

HOME RANGES OF ADULT MALE RACCOONS (*PROCYON LOTOR*) IN WESTERN TENNESSEE

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ABSTRACT—Home ranges of adult male raccoons, *Procyon lotor*, were assessed on the Shelby Forest Wildlife Management Area in Shelby Co., Tennessee. Using standard radio-telemetry procedures, home ranges were determined for 14 individuals, and the degree of overlap among home ranges was assessed. Home ranges varied from 290.6 to 22.4 ha. There was no statistical difference in the degree of overlap among seasons. Home ranges of adult males were not mutually exclusive. Additionally, there was no significant difference between home ranges determined during preseason and harvest season.

Home ranges of raccoons (*Procyon lotor*) have been the subject of several studies (see Lotze and Anderson, 1979; Kaufman, 1982). The home ranges of adult females are known to overlap broadly (Stuewer, 1943; Johnson, 1970; Urban, 1970; VanDruff, 1971; Fritzell, 1978; Tabatabai, 1988). However, Fritzell (1978) and Lehman (1984) have suggested mutually exclusive home ranges for adult males in North Dakota and Indiana, respectively. Other studies conducted at several latitudes (e.g., Stuewer, 1943; Johnson, 1970; VanDruff, 1971; Tabatabai, 1988) have not shown mutually exclusive home ranges for adult male raccoons. It appears that the movement patterns of adult male raccoons may vary geographically.

Other than Tabatabai (1988), no study of overlapping home ranges in raccoons has been conducted in Tennessee, and, throughout the species' range, there has been no attempt (with the exception of Fritzell, 1978) to quantify the degree of overlap among home ranges of adult males. Because few studies have focused on the degree of overlap among home ranges and sample sizes have been small in all cases, additional investigations are needed to better understand this aspect of raccoon biology. The purpose of the present study was to examine the degree of overlap by seasons among adult male *P. lotor*. Additionally, home ranges of adult males were assessed before and during a hunting season.

MATERIALS AND METHODS

The study was conducted over approximately 17 months on the Shelby Forest Wildlife Management Area, Shelby Co., Tennessee, located about 15 km north of Memphis, Tennessee, during 1987 to 1989. Habitat was deciduous hardwood forest in the floodplain of the Mississippi River and adjacent upland areas. A more detailed description of this site is given in Moore and Kennedy (1985) and Allsbrooks and Kennedy (1987).

All raccoons were captured in the same portion of the study area. The greatest distance between trapping sites was 1,700 m. Animals were captured using Havahart and folding Tomahawk live traps baited with fish, usually sardines. After capture, adult males (>14 months in age following Grau et al., 1970) were immobilized with a mixture of ketamine hydrochloride and acetylpromazine (Bigler and Hoff, 1974). Standard external measurements (see Table 1), weight, and age were recorded. Animals were tagged in both ears (using #3 Monel ear tags),

equipped with radio-collars, and released at the site of capture. Fourteen radio-collared raccoons were monitored periodically from August 1987 to January 1989 (Table 1). Locations were obtained using hand-held receiving equipment, lithium-powered transmitters (motion sensitive), and standard radio-tracking procedures. Recorded bearings were plotted on 1:24,000 scale USGS (United States Department of the Interior Geological Survey) 7.5 Minute Series Quadrangle Maps and later transformed into grid coordinates. Only raccoons that had been located >16 times (arbitrarily selected) over a number of days were used in determining seasonal home ranges. Seasons were those of the calendar year. Home ranges were calculated using the minimum-area method of Mohr (1947). Winter data were minimal due to poor road conditions during this season.

Preseason (60 days before hunting season) and harvest-season home ranges were compared by monitoring animals before and during hunting seasons. Raccoon hunting was allowed from 6 November 1987 to 17 January 1988 and from 4 November 1988 to 13 February 1989. For both seasons, hunting was allowed on Monday, Wednesday, and Saturday nights with a limit of two raccoons per person per night. The degree of overlap among home ranges, differences in home ranges among seasons, and differences among preseason and harvest-season home ranges were tested using single-classification analysis-of-variance tests from the Statistical Package for the Social Sciences (SPSS; Norusis, 1990). For statistical tests, significant probability was $P < 0.05$. A sequential Bonferroni adjustment (Rice, 1989) was used to control for experiment-wise error.

RESULTS

During the study, 18 raccoons (adult males) were captured and fitted with radio-collars. Sufficient data were collected to compute home ranges for 14 of these. Capture histories, age, weight, body measurements, number of locations, and annual home ranges are given in Table 1. The total number of radio locations for individuals ranged from 21 to 251. Dates and numbers of locations for each individual are given in appendix I of Sumners (1992). Home ranges for animals with ≥ 12 months of data ranged from 131.2 to 156.8 ha (mean = 144 ha; $n = 2$).

Seasonal home ranges are given in Table 2. The number of radio locations per season ranged from 16 to 152. Little seasonal variation

TABLE 1. Capture summary, external features, and home ranges for radio-collared raccoons at Shelby Forest Wildlife Management Area, Shelby Co., Tennessee.

Raccoon number	Date of capture	Age class	Weight (kg)	Total length (mm)	Tail length (mm)	Hindfoot length (mm)	Ear length (mm)	Date contact lost	Number of locations	Home-range size (ha)
1	7/20/87	II	4.5	780	240	105	57	3/26/88	64	160.3
2	7/22/87	II	4.0	810	240	110	60	3/27/88	59	80.8
3	7/23/87	III	5.0	740	230	105	55	9/21/88	165	156.8
4	7/23/87	II	3.5	805	220	103	57	3/26/88	60	188.1
5	7/30/87	III	3.5	775	250	98	54	1/13/89	251	131.2
6	8/01/87	II	3.5	855	275	112	55	9/12/87	24	44.8
8	8/18/87	II	3.7	770	220	110	57	12/15/87	35	43.7
9	8/19/87	II	4.0	790	270	108	61	12/15/87	32	210.3
10	9/01/87	II	4.0	780	200	106	55	11/25/87	38	63.0
13	4/03/88	III	4.5	910	210	103	47	8/16/88	27	163.9
15	4/03/88	II	4.0	760	200	103	47	11/03/88	41	52.9
16	5/04/88							11/23/88	155	172.7
17	5/05/88							11/23/88	40	290.6
18	9/21/88							11/23/88	21	22.4

existed among home ranges. Home-range sizes for fall 1988 differed significantly from those of fall 1987, summer 1987, and summer 1988. There was no statistical difference in the degree of overlap among seasons.

In the summers of 1987 and 1988, mean home ranges (Table 2) were estimated as 76.6 ha ($n = 6$, range = 39.9-143.9 ha) and 100.2 ha ($n = 6$, range = 27.2-164.6 ha), respectively. Individual home ranges for both summers and the total home-range overlap with other adult

males are given in Table 3. For 1987, overlap among individual home ranges ranged from 0.0 to 93.3% (Table 3); for 1988, this overlap ranged from 0.0 to 93.0% (Table 3). During both summers, adult males shared a large portion of their home ranges with at least one other adult male and, in several cases, more than one (Table 3, Fig. 1A,B).

Home ranges for individuals during the fall seasons of 1987 and 1988 are given in Table 4. Mean home ranges were 87.1 ha ($n = 8$, range = 43.7-210.3 ha) and 32.6 ha ($n = 5$, range = 10.8-66.6 ha),

TABLE 2. Seasonal home ranges and degree of overlap of home ranges of adult male raccoons with other adult males. Estimates are in hectares.

Raccoon	Summer 1987		Fall 1987		Spring 1988		Summer 1988		Fall 1988	
	Range	Total overlap	Range	Total overlap	Range	Total overlap	Range	Total overlap	Range	Total overlap
1	86.2	39.9	78.0	48.6						
2	39.9	32.8	56.5	51.0						
3	62.3	52.9	96.8	57.4	83.7	47.5	137.4	105.8		
4	143.9	86.9	104.8	96.0						
5	78.6	78.5	45.8	45.8	56.8	41.8	38.8	25.9	11.7	11.4
6	49.1	49.1								
8			43.7	11.4						
9			210.3	11.1						
10			61.2	51.4						
13							117.1	69.5		
15							27.2	25.4	10.8	5.0
16					30.9	7.5	164.6	67.9	66.6	21.7
17					209.6	56.5	116.2	29.4	51.3	0.0
18									22.4	13.0
Mean	76.6		87.1		95.2		100.2		32.6	

TABLE 3. Summer home-range overlap for adult male raccoons at Shelby Forest Wildlife Management Area, Shelby Co., Tennessee¹. Overlap is given in hectares; percentage of an animal's home range within the overlap is given in parentheses.

Raccoon number	Overlap in 1987						Overlap in 1988					
	1	2	3	4	5	6	3	5	13	15	16	17
1		0.0 (0.0)	31.5 (36.5)	5.1 (5.9)	0.0 (0.0)	32.1 (37.2)						
2	0.0 (0.0)		4.2 (10.5)	15.9 (39.8)	32.2 (80.7)	0.1 (0.2)						
3	31.5 (50.6)	4.2 (6.7)		22.7 (36.4)	8.6 (13.8)	41.8 (67.1)		11.5 (8.4)	63.1 (45.9)	3.7 (2.7)	29.2 (21.3)	29.2 (21.3)
4	5.1 (3.5)	15.9 (11.0)	22.7 (15.8)		61.8 (42.9)	16.8 (11.7)						
5	0.0 (0.0)	32.2 (40.0)	8.6 (10.9)	61.8 (78.6)		2.9 (3.7)	11.5 (29.6)		8.8 (22.7)	10.0 (25.8)	24.8 (63.9)	0.0 (0.0)
6	32.1 (71.7)	0.1 (0.2)	41.8 (93.3)	16.8 (37.5)	2.9 (6.5)							
13							63.1 (53.9)	8.8 (7.5)		2.5 (2.1)	20.7 (17.7)	14.7 (12.6)
15							3.7 (13.6)	10.0 (36.8)	2.5 (9.2)		25.3 (93.0)	0.0 (0.0)
16							29.2 (17.7)	24.8 (15.1)	20.7 (12.6)	25.3 (15.4)		0.0 (0.0)
17							29.2 (25.1)	0.0 (0.0)	14.7 (12.7)	0.0 (0.0)	0.0 (0.0)	

¹Chart interpretation: e.g., raccoon 1 and raccoon 3, in 1987, have an overlap of 31.5 ha; this is 36.5% of the home range of raccoon 1 and 50.6% of the home range of raccoon 3.

respectively. In the falls of 1987 and 1988, overlap among individual home ranges varied from 0.0 to 98.9% and 0.0 to 74.4%, respectively (Table 4; Fig. 1C,D). Only raccoon number 17 failed to share a large portion of its home range with another radio-collared animal. A winter home range was determined only for animal number 5; home-range size was 161.5 ha (Fig. 2A).

For the spring of 1988, mean home range was estimated as 95.2 ha ($n = 4$, range = 30.9-209.6 ha). The degree of overlap in home ranges among individuals ranged from 0.3 to 66.4% (Table 5, Fig. 2B). As in summer and fall, males tended to share a large portion of their home range with other males.

Seasonal shifts in the percentage of home-range overlap among individuals were demonstrated by raccoons number 3 and 5. In summer 1987, they shared (with each other) about the same percentage of overlap in their home ranges (13.8 and 10.9%, respectively). In fall 1987, the percentage shared between the two individuals was still about the same (0.6 and 1.3%, respectively), but the amount of overlap was much reduced. In spring 1988, the degree of home-range overlap between the two individuals increased for both animals (number 3 = 18.8%, number 5 = 27.6%); however, the percentage of the home range of animal number 3 overlapping with the home range of animal number 5 decreased in summer 1988 to 8.4% while that of animal number 5 increased slightly to 29.6%. There was little difference in the degree of overlap in the home range of male number 3 with that of male number 5 between summers (13.8% in 1987, 8.4% in 1988); however, male number 5 shared a larger portion of its range with number 3 during summer 1988 (29.6%) than during summer 1987 (10.9%).

There was no significant difference between the preseason and harvest-season home ranges for raccoons tested (1, 2, 5, and 8; Table 6, Fig. 3). Raccoons number 2 and 8 showed a decrease in home-range size, while animals 1 and 5 showed an increase in home-range size. No overall pattern was evident in the size of the home range, but considerable overlap was noted for three of the four individuals between their preseason and harvest-season home ranges.

DISCUSSION

As pointed out by Tabatabai (1988), substantial variation exists in the home ranges recorded for raccoons. Kaufman (1982) indicated variation in home-range size from ≤ 5 ha to about 5,000 ha with most sizes within a range of 40 to 100 ha. He suggested such variation was caused by differences in sex, age, density, habitat quality, season, length of study, and methods of obtaining and analyzing data. Additionally, studies by Fritzell (1978), Lotze (1979), and Tabatabai (1988) indicate annual differences in home-range size for some individual raccoons. It appears that home ranges of raccoons fluctuate depending upon a number of factors. Because of the extent of variation reported in prior investigations (e.g., see Lotze and Anderson, 1979; Kaufman, 1982), it is not surprising that annual home ranges determined in the present study are within the range previously reported for the species. With the exception of Lotze (1979), investigations recording long-term movements of the same individual are lacking.

Allsbrooks and Kennedy (1987) called attention to the fact that seasonal fluctuations in home ranges of *P. lotor* had not been studied in

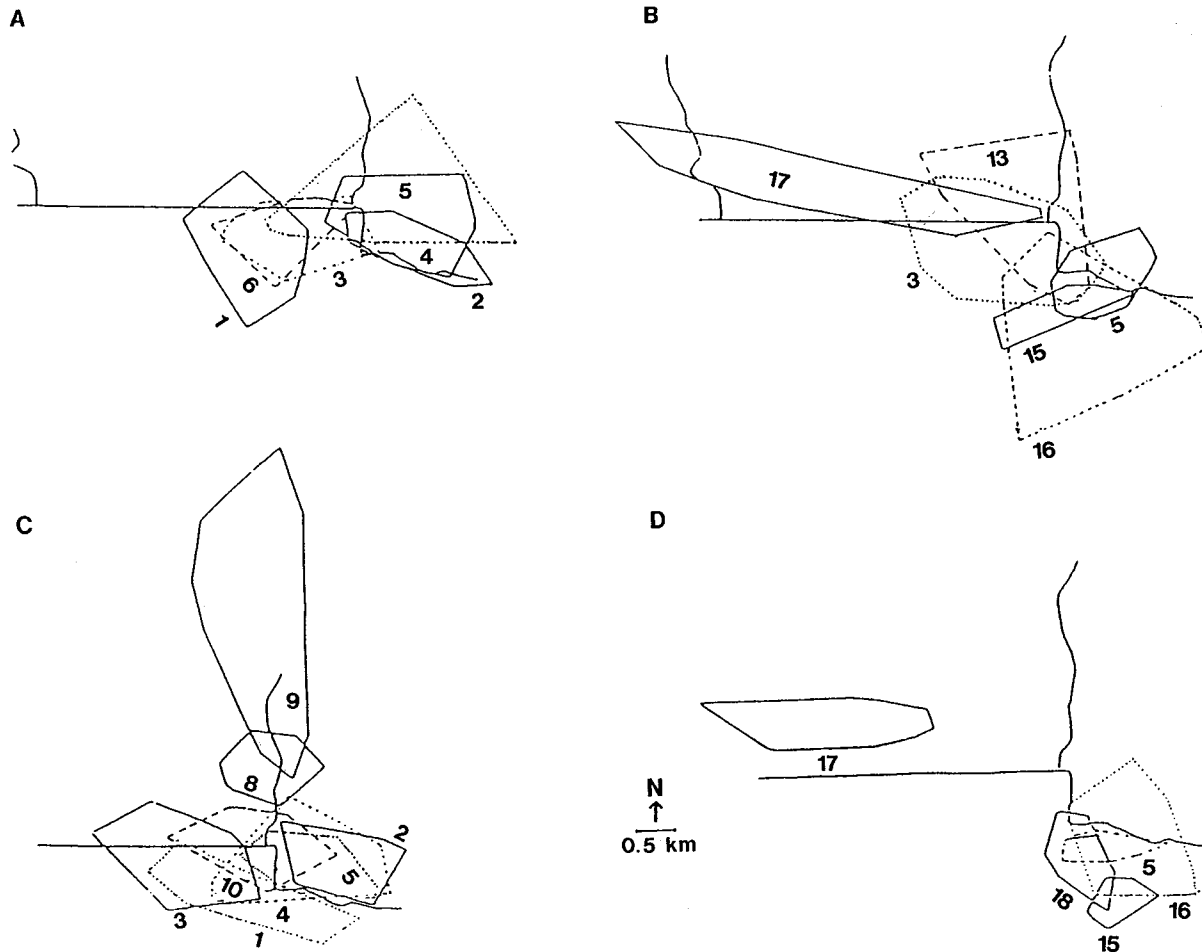


FIG. 1. Seasonal home ranges of adult male raccoons studied on Shelby Forest Wildlife Management Area, Shelby Co., Tennessee (A, summer 1987; B, summer 1988; C, fall 1987; D, fall 1988). Numbers represent individual animal numbers; see Table 1 for additional information.

detail. Previous studies (e.g., Stuewer, 1943; Johnson, 1970) have reported largest home ranges in winter while others (e.g., Taylor, 1979; Allsbrooks and Kennedy, 1987; Tabatabai, 1988) have recorded summer home ranges to be significantly larger than winter and fall ranges. Because the investigations of Allsbrooks and Kennedy (1987) and Tabatabai (1988) were conducted in the same general area as the present study, the lack of variation across seasons in this investigation suggests that seasonal home ranges vary among years as well as among geographic regions. Mean seasonal home ranges determined in the present study are larger than those reported by Tabatabai (1988) and are at variance (some larger and some smaller) with those reported by Allsbrooks and Kennedy (1987). Stuewer (1943) and Johnson (1970) suggested that home-range size increased as food became scarce. Allsbrooks and Kennedy (1987) indicated that smaller home ranges in fall and winter may reflect an increase in use of mast crops and a less selective diet, while, when food became scarce, raccoons utilized the most readily available foods. This would reduce home-range size and minimize energy expenditure in search of food when foods are more scarce. It appears that additional studies are needed to more clearly understand the factors driving seasonal fluctuations in home ranges of *P. lotor*.

The degree of overlap among seasonal home ranges has not been investigated in detail. Precision is often questionable in determining the

exact locations of individuals using standard radio-telemetry techniques. However, due to the small size of the geographic area studied and familiarity with the area by the investigator, accuracy of the data collected in the present study should be at a level that allows a general assessment of the relationship of home ranges of adult male raccoons. Results of this study gave little evidence to support the premise that adult males in western Tennessee have home ranges exclusive of other adult male raccoons. Only animal number 17, during fall 1988, demonstrated a home range mutually exclusive of others. Because home ranges overlapped during spring and summer for this animal and because all other raccoons displayed overlapping home ranges, it is thought that the lack of overlap by number 17 is best explained by small sample sizes. Overall, home ranges of adult males overlap during all seasons; however, the level of overlap varies among individuals. This is probably best explained by the many factors that have been used to explain variation in home-range sizes (e.g., population level, habitat quality, season, length of study; see Kaufman, 1982).

Fritzell (1978) reported that, in spring and summer in North Dakota, adult males exhibited a form of territoriality (based on mutually exclusive home ranges in response to access to females). He reported that social organization described for *P. lotor* in North Dakota may differ from those at lower latitudes where climate, habitat, food resources, and raccoon abundance differ from those in northern prairies. Lehman

TABLE 4. Fall home-range overlap for adult male raccoons at Shelby Forest Wildlife Management Area, Shelby Co., Tennessee¹. Overlap is given in hectares; percentage of an animal's home range within the overlap is given in parentheses.

Raccoon number	Overlap in 1987								Overlap in 1988				
	1	2	3	4	5	8	9	10	5	15	16	17	18
1		0.0 (0.0)	35.9 (46.0)	17.2 (22.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.5 (7.0)					
2	0.0 (0.0)		0.0 (0.0)	45.3 (80.2)	31.5 (55.8)	0.0 (0.0)	0.0 (0.0)	11.8 (20.9)					
3	35.9 (37.1)	0.0 (0.0)		14.4 (14.9)	0.6 (0.6)	0.0 (0.0)	0.0 (0.0)	20.1 (20.8)					
4	17.2 (16.4)	45.3 (43.2)	14.4 (13.7)		45.9 (43.8)	0.3 (0.3)	0.0 (0.0)	35.3 (33.7)					
5	0.0 (0.0)	31.5 (68.8)	0.6 (1.3)	45.9 (98.9)		0.0 (0.0)	0.0 (0.0)	23.4 (51.1)	0.0 (0.0)	8.7 (74.4)	0.0 (0.0)	5.0 (42.7)	
8	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.7)	0.0 (0.0)		11.1 (25.4)	0.0 (0.0)					
9	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	11.1 (5.3)		0.0 (0.0)					
10	5.5 (8.3)	11.8 (19.3)	20.1 (32.8)	35.3 (57.7)	23.4 (38.2)	0.0 (0.0)	0.0 (0.0)						
15									0.0 (0.0)		3.9 (36.1)	0.0 (0.0)	2.0 (18.5)
16									8.7 (13.1)	3.9 (5.9)		0.0 (0.0)	9.1 (13.7)
17									0.0 (0.0)	0.0 (0.0)	0.0 (0.0)		0.0 (0.0)
18									5.0 (22.3)	2.0 (8.9)	9.1 (40.6)	0.0 (0.0)	

¹Chart interpretation: e.g., raccoon 1 and raccoon 3, in 1987, have an overlap of 35.9 ha; this is 46.0% of the home range of raccoon 1 and 37.1% of the home range of raccoon 3.

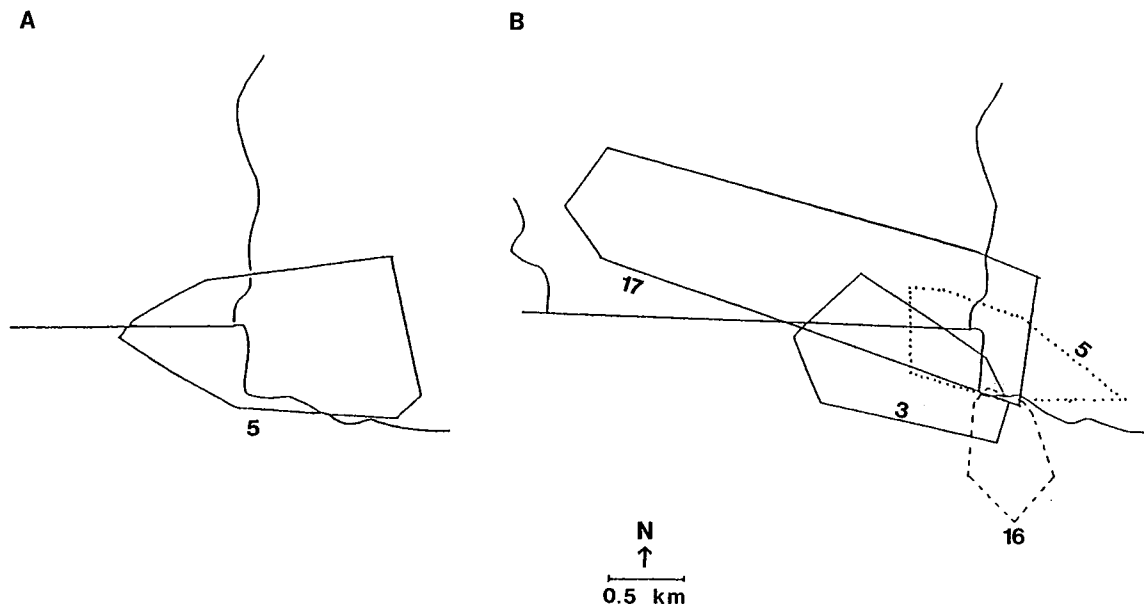


FIG. 2. Seasonal home ranges of adult male raccoons on Shelby Forest Wildlife Management Area, Shelby Co., Tennessee (A, winter 1988; B, spring 1988). Numbers refer to individual animal numbers; see Table 1 for additional information.

TABLE 5. Spring home-range overlap for adult male raccoons at Shelby Forest Wildlife Management Area, Shelby Co., Tennessee¹. Overlap is given in hectares; percentage of an animal's home range within the overlap is given in parentheses.

Raccoon number	Overlap in 1988			
	3	5	16	17
3		15.7 (18.8)	5.3 (6.3)	36.8 (44.0)
5	15.7 (27.6)		0.6 (1.1)	37.7 (66.4)
16	5.3 (17.2)	0.6 (1.9)		0.7 (2.3)
17	36.8 (17.6)	37.7 (18.0)	0.7 (0.3)	

¹Chart interpretation: e.g., raccoon 3 and raccoon 5 have an overlap of 15.7 ha; this is 18.8% of the home range of raccoon 3 and 27.6% of the home range of raccoon 5.

(1984) indicated relatively mutually exclusive home ranges in Indiana ($n = 3$) for adult male raccoons and suggested possible territoriality. Additionally, Keeler (1978) reported that home ranges of adult males did not overlap in eastern Tennessee. The work of Keeler (1978) could be taken to support the conclusions of Fritzell (1978) and Lehman (1984). However, the number of recaptures recorded by Keeler (1978) for adult males was small ($n = 4-6$). Results of the present study support other studies (e.g., Stuewer, 1943; Johnson, 1970; Urban, 1970; VanDruff, 1971; Taylor, 1979; Allsbrooks and Kennedy, 1987; Tabatabai, 1988) conducted between Michigan and New York and Alabama and Tennessee that have shown overlapping home ranges of adult males. Evidence to support territoriality (based on mutually exclusive home ranges) among adult male raccoons as described by Fritzell (1978) is lacking in many areas. As pointed out by Tabatabai (1988), few studies have focused on territoriality, and sample sizes have been small for investigations that have addressed this topic; additional studies are needed to understand home-range dynamics of this species.

With the exception of Glueck et al. (1988), assessment of pre-season and harvest-season home ranges have not been conducted for raccoons. Results of the present study follow those of Glueck et al. (1988) in that home-range areas were highly variable among individuals and that a large percentage of the harvest-season home range was contained within the pre-season area for most individuals. Glueck et al. (1988) indicated that prevailing weather conditions during the harvest season had a greater influence on raccoon movements than did hunters. The present study supports this conclusion. Inhibitory effects of low temperature on the activity of raccoons also has been reported in western Tennessee by Allsbrooks and Kennedy (1987).

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TABLE 6. Home ranges for the 60 days before raccoon-hunting season (preseason) and during raccoon-hunting season (harvest season) and degree of overlap between these ranges at Shelby Forest Wildlife Management Area, Shelby Co., Tennessee.

Raccoon number	Home range (ha)		Overlap (ha)	% overlap of	
	Preseason	Harvest season		Preseason	Harvest season
1	36.8	49.7	22.5	61.2	45.4
2	68.9	26.1	24.7	35.9	94.7
5	10.4	114.5	0.0	0.0	0.0
8	36.5	13.2	12.7	34.8	95.8

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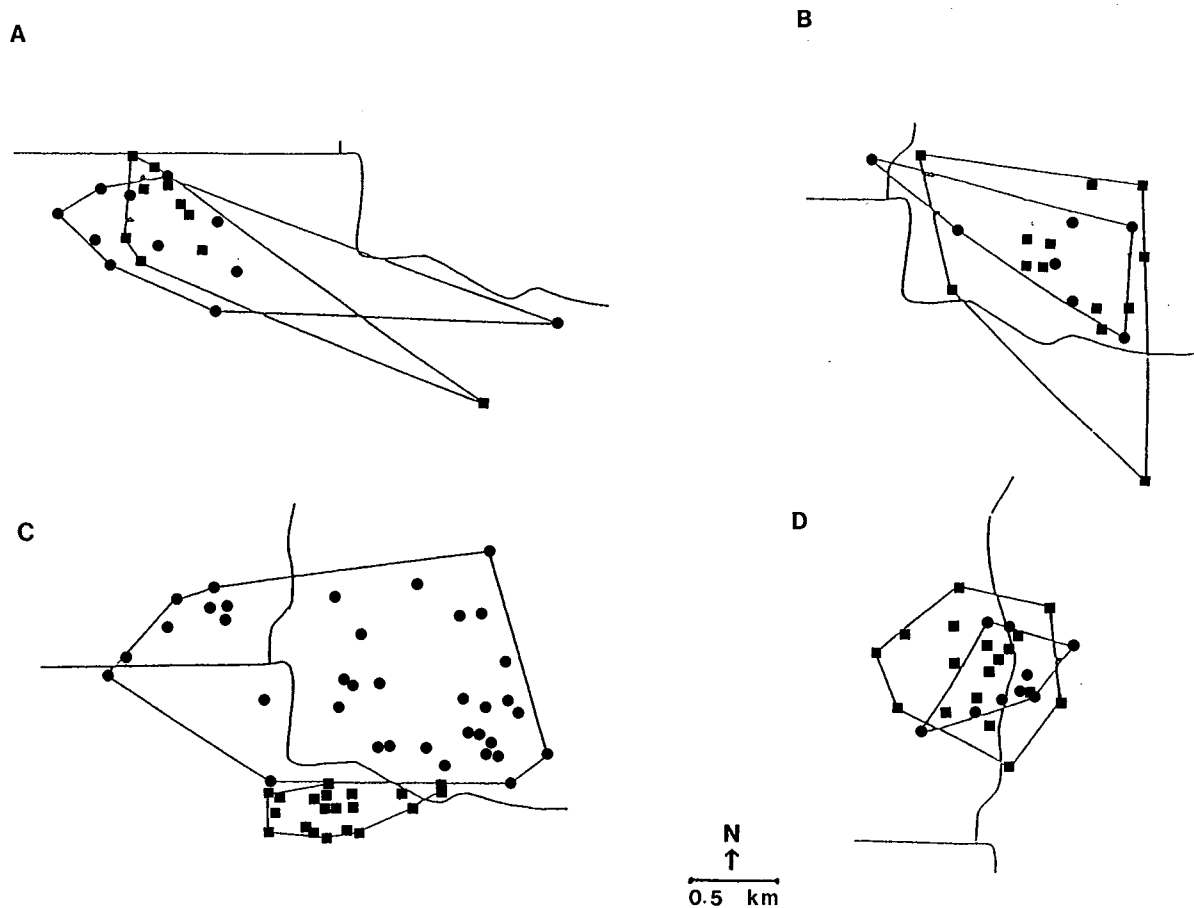


FIG. 3. Home ranges of adult male raccoons studied at Shelby Forest Wildlife Management Area, Shelby Co., Tennessee (solid squares = pre-season; solid circles = harvest season; A, raccoon number 1; B, raccoon number 2; C, raccoon number 5; D, raccoon number 8). See Table 1 for explanation of animal numbers.

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