# Home-range Size and Overlap of Eastern Kentucky Bobcats

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*Abstract:* Ten adult bobcats (*Felis rufus*) were located by radio-telemetry during 15 months in Breathitt County, Kentucky. Annual home ranges, calculated by using the 95% Minimum Convex Polygon Method, averaged 59.4 $km^2$ (range 14.5–133.3 $km^2$, $N = 6$) for males and 4.7 $km^2$ (range 2.8–8.1 $km^2$, $N = 4$) for females. Female intrasexual overlap was not observed, while male intrasexual overlap averaged 71%. There were no differences among seasons in home-range size or percentage overlap for males or females ($P > 0.05$). Variability in home-range size and the high degree of male intrasexual overlap may indicate a relatively dense population.

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Although bobcats are wide-spread, intense management and research concerning the animals did not begin until nearly a decade ago. The listing of bobcats in Appendix II of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES), requires that states that export bobcat pelts maintain conservation programs that ensure healthy and sustainable populations (McCord and Cardoza 1982).

Bobcats have not been legally harvested in Kentucky since 1974 because of previously low harvest rates and a lack of information on population status. Bobcats were considered scarce in Kentucky (Barbour and Davis 1974). However, scent-station (Linhart and Knowlton 1975) data, road kill records, conservation officer sightings, and furtaker interviews from 1981 through 1984 have shown that bobcats occur in 28 eastern Kentucky counties and at least 25 other counties throughout the rest of the state (Ky. Dep. Fish and Wildl. Resour., unpubl. data).

With the goal of estimating bobcat densities in Kentucky, the objective of this study was to estimate bobcat home-range size and the amount of home-range overlap in eastern Kentucky.

## Methods

The study was conducted in the southeast portion of Breathitt County in the Cumberland Plateau of eastern Kentucky. Breathitt County was chosen because: (1) the county is centrally located in eastern Kentucky, (2) habitat is representative of both the naturally occurring and disturbed environments, and (3) bobcats occur in the county. The 500-km$^2$ study area was characterized by steep slopes and narrow valleys, with a mixture of mesophytic forest and surface-mined areas. Elevation ranged from 275 to 485 m, but surface mining eliminated many ridgetops above 365 m. Stripped land consisted of active mining areas as well as areas in various stages of reclamation.

Bobcats were captured with Number 1½ single- or double-spring steel leg-hold traps. Trapped bobcats were immobilized with ketamine hydrochloride at 22 mg/kg of body weight. Body weight, body condition, and tooth wear were used to classify bobcats as adults or juveniles (Marshall and Jenkins 1966). Each bobcat was ear tagged and fitted with a radio-transmitter collar.

An attempt was made to relocate each collared bobcat twice per week by ground triangulation by using a 3-element hand-held folding yagi antenna. Azimuth readings were taken from 3 to 5 known positions for each recorded location. When animals could not be satisfactorily located from the ground, they were located from the air with a dual-wing antenna system mounted on an airplane. An effort was made to vary the time of day when radio-tracking was performed, but because of difficulties in accessing many areas, daytime tracking accounted for approximately 80% of all locations.

Telemetry data were analyzed by using the TELEM computer program (Koeln 1980). Bobcat locations were calculated by TELEM as the average X and Y coordinates of all bearing crosses. If the averaged coordinates were further than 500 m from any bearing cross, the locations were eliminated.

Bobcats were relocated from 24 February 1986 through 30 May 1987. Annual home ranges were calculated by using the 95% minimum convex polygon method, which involved eliminating the outermost 5% of locations before calculating the polygon (Fuller et al. 1985). Seasonal home ranges were convex polygons comprising appropriate portions of the annual 95% convex polygon. Seasons were categorized as: spring, 1 March 1986–31 May 1986; summer, 1 June 1986–31 August 1986; fall, 1 September 1986–30 November 1986; winter, 1 December 1986–28 February 1987. Percentages of inter- and intrasexual overlap were calculated on an annual, as well as a seasonal basis, using a compensatory polar planimeter.

All data were tested for normality using the Shapiro-Wilk statistic (SAS Inst. Inc. 1985). For seasonal home range analyses, normality tests were performed on the residual values resulting from an analysis of variance (ANOVA) to determine if the assumption of normality was met, and the seasonal home-range sizes, corresponding to the highest and lowest residual values, were deleted. Student's *t*-test was used to determine potential differences in the annual home-range sizes between males and females. Spearman's correlation coefficient was used to determine whether there was a linear correlation between the number of bobcat locations used, and the corresponding home-range size. Split-plot ANOVA was used to analyze differences observed among seasonal home-range sizes. A two-way ANOVA randomized block design was used to analyze percentages of intra- and intersexual seasonal overlap.

## Results

Six adult male and 3 adult female bobcats were captured in a 16-$km^2$ portion of the study area, and a fourth female was captured and radio-collared outside of the original trapping area. Four additional bobcats captured during the study were not included in the analyses because data were insufficient for home-range size estimation.

Most bobcats, evidently, were resident adults, although male 157 appeared to be a nomadic resident adult (McCord and Cardoza 1982). Male 157 did establish a home range, however, and maintained an area of high use. Nomadic movements accounted for the large home-range size (Table 1).

Mean annual home-range size of male bobcats was 59.4 $km^2$. Excluding male 157's unusually large home range, annual male home-range size averaged 44.7 $km^2$ (Table 1). Female annual home-range size averaged only 4.7 $km^2$ (Table 1). Male home ranges were 12.6 times larger than females' ($t = -3.21$, $P = 0.012$). Excluding male 157, male home ranges were 9.5 times larger than females.

There was no linear correlation between the number of locations and the size of seasonal home ranges for either males or females ($r_s = -0.124$, $P = 0.583$ and $r_s = -0.073$, $P = 0.832$, respectively). There was no difference among the

**Table 1.** Annual and seasonal home-range size ($km^2$) and average number of locations collected per season for bobcats in eastern Kentucky.

| Sex | Bobcat number | Home-range size ($km^2$) | | | | | Number of locations per season | |
|---|---|---|---|---|---|---|---|---|
| | | Annual | Spring | Summer | Fall | Winter | $\bar{X}$ | Range[a] |
| M | 157 | 133.2 | 59.5 | 61.0 | 63.7 | 64.4 | 26 | 22–30 |
| M | 158 | 66.4 | 22.8 | 38.9 | | | 22 | 20–23 |
| M | 162 | 52.1 | 0.9 | 14.8 | 49.7 | 20.3 | 28 | 19–35 |
| M | 166 | 64.0 | 24.0 | 37.0 | 37.6 | 27.6 | 28 | 17–43 |
| M | 168 | 26.3 | 9.9 | 19.2 | 8.3 | 10.8 | 29 | 20–37 |
| M | 170 | 14.5 | 11.4 | 9.9 | 7.6 | 3.7 | 30 | 18–37 |
| F | 159 | 4.1 | 1.7 | 2.7 | 3.2 | 2.0 | 32 | 26–42 |
| F | 160 | 2.8 | 2.2 | | | 1.6 | 26 | 12–40 |
| F | 167 | 8.1 | 6.3 | 5.3 | 4.2 | 5.1 | 30 | 24–35 |
| F | 171 | 3.7 | | | | 2.9 | 45 | 45–45 |

[a]There was no correlation ($P > 0.05$) between number of locations and home-range size.

**Table 2.** Percentage of average annual and seasonal inter- and intrasexual home-range overlap for bobcats in Breathitt County, Kentucky.

| Sex[a] | Annual | Spring | Summer | Fall | Winter |
|---|---|---|---|---|---|
| Male by male | 71 | 50 | 61 | 53 | 53 |
| Female by male | 100 | 92 | 100 | 81 | 84 |

[a]There was no female by female overlap.

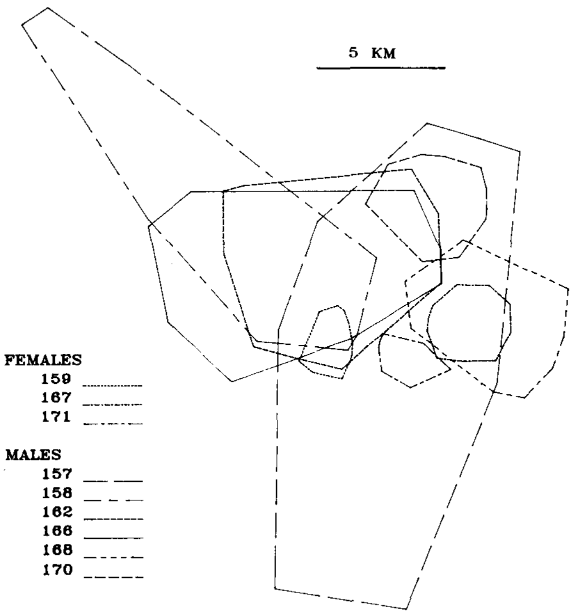


**Figure 1.** Annual home ranges for male and female bobcats collared in Breathitt County, Kentucky.

seasonal home-range sizes for either males or females ($F$ = 1.67, $P$ = 0.209). Home ranges were largest during fall for males and summer for females ($\bar{x}$ = 33.4 $km^2$ for males, $\bar{x}$ = 4.0 $km^2$ for females) (Table 1). The smallest male seasonal home ranges occurred in spring ($\bar{x}$ = 21.4 $km^2$) (Table 1). Female seasonal home ranges were smallest in winter ($\bar{x}$ = 2.9 $km^2$).

Annual male home-range overlap was variable, averaging 71% (range 40%–100%) (Table 2). The number of males overlapping any individual male ranged from 2 to 5 (Fig. 1). Male 157's home range was included in the overlap analysis because the portion of his home range that overlapped males 168 and 170 were areas that 157 visited regularly. Although there was no female intrasexual overlap observed, 3 of the 4 females did have adjacent home ranges. The same 3 females' home ranges were entirely overlapped by males over the year. The number of males overlapping any individual female ranged from 1 to 4. The fourth female, 160, was isolated from the other 9 bobcats, and therefore was not included in the analysis.

The differences in the amount of inter- and intrasexual overlap among seasons were not significant ($F = 1.14$, $P = 0.458$ and $F = 0.37$, $P = 0.776$, respectively).

## Discussion

The average home-range size of male bobcats in Breathitt County was consistent with previous studies (Bailey 1974, Kitchings and Story 1979, Knowles 1985, Fuller et al. 1985). The mean female home-range size, however, was generally smaller than what has been reported. Marshall and Jenkins (1966), and Hall and Newsom (1976) did report smaller female home ranges, but their home ranges were for time spans of less than a year. Also, Hall and Newsom (1976) used the modified minimum area method of home range calculation which consistently yields smaller home-range estimates than the minimum convex polygon method. Home-range size differences between the sexes also were consistent with previous studies (Marshall and Jenkins 1966, Bailey 1974, Hall and Newsom 1976, Kitchings and Story 1979), but the size of male home ranges, relative to females', was extremely high in this study.

Home-range size of adult bobcats has been considered to be related to prey availability and the degree of exploitation (Young 1958, Bailey 1974). Kitchings and Story (1978) believed that the relatively large home ranges of 2 adult bobcats in Tennessee were the result of a low food base. Marshall and Jenkins (1966) found small home ranges under conditions of high food availability and lack of hunting pressure. Small female home ranges, observed in this study, may be the result of the known lack of hunting pressure, but food availability was not measured. According to Lembeck and Gould (1979), harvesting does not affect how bobcats occupy an area because juveniles can move into vacant areas created by harvesting. Instead, they stated that harvested and unharvested bobcat populations differ in population age structure, kitten survival rate, and form of mortality.

Because of the high variability in seasonal home-range size among the bobcats, differences in seasonal home ranges were not significant. Also, because a different combination of individual females was used in calculating each mean seasonal home range, differences in mean seasonal home-range size may be due to variation among those individuals and not due to season. Knowles (1985) suggested that larger female home ranges in the summer may be the result of females moving their kittens at various times during the season. Home ranges are thought to increase in fall and winter probably as the result of decreasing prey densities (Fendley and Buie 1982). Our data indicated that home-range size was not different among seasons and seasonal increases or decreases in home-range size were highly variable among individuals.

Intrasexual overlap in female and male bobcats has been reported by several authors to be only slight (Bailey 1974, Buie et al. 1979, Kitchings and Story 1979, Fendley and Buie 1982, Miller and Speak 1979). In studies where greater male intrasexual overlap has been reported, bobcat populations were considered to be high (Lembeck and Gould 1979, Zezulak and Schwab 1979) or not harvested (Bailey 1974). Female overlap in this study was not observed, even though 3 females had adjacent home ranges. Male intrasexual overlap, however, was extensive.

Male overlap of female home ranges has been commonly reported (Bailey 1974, Berg 1979, Buie et al. 1979, Kitchings and Story 1979, Zezulak and Schwab 1979). Because female home ranges were so much smaller than males', males were able to completely overlap 1 or more females.

There is a potential influence of bobcat density on the home-range size and on the amount of intrasexual home-range overlap. Because bobcats are considered to be territorial, large home-range size was considered to reflect a low bobcat density in South Carolina (Buie et al. 1979). If this is true, then smaller home ranges may reflect a high bobcat density. Under conditions of increasing density, territorial compression would reach a point where territory holders would be unable to maintain an area exclusive of neighboring individuals because of space/energy demands (Fendley and Buie 1982). Thus, high density may be the cause of the high degree of male intrasexual overlap observed in this study. Also, because unmarked bobcats were observed within the study area, and assuming some of these may have been males, actual male intrasexual overlap may have been greater than observed.

Zezulak and Schwab (1979) also suggested that increased intrasexual contact and competition could result from crowding. Furthermore, they suggested that crowding could be characterized by a shift in age and sex structure toward adult males, instability in home-range size, extensive intrasexual home-range overlap, and decreased reproduction. There was evidence of each of these characteristics in eastern Kentucky. Although our sample was small, only 2 of the 13 bobcats captured within our trapping area were juveniles. The sex ratio of trapped bobcats was skewed toward males (9 of 13 were males). In addition to the skewed age and sex ratios of trapped individuals, the high variability of home-range size and the high degree of male intrasexual home-range overlap may indicate that this adult bobcat population is dense.

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