Population Characteristics and Harvest Relationships of a Raccoon Population in East Tennessee

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Abstract: Controlled hunting (9-night season) and livetrapping of raccoons (*Procyon lotor*) on the Chuck Swan Wildlife Management Area was assessed in relation to total harvest, age and sex characteristics, reproductive parameters, and density estimates. From 1976 to 1978 hunting pressure and hunting success remained relatively constant while the total harvest decreased at an average of 23% annually from 175 (1975) to 80 (1978). Seventy-five, 69 and 69% of the 1976, 1977, and 1978 harvests were juveniles suggesting a greater vulnerability compared to adults; this occurrence also may be related to dispersal or other factors. Reproductive data did not appear to compensate for high harvest and may be related to the quality of the upland hardwood habitat areas of the southern Appalachians. Tag return ratios in the harvest (Lincoln Index) yielded an estimated density of 1 raccoon per 23.1–27.5 ha. Thirty-four (30.4%) of the trapped raccoons (112) were harvested in 1976, 11 in 1977 and 4 in 1978. The total harvest in 1976 comprised between 31.2% and 37.2% of the estimated population and appeared too high to permit sustained yields. These harvest and density relationships may be indicative of other upland hardwood habitats and necessitate more restrictive management procedures.

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Proper management of raccoons has become increasingly important to state wildlife agencies in the Southeast. This task is especially critical in the southern Appalachians where raccoon hunting is a tradition and intense demand may exceed raccoon abundance. Illegal harvests likely depress harvestable raccoon populations (Wright 1977, Taylor and Pelton 1979). Raccoon hunters translocate raccoons from coastal areas that may introduce parasites and diseases, and further depress native raccoon populations (Johnson 1970, Schaffer et al. 1978, Nettles et al. 1979). State laws permitting year-round dog training and county acts generated by hunting groups frequently override state wildlife agencies' authority to manage raccoon populations.

Hunting may have considerable impact on raccoon populations in some areas of the South; in upland and mountain areas of Alabama hunting is likely a limiting factor (Johnson 1970). The impact of hunting was evident at Wheeler National Wildlife Refuge (Wheeler NWR) when, after a 6-year closure and reopening, the raccoon harvest increased 4 times (Johnson 1970). Additional information from Wheeler NWR indicated a continuous reduction in raccoon harvest from hunting pressure that was practically constant or declining (Johnson 1970). Atkeson and Hulse (1953) demonstrated that public hunting was more effective in reducing a dense raccoon population on Wheeler NWR than was trapping. Collecting raccoons with dogs in South Carolina was 5 times more successful on an area closed to public hunting than on comparable adjacent lands that were hunted (Cunningham 1962).

Objectives of this paper are to evaluate (1) harvest parameters, (2) reproductive parameters, (3) age and sex characteristics, and (4) density estimates for the raccoon population in the Chuck Swan Wildlife Management Area (CSWMA) in East Tennessee.

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Methods

The CSWMA, administered by the Tennessee Wildlife Resources Agency (TWRA) is a 10,053-ha peninsula between the Clinch and Powell Rivers in eastern Tennessee. Underlain by dolomitic limestone, CSWMA is characterized by well-rounded ridges and V-shaped valleys (USDA 1953).

Two perennial surface streams occur in the study area. The soils are generally low in fertility, low in organic matter, and strongly acidic. The climate is temperate with the most precipitation occurring in late spring and early summer. The average frost-free period is 173 days extending from 25 April to 16 October; the mean winter temperature is 2.2 C and mean summer temperature is 22.8 C (USDA 1953). Approximately 92% of CSWMA is forested and comprised largely of the oak-hickory forest association; other forests consist of the oak-hickory-pine association and pine plantations. Open cropland, predominantly hay fields, comprises 8.6% of the area.

Livetrapping for population estimation was conducted from July 1976 to mid-October 1976. To maximize trapping efficiency, the study area was divided into 5 compartments; only 1 compartment was trapped at a time with 30 traps being utilized. After sampling all compartments, trapping was concentrated in the most productive sites to facilitate marking as many animals as possible. Collapsible, wire, live traps (Tomahawk Live Trap Co., Tomahawk, WI) baited with sardines were utilized to capture raccoons. Raccoons were immobilized with Phencyclidine hydrochloride (Sernylan) and measured, weighed, aged, sexed, and evaluated for general physical and reproductive conditions. Teat size and pigmentation were used to determine female reproductive condition (Stuewer 1943, Sanderson 1950, 1951). Age of raccoons was determined by tooth eruption and tooth wear methods described by Montgomery (1964) and Grau et al. (1970), respectively. The tooth wear technique allowed dividing raccoons into 5 age classes. Captured raccoons were ear-tagged with a numbered Monel tag (National Band and Tag Co., Newport, KY) and a numbered plastic rototag (NASCO, Ft. Atkinson, WI) and released at trap locations.

Public hunts were conducted on CSWMA in late November and early December 1975–1978. Hunts were held on 3 consecutive weekends with each consisting of 3 nights of hunting. Although no hunter quota was set, the season was 9 days compared to 120 (1975–1977) or 94 days (1978) for the state-wide seasons. Hunting parties utilized dogs to trail and tree raccoons; treed raccoons were shot. Hunting regulations limited the number of raccoons harvested to 1 per party and the number of hunters per party to 6.

In 1975 a road check point was established to estimate the raccoon harvest, but no data were collected on numbers of hunters. From 1976 to 1978 hunters were required to stop at a checking station at the entrance of the management area. In 1976, data on the number of hunters, number of parties, and dogs per party were obtained; female reproductive tracts were collected to obtain litter size information. Age (5 tooth wear classes only in 1976), sex, weight, and location of harvest were recorded for harvested raccoons from 1976 to 1978. In 1977 and 1978 age classifications were recorded as juvenile and adult only and the number of parties was not recorded.

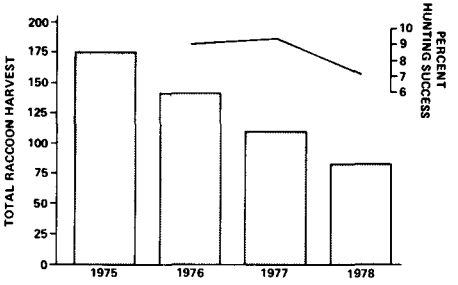

Figure 1. Total raccoon harvest and the annual percentage hunting success (harvest/no. hunters) on the Chuck Swan Wildlife Management Area. The number of hunters in 1975 was not recorded which precluded deriving a percent hunting success.

In 1976, population estimates and 95% confidence limits were derived from tag return ratios in the harvest and application of the Lincoln Index (Tanner 1978:33–35). Chi-square analyses were calculated to determine associations between sample distributions of various hunting and population data; confidence limits were established at 95%.

Results and Discussion

Harvest

Harvest of raccoons on CSWMA decreased steadily from 175 in 1975, to 136 in 1976, to 107 in 1977, and to 80 in 1978 with a consistent 9-night hunting season (Fig. 1). From 1975 to 1978 the percentage decline in annual harvest averaged 23% and ranged from 21% to 25%. No major changes in oak mast production (TWRA 1978) or habitat occurred over this period, indicating a minimal influence by these variables on the raccoon population. Condition of trapped and harvested raccoons also indicated no disease problems.

In 1976 approximately 1,516 hunters and 1,849 dogs comprised 638 parties; the average number of hunters and dogs per party were 2.4 and 2.9, respectively. Approximately 1,149 and 1,163 hunters participated in 1977 and 1978, respectively; the number of parties was not recorded for 1977 and 1978. For consistent comparisons, calculations of hunter success were based on harvest per hunter although bag limits were established per party. The annual hunting success was 9.0%, 9.3%, 6.9% for 1976, 1977, and 1978 (Fig 1).

Hunting success during the present study appeared to be influenced by weather conditions. An increase of 25% to 39% hunting success per party was noted between 2 consecutive nights and appeared to be related to rainfall (Woods 1978:22). Johnson (1970) noted hunting success declined on dry nights and when temperatures fell below −3.8 C. Stains (1956) suggested a

similar influence of cold weather. The sensitivity of harvest to weather demonstrates that population monitoring by total harvest or harvest per unit effort may be subject to strong biases without recording weather data.

No significant differences in hunting success between 1976–77 and 1977–78 were detected although the harvest steadily decreased an average of 23% annually (Fig. 1). This relationship indicated a high efficiency in harvesting raccoons and may be a reflection of more time spent hunting. An increase in hunting success from 12.4% to 19.7% between the second and third hunts in 1976 was attributed to an increase in time spent hunting and more favorable weather conditions (Woods 1978:22). Comparison of harvest from CSWMA with statewide hunting success was not possible because no quantitative data were collected on the amount of time spent hunting.

Thirty-four (30.4%) of the tagged raccoons (112) were harvested in 1976, 11 in 1977, and 4 in 1978. A 42.8% annual tag return was reported in Michigan but was obtained from pen-reared raccoons that were hunted over a 45-day season (Stuewer 1943). In Ohio, a 27.3% tag return was noted on 3 unsupervised hunting areas and a 12% return for 3 refuge areas that were also unsupervised in regard to hunting (Butterfield 1944). In this study, calculation of annual exploitation (harvest) rates from tag returns (Seber 1973:271) produced questionable estimates due to insufficient sample sizes.

Hunting intensity was high due to lack of hunter quotas. Annual hunting pressure varied little from 1 hunter/6.6 ha in 1976 to 1/8.7 ha in 1977 to 1/8.6 ha in 1978; this occurrence minimized possibilities that a decline in hunting pressure contributed to a decline in harvest. In 1976, a hunter to raccoon density ratio of 4 to 1 was recorded and may partially account for high daily raccoon harvests of 25, 28, and 34 raccoons per night. These harvests suggested a high harvest pressure and exceeded an average daily harvest of 23 from a dense raccoon population on the 7,692 ha Wheeler NWR (Atkeson and Hulse 1953).

Sex and Age

The 1976 sex ratio of livetrapped raccoons was 94 males per 100 females, while the sex ratio from hunting was 114 males per 100 females in 1976 (Fig. 2). Variability in sex ratios of raccoons is difficult to explain due to inconsistencies between collection methods and types of areas (Johnson 1970).

Juvenile raccoons (Class I) composed 75% of the 1976 harvest and 69% of the harvest in both 1977 and 1978. In 1976, juveniles composed 33% of the trapped population but this percentage was likely influenced by trapping that ended during juvenile dispersal (Fig. 2). A Chi-square test demonstrated a significant difference in age composition between hunting and

trapping. These data suggest a greater hunting vulnerability of juveniles compared to adults.

The percentage juveniles (75%) in 1976 is the highest reported for a population in the South. Cunningham (1962) reported taking 25% juveniles from the Savannah River Plant in South Carolina and Caldwell (1963) noted a 37% juvenile harvest in north-central Florida. Johnson (1970) reported that juveniles comprised 34% to 47% of the raccoons sampled by hunting in 3 different areas of Alabama. Reasons for the high vulnerability of juveniles to harvest are not apparent but may be related to dispersal or other factors. Juveniles may have been more vulnerable to fall hunting because dispersal of juveniles probably occurs during this time (Stuewer 1943, Johnson 1970,) increasing the likelihood of their being discovered by dogs. Old raccoons may be less vulnerable based on their learning experiences from hunting (Whitney and Underwood 1952, Johnson 1970). Sharp and Sharp (1956) studied the nocturnal behavior of raccoons at a feeding station and found that older raccoons became active later at night than juveniles and were more alert and apprehensive than young raccoons. Based on these observations Johnson (1970) indicated hunting may bias harvest age composition if conducted during early evening. During this study most hunters were hunting by 2000 hours and had checked out by 0100 hours (Woods 1978:50); this may partially explain the high juvenile harvest.

Harvested raccoons in 1976 exhibited a juvenile : adult ratio of 3 : 1. The juvenile to adult ratio was 2.2 : 1 for both the 1977 and 1978 harvests.

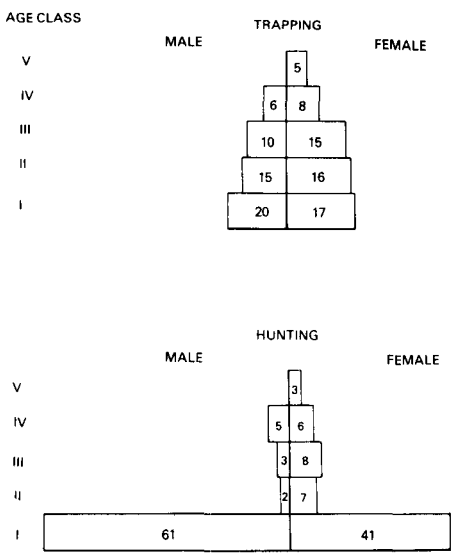

Figure 2. Sex and age composition of raccoons livetrapped and harvested on the Chuck Swan Wildlife Management Area, 1976.

Chi-square analyses revealed no significant differences in sex and age composition of harvested raccoons between 1976 and 1977, and between 1977 and 1978.

Reproductive Parameters

A livetrapping and harvest sample of 66 adult females (Class III, IV, and V, or >39 months of age) was examined in 1976 for reproductive condition. Teat size and coloration indicated that approximately 58 (88%) had bred in 1976. Eleven of 16 (69%) Class II (15–38 months) females from a livetrapping sample were determined to have bred. This sample probably contained some yearlings as parturition from the previous year was estimated to have begun as early as April (Woods 1978:58). A resultant overlap of yearling females in the Class II group precluded determining the reproductive input of yearlings. According to Johnson (1970:39–40) most studies indicated that less than 50% of the yearling females breed.

Twenty adult females suitable for necropsy were collected over the 1976 hunting period and examined for placental scars. Average litter size was 2.8 with the largest portion ($N = 15$) containing 3 scars which compared similarly with other studies in the South. Rabinowitz (1981:29) reported that 91% of the females sampled in summer from a protected population had bred. The litter size in this study was similar to litter sizes reported by Johnson (1970:50) for Alabama (2.5), by Dew (1978:36) for Tennessee (2.6), and by Cunningham (1962) for South Carolina (2.8). It appeared that these reproductive parameters did not compensate for high annual harvest.

Density

Because the probability of capture, mortality, and dispersal likely was more equal among members of the same sex and age class, separate population estimates were made for these groups. Estimates were 88 ± 55 for juvenile females, 78 ± 60 for adult males, and 113 ± 59 for adult females. Population size by this method totaled 366 or approximately 1 raccoon per 27.5 ha; this estimate was considerably below the estimate of 436 (1 raccoon per 23.1 ha) obtained by pooling all the individuals together.

Violation of the assumption of a closed population likely occurred because trapping ceased prior to completion of juvenile dispersal. Concentrating trapping in areas of high trapping success, an apparent differential vulnerability of juveniles to harvest, and ending the tagging session during juvenile dispersal contributed to unequal probabilities in sampling. The above factors likely combined to overestimate the population; this would result in a lower population density than revealed by the original estimate.

Estimates of raccoon density for CSWMA were generally lower than those reported for other areas of the United States but were consistent be-

tween 2 areas of upland hardwood-pine habitats in East Tennessee (Table 1). Highest densities generally were associated with swampy, bottomland hardwood habitats (Cunningham 1962, Johnson 1970:99, Urban 1970, Lehman 1977). The presence of low soil fertility, only 2 flowing streams, and a 92% forest canopy of oak-hickory-pine suggested that the CSWMA cannot support raccoon densities as high as other areas.

These habitat-density relationships emphasize the importance of more careful regulation of harvest levels in the southern Appalachian region. Density estimates and total harvest in 1976 illustrated that between 31.2% and 37.2% of the population on the CSWMA was harvested; this was apparently too high to maintain sustained yields as indicated by the declines of total harvest in 1977 and 1978. As stated earlier, these estimates are likely conservative due to suspected over-estimation of the raccoon population.

Management Implications

Although tighter regulations were exercised on CSWMA than on lands under state-wide regulations, high potential for overharvest of raccoons was still exhibited. Regulation of harvest by the number of nights of hunting was not sensitive enough to ensure that over-exploitation did not occur. More detailed hunting information such as time spent hunting, weather during hunting, and number of hunting parties is needed to further assess harvest data. Experimental hunts with various hunter and harvest levels on populations with estimated densities are needed to determine acceptable population reduc-

Table 1. Raccoon Densities Reported from Different Areas of the United States (Mark-recapture Estimates Only)

State	Density Estimate	Reference
Alabama	1/8.5 ha	Johnson (1970:99)
Indiana	1/2.8–1/0.45 ha	Lehman (1977)
Michigan	1/6.6–1/12.5 ha	Stuewer (1943)
N. Dakota	1/170–1/85 ha	Fritzell (1978)
Ohio	1/2.4 ha	Williams (1936)
	1/10.9–1/42.9 ha	Butterfield (1954)
	1/1.5 ha	Hoffman and Gottschang (1977)
Illinois	1/5.7 ha	Urban (1970)
S. Carolina	1/4.0 ha	Cunningham (1962)
Tennessee:		
CSWMA	1/27.5 ha	This study
Cades Cove, 1973–74	1/17.8 ha	Keeler (1978:42)
Cades Cove, 1973–74	1/52.6 ha	Keeler (1978:58)[a]
Cades Cove, 1979–80	1/17 ha	Rabinowitz (1981:22)
Virginia	1/5.7 ha	Sonenshine and Winslow (1972)
Wisconsin	1/44.0 ha	Dorney (1954)

[a] After outbreak of canine distemper.

tions to maintain sustained yields. No data are currently available concerning allowable harvest for maintaining sustained yields in upland habitats of the southern Appalachians. Inherent biases and other inadequacies of harvest data demonstrate a need for more accurate population monitoring techniques to ensure that harvest regulations be established in accordance with population abundance.

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