Habitat Characteristics of Bobcat Core Use Areas in Mississippi

L. Mike Conner[1], *Department of Wildlife and Fisheries, P.O. Drawer LW, Mississippi State University, Mississippi State, MS 39762*

Bruce D. Leopold, *Department of Wildlife and Fisheries, P.O. Drawer LW, Mississippi State University, Mississippi State, MS 39762*

Abstract: Sixteen adult bobcats (11 females, 5 males) (*Felis rufus*) were monitored using radio-telemetry from 1 January 1989–31 December 1992 in Mississippi to determine habitat components influencing core use area (CUA) location and size. Male bobcat CUA size ($\bar{x}$ = 26.5 km^2, SE = 6.1) was larger (P = 0.047) than females ($\bar{x}$ = 11.8 km^2, SE = 2.8). Habitat components of bobcat CUA's did not differ (P > 0.10) by sex. There was a higher (P < 0.01) proportion of pine plantations and agricultural habitats in CUA's than in random areas. There was a lower (P = 0.06) proportion of hardwood stands in CUA's ($\bar{x}$ = 0.23: SE = 0.03) than in random areas ($\bar{x}$ = 0.36, SE = 0.04). Occurrence of creeks, roads, and pine stands were not significantly different (P > 0.10) between CUA's and random areas. We propose prey abundance influenced location of bobcat CUA's and thus home ranges on our study area. However, we found evidence contradicting the hypothesis that bobcat home range size is a function of prey abundance.

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Passage of the Endangered Species Conservation Act of 1969 increased the demand for the nonendangered spotted cats of North America, specifically the bobcat and lynx (*F. lynx*). Concern of overexploitation of bobcats caused their listing in Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 1973. These events have fostered abundant research concerning bobcat ecology as each state is responsible under CITES for ensuring non-detrimental bobcat harvest (Gluesing et al. 1986). Data concerning basic bobcat ecology are needed on a regional basis to assist managers in making management decisions concerning this species.

[1]Present address: School of Physical and Life Sciences, Arkansas Tech University, Russellville, AR 72801

Bobcats use a variety of habitats. In the Southeast, bobcats used early successional vegetation (Kitchings and Story 1979), bottomland hardwoods in mid-successional stages (Hall and Newsom 1976), mature bottomland hardwoods, old fields, young pine plantations (Heller and Fendley 1986, Conner et al. 1992), and agricultural areas (Lancia et al. 1986). Wassmer et al. (1988) found bobcats to use habitats within their home range disproportionately to their availability; however, there were no consistent trends in habitat use. Rucker et al. (1989) found bobcats preferred 0- to 20-year-old forest regeneration areas and mature hardwood timber more than other habitats.

Animals select areas for colonization based on a large geographical location with features suitable for their survival. Afterward, the animal finds a specific area within this geographical region that contains the necessary habitat requirements (Johnson 1980). Most habitat use studies do not account for habitat selection that has taken place before the researcher observed the animal in a particular habitat. When analyzing habitat use data, researchers must realize the animal has already positioned its home range to take advantage of surrounding habitats.

Classical habitat use studies versus availability studies can be flawed as habitats used less than available may have been important in the animal choosing the home range location. Hypothetically, an animal may choose to establish a home range in a given area due to a high proportion of habitat patch "A". Because of the high availability of "A", researchers may find the animal to use "A" less than its availability. Researchers could easily conclude that "A" is of no benefit to the animal's fitness and in a worse case, suggest "A" be converted to an alternative habitat to manage for the species in question.

Burt (1943) defined home range as "that area traversed by the individual in its normal activities of food gathering, mating, and caring for young." Core use areas (CUA's) are used to denote areas of intense use (Ackerman et al. 1990), thus providing conservative estimates of home range. Core use areas have several additional features that make them ideally suited for identifying habitat variables affecting location of home ranges. Core use areas are not affected by outliers and are much less susceptible to sample size than typical home range models. Furthermore, because CUA's represent areas of intense use, detecting differences in habitat composition between CUA's and the study area as a whole should be easier as "noise" created from areas included by classical home range models is eliminated (Ackerman et al. 1990).

Few researchers have attempted to link home range size to density and habitat quality (Buie et al. 1979, Litvaitis 1985, Griffith and Fendley 1986, Anderson 1987, Knick 1990, Conner 1991). However, no data exist to indicate whether bobcat home range size truly reflects habitat quality. We propose that if habitat quality is dictated by prey abundance (Buie et al. 1979, Litvaitis 1985, Anderson 1987, Knick 1990, Conner 1991), there should be an inverse relationship between CUA size and proportions of habitat patches known to produce abundant prey.

The objectives of this paper are to describe bobcat CUA's, assess sex specific differences in bobcat CUA's, determine if habitat composition of CUA's differs from that of random areas, and to determine habitat factors which may influence CUA size (including proportions of habitats known to produce abundant prey).

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Methods

The study was conducted on the 142-km^2 Tallahala Wildlife Management Area (WMA) in the Strong River District of the Bienville National Forest in central Mississippi. Mean annual temperature was 18° C and annual precipitation averaged 152 cm (Carraway 1990). Mature (> 20 years of age) pine (*Pinus* spp.) stands comprised approximately 54% of the study area. Mature bottomland hardwood stands accounted for 30% of the area. Approximately 15% of the area was pine plantation forest (< 20 years of age). The remaining 1% of the area was in agriculture (row crops or pasture).

Bobcats were captured using Victor Soft-catch traps (Woodstream Corp. Lititz, Pa.). Following capture, bobcats were netted and drugged with ketamine hydrochloride (15 mg/kg body mass). Bobcats were weighed, standard measurements were taken, and ear tags installed. Bobcats were separated into 3 age classes (kitten < 1.0 year, sub-adult 1–2 years, adult > 2 years based on tooth eruption, staining and wear, body size, (Crowe 1975) pelage characteristics, teat condition on females, and scrotum size of males. All adult females were fitted with a radio-collar (151–152 Mhz, Wildlife Materials Inc., Carbondale, Ill.). Selected adult males (animals captured in the interior of the study area) also were monitored. Cats were monitored in a cage at approximately 20° C for 24 hours to assess recovery then were released at the capture site. Transmittered animals were allowed 1 week to recover from capture before radio-tracking was initiated. Animals were trapped during winters (7 Jan–15 Mar) of 1989–1992. Each year, we attempted to capture all bobcats on the study area.

Bobcats were monitored using a TRX-1000S receiver and a hand-held 3-element Yagi antenna (Wildlife Materials Inc., Carbondale, Ill.). Locations were determined by triangulation from fixed points within the study area (Cochran 1980, Kenward 1987, White and Garrott 1990). Three or more azimuths were frequently recorded to minimize erroneous locations. A maximum of 15 minutes was allowed between azimuths to decrease error associated with animal movement. Azimuths were converted to x,y coordinates using the program TELEBASE (Wynn et al. 1990). Telemetry locations were non-biased and estimated accurate within 117 m based on accuracy tests as described by White and Garrott (1990).

Bobcat CUA's were delineated by comparing the harmonic mean utilization distribution with a uniform use model. Core use areas were defined as the maximum area where the observed utilization distribution exceeds a uniform utilization distribution as determined using a Chi-square test (Samuel et al. 1985, Samuel and Green

Table 1. Comparison of proportion of habitat components and creek and road density of core use areas of male and female bobcats in central Mississippi.

	Male		Female		
Habitat component	$\bar{x}$	SE	$\bar{x}$	SE	P^a
Pine plantation	0.23	0.02	0.25	0.02	0.86
Pine	0.42	0.06	0.46	0.06	0.53
Hardwood	0.31	0.05	0.19	0.04	0.13
Agriculture	0.04	0.02	0.10	0.05	0.91
Creeks (m/km^2)	1440	48	1386	97	0.61
Roads (m/km^2)	1054	498	1155	258	0.78

[a] Based on Mann-Whitney *U*-tests.

1988, Ackerman et al. 1990). Because the utilization distribution is calculated using a harmonic mean model, we omitted animals from analysis with ≤ 50 relocations (Ackerman et al. 1990, Boulanger and White 1990). To eliminate autocorrelation (Swihart and Slade 1985), we omitted observations separated by < 12 hours. Core use areas were calculated using HOME RANGE (Ackerman et al. 1990).

A habitat map was constructed by transferring vegetative types from color infrared photography to U.S. Geological Survey (USGS) 7.5-minute quadrangles. The habitat map was then digitized into PC ARC/INFO (Environ. Systems Res. Inst. 1989) for further analysis. Roads and creeks were digitized directly from the USGS quadrangles into PC ARC/INFO.

Habitat composition of CUA's was determined by overlaying CUA's with habitat, road, and creek coverages using PC ARC/INFO. We expressed availability of vegetative habitat variables as percentages of the total CUA, while lengths of creeks and roads were divided by CUA size (in km^2) to determine their relative density within the CUA.

Random areas were paired with each animal CUA to determine if habitat characteristics affected CUA location. Circles were constructed with an area equal

Table 2. Comparison of proportion of habitat components and creek and road density of bobcat core use areas and randomly generated "pseudo-cores" in central Mississippi.

	Cores		Pseudo cores		
Habitat component	$\bar{x}$	SE	$\bar{x}$	SE	P^a
Pine plantation	0.24	0.02	0.17	0.01	0.006
Pine	0.45	0.04	0.45	0.04	0.92
Hardwood	0.23	0.03	0.36	0.04	0.06
Agriculture	0.08	0.04	0.02	0.01	0.009
Creeks (m/km^2)	1403	67	1518	91	0.41
Roads (m/km^2)	1123	226	812	89	0.72

[a] Based on Wilcoxon paired sample tests.

to the CUA to which they were paired. These circles were randomly overlaid onto habitat, road, and creek coverages to build "pseudo-cores".

Correlation analyses were used to determine sampling adequacy by assessing the relationship between the size of CUA's, number of locations, and duration of monitoring. We used Mann-Whitney tests to determine if sex specific differences in CUA variables existed. Wilcoxon paired sample tests were used to determine if habitat composition differed between CUA's and "pseudo cores." Spearman rank correlations were used to determine relationships of habitat variables to CUA size (Steel and Torrie 1980, Zar 1984). An alpha of 0.10 was used for all hypothesis tests.

Results

Sixteen bobcats (11 females, 5 males) were monitored between 1 January 1989 through 31 December 1992. All animals were not monitored concurrently. Male CUA's ($\bar{x}$ = 26.5 km^2, SE = 6.1) were larger (U = 10.0; P = 0.047) than female's ($\bar{x}$ = 11.8 km^2, SE = 2.8). Because there was a significant difference between male and female CUA sizes, we performed correlations of CUA size on number of months monitored and number of locations separately for each sex. There was no correlation between number of locations or number of months monitored, and bobcat CUA size for either sex ($P \geq 0.13$; $r = 0.49$).

No sex specific differences in habitat components were detected ($U \geq 14$; $P \geq 0.13$), thus sexes were pooled for further analysis (Table 1). There was a higher ($Z = 2.7$; $P = 0.006$) proportion of pine plantations in core areas ($\bar{x}$ = 0.24; SE = 0.02) than in pseudo cores ($\bar{x}$ = 0.17; SE = 0.01). Additionally, there was a higher ($Z = 2.6$; $P < 0.01$) proportion of agricultural areas in cores ($\bar{x}$ = 0.08; SE = 0.04) than in pseudo cores ($\bar{x}$ = 0.02; SE = 0.01). There were fewer ($Z = 1.91$; $P = 0.06$) hardwoods present in CUA's ($\bar{x}$ = 0.23; SE = 0.03) than in pseudo cores ($\bar{x}$ = 0.36; SE = 0.04). No significant differences in proportion of pines, and creek or road densities were found between cores and pseudo cores ($P \geq 0.41$) (Table 2).

Male CUA size was negatively correlated with creek density (P = 0.04; $r = -0.90$). No other habitat variable was correlated with CUA size ($P \geq 0.12$; $|r| \leq 0.50$).

Discussion

The lack of correlation between number of locations and CUA size is evidence of adequate sampling intensity for determination of individual CUA size. Male bobcat home ranges are generally larger than females (Hamilton 1982, Lancia et al. 1986, Whitaker et al. 1987, Rucker et al. 1989, Conner et al. 1992), thus the observation of larger male CUA's than females is expected.

Females locate home ranges to secure sufficient nutrition for their survival and the survival of their young (Bailey 1979, Anderson 1987, Sandell 1989). If male home ranges are placed to maximize breeding opportunities (Miller 1980, Rolley 1983, Anderson 1987, Sandell 1989, James 1992) one could hypothesize that habitat components of CUA's would be less important to males than females. However, our data do not support this hypothesis as habitat composition between male and female CUA's did not differ. One could argue that this is because males were concentrating their activities in areas with high female activity. This argument is not negated based on our data, but we question the perceived lack of importance of habitat parameters on location of male bobcat home ranges. We feel further investigation is needed before accepting the above hypothesis (Miller 1980, Rolley 1983, Anderson 1987, Sandell 1989, James 1992) concerning male bobcat home range location.

Pine plantations and agricultural areas appeared to influence home range location most. Bobcats prefer early successional vegetation, young pine plantations, and old fields (Kitchings and Story 1979, Heller and Fendley 1986, Conner et al. 1992). Each of these habitat types would have been classified as pine plantations on Tallahala WMA. The agricultural habitat type was available on the study area only in limited locations, and although it only comprised a small portion of CUA's, it did appear important to bobcats. It should be noted that agricultural areas on Tallahala WMA were not "clean-farmed," but rather had numerous vegetated fence and ditch rows. We feel that importance of these habitats is due to their ability to produce prey. Conner (1991) found pine plantations on Tallahala WMA to produce a greater abundance of bobcat prey items than other habitat types. In reality, the agricultural type could be considered similar to the pine plantation forest regarding prey production. Numerous ditch and fence rows coupled with plant litter around edges of cultivated areas produced an abundance of bobcat prey (Conner 1991).

We found pine plantations and agricultural areas influenced location of bobcat home ranges while abundance of roads, creeks, and pine stands appeared unimportant. Furthermore, bobcats selected home ranges that contained fewer hardwoods than expected. Conner et al. (1992) found bobcats used pine plantations and agricultural areas greater than their availability and concluded that these habitat types were important to bobcats on our study area. This finding continues to appear valid. In addition, Conner et al. (1992) also found mature pine stands to be avoided and hardwood stands to be used equal to their availability. The results of Conner et al. (1992) could have been misleading as availability of pine stands did not seem to influence location of home ranges and bobcats appeared to show avoidance of hardwoods in selecting home ranges.

Home range size has often been used as an indicator of habitat quality (Buie et al. 1979, Anderson 1987, Knick 1990, Conner et al. 1992). Results of our correlation analyses casts serious doubt on the validity of this hypothesis. Bobcat diet on Tallahala WMA is comprised largely (≥90% occurrence) of cotton rats (*Sigmodon hispidus*), mice (*Peromyscus* spp. and *Ocrotomys nuttalli*), rabbits (*Sylvilagus* spp.), white-tailed deer (*Odocoileus virginianus*), and squirrels (*Sciurus* spp.) (L. M. Conner and B. D. Leopold, unpubl. data). Conner (1990) found relative abundance of cotton rats, mice, rabbits, and deer to be significantly higher in pine plantations than in other Tallahala WMA habitat types. Further, abundance of squirrels was significantly higher in mature hardwoods than in other habitats. The usual explanation for differential habitat use by bobcats is prey abundance (Bailey

1979, Fuller et al. 1985, Knowles 1985, Litvaitis 1985, Boyle and Fendley 1987, Conner et al. 1992). If the primary factor affecting bobcat home range size is habitat quality, and if prey abundance dictates habitat quality (Buie et al. 1979, Anderson 1987, Sandell 1989, Knick 1990, Conner et al. 1992), an inverse correlation between percent pine plantations and CUA size should have been detected. A similar relationship could possibly be expected between percent mature hardwoods and CUA size. Neither relationship was observed. In fact, increasing proportion of hardwoods seemed to increase CUA size. This leads us to believe that prey abundance may not be the primary factor influencing habitat quality. Alternatively, bobcat home range size may be a function of density (Griffith and Fendley 1986) or habitat variables not measured such as level of human disturbance of availability of den sites (Bailey 1979). Maximum density and minimum home range size are likely regulated by habitat quality. If this hypothesis is true, and if we measured habitat variables most important to bobcats, we feel that habitat related factors are not yet limiting bobcat densities on Tallahala WMA due to lack of correlation between proportion of habitats and CUA size.

Creek density did appear to influence CUA size of males. As creek densities increased male CUA size decreased. However, creek density did not appear to influence location of CUA's. Males possibly use creeks as travel corridors within the home range (Rolley 1983, Shiftlet 1984). An increase in creek network density may reduce male movements by providing more direct travel routes within the home range.

We reiterate our earlier (Conner et al. 1992) findings concerning importance of early successional habitats to bobcats. Further, we feel managers should provide pine plantations which are well dispersed within mature forest types. This may be of particular importance in mature forests predominated by hardwoods.

We caution managers and scientists that home range size is not necessarily related to habitat quality. More work is needed relating habitat composition to habitat quality and bobcat fitness.

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