

Spatial Organization of Adult Bobcats in a Longleaf Pine-Wiregrass Ecosystem in Southwestern Georgia

Jessica C. Cochrane^{1,*}, Jordona D. Kirby¹, Ivy G. Jones¹, L. Mike Conner¹,
and Robert J. Warren²

Abstract - *Lynx rufus* (bobcat) home-range sizes have been studied throughout the Southeast, but study duration is generally ≤ 2 years and number of bobcats sampled is often < 20 . There have been even fewer studies dealing with spatial interactions of bobcats, and fewer still within a *Pinus palustris* (longleaf pine) ecosystem. Because both bobcat home-range sizes and the degree that space is shared by bobcats are highly variable, it is important to understand factors that influence bobcat home-range size and spatial organization within the various habitats where this species is found. Therefore, we determined seasonal and annual home-range sizes and spatial overlap of bobcats in a longleaf pine forest in southwestern Georgia. We monitored 44 radio-collared bobcats (17 M and 27F) during 2001–2004. Gender and year did not interact to affect bobcat annual home-range sizes (95% adaptive kernel), and annual differences in annual home-range sizes were insignificant. However, male bobcats had annual home-range sizes almost 2 times greater than those of females. Gender and season interacted to affect seasonal home-range sizes of bobcats; thus, we analyzed seasonal home-range sizes for each gender separately. Seasonal home-range sizes of male bobcats did not differ. However, for female bobcats, the greatest home-range sizes occurred during winter of 2003 and the smallest during summer of 2002. We examined 3 types of spatial overlap: male-male, female-female, and female-male. Home-range overlap differed among types; female-male overlap was approximately 1.6 times greater than female-female overlap and approximately 2.8 times greater than male-male overlap. Our home-range sizes were among the smallest reported in the Southeast. While intrasexual overlap is generally considered rare in bobcats, we observed sharing of space by male-male and female-female pairs. Furthermore, space shared by female-female pairs exceeded that of male-male pairs, contrary to hypotheses concerning land tenure of solitary carnivores. Land-management practices, such as prescribed burning and maintenance of food plots, provided abundant small prey for bobcats and best explain smaller home-range sizes of bobcats in this study relative to that reported in most other southeastern studies. We suggest that spatial exclusivity among male-male and female-female pairs is most likely when prey are moderately abundant, but that exclusivity of home ranges may be abandoned when prey are either abundant or rare. Further investigation into home-range overlap is needed to consider the effect of bobcat density on these variables.

Introduction

Lynx rufus Schreber (bobcat) is a solitary carnivore with home-range sizes apparently influenced by geographic region (Anderson 1987, Berg 1979), gender (Hall and Newsome 1976, Kitchings and Story 1979), season

¹Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 39870. ²Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30606. *Corresponding author - jessicacochrane@yahoo.com.

(Anderson 1987, Sandell 1989), habitat quality (Rucker et al. 1989), prey availability and abundance (Fendley and Buie 1986), and time-in-residence (Conner et al. 1999). Home ranges of bobcats in the Southeast vary from 1.1 km² for females and 2.6 km² for males (Miller and Speake 1979) to 24.5 km² for females and 64.2 km² for males (Rucker et al. 1989).

Male home ranges typically exceed those of females by 2–3 times, and may be as much as 5 times greater (Buie et al. 1979, Hall and Newsom 1976, Kitchings and Story 1979, Whitaker et al. 1987). Male home-range size is thought to be affected by size of female home ranges and number of mating opportunities; whereas, female home ranges appear to be regulated by diversity, abundance, stability, and distribution of prey populations (Anderson 1987, Sandell 1989). Differences in habitat quality often are used to explain home-range variability in *L. rufus* (Anderson 1987). According to the bobcat habitat suitability index model, suitability of habitat is determined by the ability of an area to support prey populations (Boyle and Fendley 1987). Studies have documented an inverse relationship between prey abundance and home-range size (Buie et al. 1979, Knick 1990). Habitats more suitable for abundant prey densities are more likely to be included in a bobcat's home range, and greater quality habitat should result in smaller home ranges (Buie et al. 1979, Knick 1990). Conner et al. (2001) suggested that habitat quality influences bobcat home-range size, but once habitat quality increases to a threshold, home ranges become influenced by other factors such as bobcat density and breeding opportunities.

Although few studies of bobcats in the Southeast have addressed seasonal variation in home-range size, existing studies throughout the United States suggest that males have greater home ranges during the breeding season, and females have smallest home ranges during parturition and kitten-rearing (Anderson 1987, Conner et al. 1992, Knick 1990). Seasonal fluctuation in home-range sizes also may relate to seasonal differences in prey availability. Home ranges were smallest during summer in Arkansas, probably because prey abundance was greatest during the warmest months (Rucker et al. 1989). In South Carolina, bobcat home-range size did not vary seasonally (Fendley and Buie 1986).

Male bobcat home ranges typically overlap several female home ranges and those of other males (Anderson 1987, Bailey 1974, Buie et al. 1979, Hall and Newsom 1976, Miller and Speake 1978, Nielsen and Woolf 2001, Whitaker et al. 1987). Intersexual overlap typically is greater than intrasexual overlap, and female home ranges typically are exclusive of other females (Anderson 1987, Buie et al. 1979, Hall and Newsom 1976, Marshall and Jenkins 1966, McCord and Cordoza 1982, Miller and Speake 1979, Whitaker et al. 1987). However, some studies reported frequent overlap among female home ranges, ranging from 21% (Chamberlain and Leopold 2001) to 36% in California (Zezulak and Schwab 1979). Kitchings and Story (1984) observed 2 adult females with kittens using the same area, and studies have documented extensive evidence of sub-adults and transients being

tolerated within adult home ranges (McCord 1974, Miller and Speake 1979, Provost et al. 1973). In some cases, male exclusivity also was observed (Zezulak and Schwab 1979).

Spatial organization in bobcats may be influenced by climate, habitat, population density, and prey abundance (Anderson and Lovallo 2003). In 2 studies of bobcats in South Carolina, bobcats had greater home ranges and less intrasexual overlap 12 years after the initial study had occurred (Buie et al. 1979, Marshall and Jenkins 1966), presumably the result of altered land use and decreased prey abundance. Increased bobcat densities and smaller home ranges were associated with exclusive home ranges for both genders (Lembeck and Gould 1979, Miller and Speake 1979). Bailey (1981) suggested that female home ranges should be small and exclusive in warm climates where resources are abundant. Male home ranges also should be small in warm climates with minimum overlap from other males (Anderson 1987, Bailey 1981). Another potential factor influencing home-range overlap is genetic relatedness, but spatial and genetic relatedness in bobcats have not been extensively investigated (Chamberlain and Leopold 2001). Because there are relatively few studies of bobcat spatial organization with > 2 year duration, particularly within a *Pinus palustris* P. Mill (longleaf pine) ecosystem, our objectives in this study were to determine annual and seasonal home-range sizes of bobcats in a longleaf pine ecosystem in southwestern Georgia, and to determine the extent that bobcats shared space with neighboring individuals.

Study Area

We conducted the study on Ichauway, which is a privately-owned, 11,735-ha research facility located in Baker County, GA, 16 km south of Newton, GA. It is located in the Dougherty Plain physiographic province in the southeastern Gulf Coastal Plain. Approximately 24 km of the Ichawaynochaway Creek flows through the study area, and the Flint River forms almost 22 km of Ichauway's eastern boundary. Ichauway is characterized by flat to gently rolling karst topography, with elevations ranging from 27 to 61 m. It has hot, humid summers and short, mild, wet winters, with average daily temperatures ranging from 11 °C (winter) to 27 °C (summer) and an average annual precipitation of 132 cm (Boring 2001).

Longleaf pine woodlands and limesink wetlands are the dominant habitat types at Ichauway. The longleaf pine understories are dominated by *Aristida stricta* Michx.(wiregrass) and old-field grasses (e.g., *Andropogon* spp.), but > 1000 vascular plant species occur on the site (Drew et al. 1998, Goebel et al. 1997). Other habitats include mixed pine-hardwood areas, food plots, agricultural fields, *P. elliotii* Engelm (slash pine) flatwoods, riparian hardwood hammocks, oak (*Quercus* spp.) sandhill barrens, natural and old-field *P. taeda* Linnaeus (loblolly pine) stands, *Taxodium ascendens* Brongn. (grassy gum) and *Nyssa biflora* Walter (cypress-gum) limesink ponds, creek swamps, forested wetlands,

riverine areas, shrub-scrub upland, and human/cultural (i.e., resident quarters) areas (Boring 2001).

Much of Ichauway is managed by prescribed fire. Burning is performed on a 2-year rotation, usually during winter and early spring, on 4000–6000 ha throughout the entire site (Godbois et al. 2004). Prescribed burning is used to control understory vegetation, reduce hardwoods, manage wildlife habitat, reduce fuel buildup, promote wiregrass seed production, prepare sites for pine regeneration, and for experimental research and educational activities (Boring 2001).

Food plots, consisting of *Brachiaria ramose* (L.) Stapf (brown top millet), *Triticum aestivum* Linnaeus (winter wheat), (*Vigna* spp. (cow-pea), *Sorghum vulgare* Persoon (grain sorghum), and *Sorghum* spp. (Egyptian wheat) comprise 20% of the property (Godbois et al. 2004). Fields are disced to improve *Colinus virginianus* Catesby (Northern Bobwhite) food availability by allowing *Ambrosia artemisiifolia* Linnaeus (ragweed) and *Chamaecrista fasciculata* Michaux (partridge pea) seedlings and other plants to grow (Davis 2001, Landers and Mueller 1986). Supplemental food, comprised of various agricultural grains, is provided across the property as part of the quail-management activities during November–May. The open-canopied forest, frequent prescribed fires, food plots, and supplemental feeding, contribute to a dense prey population for bobcats (Godbois et al. 2004).

Annually during March–May, limited predator removal occurs in select quail-management zones on the property. The primary predators removed are *Procyon lotor* Linnaeus (raccoons) and *Didelphis virginiana* Kerr (opossums). Low numbers of *Canis latrans* Say (coyote), *Vulpes vulpes* Linnaeus (red fox), *Urocyon cinereoargenteus* Schreber (gray fox), and *Mephitis mephitis* Schreber (striped skunk) also are removed annually. Bobcats were not harvested during this study.

Methods

Bobcat capture and monitoring

We trapped bobcats using Victor Number 1.75 offset and Number 3 Soft Catch® traps (Woodstream Corp., Lititz, PA). Animals were captured from December 2000 until May 2004, although trapping efforts were sporadic between July 2001 and October 2003. Captured animals were netted and given an intramuscular injection of ketamine hydrochloride (10 mg/kg body weight) (Seal and Kreeger 1987). We classified animals as adult or juvenile based on secondary gender characteristics, length, and weight (Crowe 1975). Adults were fitted with a 180-g VHF radio-collar (Advanced Telemetry Systems, Isanti, MN). Each bobcat received a uniquely numbered ear tattoo. Bobcats were monitored and released 8 to 24 hours after sedation at the trap site to ensure full recovery. All trapping procedures were approved by the University of Georgia Institutional Animal Care and Use Committee (IACUC #A990159).

Using radio telemetry, we began monitoring bobcats 2–7 days after release. We obtained locations by triangulation, taking ≥ 2 azimuths from known reference points with a 3-element Yagi antenna (Sirtrack, New Zealand) and hand-held receiver (Wildlife Materials Inc., Carbondale, IL). To minimize error due to animal movement between readings, time between consecutive bearings was always < 15 minutes, but rarely exceeded 5 minutes (Cochran 1980, Kenward 1987, White and Garrott 1990). Each bobcat was located 4–6 times weekly, and locations were obtained equally throughout the diel period, with > 8 hours between each location to ensure biological independence.

Data analysis

We used the FORTRAN program EPOLY (L.M. Conner, Joseph W. Jones Ecological Research Center, Newton, GA, pers. comm.) to convert radio-telemetry locations into Universal Transverse Mercator (UTM) coordinates. We calculated 95% adaptive kernel (ADK; Worton 1989) annual and seasonal home ranges for bobcats with ≥ 30 locations per calendar season using CALHOME (Kie et al., 1996). We also calculated 95% minimum convex polygon (MCP) home-range estimates to compare with other studies and for overlap analysis (Mohr 1947). However, we did not test hypotheses regarding home-range size using MCP home ranges as this would have been redundant. Annual home ranges were determined for animals monitored for 4 consecutive seasons. When the same animal was tracked for multiple years, we considered the animal within a year as the experimental unit.

To determine if annual home-range size differed as a function of gender, year, or a gender \times year interaction, we performed an analysis of variance (ANOVA) using PROC GLM (SAS Institute 2003). We used PROC MIXED (SAS Institute 2003) and a repeated measures ANOVA to determine whether seasonal home-range size differed as a function of gender, season, or their interaction. In the repeated measures ANOVA, animals were treated as the subject, repeated over seasons. We considered statistical significance at $\alpha = 0.10$.

To determine spatial overlap of bobcats, we overlaid home ranges for all individuals to determine the common area shared by pairs of animals. We then classified overlap by type (i.e., male-male, female-female, male-female). We calculated percentage area overlap associated with each home range (common area/home-range area), and calculated percentage point overlap by extracting all telemetry locations for each bobcat within the overlap area and dividing this number of locations by the total number of locations for that animal. We then calculated an index of overlap, which was the product of the percentage area overlap and the percentage point overlap for all overlapping bobcats. For example, assume bobcat A and B have overlapping home ranges. The index of overlap for bobcat A would be the percentage area overlap A \times percentage point overlap A \times percentage point overlap B. Because the index of overlap ranged between 0 and 1, we used an

arcsine square root transformation on index of overlap prior to analysis (Zar 1996). We then used ANOVA to determine if overlap varied by type (i.e., MM, FF, or FM), season, and their interaction. We considered statistical significance at $\alpha = 0.10$.

Results

We radio-tracked 13–27 bobcats seasonally during 21 September 2001–20 June 2004. We monitored 44 individual animals (17 M and 27 F). Of these, we monitored 29 bobcats (7 M and 22 F) for ≥ 4 consecutive seasons and used these 29 animals to estimate annual home ranges.

When we analyzed annual ADK home-range sizes, there was no gender \times year interaction ($F_{1,25} = 0.15$, $P = 0.700$). Annual home ranges of male bobcats ($11.0 \pm 1.4 \text{ km}^2$) were almost 2 times greater ($F_{1,25} = 7.54$, $P = 0.011$) than those of female bobcats ($6.4 \pm 1.0 \text{ km}^2$), but annual home ranges did not differ ($F_{1,25} = 2.79$, $P = 0.107$) among years.

Analysis of seasonal home ranges indicated a significant gender \times season interaction ($F_{10,181} = 1.64$, $P = 0.100$); thus, we examined seasonal home ranges separately for each gender. Seasonal home-range sizes varied ($F_{10,124} = 3.22$, $P = 0.001$) for females, but not for males ($F_{10,51.6} = 0.88$, $P = 0.554$; Fig. 1). Seasonal home range of male bobcats averaged $8.5 \pm 1.0 \text{ km}^2$ and female bobcats averaged $5.3 \pm 0.7 \text{ km}^2$. The smallest female home ranges

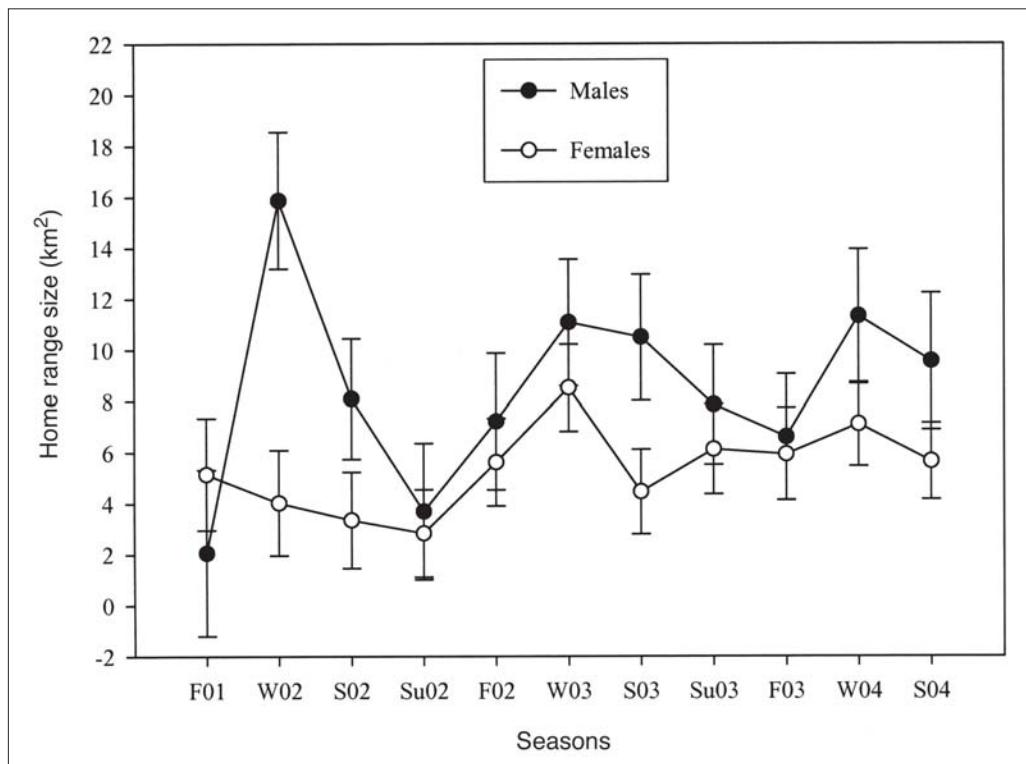


Figure 1. Seasonal home-range sizes for male and female bobcats (F01 = Fall 2001; W02 = Winter 2002; S02 = Spring 2002; Su02 = Summer 2002; F02 = Fall 2002; W03 = Winter 2003; S03 = Spring 2003; Su03 = Summer 2003; F03 = Fall 2003; W04 = Winter 2004; S04 = Spring 2004) on Ichauway, Baker County, GA, 2001–2004.

($2.8 \pm 1.7 \text{ km}^2$) occurred during summer of 2002, and the largest home ranges ($8.5 \pm 1.7 \text{ km}^2$) occurred during winter of 2003.

Type of overlap and season did not interact to affect index of overlap ($F_{20,351}=0.63$, $P=0.8903$), and home-range overlap ($F_{10,351} = 0.39$, $P = 0.952$) did not vary seasonally. However, type of home-range overlap differed ($F_{2,351} = 8.67$, $P \leq 0.001$). Intersexual home-range overlap (22.6%) was approximately 1.6 times greater than female-female (13.8%) and 2.8 times greater than male-male (8.2%) home-range overlap.

Discussion

Similar to most studies of bobcat home ranges in the southeastern US, we observed that male bobcats had greater home ranges than females (Table 1). However, home ranges on our study area were among the smallest home ranges reported in the region (Buie et al. 1979; Conner et al. 1992, 2001; Diefenbach et al. 2006; Hamilton 1982; Kitchings and Story 1979; Lancia et al. 1986; Rucker et al. 1989; Shiftlet 1984). Bobcats in areas with abundant prey do not have to travel as far while foraging, resulting in decreased home-range size (Buie et al. 1979, Knick 1990). The size of prey eaten by bobcats also may explain our smaller home-range sizes; predators that prey on smaller animals tend to have smaller home ranges (McNab 1963). *Sigmodon hispidus* Say and Ord (cotton rats), an approximately 100-g rodent, are the primary prey species consumed by bobcats on our study site (Godbois et al. 2003). Therefore, bobcats on our study site may hunt shorter distances than bobcats which prey on larger animals. Because prey abundance (Bailey

Table 1. Studies documenting bobcat annual home-range sizes (km^2) in the southeastern United States (MMA = modified minimum area; MCP = minimum convex polygon; ADK = adaptive kernel).

Reference	State	Sample size	Home range		Home-range model
			Male	Female	
Hall and Newsom 1976 ^A	LA	3F, 3M	4.9	1.0	MMA
Kitchings and Story 1979	TN	3F, 2M	42.9	11.5	MCP
Miller and Speake 1979	AL	6F, 6M	2.6	1.1	MCP
Buie et al. 1979 ^B	SC	3F, 4M	20.8	10.3	MCP
Hamilton 1982	MO	10F, 20M	60.4	16.1	MCP
Shiftlet 1984	MS	3F, 4M	10.1	5.9	MCP
Fendley and Buie 1986	SC	3F, 4M	3.2	1.6	MCP
Lancia et al. 1986 ^A	NC	3F, 5M	37.7	22.1	MCP
Rucker et al. 1989	AR	3F, 5M	64.2	24.5	MCP
Conner et al. 1992	MS	10F, 5M	36.5	20.6	MCP
Griffin 2001	SC	7F, 5M	10.5–16.7	3.5–10.5	ADK
Chamberlain et al. 2003	MS	38F, 20M	20.2	12.3	MCP
Diefenbach et al. 2006	GA	38F, 32M	22.1	13.6	ADK
This study	GA	22F, 7M	8.2	5.2	MCP
This study	GA	22F, 7M	11.0	6.4	ADK

^AUsed only summer data.

^BUsed only fall and winter data.

1974, Buie et al. 1979, Sandell 1989) and prey size (McNab 1963) may partially explain bobcat home-range size, prey abundance and prey size are perhaps the best explanation for the relatively small bobcat home ranges observed during our study.

We suggest that management practices conducted on our study area were responsible for creating relatively abundant prey populations. Management of our study area included prescribed fire at approximately 2-year return intervals, with 4000–6000 ha being burned annually. Prescribed fire increases and maintains a dense herbaceous understory, ultimately providing habitat capable of supporting abundant bobcat prey (Golley et al. 1965, Miller and Speake 1979). Approximately 20% of the study area is composed of wildlife food plots and agriculture (Godbois et al. 2004). Planting agricultural crops and maintaining quail food plots increases edge, providing ample resources for prey (Cummings and Vessey 1994, Hall and Newsom 1976, Miller and Speake 1978). Additionally, approximately 270 metric tons of grain sorghum are spread for quail over 7020 ha throughout Ichauway between November and May each year (Godbois et al. 2004). In a preliminary analysis of small mammal data collected on our study area, cotton rat populations were 5.5 times greater, *Mus musculus* Linnaeus (house mouse) were 3.5 times greater, *Peromyscus gossypinus* LeConte (cotton mouse) were 1.5 times greater, and *Reithrodontomys humulis* Audubon and Bachman (eastern harvest mouse) were 2 times greater in supplementally fed versus unfed areas (L.M. Conner, unpubl. data). Doonan and Slade (1995) also observed an increase in small mammal densities in supplementally fed areas compared to controls. This concentration of prey may alter foraging behavior of predators like the bobcat, thus resulting in a spatial response by bobcats (Crabtree and Wolfe 1988, Gasaway et al. 1992, Godbois et al. 2004, Jones et al. 2002, and Vander Lee et al 1999). It has been reported that bobcats on our study site are found 10 times closer to supplemental food than expected under a null hypothesis (Godbois et al. 2004). Thus, management practices on our study site may have likely influenced bobcat home-range sizes by maintaining abundant prey.

Seasonal home-range sizes differed by gender. Male home ranges were larger than females during all seasons except fall 2001. An exceptionally large home range of one female (Bobcat #27, 18.4 km²) may have contributed to the average female home range for fall 2001 being greater than the average male home-range size during that season. Although male seasonal home-range sizes did not differ significantly, we observed that males had the greatest home ranges during winter in all 3 years, suggesting that male bobcats may have increased their home ranges during the breeding period to provide greater breeding opportunities by overlapping more female home ranges (Anderson and Lovallo 2003).

Female home-range sizes varied seasonally. The average home-range size during winter 2003 was greater than 9 of the other 10 seasons, which explains the seasonal variation in home-range size for female bobcats and

the interaction between gender and season as predictors of home-range size. Three female bobcats had atypically large home ranges during winter 2003; Bobcats 40, 6, and 18 had home-range sizes of 34.7 km², 17.5 and 14.0 km², respectively. While we can not explain why their home ranges were greater during this season, we are confident that the large home ranges exhibited by these animals are responsible for the large mean home ranges during this season. The smallest female home ranges occurred during summer 2002, during the period of the year that females provide prey to kittens (Bailey 1979, Jackson and Jacobson 1987).

Similar to most studies of home-range overlap among bobcats, we found that there was more intersexual overlap than intrasexual overlap and that male home ranges typically overlapped at least 2 female home ranges (Anderson 1987, Buie et al. 1979, Hall and Newsom 1976, McCord and Cordoza 1982, Marshall and Jenkins 1966, Miller and Speake 1979, Whitaker et al. 1987). It has been observed frequently that male home ranges overlap several female home ranges and other male home ranges (Anderson 1987, Bailey 1974, Buie et al. 1979, Hall and Newsom 1976, Miller and Speake 1978, Nielsen and Woolf 2001, Whitaker et al. 1987) and that female home ranges are typically exclusive of other females (Anderson 1987, Buie et al. 1979, Hall and Newsom 1978, Marshall and Jenkins 1966, Miller and Speake 1979, McCord and Cordoza 1982, Whitaker et al. 1987). However, a few other studies found that female and male bobcats maintained shared portions of their home range with other bobcats of the same gender (Chamberlain and Leopold 2001, Diefenbach et al. 2006, Nielsen and Woolf 2001). We observed that male-male overlap was less pronounced than female-female overlap. We speculate that abundant prey resources on our study site permitted female bobcats to share portions of their home range with other females; male bobcats, on the other hand, were less tolerant of other males in an attempt to maintain exclusive breeding opportunities.

Contrary to a hypothesis proposed by Bailey (1981), who suggested that female home ranges should be smaller and more exclusive in warmer regions where resources are abundant and evenly distributed, female bobcats on our study area did not maintain spatial exclusivity. Although abundant resources existed throughout the study area, there were examples where individual home ranges of females were overlapped entirely by other females, similar to that reported by Chamberlain and Leopold (2001). Conner et al. (1999) suggested that experience leads to increased hunting success and efficiency, which would cause home-range size to decrease (i.e., time-in-residence). It is possible that females with more experience and hunting efficiency also share space with other females (Chamberlain and Leopold 2001). Genetic relatedness also may influence sharing of space between individuals of the same gender (i.e., females on our study site).

Knick (1990) concluded that a decrease in prey abundance caused bobcats to wander and led to a breakdown in land tenure; we suggest that an increase in prey abundance also may lead to a relaxation of land tenure,

agreeing with the hypothesis that defending an exclusive area is most energetically feasible when resources are at an intermediate level (Brown 1964, Krebs and Davies 1993, Maher and Lott 2000, Wittenberger 1981). Spatial exclusivity within bobcat populations likely occurs at an energetic expense; thus, when resources are abundant, it may be more energetically profitable to relax land tenure and tolerate the presence of other conspecifics than to defend a resource that is not limiting.

Future research should address effects of prey abundance on bobcat home-range size and overlap. Without designed experiments, a meta-analysis of existing data may provide evidence to substantiate or refute the hypothesis that land tenure in bobcats breaks down at high and low prey abundances. The potential relationship between genetic relatedness and home-range overlap would address the likelihood that related conspecifics are more likely to share space. Finally, effects of time-in-residence on home-range overlap should be addressed to further provide insight about factors that may affect spatial organization in bobcats.

Acknowledgments

Funding and other support was provided by the Joseph W. Jones Ecological Research Center, University of Georgia, and Georgia Department of Natural Resources. S.B. Castleberry, M. Tarrant, and R.L. Hendrick, Jr. provided editorial assistance. We thank the Jones Center Wildlife Lab, especially B. Rutledge, J. Wade, R. Varnum, B. Cross, M. Perkins, A. Subalusky, B. Howze, and A. Reid for trapping assistance. Several Jones Center personnel, especially B. Bass, M. Melvin, and A. Sheffield, also provided critical help with other aspects of our field work.

Literature Cited

- Anderson, E.M. 1987. A critical review and annotated bibliography of literature on the bobcat. Colorado Division of Wildlife Special Report 62. Denver, CO.
- Anderson, E.M., and M.J. Lovallo. 2003. Bobcat and lynx. Pp. 758–786, *In* G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (Eds.). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, MD.
- Bailey, T.N. 1974. Social organization in a bobcat population. *Journal of Wildlife Management* 38:435–446.
- Bailey, T.N. 1979. Den ecology, population parameters, and diet of eastern Idaho bobcats. Pp. 62–69, *In* L.G. Blum and P.C. Escherich (Eds.). *Proceedings of the Bobcat Research Conference, National Wildlife Federation Scientific and Technical Series 6*. National Wildlife Federation, Washington, DC.
- Bailey, T.N. 1981. Factors of bobcat social organization and some management implications. Pp. 984–1000, *In* J.A. Chapman and D. Pursley (Eds.). *Proceedings of the Worldwide Furbearer Conference*. Frostburg, MD.
- Berg, W.E. 1979. Ecology of bobcats in northern Minnesota. Pp. 55–61, *In* L.G. Blum and P.C. Escherich (Eds.). *Proceedings of the Bobcat Research Conference, National Wildlife Federation Scientific and Technical Series 6*. National Wildlife Federation, Washington, DC.

- Boring, L.R. 2001. The Joseph W. Jones Ecological Research Center: Co-directed applied and basic research in the private sector. Pp. 233–258, *In* G.W. Barrett and T.L. Barrett (Eds.). *Holistic science: The evolution of the Georgia Institute of Ecology (1940–2000)*. Taylor and Francis, New York, NY.
- Boyle, K.A., and T.T. Fendley. 1987. Habitat suitability index models: Bobcats. US Fish and Wildlife Service Biological Report 82(10.147), Washington, DC.
- Brown, J.L. 1964. The evolution of diversity in avian territorial systems. *Wilson Bulletin* 76:160–169.
- Buie, D.E., T.T. Fendley, and H. McNab. 1979. Fall and winter home ranges of adult bobcats on the Savannah River Plant, South Carolina. Pp. 42–46, *In* L.G. Blum and P.C. Escherich (Eds.). *Proceedings of the Bobcat Research Conference*. National Wildlife Federation Scientific and Technical Series 6. National Wildlife Federation, Washington, DC.
- Chamberlain, M.J., and B. D. Leopold. 2001. Spatio-temporal relationships among adult bobcats in central Mississippi. Pp. 45–50, *In* A.C. Woolf, C.K. Nielsen, and R.D. Bluett (Eds.). *Proceedings of a symposium on current bobcat research and implications for management, The Wildlife Society 2000 Conference*, Nashville, TN.
- Chamberlain, M.J., and B. D. Leopold. 2001. Spatio-temporal relationships among adult bobcats in central Mississippi. Pp. 45–50, *In* A.C. Woolf, C.K. Nielsen, and R.D. Bluett (Eds.). *Proceedings of a symposium on current bobcat research and implications for management, The Wildlife Society 2000 Conference*, Nashville, TN.
- Cochran, W.W. 1980. Wildlife telemetry. Pp. 507–520, *In* S.D. Schemnitz (Ed.). *Wildlife Management Techniques Manual*. 4th Edition. The Wildlife Society Inc., Washington, DC.
- Conner, L.M., B.D. Leopold, and K.J. Sullivan. 1992. Bobcat home range, density, and habitat use in east-central Mississippi. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 46:147–158.
- Conner, L.M., B. Plowman, B.D. Leopold, and C. Lovell. 1999. Influence of time-in-residence on home range and habitat use of bobcats. *Journal of Wildlife Management* 63:261–269.
- Conner, L.M., M.J. Chamberlain, and B.D. Leopold. 2001. Bobcat home-range size relative to habitat quality. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 55:418–426.
- Crabtree, R.L., and M.L. Wolfe. 1988. Effects of alternate prey on skunk predation of waterfowl nests. *Wildlife Society Bulletin* 16:163–169.
- Crowe, D.M. 1975. Aspects of aging, growth, and reproduction of bobcats from Wyoming. *Journal of Mammalogy* 56:177–198.
- Cummings, J.R., and S.H. Vessey. 1994. Agricultural influences of movement patterns of white-footed mice (*Peromyscus leucopus*). *American Midland Naturalist* 132:209–218.
- Davis, M.S. 2001. Creature feature: Northern Bobwhite Quail. Pp. 19–29, *In* J.R. Wilson, (Ed.). *The Fire Forest: Longleaf Pine-wiregrass Ecosystem*. Georgia Wildlife Federation Natural Georgia Series 8(2). Georgia Wildlife Press, Covington, GA.
- Diefenbach, D.R., L.A. Hansen, R.J. Warren, and M.J. Conroy. 2006. Spatial organization of bobcats reintroduced to an island. *Journal of Mammalogy* 87:394–401.
- Doonan, T.J., and N.A. Slade. 1995. Effects of supplemental food on population dynamics of cotton rats, *Sigmodon hispidus*. *Ecology* 76:814–826.

- Drew, M.B., L.K. Kirkman, and A.K. Gholson, Jr. 1998. The vascular flora of Ichauway, Baker County, Georgia: A remnant longleaf pine/wiregrass ecosystem. *Castanea* 63:1–24.
- Fendley, T.T., and D.E. Buie. 1986. Seasonal home range and movement patterns of the bobcat on the Savannah River Plant. Pp. 237–259, *In* S.D. Miller and D.D. Everett (Eds.). *Cats of the World: Biology, Conservation, and Management*. National Wildlife Federation, Washington, DC.
- Gasaway, W.C., R.D. Boertje, D.V. Grandaard, D.G. Kelleyhouse, R.O. Stephenson, and D.G. Larson. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. *Wildlife Monographs* 120.
- Godbois, I.A., L.M. Conner, and R.J. Warren. 2003. Bobcat diet on an area managed for northern bobwhite. *Proceedings of the Southeastern Association of Fish and Wildlife Agencies* 57:222–227.
- Godbois, I.A., L.M. Conner, and R.J. Warren. 2004. Space-use patterns of bobcats relative to supplemental feeding of Northern Bobwhites. *Journal of Wildlife Management* 68:514–518.
- Goebel, P.C., B.J. Palik, and L.K. Kirkman. 1997. Landscape ecosystem types of Ichauway. Technical Report 97 1. Joseph W. Jones Ecological Research Center, Newton, GA.
- Golley, F.B., J.B. Gentry, L.D. Caldwell, and L.B. Davenport. 1965. Number and variety of small mammals on the AEC Savannah River Plant. *Journal of Mammalogy* 46:1–18.
- Hall, H.T., and J.D. Newsom. 1976. Summer home ranges and movements of bobcats in bottomland hardwoods of southern Louisiana. *Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies* 30:427–436.
- Hamilton, D.A. 1982. Ecology of the bobcat in Missouri. M.Sc.Thesis. University of Missouri, Columbia, MO.
- Jackson, D.L., and H.A. Jacobson. 1987. Population ecology of the bobcat (*Felis rufus*) in managed southern forest ecosystems. Final Report Federal Aide Project, W-48-30, 31, 32,33,32. Mississippi Department of Wildlife Conservation, Jackson, MS. Study XX. 69 pp.
- Jones, D.D., L.M. Conner, R.J. Warren, and G.O. Ware. 2002. The effect of supplemental prey and prescribed fire on success of artificial nests. *Journal of Wildlife Management* 66:1112–1117.
- Kenward, R. 1987. *Wildlife Radio Tagging*. Harcourt Brace Jovanovich. London, UK. 222 pp.
- Kie, J.G., J.A. Baldwin, and C.J. Evans. 1996. CALHOME: A program for estimating animal home range. *Wildlife Society Bulletin* 24:342–344.
- Kitchings, J.T., and J.D. Story. 1979. Home range and diet of bobcats in eastern Tennessee. *Proceedings of the Bobcat Research Conference, National Wildlife Federation Scientific and Technical Series* 6:47–52.
- Kitchings, J.T., and J.D. Story. 1984. Movements and dispersal of bobcats in eastern Tennessee. *Journal of Wildlife Management* 48:957–961.
- Knick, S.T. 1990. Ecology of bobcats relative to exploitation and a prey decline in southeastern Idaho. *Wildlife Monographs* 106.

- Krebs, J.R., and N.B. Davies. 1993. An Introduction to Behavioral Ecology. Sinauer Associates, Inc., Sunderland, UK. 420 pp.
- Lancia, R.A., D.K. Woodward, and S.D. Miller. 1986. Summer movement patterns and habitat use by bobcats on Croatan National Forest, North Carolina. Pp. 425–436, *In* S.D. Miller and D.D. Everette (Eds.). *Cats of the World: Biology, Conservation, and Management*. National Wildlife Federation, Washington, DC.
- Landers, J.L., and B.S. Mueller. 1986. Bobwhite Quail management: A habitat approach. Tall Timbers Research Station and Quail Unlimited, Tallahassee, Florida, USA. *Southwestern Naturalist* 29:105–113.
- Lembeck, M., and G.I. Gould, Jr. 1979. Dynamics of harvested and unharvested bobcat populations in California. *Proceedings of Bobcat Research Conference, National Wildlife Federation Scientific and Technical Series* 6:53–54.
- Maher, C.R., and D.F. Lott. 2000. A review of ecological determinants of territoriality within vertebrate species. *American Midland Naturalist* 143:1–29.
- Marshall, A.D., and J.H. Jenkins. 1966. Movements and home ranges of bobcats as determined by radio-tracking in the upper coastal plain of South Carolina. *Proceedings of the Annual Conference of the Southeastern Game and Fish Commission* 20:206–214.
- McCord, C.M. 1974. Selection of winter habitat of bobcats (*Lynx rufus*) on the Quabbin Reservation, Massachusetts. *Journal of Mammalogy* 55:428–437.
- McCord, C.M., and J.E. Cordoza. 1982. Bobcat and lynx. Pp. 728–766, *In* J.A. Chapman and G.A. Feldhamer (Eds.). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, MD.
- McNab, B.K. 1963. Bioenergetics and determination of home-range size. *The American Naturalist* 97:133–140.
- Miller, S.D., and D.W. Speake. 1978. Prey utilization on quail plantations in southern Alabama. *Proceedings of the Southeastern Association of Fish and Wildlife Agencies* 32:100–111.
- Miller, S.D. and D.W. Speake 1979. Demography and home range of the bobcat in South Alabama. *Proceedings of the Bobcat Research Conference, National Wildlife Federation Scientific and Technical Series* 6:123–124.
- Mohr, C.O. 1947. Table of equivalent populations of North America small mammals. *American Midland Naturalist* 37:223–249.
- Nielsen, C.K., and A. Woolf. 2001. Spatial organization of bobcats (*Lynx rufus*) in southern Illinois. *American Midland Naturalist* 146:43–52.
- Provost, E.E., C.A. Nelson, and D.A. Marshall. 1973. Population dynamics and behavior in the bobcat. Pp. 42–67, *In* R.L. Eaton (Eds.). *The World's Cats: Ecology and Conservation*. World Wildlife Safari, Winston, OR. 349 pp.
- Rucker, R.A., M.L. Kennedy, G.A. Heidt, and M.J. Harvey. 1989. Population density, movements, and habitat use of bobcats in Arkansas. *Southwestern Naturalist* 34:101–108.
- Sandell, M. 1989. The mating tactics and spacing patterns of solitary carnivores. Pp. 164–182, *In* J.L. Gittleman, (Ed.). *Carnivore Behavior, Ecology, and Evolution*. Cornell University Press, Ithaca, NY.
- SAS Institute, Inc. 2003. SAS User's Guide: Statistics, 2003 Edition. SAS Institute Inc., Cary, NC.
- Seal, U.S., and T.J. Kreeger. 1987. Chemical immobilization of furbearers. Pp. 191–215, *In* M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch (Eds.). *Wild Furbearer Management and Conservation in North America*. Ministry of Natural Resources, Ottawa, ON, Canada.

- Shiflet, B.L. 1984. Movements, activity, and habitat use of the bobcat in upland mixed pine hardwoods. M.Sc. Thesis. Louisiana State University, Baton Rouge, LA.
- Vander Lee, B.A., R.S. Lutz, L.A. Hansen, and N.E. Mathews. 1999. Effects of supplemental prey, vegetation, and time on success of artificial nests. *Journal of Wildlife Management* 63:1299–1305.
- Whitaker, J., R.B. Fredrick, and T.L. Edwards. 1987. Home-range size and overlap of eastern Kentucky bobcats. *Proceedings of the Southeastern Association of Fish and Wildlife Agencies* 41:417–423.
- White, J.C., and R.A. Garrott. 1990. *Analysis of Wildlife Radio-tracking Data*. Harcourt Brace Jovanovich, New York, NY. 633 pp.
- Wittenberger, J.F. 1981. *Animal Social Behavior*. Duxbury Press, Boston, MA. 722 pp.
- Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70:164–168.
- Zar, J.H. 1996. *Biostatistical Analysis*. Third Edition. Prentice Hall, Upper Saddle River, NJ.
- Zeulak, D.S., and R.G. Schwab. 1979. A comparison of density, home-range, and habitat utilization of bobcat populations at Lava Beds and Joshua Tree National Monuments, California. *Proceedings of the Bobcat Research Conference, National Wildlife Federation Scientific and Technical Series* 6:74–79.