Use of Scent-station Methodology to Assess Raccoon Abundance

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Abstract: Monthly scent-station visitation rates, derived from 19 transects located in 4 habitat types (bottomland hardwood, bluff-shoreline, upland hardwood, and pine-hardwood) in western Tennessee during May 1982 through November 1984 were evaluated as indices of raccoon (*Procyon lotor*) abundance. The correlation between scent-station indices and winter raccoon density estimates was assessed at 9 sites. Generally, scent-station visitation rates were high from May to October in all habitats, and moderate to low from November to April. Highest visitation occurred in June and July, and lowest in December and January. Differences in visitation rates among habitats were significant for 8 of 11 months examined; greatest differences among habitats occurred during June and July. Visitation rates were greatest in habitats that supported high winter densities of raccoons. In 7 out of 12 months, visitation rates were significantly correlated with winter density estimates. Scent-station methodology, as applied in this study, appears to provide a useful tool for monitoring trends in raccoon abundance.

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Despite widespread use of scent-station transects to assess relative abundance of mammalian carnivores (Linhart and Knowlton 1975, Sumner and Hill 1980, Morrison et al. 1981, Roughton and Sweeny 1982), questions concerning this technique remain unanswered. Further investigation is needed concerning the relationship between population size and scent-station indices. The existence of this relationship has been disputed (Minser 1984, Conner et al. 1984). Documentation of such an association is critical to evaluating the validity of the scent-station technique for determining trends in population size.

Because densities of the raccoon can be estimated using mark-recapture techniques (Lotze and Anderson 1979, Kaufmann 1982), the species can be used in

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studying the relationship between population abundance and rates of scent-station visitation. Therefore, the purposes of this study were to determine the pattern of scent-station visitation of the raccoon in different habitat types in western Tennessee and to assess the relationship of raccoon density to rates of scent-station visitation.

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Methods

Nineteen scent-station transects (= lines or surveys) were established in 8 counties in western Tennessee. Fifteen lines were maintained between May 1982 and November 1984; 4 additional lines were surveyed during January through November 1984. Raccoon densities were estimated at 9 of these sites (Leberg 1985). Transects were categorized into 1 of 4 habitat types (bottomland, bluff-shoreline, upland hardwood, and pine-hardwood) that supported varying levels of raccoon abundance as indicated by previous studies (Lotze and Anderson 1979, Kaufmann 1982, Leberg 1985). Five transects, 2 of which were used in the comparison between density estimates and visitation rates, were located in bottomland habitat which consisted of riparian deciduous forest that flooded annually. Five lines, 4 of which were used in the density-visitation rate comparison, were located in bluff-shoreline habitat, a hybrid category of 2 habitats which represented "edge" between aquatic and upland areas and supported similar raccoon densities. Bluff represented the interface between bottomland and upland areas, while shoreline consisted of upland hardwood forest adjacent to major rivers and lakes. Five transects, including 1 used in the density-visitation comparison, were located in upland hardwood habitat which consisted of deciduous forest containing little or no permanent water. Four transects, including 2 used in the density-visitation rate comparison, were located in pine-hardwood habitat which was similar to upland habitat except that over 50% of the overstory was dominated by loblolly pine (*Pinus taeda*). Habitat types and site locations were described in detail by Kennedy (1987).

Surveys were conducted monthly; however, flooding prevented occasionally aquatic-associated sites from being surveyed. Scent-station design was modified from Linhart and Knowlton (1975) and Roughton and Sweeny (1982). Survey lines consisted of 10 scent-stations (0.32 km intervals) along a continuous route; however, station placement took advantage of local terrain to maximize the likelihood of receiving a raccoon visit. Consistency in station placement was obtained by selection of the most likely site (e.g. adjacent to a stream or pond rather than a dry upland site) for a raccoon visit within 50 m of the proposed station location on the transect. Each scent-station consisted of a circle of sifted sand 1 m in diameter. A cotton ball saturated with bobcat urine was attached to a wooden applicator stick placed in the center of the circle. Stations were operated for 1 night. A visit was defined as the presence of 1 or more raccoon tracks present in the station. If the cotton ball or applicator stick was removed and no raccoon tracks were present, the station was judged inoperable. The index of relative abundance was calculated by dividing the total number of operable stations into the number of stations that were visited by raccoons, and multiplying by 1,000.

Scent-station visitation rates were square-root, arcsine transformed to approximate a normal distribution (Kirk 1982). Analysis of variance was used to test for differences in visitation rates among months and habitats. Year effects were examined using June through November rates; during other months there was missing data for some sites due to seasonal flooding. Duncan's multiple range test was used to determine the maximal number of nonsignificant ($P > 0.05$) subsets for temporal variation and habitat comparisons.

To evaluate correlations between scent-station indices and density estimates, transects were sampled for visitation during approximately the same time period for which density estimates were being obtained on 9 sites (Table 1). One estimate (Kennedy et al. 1985) was based on the assessment line methodology of O'Farrell et al. (1977). Data from the other sites were analyzed with the program CAPTURE (White et al. 1978). Based on the results of the model selection subroutine of that program, the Jackknife estimator (Otis et al. 1978), which assumes individual heterogeneity in capture probabilities, was used to estimate population sizes. Density

Table 1. Results of raccoon capture-recapture studies for 9 sites in western Tennessee.[a]

Habitat[b]	n[c]	N[d]	Total grid[e] size (ha)	Density (animals/100 ha)	95% CI
BO	23	48	297.2	16.1	8.8–23.8
BO	17	47	256.9	18.3	10.8–27.8
BS	21	38	430.5	8.9	5.1–12.5
BS	32	35	457.5	7.6	4.6–10.6
BS	16	27	149.3	18.2	9.4–27.0
BS[f]	18	18	550.0	5.8	—
UH	12	16	549.7	2.9	1.7–4.1
PH	6	7	483.3	1.4	0.8–2.0
PH[g]	2	2	255.6	0.8	—

[a]Density values were taken from Kennedy et al. (1985), Leberg (1985), and Kennedy et al. (1986).
[b]Habitat types are Bottomland (BO), Bluff-Shoreline (BS), Upland Hardwood (UH), and Pine Hardwood (PH).
[c]Total number of raccoons captured on each grid.
[d]Number of animals estimated on each grid.
[e]Size of each grid plus area of effect.
[f]Methodology did not permit calculation of confidence intervals.
[g]Due to a lack of recaptures, only a minimum density estimate could be calculated. Confidence intervals could not be calculated.

was estimated using the mean maximum distance moved (MMDM) method of Wilson and Anderson (1985).

Additional information on the density estimates is presented in Kennedy et al. (1985, 1986); for detailed explanations of the methodology see Leberg (1985). Estimates were made between mid December and mid March, so the scent-station and density associations are based on winter density estimates. It is assumed, since raccoon home ranges are seasonally stable (Allsbrooks and Kennedy 1987; F. R. Tabatabai, unpubl. data), that habitats which support high densities in the winter also support high densities in the summer. More direct comparisons of rates of visitation and density are not feasible, due to low capture success of raccoons in western Tennessee during summer (Moore and Kennedy 1985). Spearman rank order correlations and regression analysis were used to evaluate the relationship between density and scent-station visitation rates.

Results and Discussion

Because there were no year effects, year-month, or year-habitat interactions ($P > 0.10$), years were combined in further analyses. There was an interaction between month and habitat effects on visitation rates ($P < 0.01$); visitation rates in upland habitats had different patterns of monthly variation than those of aquatic habitats (bottomland and bluff-shoreline). Monthly variation in visitation rates ($P < 0.05$) was found in bottomland (number of transects, $N = 67$), bluff-shoreline ($N = 91$), and upland hardwoods ($N = 108$) habitats; no monthly variation was detected in pine-hardwood habitat ($N = 90$; $P = 0.075$). Results of Duncan's multiple range tests (Table 2) indicate that visitation in the summer and fall was higher than visitation during winter in the bottomland, bluff-shoreline, and upland

Table 2. Results of Duncan's multiple range test for arcsin transformed scent-station visitation rates[a] by month for raccoons in 3 habitats in western Tennessee, 1982–1984.

Bottomland			Bluff-shoreline			Upland hardwood		
Month	N^b	Rate	Month	N	Rate	Month	N	Rate
Jul	9	710 A	Jun	10	550 A	Oct	12	250 A
Jun	9	700 A	Jul	11	550 A	Jul	13	220 A
Oct	9	610 A	Aug	10	490 A	Sep	13	210 A
Sep	9	550 A	Oct	9	490 A	Jun	13	180 AB
May	2	520 A	Sep	12	400 AB	Dec	6	140 AB
Aug	9	410 AB	Mar	8	270 BC	Aug	14	130 AB
Mar	2	170 B	Nov	11	230 BC	Apr	2	120 AB
Nov	9	160 B	May	5	190 CD	Nov	13	110 AB
Feb	4	140 B	Feb	6	170 CD	May	12	90 AB
Dec	1	0 C	Dec	4	150 CD	Mar	10	70 AB
Jan	4	0 C	Jan	5	90 D	Jan	5	40 B
						Feb	7	30 B

[a]Visitation rates are actual mean monthly indices, not the arcsin transformed rates; those rates followed by the same letter are not different ($P > 0.05$).
[b]Refers to the number of scent-station transects.

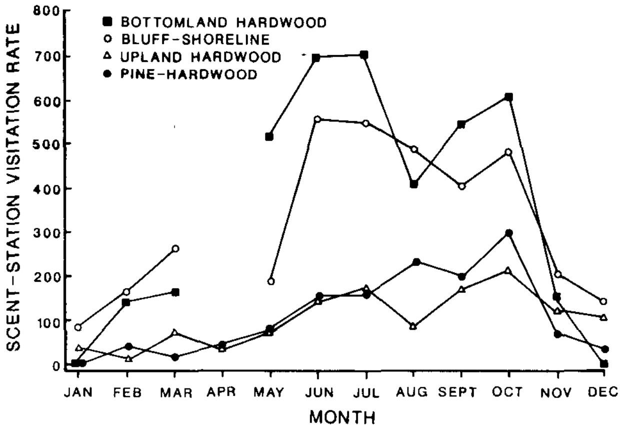

Figure 1. Mean rates of scent-station visitation among months for raccoons in 4 habitat types in western Tennessee. Gaps in lines representing bottomland hardwood and bluff shoreline reflect periods when habitats were under water and inaccessible for sampling.

hardwood habitats. Monthly indices in aquatic habitats increased sharply during June, fluctuated during summer, and increased again in October (Fig. 1). In upland habitats, visitation rates, generally, increased throughout summer, reaching a peak in October. Visitation rates in all habitats decreased in November, and remained at moderate to low levels throughout winter and spring. Lowest visitation occurred in December and January. The difference in seasonal visitation patterns between the aquatic and upland habitats may have been due to seasonal habitat shifts in raccoon activity, habitat-specific seasonal shifts in raccoon behavior regarding stations, or disproportionately higher reproduction in the aquatic-associated habitats than in the upland habitats.

Sumner and Hill (1980) indicated that mean raccoon scent-station indices for April and October in Alabama were about 3 times greater than the mean computed from monthly indices for November through March. In eastern Tennessee, monthly raccoon visitation rates were low and erratic, but summer visitation rates were greater than winter rates (Nottingham 1985). Conner et al. (1983) found highest visitation in September and lowest in November in Florida. These studies, as well as the present investigation, indicate that peaks in visitation do occur. Such peaks appear to vary geographically and probably reflect, during summer in western Tennessee, fluctuations in population abundance due to births, increased activity of females to feed young, and seasonal movements in relation to food availability. In most cases, lowest visitation occurred in winter, reflecting reduced raccoon abundance due to hunting and trapping, and diminished movements due to colder ambient temperatures (Moore and Kennedy 1985).

Differences in scent-station visitation among habitats were significant ($P < 0.05$) for 9 of 11 months (Table 3), the greatest differences occurring in June and July. Only rates recorded in November, December, and January failed to vary among habitats. Visitation rates during the months with the greatest inter-habitat variation, June–October (Fig. 1, Table 4), were not statistically different between high density bottomland hardwood and bluff-shoreline habitats, or the low density

Table 3. Results of one-way analysis of variance of variation among 4 habitat types[a] in monthly[b] arcsin-transformed scent-station visitation rates of raccoons in western Tennessee, 1982–1984.

Month	df	*F*-ratio	*P*-value
January	3, 12	0.709	0.57
February	3, 18	4.902	0.01
March	3, 22	6.770	0.00
May	3, 22	5.464	0.01
June	3, 35	30.688	0.00
July	3, 38	29.748	0.00
August	3, 38	10.391	0.00
September	3, 39	8.132	0.00
October	3, 35	5.710	0.00
November	3, 38	2.682	0.06
December	3, 12	1.903	0.18

[a]See text for explanation of habitat types.
[b]April was excluded in this analysis due to small sample size.

upland hardwood and pine-hardwood habitats. However, rates for bottomland hardwood and bluff-shoreline habitats were different from upland hardwood and pine-hardwood habitats. Linscombe et al. (1983) also reported bottomland habitat to have higher visitation rates than pine or mixed pine-hardwoods. Because aquatic-associated or bottomland hardwoods usually sustain greater densities of raccoons than upland forests (Lotze and Anderson 1979, Kaufmann 1982, Minser and Pelton 1982, Leberg 1985), it is not surprising to find a difference in visitation rates between these habitats. Our results demonstrated a clear separation of aquatic habitats and nonaquatic habitats based on scent-station visitation.

Rank-order correlations between winter density and monthly scent-station visitation were seen throughout the year (7 out of 12 months); however, highest correlations were seen during November and December (Table 5). Results of the regression analysis agreed with the results of the Spearman test and provided no evidence of nonlinear or polynomial relationships between winter density and scent-station visitation. However, the possibility of nonlinear relationships between density and scent-station visitation cannot be ruled out because the regression analyses were based on small sample sizes and variables with unknown distributions. A general association between monthly scent-station visitation and winter density estimates was evident.

Areas with high density reflected high visitation rates; those with low density exhibited low visitation. Scent-station visitation rates were different between habitats which supported 1 raccoon/5.2–17.4 ha (bottomland and bluff-shoreline) and those which supported densities ranging from 1/34.4–127.8 ha (upland-hardwood and pine-hardwood). Above and below this range of sensitivity, the methodology failed to distinguish between habitats with varying densities (between bottomland and bluff-shoreline, or between upland hardwood and pine-hardwood). Although

Table 4. Results of Duncan's multiple range test for arcsin transformed scent-station visitation rates for raccoons by habitat type for months of highest scent-station visitation in western Tennessee, 1982–1984.

Habitat	Jun		Jul		Aug		Sep		Oct	
	N[a]	Rate[b]	*N*	Rate	*N*	Rate	*N*	Rate	*N*	Rate
Bottomland hardwood	9	700 A	9	710 A	10	410 A	9	550 A	9	610 A
Bluff-shoreline	10	550 A	11	550 A	9	490 A	12	400 A	9	490 A
Upland hardwood	13	180 B	13	220 B	14	130 B	13	210 B	12	250 B
Pine-hardwood	7	110 B	9	100 B	9	170 B	9	150 B	9	260 B

[a]Refers to the number of scent-station transects.
[b]Visitation rates are actual mean monthly rates, not arcsin transformed rates; those rates followed by the same letter are not different ($P > 0.05$).

Table 5. Spearman (*rho*) correlations of monthly scent-station visitation rates and winter density estimates for raccoons in western Tennessee.

Month	*N*	*rho*	*P*-value
Jan	5	0.671	0.11
Feb	7	0.364	0.21
Mar	9	0.809	0.00
Apr	6	0.829	0.02
May	9	0.611	0.04
Jun	9	0.695	0.02
Jul	9	0.498	0.09
Aug	9	0.017	0.48
Sep	9	0.650	0.03
Oct	8	0.452	0.13
Nov	9	0.843	0.00
Dec	5	0.894	0.02

the detectability of interhabitat variation appears to be independent of the sample sizes used in this study (Table 4), it is possible that additional transects in each habitat could increase the probability of detecting differences in visitation.

Broad changes in raccoon abundance can be detected by annual indices in these habitats, but small fluctuations may not be recognized. For some management decisions, the knowledge that populations are high or low may be sufficient. In areas with very low density, visitation rates may never reach a level which will reflect general trends in population density as illustrated by the upland habitats (Fig. 1). Roughton and Sweeny (1982) cited D. R. Anderson and C. M. Romesburg (pers. commun.) as indicating that, theoretically, the optimal range for detecting percent change in visitation rates was 40% to 60%. The significant habitat and month effects on visitation rates, detected in this study, fall within this range. Low visitation rates precluded statistical detection of population fluctuations. Visitation rates of the magnitude observed in upland habitats appear to tell the manager only that raccoon abundance is low (not how low), and high visitation rates in aquatic habitats indicate densities are high. Nottingham (1985), working in an upland habitat in eastern Tennessee, concluded that low visitation rates may have precluded the ability of scent-station surveys to reflect differences in population size. He reported changes in population size of 25% and 38% which were not detected in the scent-station surveys.

Visitation rates recorded during summer and early fall months of this study were higher than those reported in other studies (Sumner and Hill 1980, Rucker 1983, Conner et al. 1983, Linscombe et al. 1983, Nottingham 1985). The higher rate of visitation in the present work is attributed to transects designed specifically to monitor raccoon abundance. During preliminary studies, emphasis was placed on precise intervals between stations, and regular placement of stations across months was maintained irrespective of local environmental conditions. Results from these attempts were unclear. Visitation was low, and it was not unusual to get higher visitation in what would be considered poor habitat (low harvest) than in habitat with high raccoon harvest. When station placement took advantage of local terrain, the number of stations likely to receive a raccoon visit was increased. Consistency in this procedure was obtained by placing stations at the most likely places for raccoon visits each time transects were established. For example, initial placement was adjacent to a shoreline. The shoreline receded 20 m between sampling periods. The optimal placement was still adjacent to the shoreline, so the station was moved to the new shoreline. While these procedures only slightly modified the original design, they resulted in significant increases in visitation. Although the method of station placement used in this study was more subjective than that used in previous studies (e.g. Sumner and Hill 1980, Conner et al. 1983), patterns of raccoon visitation in 4 habitat types were repeatable over a 3 year period. Additionally, the results of 3 years of scent-station surveys, conducted by the Tennessee Wildlife Resources Agency in western Tennessee (Kennedy 1987) suggest that repeatable results are obtained when a large number of field personnel use the methodology presented in this study. Scent-station methodology, as applied in this investigation, is useful in monitoring broad trends in raccoon abundance.

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