DEMOGRAPHIC CHARACTERISTICS AND HABITAT ASSOCIATIONS OF AN EXPANDING BLACK BEAR (*URSUS AMERICANUS*) POPULATION IN OKLAHOMA

By

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Bachelor of Science Biology

University of Arkansas

Fayetteville, Arkansas

2004

Submitted to the Faculty of the
Graduate College of
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2008

DEMOGRAPHIC CHARACTERISTICS AND HABITAT

ASSOCIATIONS OF AN EXPANDING BLACK

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ACKNOWLEDGEMENTS

Financial assistance for this study was provided by the Oklahoma Department of Wildlife Conservation (ODWC) Federal Aid Project W-155-R. Funds were administered through the Oklahoma Cooperative Fish and Wildlife Research Unit (OK Cooperative Unit) at Oklahoma State University (OSU). Financial assistance for travel to professional conferences to present this project was provided by the OK Cooperative Unit and the OSU Department of Zoology.

I sincerely thank Dr. David M. Leslie for his support and guidance throughout this study. He generously accepted me as a graduate student and was always available to answer questions, provide advice, and gave ample support to attend and present at professional conferences. His encouragement and outstanding editing was greatly appreciated throughout this study. I would have never had the opportunity to work on such an amazing project without Dr. Eric C. Hellgren, who initially encouraged me to volunteer on the OSU black bear project when I contacted him fresh out of high school, hired me as a technician when I was an undergraduate, and graciously invited me to become a graduate student for the project. He generously shared his knowledge of bear biology and Program MARK, and his editing advice was greatly appreciated. I would also like to thank Dr. William Fisher for his assistance, especially with GIS portions of this project. Additionally, I would like to thank Dr. R. A. Van Den Bussche for his assistance on the genetic analysis. Jonathan Fisher, Dr. Bill Warde, and Elizabeth Doxon provided generous help with the statistics analysis of this research.

I cannot give enough thanks and acknowledgement to fellow graduate student and friend, Lynne Gardner-Santana, for her endless work on the genetic portion of this study. Her hard work and dedication always provided me with motivation when I was most exhausted and her assistance during field work will always be remembered. I am forever thankful to Sara Bales Lyda, who allowed me to help with her research project when I was dying to learn more about bears. The experiences I had while volunteering on her project inspired me to continue studying black bears, and I never would have the opportunity to do this research without those experiences and connections.

The hard work in the field over 4 amazing summers could not have been accomplished without the hard work from field technicians. I will never forget the times with April Estep, Brad Nichols, Mike Disney, Kendra Phelps, Kelsey Piper Oberneuferman, Marc Criffield, Meredith Magnuson, Rex Medlin, and J. D. Davis, and this project could not have been completed without them. Mike Disney, Marc Criffield, and Kendra Phelps made me laugh so hard I cried and no one else could turn a hornet-sting on the nose into such fun. Meredith Magnuson, who couldn't get enough of the bears, will always be a true friend and eye twin!

Joe Hemphill, Jeff Ford, and Wayne Smith from the ODWC provided invaluable assistance with all aspects of the project, ranging from housing, logistics, and knowledge of the bears in the study area. I was extremely lucky to have the help from so many volunteers. Visits and help provided by Kevin Burgess, Zac Roehrs, Jonathan Fisher, Erin Berghammer, Hailey Dingfelder, Brandi Coyner, Dane Balsman, Lucky Gardner-Santana, Eric Whelan, Matt Stone, Dominic Barrett, Stacey Davis, Morgan Nolan, Samantha Porec, and Vince Cavelleri were greatly appreciated and provided needed entertainment during those long days. Much thanks to the ladies of the Coop Unit, Judy Gray, Sheryl Lyons, and Joyce Hufford. They provided logistic assistance throughout the year, and their help was essential during the months of field work.

Finally, I would like to thank my friends and family for supporting me during my time at OSU. The good times had with the graduate students from the Zoology and NREM departments will never be forgotten. Thanks especially to Kevin Burgess, who was always there for me. Thanks to my parents, Kenny and Diane Brown, sisters, Amy Brown and Stephanie Dillingham, brother-in-laws, Christopher Johnston and Jeremy Dillingham, and grandmother, Katharine Kreie, for supporting me, giving me advice, and listening to me talk about bears my entire life.

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CHAPTER I

DEMOGRAPHICS OF BLACK BEARS IN THE OUACHITA MOUNTAINS OF OKLAHOMA

INTRODUCTION AND JUSTIFICATION

Expansion of a population is a complex process involving dispersal of individuals to accommodate population growth and ecological needs (Swenson et al. 1998). Foraging, finding mates, avoiding predators, and aggressive intraspecific interactions may cause individual dispersal to new areas (Pyke 1983). Pre-saturation dispersal, which involves movement of large animals to new localities before carrying capacity of a particular habitat has been reached (Sinclair 1992), may occur in expanding populations (Swenson et al. 1998). Growing populations have high reproduction resulting in dispersal of some individuals to new areas where resources may be abundant, whereas stable populations tend to exhibit low rates of dispersal (Bunnell and Tait 1981).

Population expansion into previously occupied habitat is often associated with translocation and reintroduction efforts intended to re-establish species. Reintroduction of a species can be an expensive and labor-intensive process, and it is often unsuccessful (Clark et al. 2002). For these reasons, it has been suggested that reintroduced populations should be monitored to ensure their continued success (Clark et al. 2002). Demographic characteristics, such as sex ratio, age structure, and morphometrics are important for assessing the success of reintroduced populations. These characteristics are especially important in terrestrial carnivores, because they have relatively low reproductive rates and densities, and are long lived and typically solitary (Schaller 1996, Brongo et al. 2005).

Dispersal from expanding populations of black bears (*Ursus americanus*) into unoccupied areas has been relatively unstudied. Populations of black bears that are stable or declining have sex-biased dispersal, with males dispersing several home-range diameters from their natal area and females exhibiting natal philopatry (Rogers 1987, Schwartz and Franzmann 1992). A population of brown bears (*Ursus arctos*) in Sweden had a peripheral area dominated by males and a core area dominated by females (Swenson et al. 1998). However, there was no significant difference between distances from the core areas of males and females, suggesting pre-saturation dispersal in brown bears (Swenson et al. 1998). In Alaska, young male black bears dispersed from natal areas more frequently than young females and had higher mortality rates due to human-related factors such as hunting and nuisance problems (Schwartz and Franzmann 1992).

Historically, black bears were present in Oklahoma but were eliminated early in the 20th Century due to habitat loss and unregulated hunting (Tyler and Anderson 1990, Smith and Clark 1994, Bales et al. 2005). Reintroduction of black bears from Minnesota and Manitoba, Canada, into the Ozark and Ouachita national forests in Arkansas in 1958–1967 by the Arkansas Game and Fish Commission successfully re-established populations (Rogers 1973, Smith and Clark 1994). By 1991, >2,500 black bears were estimated to have spread throughout Arkansas, Missouri, and Oklahoma (Smith and Clark 1994). Recent black bear expansion into eastern Oklahoma, including the Ouachita

National Forest, has led to management questions involving the size and distribution of the growing bear population.

A study in the Ouachita National Forest, LeFlore County, Oklahoma, was conducted to assess demographic characteristics of the colonized black bear population in 2001–2003 (Bales et al. 2005). Because the study area in LeFlore County was thought to be the first site colonized by bears moving from Arkansas into Oklahoma, population characteristics of that core area (Bales et al. 2005) may not be the same as in peripheral areas of the western Ouachita Mountains. Effective management of the black bear populations in Oklahoma requires an understanding of bear dispersal and demographics in peripheral parts of the Ouachita Mountains that are currently being colonized. This study focused on peripheral areas to the north and west of the core area, although expansion of black bears to the south has also occurred. My objective was to determine age structure, sex ratio, morphometrics, and coloration of the black bears in the western and northern peripheral area of their range in Oklahoma. I hypothesized that demographics of the peripheral population would be skewed toward young individuals and a male-biased sex ratio, characteristic of expanding populations (Clark and Smith 1994, Swenson et al. 1998, Bales et al. 2005, Hellgren et al. 2005). I hypothesized that morphometrics and color variation would be similar to those in the core area of the population in Oklahoma (Bales 2003, S. L. Bales, unpublished data) and Arkansas (Clark and Smith 1994).

MATERIALS AND METHODS

Study Area

The study area encompassed part of the Ouachita National Forest in southeastern Oklahoma, private lands, and state wildlife management areas in southern Leflore and northeastern Pushmataha counties (Fig. I.1). The Ouachita Mountains mainly consist of a series of east-west valleys and ridges with elevations of 300 and 800 m, respectively (Hunt 1974). Vegetation in southeastern Oklahoma is characterized by 5 community types, each with different dominant species (Johnson 1986) but typically dominated by oak-hickory-pine (Duck and Fletcher 1943, Clark et al. 1993). Upper and middle north-facing slopes are strongly dominated by mockernut hickory (*Carya tomentosa*), south-facing slopes are dominated by shortleaf pine (*Pinus echinata*) and oaks (*Quercus* spp.), ridgetop communities are usually dominated by white oak (*Q. alba*), and the valley bottom-floodplain has no dominant species because of the diversity of habitats (Johnson 1986). Although microclimates often vary in mountainous regions, the climate of the general area is considered humid subtopical (Curry 1970), with mean annual precipitation of 135 cm and mean annual temperature of 17.2° C.

Capture and Handling

Black bears were captured using barrel traps on 4 trapping lines in the western and northern parts of the study area in May–August 2005–2007. Traps were made of 2 200-L drums bolted together with a padded sliding door at one end and heavy wire mesh at the other (Onorato 2003). One can of sardine bait was placed on a trigger arm, which activated the sliding door. Sardine bait and raspberry extract also were placed around the trap to attract bears.

Trapped bears were anesthetized with Telazol® (A.H. Robins Company, Richmond, Virginia, USA), a combination of tiletamine hydrochloride and zolazepam hydrochloride. A dosage of 5.5 mg/kg (Onorato 2003) was injected with a jabstick (Clark 1991). Vital signs (heart rate, respiration, rectal temperature) were recorded and checked periodically throughout immobilization and recovery. Eyes were covered with ophthalmic ointment and a light cloth for protection.

A first premolar tooth was extracted with a dental elevator and extractor tools for estimation of age by cementum annuli at Matson's Laboratory (Milltown, Montana, USA). Hair samples were pulled directly off the bear to ensure removal of hair follicles and analyzed genetically (Gardner-Santana 2007). Tissue samples were collected from ears using disposable biopsy punches and stored in lysis buffer.

Morphometric measurements (Onorato 2003) were collected from each captured bear: mass (to the nearest kg), total length (cm), chest girth (cm), head length (cm), neck girth (cm), fore and hind paw pad widths (mm), fore and hind paw pad length (mm), and fore and hind paw middle claw length (mm). Bears were weighed using a spring scale (Hanson Scale Company, Shubuta, Mississippi, USA). Captured bears were marked with lip tattoos and plastic ear tags with identification numbers that corresponded to tattoos. A passive integrator transponder (PIT) tag (Biomark, Boise, Idaho, USA) was implanted subcutaneously with a large gauge syringe between the scapulae. PIT tags were identified by alpha-numeric codes that were read with a Biomark Pocket Reader.

Coloration was recorded based on researcher's classifications. Coloration classifications were black (majority of fur was black) and brown (majority of fur was brown). Chest blaze occurrence (any white/cream-colored fur on chest) was recorded, with a description of extent of white markings.

At the end of handling procedures (Jonkel 1993), captured bears were placed in a shaded area. Water was poured over fur to aid in thermoregulation and prevented dehydration. Bears were placed facing away from nearby water sources, steep hills, and roads or trails that could cause injury during recovery from anesthesia. If vital signs were stable (Jonkel 1993), handling personnel moved away from the immediate vicinity to allow recovery; time of recovery was recorded when researchers visualized the bear walking away from the capture site. Animal handling protocols were approved by the Institutional Animal Care and Use Committee of Oklahoma State University (Protocol No. A50412).

Demographic Characteristics

Sex Ratio

Sex ratio of adults (≥ 1 year old) was calculated from the captured bears. Chi-square tests were used to determine if sex ratios of adults differed from 50:50 (Doan-Crider and Hellgren 1996). Chi-square tests were used to determine if sex ratio of bears caught in the peripheral areas of Oklahoma differed from bears in the core area (Bales et al. 2005) of Oklahoma and bears in the Ouachita Mountains of Arkansas (Clark and Smith 1994).

Age Structure

Bears trapped in the study area were placed into age classes of yearlings, subadults (2–3 years old), and adults (≥ 4 years old). A Wilcoxon rank sum test was used to determine differences in median ages between males and females, and a Kolmogorov-Smirnov test was used to determine if age distribution of males and females differed (Doan-Crider and Hellgren 1996). Kolmogorov-Smirnov tests (Clark 1991) also were used to compare age distributions among bears caught in the peripheral area, bears in the core area (Bales et al. 2005), and bears in the Ouachita Mountains of Arkansas (Clark and Smith 1994).

Morphometrics

Bears were separated into sex and age class (yearling: ≥ 1 year and < 2 years and adult: ≥ 2 years) categories for morphometric analysis. A one-way analysis of variance was used to determine age-class differences in physical characteristics within each sex (Hellgren and Vaughan 1994). Relationships among body mass and body measurements were assessed using simple linear regression. Analysis of covariance with age as the covariate (Clark 1991) was used to determine if mass (kg) of male and female bears in the peripheral areas of Oklahoma differed from bears in the core area of Oklahoma (Bales et al. 2005) and bears in the Ouachita Mountains of Arkansas (Clark and Smith 1994).

Coloration

Percentage of bears in each coloration category was calculated. Chi-square tests were used to determine if coloration of bears in the peripheral areas of Oklahoma differed from bears in the core area of Oklahoma (S. L. Bales, unpublished data), and bears in the Ouachita Mountains of Arkansas (Smith and Clark 1994). Chi-square tests were used to determine if chest blaze occurrence in the peripheral areas of Oklahoma differed from the bears in the core area of Oklahoma (S. L. Bales, unpublished data).

RESULTS

Forty-three captures of 38 black bears were made during 906 trapnights (4.7% trapping success) in 2005–2007. Trapping success was 3.7% (10 captures in 269 trapnights) in 2005, 7.8% (18 captures in 232 trapnights) in 2006, and 3.7% (15 captures in 405 trapnights) in 2007. Five of the 38 (13.2%) unique bears were recaptured throughout the study. One adult female bear was released after capture without conducting measurements because of difficulty immobilizating her.

Sex ratio

Sex ratio of all captured bears (0.95M:1F, n = 37), captured bears > 2 years of age (0.8M:1F, n = 27), and captured bears ≤ 2 years of age (1.5M:1F, n = 10) did not differ from 50:50 (χ^2 = 0.027, df = 1, P = 0.870; χ^2 = 0.333, df = 1, P = 0.564; χ^2 = 0.400, df = 1, P = 0.527, respectively). The population of black bears in the core part of the Ouachita Mountains ≥ 1 year of age had a female-biased sex ratio of 0.76M:1F (n = 51; Bales et al. 2005). Sex ratio of bears ≥ 1 year of age did not differ between the core and peripheral areas of the Ouachita Mountains in Oklahoma (χ^2 = 0.451, df = 1, P = 0.502). The peripheral area showed an even sex ratio in the subadult (1M:1F, n = 12) category compared with the female-biased core area (0.81M:1F, n = 20, Bales et al. 2005). The peripheral areas had a female-biased sex ratio (0.63M:1F, n = 13) in the adult category (≥ 3 years) compared with the core area (0.28M:1F, n = 18; Bales et al. 2005). Both peripheral and core areas had the same male-biased sex ratio in the yearling category (1.5M:1F, n = 10).

The population of black bears in the Ouachita Mountains of Arkansas (Clark and Smith 1994) had a female-biased sex ratio of 0.63M:1F (n = 69). The sex ratio of bears ≥ 1 year of age did not differ between bears in Arkansas (Clark and Smith 1994) and peripheral part of the Ouachita Mountains in Oklahoma (χ^2 = 1.56, df = 1, P = 0.212).

Age Structure

The mean age of black bears captured in our study area was 2.7 years ± 0.5 (n = 17) for males, and 4.2 years ± 0.8 (n = 18) for females, and 3.5 years ± 0.5 (n = 35) overall. Median age of males (2 years) and females (3 years) did not differ (Wilcoxon rank sum, $Z = 1.32$, $P = 0.097$). The oldest male and female bears were 8 and 11 years old, respectively. Age distribution did not differ by sex ($D = 0.27$, $P = 0.47$; Fig. I.2).

Mean ages of males and females in the core area of the Ouachita Mountains (Bales et al. 2005) were 3.0 years and 4.3 years, respectively. Median ages were 2 and 3 years for males and females, respectively. Median ages of the core and peripheral areas of the Ouachita Mountains in Oklahoma were the same. Mean ages ($\chi^2 = 0.23$, $P = 0.63$) and age distributions ($D = 0.21$, $P = 0.25$) of the core and peripheral areas of the Ouachita Mountains in Oklahoma did not differ.

Black bears in the Ouachita Mountains of Arkansas (Clark and Smith 1994) had an older age structure, with mean ages of 3.85 and 4.52 years for males and females, respectively. Median ages were 3 and 4 years for males and females, respectively. Both mean ages ($\chi^2 = 0.06$, $P = 0.81$) and median ages ($\chi^2 = 0.24$, $P = 0.62$) of the peripheral area of the Ouachita Mountains in Oklahoma and the bears in the Ouachita Mountains of Arkansas did not differ. Shape of the age distribution did not differ by area ($D = 0.21$, $P = 0.22$).

Morphometrics

Body mass of bears trapped in our study area in May–August 2005–2007 averaged 95.7 kg ± 9.4 (n = 12, range = 54–159) for adult (>1 year) males and 67.6 kg ± 3.8 (n = 15, range = 45–100) for adult (>1 year) females. As mass of males and females increased, other body measurements increased (Figure I.3). For all measurement classes (weight, total length, head length, chest girth) (Table I.1), adult measurements differed from yearling measurements when analyzed by sex (Table I.1). Male mass was directly related logarithmically to age (Y = 31.572 + 58.179ln(x), r^2 = 0.9397, *n* = 17, Figure I.4). The relationship of female mass to age (Y = 43.727 + 16.989ln(x)) did not fit the logarithmic regression model as strongly (r^2 = 0.4586, *n* = 18, Figure I.4), but fit the polynomial model (Y = -1.3623x^2 + 18.641x + 20.466, r^2=0.6902). Females reached a maximum mass at 6 years and mass decreased in older age classes.

Body mass of bears trapped in the core area of the Ouachita Mountains (Bales 2003) in May–August averaged 100.0 kg ± 8.0 (*n* = 12, range = 77.1–158.8 kg) for adult (>1 year) males and 59.2 kg ± 2.5 (*n* = 25, range = 38.6–82 kg) for adult (>1 year) females. Analysis of covariance indicated that masses of males (*F* = 2.2, df = 1, 34, *P* = 0.147) and females (*F* = 2.9, df = 1, 45, *P* = 0.098) in the core area and peripheral areas did not differ.

Body mass of bears in the Ouachita Mountains of Arkansas (Clark 1991) in May–August averaged 99.7 kg ± 8.5 (*n* = 14, range = 55–155 kg) for adult (> 1 year) males and 64.8 kg ± 3.0 (*n* = 24, range = 43–91 kg) for adult (> 1 year) females. Analysis of covariance indicated that mass of males (*F* = 0.01, df = 1, 37, *P* = 0.921) and females (*F* = 0.02, df = 1, 45, *P* = 0.888) in the peripheral area of the Ouachita Mountains in Oklahoma and the Ouachita Mountains of Arkansas did not differ.

Coloration

Brown coloration occurred in 13.5% (*n* = 37) and chest blazes occurred in 24.3% (*n* = 37) of bears trapped. Of bears trapped in the core area of the Ouachita Mountains (S. L. Bales, unpublished data), 14.9% (n = 47) had brown coloration and 12.8 % had chest blazes. Bears in the core and peripheral parts of the Ouachita Mountains of Oklahoma did not differ in coloration ($\chi^2 = 0.032$, $P = 0.857$). However, bears in the peripheral parts of the Ouachita Mountains of Oklahoma had more chest blazes than bears in the core part ($\chi^2 = 4.40$, $P = 0.036$). Coat color of bears in the Ouachita populations in Arkansas (Smith and Clark 1994) was 2.8% ($n = 72$) brown, which was a lower proportion of the population than in the peripheral part of the Ouachita Mountains of Oklahoma ($\chi^2 = 16.44$, $P = <0.001$). Chest blaze occurrence in Arkansas bears was not determined.

DISCUSSION

Sex Ratio

The population of black bears in the peripheral part of Oklahoma was equally composed of males and females (0.95M:1F). This composition is similar to characteristic sex ratios of black bear population, which are assumed to be 50M:50F (Pelton 1982, Beecham 1983, Kolenosky and Strathearn 1987, Garshelis 1990). The core area (0.76M:1F, Bales et al. 2005) had a female-biased sex ratio, which is often associated with expanding bear populations (0.63M:1F, Clark and Smith 1994; 0.33M:1F, Onorato 2003). Although it was hypothesized that the peripheral area would be male-biased, there was no significant difference between sex ratios of the peripheral and core study area. However, trends in the sex ratio of subadults and adult in the peripheral area, although not statistical significant, were consistent with my predictions. The female-biased sex ratio possibly resulted from a relatively small sample size. Our population sample could have been biased towards females and young males due to size restrictions of the culvert traps used.

The expansion of black bears into the peripheral trapping area, located north and west of the core area, may have occurred prior to my study. I hypothesize that bears trapped farther west of the peripheral trap lines would have sex ratios skewed toward males. Bales et al. (2005) suggested that the female-biased sex ratio in the core area was caused by higher survival rates of females than males and by emigration of subadult males exceeding immigration. It would follow that the peripheral area in Oklahoma would have higher numbers of subadult males than the core area. Similarly, female black bears typically do not disperse far from their mother's home range (Elowe and Dodge 1989, Schwartz and Franzmann 1992), causing a slower rate of expansion for females compared with males, which may cause a decreased percentage of females in the peripheral area.

Age Structure

The peripheral part of the black bear population in Oklahoma is relatively young compared with other unhunted populations (Hellgren and Vaughn 1989, Doan-Crider and Hellgren 1996), which typically have older age structures than hunted populations (Bunnell and Tait 1981). Additionally, our population had mean ages lower than many hunted populations (Clark 1991, McLean and Pelton 1994, Koehler and Pierce 2005).

I hypothesized that black bears in the peripheral study area would be younger than the core area in Oklahoma, which was not supported by our data. However, the small sample size and trap bias toward smaller, and likely, younger individuals, should be considered when examining the results. An expanding population of brown bears had higher percentages of younger males in peripheral areas of expansion compared with the core area of colonization (Swenson et al. 1998). My data showed a higher percentage of young males (1–4 years) in the peripheral area (88% of all males) compared with the core area (53%). In comparison, young females (1–4 years) composed 61% of the female population in the peripheral area compared with 59% in the core area. We contend that the relatively young age structure was due to the high proportion of dispersing males in the study area.

Morphometrics

Body measurements of bears trapped in the peripheral area of Oklahoma were consistent with measurements that are typical for black bears. Sexual dimorphism was observed, with males larger than females when analyzed by age class and males growing at a faster rate than females. Larger body size in male black bears has been correlated with home-range size (Kovach and Powell 2003). Larger males have the ability to travel farther, allowing more encounters with females for a greater chance of reproductive success. Larger females have greater reproductive success and the ability to provide more food for cubs. Although my sample size was small, mass of females decreased after age 6, possibly indicating insufficient resources to maintain maximum body size. Older females are more likely to have offspring than younger females; the raising of cubs has high energy requirements and possibly contributes to the lower mass.

Compared with bears in the core area of Oklahoma and the Ouachita Mountains of Arkansas, bears in the peripheral area had similar masses when analyzed by sex. Although it has been reported that the size of black bears differs by latitude (Kennedy et al. 2002), but latitude does not explain all variation in mass (Maehr et al. 2001). Because bears in the peripheral area did not differ in mass from the bears in the core area, it might indicate similar habitat quality (i.e., ratio of density to resources) in all areas currently occupied by bears in the Ouachita Mountains of Arkansas and Oklahoma. A decrease in habitat quality likely would be correlated with decreased food availability, thereby decreasing mass and general health of black bears in the area.

Coloration

The percentage of bears that had some brown coloration did not differ between the core and peripheral study areas of Oklahoma. The percentage of brown-colored bears in Arkansas, by contrast, differed from both the core and peripheral study areas in Oklahoma. Historically, it was believed that almost 100% of black bears in Arkansas and Oklahoma were black. This proportion is similar to other populations of black bears in the eastern part of the United States, ranging from Maine, Tennessee, Georgia, and Florida (Rounds 1987).

Brown coloration occurring in present-day populations in Oklahoma may be due to genetic factors associated with the reintroduction of bears from Minnesota and Manitoba, Canada. Founder populations in Minnesota and Manitoba, Canada, have different percentages of non-black bears. In Manitoba, 16% of bears have non-black coloration (Rounds 1987). Ten to 20% of bears in Minnesota have non-black coloration, depending on location within the state (Rounds 1987). Coat color was described in Ozark and Ouachita populations in Arkansas (Smith and Clark 1994), which were both reestablished by the aforementioned founder populations. There was a significant difference in the number of brown bears in the Ozark and Ouachita populations, with 22.5% (n = 49) of bears showing brown coloration in the Ozarks and only 2.8% (n = 72) of bears showing brown coloration in the Ouachita Mountains of Arkansas. That difference was thought to be genetic, because few, if any, brown-colored black bears were released during translocation in the Ouachita Mountains of Arkansas (Smith and Clark 1994).

The combination of historic coloration of bears in Oklahoma and the low percentage of brown-colored bears in the Ouachita Mountains of Arkansas suggest a low likelihood that bears in the Ouachita Mountains of Oklahoma would have brown coloration. However, the increased proportion of brown-colored bears in Oklahoma relative to the Arkansas Ouachita Mountains suggests a higher percentage of bears dispersing into Oklahoma carried the genetic variation for coloration and were reproductively successful.

Selection due to habitat variation also could influence the coloration of black bears. It has been hypothesized that canopy cover and forest density influence coloration through heat stress or abrasion resistance (Rounds 1987). Denser forests may select for a higher percentage of black-colored bears because melanin-rich hair tends to be more resistant to abrasion. Less dense forest may select for a higher percentage of brown-colored bears to lessen the effects of heat stress due to an open canopy. It is unlikely, however, that the time scale of colonization combined with habitat variation in the Ouachita National Forest was sufficiently long to select for brown-colored bears.

MANAGEMENT IMPLICATIONS

The population of black bears in Oklahoma is expanding. Although black bears in Oklahoma have similar demographics to other expanding bear populations and are expanding their range, several factors could limit this growth. It is likely that habitat quality for black bears decreases outside the Ouachita Mountains, especially to the west. Habitat to the west of our study area is not mountainous, has less forested areas, and more agriculture and human development. Also, although this study focused on areas of expansion to the west and north of the core area, black bears are also likely expanding to the south of the study area, an area that could use additional study. Bears are likely still emigrating from Arkansas, so the status of this population source also is important. If regulated hunting begins in Oklahoma, this pressure combined with possible poaching may cause the demographics to shift quickly given the relatively small population size. Sex ratios and age structures should be monitored to maintain the health of the population if hunting is implemented.

In the core area of Oklahoma, the population growth rate was about 11% annually due to high reproductive rates and low mortality rates (Bales et al. 2005) compared to other populations. However, reproductive and mortality rates were not examined in the peripheral area, which could be different given the higher mortality rate typically seen in dispersing individuals. I suggest that future research should focus on unexplored demographic characteristics of the peripheral area.

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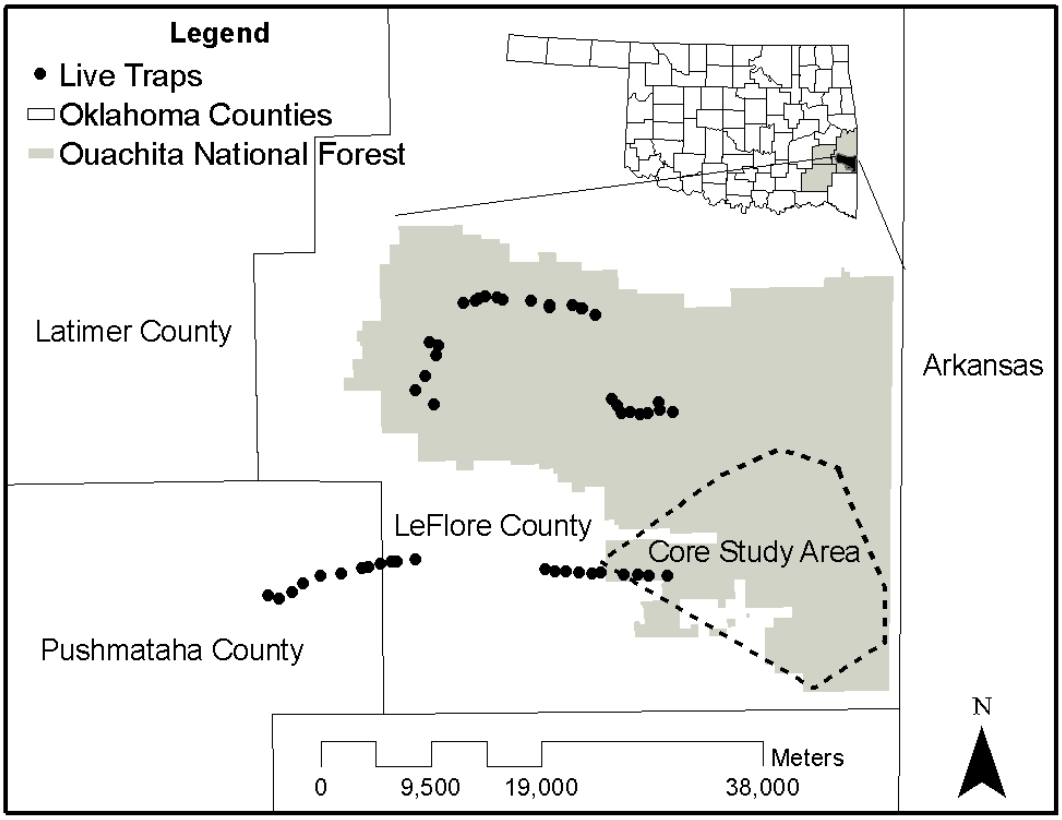

Figure I.1. Map of trapping transects for black bears in the peripheral area of the black bear recolonization in the Ouachita National Forest, LeFlore County and Pushmataha County, Oklahoma. Polygon outlined by dotted line represents core area trapped by Bales et al. (2005).

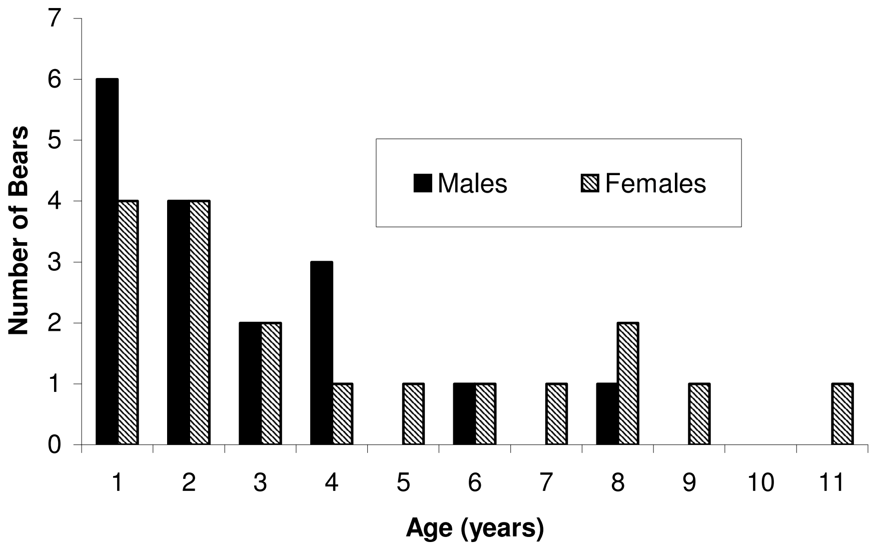

Figure I.2. Age structure of male and female bears captured in study area, Ouachita National Forest, LeFlore County and Pushmataha County, Oklahoma, 2005–2007.

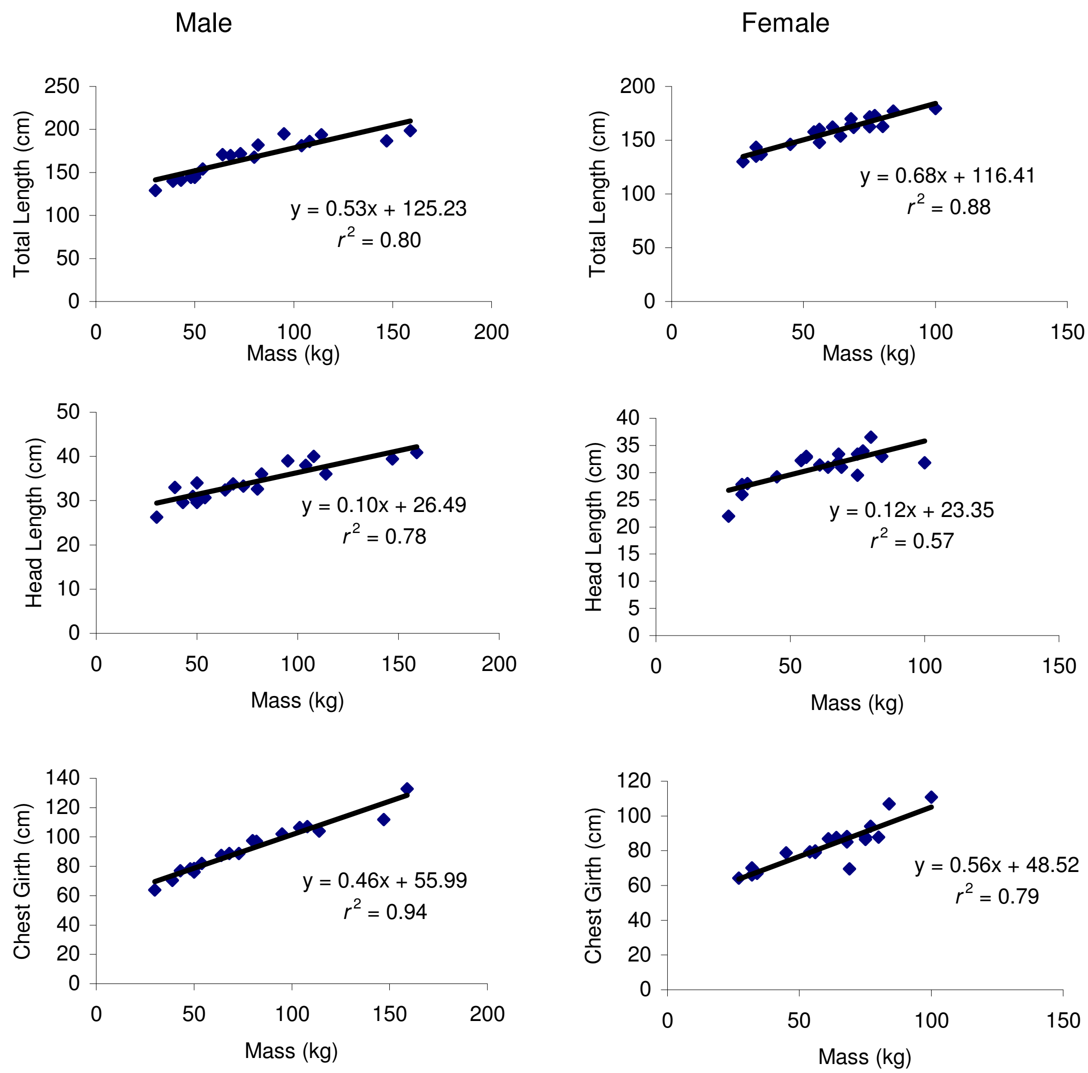

Figure I.3. Linear regressions of mass versus total length, head length, and chest girth, by sex, of black bears captured in Ouachita National Forest, LeFlore and Pushmataha counties, Oklahoma, 2005–2007.

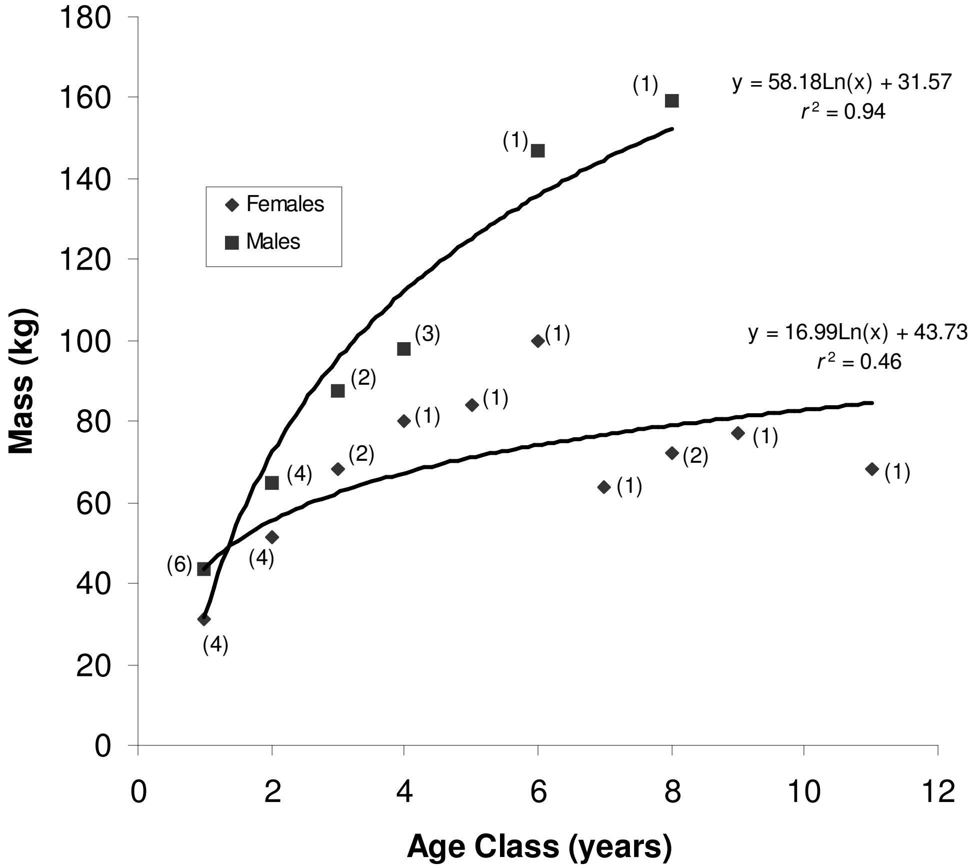

Figure I.4. Logarithmic regression of average mass versus age class, by sex, of black bears captured in Ouachita National Forest, LeFlore and Pushmataha Counties, Oklahoma, 2005–2007.

Table I.1. Morphometrics of bears captured in Ouachita National Forest, LeFlore and Pushmataha Counties, Oklahoma, 2005–2007. *P* values from ANOVA test used to determine if size of adults and yearlings differed.

	Males					Females				
Characteristic	*n*	*X*	*SE*	*Range*	*P values*	*n*	*X*	*SE*	*Range*	*P values*
Adults										
Weight (kg)	12	95.7	9.4	54.0–159.0	0.0014	15	67.6	3.8	45.0–100.0	0.0002
Total Length (cm)	12	179.8	3.8	154.0–198.5	<0.0001	15	163.3	2.5	146.1–179.5	<0.0001
Head Length (cm)	12	36.0	1.0	30.7–40.9	0.004	15	32.1	0.5	29.2–36.5	<0.0001
Chest Girth (cm)	12	100.5	4.0	82.0–132.8	0.0004	15	86.8	2.8	69.5–110.8	0.002
Yearlings										
Weight (kg)	6	43.3	3.2	30.0–50.0		4	31.3	1.5	27.0–34.0	
Total Length (cm)	6	141.1	2.6	129.1–147.5		4	136.4	2.8	130.0–143.5	
Head Length (cm)	6	30.6	1.1	26.3–34.0		4	26.0	1.4	64.2–70.2	
Chest Girth (cm)	6	73.4	2.4	63.8–78.4		4	66.9	1.3	22.0–28.0	

CHAPTER II

POPULATION ESTIMATION AND HABITAT ASSOCIATIONS OF BLACK BEARS IN THE OUACHITA MOUNTAINS OF OKLAHOMA USING HAIR SAMPLES

INTRODUCTION AND JUSTIFICATION

Knowledge of distribution, density, and spatiotemporal trends of a species are necessary for conservation and management (Apps et al. 2004). Using standard techniques of physical capture and radiotelemetry to examine these characteristics can be problematic for some species because of relatively large scales of habitat use, capture difficulties, and solitary behavior (Apps et al. 2004). The invasive nature and cost of physical capture often limits research scale, reducing effectiveness of population estimation (Woods et al. 1999).

Recent applications of noninvasive sampling protocols, such as DNA analysis of hair samples (Woods et al. 1999, Mowat and Strobeck 2000, Boersen et al. 2003), have been a positive addition in population and habitat analysis (Apps et al. 2004). DNA analysis allows researchers to identify and sex unique individuals and examine genetic diversity and relatedness of a population (Gardner-Santana 2007). Hair and feces collected by noninvasive techniques have been used to estimate population size of American black bears (*Ursus americanus*; Boersen et al. 2003, Triant et al. 2004), grizzly bears (*U. arctos*; Mowat and Strobeck 2000, Poole et al. 2001), and coyotes (*Canis latrans*; Kohn et al. 1999).

Hair sampling also allows habitat analysis comparing where the species was detected to where the species was not (Apps et al. 2004). Black bears are considered habitat generalists; they have an opportunistic feeding behavior (Lariviere 2001) and use a wide variety of habitats, from burned or logged forest (Hellgren et al. 1991) to non-managed and mature hardwood forests (Costello and Sage 1994). Understanding habitat associations in populations that are expanding or colonizing occupied habitat is important because quality of habitat could become a limiting factor and thereby influence management options.

A study of the black bear population in the Ouachita National Forest, LeFlore County, Oklahoma, was conducted in 2001–2003 to assess habitat characteristics preferred by a colonizing population (Bales 2003). Because the study area in LeFlore County was considered the first area colonized by black bears moving from Arkansas into Oklahoma, these habitat characteristics (Bales et al. 2005) may not be the same as in western areas of the Ouachita Mountains, where black bears are expanding their range. Habitat of the southeastern part of the Ouachita National Forest was considered suitable given the relatively small size of female home-ranges (Bales 2003). Habitat analysis in that study area indicated female bears used pine stands more than expected, possibly due to intense harvesting practices on pine and pine-hardwood stands (Bales Lyda et al. in press). Total production of soft mast was greater in harvested versus unharvested stands in the Ouachita Mountains of Oklahoma and Arkansas (Perry et al. 1999), possibly increasing habitat-use by bears (Bales 2003). Habitat suitability of the western part of the

Ouachita Mountains may lack adequate resources necessary to sustain a black bear population (Bales 2003).

Effective management of the black bear populations in Oklahoma requires an understanding of population dynamics in the western parts of the Ouachita Mountains that are currently being colonized. With mark-recapture techniques using hair sampling (Woods et al. 1999, Mowat and Strobeck 2000, Boersen et al. 2003) characteristics of the black bear population in Oklahoma can be better elucidated. My objective was to estimate abundance, density, and distribution of black bears in southeastern Oklahoma from DNA profiles of hair samples (Gardner-Santana 2007) using GIS modeling tools. I examined associations between landscape features and black bear presence in southeastern Oklahoma. I hypothesized that the population was expanding across the mountain ridges to the west with abundances higher in the eastern part of the study area (closer to the Arkansas border). I predicted higher black bear presence in habitats that were heavily forested and had high mean elevation and slope (Apps et al. 2004). I predicted lower black bear presence in areas with higher human disturbance and agriculture (Apps et al. 2004).

MATERIALS AND METHODS

Study Area

The study area encompassed approximately 3,420 km^2 of private land, state wildlife management areas, and the Ouachita National Forest in southeastern Oklahoma, including southern Leflore and Latimer counties and northern Pushmataha County (Figure II.1). The Ouachita Mountains mainly consisted of a series of east-west valleys and ridges with elevations of 300 m and 800 m, respectively (Hunt 1974). Vegetation in southeastern Oklahoma was characterized by 5 community types, each with different dominant species (Johnson 1986), but it was typically considered oak-hickory-pine dominated (Duck and Fletcher 1943, Clark et al. 1993). Upper and middle north-facing slopes were strongly dominated by mockernut hickory (*Carya tomentosa*), south-facing slopes were dominated by shortleaf pine (*Pinus echinata*) and oaks (*Quercus* spp.), ridgetop communities were usually dominated by white oak (*Q. alba*), and the valley bottom-floodplain had no dominant species because of the diversity of habitats (Johnson 1986). Climate of the study area was considered humid subtopical (Curry 1970), with mean annual precipitation of 135 cm and mean annual temperature of 17.2°C.

Hair Collection

A grid of 4.8- x 4.8-km cells was plotted to encompass areas of known black bear activity (Bales et al. 2005) and suspected recolonization areas. The average home range for a female bear was 21 km^2 in this area (95% adaptive kernel; Bales et al. 2005), and this grid size allowed 0.9 hair-snares/female home range. Hair snares were set within habitat that was both suitable for bear use and allowed researcher access for hair collection. The Universal Transverse Mercator (UTM) coordinates for each snare location was recorded with a GPS (Global Positioning System) receiver (Garmin International Incorporated, Olathe, Kansas, USA). All snares consisted of one strand of barbed wire, one 106-g (3.75 oz) can of sardines, and one tampon soaked with raspberry (*Rubus* spp.) extract (Mother Murphy's, Greensboro, North Carolina, USA). Barbed wire was cut in approximately 20-m strips, formed into an enclosure by wrapping it around 3–6 trees at a height of 30–60 cm above ground, and nailed to the trees using standard fencing nails (Woods et al. 1999, Settlage 2005). Bait was hung on a thin-gauge wire in the center of the trap, away from all trees, approximately 1.2–1.8 m above ground to avoid consumption by non-target species (Settlage 2005). Sardine bait was replaced when consumed or every other sampling occasion when untouched and tampons were re-soaked with raspberry extract every sampling session. Snares were located 10–100 m from a road, depending on human access to the area. Snares located by roads with high daily traffic were set at greater distances from the road to limit black bear interaction with roadways, enhance researcher safety, and prevent vandalism to snares.

Snares were checked for hair samples approximately every 7 days (range: 5–10 days) from June to August, 2004–2006. A sample was defined as any independent cluster or single strand of hair. All hair samples were collected regardless of color, characteristics, or number. Hair was removed from individual barbs with tweezers and placed in coin-sized envelopes, which were stored in a freezer until DNA extraction. Envelopes were marked with date, time, hair-snare location, and barb location. After hair removal, the barb and surrounding wire were sterilized using a disposable lighter to destroy any remaining material that could affect subsequent samples.

Hair Analysis

DNA was extracted from hair samples collected at barbed-wire hair snares, and the samples were sexed and genotyped at $\geq$ 7 of 10 microsatellites for black bears (Gardner-Santana 2007). DNA microsatellite analysis identified unique genotypes, recaptures, and sex of individuals (Gardner-Santana 2007). Hair samples were categorized with the unique or recapture identity and associated with their location of collection. Samples were considered recaptures if they had the same genotype but were collected on different dates and/or locations. Samples were considered duplicates if they had the same genotype and also were collected at the same location on the same date (Gardner-Santana 2007). Sex ratios of unique genotypes were calculated at each hair snare to examine the sex ratio across the study area. Because the Ouachita Mountains in Oklahoma primarily consist of 2 main mountain ridges, Winding Stair mountain ridge and Kiamichi mountain ridge (Figure II.3.), unique genotype numbers and sex ratios were calculated for each ridge (Gardner-Santana 2007). Additionally, the sex ratio was calculated for unique captures in the core area, the area thought to be the first site colonized by bears moving from Arkansas into Oklahoma (Gardner-Santana 2007).

Population Estimation

Population size was estimated using the robust design for closed captures in program MARK (White and Burnham 1999). Annual female and male survival was assumed to be 0.90 (Hellgren and Vaughan 1989, Bales et al. 2005) and 0.70 (Hellgren and Vaughan 1989, Kasworm and Thier 1994), respectively. No emigration or immigration from the study area was assumed due to the size of our study area and relatively short sampling sessions. The models were ranked using Akaike's Information Criterion (AIC, Burnham and Anderson 1998).

Number of unique captures genetically-identified at each hair snare was interpolated using the inverse distance weighted technique in ArcMap version 9.1 (ESRI, Redlands, California). The estimate of population size derived by program MARK was used to estimate density throughout the study area. To assess trends in spatial density throughout the study area, the estimated density within each grid was calculated. I divided the estimated population size of the entire study area by the number of unique bears genetically-identified in the grid. I multiplied that ratio (total bears/identified bear) by the number of unique bears identified in each grid, and divided by the grid square size for an estimated density for each grid. The estimated abundance and density by grid was then interpolated using inverse distance weighted interpolation tool in ArcMap 9.1. Interpolations included only hair-snares that had unique bear identifications to allow conservative abundance and density estimates.

Habitat Analysis

Habitat around hair snares where black bears were detected was compared with the habitat around hair snares where they were not detected. Habitat around each hair snare was analyzed at 3 landscape levels of habitat selection: 1) average summer home range of female black bear (SHR) in study area (13.3 km^2; Bales 2003), 2) average year-around home range of female black bear (FHR) in study area (21.0 km^2; Bales et al. 2005), and 3) home range of male black bear (MHR) in Ouachita mountains of Arkansas (39.7 km^2; Clark and Smith 1994). Circular buffers of the 3 landscape levels were created around each hair snare using the buffer tool in ArcMap 9.1 (Figure II.2). Each buffer was centered on the corresponding hair snare.

A vector layer of hair-snare location points was georeferenced and integrated with a layer of the Oklahoma border, the 2001 National Land Cover Database (NLCD) raster layer (30-m resolution), standard 30-m USGS digital elevation models (DEM), and road, highway, and stream layers obtained from University of Oklahoma Center for Spatial Analysis website (http://www.csa.ou.edu) accessed on 7 March 2007. Within each buffer around each snare, land-cover classifications were summarized in square meters using Hawth's Analysis Tools extension for ArcMap version 9.1 (ESRI, Redlands, California). Landscape categories were reclassified based on bear ecology and included: forest (mixed forest, evergreen forest, and deciduous forest), human development (open space, low, medium, and high intensity), fields (pasture, agricultural land, and grassland), wetlands (woody and herbaceous), and open water (lakes, ponds, and reservoirs). Average slope (degrees) and elevation (meters) were computed within each buffer from the DEMs using zonal statistics tools in ArcMap. The total linear distance of roads (meters), streams (meters), and highways (meters) were calculated within each buffer using Hawth's tools. The distance from each snare to the Arkansas border was determined using the near tool in spatial analysis of ArcMap.

Multiple logistic regression with backward elimination (PROC GENMOD—SAS Institute Inc. 2000), was used to associate habitat variables with bear presence or absence. Variables were eliminated from the model using $P < 0.15$. Models were fitted using the maximum-likelihood method. The Hosmer and Lemeshow test was used to test the goodness-of-fit of each model (Hosmer and Lemeshow 2000). *P*-values > 0.05 indicated adequate model fit in the Hosmer and Lemeshow test.

RESULTS

A total of 275 genotypes were identified from the collected hair samples. Of the 275, 161 (58.6%) were unique genotypes. Of the remaining 114 genotypes, 52 (45.6%) were recaptures and 62 (54.4%) were duplicate samples. In 2004, 74 (44 M: 30 F; 4 recaptures) unique genotypes were captured at 32 (32.3%) of 99 traps. In 2005, 58 (39 M: 19 F; 22 recaptures) unique genotypes were captured at 33 (26.4%) of 125 traps. In 2006, 29 (19 M: 10 F; 26 recaptures) unique genotypes were captured at 26 (26.4%) of 125 traps. From the 161 useable genotypes, the study area had a male-biased sex ratio of 1.7 M:1.0 F ($\chi^2 = 11.48$; df = 1; $P < 0.005$; 102 M: 59 F; Gardner-Santana 2007).

Using initial captures, the Winding Stair mountain ridge had approximately 61 unique genotypes (37.9%) with a 2.1M:1F male-biased sex ratio (χ^2 = 7.23; df = 1; $P <$ 0.005; 41 M: 20 F). The Kiamichi mountain ridge had 100 unique genotypes (62.1%) with a 1.6M:1F male-biased sex ratio (Figure II.3; χ^2 = 5.76; df = 1; $P < 0.025$; 62 M: 38 F; Gardner-Santana 2007). The core area had an overall sex ratio of 1:1 (χ^2 = 0.016; df = 1; $P < 0.75$; 32 M: 31 F).

Hair samples with usable genotypes were collected at 55 traps (44%) over the 3 sampling seasons. Thirty-five (63.6%) of the traps had male-biased genotypes and 14 (25.5%) of the traps had female-biased genotypes. The majority of females were trapped in the southeastern corner of the study area, with 53% of females trapped at 6% of traps (n = 8). The same 8 traps accounted for 31% of male captures and 38.5% of total captures. In the western one-half of the study area, 7 (63.3%) of the 11 traps with usable genotypes were male-biased (Figure II.3) (Gardner-Santana 2007).

Population Estimation

The best fitting model (lowest AIC) estimated population sizes of 174 ± 46 (95% confidence interval: 108 – 294) for females and 277 ± 71 (95% confidence interval: 174 – 461) for males, for a total population estimate of 451 bears in the study area (Table II.1). Capture probability (p) was estimated at 0.020 and recapture probability (c) was estimated at 0.118 for females and 0.031 for males. Density estimation of t

he entire study area (125 snares x 23 km^2 = 2875 km^2) was approximately 0.15 bears/km^2.

Number of unique genotypes at a trap ranged from 1 to 27 and estimated densities of bears ranged from 0.1 to 2.3 bears/km^2. The interpolation of unique genotypes (Figure II.4) showed that more black bears were identified in the southeastern portion of the study area and bear numbers decreased to the north and west of the southeast corner. The interpolation of estimated densities (Figure II.5) showed higher densities in the southeastern portion of the study area with decreasing densities to the north and west of the southeast corner.

Habitat Analysis

Hosmer and Lemeshow goodness-of-fit test indicated that results of the logistic models adequately fit the data (SHR, $P = 0.4734$; FHR, $P = 0.985$; MHR, $P = 0.956$). Open water and field categories were eliminated from all models. Development, forest, and stream length were related positively with all three buffer sizes. Elevation was related positively with the SHR buffers, whereas slope was related positively with the FHR and MHR buffers. Road length, highway length, and distance from Arkansas were correlated negatively with all three buffer sizes (Table II.2).

DISCUSSION

Population Estimation

More black bears were captured in the eastern part of the study area, supporting the hypothesis that more bears would be identified closer to the Arkansas border. Black bears likely used the Kiamichi mountain ridge as a corridor of expansion (Fig. II.3) into Oklahoma. These data support the idea of the core area of black bears in the southeastern corner of the study area, studied by Bales et al. (2005). The live-trapped black bears in the core area had a female-biased sex ratio (Bales et al. 2005). The majority of female captures at hair snares were captured in the core area, whereas snares to the north and west of the core were typically male-biased. This shift is similar to a population of brown bears in Sweden, which had a peripheral area dominated by males and a core area dominated by females (Swenson et al. 1998). Several females were identified in the western peripheral area, likely due to occasional female dispersal (Schwartz and Franzmann 1992).

The overall study area had a male-biased sex ratio, common in populations of black bears (Smith 1985, Hellgren and Vaughan 1989, Doan-Crider and Hellgren 1996). However, several factors could have influenced the male-biased sex ratio of the study area. Snares were set at a density of only 1 snare per female home range. Males typically have larger home ranges (Lariviere 2001) and therefore have an increased likelihood of encountering snares. Raising cubs can limit mobility of females (Boulanger et al. 2004), thereby decreasing likelihood of females encountering snares.

The overall density of the study area (0.15 bears/km^2) was lower than the density of live-trapped bears in the core area (0.21 bears/km^2, Bales et al. 2005). Based on estimated densities from hair captures, the core area had a higher density (1.0–2.3 bears/km^2) than estimated by Bales et al. 2005, whereas the peripheral areas had lower densities (0.10 bears/km^2). Estimated densities are possibly overestimated because home ranges of individuals were not included in calculations. Grid cells used to calculate estimated densities were the size of an average female home range, which is likely smaller than most male home ranges and possibly larger than some female home ranges. Additionally, the estimated density is dependent on the spacing of the hair snares. The core area had relatively high estimated densities similar to black bear populations in North Carolina (1.35 bears/km^2, Martorello 1998; 1.2–1.78 bears/km^2, Thompson 2003). The peripheral areas had relatively low estimated densities similar to black bear populations in the Ouachita Mountains of Arkansas (0.09 bears/km^2, Clark and Smith

1994), the Great Smoky Mountains National Park (0.29 bears/km^2, McLean and Pelton 1994), and Mexico (0.35 bears/km^2; Doan-Crider and Hellgren 1996).

Habitat Analysis

Bear presence was associated with a number of habitat characteristics. For example, black bears were positively associated with areas of higher densities of forest and streams. Delineation of forest age classes and types would have been preferred in my analysis, but previous research has indicated several forest preferences of black bears in Oklahoma. Pine stands, which are heavily harvested in southeastern Oklahoma were used more than expected (Bales 2003), possibly due to the greater amount of total production of soft mast in harvested versus unharvested stands of forest in the Ouachita Mountains (Perry et al. 1999). Riparian zones associated with streams have been used by black bears as foraging and bedding areas (Unsworth et al. 1989). Streams also act as water sources and movement corridors for black bears (Unsworth et al. 1989).

When examined on the smallest landscape level (SHR), higher elevations were associated with black bear presence, whereas steeper slopes were associated with black bear presence at the two larger landscape levels (FHR, MHR). Areas with higher elevations and steeper slopes typically inhibit human access and habitation (Apps et al. 2004). Within the Ouachita Mountains of Oklahoma, areas with the steepest slopes and highest elevations had forest that was typically harvested less frequently, possibly providing habitat requirements not met by more frequently timber-harvested areas.

Bear presence was positively related to human development in all 3 landscape levels. This association could be an artifact of sampling design, in which hair-snare locations were constrained by researcher access. Researcher access to snares by vehicle required some association between the hair snare and human development areas, since roads and/or highways facilitate human access to areas (Apps et al. 2004). Human development is typically not associated with quality bear habitat; however, both the number of humans in the habitat and the behavior of those humans determined bear occurrence (Apps et al. 2004). My study area was sparsely populated with < 1 person per 2.6 km^2 (U.S. Census Bureau, 2000). Of the areas classified as development, 90.8% was classified as open space and 7.4% was low intensity development, whereas medium and high intensity development accounted for only 1.8% of the total development. This development, although impacted by humans, may have had some habitat characteristics preferred by black bears. The majority of development in the study area was located in valley regions, which were often associated with riparian habitat. Black bears have used burned or logged habitat as areas of high fruit and berry production (Hellgren et al. 1991). Areas classified as developed also include garbage dumps, campgrounds, and agricultural centers, which may act as a food source for bears. Because these food sources can be a major source of mortality for black bears, increased black bear presence in areas with human development would seem to affect survival rates. However, few bears were reported and trapped multiple times because of nuisance behavior (Joe Hemphill, Oklahoma Department of Wildlife Conservation, personal communication), so it seems unlikely that many black bears become habituated to developed areas and perhaps find suitable food sources.

Black bears were associated negatively with roads and highways. Researcher access to snares by vehicle required some association between the hair snare and roads. However, roads were present throughout the entire study area, including remote areas used primarily for timber harvest. Because roads and/or highways facilitate human access to areas (Apps et al. 2004), there seems to be some negative association of black bears to human development. Highways had more negative associations than all roads combined, possibly showing a relationship between traffic volume and bear preference. Highways have previously been reported as a barrier to dispersal for brown bears (Apps et al. 2004). Black bears avoid roads with relatively high traffic volume, which pose high risk of mortality (Beringer et al. 1989, Fecske et al. 2002), and prefer roads with relatively low traffic volume, which can be used as travel corridors (Mannville 1983, Hellgren et al. 1991). In areas with open hunting seasons, black bears avoided dirt roads more than paved highways, possibly because hunters gain access through dirt roads (Reynolds-Hogland and Mitchell 2007). If a hunting season for black bears is opened in Oklahoma, an increased avoidance of all roads by black bears may occur.

Black bear presence was associated negatively with areas farther from Arkansas, not surprisingly because black bears in Arkansas were the source population for the black bears in Oklahoma. The category, fields, which included most land used for agriculture purposes, was dropped by the multiple logistic regression model. Hair-snare placement in agricultural areas was often limited by the habitat available to set snares and private property issues, possibly explaining why these data were not suitable for regression analysis.

MANAGEMENT IMPLICATIONS

Although the entire study area seems to have densities of black bears comparable to many other populations of black bears, the core area in the southeastern corner of the study area had larger population estimates and higher densities. The core area was likely the initial location of black bear expansion into Oklahoma, but it also appears to have the highest quality of habitat preferred by black bears. The core area, which includes the Kiamichi mountain ridge, had the steepest slopes, highest elevation, highest densities of forests and streams, and lowest densities of roads and highways in the study area. Slope, elevation, and forest densities decrease rapidly to the west of the study area. As black bears continue to move away from the core area, the required travel distances to obtain the same resources may limit expansion. The density of roads and highways could act as barriers restricting movement of black bears outside of the study area. As black bears expand into areas of higher human populations, nuisance activities could increase substantially. Use of agricultural areas by black bears in Oklahoma is currently unknown but could be a source of future human/black bear conflicts. These possible habitat limitations of areas outside the Ouachita Mountains should be incorporated into management practices. Habitat selection by black bears in the peripheral and valley regions should be studied further, possibly through tracking of individuals using GPS collars.

Although the numbers of black bears are highest in the Ouachita Mountains, black bears have also been reported in several other regions of the state, including northeastern Oklahoma in the Ozark Mountains and the Black Mesa region in the western end of the Oklahoma panhandle (Kamler et al. 2003). Other than occasional sightings, camera trail pictures, and documented footprints, little information exists regarding the population size, density, or habitat preferences of black bears in these areas. Black bears in these areas should be studied to get a more accurate status of black bears in Oklahoma.

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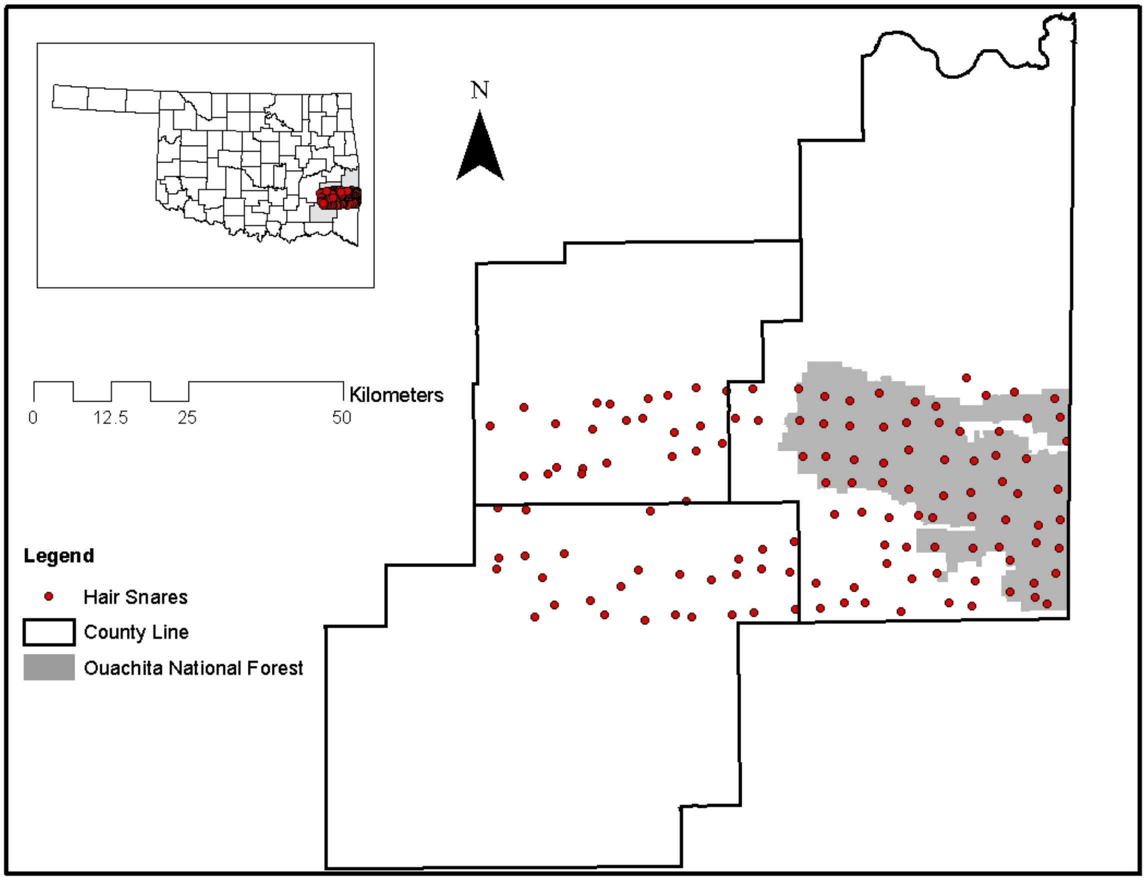

Figure II.1. Map of black bear study area within the LeFlore, Latimer, and Pushmataha Counties, Oklahoma.

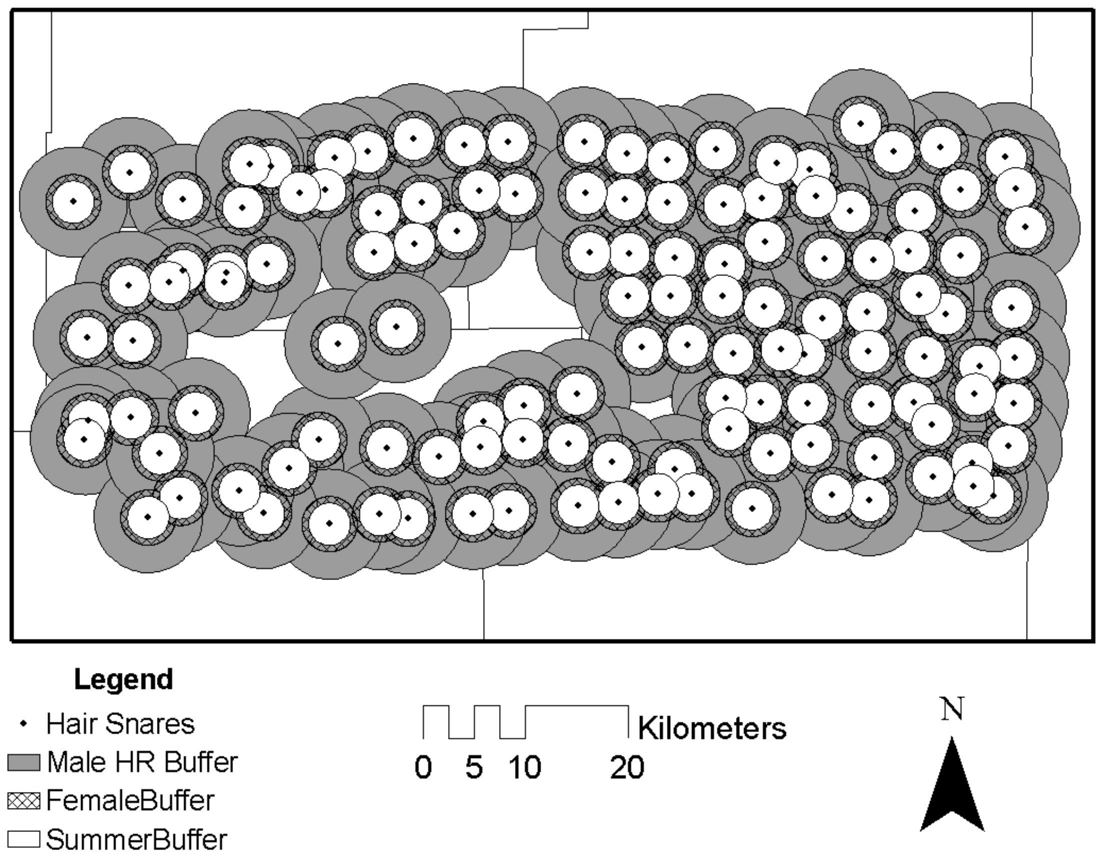

Figure II.2. Home-range (HR) buffer sizes used for analysis of habitat around hair snares, LeFlore, Latimer, and Pushmataha counties, Oklahoma. Buffers comprised of all areas from center point to outer edge. Gaps in buffer overlap (west-central portion of study area) are in valley region between the 2 mountain ridges. These locations had limited areas available for hair-snare placement; valley was primarily private property used heavily for agriculture.

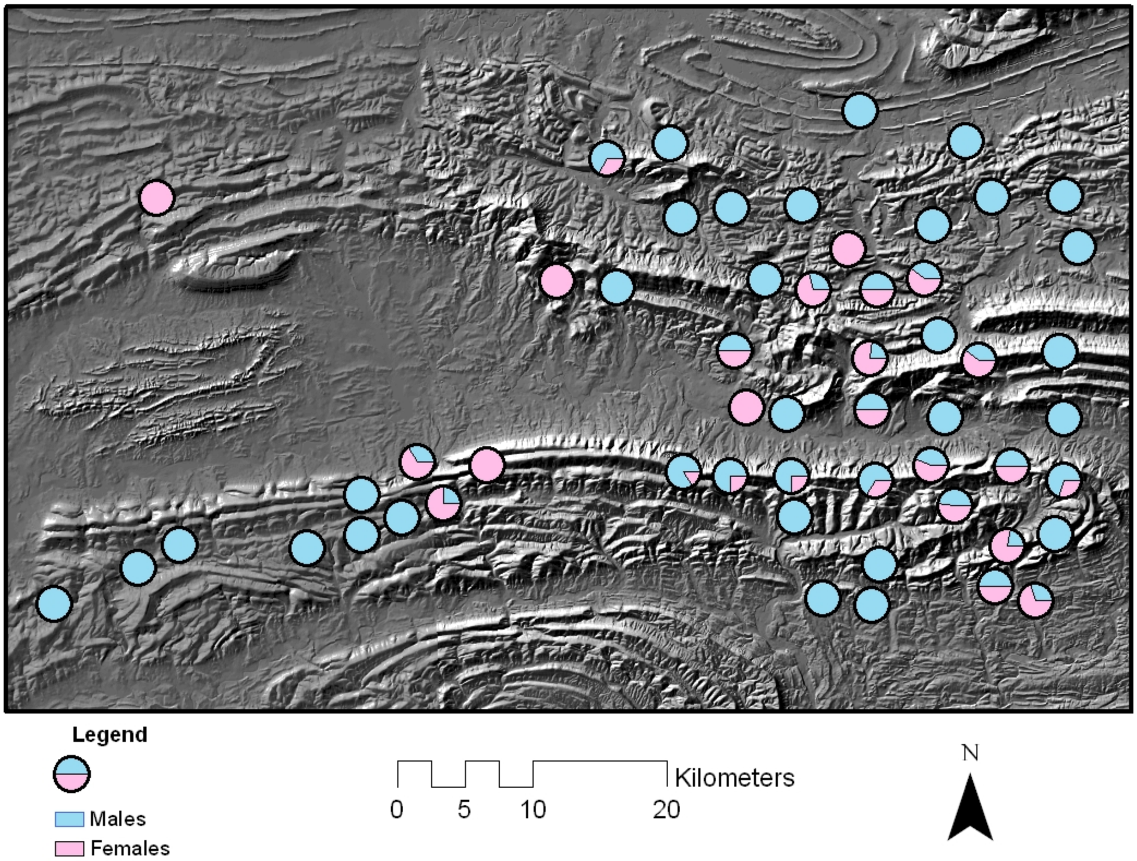

Figure II.3. Sex ratio of hair samples collected at hair snares in study area, LeFlore, Latimer, and Pushmataha counties, Oklahoma, 2004–2006. The majority of females were captured in the southeastern corner of the study area, while western and northern areas were typically male-biased. Elevation image of the Ouachita Mountains shows 2 primary ridges, the Winding Stair Mountain (north) and the Kiamichi Mountain (south).

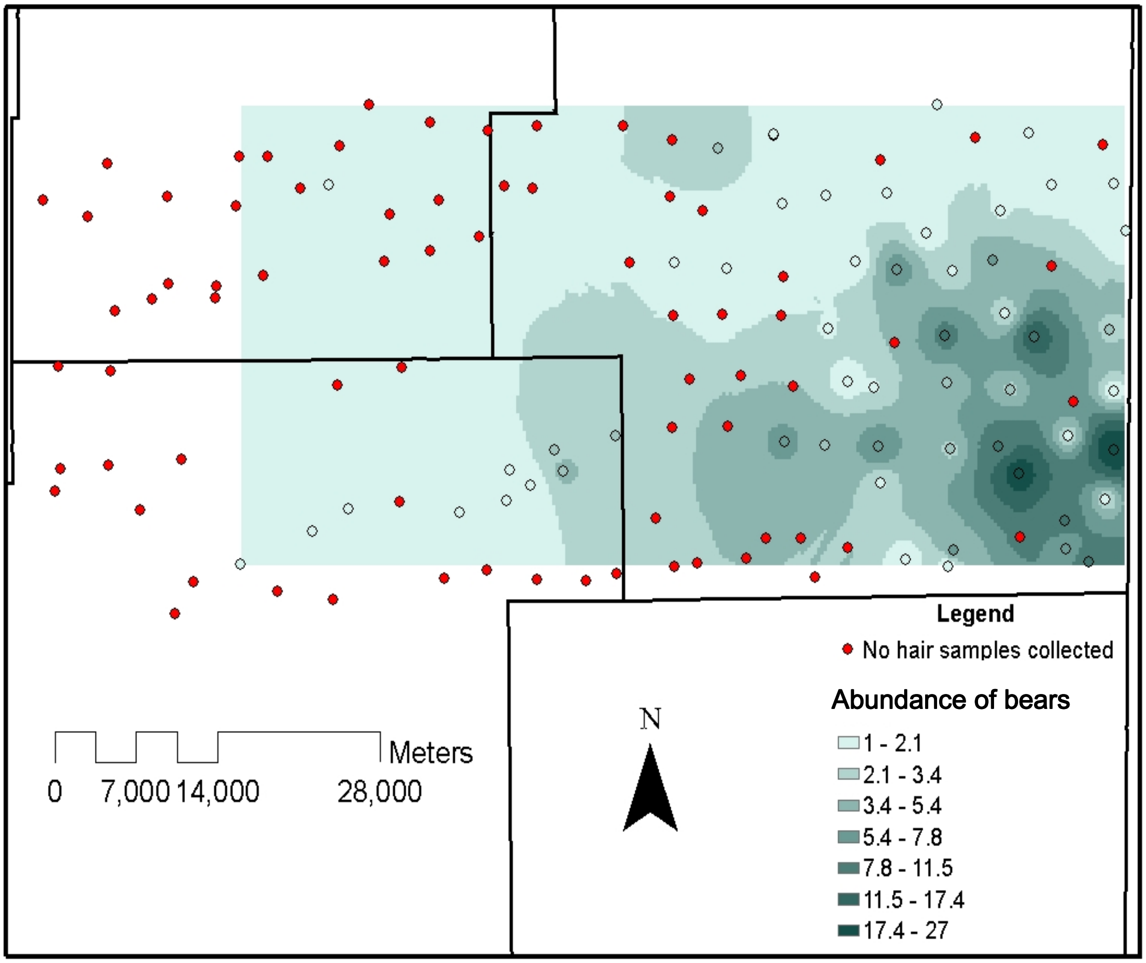

Figure II.4. Relative abundance interpolation of unique black bears based on hair sample analysis, LeFlore, Latimer, and Pushmataha counties, 2004–2006. Interpolation includes only hair-snares that had unique bear identifications to allow a conservative abundance interpolation.

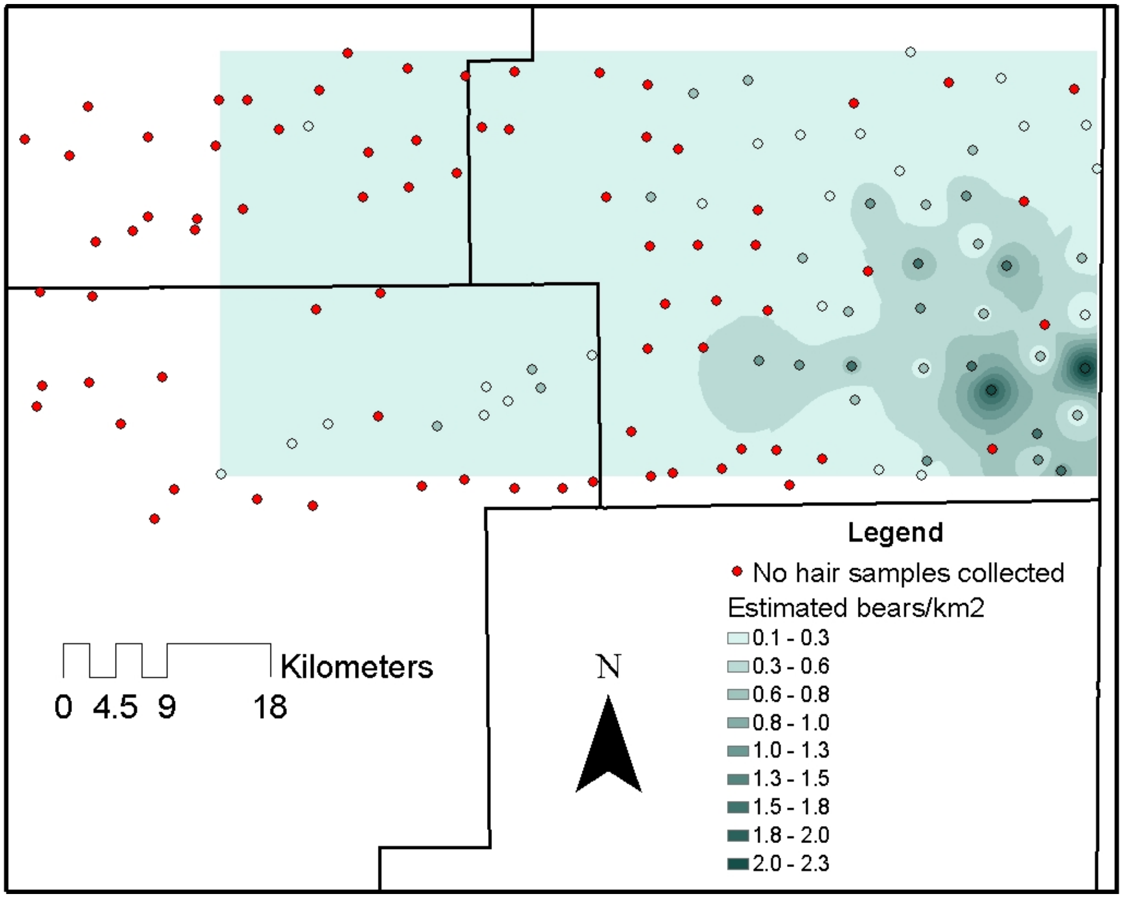

Figure II.5. Estimated density interpolation of black bears in Oklahoma, according to unique numbers from genetic hair samples and calculated population estimate, LeFlore, Latimer, and Pushmataha counties, Oklahoma, 2004–2006. Interpolation includes only hair-snares that had unique bear identifications to allow a conservative density interpolation.

Table II.1. Program MARK closed-capture models used to estimate population size of black bears in LeFlore, Latimer, and Pushmataha counties, Oklahoma, 2004–2006. s = survival estimates; gamma = immigration/emigration; p = capture probability; c = recapture probability, N = population estimate.

Model	AICc	ΔAICc	AICc Weight	N	95% CI
s(fixed) gamma (fixed) p(.)c (sex,yr1 vs other), N(sex)	165.3889	0.0000	0.4249	451	292-755
s(fixed) gamma (fixed) p(sex)c (sex,yr1 vs other), N(sex)	166.3999	1.0110	0.2563	505	264-1061
s(fixed) gamma (fixed) p(.)c (sex,yr1 vs other), N(sex)	167.4817	2.0928	0.14922	451	292-755
s(fixed) gamma (fixed) p(sex)c (sex,yr1 vs other), N(sex)	168.5149	3.1260	0.08902	505	264-1061
s(fixed) p(sex year)c (sex year), N(sex)	169.5149	4.0157	0.05705	414	217-881
s(fixed) gamma (fixed) p(.)c (sex,yr1 vs other), N(.)	171.1784	5.7895	0.0235	208	130-347

[a] In all models, survival rates were fixed at 0.90 for females (Bales et al. 2005) and 0.70 for males. Populations were assumed to be closed given the size of the study area; therefore, gamma parameters (i.e., immigration and emigration) were fixed at 0.0.

Table II.2. Logistic regression relating probability of occurrence of black bears to habitat characteristics, LeFlore, Latimer, and Pushmataha Counties, Oklahoma, 2004–2006. SHR = buffer size equivalent to summer female home range (13.3 km^2; Bales 2003); FHR = annual female home range (21.0 km^2; Bales 2003); MHR= male home range (39.7 km^2; Clark and Smith 1994); b = regression coefficient; *P* = probability value associated with habitat characteristic.

	Landscape scale					
	SHR		FHR		MHR	
Habitat Characteristic	b	*P*	b	*P*	b	*P*
Water						
Development	0.1276	0.0013	0.085	0.0009	0.0316	0.0014
Forest	0.5417	0.0445	0.373	0.0225	0.11	0.0473
Fields						
Road Length	-0.3071	0.015	-0.1728	0.0334	-0.083	0.0148
Stream Length	0.2492	0.1134	0.2091	0.078	0.0902	0.1081
Highway Length	-0.7854	0.0016	-0.6058	0.0004	-0.2534	<.0001
Slope			0.4105	0.0022	0.619	0.0016
Elevation	11.4371	0.0012				
Distance from Arkansas	-0.0454	0.0003	-0.0443	0.0005	-0.0371	0.0116

APPENDIX

Appendix 1. Sex, age, coloration, and mass of bears captured in study area, Ouachita National Forest, LeFlore County and Pushmataha County, Oklahoma, from 2005–2007.

Bear ID	Capture Date	Sex	Age	Color	Weight (kg)
0	5/20/05	Female	unknown	black	unknown
1	5/24/05	Female	2	black	50
2	5/29/05	Female	1	black	32
3	6/1/05	Female	8	black	69
5	8/5/05	Male	4	black	108
6	8/5/05	Male	3	black	95
7	8/8/05	Female	9	black	77
8	8/8/05	Female	5	black	84
9	8/11/05	Female	unknown adult	brown	56
10	5/14/06	Male	8	black	159
11	5/24/06	Male	unknown adult	black	114
12	5/25/06	Male	2	brown	68
13	5/26/06	Male	3	brown	80
14	5/26/06	Male	1	brown	30
15	5/26/06	Male	2	brown	73
16	7/23/06	Female	8	black	75
17	7/24/06	Male	1	black	50
18	7/25/06	Female	11	black	68
19	7/26/06	Female	2	black	56
20	7/26/06	Female	1	black	32
21	7/27/06	Male	1	black	39
22	7/30/06	Male	1	black	48
23	8/3/06	Female	4	black	80
24	8/4/06	Female	3	black	61
25	5/29/07	Female	2	black	45
26	5/30/07	Male	6	black	147
27	6/3/07	Male	4	black	82
28	6/4/07	Male	4	black	104
29	6/15/07	Female	1	black	34
30	7/7/07	Female	1	black	27
31	7/7/07	Female	7	black	64
32	7/17/07	Female	3	black	75
33	7/17/07	Male	2	black	54
34	7/21/07	Male	1	black	50
35	7/21/07	Female	2	black	54
36	7/22/07	Female	6	black	100
37	7/23/07	Male	1	black	43
38	7/24/07	Male	2	black	64

VITA

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Candidate for the Degree of

Master of Science

Thesis: DEMOGRAPHIC CHARACTERISTICS AND HABITAT ASSOCIATIONS OF AN EXPANDING BLACK BEAR (*URSUS AMERICANUS*) POPULATION IN OKLAHOMA

Major Field: Natural Resources Ecology and Management, Wildlife Ecology and Management Emphasis

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Name: Brown, Angela Gayle Date of Degree: May, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: DEMOGRAPHIC CHARACTERISTICS AND HABITAT ASSOCIATIONS OF AN EXPANDING BLACK BEAR (*URSUS AMERICANUS*) POPULATION IN OKLAHOMA

Pages in Study: 55 Candidate for the Degree of Master of Science

Major Field: Natural Resources Ecology and Management, Wildlife Ecology and Management Emphasis

Scope and Method of Study: Recent black bear expansion into Oklahoma from Arkansas has led to management questions involving the growing bear population. Demographic characteristics of the peripheral portion of the black bear population were analyzed using live-trapping. Distribution, population estimation, and habitat preferences of the population were determined using hair sampling and genetic analysis.

Findings and Conclusions: Black bears in the peripheral part of Oklahoma were equally composed of males and females (0.95M:1F) and had a relatively young age structure. Brown coloration occurred more in black bears captured in Oklahoma compared with Arkansas. The population size was estimated at 451 bears: 174 ± 46 (95% confidence interval: 108 – 294) females and 277 ± 71 (95% confidence interval: 174 – 461) males. Black bears in Oklahoma were associated positively with forest, streams, and development. Black bears were associated negatively with roads, highways, and areas farther away from Arkansas.

ADVISER'S APPROVAL: ____________________