To the Graduate Council:

I am submitting herewith a thesis written by Andrew Sean Edwards entitled "Status of the Black Bear in Southwestern Alabama." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Joseph D. Clark, Major Professor

We have read this thesis
and recommend its acceptance:

Dr. David A. Etnier

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Dr. Frank T. van Manen

Accepted for the Council:

Vice Provost and Dean of Graduate Studies

STATUS OF THE BLACK BEAR IN SOUTHWESTERN ALABAMA

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Andrew Sean Edwards

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ABSTRACT

Black bears (*Ursus americanus floridanus*) once were abundant throughout Alabama (Hall 1981), but today sightings of bears are common only in the extreme southwestern portion of the state. The objectives of my study were to determine the distribution of black bears in southwestern Alabama, estimate basic demographic parameters, and evaluate their habitat needs. To determine bear distribution I established and monitored 168 bait stations within the study area from 1998 to 2000. Baits were checked for bear activity at approximately weekly intervals. In areas where bear presence was detected I trapped from 22 October–20 November 1998, 22 June–4 November 1999, and 24 May–29 October 2000, using Aldrich spring-activated foot snares. I recorded 23 captures of 17 (10F: 7M) individual bears from 53 trap sites. I radiocollared 16 (10F: 6M) individual bears and monitored movements once every 10 days in 1999 and twice every 7 days in 2000 by fixed-wing aircraft. Sizes of average home range using the 95% minimum convex polygon technique were 7.8 km^2 for females (n = 10) and 67.1 km^2 for males (n = 6). Home range overlap was extensive between and within sexes. I estimated second-order habitat selection (Johnson 1980) for bears in southwest Alabama using compositional analysis (Aebischer et al. 1993). I generated 2 available habitat areas for the analysis, one including the Mobile-Tensaw Delta, and the other excluding the delta. The analysis extent including the delta suggested that bears were more likely to position their home ranges in areas that contained pine, and the analysis extent excluding the delta suggested that bears were more likely to position their home ranges in areas that contained woody wetlands.

Among 16 radiocollared bears, 4 lost their collars (3 summer 2000, 1 winter 2001) and 1 bear died in fall 2000. Cumulative annual survival over the duration of the study was 0.957 (95% CI = 0.880–1.0). I used a population model (RISKMAN version 1.5.413; Ontario Ministry of Natural Resources, Toronto, Ontario, Canada) to estimate population growth and probability of extinction. With the given parameter estimates for the population growth simulation, and an estimated initial population of 30 individuals, the mean annual growth rate (λ) was 1.027. Additionally, I estimated extinction probability for initial populations of 20, 30, and 40 individuals. Extinction occurred in 17, 13, and 4% of the trials, respectively. This variation in extinction probability suggests that the loss or gain of only a few individuals could greatly affect the stability and perpetuity of the population. I used 19 hair samples from 17 live captured and 2 vehicle-killed bears to determine the total observed alleles and frequencies and an overall measure of heterozygosity for the samples collected. Average number of alleles per locus was 2.88 (range 2–4) and average heterozygosity for the 8 loci sampled was 31.6% (range 5– 58 %). These numbers were low compared to similar analyses for other southeastern black bear populations; this was likely due to the low amount of genetic interchange with other bear populations and the low number of breeding individuals in the population.

The bear population in southwest Alabama is being maintained in only a few small isolated areas where breeding females occur, and thus may be one of the most threatened populations of black bears in North America. These breeding females appear to be associated with feeder streams and associated swamps and bays not subject to river flooding adjacent to pine and oak-pine upland habitats. Bears appear to be scarce in the extensive seasonally flooded habitats along the Mobile, Tensaw, Alabama, and Tombigbee rivers; this is likely due to the low number of sufficient den trees, and isolation from current populations. However, because of its extensive size (app. 100 km^2) and natural isolation, these seasonally flooded wetlands may hold the greatest potential for bear habitat in the region.

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CHAPTER I

INTRODUCTION

Merriam (1896) classified black bears (*Ursus americanus*) in southern Alabama as belonging to the Florida subspecies (*U. a. floridanus*). The range of this subspecies also extends throughout Florida and the coastal plain of Georgia. Two other subspecies of black bears occur in the Southeast: the Louisiana black bear (*U. a. luteolus*), occupies portions of Louisiana, Texas, Arkansas, and Mississippi, and the American black bear (*U. a. americanus*), occupies the remaining portion of the southeastern United States (Hall 1981). In the southeast, black bears inhabit only 10% of their former range (Fig. 1; Maehr 1984, Pelton and van Manen 1997) due to deforestation and development. Today the Florida black bear occupies only 27% of its former range, and its range may be the most fragmented of the 3 subspecies in the region.

Bartram visited the area in 1778 and wrote of a family of hunters along the Mobile River who "kills three hundred deer annually, besides bears, tygers, and wolves" (van Doren 1928). Howell (1921), in his *Biological Survey of Alabama,* tells of bears being exterminated everywhere except "In the big swamps bordering the Tensaw and Mobile Rivers [where] they are still common and a number are killed there every fall." Howell (1921) also tells of a hunter from Carlton, Alabama who "is reported to have killed in recent years over 100 bears and to have caught 10 cubs." He continues with accounts of bears killed in southern Alabama near Bayou Labatre, Irvington, and Bon Secour. *Ursus americanus floridanus* is classified by Florida as a threatened subspecies and Alabama as a game animal with no open season. In Georgia, a short hunting

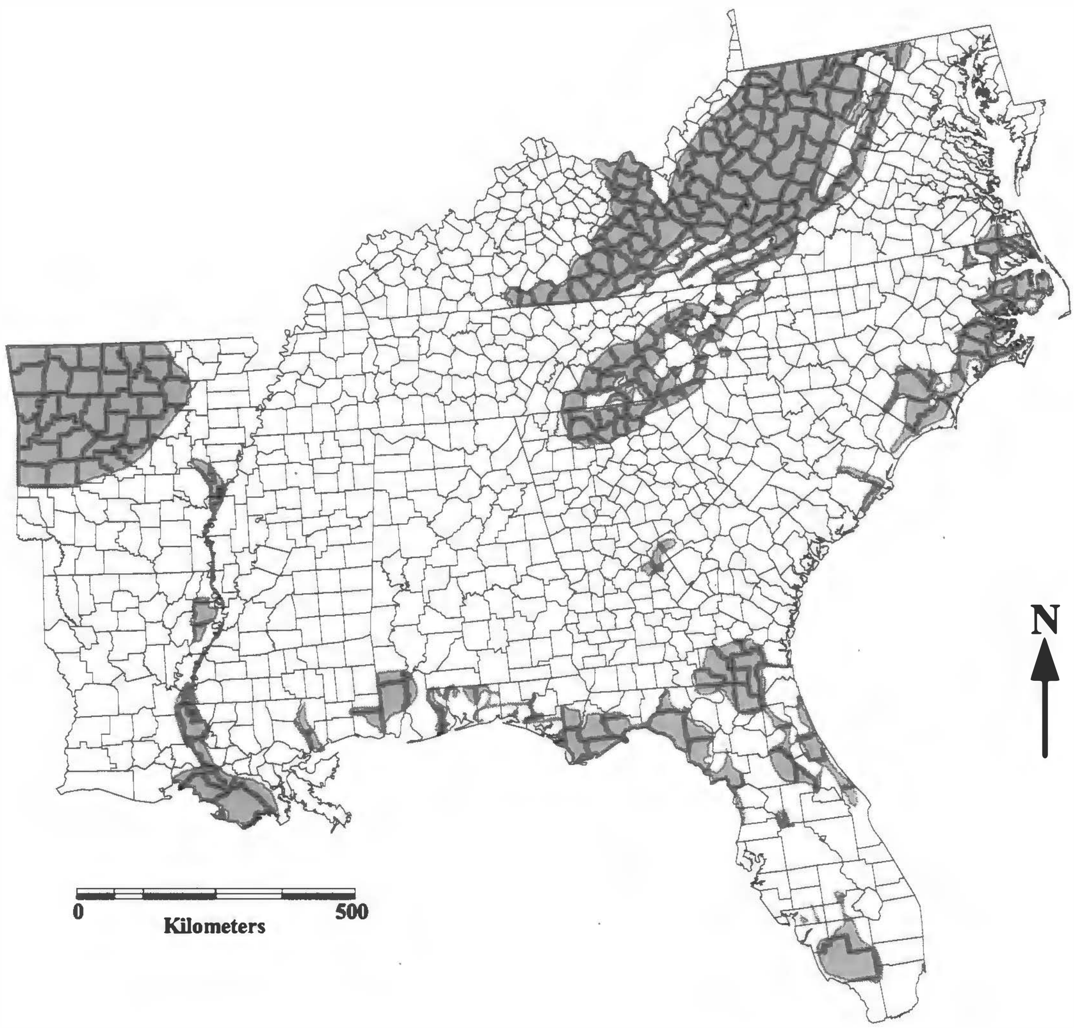


Fig. 1. Current distribution of the American black bear (*Ursus americanus*) in the southeastern United States. (Pelton and van Manen 1997).

season is held adjacent to the Okefenokee National Wildlife Refuge, where numbers are deemed sufficient to support harvest (Kasbohm and Bentzien 1998). In 1990, the U. S. Fish and Wildlife Service (USFWS) was petitioned by The Fund for Animals to list the Florida black bear as a threatened subspecies under provisions of the Endangered Species Act of 1973. The petition cited illegal hunting, loss and fragmentation of critical habitat, and road mortality as the primary threats (Kasbohm and Bentzien 1998). On 7 January 1992, the USFWS concluded that the listing of the Florida black bear as a threatened species was warranted but precluded by higher priority listing actions (Wooding 1992). In 1997, the USFWS entered into a revised settlement agreement with The Fund for Animals, agreeing to resolve the conservation status of the Florida black bear by 31 December 1998. After reviewing all available information, the USFWS ruled that federal listing of the Florida black bear was not warranted at that time (Kasbohm and Bentzien 1998). Bentzien (1998) indicated that 4 of 7 distinct black bear populations were viable, which would ensure the perpetuation of the subspecies over its current range. The Alabama population, however, was not considered viable due to low numbers, shrinking habitat, and genetic deficiencies. The Defenders of Wildlife, Fund for Animals, and Sierra Club sued the USFWS in August 1999 concerning listing of the Florida black bear, citing habitat loss and fragmentation as major reasons for listing. In December 2001, the federal judge for this case directed the USFWS to readdress the listing decision, citing inadequate regulatory measures (J. Kasbohm, USFWS, personal communication). Thus, the future listing status of the subspecies remains uncertain.

Because of concerns regarding the viability of this subspecies in Alabama, a partnership between state and federal wildlife agencies, conservation groups, the academic community, and forest industry was formed in May 1997: the Alabama Black Bear Alliance (ABBA). The mission of ABBA is to promote awareness and conservation of the black bear in Alabama through education, research, and habitat management. ABBA was modeled after the Black Bear Conservation Committee formed in 1990 to address issues regarding the Louisiana black bear. ABBA was founded on the premise that providing landowners with incentives to protect and manage bears can be a successful alternative to restrictive regulatory processes.

Justification

Black bears in Alabama represent one of the least understood populations of bears in the Southeast. Most historical accounts of black bears in Alabama are unsubstantiated or anecdotal, and demographic data are scarce. Since the mid-1980s, only 2 brief studies were conducted on black bears in Alabama.

Dusi et al. (1987) captured and radiomonitored 5 bears from 1985 to 1987 on a 65-km^2 area containing Hell's Creek Swamp northwest of Saraland, in Mobile County. Annual and winter (January–March) home ranges were calculated. During 1993, Kasbohm et al. (1994) captured 10 bears in the same general area of Mobile County for a taxonomic review of bears in the southeastern United States. Bears were captured to obtain tissue samples for a genetic study. The genetic analysis, along with morphological traits of some animals (i.e., cryptorchidism, prolapsed rectum, kinked or absent coccygeal vertebrae), suggested that inbreeding was occurring within this population (Kasbohm et al. 1994). Inbreeding can decrease overall heterozygosity resulting in inbreeding depression (Ralls et al. 1986), which may lead to an increase in the expression of harmful recessive genes (Allendorf and Leary 1986).

According to the Alabama Department of Economic and Community Affairs (1997), the human population of Baldwin, Choctaw, Clarke, Mobile and Washington counties in southwestern Alabama was 436,244 in 1970. By 1990, the human population had increased by 23% to 536,875, and is expected to reach 656,995 by 2010. Ninety-nine percent of the population growth in these 5 southwestern Alabama counties from 1970 to 1990 occurred in Mobile and Baldwin counties (Alabama Department of Economic and Community Affairs 1997). Continued development is expected in north Mobile County where the majority of bears have been captured in past studies (Kasbohm and Bentzien 1998). Thus, the future of the black bear in the region could remain uncertain. Reproductive rates, distribution, relative density, and factors influencing reproductive success have not been adequately documented in this population. Such information is needed to guide management decisions and to determine proper measures to secure the future of this population.

Objectives

This study was conducted to investigate the ecology and life history of black bears in southwest Alabama. Specifically, my study objectives were to:

1) determine the distribution of black bears in southwest Alabama,
2) estimate demographic parameters such as population viability, probability of extinction, and population growth rate, and
3) determine habitat use, home range, and movement patterns of black bears.

CHAPTER II

STUDY AREA

General

The study area encompassed all or portions of Mobile, Washington, Baldwin, Clarke, and Choctaw counties in Alabama (Fig. 2). Within these counties, the Alabama and Tombigbee rivers converge to form the Mobile River. This river and its distributaries, the Tensaw and Middle rivers, form the Mobile-Tensaw River Delta. Habitat in the delta mainly consists of permanently flooded swamp forests and seasonally flooded bottomland hardwood forests. Habitats adjacent to the delta included small creek swamps with mixed pine-hardwood uplands.

Climate

The climate in southwest Alabama is subtropical with long, hot, and humid summers and short, mild winters (National Oceanographic and Atmospheric Administration [NOAA] 1978). Daily temperatures ranged from 6–17° C in January and from 22–32° C in July. The growing season averages 275 days per year (NOAA 1978).

Annual mean precipitation for the study area was 170 cm, with summer thunderstorms accounting for a high percentage of annual rainfall totals. July is the wettest month, with precipitation averaging 22.5 cm. Fall is the driest season with October precipitation averaging 6.4 cm. Hurricanes occasionally strike the coastal areas

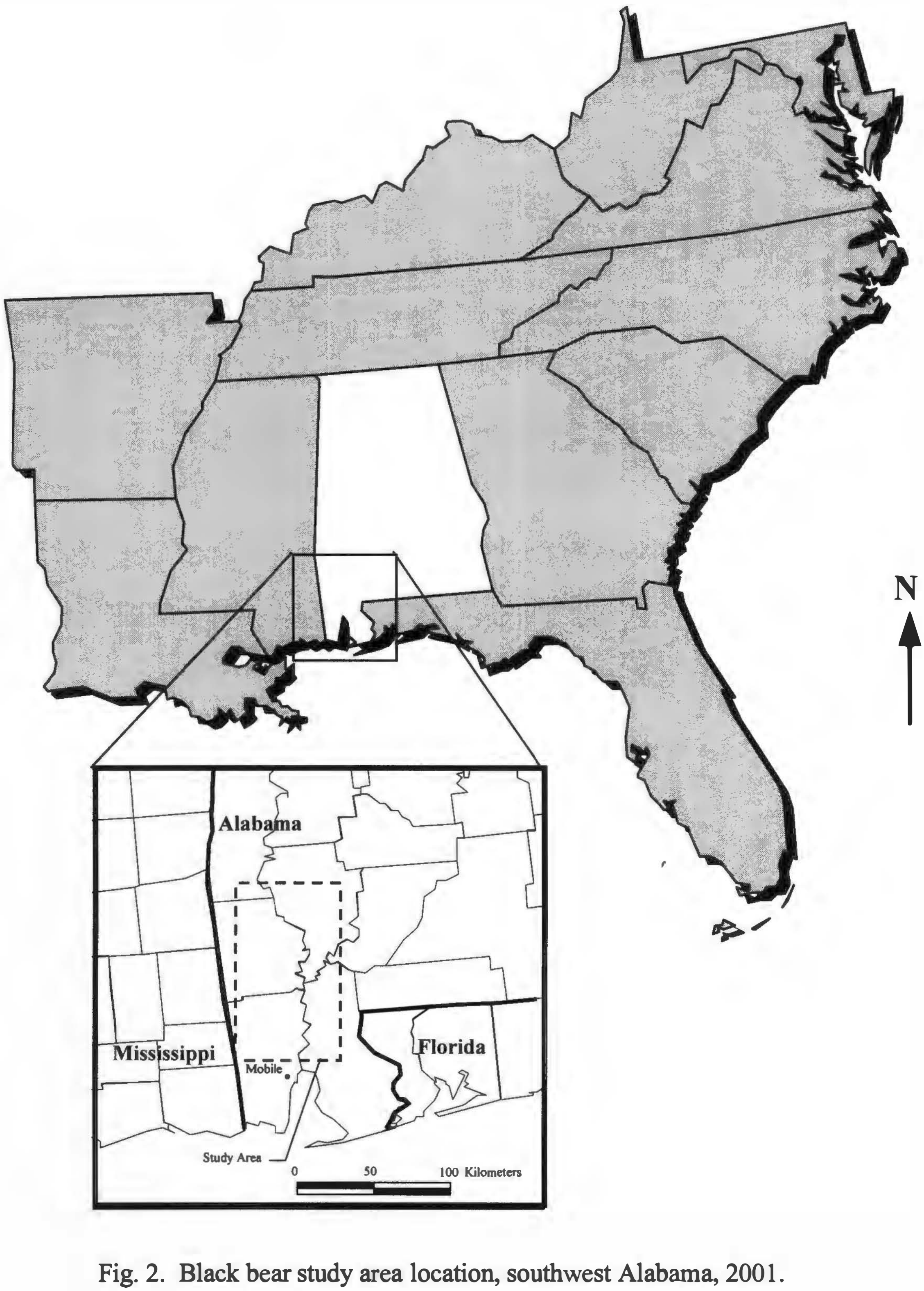


Fig. 2. Black bear study area location, southwest Alabama, 2001.

from August through early October, bringing heavy wind and rain (NOAA 1978). Winter precipitation is usually associated with west to east frontal movement (Bailey 1980); snowfall is rare (NOAA 1978).

Geology and Soils

The study area lies in the ecological province classified by Bailey (1980) as the Outer Coastal Plain Mixed Forest. Topography of the area is gently rolling with local relief <90 m. Sluggish streams, marshes, swamps, and lakes are numerous. Soils of the area are mainly Ultisols, Spodosols, and Entisols. Most are acidic and upland soils are low in major plant nutrients. The soils are derived mainly from coastal plain sediments ranging from heavy clay to gravel, with sandy materials predominant. Sands are prevalent in hilly areas, with silts occurring in lower areas (Bailey 1980).

Flora

Southwest Alabama lies in the temperate rainforest zone (Bailey 1980). Temperate rainforests have fewer species of trees than equatorial or tropical forests but larger populations of individual species. Common tree species include evergreen oaks (*Quercus* spp.), bays (*Persea* spp.), and magnolias (*Magnolia* spp.). Temperate rainforests have a well-developed understory that includes small palms, shrubs, and herbaceous plants (Bailey 1980). The sandy uplands support forests of various oak species, as well as loblolly pine (*Pinus taeda*), longleaf pine (*P. palustris*), and slash pine (*P. elliottii*), whereas baldcypress (*Taxodium distichum*), tupelos (*Nyssa* spp.), and oaks dominate swamp canopies.

Fauna

The diversity of habitats in southwest Alabama supports a wide variety of terrestrial wildlife. Over 300 species of birds occur within the Mobile-Tensaw Delta, of which >110 species nest in the area. The area also hosts >40 mammal, 69 reptile, and 40 amphibian species (B. Hart, Alabama Natural Heritage Program, unpublished data). Game species include white-tailed deer (*Odocoileus virginianus*), feral swine (*Sus scrofa*), raccoon (*Procyon lotor*), squirrel (*Sciurus* spp.), rabbit (*Sylvilagus* spp.), bobwhite quail (*Colinus virginianus*), eastern wild turkey (*Meleagris gallopavo*), mourning dove (*Zenadia macroura*), and various waterfowl species. Non-game species include nine-banded armadillo (*Dasypus novemcinctus*), river otter (*Lutra canadensis*), American alligator (*Alligator mississippiensis*), and the eastern diamondback rattlesnake (*Crotalus adamanteus*). Federally threatened or endangered species inhabiting southwest Alabama include the wood stork (*Mycteria americana*), gopher tortoise (*Gopherus polyphmus*), and the red-cockaded woodpecker (*Picoides borealis*).

Land Use

Land in the study area was primarily used for timber production. Vissage and Miller (1990) classified 78% (12,252 km^2) of the land area for these 5 counties as a forested habitat type. The forested land was primarily in private and industrial ownership, with a small portion in state and federal ownership. Even-aged plantations of loblolly, longleaf, and slash pine dominated upland sites and were managed on a 30- to 60-year harvest rotation. Hardwood forests in lowland areas were generally maintained through natural regeneration. Timber harvested in the creek swamps and river delta consisted of larger and more mature trees compared with upland sites. These bottomland species included bald cypress, tupelo, sweetgum (*Liquidambar styraciflua*), green ash (*Fraxinus pennsylvanica*), American sycamore (*Platanus occidentalis*), and various oak species including water oak (*Quercus nigra*), willow oak (*Q. phellos*), Nuttall oak (*Q. nuttalii*), overcup oak (*Q. lyrata*), and swamp chestnut oak (*Q. michauxii*).

Timber regeneration techniques on bottomland and upland sites include clearcutting and shelterwood cuts. The average clearcut area was <40 ha (100 ac). There were 23 wood-product mills that used wood or wood fiber grown within the study area (D. Powell, Mobile Forest Products, personal communication). Income from forest products for the 5 counties in the study area totaled $144 million in 1999 (Alabama Agricultural Statistics Service 2000). Six percent (958 km^2) of the land area of the 5 counties was in hay, corn, and cotton production (United States Department of Agriculture 1997). The remaining 16% of the land area in these counties was in developed urban or suburban areas (Vissage and Miller 1990).

CHAPTER III

MATERIALS AND METHODS

Bait-Station Surveys

Low black bear densities in the large study area precluding systematic trapping of the entire area. Therefore, I employed bait-station surveys to indicate where bears were present within the large study area (Johnson and Pelton 1980). I established bait sites in 1998 throughout the 5-county study area. Bait stations consisted of cotton swabs soaked in raspberry candy base extract (Mother Murphy's, Greensboro, North Carolina, USA) and plastic drink bottles filled with shelled corn suspended about 2 m high from tree limbs. Bear presence was denoted by the removal of bait or claw marks on the tree. I checked some baits every 3 to 4 days, and others at approximately weekly intervals for evidence of bear visitation. If necessary, I freshened scent lures and baits at that time. I conducted bait-station surveys from June through October during 1998, and from May to November during 1999 and 2000. Individual bait sites remained in place from 2 weeks to 3 months. Because I could not calculate the total number of station-nights for the first year of the study, bait-site visitation only served as an indicator of bear presence, not as a quantitative measure of bear density or abundance.

Trapping and Handling

I established traps in areas where bear presence was detected (i.e., observation of field sign or bait-station visits). I conducted trapping from 22 October–20 November 1998, 22 June–4 November 1999, and 24 May–29 October 2000. I captured bears using

Aldrich spring-activated foot snares (Aldrich Animal Trap Company, Clallam Bay, Washington, USA) as described by Johnson and Pelton (1980). Snares were equipped with swivels and automobile hood springs to minimize injuries to captured animals (Johnson and Pelton 1980). Snares were secured to trees $\geq$15 cm in diameter, or when suitable trees were not available, mobile home earth anchors were used. I placed traps in shaded areas near stream drainages and food plots and removed vegetation with stems >1 cm in diameter to prevent entanglement. All traps were checked daily before noon.

I used trail sets and modified cubby sets to capture bears (Clark 1991). Traps were baited with a mixture of whole shelled-corn and cattle-feed molasses placed in plastic beverage bottles. Additionally, I used raspberry extract as a scent attractant. When bears visited traps on >2 occasions without a capture, I changed trap appearance and placement, or placed additional snares at trapsites where bears were particularly trap savvy. I also used motion-sensitive cameras (Cam Trakker, Watkinsville, Georgia, USA; Moultrie Game Cam, Moultrie Feeders, Alabaster, Alabama, USA) at trap sites to take pictures of bears that were taking bait.

I immobilized captured bears using a mixture of ketamine hydrochloride (Ketaset®, Fort Dodge Animal Health, Fort Dodge, Iowa, USA) 200 mg/ml, and xylazine hydrochloride (Rompun®, Bayer Corporation, Shawnee Mission, Kansas, USA) 200 mg/ml. Body mass of captured bears was estimated to determine the proper drug volume based on a dosage of 1 ml/22.7 kg (50 lb) body mass. I intramuscularly administered the immobilization drug with a push pole.

Upon immobilization, I placed an optical wetting solution (Akwa Tears, Akorn Incorporated, Abita Springs, Louisiana, USA) in the bear's eyes to prevent desiccation or contamination. I removed the snare loop and examined the bear's foot for injury and monitored pulse, body temperature, and respiration throughout the workup. Bears with body temperatures >103° F were doused with water to prevent overheating. Injuries were treated with external and internal antibiotics (LA-200® liquamycin, oxytetracycline, Pfizer Animal Health, New York, New York, USA) at a dosage of 4.5 ml/45.4 kg (100 lbs). I injected lactating females with 1 ml of oxytocin (Oxoject®, Burns Veterinary Supply, Rockville Centro, New York, USA) to counteract the inhibiting effect of the immobilization drug on lactation.

Each bear received a uniquely numbered ear tag (Fearing Corporation, South Saint Paul, Minnesota, USA) and a lip tattoo, which was applied using 0.8-cm numeric digits (Nasco, Fort Atkinson, Wisconsin, USA) and animal tattoo ink (Ketchum Manufacturing Inc, Ottowa, Ontario, Canada). I fitted a radio collar (Lotek Wireless Inc., Newmarket, Ontario, Canada) on bears I estimated to be >1 years of age (i.e., >22.5 kg). The collar was equipped with a leather spacer measuring 12.5 cm long by 4 cm wide between the collar ends. This spacer was treated with linseed oil and was expected to deteriorate within 2 years, thus allowing collars to be retrieved before the batteries expired.

I extracted a first upper premolar from each bear for aging by cementum annuli analysis (Willey 1974). Sectioning, staining, and aging of teeth was performed by Matson's Laboratories (Milltown, Montana, USA). Each bear was weighed using a spring scale, and the following body measurements were recorded: total body length, head length, head width, zygomatic circumference, shoulder height, forearm circumference, foot pad length and width, and chest circumference (Eason 1995). I also recorded descriptive information including sex, general condition, reproductive status, age class, ectoparasite load, prominent scars and wounds, and anomalies. Finally, I collected hair samples for microsatellite DNA analysis (Paetkau and Strobeck 1994).

After I collected all measurements and information, I injected bears with yohimbine hydrochloride (Spectrum Laboratory Products, New Brunswick, New Jersey, USA), (an antagonist for xylazine hydrochloride) at a dosage of 5 mg/22.5 kg into the sublingual or femoral vein. Recovery time was approximately 30 min for most bears. All immobilization procedures were in accordance with University of Tennessee Animal Care Protocol #905.

Radio Telemetry

In 1999, I attempted to locate collared bears once every 10 days with fixed-wing aircraft (Cessna 172) or from the ground. In 2000, I located bears 2 times per week by airplane. I collected aerial locations during morning hours, generally from 0800 to 1200. Aircraft were equipped with 2 wing-strut mounted, 2-element, H-antennas (Telonics Incorporated, Mesa, Arizona, USA), a model TR-2 receiver (Telonics Incorporated, Mesa, Arizona, USA), and a toggle twitch to change reception between antennae. I obtained locations by directing the pilot toward the strongest radio signal for a particular bear. When signal strength was the same from both antennae, the pilot flew along the same bearing until the strongest signal was achieved. I then assumed bears to be directly under the airplane, at which time I estimated Universal Transverse Mercator (UTM) coordinates using a global positioning system (GPS; Garmin GPS II, Olathe, Kansas, USA). Flights typically were at an altitude of 300 m (1000 ft).

Telemetry Error Analysis

I estimated telemetry error by placing test collars throughout the study area, in locations unknown to the observer. I then estimated the location of the test collars using procedures identical to those used to estimate bear locations. I obtained an error distribution by calculating the distance between the estimated location and the actual location (Schmutz and White 1990, Clark 1991).

Den Visits

I evaluated denning habitat and cub production in March 2000 and 2001. To do so, I first collected radiolocations by airplane for collared bears. I then located denning females using ground telemetry and approached densites to count cubs and assess den characteristics.

Home Range Estimation

I estimated home ranges using the Animal Movement Extension (Hooge and Eichenlaub) to ArcView® Geographic Information System (GIS; ESRI, Redlands, California, USA) with 100% and 95% minimum convex polygon (MCP), and 85% and 95% fixed kernel (Worton 1989) methods. The minimum convex polygon method was chosen because of its graphic simplicity (Clevenger 1986), although overestimation of actual area of activity can occur (Mykytka and Pelton 1988, Lombardo 1993). The fixed kernel method is a nonparametric method that requires no assumptions about underlying distributions (Worton 1989); as such, the effect of outliers is small. Because of the small number of radio-collared bears (16), I chose to include all bears in the estimates of home range size. Minimum sample size requirements were not met for all bears for the methods used. However, I included all bears in the analysis because the knowledge gained from including all bears would outweigh the biases caused by small sample sizes.

Home range overlap was calculated for all radiocollared females. I computed the total area (km^2) for all females using the 95% MCP method, and then measured the area of each bears home range that did not overlap with any other females' home range. I then divided the area of non-overlap by the total area of all MCPs, and subtracted the resulting fraction from 1.

Habitat Use Analysis

Many techniques have been used to analyze habitat use. Habitat analysis methods that measure habitat preference or avoidance (e.g., Neu et al. 1974) encounter the problem of non-independence of proportional use. The avoidance of one habitat type will automatically lead to the apparent preference for the other habitats. To alleviate this, I used compositional analysis (Aebischer et al. 1993) to compare habitat use with availability. Compositional analysis is based on log-ratios of use versus availability. Habitat types were compared using a multivariate analysis of variance (MANOVA). Habitat types are then ranked relative to each other from least to most used. I delineated habitat types for the study area using Multi-Resolution Land Cover data (MRLC; Vogelmann et al. 1998*a*, *b*) at a 30- x 30-m cell resolution. I identified locations in 4 major habitat types: evergreen forest, mixed forest, woody wetlands, and disturbed. The disturbed classification type was composed of urban, open water, pasture, row crop, or orchard. I consolidated these types because of low use by bears and low availability in the landscape. Finally, compositional analysis avoids using individual bears as the sampling unit, thus avoiding the problems associated with pooling radiolocations for individual animals.

Johnson (1980) described habitat use based on a hierarchical framework. First-order selection is the selection of physical or geographical range of a species, second-order selection is the selection of a home range within this geographical range by an individual or social group, and third-order selection is the use of habitats within the home range. I chose to analyze habitat use at the second-order selection level. I used 95% MCP home ranges to estimate the percent use in each habitat class. I did not analyze habitat use at the third-order level due to problems associated with data and analysis methods. These problems included overall small sample sizes of individual locations, an unequal temporal distribution of these radiolocations (0900 and 1200), large telemetry error, inaccuracies in habitat classification of MRLC data, and small habitat patch size.

Various methods of determining available habitat have been used. These include: areas which include the greatest quantity of bear locations (Quigley et al. 1979), utilization distributions of all bears (Brody 1984, Hellgren 1988), and selection of a study area core as available habitat (Smith 1985, Hellgren 1988). To define available habitat, I generated a polygon and an ellipse in ArcView that encompassed all MCP's (Fig. 3); I considered the areas and the habitats within them available habitat. The ellipse included a large portion of the Mobile-Tensaw Delta, whereas the polygon contained only lands west of U.S. highway 43, which runs along the western edge of the delta. I chose to use both analysis extents because the MRLC does not distinguish between bottomland

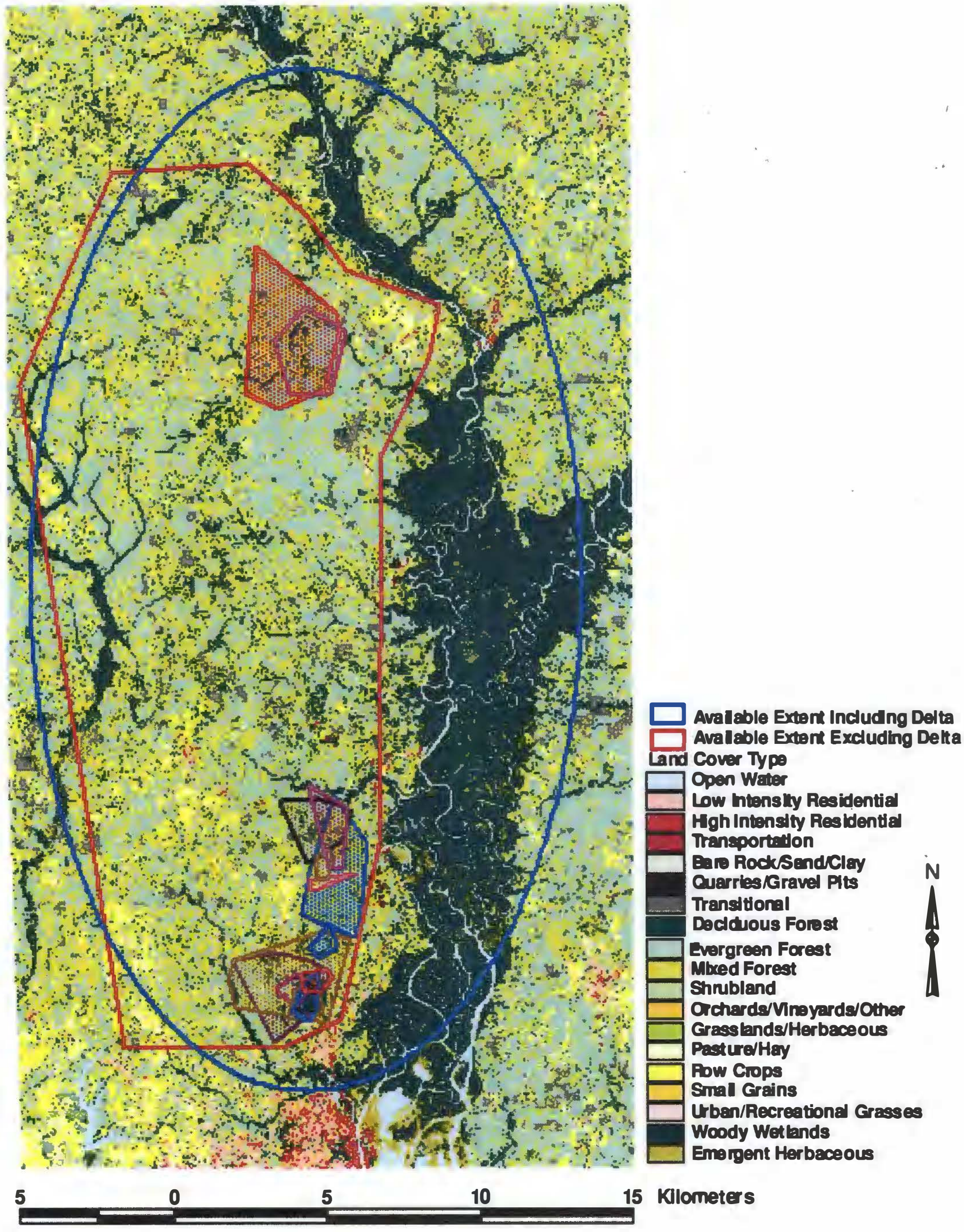


Fig. 3. Study area boundaries to define available habitat use for compositional analysis of black bear habitat selection, and 95% minimum convex polygon home range estimates of all radiocollared bears, southwest Alabama, 2001.

hardwood and permanently flooded swamps of the delta, and small creek swamps and depressional wetlands associated with feeder streams adjacent to the delta. The former were subjected to extensive winter flooding whereas the latter were not. By including the delta in the extent, the importance of these small wetlands may not have been as evident. Thus, both extents were compared. I pooled location data across years for summer and fall seasons because of low sample sizes.

Survival

Techniques used by Trend and Rongstad (1974) and Heisey and Fuller (1985) assume the probability of survival is equal for all individuals and is consistent over the time interval (Folta 1998). It has been shown, however, that bears exhibit different mortality rates depending on sex, age, and time of year (Warburton et al. 1993). Therefore, I estimated annual adult ($\geq$ 3 years; Maddrey 1995) survival with the Kaplan-Meier staggered entry procedure (Pollock et al. 1989), which allows individuals to be added to the sample at any time. The procedure is based on the equation:

$$\hat{S}(t) = \prod_{j/a_j < t} (1 - d_j/r_j),$$

where $\hat{S}$ is the estimated survival rate, a_j is the time of death, d_j is the number of bears that died at time a_j, r_j is the number of bears at risk at time a_j, and t is the time interval. I considered the product of all j terms for which $a_j < t$. The variance (var) of the survival rate is estimated as follows:

$$\mathrm{var}(S[t]) = \frac{[S(t)]^2 [1 - S(t)]}{r(t)}.$$

The Kaplan-Meier procedure is based on the assumption that all bears monitored for survival were randomly sampled, survival times were independent among bears, capturing or radiocollaring did not influence survival, censoring (e.g., dropped collars, bears leaving the study area, etc.) mechanisms were random, and newly radiocollared bears had the same survival function as previously radiocollared bears (Pollock et al 1989, Eastridge 2000). Some bears lost their radio collars before the completion of the study, so I censored them at that time (Pollock et al. 1989).

Population Modeling

I used a population model (RISKMAN, version 1.5.413; Ontario Ministry of Natural Resources, Toronto, Ontario, Canada) to estimate population growth and probability of extinction. This model was based on estimates of cub survival, litter survival (the probability that at least 1 cub in the litter survived), subadult male and female survival, adult male and female survival, litter production rate (the probability that females in reproductive condition [i.e., without the previous year's cubs] would produce a litter), and the probability of producing 1-, 2-, 3-, or 4-cub litters. I generated these estimates from 2 seasons of den work, field observations (i.e., seeing cubs or yearlings with a trapped female), survival estimates generated from my field data, and from a review of literature from other southeastern black bear studies (Table 1). Lombardo (1993), Coley (1995), and Eastridge and Clark (2001) reported cub-of-the-year survival at 0.53, 0.61, and 0.75, respectively, and I chose an estimate of 0.75 because densities were low in Alabama, cub survival should be similar to those reported by Eastridge and

Table 1. Black bear population parameter estimates and standard errors used for population modeling, southwest Alabama.

Parameter	$\bar{x}$	SE	Source
Cubs-of-the-year (COY) survival	0.75	0.23	*A, B, F*
Litter COY survival	0.75	0.23	*F*
Subadult (1yr.) survival (M)	0.75	0.23	*A, F*
Subadult (1yr.) survival (F)	0.78	0.23	*A, F*
Adult (2+) survival (M)	0.85	0.26	This study
Adult (2+) survival (F)	0.88	0.26	This study
Litter production rate (age 3)	0.50	0.15	*A*, This study
Litter production rate (age 4+)	0.75	0.23	*A*, This study
Mean litter size	2.12	0.64	*A, B, C, D*
Probability of COY litter = 1	0.15	0.05	*B, F*
Probability of COY litter = 2	0.60	0.18	*B, F*
Probability of COY litter = 3	0.23	0.07	*B, F*
Probability of COY litter = 4	0.02	0.01	*B, F*

A. Lombardo 1993

B. Coley 1995

C. Anderson 1997

D. Folta 1998

E. Martorello 1998

F. Eastridge and Clark 2001

Clark (2001) for a reestablished population of bears in the Big South Fork National River and Recreation Area, Kentucky-Tennessee. I also incorporated estimates from Eastridge and Clark (2001) in the litter survival (0.75) and probability of producing 1-, 2-, 3-, or 4- cub litters (0.15, 0.49, 0.34, and 0.02, respectively. These estimates are similar to those reported by Coley (2001), for bears in the Great Smoky Mountains National Park, and I adjusted the litter size estimate to account for a higher probability of producing 2 cubs (0.60), because I only documented 2-cub-litters. Adult and subadult survival estimates were generated from the Kaplan-Meier staggered entry procedure for the Alabama population, and adjusted lower to account for small sample size of radiocollared bears, and evidence of significant uncollared bear mortality. The resulting estimates of 0.85, and 0.88 for adult male and female survival, respectively, were similar to those reported by Martorello (1998; 0.83 for females), and Lombardo (1993; males = 0.77, females = 0.69). I incorporated a standard error of 30% of the sample means to account for uncertainty as well as demographic and environmental stochasticity. Additionally, I used the covariance option in RISKMAN to simulate non-independence of parameter variances because environmental variation would likely affect survival and reproduction of all age classes, and the covariance option would allow for this in the stochastic trials.

I performed 100 stochastic simulation trials starting with the standing age distribution from 1998. Ages for bears captured after 1998 were back calculated from capture age, and considered to be in the population in 1998. To evaluate the effect that starting population sizes may have had on the simulation, I used starting population sizes of 20 and 40 in addition to my best estimate of 30 bears. I normalized the age structure to fit the new initial population estimate. Density effects were not included in the simulations.

Microsatellite DNA Analysis

I used DNA extracted from hair samples of captured or deceased bears to determine levels of heterozygosity as described by Boersen (2001). I inspected hairs for attached roots, and cut approximately 0.6 cm of the root end from $\geq$10 hairs for microsatellite analysis. Microsatellite analysis was performed at the USGS Aquatic Ecology Laboratory (AEL) at the Leetown Science Center, Kearneysville, West Virginia.

Eight microsatellite loci described by Paetkau and Strobeck (1994; G1A, G1D, G10B, and G10L), and by Paetkau et al. (1995; G10C, G10M, G10P, and G10X) were analyzed for all hair samples. Materials and methods used by AEL staff were described by Dobey (2001). I calculated the number of observed alleles and their frequencies and an overall measure of heterozygosity.

I used the neighborhood-joining method (Saitou and Nei 1987) of numerical taxonomy to fit an unrooted tree to a pair-wise genetic distance matrix using the neighbor-joining algorithm in program Phylip 3.6 (Joe Felsenstien, University of Washington, Seattle, Washington, USA). TreeView (Page 1996) was used to visualize the tree and relatedness among individuals. The neighborhood-joining method creates a modified distance matrix in which closely related individuals are paired on a node. The separation between each pair of nodes is adjusted based on their average divergence from all other nodes. The neighborhood-joining tree is constructed by linking the least-distant pair of nodes in the matrix and creating a parent node. The two nodes are then replaced with the parent node, and this step is repeated until all associations between individuals are represented.

CHAPTER IV

RESULTS

Bait-Station Surveys

I established and monitored 168 bait stations within the study area from 1998 to 2000. Some stations were monitored for as long as 6 weeks. I recorded bear visits at only 25 bait stations, all of which were located in Mobile and Washington counties (Fig. 4).

Trapping and Handling

From 1998 through 2000, 1,263 trapnights at 53 trap locations resulted in 23 captures of 17 (10F: 7M) bears. Of the 53 trap sites, 34 had bear activity (Fig. 5). I captured 3 (2F: 1M), 7 (4F: 3M), and 7 (4F: 3M) different bears in 1998, 1999, and 2000, respectively (Table 2). Overall trap success was 1.8%, averaging 55 trap-nights per capture. In 2000, approximately 200 pictures were taken with motion-triggered cameras of bears at bait stations or trapsites.

Radio Telemetry

I radiocollared 16 (10 female, 6 male) bears from October 1998 to September 2000. Bear M14 was captured as a cub, and was not fitted with a radio collar. One bear (F02) dropped her collar shortly after being captured in 1998, and I did not monitor her until she was recaptured in June 2000. I collected 466 aerial locations on the 16 bears from May 1999 to March 2001 averaging 29 locations (range = 11–45) per bear.

Fig. 4. Bait-station locations and associated bear activity southwest Alabama, 2001.

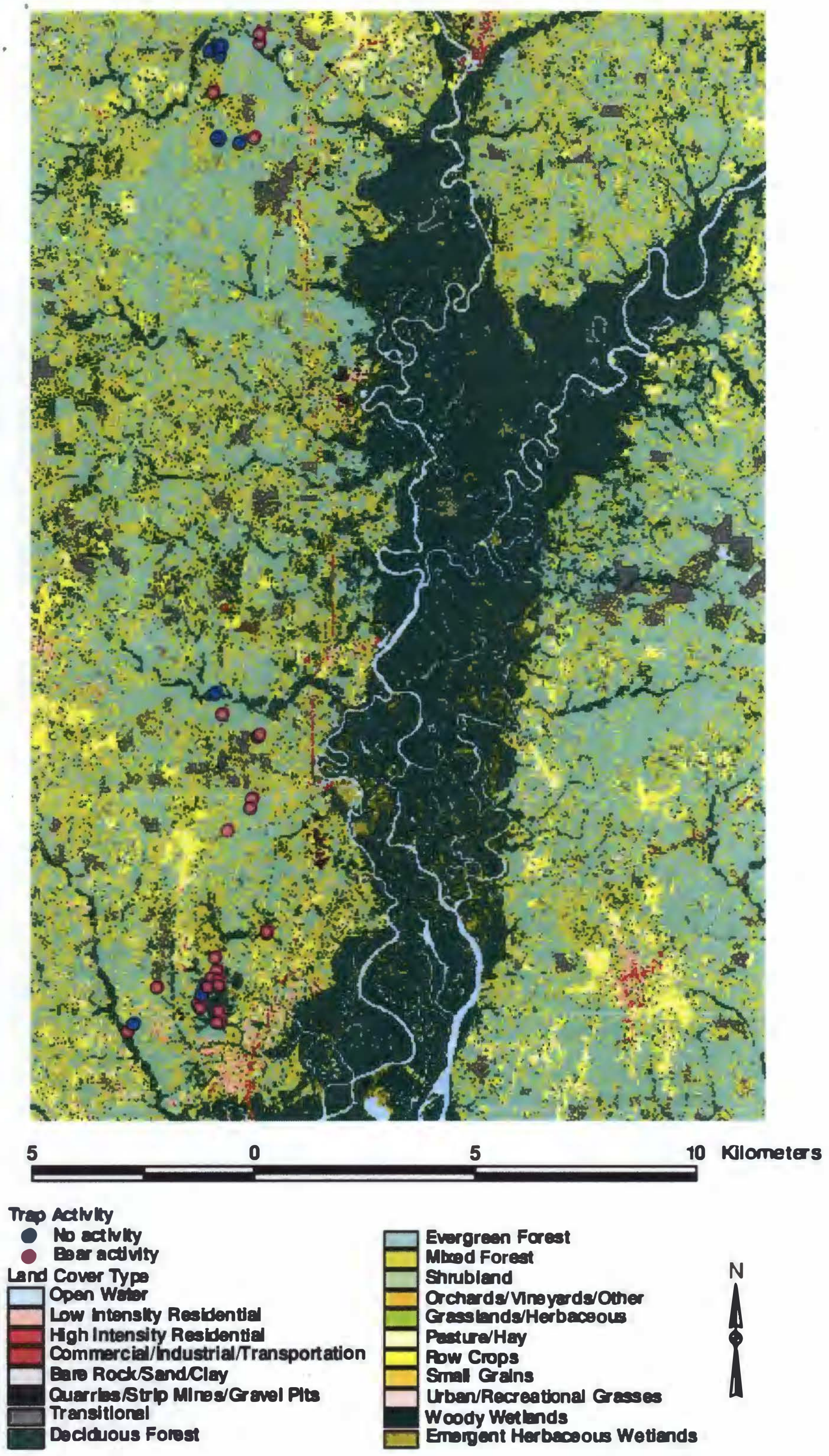


Fig. 5. Trap locations and associated bear activity southwest Alabama, 2001.

Table 2. Capture histories and fates of bears captured in southwest Alabama, 1998–2000.

Bear ID	Capture Method	Initial Capture	Sex	Weight (kg)	Age (Years)	# of Locations	Fate as of March 2000
F00	Vehicle	02/08/98	F	55	2.75	0	Mortality
F01	Snare	23/10/98	F	36	1.75	43	Dropped collar
F02	Snare	25/10/98	F	55	2.75	30	Alive
M03	Snare	19/11/98	M	95	3.75	24	Dropped collar
F04	Snare	18/07/99	F	48	5.50	45	Alive
M05	Snare	18/07/99	M	48	2.50	45	Alive
F06	Snare	25/07/99	F	41	3.50	44	Alive
F07	Snare	28/07/99	F	55	17.50	44	Dropped collar
M08	Snare	02/08/99	M	95	4.75	15	Dropped collar
F09	Snare	04/08/99	F	27	2.75	43	Alive
M10	Snare	03/10/99	M	52	2.75	38	Alive
M11	Snare	11/07/00	M	100	13.50	16	Mortality
F12	Snare	12/07/00	F	43	4.50	24	Alive
M13	Snare	26/07/00	M	50	3.50	21	Alive
M14	Snare	08/08/00	M	16	0.75	0	Unknown
F15	Snare	13/08/00	F	36	2.75	17	Alive
F16	Snare	31/08/00	F	39	2.75	13	Alive
F17	Snare	25/09/00	F	57	8.75	11	Alive
M18	Vehicle	16/10/00	M	45	1.75	0	Mortality

Telemetry Error Analysis

Based on 23 aerial test locations, mean telemetry error was 368.5 m (SD = 147.4, range = 114–640). Seventy-five percent of the estimated locations were within 383 m of the actual location.

Den Visits

I observed bear F17 with 2 cubs during the summer of 2000 from photographs taken at trap sites. In March 2001, I observed her in a tree with 2 yearlings. In March 2001, I also located females F02 and F06 at their den sites with 2 cubs each. Both females were denning in ground nests in thick cover, and they moved away when I approached. Ground nests were similar in size and habitat characteristics to those described by Martorello (1998), where nests averaged 71.8- x 93.3 cm and were 5.6 cm above the ground.

Home Range Estimation

Annual 95% MCP home range sizes averaged 7.8 km^2 (range = 3.6–20.8 km^2) for females (n = 10; Fig 6), and 67.1 km^2 (range = 31.9–113.8 km^2) for males (n = 6; Fig. 7), and differed by sex ($t_{14} = -8.70$, $P < 0.0001$). The 85% and 95% fixed kernel method produced an average home range size of 11.4 km^2 and 17.6 km^2, respectively, for females (n = 10), and 69.0 km^2 and 114.8 km^2, respectively for males (n = 6; Table 3). Home range overlap using the 95% MCP method was 47.1% for all females, and 81.0% for females in the Hell's Swamp area (Fig. 6).

Table 3. Annual home ranges (km^2) of black bears based on fixed kernel (FK) and minimum convex polygon (MCP) methods, southwest Alabama, 1998–2000.

Bear #	Sex	# of Locations	FK 85%	FK 95%	MCP 95%	MCP 100%
01	F	43	5.6	9.3	5.9	11.1
02	F	30	10.1	17.9	8.1	14.1
03	F	45	9.0	14.4	11.0	13.5
06	F	44	5.8	9.4	4.6	9.20
07	F	44	5.9	10.1	6.8	10.0
09	F	43	5.5	8.6	7.2	6.01
12	F	24	6.4	10.3	6.0	9.0
15	F	17	48.1	64.9	20.8	28.1
16	F	13	8.5	12.9	4.2	7.0
17	F	11	9.6	17.9	3.6	13.0
Average female home range			11.4	17.6	7.8	12.1
03	M	24	56.7	92.4	49.1	62.0
05	M	45	71.2	121.7	88.0	102.5
08	M	15	63.2	109.3	56.3	62.0
10	M	38	66.7	126.6	113.8	227.3
11	M	16	42.8	77.9	31.9	41.1
13	M	21	113.6	160.9	63.4	88.8
Average male home range			69.0	114.8	67.1	97.3

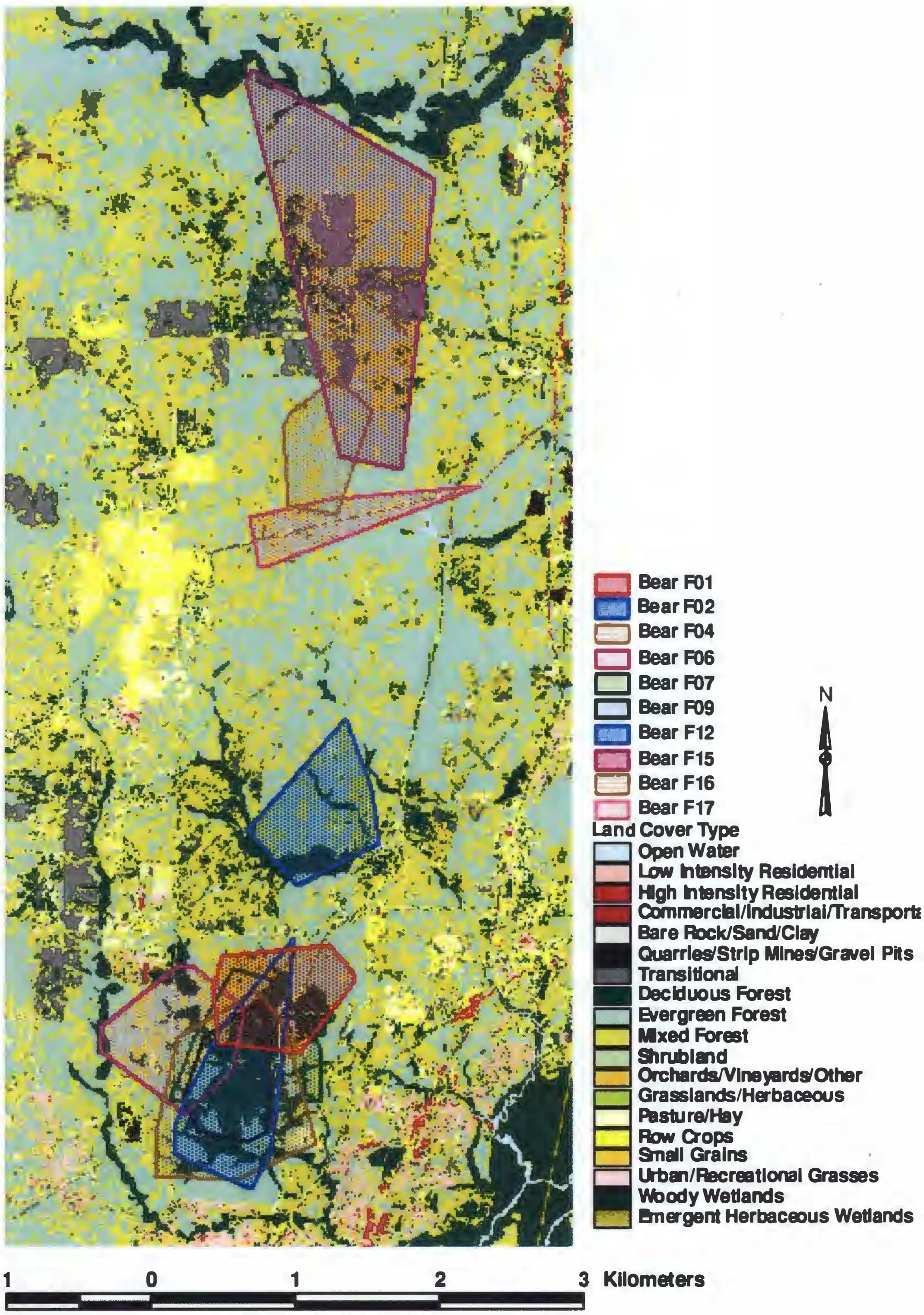


Fig. 6. Minimum convex polygon home ranges (95%) of female black bears, southwest Alabama, 2001.

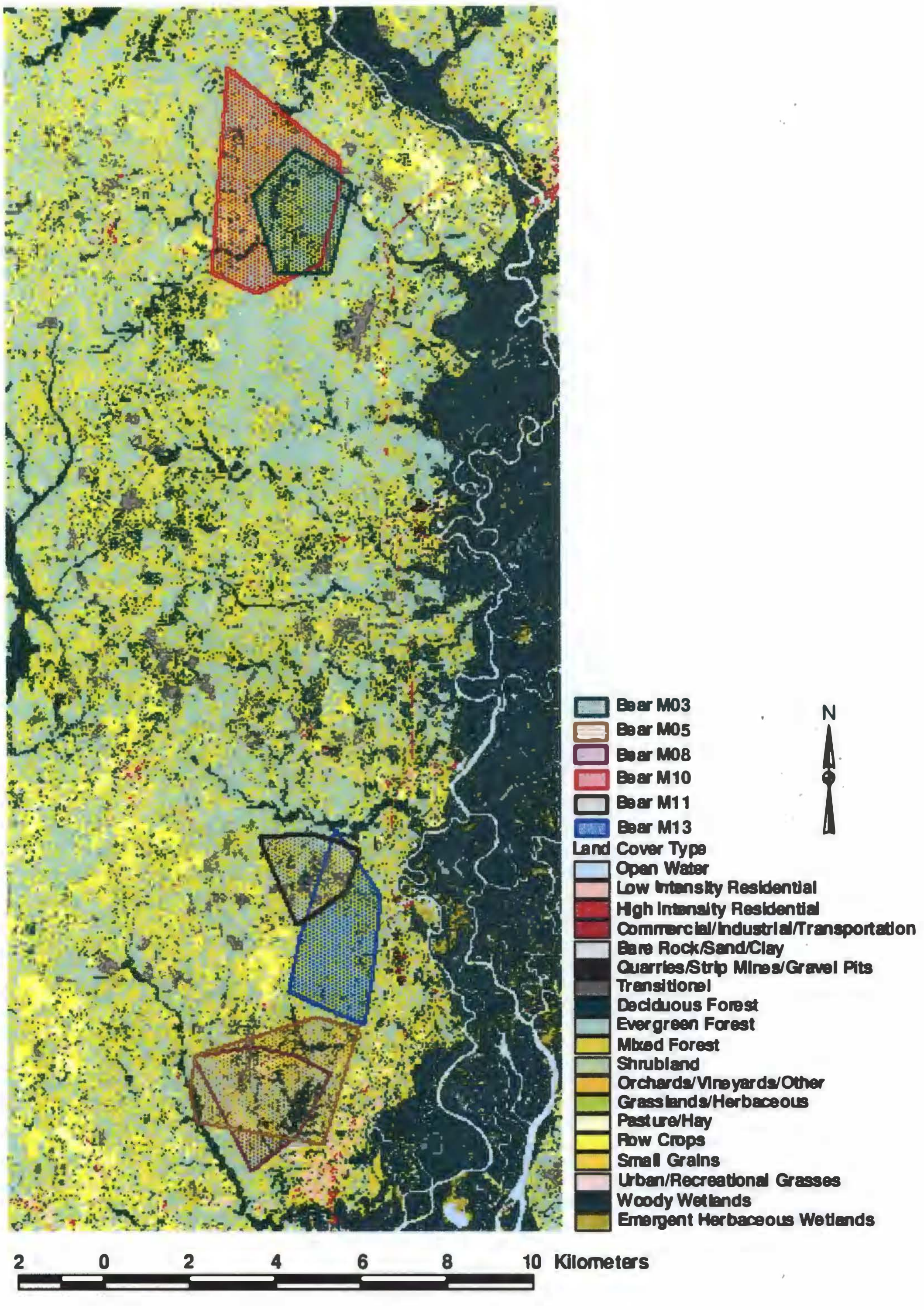


Fig. 7. Minimum Convex Polygon home ranges (95%) of male black bears, southwest Alabama, 2001.

Habitat Use Analysis

The data for compositional analysis were based on the 2 available habitat areas generated around all MCPs (Fig. 3). The data for the available habitat including the delta did not differ from a normal distribution (W = 0.957, *P* = 0.079) and the MANOVA indicated an overall effect (Wilks' Lamda = 0.524, $F_{3, 13}$ = 3.94, *P* = 0.035) of habitat selection at the landscape level (second-order selection). Evergreen forests were ranked higher than woody wetlands, mixed forests, or disturbed habitat types, respectively (Table 4). Evergreen forest did not differ in rank from woody wetlands (*P* = 0.084), but did differ from mixed forests and disturbed habitats (*P* = 0.002 and 0.004, respectively; Table 5).

The data for the available habitat excluding the delta also did not differ from normal (W = 0.958, *P* = 0.083) and the MANOVA indicated an overall effect (Wilks' Lamda = 0.488, $F_{3, 13}$ = 4.55, *P* = 0.022) in the analysis of habitat use at the landscape level (second-order selection). Woody wetlands were ranked higher than evergreen forests, mixed forests, or disturbed habitat types, respectively (Table 4). Woody wetlands did not differ in rank from evergreen forests (*P*= 0.313), but both differed from mixed forests and disturbed habitats (*P*= 0.007 and 0.007 respectively), when compared to evergreen forests (Table 5).

Table 4. Ranking *t*-values and associated *P*-values (in parenthesis) from compositional analysis of 4 major habitat types used by black bears in southwestern Alabama, 1998–2000. The sign of the *t*-value indicates selection relative to referenced habitat type.

Available Habitat Extent: Including Delta

Habitat Type	Evergreen	Mixed	Woody wetland	Disturbed	Rank
Evergreen forests	-	3.6913 (0.0022)	1.8512 (0.0835)	3.4608 (0.0036)	3
Mixed forests	-3.6913 (0.0022)	-	-0.5026 (0.6234)	0.4885 (0.6246)	1
Woody wetlands	-1.8512 (0.0835)	0.5026 (0.6234)	-	0.6214 (0.5409)	2
Disturbed	-3.4608 (0.0036)	-0.4885 (0.6246)	-0.6214 (0.5409)	-	0

Available Habitat Extent: Excluding Delta

Habitat Type	Evergreen	Mixed	Woody wetland	Disturbed	Rank
Evergreen forests	-	3.1423 (0.0067)	-1.0445 (0.3128)	3.0966 (0.0074)	2
Mixed forests	-3.1423 (0.0067)	-	-3.4201 (0.0038)	0.6977 (0.4960)	1
Woody wetlands	1.0445 (0.3128)	3.4201 (0.0038)	-	3.2332 (0.0056)	3
Disturbed	-3.0966 (0.0074)	-0.6977 (0.4960)	-3.2332 (0.0056)	-	0

Rank based on number of positive *t*-values in each row with 3 as the highest rank, and 0 as the lowest.

Table 5. Habitat use rankings of black bears during summer and fall in southwest Alabama, October 1998–November 2000.

Habitat Use Ranking: Analysis Including Delta

	Preference Rank			
	1	2	3	4
Compositional Analysis	Evergreen forest	Woody wetland	Mixed forest	Disturbed

Habitat Use Ranking: Analysis Excluding Delta

	Preference Rank			
	1	2	3	4
Compositional Analysis	Woody wetland	Evergreen forest	Mixed forest	Disturbed

Rank of 1 indicates most preferred, 4 least preferred.

Relative preferences if habitats sharing an underline were not significantly different (P > 0.05).

Survival

I monitored survival of 16 adult bears for between May 1999 and March 2001. Of the 16 bears, 4 lost their collars (3 in summer 2000, 1 in winter 2001) and 1 bear was killed during fall 2000. Cumulative annual survival over the duration of the study was 0.957 (95% CI = 0.88–1.0; Fig. 8).

Population Modeling

With the parameter estimates for the population growth simulation (Table 1), and the initial population set at 30 individuals, the population size was projected to be 289.3 (SE = 31.4) after 100 years (Fig. 9). The mean annual growth rate (λ) was 1.027 ($\pm$ 0.308) (Fig. 10). Given the variance estimates used, the model predicted extinction in 17, 13, and 4% of the trials for initial populations of 20, 30, and 40 individuals, respectively.

Microsatellite DNA Analysis

I analyzed 19 hair samples from 17 live-captures and 2 collected from vehicle-killed bears for genetic variability and calculated observed alleles and frequencies for each of 8 microsatellite loci (Table 6). The average number of alleles per locus was 2.8 (range = 2–4), and the average heterozygosity based on the 8 loci was 31.6% (range = 5–58 %).

The neighborhood-joining tree (Fig. 11) gives a visual representation of the relatedness among individual bears. Bears are represented by identification number, age at capture, and capture location.

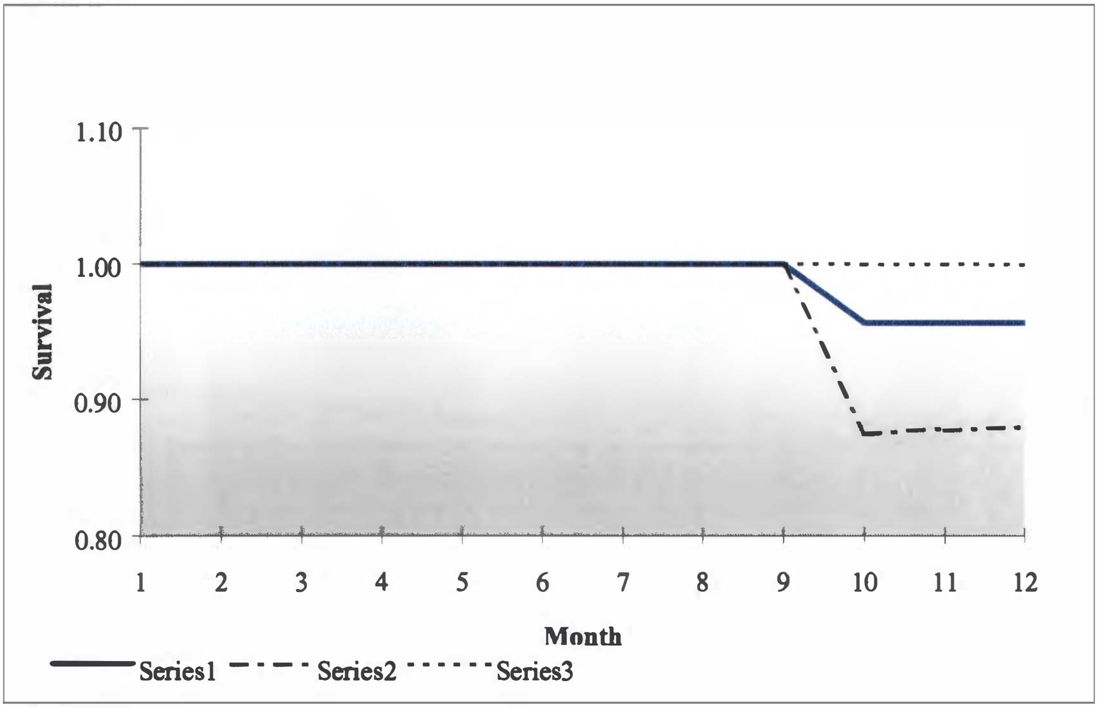


Fig. 8. Combined estimated annual survival curve for radiocollared bears, southwest Alabama, 2001.

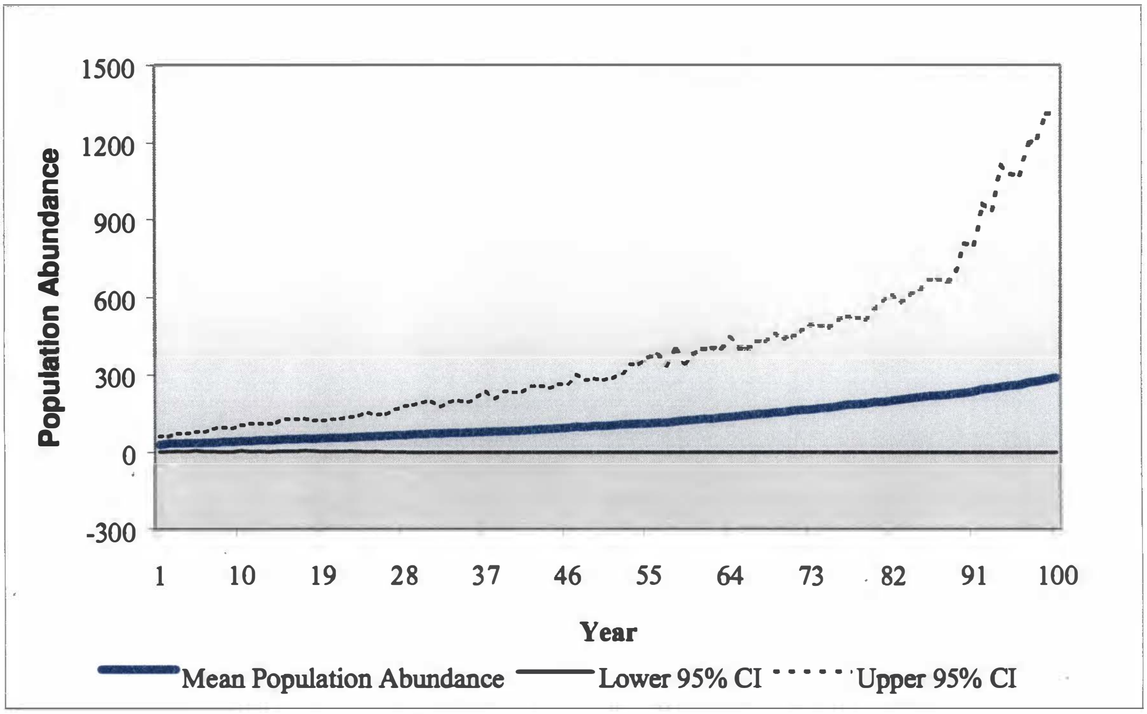


Fig. 9. Projection of black bear population abundance for 100 years beginning in 1998, southwest Alabama.

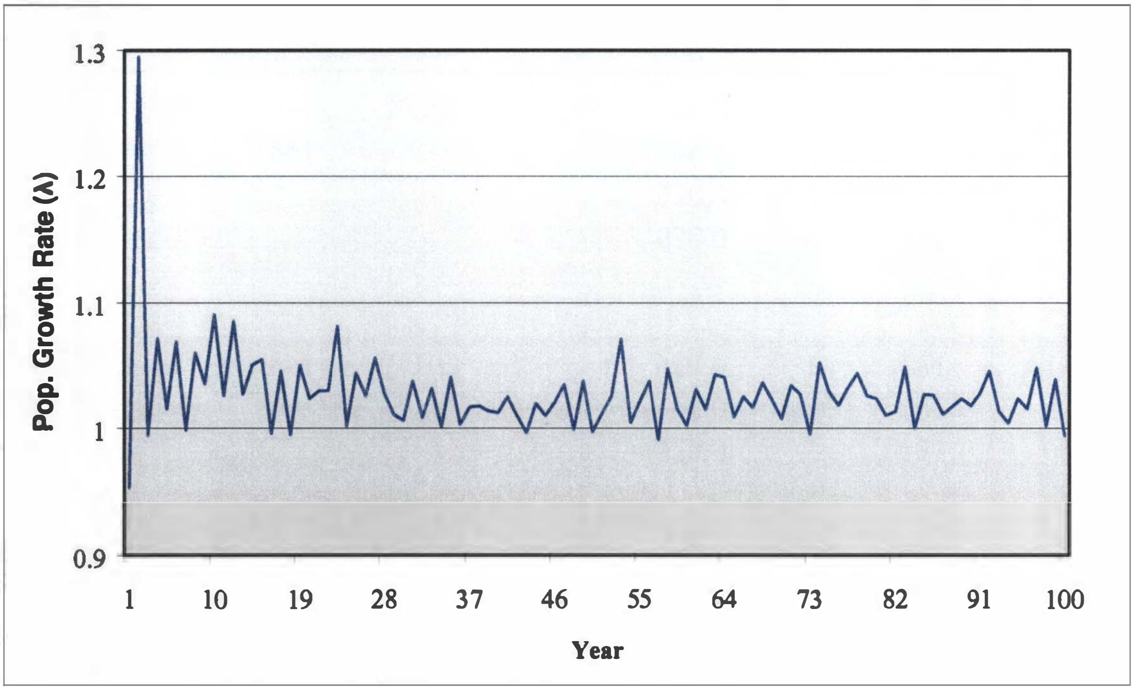
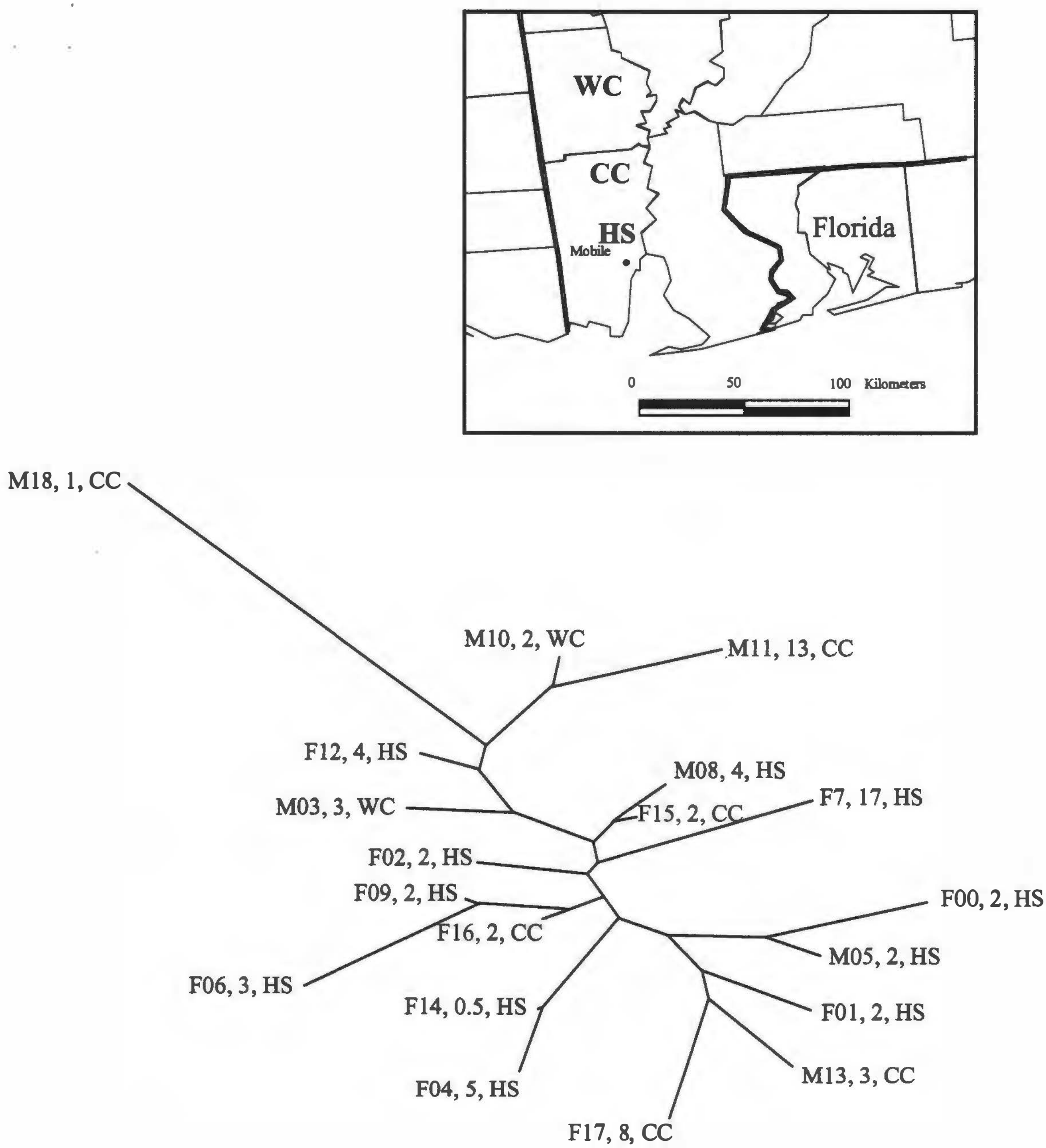


Fig. 10. Projected population growth rate over 100 years for black bears in southwest Alabama beginning in 1998.

Table 6. Observed alleles and frequencies of black bears identified from live captures (n = 17) and mortalities due to vehicle collisions (n = 2), southwest Alabama, 1998–2001.

Locus	Allele	*n*	Frequency	Locus	Allele	*n*	Frequency
G10C	108	17	0.447	G10X	146	35	0.921
	110	17	0.447		158	3	0.079
	112	1	0.026				
	114	3	0.079				
G1A	183	1	0.026	G10P	148	37	0.974
	187	36	0.947		160	1	0.026
	191	1	0.026				
G10B	155	1	0.026	G10L	133	6	0.158
	157	30	0.789		135	1	0.026
	159	1	0.026		151	31	0.816
	167	6	0.158				
G10M	207	21	0.553	G1D	176	13	0.342
	211	15	0.395		186	25	0.658
	217	2	0.053				



CC = Cedar Creek Drainage HS = Hell's Swamp WC = Washington County

Fig. 11. Neighborhood-joining tree representing genetic association between black bears in southwest Alabama, 2001. Labels represent bear identification number, age, and capture location, respectively. Capture locations are indicated on the map above the tree.

Age Determination

Ages were determined for bears captured from 1998–2000, and from 2 mortalities due to vehicle collisions (Table 2). Ages ranged from 0.5–18.0 years with more animals in the younger age classes (Fig. 12).

Vehicle Collisions and Bear-Human Interactions

I recovered an uncollared female, presumably struck and killed by an automobile, from the roadside near Saraland in Mobile County in 1998. In 2000, I documented 3 human-caused mortalities of bears. One collared male (M11) was killed by poachers in October near Turnerville in Mobile County; several days later an uncollared male was poached in this same general area. Another uncollared male was killed in a vehicle collision on highway 43 near the Barry Steam Plant in north Mobile County (Fig. 13). In summer 2001, 2 adult males were killed by vehicles, one near Peterman in Monroe County and the other in Conecuh County near Castleberry. Both bears were killed in areas where I had not previously documented bear presence.

I documented 2 substantiated reports of bears being struck by vehicles and subsequently recovering. Bear M03 ran into the side of a truck on highway 56 approximately 10 km east of Chatom in Washington County during September 1999, and subsequently ran into the wooded area south of Highway 56. I located him by ground telemetry 2 days after the collision, and tracked his movements through August 2000, when his collar dropped off. The collision did not appear to adversely affect the movements of this bear. Bear M05 was struck by a truck on Celeste Road in Mobile County in June 2000. He remained in or near the road for 5–10 minutes after the

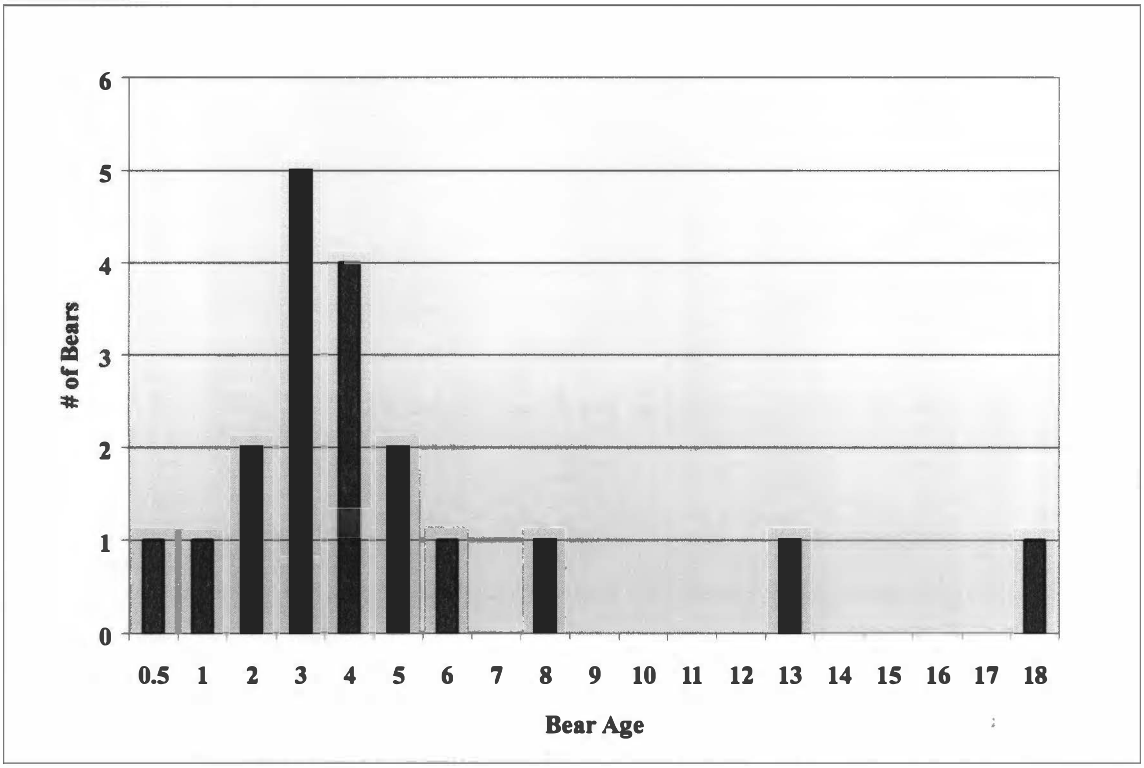


Fig. 12. Standing age distribution of captured black bears, southwest Alabama, 2000.

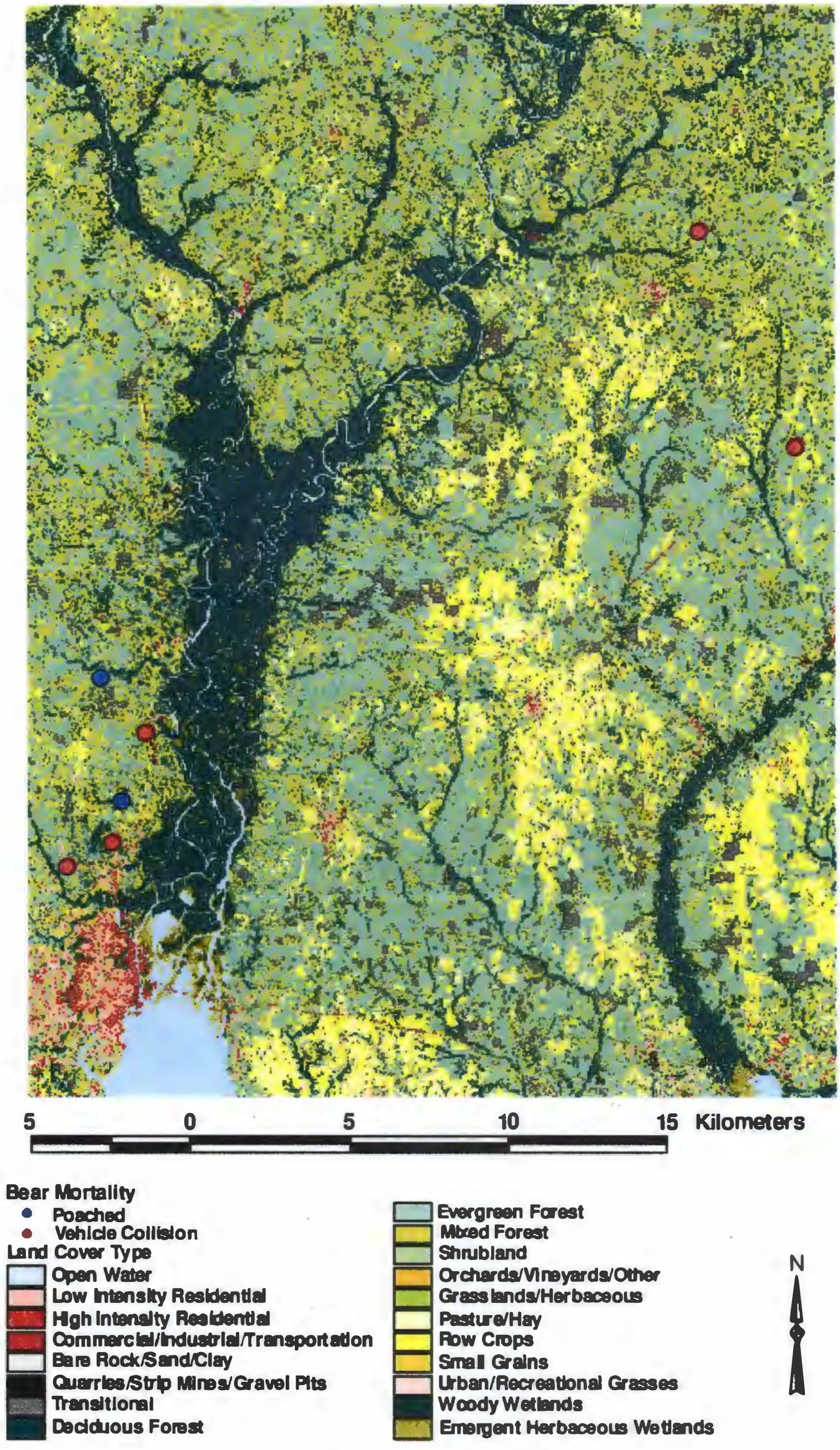


Fig. 13. Human-caused black bear mortalities in southwest Alabama, 1998-2001.

incident. I captured that bear 3 days after the collision, and the only signs of injury were a small cut over his left eye and some abrasions on his forelimbs.

In November 2001, a large male bear began nuisance activity in an area of Mobile County where several radiocollared bears resided. The bear had large ear tags and a collar, but neither matched the description of the ones I had used. It was later discovered that the bear was a nuisance animal from the Poplarville, Mississippi area. Local project supporters monitored his activities, and upon receiving a permit to trap and transport bears, they captured this bear in December 2001 and took it to the Jackson Mississippi Zoo. Other than the incident with the bear from Mississippi, little nuisance activity was reported in the study area. Bears frequently fed at wildlife feeders filled with corn, but rarely ventured into residential areas that surrounded their habitat.

CHAPTER V

DISCUSSION

Population Demographics

Den Visits.– Bears in the southeastern coastal plain have been documented using a variety of den types. These types include ground cavities, rock crevices, tree bases and hollows, brush piles, and ground nests (Johnson 1978, Smith 1985, Hellgren 1988, Martorello 1998). Excavated ground dens are uncommon here because of periodic flooding, and rock crevice dens are rare because of the geologic processes that formed the region (Hellgren 1988). The use of hollow trees dens in the region is common in areas where large diameter trees are available to bears (White River NWR Smith 1985, Tensas NWR Anderson 1997, Okefenokee NWR J. D. Clark, University of Tennessee, unpublished report); however, the most common den type for this and other studies in the region was the ground nest (Hellgren 1988, Lombardo 1993, Brandenburg 1996, Folta 1998, Martorello 1998). In my study, bears likely denned in ground nests because past logging practices had removed many suitable den trees.

Human activities (e. g., deer hunting, logging, land clearing) are common in the areas where the dens were located, and could have some negative impacts on denning bears due to disturbance. For example, F06 denned in a ground nest near Creola in 2001; that area has since been cleared for development. This and other human disturbance may cause reductions in the availability of quality denning habitat and, possibly decrease future breeding success.

I documented reproduction in 3 instances based on den visits. The dens ($n = 4$) that I found in 2001 were located in pine stands with thick understory vegetation and consisted of ground nests constructed of pine duff and leaves. Although sample sizes were small, I documented 3 adult females with cubs. Additionally, younger age classes were well represented in this population, further suggesting that reproduction is occurring in southwest Alabama. The presence of young-aged individuals in the Alabama population is in contrast to a small population of *U. a. floridanus* at Chassahowitzka NWR, Florida, 550 km southeast of my study area. Researchers reported that this bear population consists mostly of old-age individuals, with little or no reproduction (D. Maehr, University of Kentucky, personal communication).

Survival.– The survival rate for collared bears in southwest Alabama was similar to or greater than populations in North Carolina (0.83 and 1.0 Martorello 1998, 0.71 Brandenburg 1996), Virginia (0.84 Hellgren and Vaughan 1989), and Arkansas (0.95 Smith 1985). However, I observed 6 mortalities of uncollared bears (1F, 5M); 5 bears (1F, 4M) were struck and killed by cars and 1 uncollared male bear was poached. The mortality of bear M11, poached in October 2000, was the only mortality of a collared bear during this study. These observations suggest that the cumulative annual survival rate (0.957), estimated from collared bear mortalities, may have been biased high because the sample size of radiocollared bears was low.

Additionally, 2 collared bears survived vehicle collisions during the study, further suggesting that roads are a major mortality factor for bears in southwestern Alabama. Road mortalities are a common cause of death for bears in Florida, where 12 chronic roadkill areas have been identified (Gilbert and Wooding 1996). Finally, poaching may also be a significant mortality factor for the Alabama population. Although it had been speculated that poaching had occurred in the past, the 2 poaching incidents in October 2000 were the first that had been detected during this study. These mortality factors could all be limiting recruitment into this population (Kasbohm and Bentzien 1998).

Population Modeling.– Population viability analysis (PVA) provides a quantitative summary of the conservation status of populations and permits evaluation of the effects on different management recommendations on their long-term survival (Ballou and Padua 1990). PVA has been used to evaluate species in the Southeast including Florida panthers (*Puma concolor coryi*; Seal and Lacy 1989), Florida key deer (*Odocioleus virginianus clavium*; Seal and Lacy 1990), and red-cockaded woodpeckers (*Picoides borealis*; Haig et al. 1993). Some PVA models (i. e., INMAT, VORTEX) take genetic heterozygosity into account in the estimation of viability (Mills et al. 1996), but RISKMAN does not currently include this function. Because I did not know the actual population parameters for bears in southwest Alabama, I could not accurately predict bear population abundance over the next 100 years. Nevertheless, parameter estimates that I chose were realistic if not conservative compared to other southeastern coastal plain populations. For example, only 1 collared bear died during my study, resulting in an adult survival rate of 0.957. Given the number of uncollared bears that died during the study, I adjusted the rate to 0.850 for adult males and 0.875 for adult females. I also assigned high (0.30) standard errors to all the parameters to account for uncertainty in the data, and normal environmental and demographic variation (Miller and Lacy 1999).

Although population growth rates are important, projections beyond a few years can be misleading given my imprecise parameter estimates. More important is the wide variation around those projections illustrated by the model. Thus, stochastic events can have dramatic effects on small populations such as in southwest Alabama. Nevertheless, it is important to note that, in 20 years, the population only increased from 30 to 57 individuals. A population of 57 bears is still at serious risk to stochastic events such as hurricanes, drought, or poor mast years.

Extinction probabilities varied greatly depending on the size of the founding population. With 20 individuals and the parameter estimate I used, the population has a 17% extinction probability, or >4 times that with an initial population of 40 (4%). This suggests that bears are at a critical time in their existence in Alabama. The loss or gain of only a few individuals could greatly affect the stability and perpetuity of the population, illustrating that an error in the population estimate could affect how the health of the bear population is perceived. Finally, my model is based on the assumption that habitat conditions will remain stable. This is unlikely; bears near Creola could eventually be surrounded or displaced by development, which would dramatically increase the extinction probability.

A PVA conducted on the giant panda (*Ailuropoda melanoleuca*) suggested that, to meet the conservation goals for the population, extinction probability must be <2% (Wei et al. 1997). That objective is currently out of reach for the bear population in Alabama, with extinction probability >4% at best.

Microsatellite DNA Analysis.– The size of the southwest Alabama population is unknown (Kasbohm and Bentzien 1998) but was estimated to be <50 (Pelton and van Manen 1997); my field observations and genetic data support this estimate. Miller

(1995), with the use of DNA fingerprinting band sharing data, indicated that this population had the lowest level of genetic diversity of 18 black bear populations examined in the southeastern United States; my data also support that claim. Although I captured no previously untagged bears in my study that exhibited morphological anomalies described as common by Kasbohm (1994), this may not indicate that inbreeding problems do not exist. The symptoms of inbreeding depression simply may not have been as outwardly expressed in my study.

The average number of alleles per locus and average heterozygosity for the Alabama population was low compared with other southeastern black bear populations (Table 7). Dobey (2002) found heterozygosity levels of 66.3% and 67.9% for black bear populations at Okefenokee NWR, Georgia, and Osceola National Forest, Florida, respectively. Those levels may be relatively high when compared to other populations in the southeastern United States. Boersen (2001), and Maehr (2000) reported heterozygosity levels of 47.4% and 39.0% for black bear populations at Tensas NWR, Louisiana and Chassahowitzka NWR, Florida, respectively. In southwest Alabama, low number of alleles per locus (indicative of genetic drift and a severe population bottleneck) and decreased heterozygosity (likely indicative of inbreeding) are likely due to geographic isolation and habitat fragmentation that limited genetic interchange with other bear populations. A low number of breeding individuals in the population may also be adversely affecting genetic health. Again, the conservation goal for heterozygosity for giant pandas is >90% (Wei et al. 1997); though direct comparisons are difficult to make, my population falls far short of that at only 31.6%.

Table 7. Allele frequency and average heterozygosity comparisons for 5 black bear populations in the southeastern United States.

Population	*n*	Alleles Per Locus	Average # of Alleles	Average % Heterozygosity
Southwest Alabama	19	2–4	2.8	31.6
Chassahowitzka NWR, Florida [a]	21	- [e]	2.7	39.0
Osceola National Forest, Florida [c]	37	4-8	5.8	67.9
Okefenokee NWR, Georgia [c]	39	5-8	6.1	66.3
Tensas River NWR, Louisiana [b]	58	2-5	3.5	47.4
Washington County, North Carolina [d]	145	4-10	6.5	66.2

[a] Maehr et al. 2000

[b] Boersen 2001

[c] Dobey 2001

[d] L. M. Thompson 2002, University of Tennessee, unpublished data

[e] Data not available

Finally, the neighborhood-joining tree provided insight on the relatedness of the bears in my study. Bears F17 and M13 were paired at a node; both were captured in the same creek drainage. It was quite likely that F17, an 8-year-old female, was the mother of bear M13, a 3-year-old male. Bear M10, a 2-year-old male from Washington County, was paired with M11, a 13-year-old male from the Cedar Creek drainage. This pairing indicates mixing of genes within these 2 areas. Bear M18, a subadult male killed by a car on highway 43 just west of the Mobile-Tensaw Delta, did not appear to be closely related to any of the other bears in the study. This could be an indication of emigration from another population, possibly east of or within the delta. The overall genetic similarity of bears captured at the 3 different locations suggests that significant interchange is occurring, especially with males. Despite this evidence of interchange within the Alabama population, overall heterozygosity was low, suggesting population isolation.

Spatial Distribution

Bait-Station Surveys.–The bait-station survey served as an objective and easily employed indicator of sites with the highest potential for trap success and as an indicator of relative abundance and distribution (Johnson and Pelton 1980). I believe that the bait and trap stations with bear activity were indicative of the general distribution of bears in southwest Alabama (Figs. 4 and 5). Extensive baiting in the Mobile-Tensaw River Delta in 1998 and 2000 yielded no bear activity. Although bears likely occurred in areas where baits were not taken, densities may be so low that the probability of encountering bait-stations was much reduced. Continued bait-station surveys in southwest Alabama may provide information about further expansion or contraction of bear range.

The use of the motion-triggered cameras at bait and trapsites in 2000 increased trapping efficiency because they indicated whether bears taking the bait had been previously captured. Incorporating these cameras into future studies is recommended.

Home Range Size and Overlap.– Annual home range sizes of males (67.1 km^2) were similar to those reported from most other studies in the southeastern coastal plain, but females were generally smaller (7.8 km^2; Table 8). Black bear home range size and shape are influenced by factors such as age, sex, habitat quality, and population density (Pelton 1982). Armstrup and Beecham (1976) suggested that the high mobility of males increased reproductive success, allowing males to find more females for mating; females cover only the minimum area necessary to meet the requirements of maintenance. Female home ranges in southwest Alabama likely were influenced by the fragmentation of their current habitat, and isolation from other high-quality habitats. Residential development in north Mobile County is threatening to further fragment available habitat and dispersal corridors for bears in Hell's Swamp. Currently, bears are limited to movements North and possibly West of Hell's Swamp, but development along roads bordering the swamp could further hamper these movements. This high degree of fragmentation is similar to that described by Stratman (1998), Beausoleil (1999), and Maehr (2000). It is important to note, however, that home range sizes for southwest Alabama bears are significantly smaller than populations at Eglin Air Force Base, Florida

Table 8. Home range estimates (km^2) reported for black bear populations in the southeastern United States.

		Home range area (km^2)		
Location	**Method**	**Females**	**Males**	**Source**
Southwest Alabama	95% MCP	7.8	67.1	This study
Eglin Air Force Base, Florida	95% Adaptive Kernel	88.0	351.0	Stratman 1998
Okefenokee NWR, Georgia	95% MCP	53.9	325.5	Clark 2000
Chassahowitzka NWR, Florida	95% Fixed Kernel	22.5	164.4	Maehr et al. 2000
Osceola National Forest, Florida	95% MCP	29.9	–	Clark 2000
Deltic Tract, Louisiana	95% MCP	4.2	7.0	Beausoleil 1999
Alligator River NWR, North Carolina	95% MCP	2.9	12.5	Allen 1999
Camp Lejeune, North Carolina	100% MCP	20.4	60.5	Lombardo 1993
Great Dismal Swamp, Virginia	95% MCP	21.0	79.0	Hellgren and Vaughan 1989

(Stratman 1998), and Chassahowitzka NWR, Florida (Maehr 2000), but similar to those reported by Beausoleil (1999) in the Tensas River Basin of Louisiana. At Chassahowitzka and Eglin, seasonal food resources seem to be scattered across the landscape (Stratman 1998), forcing bears to seek out food over a larger area. Bears in Louisiana on the Deltic Farm and Timber Company tracts feed on agricultural crops surrounding small remnant patches of bottomland hardwoods (Beausoliel 1999) and thus are able to subsist on a much smaller area. Bears in southwestern Alabama, particularly in and around Hell's Swamp, may be able to subsist on a smaller area than other southeastern black bear population due to the high quality of habitat in the swamp. Powell (1987) found that bears in the southern Appalachians exhibited greater home range overlap in more productive habitat, suggesting some degree of interspecific tolerance in high quality habitats; this was supported by the extensive home range overlap among females (47.1%), particularly in Hell's Swamp (81.0%). Other factors influencing home range overlap may have been the presence of a kinship relationship among adult females and subadults (Garner 1986), likely due to habitat fragmentation and patch isolation, limiting juvenile dispersal to areas within their mother's home range.

Habitat Use.– The available habitat extent that included the delta indicated that bears used evergreen forests more than mixed forests or disturbed habitat types. Woody wetlands were used less than expected. This finding was likely a result of the Mobile-Tensaw Delta being included in the analysis extent as available habitat. Although bears were in close proximity to the delta, only 1 male (M10) used this area. Physical barriers, such as U.S. Highway 43 (a 4-lane divided highway) and the cities of Saraland, Satsuma, and Creola likely limited accessibility to the delta. When I excluded the delta from the analysis area, woody wetlands were selected more than mixed forests and disturbed habitats. Differences between small creek swamps that do not flood for long periods of time and the seasonally flooded river delta could not be detected with the MRLC data. Excluding the delta indicated the potential importance of these small creek swamps, and I believe this analysis extent best represents available habitat for bears.

Other studies of black bear habitat use in the southeastern coastal plain reported that pocosins are an important habitat type and provide food, escape, and denning cover (Hamilton 1978, Hellgren 1988, Lombardo 1993, Jones 1996, Martorello 1998, Allen 1999). Stratman (1998) found that bears at Eglin Air Force Base, Florida used riparian zones and swamps more than expected based on availability. Mykytka and Pelton (1990) found that bears in northeast Florida generally centered their home ranges around swamp systems >300 ha with adjacent pine forests; this can be explained by the availability of foods in pine uplands and presence of escape cover in swamps.

As reported in other southeastern coastal plain studies, habitat use by bears in southwest Alabama seemed highly influenced by the presence of riparian areas adjacent to pine and mixed pine-hardwood uplands. In the Hell's Swamp area, bear home ranges were smaller and centrally located around the ~ 8–km^2 circular swamp, whereas home ranges near Cedar Creek in Mobile County were associated with linear riparian habitats, and consequently were larger in size. Results from compositional analysis support this hypothesis; although woody wetlands were ranked above evergreen forests, there was not a significant difference in use between the 2 types. This illustrates the importance for bears of these habitat types interspersed throughout the landscape.

CHAPTER VI

MANAGEMENT IMPLICATIONS

The bear population in southwest Alabama is being maintained in only a few small isolated areas where breeding females occur. Bears have been seen over a wider area but my telemetry and road-kill data suggest that those are mostly males. The small core of breeding females makes the population susceptible to extinction.

It is important to view the Alabama black bear within the context of other neighboring bear populations in the southeastern coastal plain. Florida black bears exist today in what may be characterized as a metapopulation, i.e., localized groups of interacting populations occupying several habitat patches (Hanski 1996). Bear populations among habitat patches are maintained by constant immigration and emigration. The black bear population in southwest Alabama could play an important role in this respect by providing emigrants to adjacent areas and habitat to immigrating bears from adjacent populations, and in fact, bears from populations in Florida and Mississippi have been documented in Alabama. Southwest Alabama bears represent the westernmost population of the Florida subspecies, and are in relatively close proximity (<200 km) to populations of the threatened Louisiana black bear (*U. a. luteolus*). Thus, the southwest Alabama bear population could be important, not just to Alabama, but to the viability of coastal bear populations as a whole.

Areas where breeding females occur appear to be associated with feeder streams and associated swamps and bays, not subject to river flooding, adjacent to pine and oak-pine upland habitats. Bears seem to use these thick swamp habitats for seclusion and escape cover and utilize adjacent pine and oak-pine uplands for foraging. Unfortunately, this combination of habitat associations is in limited supply and is being further degraded because of commercial and residential development. Thus the future of bear habitat on upland areas adjacent to the swamps and riparian thickets is uncertain, and losses here would substantially raise any estimate of extinction risk.

Perhaps the most noteworthy finding is the near absence of bears in the extensive seasonally flooded habitats along the Mobile, Tensaw, Alabama, and Tombigbee rivers. This area may hold the greatest potential for bear habitat in the region because of its extensive size (app. 100 km^2) and natural protection. Bears have attained high densities in similar alluvial floodplain habitats in the Mississippi Alluvial Valley, such as White River NWR in Arkansas, where flooding is prolonged and widespread (Smith 1985). At White River, bears den in cavities in large trees, which are considered to be a key habitat component (Oli et al. 1997). In contrast, Alabama bears appeared to reside and den in areas not prone to winter flooding. The combination of heavy winter flooding and the past removal of den trees by loggers (D. Powell, personal communication) may have excluded bears from the extensive habitats adjacent to the Mobile River and associated drainages. If den trees seem to be the only factor limiting bear population growth in the Mobile River floodplain, it may be possible to provide future den sites by modifying current silvicultural practices or, perhaps, by developing artificial denning structures to provide safe havens for denning above normal flood levels. These denning structures, typically constructed of plywood and resembling a large doghouse, have been used successfully at Felsenthal NWR, Arkansas as part of a reintroduction effort occurring there (B. J. Wear, University of Tennessee, personal communication). Structures are placed in areas not prone to winter flooding, and denning female bears with cubs are translocated from White River NWR and placed in the structures. Thus far, the effort has been successful in reestablishing a population of resident bears at Felsenthal NWR (B. J. Wear, University of Tennessee, personal communication). Bottomland hardwood floodplain systems have been shown to be some of the most productive systems on earth (King et al. 1999), and I believe that the greatest potential for black bear management in the region lies in the extensive Mobile-Tensaw floodplain.

Several studies have shown that roads, especially high-speed, divided highways have significant impacts on black bear survival (Brandenburg 1996, Lombardo 1993, Maehr 2000). This study identified 5 bear mortalities from vehicle collisions, 4 of which were at intersections of creek drainages and highways. It has been shown that bears prefer to cross primary roads at drainages, likely because thick vegetation allows bears to move undetected (Brandenburg 1996). Studies have been conducted to assess the effectiveness of "wildlife underpasses" on high-speed highways (van Manen et al. 2001). These underpasses are typically longer, and maintain more natural vegetation than conventional bridges. High fencing is often used in conjunction with these underpasses, and serves to funnel animals into the underpass facilitating safe travel under highways. These passageways have been shown to significantly reduce wildlife road mortalities (van Manen et al. 2001). Road mortality impacts could be reduced by less costly methods as well. The establishment of slower traffic speeds at known bear crossings, placement of bear crossing signs, and removal of roadside vegetation to increase reaction time of motorist who could potentially strike bears can all help to reduce vehicle-kills. These underpasses have been shown to significantly reduce wildlife road mortalities. To help alleviate human-caused mortalities, facilitate juvenile dispersal and gene flow, and reduce isolation of high quality habitat encouraging recolonization of unoccupied bear habitat, I suggest that problems associated with critical bear corridors be addressed.

Public awareness and education is critical for the long-term conservation of the Alabama black bear. The Alabama Black Bear Alliance (ABBA) has played an essential role in this regard. ABBA solicited and gained support from public and private entities when there was little interest in the Alabama black bear. ABBA has since taken the initiative to coordinate research, funding, and in-kind support and increase public awareness of the plight of the black bear population in Alabama. It is critical that such cooperative relationships between public and private stakeholders continue. ABBA has agreed to support research to assess habitat suitability of the delta for bears. If this assessment finds that habitat is suitable, bears could be reintroduced to the delta to help boost the viability of the Alabama population, and help link this population with other coastal black bear populations.

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