on the 1985 harvest in the experimental area appears to favor Age Class 2 individuals more than the 1984 pyramid (Figure 13). However, these 2 pyramids are statistically similar (X^2=3.19, P>0.5). Because a greater percentage of animals were aged as Class 2 rather than Class 3, the J:A ratio of 1985 was markedly higher (1.42:1) than that of 1984; however, data from 1986 reflects a J:A ratio which is more comparable to that of the 1984 harvest (0.78:1) (M. Cantrell, Univ. of TN., unpubl. data).

Movements

Trapping. Raccoons exhibiting 1 or more movement(s) between the 2 study areas from 1983-85 on CSWMA accounted for 18 (6%) of the 328 individuals captured (Table 11). These individuals include those that were captured in one area by Nottingham (1985) but later trapped in the other area during the present study. The number of individuals from the control area (n=11) and the experimental area (n=7) did not differ significantly from a 1:1 ratio (X^2=0.89, P>0.1). Of these 18 raccoons, 5 (28%) were individuals which consistently moved between the 2 study areas. Only 5 (1.5%) of all the individuals captured (n=328) had a home range which overlapped the 2 study areas suggesting that the dividing ridge was a barrier to the movements of most raccoons (Butterfield 1944, Nottingham 1985).

These 18 individuals were significantly different from all trapped individuals with respect to sex and age (X^2=18.88, P<0.001). Males comprised 72% (n=13) of all the raccoons which moved between the 2 study areas; 83% of both sexes were either Age Class 2 or 3 individuals. Larger home range sizes for male raccoons, which have been consistently reported in east Tennessee (Hardy 1979, Taylor 1979, Rabinowitz 1981), may account for the higher percentage of males within this sample.

Areas which experience a reduction in the raccoon density often receive rapid immigration by raccoons from adjacent habitat (Johnson 1970). We expected a significant number of raccoons to move from the control area into the experimental area after the 1984 harvest season. However, trapping data indicated that the 1984 raccoon hunts did not

Table 11. Known raccoon movements documented by trapping and hunting data, CSWMA, 1983-85.

ID NO	Sex	Age (when moved)	Area Moved from [a]	Period of Movement [b]
138	F	5	1	Fall 1984
156	M	3	2	Fall 1983
198	M	3	2	Spring 1984[c]
203	M	2	1	Spring 1984
211	F	3	1	Spring 1984
216	M	2	2	Spring 1984[c]
224	M	3	1	Spring 1984
228	F	4	2	Spring 1984[c]
233	F	2	1	Fall 1984
248	M	3	2	Fall 1985
275	M	2	1	Spring 1984
286	M	3	1	Spring 1985
314	M	3	1	Spring 1985
350	M	2	2	Spring 1984
390	M	3	1	Fall 1984[c]
402	F	2	1	Fall 1984[c]
409	M	1	1	Spring 1984
416	M	2	2	Spring 1985
420	M	4	1	Fall 1985
461	M	2	2	Spring 1985
462	M	3	2	Fall 1984

[a] 1=Control Area; 2=Experimental Area.

[b] Includes individuals who moved during previous research on CSWMA(1981-83).

[c] Individuals who continually moved between study areas from 1983-85 on CSWMA.

affect the tendency of individuals to move between study areas. The mean number of individuals which had moved between areas per sample period before the 1984 hunts was compared to the number which moved after the 1984 hunts. The result was not significant (X^2=0.04, P>0.5); these results support the use of these 2 study areas for research since raccoon movements between these 2 areas appear to be minimal.

Hunting. The 1984 and 1985 CSWMA raccoon harvests were comprised of 21 and 17 tagged individuals, respectively. A total of 6 (16%) individuals did not maintain a home range which was exclusively within the experimental study area (Table 11). Three of these individuals, ID NO's 211, 233, and 350 moved between the study areas, and were discussed above. One individual, ID NO 420, moved into the experimental area from the control area sometime after the Fall 1985 trapping period, as it was trapped in the control area as late as October 1985 (M. Murdock, Univ. of TN., pers. comm.). The remaining 2 individuals, ID NO's 248 and 462 were harvested in compartments 14 and 16, respectively. Nottingham (1985) suggested that movements along this long boundary of the experimental area contributed to lower survival estimates and possible density decreases within this area. Because only 2 (5.3%) of the 38 harvested raccoons which had previously been tagged exhibited such movements, frequent crossing of this long boundary, as described by Nottingham (1985) was not apparent.

Breeding and Reproduction

Trapping. Permanent teeth erupt in a young raccoon while it is being weaned by the female (Stuewer 1943b). The presence or absence of certain deciduous and permanent teeth allow preweaned raccoons to be aged to within a few days (Montgomery 1964). A total of 22 preweaned raccoons were captured during this study; 18 (82%) of these individuals were originally captured in 1984. By back-dating estimated ages (Montgomery 1964) and assuming an average gestation period of 63 days (Hamilton 1936, Stuewer 1943b), the 1984 breeding season ranged from February to early May, with a peak in April (66%) (Table 12). The breeding dates estimated from the Fall 1983 data were within this same range. Nottingham (1985) reported a similar range, with a peak in April, for CSWMA from 1981-83.

The 18 preweaned raccoons from 1984 had estimated birth dates ranging from mid-April to early-July, with 94% occurring in June. The birth dates of 4 individuals from 1983 indicated a possible peak in late May rather than June. Results from both years compare favorably to previous years on CSWMA in which parturition peaked from mid-May to mid-June (Nottingham 1985). Although a later range of parturition (mid-May to early-August) was reported for Cades Cove, GSMNP by Rabinowitz (1981), a fairly uniform pattern likely occurs throughout east Tennessee since latitudinal properties (photoperiod and temperature) appear to influence the timing of raccoon breeding (Bissonnette and Csech 1938, 1939, Sanderson and Nalbandov 1973).

Table 12. Estimated ages and parturition dates of captured young-of-the-year raccoons, CSWMA, 1983-84.

ID NO	Sex	Date Captured	Estimated Age (Days)	Range of Parturition Date
355	M	01 Aug. 1983	81	12 May 1983
365	M	17 Aug. 1983	78-81	28 May-31 May 1983
373	M	14 Sept. 1983	106-112	25 May-31 May 1983
374	F	14 Sept. 1983	106-112	25 May-31 May 1983
428	F	03 Aug. 1981	112	13 Apr 1984
440	M	22 Aug. 1984	81-86	28 May-02 June 1984
443	M	22 Aug. 1984	81-86	28 May-02 June 1984
445	F	23 Aug. 1984	81-86	29 May-03 June 1984
448	F	29 Aug. 1984	81	09 June 1984
464	F	08 Sept. 1984	86-97	03 June-14 June 1984
465	F	09 Sept. 1984	86-97	04 June-15 June 1984
469	F	10 Sept. 1984	97	05 June 1984
470	M	10 Sept. 1984	97	05 June 1984
471	M	15 Sept. 1984	78-81	26 June-29 June 1984
475	M	19 Sept. 1984	106-112	30 May-05 June 1984
479	F	20 Sept. 1984	81-86	26 June-01 July 1984
482	M	22 Sept. 1984	112	02 June 1984
483	M	22 Sept. 1984	81-86	28 June-03 July 1984
484	F	22 Sept. 1984	112	02 June 1984
485	M	24 Sept. 1984	105-112	04 June-10 June 1984
488	F	26 Sept. 1984	97-106	12 June-21 June 1984
491	F	28 Sept. 1984	112	08 June 1984

N = 22

Range of parturition:
13 April - 03 July

Hunting. Reproductive tracts from 35 female raccoons harvested in 1984 were examined for the presence and number of placental scars. Twelve individuals had not bred, while 23 (66%) had distinctive scars (Table 13). During the 1985 raccoon hunts, 28 female reproductive tracts were collected; only 9 (32%) had placental scars (Table 14). These percentages were considerably lower than the 85% (n=256) reported for a sample of harvested raccoons in Illinois (Junge and Sanderson 1982). Rabinowitz (1981), who only examined teat condition, reported that 91% of the females sampled during summer in Cades Cove, GSMNP had bred. Small sample sizes and broad age categories in the present study (i.e. Age Class 2 = 15-38 months) preclude the analysis of age related reproductive success (Junge and Sanderson 1982). Therefore, the percentage of yearling females which bred on CSWMA is unknown. The earlier a female breeds the sooner it will contribute to the rate of increase (Birch 1948). The data appear to indicate that the percentage of parous females generally increases with age.

Mean litter sizes for raccoons harvested in 1984 and 1985 were 2.0 young/breeding female and 2.1 young/breeding female, respectively (ranges = 1 to 5). Previous research on CSWMA (Woods 1978) indicated a mean of 2.8 young/breeding female, as did data from Cades Cove, GSMNP (Rabinowitz 1981). Generally larger litter sizes correspond to more northern latitudes (Johnson 1970); this may be a mechanism to compensate for higher winter mortality associated with these latitudes (Mech et al. 1968). The litter size reported herein is the second lowest reported in the literature (Table 15).

Table 13. Litter sizes for 5 age classes of raccoons harvested on CSWMA, November - December, 1984.

Number of Placental Scars	Age Class 1	Age Class 2	Age Class 3	Age Class 4	Age Class 5	Total
0	2	6	2	1	1	12
1	1	1	2	4	0	8
2	0	1	7	2	0	10
3	0	1	0	1	2	4
4	0	0	0	0	0	0
5	0	1	0	0	0	1
Total	3	10	11	8	3	35
% Parous	33%	40%	82%	88%	67%	66%

Table 14. Litter sizes for 5 age classes of raccoons harvested on CSWMA, November - December, 1985.

Number of Placental Scars	Age Class 1	Age Class 2	Age Class 3	Age Class 4	Age Class 5	Total
0	4	12	3	0	0	19
1	0	2	0	1	0	3
2	0	2	2	0	0	4
3	0	0	0	0	1	1
4	0	0	0	0	0	0
5	0	1	0	0	0	1
Total	4	17	5	1	1	28
% Parous	0%	29%	40%	100%	100%	32%

Table 15. Raccoon litter sizes reported from different areas of the United States.

State	N	Mean Litter Size	Source
North Carolina	10	1.9	Llewellyn (1952)
Washington	7	2.0	Scheffer (1950)
Maryland	12	2.3	Llewellyn (1952)
Alabama	101	2.5	Johnson (1970)
South Carolina	13	2.8	Cunningham (1962)
Tennessee	20	2.8	Woods (1978)
	4	2.8	Rabinowitz (1981)
	32	2.0	This Study
Georgia, Florida	17	3.2	McKeever (1958)
Texas	26	3.4	Woods (1955)
Illinois	?	3.5	Sanderson (1960)
Louisiana	6	3.8	Cagle (1949)
Missouri	22	3.8	Sanderson (1950)
Michigan	11	4.0	Stuewer (1943b)
Virginia	5	4.4	Kellner (1954)
Kansas	8	4.6	Stains (1956)
North Dakota	?	4.8	Fritzell (1977)
New York	4	5.0	Llewellyn (1952)
		$\overline{\text{Mean}} = 3.3$	

The raccoon density for Fall 1976 on CSWMA was estimated at 1 raccoon/27.5 ha or 366 individuals for the 9872 ha peninsula (Woods 1978). If the present fall densities of 1 raccoon/11.6 - 19.4 ha (see Density Estimation) are extrapolated for the whole peninsula, then the present raccoon density is between 509-851 individuals. Therefore, based only on these data, an increase (39-133%) in the density of raccoons on CSWMA has occurred simultaneously with a decrease (29%) in the average litter size of raccoons. Raccoon hunting was closed on CSWMA from 1979-83; estimates from as early as 1982 suggest that the raccoons had recovered from an apparent overharvest (Nottingham 1985). Exploited populations tend to have higher reproduction (Storm and Tzilkowski 1982). Reproduction which is density-dependent may be occurring (Errington 1956, Lord 1960). An inverse relationship between density and the number of offspring produced, has been reported for blacktailed jackrabbits (Lepus californicus) (French et al. 1965) and muskrats (Ondatra zibethica) (Errington 1956). This documented decline in reproduction for raccoons on CSWMA appears to be a compensatory mechanism to retard excessive population growth when raccoon hunting is not present. Although compensatory activity is common among furbearers the mechanisms involved are complex and not easily understood when based on short term studies (Storm and Tzilkowski 1982).

Longevity

Trapping. Of the 170 raccoons trapped in the control area, 4 (2%) were Age Class 5 (>86 months) individuals, and 23 (14%) were Age Class 4

(58-86 months). Trapping in the experimental area produced 7 (5%) Age Class 5, and 9 (6%) Age Class 4 raccoons (n=145). Apparently 11-16% of the raccoons on CSWMA are in these 2 older Age Classes.

Three of the Age Class 5 individuals (1 control area, 2 experimental area) were females that had been tagged by previous researchers on CSWMA in 1976 and 1977. Two of the 3 were juveniles (Age Class 1) in 1976 and therefore had minimum ages at last capture, of 8 years and 8 years 8 months, respectively. The third female was aged as a Class 2 (15-38 months) individual in September 1977 and was captured as late as May 1985. The minimum age of this raccoon was 8 years 11 months (possible age range = 8 years 11 months to 10 years 10 months). Nottingham (1985) recovered 4 individuals from previous studies on CSWMA, the oldest having a minimum age of 9 years 4 months.

The present data support a maximum longevity of at least 9 years for raccoons on CSWMA. Nottingham (1985) also reported an estimate of maximum longevity of 9 years for raccoons. A lower maximum longevity of 7 years was reported for raccoons in Cades Cove, GSMNP (Rabinowitz 1981). The maximum known longevity in the wild for raccoons is 17 years (Garrett and Goetz 1975). The present researcher and 2 others (Woods 1978, Nottingham 1985) working on CSWMA, have documented a total of 5 individual raccoons, each having reached an age comparable to that of the respective investigator's maximum longevity estimate. Each of these 5 raccoons were females. This occurrence further supports the age pyramid data (see Age Structure) which indicated that females out live males on CSWMA. Therefore an apparent reduction in the reproductive success of female raccoons (see Breeding and Reproduction) does not

appear to be a result of older, more productive females dying at earlier ages.

Hunting. Two females, ID NO's 146 and 218, with ages comparing to maximum longevity estimates, were harvested during CSWMA raccoon hunts. One was harvested in 1984 and one in 1985. Both females were aged as Class 4 (58-86 months) individuals by Nottingham (1985); one was aged in December 1981 (ID NO 146) and one in May 1982 (ID NO 218). Minimum ages for these 2 females were 7 years 10 months (ID NO 146) and 8 years 4 months (ID NO 218) (possible age ranges = 7 years 10 months to 10 years 8 months). A female harvested on CSWMA during 1976 was aged at 10-12 years based on cementum annuli (Woods 1978). These results substantiate the maximum longevity estimates produced from trapping data and also the contention that females tend to out live males on CSWMA.

Mortality

Eight raccoon mortalities were documented (Table 16) from 5 July 1983 to 29 July 1985; 7 of these animals died on CSWMA. One death was directly attributable to complications which arose while an animal was sedated and another was killed in the trap, probably by dogs. The total number of animal sedations was 293; therefore deaths directly attributable to capture and handling of raccoons were 0.7% of all sedations and 0.2% of all animal captures. Using Phencyclidine hydrochloride to sedate animals, Fritzell (1978) had a capture and handling death rate of 4% (n=50). Domestic dogs were indicated as the cause of 4 (50%) of all known raccoon mortalities from 1983-85 on CSWMA.

Table 16. Known raccoon mortalities on or near CSWMA from 19 Sept. 1983 through 13 May 1985.

Cause of Mortality	Date of Mortality or Report of Mortality	Tagged	Sex	Age	Location
Anesthesia	19 Sept. 1983	N/A	M	1	Lost Creek
Probable Fox Kill(found at den)	26 March 1984	R372/R373	M	1	Henegar Bend
Dog Kill	03 Oct. 1984	Y374/Y375	F	3	Pond Hollow at Oaks Chapel Rd
Dog/Illegal Kill	11 Dec. 1984	N/A	M	N/A	Oaks Chapel (outside experimental)
Dog/Illegal Kill	11 Dec. 1984	N/A	M	N/A	Oaks Chapel (outside experimental)
Unknown	02 Dec. 1984	R436/R437	M	3	Pond Hollow
Hunter/Legal Kill	? Dec. 1984	R404/R405	M	2	Lonesome Valley (outside of CSWMA)
Dog/Killed in trap	13 May 1985	N/A	N/A	N/A	Peavy Hollow

Prior to the hunt on 10 December 1984 several CSWMA white-tailed deer hunters reported finding raccoon carcasses along the borders of several fields on Chuck Swan. In an attempt to determine whether deaths were being caused by a disease outbreak or from illegal harvest, a search of 2 fields in the control (unhunted) area was conducted on the afternoon of 10 December 1984. No raccoon carcasses were found.

A search was conducted on the morning of 11 December in several fields where carcasses had reportedly been seen (in the RHA). This search resulted in the recovery of 2 raccoon carcasses. A brief field necropsy indicated that both individuals had died of broken backs and other injuries. These results inferred that hunting dogs, with or without the knowledge of their owners, overcame raccoons while chasing them through fields, and killed them (P. Bledsoe, TWRA, pers. comm.) Raccoon hunting dogs would probably remain at the sight of these captures until their owners retrieved them. These carcasses were not taken to the check station, therefore they were considered illegally harvested individuals. The percentage of raccoons which are illegally harvested, is unknown. A survey of the 1984 CSWMA raccoon hunters indicated that 6% witnessed rule violations (Kocka and Pelton, Univ. of TN., unpubl. data). This may or may not include incidences of illegal harvest. Atkeson and Hulse (1953) estimated that these types of losses average less than 10% of the total harvest. During the 1975-76 season, TWRA checked 522 raccoon hunters in Region IV, of which 17% were violators (Warr 1978). During the 1984 raccoon hunting season on CSWMA no violations were witnessed by TWRA personnel.

Small sample size precludes any analysis of mortality with respect to sex or age. It is noteworthy that 1 male raccoon was legally harvested outside of CSWMA, during the regular season. Nottingham (1985) also documented several raccoons being killed outside of CSWMA (n=4), the majority of which were males. Numerous studies have indicated that male raccoons exhibit greater movements than females (Urban 1970, Fritzell 1978, Woods 1978). Differences in home ranges between males and females are exaggerated during the breeding season when males expand their range to increase their ability to breed with females (Stuewer 1943a, Johnson 1970, Rabinowitz 1981). While increasing reproductive success this increase in home range may contribute to increased mortality of males on Chuck Swan (Nottingham 1985). Young individuals (Age Classes 1 and 2) represented 71% of the known age mortalities (n=7). Johnson (1970) and Nottingham (1985) have both documented higher mortality rates for young raccoons.

Estimates of Survival Rate

The J-S model produced survival estimates of raccoons for each area corresponding to each trapping period (Table 17). Estimates of 1.0 were produced for both the control (Fall 1983) and experimental (Fall 1984) areas. Throughout this study the highest estimate produced for each sample period fluctuated between the 2 areas. However, z scores and their corresponding probabilities indicated no significant difference between estimates for each sample period ($P>0.05$). Standard errors indicated a relatively consistent level of precision associated with each estimate. The estimate for Spring 1985 in the experimental area

Table 17. Jolly - Seber estimates of survival rates for raccoons on 2 study areas, CSWMA, 1983-85[a].

Fall 1983	Spring 1984	Fall 1984	Spring 1985
	Control Area		
1.0	.89	.97	.80
(.08)	(.09)	(.11)	(.12)
	Experimental Area		
.87	.98	1.0	.54
(.09)	(.11)	(.17)	(.11)

[a] Associated standard errors are given in parentheses.

(0.54) was at least 33% lower than the other estimates produced for CSWMA from 1983-85. Despite this estimate of low survival, the mean of all survival rates ($\bar{X}$=0.88) from 1983-85 was higher than that reported by Nottingham (1985) for CSWMA from Fall 1981 through Fall 1982 ($\bar{X}$=0.81).

Survival rates reflect losses due to both death and emigration (Jolly 1965); therefore, assessment of the effects of mortality is complicated. Nottingham (1985) reported that emigration may have decreased the estimates of survival in the experimental area, which were as low as 0.52 in Fall 1982. Present data from trapping and hunting on CSWMA indicate that movements of raccoons along study area borders were limited (see Movements). The survival rates of 1.0 produced for each area suggest that mortality and emigration were nonexistent in the control area during Fall 1983 and in the experimental area during Fall 1984. However, the Fall 1984 experimental area estimate had the highest standard error (0.17) of any estimate, implying a lack of precision. Trapping in the control area during Fall 1983 was characterized by low success and the capture of only 14 unmarked individuals. These factors caused J-S to over estimate the survival rate of raccoons in the control area during Fall 1983.

Little is known concerning natural survival rates of raccoons (Woods 1978). When Cunningham (1962) compared the number of placental scars to the number of young within 13 family groups, he found a juvenile survival rate of 75%. However, Mech et al. (1968) reported a lower survival rate for juvenile raccoons of 29%. Most adult raccoon mortality is attributed to exploitation by man (Stuewer 1943a, Sanderson

1950, Johnson 1970). Hunting season closure was documented as increasing the potential for survival when timed with the release of translocated raccoons (Taylor 1979). Taylor (1979) also reported 41% of all known mortality as a product of illegal hunting. Illegal hunting is present at lower levels on CSWMA (see Mortality) than in other areas of east Tennessee (Warr 1978). However, it is a source of mortality thereby decreasing the survival rate of raccoons. Therefore, the decrease in the survival rate of raccoons in the experimental area from Fall 1984 to Spring 1985 may be related to both the legal and illegal hunting pressure experienced by the raccoons in that area.

Diseases and Parasites

Virology. A total of 188 raccoon blood samples were collected during the present study; 160 of these samples were drawn from live-trapped animals, and 28 were from harvested individuals. The control area accounted for 33% of all the samples, while 61% were from the experimental area and 6% were from the RHA. This sampling effort represents 177 individuals (110 males, 67 females), 11 of which were bled twice.

Positive titers for CDV were found in 34 (18%) of the samples, whereas only 3 (1.6%) were positive for RV. None of the samples had a positive titer for CPV. Exact titers were obtained for all serum samples which tested positive for antibodies to CDV or RV. The 2 highest serum antibody titers (1 CDV, 1 RV) were 1:40, whereas 9 were 1:20 (CDV), and the remaining 26 were 1:10.

Included in the 188 samples analyzed were serum from 4 individuals (2 males, 2 females) which Nottingham (1985) had reported as having CDV titers in 1982. During the present study, only 1 of these individuals (I D NO 302) had a positive titer (1:10). Likewise, 1 of the oldest females (minimum age = 9 years 11 months) captured during this study (I D NO 193) was also found to have a positive titer for CDV. Four of these 5 individuals were captured as late as Spring 1984, while the other was captured in Spring 1985. Nottingham (1985) documented an outbreak of CDV in the raccoons on CSWMA in the spring of 1982. The low serum antibody titers reported herein most likely reflect less recent exposure to the distemper virus (Parker et al. 1961). These animals probably recovered from the CDV outbreak experienced during the spring of 1982 on CSWMA. However, Rabinowitz and Potgieter (1984) reported that samples drawn 6 years after a suspected epizootic of CDV in Cades Cove, GSMNP were negative for distemper in raccoons. Because raccoons are highly susceptible to CDV (Robinson et al. 1957), Rabinowitz and Potgieter (1984) suggested that transmission by infected animals and "carriers" was unlikely because the infection appeared to be uniformly fatal among infected individuals. Likewise, Budd (1970) stated with respect to distemper that "morbidity and mortality may be high in a susceptible population." The mortality rate was 50% in experimentally infected raccoons, but it is unknown for free ranging wild species (Kilham and Herman 1954).

All wild raccoons in east Tennessee may not be as susceptible to CDV as indicated by those in Cades Cove. Differences in the susceptibility of individual dogs to CDV have suggested that virus-host

relationships may be involved (Peckham 1967). Variation among strains of CDV may also account for the ranges in susceptibility of individuals or populations. CDV strains differ at the ultrastructural level (Confer et al. 1975); and the various disease patterns caused by viruses may range from fatal to minor or inapparent (Grist et al. 1966). Variation in strains often contributes to the disease pattern of canine distemper encephalomyelitis, which is a common manifestation of CDV infestion (Summers et al. 1984). The epizootiology of distemper in wildlife populations is unknown (Budd 1970) and the presence of CDV has been correlated with fox densities (Parker et al. 1961). Raccoons are currently at the densest levels ever documented on CSWMA; therefore, it is suggested that serological monitoring of the raccoons on CSWMA should continue.

CDV is a paramyxovirus which is antigenically, physicochemically, and biologically related to measles and rinderpest viruses (Wilner 1969, Joklik 1980). Related viruses may cross react with the same antibodies (Sigel and Beasley 1965). Measles, rinderpest, and distemper have a substantial degree of serologic cross-reactivity (DeLay et al. 1965). Therefore, the positive titers for CDV in raccoons on CSWMA may actually reflect the presence of antigens for measles or some other member of the Paramyxoviridae family. This seems unlikely since no investigator has documented the susceptibility of raccoons to other paramyxoviruses. Measles is primarily a disease of man, and rinderpest is not present in the United States.

Parasitology. Samples from 74 (37 males, 37 females) live-trapped raccoons were examined for the presence of microfilariae. Microfilariae were not present in any of the samples. These results sharply contrast those for Cades Cove, GSMNP in which 75% (108) of all raccoon samples were found to contain Tetrapelatonema llewellyni (Rabinowitz et al. 1985). Rabinowitz (1981) believed T. llewellyni to be so successful in Cades Cove that it had developed a symbiotic relationship with raccoons and was not detrimental to the host's health. The present results are not readily explainable because Cades Cove and CSWMA are both representative of upland habitats in east Tennessee (Minser and Pelton 1982). Despite the habitat similarities between these 2 areas, many factors such as the number of potential vectors available and host behavior affect the host vector relationship (Magnarrelli 1979); additionally, correct environmental conditions are necessary for vectors to survive and filaria to develop (Hawking 1961). It was not within the scope of this project to determine the difference in environmental/ vector conditions at CSWMA which allowed for such diverse results from those previously documented in east Tennessee.

Social Interaction

Many researchers have documented extensive overlap in raccoon home ranges (Stuewer 1943a, Geis 1966, Hardy 1979, Taylor 1979) thereby believing that raccoons are not territorial. However, others have reported varying forms of territoriality by raccoons (Tevis 1947, Sharp and Sharp 1956, Mech et al. 1966). Generally, larger home ranges with less overlap are associated with males.

During the present study, 3 occurrences of 2 adult males, captured in the same trap, were recorded. Each of these 'double captures' occurred in the experimental study area and involved 1 Age Class 2 and 1 Age Class 3 individual. One of these occurrences involved 2 previously tagged individuals (IDNO's 212 and 325); examination of their capture histories did not support the possibility of them being siblings. The other 2 occurrences each involved 1 new and 1 recaptured individual. Although unlikely, due to estimated ages, the possibility of these individuals being siblings (in each occurrence) still exists due to a lack of data on the newly captured raccoons. However, Fritzell (1977) indicated that males separate early in life.

The present 'double captures' occurred in summer, thereby substantiating Rabinowitz's (1981) belief that males may possibly maintain some degree of spacing from each other during breeding and parturition, but not at other times of the year. Fritzell (1978) indicated infrequent contact among adult males in the northern prairies, but suggested that lower latitudes may have dissimilar results due to differences in climate, habitat, food resources, and raccoon density. Different patterns of social organization may result from vertebrate populations in dissimilar environments (Crook 1970).

APPENDIX B

Table 18. Capture Records of raccoons trapped on CSWMA, 5 July 1983 to 29 July 1985.

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
103	352	353	22 Aug. 1984	1	153	28	1	2	4	3.2
105	82	83	9 July 1983	1	105	24	1	2	5	
105	344	345	7 Aug. 1984	2	145	25	1	2	5	3.7
105	344	345	23 Aug. 1984	3	154	22	1	2	5	
105	344	345	4 May 1985	4	175	24	1	2	5	
109	1	2	6 July 1983	1	102	30	1	1	3	
109	1	2	24 March 1984	2	122	11	1	1	3	
109	1	2	25 March 1984	3	123	8	1	1	3	
109	1	2	25 April 1984	4	136	20	1	1	3	
109	1	2	4 April 1985	5	164	8	1	1	4	
109	1	2	11 April 1985	6	167	8	1	1	4	
109	1	2	12 April 1985	7	168	11	1	1	4	
109	1	2	4 May 1985	8	175	14	1	1	4	
109	1	2	9 May 1985	9	176	11	1	1	4	
109	1	2	11 May 1985	10	178	16	1	1	4	
109	1	2	12 May 1985	11	179	14	1	1	4	
109	1	2	13 May 1985	12	180	11	1	1	4	
114	11	12	8 July 1983	1	104	14	1	1	2	
114	11	12	2 Aug. 1983	2	107	17	1	1	2	
114	11	12	4 Aug. 1983	3	109	16	1	1	2	
114	11	12	24 March 1984	4	122	16	1	1	2	
114	11	12	27 March 1984	5	125	17	1	1	2	
114	11	12	28 March 1984	6	126	16	1	1	2	
114	11	12	11 April 1984	7	128	28	1	1	2	
114	388	389	14 April 1984	8	131	18	1	1	3	4.0
114	388	389	4 Aug. 1984	9	142	17	1	1	3	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
114	388	389	24 Aug. 1984	10	155	16	1	1	3	
115	253	254	28 April 1984	1	139	21	1	1	3	
117	340	341	6 Aug. 1984	1	144	10	1	2	4	3.2
119	11	12	17 Aug. 1983	1	117	8	1	2	2	
119	334	335	4 Aug. 1984	2	142	8	1	2	3	4.1
120	142	21	25 March 1984	1	123	33	1	1	4	
120	142	21	28 March 1984	2	126	32	1	1	4	
120	142	21	25 April 1984	3	136	33	1	1	4	
120	142	21	29 April 1984	4	140	33	1	1	4	
120	564	565	3 April 1985	5	163	35	1	1	4	4.1
120	564	565	4 May 1985	6	175	35	1	1	4	
120	564	565	9 May 1985	7	176	35	1	1	4	
120	564	565	10 May 1985	8	177	35	1	1	4	
120	564	565	11 May 1985	9	178	35	1	1	4	
121	22	23	26 March 1984	1	124	26	1	1	5	
121	22	23	16 April 1984	2	133	30	1	1	5	
121	22	23	18 April 1984	3	135	30	1	1	5	
121	482	483	6 Aug. 1984	4	144	30	1	1	5	3.6
121	482	483	3 April 1985	5	163	30	1	1	5	
126	28	29	26 March 1984	1	124	19	1	1	3	
126	28	29	10 April 1984	2	127	31	1	1	3	
126	28	29	14 April 1984	3	131	29	1	1	3	
126	28	29	16 April 1984	4	133	31	1	1	3	
126	28	29	17 April 1984	5	134	15	1	1	3	
126	28	29	25 April 1984	6	136	31	1	1	3	
126	490	491	11 Aug. 1984	7	149	19	1	1	4	4.1
126	490	491	24 Aug. 1984	8	155	19	1	1	4	
126	490	491	3 April 1985	9	163	29	1	1	4	
126	490	491	4 April 1985	10	164	15	1	1	4	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
126	490	491	5 April 1985	11	165	29	1	1	4	
126	490	491	6 April 1985	12	166	15	1	1	4	
126	490	491	11 April 1985	13	167	19	1	1	4	
126	490	491	19 April 1985	14	172	30	1	1	4	
126	490	491	4 May 1985	15	175	19	1	1	4	
126	490	491	10 May 1985	16	177	29	1	1	4	
127	30	31	24 March 1984	1	122	4	1	1	2	
127	30	31	4 April 1985	2	164	4	1	1	3	
129	236	237	9 July 1983	1	105	29	1	2	4	
129	236	237	4 Aug. 1983	2	109	29	1	2	4	
129	236	237	6 Aug. 1983	3	144	29	1	2	4	
131	34	35	9 July 1983	1	105	18	1	1	4	
131	380	381	28 March 1984	2	126	27	1	1	4	5.0
131	380	381	13 April 1984	3	130	18	1	1	4	
131	380	381	14 April 1984	4	131	27	1	1	4	
131	380	381	16 April 1984	5	133	23	1	1	4	
131	380	381	25 April 1984	6	136	27	1	1	4	
131	380	381	26 April 1984	7	137	26	1	1	4	
131	380	381	29 April 1984	8	140	23	1	1	4	
131	380	381	2 April 1985	9	162	18	1	1	5	
131	380	381	17 April 1985	10	170	27	1	1	5	
131	380	381	19 April 1985	11	172	23	1	1	5	
131	380	381	4 May 1985	12	175	28	1	1	5	
131	380	381	11 May 1985	13	178	18	1	1	5	
131	380	381	13 May 1985	14	180	23	1	1	5	
132	23	24	18 April 1984	1	135	13	1	2	2	
132	23	24	29 April 1984	2	140	10	1	2	2	
133	25	26	7 Aug. 1983	1	112	20	1	2	4	
133	25	26	12 April 1984	2	129	20	1	2	4	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
133	25	26	4 Aug. 1984	3	142	20	1	2	4	
133	410	411	1 April 1985	4	161	20	1	2	4	5.0
134	215	28	26 March 1984	1	124	35	1	2	4	
137	171	39	15 April 1984	1	132	34	1	1	4	
137	406	407	27 April 1984	2	138	40	1	1	4	4.1
137	406	407	5 Aug. 1984	3	143	40	1	1	4	
138	31	32	19 Sept. 1984	1	152	46	2	2	5	3.2
139	41	40	28 March 1984	1	126	29	1	1	4	
139	41	40	17 April 1984	2	134	19	1	1	4	
139	486	487	10 Aug. 1984	3	148	19	1	1	4	5.4
139	486	487	23 Aug. 1984	4	154	8	1	1	4	
139	486	487	2 April 1985	5	162	11	1	1	4	
139	486	487	4 May 1985	6	175	20	1	1	4	
142	44	45	30 Aug. 1983	1	107	60	2	1	2	
142	44	45	17 May 1984	2	124	60	2	1	2	
142	44	45	28 May 1984	3	127	60	2	1	2	
142	442	443	30 May 1984	4	129	59	2	1	2	4.1
142	442	443	2 June 1984	5	132	74	2	1	3	
142	442	443	23 May 1985	6	163	56	2	1	3	
142	442	443	25 May 1985	7	165	59	2	1	3	
142	442	443	11 July 1985	8	169	58	2	1	3	
143	328	329	16 June 1984	1	139	66	2	2	4	3.6
146	313	314	28 May 1984	1	127	74	2	2	5	3.2
147	39	40	26 Sept. 1984	1	158	73	2	2	3	
151	54	55	7 July 1983	1	103	29	1	1	4	
156	62	189	3 Aug. 1983	1	108	39	1	1	3	
156	363	364	24 March 1984	2	122	39	1	1	3	4.5
156	363	364	16 May 1984	3	123	46	2	1	3	
156	363	364	29 May 1984	4	128	45	2	1	3	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
156	363	364	1 June 1984	5	131	47	2	1	3	
156	363	364	9 July 1985	6	167	45	2	1	4	
157	434	435	29 May 1984	1	128	70	2	1	4	4.5
157	434	435	23 May 1985	2	163	64	2	1	4	
159	432	433	28 May 1984	1	127	63	2	1	5	4.1
159	432	433	31 May 1984	2	130	59	2	1	5	
159	432	433	3 June 1984	3	133	60	2	1	5	
159	432	433	23 May 1985	4	163	62	2	1	5	
159	432	433	11 July 1985	5	169	59	2	1	5	
164	46	45	29 May 1984	1	128	61	2	2	2	
167	543	544	21 Sept. 1984	1	154	68	2	1	4	6.4
167	543	544	10 July 1985	2	168	73	2	1	4	
174	99	100	14 Sept. 1983	1	115	57	2	1	3	
176	105	106	24 March 1984	1	122	27	1	1	3	
176	396	397	25 April 1984	2	136	18	1	1	3	3.6
176	396	397	1 April 1985	3	161	28	1	1	3	
176	396	397	3 April 1985	4	163	18	1	1	3	
176	396	397	11 April 1985	5	167	23	1	1	3	
177	109	110	29 April 1984	1	140	24	1	1	4	
177	480	481	5 Aug. 1984	2	143	25	1	1	4	4.1
177	480	481	6 April 1985	3	166	22	1	1	4	
179	115	116	24 March 1984	1	122	37	1	1	4	
179	115	116	28 March 1984	2	126	37	1	1	4	
180	113	172	23 March 1984	1	121	37	1	1	4	
180	113	172	26 March 1984	2	124	37	1	1	4	
180	113	172	15 April 1984	3	132	38	1	1	4	
180	113	172	18 April 1984	4	135	38	1	1	4	
180	113	172	16 April 1984	5	136	38	1	1	4	
181	117	118	16 April 1984	1	133	34	1	1	3	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
181	606	608	11 May 1985	2	178	40	1	1	4	
183	51	52	7 Aug. 1983	1	112	26	1	2	2	
183	51	52	25 April 1984	2	136	23	1	2	3	
184	53	54	9 July 1983	1	105	35	1	2	5	
184	53	54	15 Aug. 1983	2	115	35	1	2	5	
184	53	54	18 Aug. 1983	3	118	35	1	2	5	
184	53	54	5 Aug. 1984	4	143	35	1	2	5	
185	55	56	2 May 1985	1	173	39	1	2	3	
186	121	122	15 Aug. 1983	1	115	22	1	1	2	
187	123	124	6 July 1983	1	102	23	1	1	2	
188	440	441	30 May 1984	1	129	78	2	1	4	3.6
188	440	441	2 June 1984	2	132	77	2	1	4	
188	440	441	3 June 1984	3	133	78	2	1	4	
189	394	395	18 April 1984	1	135	37	1	1	3	4.1
189	394	395	2 April 1984	2	162	36	1	1	3	
191	57	58	11 April 1984	1	128	36	1	2	4	
193	319	320	1 June 1984	1	131	61	2	2	5	
193	319	320	15 June 1984	2	138	61	2	2	5	
193	319	320	21 May 1985	3	161	61	2	2	5	
193	319	320	23 May 1985	4	163	61	2	2	5	
196	133	134	4 May 1985	1	175	32	1	1	3	
196	133	134	13 May 1985	2	180	32	1	1	3	
197	65	66	7 July 1983	1	103	25	1	2	2	
197	342	343	6 Aug. 1984	2	144	23	1	2	2	3.2
198	135	136	27 March 1984	1	125	39	1	1	3	
198	382	383	28 March 1984	2	126	39	1	1	3	5.0
198	382	383	16 May 1984	3	123	48	2	1	3	
198	382	383	17 May 1984	4	124	45	2	1	3	
198	382	383	18 May 1984	5	125	46	2	1	3	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
198	382	383	29 May 1984	6	128	47	2	1	3	
198	382	383	30 May 1984	7	129	48	2	1	3	
198	382	383	31 May 1984	8	130	45	2	1	3	
198	382	383	1 June 1984	9	131	46	2	1	3	
198	382	383	2 June 1984	10	132	48	2	1	3	
198	382	383	3 June 1984	11	133	46	2	1	3	
198	382	383	11 June 1984	12	134	46	2	1	3	
198	382	383	16 June 1984	13	139	48	2	1	3	
198	382	383	21 Aug. 1984	14	152	40	1	1	3	
198	382	383	5 Sept. 1984	15	143	59	2	1	3	
198	382	383	6 April 1985	16	166	39	1	1	3	
198	382	383	11 April 1985	17	167	39	1	1	3	
198	382	383	13 April 1985	18	169	39	1	1	3	
198	382	383	3 May 1985	19	174	39	1	1	3	
198	382	383	10 May 1985	20	177	39	1	1	3	
198	382	383	13 May 1985	21	180	39	1	1	3	
198	382	383	21 May 1985	22	161	59	2	1	3	
198	382	383	24 May 1985	23	164	59	2	1	3	
198	382	383	25 May 1985	24	165	48	2	1	3	
198	382	383	12 July 1985	25	170	46	2	1	3	
198	382	383	17 July 1985	26	171	46	2	1	3	
198	382	383	18 July 1985	27	172	45	2	1	3	
199	138	139	11 Sept. 1983	1	112	71	2	1	2	
199	551	552	26 Sept. 1984	2	158	71	2	1	4	6.8
199	551	552	21 May 1985	3	161	70	2	1	4	
199	551	552	23 May 1985	4	163	72	2	1	4	
203	266	252	28 March 1984	1	126	20	1	1	2	
203	451	452	1 June 1984	2	131	41	2	1	2	4.1
204	68	69	8 Aug. 1983	1	113	5	1	2	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
204	68	69	18 April 1984	2	135	9	1	2	2	
206	311	312	14 May 1984	1	121	51	2	2	2	3.2
210	86	87	5 July 1983	1	101	17	1	2	2	
210	86	87	8 July 1983	2	104	17	1	2	2	
210	86	87	4 Aug. 1983	3	109	17	1	2	2	
210	86	87	6 April 1985	4	166	14	1	2	4	3.2
211	326	327	15 June 1984	1	138	47	2	2	3	3.2
211	326	327	7 Sept. 1984	2	145	47	2	2	3	
211	326	327	19 Sept. 1984	3	152	47	2	2	3	
212	151	152	28 May 1984	1	127	78	2	1	2	
212	458	459	2 June 1984	2	132	78	2	1	3	4.1
212	458	459	3 June 1984	3	133	56	2	1	3	
212	458	459	13 June 1984	4	136	54	2	1	3	
212	458	459	15 June 1984	5	138	78	2	1	3	
212	458	459	16 June 1984	6	139	77	2	1	3	
212	458	459	10 Sept. 1984	7	148	55	2	1	3	
213	430	431	28 May 1984	1	127	51	2	1	3	4.1
213	430	431	2 June 1984	2	132	50	2	1	3	
213	430	431	25 May 1985	3	165	51	2	1	3	
214	153	154	16 Aug. 1983	1	116	18	1	1	4	
214	355	356	23 March 1984	2	121	13	1	1	4	
214	355	356	24 March 1984	3	122	17	1	1	4	
214	355	356	25 March 1984	4	123	18	1	1	4	
214	355	356	26 March 1984	5	124	13	1	1	4	
214	355	356	16 April 1984	6	133	14	1	1	4	
214	355	356	17 April 1984	7	134	17	1	1	4	
214	355	356	18 April 1984	8	135	17	1	1	4	
214	355	356	25 April 1984	9	136	17	1	1	4	
214	355	356	27 April 1984	10	138	18	1	1	4	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
214	355	356	28 April 1984	11	139	26	1	1	4	
214	355	356	29 April 1984	12	140	16	1	1	4	
216	155	156	25 March 1984	1	123	39	1	1	2	
216	438	439	30 May 1984	2	129	47	2	1	3	4.1
216	438	439	20 Aug. 1984	3	151	34	1	1	3	
216	438	439	4 April 1985	4	164	39	1	1	3	
216	438	439	2 May 1985	5	173	34	1	1	3	
217	92	93	5 July 1983	1	101	13	1	2	2	
217	92	93	18 Aug. 1983	2	118	12	1	2	2	
217	92	93	11 April 1984	3	128	12	1	2	2	
217	92	93	17 April 1984	4	134	12	1	2	2	
217	92	93	25 April 1984	5	136	12	1	2	2	
217	92	93	27 April 1984	6	138	12	1	2	2	
217	92	93	29 April 1984	7	140	12	1	2	2	
221	96	97	1 Aug. 1983	1	106	19	1	2	2	
221	96	97	5 Aug. 1983	2	110	12	1	2	2	
221	96	97	4 Aug. 1984	3	142	19	1	2	3	
221	350	351	20 Aug. 1984	4	151	29	1	2	4	3.6
224	445	446	31 May 1984	1	130	80	2	1	3	3.6
228	131	132	28 April 1984	1	139	39	1	2	4	
228	131	132	4 Sept. 1984	2	142	46	2	2	4	2.7
229	166	167	19 Aug. 1983	1	119	28	1	1	2	
229	166	167	23 March 1984	2	121	26	1	1	2	
229	166	167	26 March 1984	3	124	27	1	1	2	
229	166	167	10 April 1984	4	127	27	1	1	2	
229	496	497	22 Aug. 1984	5	153	27	1	1	4	4.5
229	496	497	11 May 1985	6	178	27	1	1	4	
229	496	497	12 May 1985	7	179	15	1	1	4	
230	364	365	25 Aug. 1984	1	156	29	1	2	3	3.2

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
231	220	221	26 March 1984	1	124	31	1	2	2	
231	220	221	3 Aug. 1984	2	141	32	1	2	2	
231	220	221	17 April 1985	3	170	32	1	2	3	
232	229	228	4 Aug. 1984	1	142	34	1	2	3	3.2
232	229	228	31 Aug. 1984	2	159	34	1	2	3	
233	139	140	5 Aug. 1983	1	110	40	1	2	2	
233	139	140	21 Sept. 1984	2	154	62	2	2	2	
234	362	363	24 Aug. 1984	1	155	37	1	2	4	3.2
235	143	144	8 Aug. 1984	1	146	38	1	2	4	3.6
235	143	144	11 May 1985	2	178	38	1	2	4	
238	168	169	27 Aug. 1983	1	104	48	2	1	4	
238	418	419	16 May 1984	2	123	62	2	1	4	4.1
238	418	419	10 May 1985	3	177	16	1	1	4	
239	366	367	25 Aug. 1984	1	156	34	1	2	4	3.6
239	366	367	3 May 1985	2	174	40	1	2	4	
240	151	152	7 Aug. 1983	1	112	40	1	2	2	
240	151	152	6 Aug. 1984	2	144	34	1	2	3	
241	153	154	5 Sept. 1984	1	143	64	2	2	3	3.2
245	289	290	28 May 1984	1	127	66	2	1	2	
245	449	450	31 May 1984	2	130	65	2	1	3	4.1
245	449	450	2 June 1984	3	132	70	2	1	3	
245	449	450	11 June 1984	4	134	62	2	1	3	
245	449	450	12 June 1984	5	135	67	2	1	3	
245	449	450	14 June 1984	6	137	63	2	1	3	
245	449	450	8 July 1985	7	166	66	2	1	3	
247	159	160	7 Aug. 1984	1	145	31	1	2	3	
248	426	427	19 May 1984	1	126	66	2	1	2	4.1
248	426	427	13 June 1984	2	136	66	2	1	2	
249	161	162	28 Aug. 1983	1	105	64	2	2	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
249	161	162	3 Sept. 1984	2	141	67	2	2	3	
249	161	162	27 Sept. 1984	3	159	65	2	2	3	
249	161	162	25 July 1985	4	176	65	2	2	3	
250	181	182	13 Sept. 1983	1	114	75	2	1	2	
250	460	461	2 June 1984	2	132	71	2	1	3	4.5
250	460	461	25 May 1985	3	165	70	2	1	3	
253	165	166	16 Aug. 1983	1	116	28	1	2	2	
253	165	166	2 April 1985	2	162	28	1	2	3	
255	169	170	1 Aug. 1983	1	106	40	1	2	2	
255	169	170	3 Aug. 1984	2	141	34	1	2	3	
255	169	170	6 Aug. 1984	3	144	40	1	2	3	
255	169	170	19 Aug. 1984	4	150	40	1	2	4	3.6
256	171	172	17 May 1984	1	124	65	2	2	4	
256	171	172	29 May 1984	2	128	67	2	2	4	3.6
256	171	172	17 June 1984	3	140	65	2	2	4	3.6
256	171	172	22 May 1985	4	162	63	2	2	4	
256	171	172	25 May 1985	5	164	67	2	2	4	
258	175	176	5 Aug. 1984	1	143	16	1	2	4	3.2
260	468	469	14 June 1984	1	137	73	2	1	2	3.6
260	468	469	8 July 1985	2	166	73	2	1	3	4.1
262	494	495	22 Aug. 1984	1	153	9	1	1	3	5.4
262	494	495	5 April 1985	2	165	12	1	1	3	
262	494	495	18 April 1985	3	171	10	1	1	3	
262	494	495	9 May 1985	4	176	7	1	1	3	
263	179	780	10 Sept. 1983	1	111	56	2	2	2	
263	179	180	28 May 1984	2	127	56	2	2	2	
263	179	180	30 May 1984	3	129	57	2	2	2	3.2
263	179	180	24 May 1985	4	164	57	2	2	3	
267	447	448	31 May 1984	1	130	74	2	1	3	3.6

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
267	447	448	25 May 1985	2	165	62	2	1	3	
268	185	186	15 Sept. 1983	1	116	46	2	2	5	
270	189	190	8 July 1983	1	104	1	1	2	2	
273	203	204	25 March 1984	1	123	38	1	1	2	
273	408	409	28 April 1984	2	139	37	1	1	2	3.6
273	408	409	12 April 1985	3	168	37	1	1	3	
274	191	192	27 March 1984	1	125	36	1	2	4	
275	412	413	14 May 1984	1	121	75	2	1	2	4.5
275	412	413	12 June 1984	2	135	75	2	1	2	
275	412	413	17 June 1984	3	140	80	2	1	2	
275	412	413	23 May 1985	4	163	80	2	1	2	
279	249	212	4 May 1985	1	175	40	1	1	3	
279	249	212	9 May 1985	2	176	40	1	1	3	
280	213	214	6 Aug. 1983	1	111	7	1	1	1	
280	213	214	8 Aug. 1983	2	113	31	1	1	1	
280	213	214	17 Aug. 1983	3	117	31	1	1	1	
284	195	196	17 May 1984	1	124	73	2	2	2	
284	195	196	29 May 1984	2	128	73	2	2	2	
284	195	196	25 May 1985	3	165	68	2	2	2	
286	623	624	24 May 1985	1	164	44	2	1	3	4.5
286	623	624	12 July 1985	2	170	49	2	1	3	
286	623	624	18 July 1985	3	172	50	2	1	3	
288	197	198	11 April 1985	1	167	26	1	2	3	
294	233	234	9 July 1983	1	105	13	1	1	1	
294	233	234	2 Aug. 1983	2	107	11	1	1	1	
294	233	234	6 Aug. 1983	3	111	15	1	1	1	
294	233	234	16 Aug. 1983	4	116	2	1	1	1	
294	233	234	17 Aug. 1983	5	117	1	1	1	1	
294	233	234	29 April 1984	6	140	34	1	1	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
296	235	236	24 Aug. 1983	1	101	48	2	1	1	
296	235	236	27 Aug. 1983	2	104	50	2	1	1	
296	235	236	11 Sept. 1983	3	112	44	2	1	1	
296	235	236	16 Sept. 1983	4	117	52	2	1	1	
296	235	236	28 May 1984	5	127	44	2	1	2	3.6
296	235	236	29 May 1984	6	128	50	2	1	2	
296	235	236	15 June 1984	7	138	50	2	1	2	
296	235	236	17 June 1984	8	140	49	2	1	2	
296	235	236	3 Sept. 1984	9	141	44	2	1	2	
296	235	236	8 Sept. 1984	10	146	50	2	1	2	
296	235	236	19 Sept. 1984	11	152	49	2	1	2	
296	235	236	25 Sept. 1984	12	157	44	2	1	2	
296	235	236	21 May 1985	13	161	50	2	1	2	
296	235	236	9 July 1985	14	167	44	2	1	2	
297	205	206	11 Sept. 1983	1	112	70	2	2	2	
297	205	206	30 May 1984	2	129	72	2	2	3	4.1
297	205	206	12 June 1984	3	135	66	2	2	3	
298	237	238	19 Aug. 1983	1	119	22	1	1	1	
298	237	238	28 March 1984	2	126	21	1	1	2	
298	237	238	12 April 1984	3	129	31	1	1	2	
298	237	238	18 April 1985	4	171	31	1	1	2	
298	237	238	13 May 1985	5	180	31	1	1	2	
301	209	210	16 April 1984	1	133	32	1	2	3	2.7
302	470	471	15 June 1984	1	138	70	2	1	3	4.1
303	211	212	6 April 1985	1	166	30	1	2	3	
304	213	214	7 Aug. 1983	1	112	24	1	2	1	
304	213	214	11 April 1984	2	128	23	1	2	1	
304	213	214	22 Aug. 1984	3	153	23	1	2	2	3.2
304	213	214	29 Aug. 1984	4	157	27	1	2	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
306	245	246	24 March 1984	1	122	32	1	1	2	
307	337	338	17 Aug. 1983	1	117	13	1	1	2	4.5
307	337	338	25 March 1984	2	123	13	1	1	2	
307	337	338	28 April 1984	3	139	17	1	1	2	
309	256	257	14 April 1984	1	131	6	1	1	3	
309	256	257	11 April 1985	2	167	6	1	1	4	
309	256	257	13 April 1985	3	169	7	1	1	4	
309	256	257	4 May 1985	4	175	5	1	1	4	
309	256	257	10 May 1985	5	177	5	1	1	4	
309	256	257	12 May 1985	6	179	6	1	1	4	
309	256	257	13 May 1985	7	180	10	1	1	4	
310	216	217	3 Aug. 1983	1	108	26	1	2	1	
310	216	217	1 April 1985	2	161	26	1	2	2	
311	218	219	11 April 1984	1	128	16	1	2	2	
312	258	259	7 July 1983	1	103	32	1	1	2	
312	258	259	12 April 1985	2	168	35	1	1	3	
312	258	259	10 May 1985	3	177	32	1	1	3	
314	636	637	25 July 1985	1	176	64	2	1	3	3.6
315	264	265	18 April 1984	1	135	5	1	1	2	
316	222	223	4 Aug. 1984	1	142	38	1	2	2	3.2
317	224	225	18 April 1985	1	171	18	1	2	2	
319	230	231	3 May 1985	1	174	37	1	2	2	
320	232	233	24 March 1984	1	122	33	1	2	1	
320	232	233	31 Aug. 1984	2	159	33	1	2	2	3.2
322	269	270	2 Aug. 1983	1	107	31	1	1	1	4.5
322	269	270	24 Aug. 1984	2	155	32	1	1	2	5.0
322	269	270	18 April 1985	3	171	27	1	1	2	
324	273	274	14 May 1984	1	121	42	2	1	3	
324	273	274	29 May 1984	2	128	41	2	1	3	4.1

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
324	273	274	3 June 1984	3	133	44	2	1	3	
325	275	276	12 June 1984	1	135	78	2	1	2	4.1
325	275	276	13 June 1984	2	136	54	2	1	2	
326	277	278	3 June 1984	1	133	68	2	1	2	
326	466	467	12 June 1984	2	135	69	2	1	2	3.2
326	466	467	22 May 1985	3	162	66	2	1	2	
326	466	467	24 May 1985	4	164	70	2	1	2	
328	242	243	29 May 1984	1	128	65	2	2	5	3.2
328	242	243	28 Sept. 1984	2	160	66	2	2	5	
329	240	241	18 May 1984	1	125	70	2	2	2	3.2
329	240	241	13 June 1984	2	136	70	2	2	2	3.2
329	240	241	18 July 1985	3	172	70	2	2	3	
330	281	282	23 May 1985	1	163	71	2	1	2	
330	281	282	24 May 1985	2	164	75	2	1	2	
331	244	245	18 May 1984	1	125	44	2	2	2	
333	287	288	15 May 1984	1	122	49	2	1	2	
333	287	288	17 May 1984	2	124	48	2	1	2	
333	444	288	31 May 1984	3	130	49	2	1	3	4.1
333	444	288	1 June 1984	4	131	44	2	1	3	
333	444	288	16 June 1984	5	139	58	2	1	3	
334	246	247	10 Sept. 1983	1	111	80	2	2	1	
334	246	247	14 Sept. 1984	2	149	80	2	2	3	4.5
334	246	247	22 May 1985	3	162	80	2	2	3	
335	248	249	14 May 1984	1	121	60	2	2	2	
337	252	253	17 May 1984	1	124	55	2	2	2	2.7
337	252	253	25 May 1985	2	165	55	2	2	3	3.2
338	254	255	4 Sept. 1984	1	142	68	2	2	2	3.6
338	254	255	26 Sept. 1984	2	158	68	2	2	2	
338	254	255	22 May 1985	3	162	68	2	2	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
338	254	255	24 May 1985	4	164	69	2	2	2	
339	291	292	14 May 1984	1	121	45	2	1	2	
339	291	292	1 June 1984	2	131	43	2	1	2	
339	291	292	21 Sept. 1984	3	154	43	2	1	2	
339	291	292	25 May 1985	4	165	45	2	1	2	
343	263	264	29 May 1984	1	128	60	2	2	2	
343	263	264	24 May 1985	2	164	74	2	2	3	
343	263	264	9 July 1985	3	167	74	2	2	3	
343	263	264	18 July 1985	4	172	60	2	2	3	
344	300	301	2 June 1984	1	132	64	2	1	2	
346	304	305	24 Sept. 1984	1	156	69	2	1	3	5.4
347	306	307	30 May 1984	1	129	52	2	1	2	
350	312	313	25 March 1984	1	123	19	1	1	2	
350	312	313	2 June 1984	2	132	41	2	1	2	3.6
350	312	313	15 June 1984	3	138	43	2	1	2	
350	312	313	9 Sept. 1984	4	147	43	2	1	2	
350	312	313	15 Sept. 1984	5	150	42	2	1	2	
350	312	313	19 Sept. 1984	6	152	42	2	1	2	
350	312	313	27 Sept. 1984	7	159	43	2	1	2	
350	312	313	25 May 1985	8	165	43	2	1	3	
350	312	313	10 July 1985	9	168	45	2	1	3	
350	312	313	26 July 1985	10	177	45	2	1	3	
352	316	317	16 Aug. 1983	1	116	29	1	1	2	
352	316	317	27 March 1984	2	125	19	1	1	2	
352	476	477	3 Aug. 1984	3	141	29	1	1	3	4.5
352	476	477	6 Aug. 1984	4	144	19	1	1	3	
352	476	477	10 Aug. 1984	5	148	15	1	1	3	
352	476	477	20 Aug. 1984	6	151	30	1	1	3	
352	476	477	21 Aug. 1984	7	152	31	1	1	3	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
352	476	477	31 Aug. 1984	8	159	18	1	1	3	
352	476	477	1 April 1985	9	161	29	1	1	3	
352	476	477	5 April 1985	10	165	19	1	1	3	
352	476	477	11 April 1985	11	167	30	1	1	3	
352	476	477	18 April 1985	12	171	29	1	1	3	
352	476	477	9 May 1985	13	176	29	1	1	3	
353	319	320	1 Aug. 1983	1	106	3	1	1	2	4.5
353	319	320	9 Aug. 1983	2	114	1	1	1	2	
353	319	320	15 Aug. 1983	3	115	3	1	1	2	
353	319	320	23 March 1984	4	121	1	1	1	2	
353	319	320	25 March 1984	5	123	2	1	1	2	
353	319	320	25 April 1984	6	136	1	1	1	2	
353	574	575	11 April 1985	7	167	3	1	1	3	4.5
353	574	575	12 May 1985	8	179	1	1	1	3	
354	321	322	1 Aug. 1983	1	106	10	1	1	2	3.2
355	323	324	1 Aug. 1983	1	106	14	1	1	1	3.2
356	260	261	1 Aug. 1983	1	106	34	1	2	2	3.6
357	325	326	3 Aug. 1983	1	108	33	1	1	1	4.1
357	325	326	27 March 1984	2	125	34	1	1	1	
357	325	326	18 April 1984	3	135	34	1	1	1	
357	325	326	3 Aug. 1984	4	141	33	1	1	2	
357	325	326	23 Aug. 1984	5	154	35	1	1	2	
357	325	326	6 April 1985	6	166	40	1	1	2	
357	325	326	12 May 1985	7	179	34	1	1	2	
358	267	268	3 Aug. 1983	1	108	38	1	2	2	3.6
359	327	328	4 Aug. 1983	1	109	4	1	1	2	4.5
359	327	328	6 Aug. 1983	2	111	3	1	1	2	
359	327	328	26 March 1984	3	124	4	1	1	2	4.5
360	329	330	5 Aug. 1983	1	110	28	1	1	1	3.6

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
360	329	330	25 March 1984	2	123	22	1	1	1	
360	329	330	10 April 1984	3	127	21	1	1	1	
361	331	332	8 Aug. 1983	1	113	30	1	1	1	3.6
361	331	332	24 March 1984	2	122	3	1	1	1	
361	331	332	11 April 1984	3	128	4	1	1	1	
362	333	334	9 Aug. 1983	1	114	16	1	1	2	3.6
363	269	270	9 Aug. 1983	1	114	36	1	2	1	3.2
364	335	336	16 Aug. 1983	1	116	22	1	1	2	3.6
364	335	336	28 March 1984	2	126	22	1	1	2	
364	335	336	25 April 1984	3	136	22	1	1	2	
364	335	336	8 Aug. 1984	4	146	25	1	1	2	
364	335	336	1 Sept. 1984	5	160	23	1	1	3	3.2
364	335	336	2 April 1985	6	162	25	1	1	3	
364	335	336	18 April 1985	7	171	22	1	1	3	
364	335	336	10 May 1985	8	177	25	1	1	3	
365	339	340	17 Aug. 1983	1	117	20	1	1	1	2.3
366	341	342	24 Aig. 1983	1	101	44	2	1	2	4.5
367	343	344	25 Aug. 1983	1	102	76	2	1	2	4.1
367	343	344	21 May 1985	2	161	58	2	1	2	
367	343	344	18 July 1985	3	172	56	2	1	3	
368	271	272	25 Aug. 1983	1	102	66	2	2	2	4.5
368	271	272	24 May 1985	2	164	66	2	2	3	
369	345	346	25 Aug. 1983	1	102	65	2	1	2	4.5
369	345	346	29 May 1984	2	128	62	2	1	2	
369	345	346	2 June 1984	3	132	65	2	1	2	
369	345	346	15 Sept. 1984	4	150	67	2	1	2	
369	345	346	25 May 1985	5	165	64	2	1	3	
370	273	274	29 Aug. 1983	1	106	73	2	2	2	3.6
371	275	276	30 Aug. 1983	1	107	67	2	2	1	2.7

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
371	275	276	16 June 1984	2	139	67	2	2	2	3.2
372	347	348	14 Sept. 1983	1	115	48	2	1	2	4.5
372	347	348	15 May 1984	2	122	50	2	1	2	
372	347	348	16 May 1984	3	123	44	2	1	2	
373	349	350	14 Sept. 1983	1	115	67	2	1	1	1.8
373	349	350	16 May 1984	2	123	64	2	1	1	
373	349	350	1 June 1984	3	131	67	2	1	1	
373	349	350	14 June 1984	4	137	64	2	1	1	
374	277	278	14 Sept. 1983	1	115	67	2	2	1	1.8
374	277	278	24 May 1985	2	164	65	2	2	2	
375	351	352	15 Sept. 1983	1	116	44	2	1	2	5.0
375	351	352	9 July 1985	2	167	52	2	1	2	
376	279	280	16 Sept. 1983	1	117	64	2	2	2	
376	279	280	19 Sept. 1984	2	152	64	2	2	3	3.6
377	353	354	20 Sept. 1983	1	120	70	2	1	2	3.6
377	353	354	17 June 1984	2	140	72	2	1	2	
377	353	354	15 Sept. 1984	3	150	71	2	1	3	5.4
378	265	266	3 Aug. 1983	1	108	6	1	2	1	4.1
378	265	266	3 May 1985	2	174	6	1	2	2	
379	357	358	23 March 1984	1	121	36	1	1	2	4.1
379	357	358	15 April 1984	2	132	35	1	1	2	
379	357	358	18 April 1984	3	135	36	1	1	2	
379	357	358	28 April 1984	4	139	35	1	1	2	
379	357	358	6 Aug. 1984	5	144	35	1	1	2	
379	357	358	8 Aug. 1984	6	146	35	1	1	2	
379	357	358	11 Aug. 1984	7	149	35	1	1	3	3.2
379	357	358	5 April 1985	8	165	35	1	1	3	
379	357	358	19 April 1985	9	172	35	1	1	3	
379	357	358	13 May 1985	10	180	35	1	1	3	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
380	359	360	24 March 1984	1	122	13	1	1	2	5.0
381	361	362	25 March 1984	1	123	12	1	1	1	2.3
381	361	362	12 April 1984	2	129	12	1	1	1	
381	361	362	30 Aug. 1984	3	158	12	1	1	2	3.2
382	365	366	25 March 1984	1	123	21	1	1	1	1.8
382	365	366	14 April 1984	2	131	21	1	1	1	
382	365	366	18 April 1984	3	135	22	1	1	1	
382	365	366	25 April 1984	4	136	21	1	1	1	
383	285	286	25 March 1984	1	123	29	1	2	1	2.3
383	285	286	31 Aug. 1984	2	159	29	1	2	2	2.7
384	368	369	26 March 1984	1	124	5	1	1	2	3.6
384	368	369	17 April 1984	2	134	6	1	1	2	
384	368	369	13 May 1985	3	180	12	1	1	2	
385	370	371	26 March 1984	1	124	8	1	1	1	2.7
386	287	288	26 March 1984	1	124	22	1	2	1	2.7
387	372	373	26 March 1984	1	124	23	1	1	1	2.7
388	289	290	27 March 1984	1	125	14	1	2	2	2.7
388	289	290	23 Aug. 1984	2	154	14	1	2	3	2.7
389	291	292	27 March 1984	1	125	31	1	2	2	1.8
389	291	292	30 Aug. 1984	2	158	31	1	2	2	2.3
389	291	292	10 May 1985	3	177	31	1	2	2	
390	374	375	28 March 1984	1	126	2	1	1	2	3.2
390	374	375	8 Sept. 1984	2	146	41	2	1	3	4.5
390	374	375	13 April 1985	3	169	8	1	1	3	
390	374	375	12 May 1985	4	179	3	1	1	3	
391	376	377	28 March 1984	1	126	3	1	1	2	4.5
392	378	379	28 March 1984	1	126	7	1	1	2	3.6
392	378	379	19 April 1985	2	172	10	1	1	2	
392	378	379	3 May 1985	3	174	13	1	1	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
393	293	294	28 March 1984	1	126	35	1	2	1	1.8
394	384	385	28 March 1984	1	126	19	1	1	2	3.6
394	384	385	29 April 1984	2	140	29	1	1	2	
394	384	385	18 April 1985	3	171	30	1	1	2	
394	384	385	11 May 1985	4	178	19	1	1	2	
395	295	296	11 April 1984	1	128	37	1	2	2	3.6
396	386	387	11 April 1984	1	128	17	1	1	2	1.8
396	386	387	17 April 1984	2	134	16	1	1	2	
396	386	387	26 April 1984	3	137	16	1	1	2	
396	386	387	5 April 1985	4	165	10	1	1	2	
396	386	387	9 May 1985	5	176	6	1	1	2	
397	297	298	12 April 1984	1	129	32	1	2	2	1.8
397	297	298	9 Aug. 1984	2	147	31	1	2	2	
398	299	300	14 April 1984	1	131	25	1	2	2	2.3
398	299	300	22 Aug. 1984	2	153	25	1	2	2	
399	391	390	16 April 1984	1	133	35	1	1	2	3.6
399	391	390	4 Aug. 1984	2	142	36	1	1	2	
399	391	390	9 May 1985	3	176	38	1	1	2	
401	301	302	16 April 1984	1	133	33	1	2	2	2.3
401	301	302	19 Aug. 1984	2	150	39	1	2	2	3.6
401	301	302	9 May 1985	3	176	39	1	2	2	
402	303	304	16 April 1984	1	133	40	1	2	2	2.7
402	303	304	18 April 1984	2	135	39	1	2	2	
402	303	304	5 Aug. 1984	3	143	39	1	2	2	
402	303	304	10 Sept. 1984	4	148	46	2	2	2	
403	392	393	18 April 1984	1	135	20	1	1	2	3.2
404	398	399	25 April 1984	1	136	19	1	1	2	2.7
404	398	399	4 Aug. 1984	2	142	30	1	1	2	
404	398	399	9 May 1985	3	176	15	1	1	2	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
405	400	401	26 April 1984	1	137	25	1	1	2	2.3
405	400	401	13 April 1985	2	169	23	1	1	2	
406	402	403	26 April 1984	1	137	35	1	1	2	1.8
407	307	308	27 April 1984	1	138	22	1	2	2	2.7
408	305	306	27 April 1984	1	138	2	1	2	2	3.2
409	404	405	27 April 1984	1	138	20	1	1	1	3.2
409	404	405	14 June 1984	2	137	41	2	1	1	
409	404	405	11 Aug. 1984	3	149	20	1	1	2	
409	404	405	21 Aug. 1984	4	152	20	1	1	2	4.5
410	309	310	28 April 1984	1	139	38	1	2	2	2.7
411	410	411	14 May 1984	1	121	41	2	1	2	3.6
411	410	411	29 May 1984	2	128	43	2	1	2	
411	410	411	22 May 1985	3	162	45	2	1	2	
412	414	415	15 May 1984	1	122	66	2	1	3	5.4
413	416	417	15 May 1984	1	122	69	2	1	2	4.5
413	416	417	29 May 1984	2	128	68	2	1	2	
413	416	417	31 May 1984	3	130	64	2	1	2	
413	416	417	21 May 1985	4	161	69	2	1	2	
414	420	421	16 May 1984	1	123	59	2	1	2	2.3
414	420	421	21 Sept. 1984	2	154	61	2	1	2	
414	420	421	21 May 1985	3	161	60	2	1	2	
414	420	421	24 May 1985	4	164	60	2	1	2	
415	422	423	17 May 1984	1	124	72	2	1	2	3.6
415	422	423	17 June 1984	2	140	63	2	1	2	
415	422	423	17 July 1985	3	171	74	2	1	2	
416	424	425	17 May 1984	1	124	62	2	1	2	3.6
416	424	425	15 Sept. 1984	2	150	61	2	1	2	
416	424	425	1 April 1985	3	161	40	1	1	2	
417	428	429	19 May 1984	1	126	64	2	1	2	3.2

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
417	428	429	17 June 1984	2	140	64	2	1	2	
418	436	437	29 May 1984	1	128	64	2	1	3	3.6
419	317	318	1 June 1984	1	131	53	2	2	3	3.2
420	453	454	1 June 1984	1	131	75	2	1	2	3.6
420	453	454	22 Sept. 1984	2	155	75	2	1	2	
420	453	454	19 July 1985	3	173	79	2	1	2	
421	455	457	2 June 1984	1	132	54	2	1	2	3.6
421	455	457	27 Sept. 1984	2	159	54	2	1	2	
421	455	457	21 May 1985	3	161	77	2	1	2	
422	321	322	2 June 1984	1	132	69	2	2	2	3.2
423	462	463	3 June 1984	1	133	58	2	1	2	3.6
423	462	463	13 June 1984	2	136	44	2	1	2	
424	464	465	3 June 1984	1	133	79	2	1	2	2.3
425	323	324	3 June 1984	1	133	76	2	2	3	3.2
426	325	428	14 June 1984	1	137	77	2	2	2	3.2
426	325	428	24 May 1984	2	164	79	2	2	2	
427	429	432	14 June 1984	1	137	69	2	2	2	2.7
427	429	432	9 Sept. 1984	2	147	68	2	2	2	
427	429	432	18 Sept. 1984	3	151	68	2	2	2	
428	330	331	3 Aug. 1984	1	141	11	1	2	1	2.3
428	330	331	11 May 1985	2	178	20	1	2	2	
429	472	473	3 Aug. 1984	1	141	22	1	1	2	2.7
430	474	475	3 Aug. 1984	1	141	25	1	1	3	4.5
430	474	475	7 Aug. 1984	2	145	24	1	1	3	
430	474	475	10 May 1985	3	177	22	1	1	3	
431	333	332	3 Aug. 1984	1	141	37	1	2	4	2.7
431	333	332	17 April 1985	2	170	38	1	2	4	
432	336	337	4 Aug. 1984	1	142	9	1	2	3	3.2
433	478	479	5 Aug. 1984	1	143	26	1	1	2	4.1

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
433	478	479	19 April 1985	2	172	31	1	1	2	
434	338	339	5 Aug. 1985	1	143	31	1	2	1	2.3
435	484	485	8 Aug. 1984	1	146	40	1	1	2	3.2
436	346	347	9 Aug. 1984	1	147	28	1	2	3	3.2
437	348	349	9 Aug. 1984	1	147	30	1	2	2	3.2
437	348	349	6 April 1985	2	166	33	1	2	2	
438	488	489	11 Aug. 1984	1	149	15	1	1	2	3.6
438	488	489	1 Sept. 1984	2	160	15	1	1	2	
438	488	489	1 April 1985	3	161	23	1	1	2	
438	488	489	3 May 1985	4	174	21	1	1	2	
438	488	489	10 May 1985	5	177	21	1	1	2	
439	492	493	21 Aug. 1984	1	152	15	1	1	2	3.6
440	500	501	22 Aug. 1984	1	153	12	1	1	1	1.8
441	354	355	22 Aug. 1984	1	153	32	1	2	2	3.2
442	356	357	22 Aug. 1984	1	153	36	1	2	4	3.6
442	356	357	10 May 1985	2	177	37	1	2	4	
443	498	499	22 Aug. 1984	1	153	33	1	1	1	
444	358	359	22 Aug. 1984	1	153	19	1	2	5	4.1
445	361	360	23 Aug. 1984	1	154	28	1	2	1	1.8
446	502	503	24 Aug. 1984	1	155	21	1	1	2	3.2
447	368	369	29 Aug. 1984	1	157	18	1	2	2	3.6
448	370	371	29 Aug. 1984	1	157	18	1	2	1	1.4
449	504	505	29 Aug. 1984	1	157	38	1	1	2	3.2
450	372	373	3 Sept. 1984	1	141	48	1	2	3	3.6
451	506	507	3 Sept. 1984	1	141	71	2	1	2	3.2
451	506	507	22 May 1985	2	162	75	2	1	2	
451	506	507	24 May 1985	3	164	72	2	1	2	
452	374	375	3 Sept. 1984	1	141	73	2	2	3	3.2
453	376	377	4 Sept. 1984	1	142	50	2	2	2	3.6

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
454	378	379	4 Sept. 1984	1	142	64	2	2	2	2.7
455	508	509	5 Sept. 1984	1	143	75	2	1	2	3.6
456	510	511	5 Sept. 1984	1	143	66	2	1	2	3.2
457	380	381	7 Sept. 1984	1	145	51	2	2	4	4.5
458	513	514	7 Sept. 1984	1	145	80	2	1	2	3.6
459	382	383	8 Sept. 1984	1	146	47	2	2	3	3.6
460	515	516	8 Sept. 1984	1	146	49	2	1	3	1.8
460	515	516	15 Sept. 1984	2	150	49	2	1	3	
460	515	516	18 Sept. 1984	3	151	44	2	1	3	
460	515	516	22 Sept. 1984	4	155	49	2	1	3	
460	515	516	24 Sept. 1984	5	156	49	2	1	3	
460	515	516	27 Sept. 1984	6	159	49	2	1	3	
460	515	516	28 Sept. 1984	7	160	49	2	1	3	
460	515	516	10 July 1985	8	168	49	2	1	3	
460	515	516	17 July 1985	9	171	49	2	1	3	
460	515	516	18 July 1985	10	172	49	2	1	3	
461	517	518	8 Sept. 1984	1	146	44	2	1	2	3.2
461	517	518	21 Sept. 1984	2	154	44	2	1	2	
461	517	518	11 April 1985	3	167	21	1	1	2	
461	517	518	10 May 1985	4	177	26	1	1	2	
462	519	520	8 Sept. 1984	1	146	69	2	1	2	4.1
462	519	520	20 Sept. 1984	2	153	69	2	1	2	
463	384	385	8 Sept. 1984	1	146	62	2	2	3	3.2
464	386	387	8 Sept. 1984	1	146	62	2	2	1	1.8
465	388	389	9 Sept. 1984	1	147	51	2	2	1	2.3
466	521	522	10 Sept. 1984	1	148	48	2	1	2	3.6
467	523	524	10 Sept. 1984	1	148	77	2	1	3	4.1
467	523	524	25 Sept. 1984	2	157	77	2	1	3	
468	525	526	10 Sept. 1984	1	148	69	2	1	2	4.1

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
469	390	390	10 Sept. 1984	1	148	63	2	2	1	1.8
469	390	391	8 July 1985	2	166	62	2	2	2	
470	527	528	10 Sept. 1984	1	148	63	2	1	1	1.4
470	527	528	25 May 1985	2	165	63	2	1	2	
471	529	530	15 Sept. 1984	1	150	52	2	1	1	2.3
472	531	532	15 Sept. 1984	1	150	53	2	1	3	3.6
473	533	534	15 Sept. 1984	1	150	70	2	1	3	5.4
473	533	534	21 May 1985	2	161	67	2	1	3	
473	533	534	19 July 1985	3	173	66	2	1	3	
474	535	536	18 Sept. 1984	1	151	69	2	1	3	4.5
474	535	536	12 July 1985	2	170	68	2	1	3	
475	537	538	19 Sept. 1984	1	152	77	2	1	1	2.3
475	537	538	27 Sept. 1984	2	159	56	2	1	1	
476	539	540	19 Sept. 1984	1	152	60	2	1	3	4.1
476	539	540	28 Sept. 1984	2	160	74	2	1	3	
477	541	542	20 Sept. 1984	1	153	55	2	1	2	5.0
478	392	393	20 Sept. 1984	1	153	71	2	2	4	4.5
479	394	395	20 Sept. 1984	1	153	66	2	2	1	2.3
479	394	395	24 Sept. 1984	2	156	66	2	2	1	
479	394	395	11 July 1985	3	169	66	2	2	2	
480	396	397	21 Sept. 1984	1	154	73	2	2	5	4.1
481	398	399	21 Sept. 1984	1	154	59	2	2	3	3.6
482	400	401	22 Sept. 1984	1	155	43	2	2	1	1.8
483	545	546	22 Sept. 1984	1	155	71	2	1	1	2.3
484	402	403	22 Sept. 1984	1	155	63	2	2	1	2.3
484	402	403	24 May 1985	2	164	63	2	2	2	
484	402	403	26 July 1985	3	177	62	2	2	2	
485	547	548	24 Sept. 1984	1	156	66	2	1	1	2.7
486	404	405	25 Sept. 1984	1	157	75	2	2	2	3.6

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
487	549	550	26 Sept. 1984	1	158	78	2	1	3	4.1
488	406	407	26 Sept. 1984	1	158	61	2	2	1	1.8
488	406	407	24 July 1985	2	175	61	2	2	2	
489	553	554	27 Sept. 1984	1	159	44	2	1	2	4.5
490	555	556	27 Sept. 1984	1	159	73	2	1	3	4.1
491	408	409	28 Sept. 1984	1	160	60	2	2	1	1.4
492	557	558	1 April 1985	1	161	4	1	1	3	4.5
493	559	560	1 April 1985	1	161	22	1	1	2	4.1
494	562	563	1 April 1985	1	161	32	1	1	2	3.2
495	412	413	3 April 1985	1	163	20	1	2	2	2.3
496	566	567	4 April 1985	1	164	17	1	1	2	3.2
496	566	567	6 April 1985	1	166	18	1	1	2	
497	414	415	5 April 1985	1	165	9	1	2	2	1.8
498	568	569	5 April 1985	1	164	21	1	1	2	2.3
498	568	569	3 May 1985	2	174	23	1	1	2	
499	570	571	6 April 1985	1	166	2	1	1	2	3.6
501	416	417	6 April 1985	1	166	37	1	2	2	2.3
501	416	417	13 May 1985	2	180	37	1	2	2	
502	572	573	6 April 1985	1	166	19	1	1	2	1.8
503	576	577	11 April 1985	1	167	33	1	1	2	2.3
503	576	577	12 May 1985	2	179	30	1	1	2	
504	578	579	12 April 1985	1	168	17	1	1	2	2.3
505	580	581	12 April 1985	1	168	22	1	1	2	2.7
506	582	583	13 April 1985	1	169	6	1	1	2	2.7
506	582	583	9 May 1985	2	176	4	1	1	2	
506	582	583	10 May 1985	3	177	3	1	1	2	
507	584	585	13 April 1985	1	169	9	1	1	3	4.1
508	586	587	13 April 1985	1	169	33	1	1	1	2.3
508	586	587	12 May 1985	2	179	33	1	1	1	

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
509	592	593	17 April 1985	1	171	21	1	1	2	2.7
510	588	589	17 April 1985	1	170	37	1	1	3	3.6
511	590	591	18 April 1985	1	171	12	1	1	1	2.3
512	418	419	18 April 1985	1	171	16	1	2	2	2.3
513	595	594	19 April 1985	1	172	40	1	1	2	3.6
514	596	597	2 May 1985	1	173	32	1	1	2	3.2
515	420	421	2 May 1985	1	173	38	1	2	4	3.6
516	424	425	3 May 1985	1	174	33	1	2	1	3.6
516	424	425	10 May 1985	2	177	33	1	2	1	
517	598	599	3 May 1985	1	174	22	1	1	2	2.7
518	600	601	9 May 1985	1	176	21	1	1	2	2.7
519	434	433	9 May 1985	1	176	30	1	2	2	1.8
520	602	603	10 May 1985	1	177	10	1	1	2	2.3
521	435	436	10 May 1985	1	177	17	1	2	2	2.7
522	438	439	11 May 1985	1	178	2	1	2	3	3.6
523	604	605	11 May 1985	1	178	14	1	1	2	2.7
524	440	441	21 May 1985	1	161	43	2	2	2	2.7
525	609	610	21 May 1985	1	161	62	2	1	2	3.2
526	442	443	22 May 1985	1	162	44	2	2	2	2.3
527	611	612	22 May 1985	1	162	70	2	1	2	3.2
528	613	614	22 May 1985	1	162	67	2	1	3	3.6
528	613	614	9 July 1985	2	167	64	2	1	3	
529	446	447	23 May 1985	1	163	46	2	2	3	3.2
530	615	616	23 May 1985	1	163	50	2	1	2	3.2
531	617	618	23 May 1985	1	163	79	2	1	2	3.6
532	619	620	23 May 1985	1	163	75	2	1	2	3.6
532	619	620	26 July 1985	2	177	71	2	1	2	
533	621	622	24 May 1985	1	164	49	2	1	1	2.3
534	625	561	24 May 1985	1	164	56	2	1	1	1.8

Table 18. Continued

ID NO	Right Tag NO	Left Tag NO	Capture Date	Number of Captures	Sample Period	Capture Site	Area	Sex	Age	Weight
534	625	561	25 July 1985	2	176	56	2	1	1	
535	437	422	24 May 1985	1	164	73	2	1	4	4.1
536	626	627	8 July 1985	1	166	42	2	1	2	4.1
537	448	449	8 July 1985	1	166	72	2	2	2	2.7
538	450	451	8 July 1985	1	166	60	2	2	2	2.7
539	452	453	9 July 1985	1	167	71	2	2	4	3.6
540	454	455	9 July 1985	1	167	65	2	2	2	3.6
541	628	629	9 July 1985	1	167	67	2	1	2	2.7
542	630	631	9 July 1985	1	167	68	2	1	2	2.7
542	630	631	17 July 1985	2	171	68	2	1	2	
543	456	457	9 July 1985	1	167	61	2	2	3	3.6
544	632	633	12 Jyly 1985	1	170	68	2	1	2	3.2
545	634	635	18 July 1985	1	172	56	2	1	2	3.6
546	458	459	24 July 1985	1	175	63	2	2	2	2.3
547	460	461	25 July 1985	1	176	68	2	2	3	4.1

APPENDIX C

Table 19. Total captures of non-target mammals trapped on 2 study areas, CSWMA, 1983-85.

Opossum	Ground-hog	Gray fox	Red fox	Dog[a]	House Cat[a]	Striped Skunk	Spotted Skunk	Cottontail Rabbit
419[b]	90[b]	15	7	22	3	19[b]	3[b]	10[b]

[a] Animals removed from study area.

[b] Totals may include recaptures.

APPENDIX D

Table 20. Data from raccoons harvested on CSWMA, November-December, 1984.

ID Number	Right Tag Number	Harvest Date[a]	Area	Compartment Number	Sex	Age	Wgt.
143	328	2	2	13	2	4	6.4
146	313	2	2	12	2	5	5.0
211	326	1	2	11	2	4	4.5
233	139	1	2	13	2	4	5.4
236	145	3	2	15	2	3	5.9
324	273	3	2	10	1	4	5.9
331	244	1	2	10	2	4	5.4
333	444	2	2	10	1	3	6.4
370	273	1	2	15	2	3	5.9
377	353	1	2	13	1	4	6.4
454	378	2	2	15	2	2	3.6
459	382	2	2	11	2	4	5.4
462	519	1	3	16	1	3	6.4
467	523	2	2	12	1	3	5.4
472	531	2	2	10	1	2	4.5
475	537	2	2	12	1	1	3.2
476	539	2	2	13	1	3	4.5
477	541	1	2	12	1	3	6.4
481	398	3	2	13	2	2	4.5
487	549	3	2	12	1	3	5.4
489	553	3	2	10	1	3	4.5
548	-	1	2	10	2	3	5.0
549	-	1	3	09	2	3	5.0
550	-	1	3	07	1	4	7.3
551	-	1	2	15	1	3	5.4
552	-	1	3	18	1	3	5.9
553	-	1	3	08	1	2	2.7
554	-	1	3	07	2	2	2.3
555	-	1	3	09	2	2	5.4
556	-	1	2	10	2	3	5.0
557	-	1	3	17	1	2	3.6
558	-	1	3	07	2	4	5.4
559	-	1	3	18	2	5	7.7
560	-	1	3	08	1	2	5.0
561	-	1	2	13	1	3	3.6
562	-	1	2	15	1	2	2.7
563	-	1	3	14	2	3	5.4
564	-	1	3	17	2	1	2.3
565	-	1	3	16	2	3	5.9
566	-	1	3	18	2	3	5.0

Table 20. Continued

ID Number	Right Tag Number	Harvest Date[a]	Area	Compartment Number	Sex	Age	Wgt.
567	-	1	3	14	2	2	2.7
568	-	1	3	17	2	2	3.2
569	-	1	3	14	1	2	3.2
570	-	2	3	09	1	3	5.9
571	-	2	2	13	1	3	5.0
572	-	2	2	12	2	1	2.3
573	-	2	3	09	2	5	5.4
574	-	2	2	10	2	3	4.1
575	-	2	3	14	1	3	4.5
576	-	2	3	07	1	5	5.4
577	-	2	3	16	2	4	4.1
578	-	2	3	18	1	3	5.0
579	-	2	3	09	2	2	3.6
580	-	2	3	17	1	4	6.4
581	-	2	3	17	2	5	4.5
582	-	2	2	11	2	2	2.3
583	-	2	2	11	2	2	4.1
584	-	2	2	15	2	2	3.6
585	-	2	2	15	2	1	2.7
586	-	3	2	13	1	2	3.6
587	-	3	3	09	2	2	5.4
588	-	3	2	11	2	3	3.6
589	-	3	3	09	2	3	5.0
590	-	3	2	12	2	1	2.7
591	-	3	2	15	1	1	2.7
592	-	3	3	17	2	1	2.3
593	-	3	2	10	2	2	5.0
594	-	3	3	18	1	2	5.4
595	-	3	3	09	1	3	6.8
596	-	3	3	07	1	2	4.1
597	-	3	3	18	2	4	5.0
598	-	3	3	08	2	3	4.5
599	-	3	2	13	1	2	5.4
601	-	3	3	08	1	1	2.3
602	-	3	3	14	1	3	5.0
603	-	3	3	17	2	3	5.0
604	-	3	3	18	2	4	5.4
605	-	3	3	08	1	4	6.8
606	-	3	2	12	2	4	5.0

[a] 1=12 November 1984; 2=14 November 1984; 3=10 December 1984.

APPENDIX E

Table 21. Data from raccoons harvested on CSWMA, November-December 1985.

ID Number	Right Tag Number	Harvest Date[a]	Area	Compartment Number	Sex	Age	Wgt.
218	490	4	2	11	2	5	4.0
224	446	5	2	12	1	3	5.7
248	427	6	3	14	1	3	6.8
350	313	6	2	11	1	4	6.4
367	344	5	2	12	1	4	6.0
414	421	4	2	13	1	3	5.5
420	545	4	2	12	1	4	5.7
460	516	6	2	10	1	3	4.6
483	546	5	2	13	1	2	5.2
524	441	4	2	11	2	2	4.5
527	612	4	2	15	1	3	5.5
538	451	4	2	13	2	2	4.5
570	486	4	2	15	2	2	4.1
574	682	4	2	12	1	2	3.5
584	502	6	2	15	2	1	3.5
586	506	5	2	15	2	2	3.5
591	698	5	2	15	1	3	5.5
654	.	4	2	15	1	3	6.5
655	.	4	3	17	1	2	5.5
656	.	4	3	18	1	2	3.2
657	.	4	2	13	2	3	4.7
658	.	4	3	7	2	2	3.2
659	.	4	2	10	2	1	1.7
660	.	4	3	7	1	3	5.0
661	.	4	3	9	2	2	4.8
662	.	4	3	14	2	2	5.0
663	.	4	3	16	2	2	3.2
664	.	4	3	8	2	2	5.0
665	.	4	3	9	1	2	3.0
666	.	4	2	10	1	2	3.5
667	.	4	3	17	1	5	6.7
668	.	4	3	17	2	1	2.5
669	.	4	3	18	2	2	3.8
670	.	4	3	16	2	2	3.3
671	.	4	3	14	2	2	4.5
672	.	4	3	9	2	3	4.7
673	.	4	3	8	1	2	5.1
674	.	5	3	16	2	3	5.0
675	.	5	3	8	2	2	4.0
676	.	5	2	15	2	1	2.5
677	.	5	2	11	2	1	2.7

Table 21. Continued

ID Number	Right Tag Number	Harvest Period	Area	Compartment Number	Sex	Age	Wgt.
678	.	5	3	6	1	1	3.3
679	.	5	3	7	1	3	6.0
680	.	5	3	17	1	1	2.8
681	.	5	3	9	1	3	5.7
682	.	5	3	9	2	1	2.4
683	.	5	3	8	1	3	5.0
684	.	5	3	9	2	1	2.2
685	.	5	3	18	2	3	4.5
686	.	5	3	17	1	1	2.4
687	.	5	2	15	2	2	3.8
688	.	5	3	16	1	1	3.1
689	.	5	2	13	2	2	2.5
690	.	5	3	7	1	1	3.1
691	.	5	2	10	1	2	3.0
692	.	6	3	9	2	4	4.5
693	.	6	3	17	2	3	4.8
694	.	6	2	15	2	2	4.5
695	.	6	2	12	2	2	4.0
696	.	6	3	8	2	2	2.7
697	.	6	3	7	2	2	3.3
698	.	6	3	16	1	1	3.0
699	.	6	2	12	1	3	6.2
701	.	6	3	9	1	4	4.9
702	.	6	3	18	1	3	5.9
703	.	6	3	9	1	3	6.2
704	.	6	2	10	2	1	2.0

[a] 4=18 November 1985; 5=20 November 1985; 6=2 December 1985.

APPENDIX F

Table 22. Number of visits and overall visitation rates for raccoons and other mammals to 1036 operable scent-stations in 2 study areas on CSWMA, 1983-85.

Study Area	Mammal	Total Number Visits, N	Visitation Rate % (N/ Total stations)
Control	Raccoon	31	6.0
	Opossum	13	2.5
	Gray Fox	23	4.4
	Red Fox	1	0.2
	Both Foxes[a]	32	6.1
	Dog	7	1.4
	Striped skunk	11	2.1
	Cottontail Rabbit	9	1.7
	White-tailed deer	4	0.8
	Woodchuck	15	2.9
Total:	9 species	122	Mean = 2.6
Experimental	Raccoon	21	4.1
	Opossum	26	5.0
	Gray Fox	17	3.3
	Red Fox	2	0.4
	Both Foxes[a]	22	4.2
	Dog	3	0.6
	Striped skunk	4	0.8
	Cottontail Rabbit	14	2.7
	White-tailed deer	3	0.6
	Woodchuck	7	1.3
Total:	9 species	100	Mean = 2.2

[a]Both foxes combined, plus 11 unidentified foxes.

VITA

David M. Kocka was born in Catonsville, Maryland, on October 18, 1960. He attended public schools in Catonsville and was graduated in June 1978. He entered Garrett Community College in Fall 1978 and received an Associate degree in Wildlife Technology in December 1980. In June 1983, he completed a Bachelor of Science degree in Wildlife Resources at West Virginia University. While attending West Virginia University he was a member of the Wildlife Bowl team which won first place at the 1983 student conclave in Amherst, Massachusetts. He was also the co-recipient of West Virginia's Outstanding Wildlife Student Award in 1983. He entered the graduate program at The University of Tennessee in July 1983. In March 1986 he married the former Donna L. Cruce of Knoxville. In December 1987 he graduated with a Master of Science degree in Wildlife and Fisheries Science. He also entered Oklahoma's Department of Wildlife Conservation in December, as their furbearer biologist.