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Movement Ecology of Black Bears in a Fragmented Bottomland Hardwood Habitat in Louisiana

Forrest B. Marchinton
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Forrest B. Marchinton entitled "Movement Ecology of Black Bears in a Fragmented Bottomland Hardwood Habitat in Louisiana." I have examined the final electronic 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.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Arthur Echternacht, David A. Buehler, Joe Clark

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Accepted for the Council:

Associate Vice Chancellor
and Dean of The Graduate School

MOVEMENT ECOLOGY OF BLACK BEARS IN A FRAGMENTED BOTTOMLAND HARDWOOD HABITAT IN LOUISIANA

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Forrest B. Marchinton

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ABSTRACT

Twelve Louisiana black bears (Ursus americanus luteolus) were captured 18 times on a 350-km^2 study area in the Tensas River Basin in northeastern Louisiana during 1992 and 1993. The study area, owned by Deltic Farm and Timber Co., Inc., consisted of 4 bottomland hardwood habitat fragments, several smaller woodlots, and extensive agricultural fields.

A total of 3,748 locations were collected on 10 radio-collared bears (4 male, 6 female). Mean home ranges were 52.33 km^2 and 12.61 km^2 for males and females, respectively, and were largest during fall. Home range shape appeared to be influenced by available forest cover. Extensive home range overlap, particularly among females, suggested high intraspecific tolerance.

Bears generally were crepuscular, but shifted from more diurnal activity in summer to more nocturnal activity in fall. Hourly movement rates were not different between sexes except during September (F = 374 m/hr, M = 589 m/hr). Daily movement rates were greater for males than females (F = 1079 m/day, M = 1847 m/day). No differences were found between adult and subadults in terms of home range characteristics, movement rates or activity.

Males were more likely than females to travel to other habitat fragments (P = 0.025). Black bear use of bottomland hardwood habitat fragments did not increase in proportion to the size of the fragment. Possible factors determining fragment use include human use of the habitat and differences in natural food sources. All bears

used wooded drainages, apparently to facilitate travel across the study area and to act as staging areas for foraging in agricultural fields. Males were more likely to be found in agricultural fields and were found farther from wooded cover than females during field excursions. All bears were found foraging in harvested corn fields during the fall.

No adult mortality was recorded during the study; however, two bears were killed in vehicle collisions just prior to the commencement of the study. An unconfirmed bear-vehicle collision was reported in December 1993.

Of the 6 bears monitored during the winter of 1992-1993, 1 male and 2 females denned in hollow trees, and the remainder used brushpiles or open nests. All den sites were located in bottomland hardwood habitat. Mean litter size was 2 and ranged from 1 to 3 ($\underline{N}$ = 4).

No instances of bears leaving the study area were documented. Human development, including an interstate highway and several small communities, may inhibit movement between the study area and the less-fragmented bottomland hardwood habitat to the south, effectively isolating this remnant population.

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CHAPTER I

INTRODUCTION

LOUISIANA BLACK BEAR

The Louisiana black bear (Ursus americanus luteolus) is one of 16 subspecies of the American black bear (Hall 1981). The Louisiana subspecies was first described as a separate species (U. luteolus) by Griffith (1821). Merriam (1893) used 5 skulls from Morehouse Parish in northeastern Louisiana to describe the "yellow bear of Louisiana." Miller and Kellogg (1955) found that differences between American and Louisiana black bears were insufficient to establish a distinct species, and redesignated the bear as a subspecies of the American black bear; at least one earlier source (Peterson 1946) listed the Louisiana bear as a subspecies.

The original range of U. a. luteolus is thought to have included the forested regions of southern Mississippi, Louisiana, the southern border of Arkansas, and eastern Texas (Hall 1981). Reported to be common, especially along river bottoms, black bears were hunted by the Native Americans as well as by white settlers (Le Page du Pratz in Tregle 1975). Theodore Roosevelt (1908) wrote about hunting black bear in Tensas Parish in 1907. He mentioned that bear numbers in the lower Mississippi Valley had greatly diminished in just a few years, and suggested hunting by planters as one reason for the decrease. The hunting season bag limit in the early 1900's was 5 bears per hunter; bear harvest in Louisiana was restricted in 1930 to one bear per hunter per hunting season (Taylor 1971). Legal hunting was closed in

1965. A 9-day season was opened in 1975 and continued until 1987 (Hammond 1989). The black bear distribution in Louisiana has been reduced to 2 areas in the lower Mississippi River Valley, the Tensas River Basin (TRB) in northeastern Louisiana and the Atchafalaya River Basin (ARB) in southeastern Louisiana. No formal bear population survey has been conducted for bears in Louisiana (Weaver et al. 1990a); based on trapping results and observations, it is estimated that 60-100 bears inhabit the TRB (G. Chandler, USFWS, pers. commun.).

From 1964 through 1967, the Louisiana Department of Wildlife and Fisheries translocated approximately 162 black bears from Minnesota (U. a. americanus) in an effort to augment the native population (Lowery 1974, Nowak 1986). Thirty-one of these bears were released in Tensas and Madison parishes, and the remainder in Pointe Coupee Parish. Nowak (1986) expressed doubt in the success of the relocation, because evidence suggested that the Minnesota stock immediately dispersed into unoccupied habitat. However, Pelton (1990) suggested that some interbreeding between the native and introduced subspecies may have occurred. Although it is unclear whether the Louisiana bear population gained any long-term benefit from the stocking effort, the possibility of hybridization is responsible for much controversy as to the taxonomic status of the current populations in Louisiana (Nowak 1986, Pelton 1990). Genetic analysis are currently being conducted which may resolve this taxonomic issue (M. Vaughan, Virginia Polytech. Inst., unpubl. data). Currently, the USFWS considers all wild black bears in Louisiana to be U. a. luteolus (Neal 1992).

In 1992, the Louisiana black bear received threatened status under the

Endangered Species Act of 1973 because of habitat loss and other factors (Neal 1992). In 1993, the U. S. Fish and Wildlife Service (USFWS) proposed the designation of critical habitat for the subspecies which included the TRB (Neal 1993).

FRAGMENTATION

The fragmentation of habitat due to human population expansion is an important conservation issue (Wilcox and Murphy 1985). As fragmentation increases in a region, habitat patches decrease in size and become more isolated. According to the island biogeography theory introduced by MacArthur and Wilson (1967), habitat patches may be considered habitat islands. Populations of individual species in isolated patches may not be replenished through immigration; such populations may eventually become extinct due to population fluctuations, genetic depression, or catastrophic events (Wright and Hubbell 1983). Large mammals, which typically have low population densities and high spatial requirements, are especially vulnerable to fragmentation as it is more difficult for them to attain minimum viable population sizes in fragmented habitats (Harris and Allendorf 1989).

The critical habitat type for the present study was bottomland hardwood forest. Forsythe (1985) defined bottomland hardwoods as an assemblage of tree-dominated vegetative communities that occur on soils that are saturated or inundated by water either seasonally or temporarily. Forsythe and Gard (1980) provide an overview of vegetation and wildlife characteristics of bottomland hardwood communities in the lower Mississippi River valley. The lower Mississippi River valley included approximately 97,200 km^2 of bottomland forests, of which only 20,233 km^2 remained in 1980; most of the loss resulted from conversion to agriculture (MacDonald et al. 1979). Over a third of the forest clearing occurred between 1937 and 1977 (Spencer 1981). The rising value of soybeans, a crop which can be grown on flood-prone bottomlands, was responsible for most of this rapid clearing (MacDonald et al. 1979). Vance (1976) stated that most private land use decisions are dictated by economics and, in the Mississippi delta region, agriculture is generally more profitable than silviculture (MacDonald et al. 1979). Burdick et al. (1989) estimated that 85% of the TRB's bottomland hardwood forest has been converted to farmland. Weaver et al. (1990a) estimated <450 km^2 of bottomland hardwood habitat remained in the TRB. The Tensas River National Wildlife Refuge (TRNWR) and the adjacent Big Lake Wildlife Management Area (BLWMA) comprise about 80% (318 km^2) of the contiguous bottomland hardwood forest within the TRB (Weaver et al. 1990b). Private forested lands adjoining the TRNWR/BLWMA bottomland hardwoods account for 52.6 km^2. The remainder of bottomland hardwood forest in the TRB consists of tracts ranging in size from <0.32 to 50 km^2 (Weaver et al. 1990b); these tracts are generally surrounded by agricultural fields.

Loss of forest habitat has been linked to local extinctions and population changes of several species. In a study in the TRB, Burdick et al. (1989) found a correlation between declining bird populations and a decrease in bottomland hardwood habitat over time. Tanner (1966) studied one of the last continental populations of ivory-billed woodpeckers (Campephilus principalis) on a large bottomland hardwood tract in Madison Parish in the 1930's, shortly before the tract was cut over (Ehrenfeld 1970). Bachman's warbler (Vermivora bachmanii) is presumed to be extirpated in the TRB and elsewhere throughout its range (Gosselink et al. 1989). Florida panthers (Felis concolor coryi) and red wolves (Canis rufus) were last seen in the TRB in the 1970's (Burdick et al. 1989). While more adaptable than the species listed above, the black bear is another species that is threatened by the loss of bottomland hardwood habitat (Spencer 1981, Nowak 1986, Mykytka and Pelton 1989, Weaver et al. 1990b, Hellgren et al. 1991, Hellgren and Maehr 1992).

PREVIOUS RESEARCH

Relatively few studies have been done on the effects of habitat fragmentation on mammals (Rosenfield et al. 1992); most research dealing with fragmented habitat has been on birds. Several studies have investigated the effects of roads and the clearing of forests on different mammalian predators (Hamilton 1978, Villarrubia 1982, Van Dyke et al. 1986, Brody and Stone 1987, Mech et al. 1988, Brody and Pelton 1989, Weaver et al. 1990b), with the general indication that these species avoid recently-disturbed areas.

Compared with populations in the Appalachians and in the Great Lakes states, relatively little research has been conducted on black bears in the coastal plain, or more specifically, populations of black bears in bottomland hardwoods. In the coastal plain of North Carolina, Hardy (1974) researched the habitat requirements and population characteristics of bears, and Hamilton (1978) studied 10 radio-collared black bears. Hellgren and Vaughan (1988, 1989), and Hellgren et al. (1991) reported on black bear ecology, reproductive physiology, and habitat use in a coastal plain wetland in North Carolina and Virginia. Extensive research has been conducted on the physiology and ecology of black bears in Florida; Maehr and Wooding (1992) presented a summary of this information. Smith (1985) described bear ecology in bottomland hardwood habitat in the White River National Wildlife Refuge, Arkansas.

Several black bear studies have been conducted in Louisiana. Taylor (1971) radio-tracked 6 bears in south-central Louisiana; however, 4 of the 6 were actually Minnesota stock translocated to Louisiana in the mid 1960's. Hammond (1989) detailed the history and described the current status of black bears in Louisiana. Weaver et al. (1990b) and T. Edwards (USFWS, pers. commun.) collected biological and habitat data from bears in the TRB to aid in the taxonomic and population status assessment of the Louisiana black bear by the USFWS. Weaver and Pelton (1995) reported denning characteristics of black bears in the TRB.

OBJECTIVES AND RESEARCH HYPOTHESES

The purpose of this study was to investigate the movement ecology and habitat use of black bears in fragmented bottomland hardwood habitat. Two of the working hypotheses relate directly to bear movements, while the third pertains to habitat fragment characteristics.

1) I hypothesized that males would use multiple fragments more often than females. If this were true, it would suggest that the movements and range of male black bears might be less limited by the fragmentation level of the study area than those of females.

2) One possible reason that fragments would be more accessible to males would be a tendancy to travel further across open areas to reach other fragments than would females. I therefore hypothesized that during crop field excursions (to forage in agriculture or during travel) males would tend to move farther from forested cover than females.

3) MacArthur and Wilson (1967) hypothesized that the number of species on a habitat fragment is directly proportional to the fragment size. I adapted this concept to hypothesize that the density of black bears bottomland hardwood fragments would increase in proportion to the size of the habitat fragment. If fragment size were a factor in bear use, this could have implications for future habitat protection plans.

CHAPTER II

STUDY AREA

GEOGRAPHY

The 350 km^2 Deltic study area was located in the Tensas River Basin, a 11,800 km^2 watershed in northeastern Louisiana (Fig. 1). The study area was located primarily in Madison Parish, with its northern extreme lying in East Carroll Parish. Richland and West Carroll parishes were included in the western edge of the study area. Approximate east and west boundaries of the site were 91°30′W and 91°15′W longitude, respectively, and north and south boundaries were approximately 32°36′ N and 32°27′ N latitude, respectively. The study area was located north of Interstate 20 (I-20); the TRNWR lies south of I-20 and the study area. Nearby towns included Tallulah (1990 population 8,526) to the east of the study area, Delhi (1990 population 3,169) to the southwest, and several smaller communities within and surrounding the study area (Bureau of the Census 1992). Access to the area was provided by Louisiana state highways 17, 80, 577, and 579, and several gravel roads, unimproved roads and trails. From east to west, the major drainages within the area were Bear Lake/Roundaway Bayou, the Tensas River, Joes Bayou and Bayou Macon, all of which run generally north to south. Several small ponds were located within woodlots on the study area. Elevation ranges from 19.8 to 27.4 m, with the exception of one Indian mound which rose to 39.6 m.

The forest habitat type was bottomland hardwood; principal overstory species

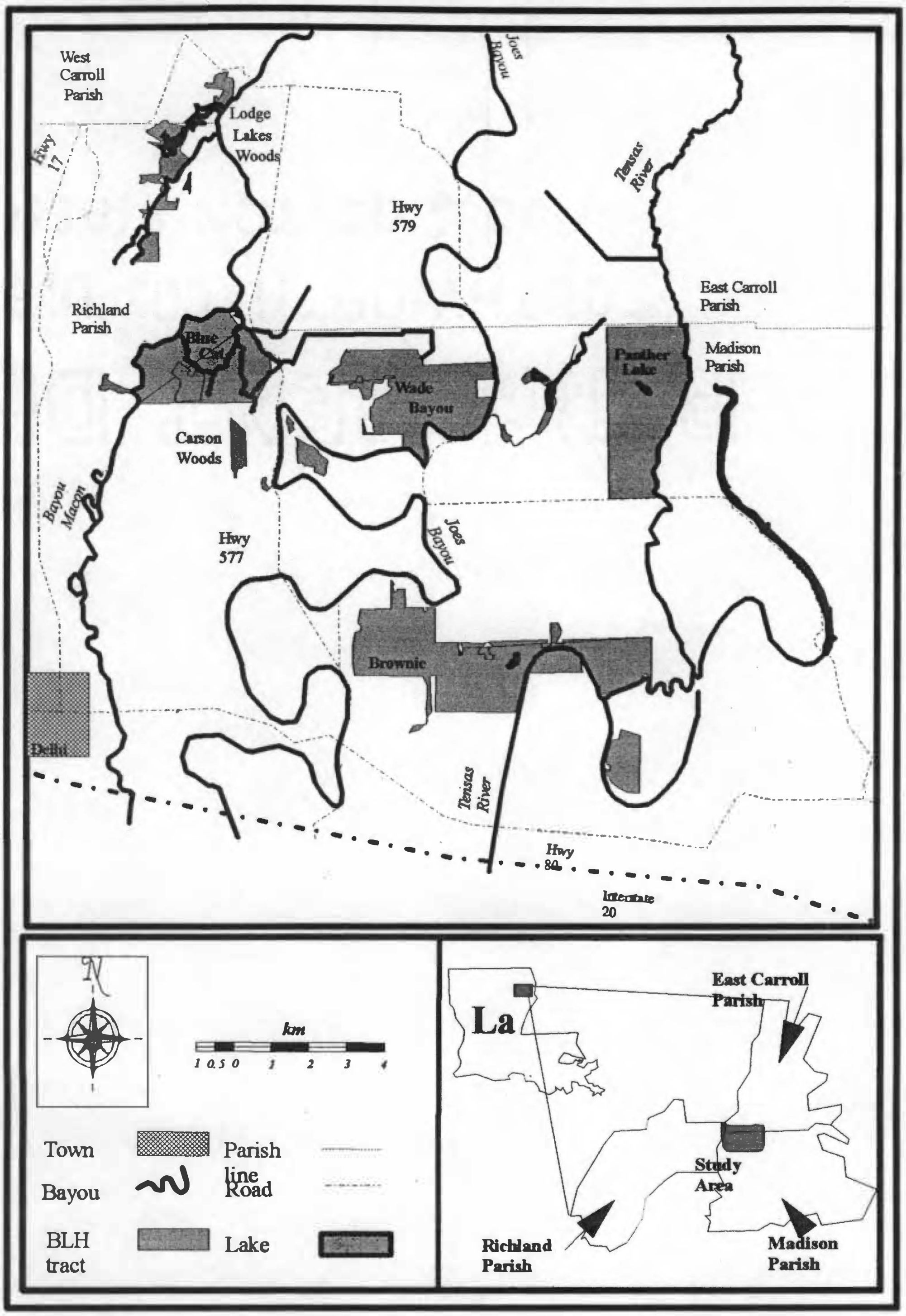

Fig. 1. Location of Deltic study area in northeastern Louisiana, and distribution of bottomland hardwood tracts.

were sweetgum (Liquidambar styraciflua), American elm (Ulmus americanus), pecan (Carya illinoensis), sugar hackberry (Celtis laevigata), green ash (Fraxinus pennsylvanica), baldcypress (Taxodium distichum) and several species of oaks, including overcup oak (Quercus lyrata), Nuttall oak (Quercus nuttallii), water oak (Quercus nigra), and willow oak (Quercus phellos). Four bottomland hardwood tracts comprise the majority of the forest component on the study area. The largest forested tract ($\approx$ 8.5 km^2) was leased by the Brownie Hunt Club from Deltic Farm & Timber Co., Inc. An adjacent tract of approximately 2 km^2 was owned by Talla Bena Plantation, Inc. (these 2 tracts will be collectively referred to as Brownie). The other 3 major tracts, Panther Lake Woods (hereafter referred to as Panther Lake; $\approx$ 7.2 km^2), Wade Bayou ($\approx$ 6.3 km^2), and Blue Cat ($\approx$ 5.5 km^2), also were owned by the Deltic Farm & Timber Co., Inc. Several smaller tracts ($\leq$0.8 km^2) were scattered throughout the area. Notable among the smaller tracts were Carson Woods (0.8 km^2), located south of Blue Cat, and a group of woodlots at the northwestern corner of the study area that were known collectively as Lodge Lakes Woods ($\approx$2 km^2). The forest fragments were interspersed among extensive agricultural fields. Woodlands in the study area were predominantly second- and third-growth stands (Weaver and Pelton 1995). Bayous were bordered by wooded strips 5-20 m wide, which served to connect wooded tracts.

GEOLOGY

The study area was located on the Mississippi River alluvial plain. The course of what is now the Tensas River was an early meander of the Mississippi River which shifted to its present channel about 1,000 years ago (Weems et al. 1982). Joes Bayou and Bayou Macon are similar relics of a shift made in the last 5,000 years by the Arkansas River (Weems et al. 1982).

Soils are primarily in the Sharkey, Dundee, and Tensas series, characterized by level or gently-undulating, poorly drained clayey or loamy soils (Weems et al. 1982). Although naturally high in fertility, for the most part the soil is arable only in a narrow range of moisture content. Permeability and runoff are slow. Seasonal flooding makes agricultural practices of any kind impractical if not impossible during the winter months.

CLIMATE

Northeastern Louisiana is characterized as a subtropical transitional region (Weems et al. 1982). Changes in airflow between southward-moving, cold, dry winds and northward-moving, warm, moist air result in significant and often abrupt weather changes. Mean daily temperatures for 1992 ranged from 6.7 C in January to 27.2 C in July; January and July mean daily temperatures for 1993 were 7.9 C and 28.2 C, respectively. Annual precipitation for 1992 and 1993 were 153.47 cm and 133.50 cm, respectively. Weather data were recorded in Tallulah, 12 km east of the study site.

AGRICULTURE AND SILVICULTURE

Agriculture consists primarily of cotton, corn, rice, soybeans, and occasionally wheat, millet, and other small grains. Much of the farmland is leased from Deltic by local farmers. Drainage ditches 1-2.5 m in depth were present throughout agricultural fields. Irrigation is common, as is aerial application of fertilizer and pesticides. Timber harvest of approximately 10% of the study area forest took place during the period of study. In Fall 1992, sections of northern Blue Cat, central Wade Bayou, and northern Panther Lake were select-cut for ash and other hardwoods. A similar timber harvest was conducted 3-5 years earlier on other tracts.

RECREATION AND OTHER ACTIVITIES

Both Brownie and Panther Lake were leased by private hunting clubs during the study, whereas Wade Bayou and Blue Cat were hunted by employees and guests of Deltic. Apart from periodic timber cuts, there was little human activity within forested tracts outside of hunting seasons (fall deer and squirrel season). Hunters frequently used all-terrain vehicles (ATVs) in the woods. Baiting for deer (Odocoileus virginianus) was legal, and evidence of bear activity was common around some corn piles. Weaver and Pelton (1995) suggested that access to corn may prolong winter activity by bears.

CHAPTER III

METHODS AND MATERIALS

TRAPPING

Capture

During 1992 and 1993, we used Aldrich spring-activated foot snares (Aldrich Animal Trap Co., Clallam Bay, Wash) to capture bears (Johnson and Pelton 1980). The snare cable was anchored to a tree or, where no suitable tree was available, to a trailer anchor. Traps were baited with meat scraps and a mixture of table syrup and raspberry extract. Two types of sets were used: cubby and trail sets. Cubby sets consisted of a circle of palmettos (Sabal minor) with an entrance by the trap; bait was placed in the center of the circle, and additional palmettos formed a "V" to funnel bears across the snare as they reached for the bait. Trail sets consisted of 2 palmetto "V"s placed along a natural or artificial trail, along which bait and lure were placed at intervals. The "V"s opened from the camouflaged snare, and acted as funnels to force the bear to walk across the snare while eating the bait. We experimented with alternate sets (e.g., varying palmetto placement, using earth instead of leaves to cover triggers) to catch "trap-wise" bears, with variable success.

Trap lines, which consisted of up to 10 trap sites, were set on each of the 4 primary wooded tracts on the study area. Trap lines primarily were established along ATV trails, and trap sites were generally located within 50 m of trails. Trap placement was based on recent bear activity in the area, although many traps were set based on the likelihood of a site to attract bears (e.g., where 2 trails met, near a berry thicket). In areas with low bear density, prebaiting was used to determine areas of bear activity (Johnson and Pelton 1980, Villarrubia 1982).

Traps were checked in the morning and again in the afternoon. Snares were rebaited and reset in the afternoon if bait had been taken. If we were precluded from checking traps or processing captures the following day, we disabled the traps until regular monitoring could resume.

Handling and Examination

Captured bears were immobilized with a mixture of ketamine hydrochloride (200 mg/cc), xylazine hydrochloride (100 mg/cc), and mepivicaine hydrochloride (20 mg/cc). Standard dosage was 1 cc/23 kg, using an estimate of the bear's weight. The drug mixture was delivered using a wooden jab stick or capture gun (CAP-CHUR, Palmer Chemical Equipment Co., Douglasville, Ga.).

After an animal was immobilized, the snare was removed. The eyes were covered for protection and to keep the animal calm. Antibiotics were injected intramuscularly prior to release, and alcohol or antiseptic ointment was applied if wounds were sustained during capture. Bears were released at their capture sites and observed until they recovered from immobilization.

If bears were not previously captured, a premolar was pulled for cementum annuli counts to estimate age (Willey 1974, Eagle and Pelton 1978). Bear ages were divided into 3 age classes: Cubs (<1 year old), subadults (1 to 3 years old) and adults (≥3 years old). Samples were labeled by collection date, bear identification number, and study site.

Marking and Radiotagging

We placed one numbered metal tag in each ear. The ID number was also tattooed on the inside of the upper lip to insure identification in case of tag loss. Physiological condition was monitored during processing. To prevent overheating, bears were cooled with water.

All adult bears and 2 subadults were fitted with radio collars (Telonics, Inc., Mesa, Ariz.). Collar frequencies were in the 164-165 mHz range. Two collar configurations were used in the study: an "instantaneous" motion sensitive collar and a "reset" motion sensitive collar (Garshelis et al. 1982). Collars were fitted with breakaway inserts, both to facilitate collar retrieval and to protect the animal from the possibility of a tight collar (Hellgren et al. 1988). Inserts were made of heavy canvas belts covered in either electrical tape or duct tape. These inserts had an estimated life of 1 to 2 years.

TELEMETRY

A portable receiver (Telonics Model TR-2, Telonics, Inc., Mesa, Ariz.), hand-held 2-element (H-antenna) antennas (Telonics, Inc., Mesa, Ariz.), and vehicle-mounted 5-element antennas (Wildlife Materials, Inc., Carbondale, Ill.) were used to obtain azimuths on radio-collared bears. Radio bearings were taken from points that could be accurately located on a United States Geological Survey (USGS) 1:24000 scale topographical map. Universal Transverse Mercator (UTM) coordinates could then be obtained for each plotted location using the computer program TELEM88 (Coleman and Jones 1988).

Bearings generally were obtained using both the "loudest signal method" (Springer 1979) and the "null-average method" (Springer 1979). The latter method appeared to be a more effective technique for the H-antenna for this study, while the former was more effective with the vehicle-mounted antenna. A hand-held Silva mirror compass (Johnson Camping, Inc., Binghamton, N.Y.) was used to determine the azimuth. When using vehicle-mounted antennas, the observer sighted down the central bar of the antenna with the compass to obtain an azimuth. Bearings taken with H-antennas were obtained by visually noting local landmarks along the azimuth, and then aligning the compass with the landmarks. Bear locations were determined using a triangulation of 2 or more azimuths for each location. Aerial telemetry, important for locating wide-ranging male bears, was only used 4 times because of poor weather and the high cost of air time. Aerial telemetry involved the use of 2 H-antennas, mounted to the wing of a small airplane and attached by cable to the receiver, to find the general location of a missing bear. A telemetric search could then be conducted on the ground in that area.

In addition to daily triangulation attempts, diel movements in 6- to 12-hour blocks were recorded on selected individuals to obtain a 24-hour movement/activity record every 1 to 2 weeks. In addition to transmitter location and signal azimuth, time, activity mode, and relative signal strength were recorded. Local weather conditions were also recorded.

Triangulation error

Thirty-five locations were obtained using radio collars at various known locations in Blue Cat. Test collars were placed 0-1 m off the ground in a non-random fashion, attempting to simulate a variety of radio conditions. Test azimuths were taken during normal telemetric sampling by different researchers in various climatic conditions and at various times of day. Actual transmitter locations were marked on a USGS map; estimated locations (derived from test azimuths) were also plotted on the map, and the distance between the estimated and actual locations was measured to within 10 m.

Activity Monitoring

As mentioned previously, 2 types of activity sensors were used in the study: tip-switch and 2-minute reset monitors. The "instantaneous", or "tip switch" collar changes radio pulse rate as the collar shifts position (i.e., the animal is moving). The "reset" collar signal shifts into a faster-pulse "active mode" when the animal moves; 2 minutes after activity ceases, the collar resets to a slower, "inactive" mode. Quigley et al. (1979) and Garshelis et al. (1982) discussed the advantages and disadvantages of both tip-switch and reset monitors. For this study, variation in pulse speed and modulation of radio signals was used to determine if a bear with a tip switch collar was active during a location. Collar signals were monitored for 10-15 seconds; an irregular (frequently shifting between fast and slow modes) pulse indicated activity. For reset collars, 2 readings were taken between 2 and 10 minutes apart; if both readings were rapid pulse, then the collar was considered active. Garshelis et al. (1982) recommended visual observation of collared animal activity before beginning a study to learn how to best interpret signal changes; given the density of vegetation in much of the study area, this was seldom possible.

ANALYSIS

General

Telemetry azimuths taken greater than 20 minutes apart were omitted from the analysis to reduce error from movement (Schmutz and White 1990). Locations derived from bearing angles of less than 30° were also omitted to increase reliability of locations (Coleman and Jones 1988, White and Garrott 1990). Because of incomplete annual records for most bears, overall home ranges (pooling all available independent locations) were used instead of annual home ranges. Statistical Analysis System software (SAS) (SAS Institute, Inc. Cary, N.C.) was used to analyze all data. Results were tested at the $\underline{P} = 0.05$ level.

For seasonal data analysis, seasons were defined based on climatic conditions, plant phenology, and bear activity patterns. Winter was designated as the period of 16 December-31 March; spring, 01 April-15 June; summer, 16 June-15 September; and fall, 16 September - 15 December.

Independence of Locations

Although independence of successive locations is a critical assumption for many home range estimators, independence is seldom possible in telemetry studies of large animals (Worton 1987). As an animal's movements are not truly random, no location is ever completely independent of another (White and Garrott 1990); however, longer intervals reduce the dependence of locations. Intervals between locations for bears vary from study to study, from as little as 6 hours (Garshelis

1978) to over 30 (Powell 1987). The data set for home range estimation for Deltic bears included only those locations which were recorded $\geq$12 hours apart.

Home Range Estimation

The software program CALHOME (J. Kie, U.S. Dep. Ag. For. Serv. Pacific Southwest For. Exp. Stat., Fresno Calif.) was used to estimate seasonal and overall home range sizes. Methods used to estimate range sizes were the minimum convex polygon (MCP) (Ackerman et al. 1990), harmonic mean (HM) (Dixon and Chapman 1980), and adaptive kernel (AK) (Worton 1989). These methods are discussed and compared by Worton (1987) and Ackerman et al. (1990). The HM and AK are nonparametric methods that use bear locations to estimate area contours of potential use. A disadvantage of these 2 methods is that they require relatively large sample sizes; Worton (1987) suggested that a minimum sample size for nonparametric methods be between 30 and 100 and Akerman et al. (1990) suggested 50 locations to be a minimum. For use of HM and AK methods in this study, the minimum number of locations was set at 50. Data sets of overall locations contained >50 locations; data sets of seasonal locations did not always meet this criterion and thus were analyzed using the MCP method only.

For all home range methods, contours of potential use were fixed at 95%, 75%, and 50% to delineate different degrees of usage within the home range of the bear. The 95% contour estimates total home range while excluding outliers, whereas the 50% contour delineates core use areas. Harmonic centers of activity (Coleman and Jones 1988) were calculated by TELEM88 using 100% of the locations.

Larkin and Halkin (1994) found that CALHOME estimates of home ranges for the AK and HM methods were more conservative than estimates from other home range programs. CALHOME was used for this study in part because of the program's conservative estimates.

Within CALHOME, the AK method tends to be more conservative than the HM method where locations are clumped, but where locations are scattered over a larger area AK gives larger estimates than HM (Larkin and Halkin 1994). Both nonparametric methods, because they estimate probability of use rather than actual locations, produce larger estimates than the convex polygon method. However, both the AK and HM methods tend to show movement patterns more clearly than the MCP.

Home range overlap of Blue Cat females was calculated by measuring the percentage of home range A (MCP method) overlapped by a neighboring home range (B), with the overlapped portion defined as area C. The percentage of overlap of B on A was given by C/A x 100, and C/B x 100 resulted in the percentage that B was overlapped by A. These overlap percentages were calculated for all female home ranges on Blue Cat. Both seasonal and overall home range overlap were calculated.

Overall home range estimates were compared by sex and age using a Wilcoxon Rank Sum Test (Ott 1993). Differences in MCP seasonal home ranges were compared using Bonferroni t-tests (SAS Institute 1990).

Activity

All locations (independent and diel) were used for activity analysis. The percentage of collar locations which were recorded as "active" was expressed as a probability of activity (0 = inactivity, 1 = most active). A Wilcoxon Rank Sum test (Ott 1993) was used to compare male and female probability of activity by month and by hour. A Bonferroni t-test (SAS Institute 1990) was used to compare monthly and hourly probability of activity for each sex.

Movement

Diel locations were used for the hourly movement analysis. All locations were pooled; locations approximately 1 hour apart (diel locations) were used to determine hourly movement rates, whereas locations approximately 24 hours apart were used to determine daily movement rates. Movement rates of males and females were compared using a Wilcoxon Rank Sum test (Ott 1993). A Bonferroni t-test (SAS Institute 1990) was used to compare movement rates among seasons and time of day.

Crop Field Excursions

To test the hypothesis that during crop field excursions (to forage in agriculture or during travel), males would tend to move farther from forested cover than females, field location points were overlaid on a habitat map. The distance from the nearest woodland edge to each location point was measured. The means were compared using the Wilcoxon Rank Sum test.

Roads

In the Deltic study area, it was not possible to test the effect of roads on bears because roads were always located on the edge of bottomland hardwood habitat rather than in it. Therefore, it was impossible to determine whether an effect was the result of the road or of the habitat (usually field) beyond.

Bottomland Hardwood Habitat Use

The areas of the largest wooded tracts were calculated using Geographic Information System (GIS) analysis of satellite imagery data. The areas of other wooded fragments, including woodlots and drains, were estimated using USGS topographic maps. The 2 land use types used in this analysis were wooded and nonwooded. Agricultural areas comprised the bulk of the nonwooded type; residential areas and roads also were grouped in this category. A Chi-square goodness-of-fit test (Ott 1993) was used to compare the frequency of bear locations in the 2 categories.

Utilization Indices

To compare relative use by bears among the 4 main tracts, 2 indices were used: trap nights per capture and the occurrence of bear sign along transects. From 3 May 1993 until 1 July 1993, trap lines were run for approximately 2 weeks on each tract; the order of the tracts was chosen at random. During this period, the number of trap nights for each tract was approximately proportional to the size of the tract, with the Brownie tract sustaining the most trap nights and Blue Cat the fewest. The purpose of this rotating schedule was to use trap nights per capture to determine relative use of each tract by bears. The rotating schedule was to be followed throughout the trapping season, but several collared bears dropped their transmitters during the second trapping iteration. Thus, it was necessary to return to Blue Cat to attempt to recollar the animals. Therefore, trapping after 1 July did not follow the original methodology but was opportunistic. Because 2 of the tracts had no captures, the analysis was altered to include trap nights per bear visit rather than trap nights per capture. A bear visit was definitive sign that a bear had visited the trap, and included captures, tracks, claw marks, scat, hair, and disturbance or damage to the trap set. The measure of activity was expressed in terms of visits per trap night so that trap sites with zero visitation could be included in the analysis. Bear activity may have been underestimated because researchers were sometimes unable to determine the species visiting a trap site.

The second method used to estimate relative bear use was by recording bear sign (e.g., foraging activity, tracks, claw marks, scat, or direct observation of bears) along habitat survey transects (Appendix A). Sign within 3 m of the transect line was included in the calculation.

The data from these 2 methods were not normally distributed. Therefore, a Chi-square approximation of the Kruskal-Wallis test (Ott 1993) was used to determine if there were differences in bear use among tracts.

DENNING

The median date between the first location at the den site and the previous location was designated as the date of den entry. Researchers visited den sites of radio-collared bears after radio signals became stationary and inactive. Periodic visits to den sites continued throughout the winter; after the first observation, ground-denned bears were generally not approached closer than 40 m to avoid disturbance. Tree-denned bears rarely showed signs of being aware of human presence. Females with cubs may stay near the den site for some time after emergence (Hellgren and

Vaughan 1989) but due to the difficulty in approaching dens without disturbance, abandonment of the den site was used as the emergence date. Denning chronology between sexes was compared using a Bonferroni test (SAS Institute 1990).

CHAPTER IV

RESULTS

TRAPPING

During 1992 and 1993, 12 bears were captured 18 times (Table 1) in 565 trap-nights, for an average capture rate of 1 bear per 31.4 trap-nights. The 1992 trapping season was from 2 June until 5 August; 267 trap-nights were accumulated, with a maximum of 9 snares set at any time. There were 10 bear captures (including recaptures), for an average of 26.7 trap-nights per capture. During 1992, 8 different bears were captured. Of these, 6 were recaptures from previous years. All captures were on Blue Cat. Bear F162, a cub of the year, was not collared.

The 1993 trapping season lasted from 2 May until 19 November 1993. Two hundred ninety-eight trap-nights were accumulated, with a maximum of 10 snares set at any one time. Eight bears were captured, for an average of 37.3 trap-nights per capture. Seven of these bears were captured on Blue Cat while the eighth was captured on the Panther Lake tract. Four of the bears (M106, F124, F128, and F156) were recaptures. The breakaway insert of F124's collar insert was replaced, and the other 3 were refitted with new collars.

Bait was scavenged from trap sites 42% of the time, and traps were disturbed (tripped or exposed) 30% of the time. Two scavengers, a dog (Canis familiaris) and a coyote (Canis latrans), were captured.

Table 1. Capture summary of black bears on Deltic study site, Tensas River Basin, Louisiana (1992-1993).

Bear ID	Date	Sex	Location	Weight (kg)	Age[a]
M106	23 July 92	M	SE Blue Cat	123	7±1
	20 Oct 93	M	Central Blue Cat	163	8±1
F124	08 July 92	F	SE Blue Cat	75	6
	20 July 93		Central Blue Cat	68	7
F128	30 June 92	F	Central Blue Cat	77	10
	21 July 93	F	Central Blue Cat	78	11
M149	26 July 92	M	W Blue Cat	75	4±1
M151	20 June 92	M	Central Blue Cat	159[c]	5
F156	17 June 92	F	SE Blue Cat	48	A
	08 July 92		SE Blue Cat	48	A
	06 Oct 93		Central Blue Cat	56	A
F160	08 June 92[b]	F	NE Blue Cat	49	A
	17 July 92		W Blue Cat	43	A
F162	05 May 93[b]	F	SE Blue Cat	26	1
M164	02 July 92[b]	M	E Blue Cat	8	<1
F180	02 June 93[b]	F	E Panther Lake	59	10±2
M182	11 May 93[b]	M	SE Blue Cat	35	1
F184	14 July 93[b]	F	N Central Blue Cat	18	1

[a] Exact ages not determined.

[b] Initial capture.

[c] Estimate.

All trapping efforts on the Deltic study area since 1988 have resulted in 41 captures of 19 different bears (Table 2); 83% of the Deltic captures occurred on Blue Cat. Bears were captured an average of 2.2 times.

TELEMETRY

During the period of May 1992 through Dec 1993, 3,748 telemetry locations were obtained from 10 bears (Table 3). After excluding locations that did not meet analysis parameters, the number of locations narrowed to 2,718. Of these, 1,230 were considered independent for purposes of determining home range. The mean error for 35 test locations was 116.7 m, with a standard deviation of 108.3 m. Fifty percent of the estimated locations were within 100 m of the true locations, whereas 95% of the estimated locations were within 350 m. Signal strength varied depending on atmospheric conditions and local vegetation.

HOME RANGE

Size

Overall home range estimates of males were larger than female overall home range estimates at all contour levels ($\underline{P} \leq 0.043$) (Table 4). Overall home ranges of adult and subadult bears did not differ. Seasonally, bear home ranges were largest in fall, and smallest during winter and spring (Table 5). Male home ranges were larger than female ranges during summer 1992 and both fall seasons.

Table 2. Capture summary of black bears on Deltic study site, Tensas River Basin, Louisiana (1988-1993).

Bear ID	Date	Capture Site	Sex	Weight (kg)
101	29 Apr 88	Blue Cat	F	73.5
104	30 Apr 88	Wade Bayou	F	88.5
106	01 May 88	Wade Bayou	M	104.0
	19 May 89	Blue Cat		126.5
	23 Jul 92	Blue Cat		122.5
	20 Oct 93	Blue Cat		163.5
108	02 May 88	Blue Cat	F	60.8
	29 Sep 90	Blue Cat		60.8
110	03 May 88	Wade Bayou	M	180.0[a]
	28 Apr 89	Wade Bayou		163.3
122	01 Dec 88	Blue Cat	M	32.5
	09 Jun 89	Blue Cat		38.5
	27 Sep 90	Blue Cat		80.5
124	02 Dec 88	Blue Cat	F	43.5
	21 May 89	Blue Cat		48.5
	28 Sep 90	Blue Cat		64.5
	08 Jul 92	Blue Cat		75.0
	20 Jul 93	Blue Cat		68.0
126	21 May 89	Blue Cat	F	29.0
	11 Jun 89	Blue Cat		28.5
128	23 May 89	Blue Cat	F	81.5
	09 Jun 89	Blue Cat		82.0[a]
	27 Sep 90	Blue Cat		75.0
	30 Jun 92	Blue Cat		81.0
	21 Jul 93	Blue Cat		78.0
149	28 Nov 90	Wade Bayou	M	60.0
	26 Jul 92	Blue Cat		70.5

Table 2 (Cont.).

Bear ID	Date	Capture Site	Sex	Weight (kg)
151	30 Nov 90	Wade Bayou	M	147.0
	20 Jun 92	Blue Cat		159.0[a]
153	21 Nov 91	Blue Cat	M	72.5[a]
156	17 Nov 91	Blue Cat	F	47.5
	17 Jun 92	Blue Cat		47.5
	08 Jul 92	Blue Cat		47.5
	06 Oct 93	Blue Cat		56.5
160	08 Jun 92	Blue Cat	F	50.0
	17 Jul 92	Blue Cat		43.0
162	05 May 93	Blue Cat	F	26.5
164	02 Jul 92	Blue Cat	M	8.0
180	02 Jun 93	Panther Lake	F	59.0
182	11 May 93	Blue Cat	M	35.5
184	14 Jul 93	Blue Cat	F	18.0

[a] Estimate.

Table 3. Telemetry location data from radio-collared black bears on Deltic tracts of the Tensas River Basin, Louisiana (1992-1993).

Bear ID	Total locations	No. valid locations[a]	No. home range locations[b]
M106	290	246	139
F124	683	483	188
F128	920	639	243
M149	399	268	101
M151	168	124	71
F156	547	420	195
F160	694	468	185
F180	63	49	45
M182	152	102	56
M184	231	187	63
Total	4147	2986	1286

[a]Excluded locations did not meet the requirements of time ($\leq$ 20 minutes between azimuth readings) or angle (azimuth angle $\geq$ 30°).

[b]Home range locations were considered independent.

Table 4. Comparison of estimates of annual home range size (km^2) of male and female black bears by calculation method, Deltic study area, Tensas River Basin, Louisiana (1992-93).

		Females				Males				
	Contour	*n*	$\bar{x}$	SD	Range	*n*	$\bar{x}$	SD	Range	*P*
AK	95%	6	12 .61	8.69	4.14-27.95	4	52.33	21.49	23.68-73.78	0.025
	75%	6	5.07	3.87	1.98-12.71	4	21.32	9.19	9.45-29.38	0.025
	50%	6	1.98	1.66	0.45-5.18	4	6.19	2.60	2.99-9.22	0.025
HM	95%	6	11.63	7.10	4.30-21.03	4	54.63	22.56	24.43-78.98	0.014
	75%	6	4.27	2.42	1.92-8.93	4	16.24	4.79	11.40-22.81	0.014
	50%	6	1.94	0.89	1.20-3.09	4	4.10	0.87	2.87-4.88	0.043
MCP	95%	6	8.78	6.37	3.09-20.73	4	46.13	18.03	27.67-70.48	0.014
	75%	6	4.12	3.24	1.73-10.65	4	21.14	9.31	15.03-35.09	0.014
	50%	6	1.82	1.79	0.37-5.37	4	6.64	3.02	4.02-10.46	0.043

Table 5. Comparison of mean estimates of seasonal home range size (km²) between sexes by MCP contour level, Deltic study area, Louisiana (1992-1993).

		Sum 92	Fall 92	Win 93	Spr 93	Sum 93	Fall 93
n	M	3	3	2	3	2	2
	F	4	4	4	4	6	6
95%	M	14.77A[1]	34.73A	9.70A	7.80A	4.35A	30.05a
	F	1.93B	4.53B	0.58A	1.18A	4.87A	5.87b
75%	M	10.53A	17.33A	4.35A	1.80A	1.40A	5.20a
	F	0.85B	2.30B	0.14B	0.50A	2.27A	2.18b
50%	M	4.00A	6.13A	0.25A	1.57A	0.48A	2.60a
	F	0.38B	1.20B	0.06A	0.14A	1.19A	0.92b

[1] Different letters indicate significant ($p \leq 0.05$) difference in home range contour sizes between sexes for a season.

Shape

Home range shape appeared to be influenced by the configuration of available forest cover (Appendix C). Activity of most females were centered on the tract of capture. Locations outside this tract were generally centered on a bayou or smaller woodlot (Fig. 2), indicating use of areas with wooded cover.

Overlap

Home range overlap among females on Blue Cat was extensive. Overall home range overlap exceeded 50% in all cases, and was nearly 100% among several females (Fig. 2). Seasonal overlap among females was less obvious but still substantial, with a mean overlap of 30%. During and after corn harvest (late summer and fall), female bears and cubs were observed within sight (<100 m) of each other. Females were found in close proximity (< 40 m) on several occasions, usually in cornfields after harvest. Core areas of female home ranges overlapped in most cases during the fall. Home range overlap among males was also extensive, but much less common seasonally, as males were frequently occupying separate tracts.

ACTIVITY

Daily activity

Bears were most active in the early evening. Daily probability of activity (POA) for bears peaked at 1800 hrs (POA = 0.74), with a secondary peak at 0800 hrs (POA = 0.63). Activity was least likely at 0500 hrs (POA = 0.25) (Fig. 3). Male activity peaked at 1900 hrs (POA = 0.82) and 0100 hrs (POA = 0.71), whereas female activity peaked at 1800 hrs (POA = 0.76) and 0800 hrs (POA =

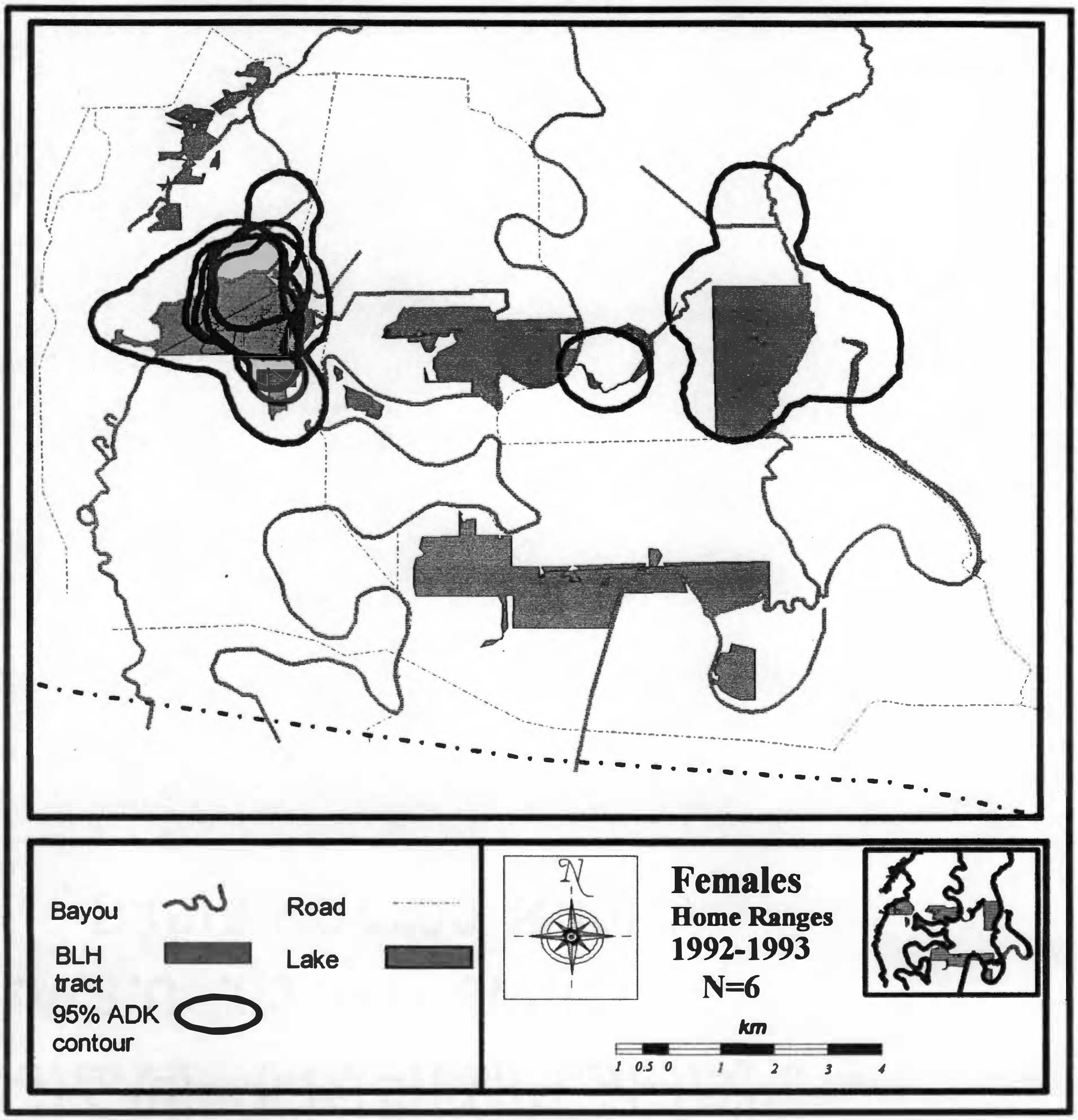

Fig. 2. Overall home ranges (95% AK) of female black bears on Blue Cat, Deltic study area, Tensas River Basin, Louisiana.

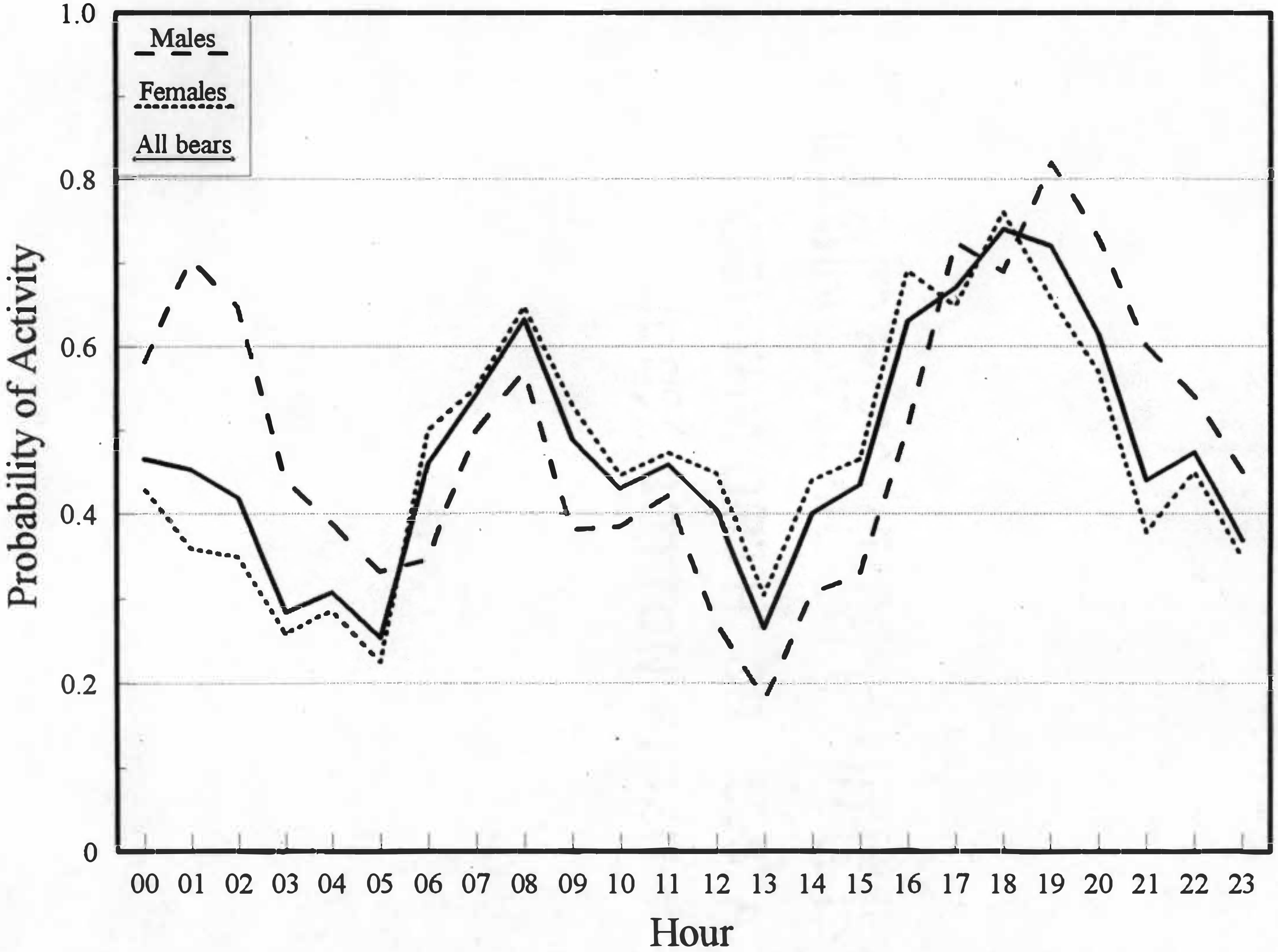

Fig. 3. Hourly probability of activity of male and female black bears, Deltic study area, Louisiana.

0.64). Analyzed by season, bears were diurnal during the summer, with a shift to more nocturnal activity in the fall ($\underline{P}$ < 0.00001) (Fig. 4). Fall and spring movements were highly variable ($\underline{P}$ > .05).

Monthly and seasonal activity

Probability of bear activity peaked in September (POA = 0.61), and was lowest in January (POA = 0.13) (Fig. 5). Probability of activity for males and females peaked in the fall (POA = 0.48-0.59) and summer (POA = 0.50-0.63), respectively. Seasonal activity only differed between sexes during the summer season, with males more active than females ($\underline{P}$ = 0.0024); there were no significant differences between sexes for other seasons.

MOVEMENT

Hourly movement rates

Mean hourly movement rates for males and females was 259 m/hr and 119 m/hr, respectively, but were not different. Comparing movement rates by month, movement differences between sexes were only significant for September (F = 374 m/hr, M = 589 m/hr, $\underline{P}$ = 0.004).

Daily movement rates

Males moved farther than females during summer ($\underline{P}$ = 0.03) fall ($\underline{P}$ = 0.02) and overall ($\underline{P}$ < 0.00001) (Table 6); overall daily movement rates for males and females were 1847 m and 1079 m, respectively. Females travelled farther during the fall than any other season ($\underline{P}$< 0 .00001). Male daily rates did not differ between seasons. No differences were found between daily movement rates of adults

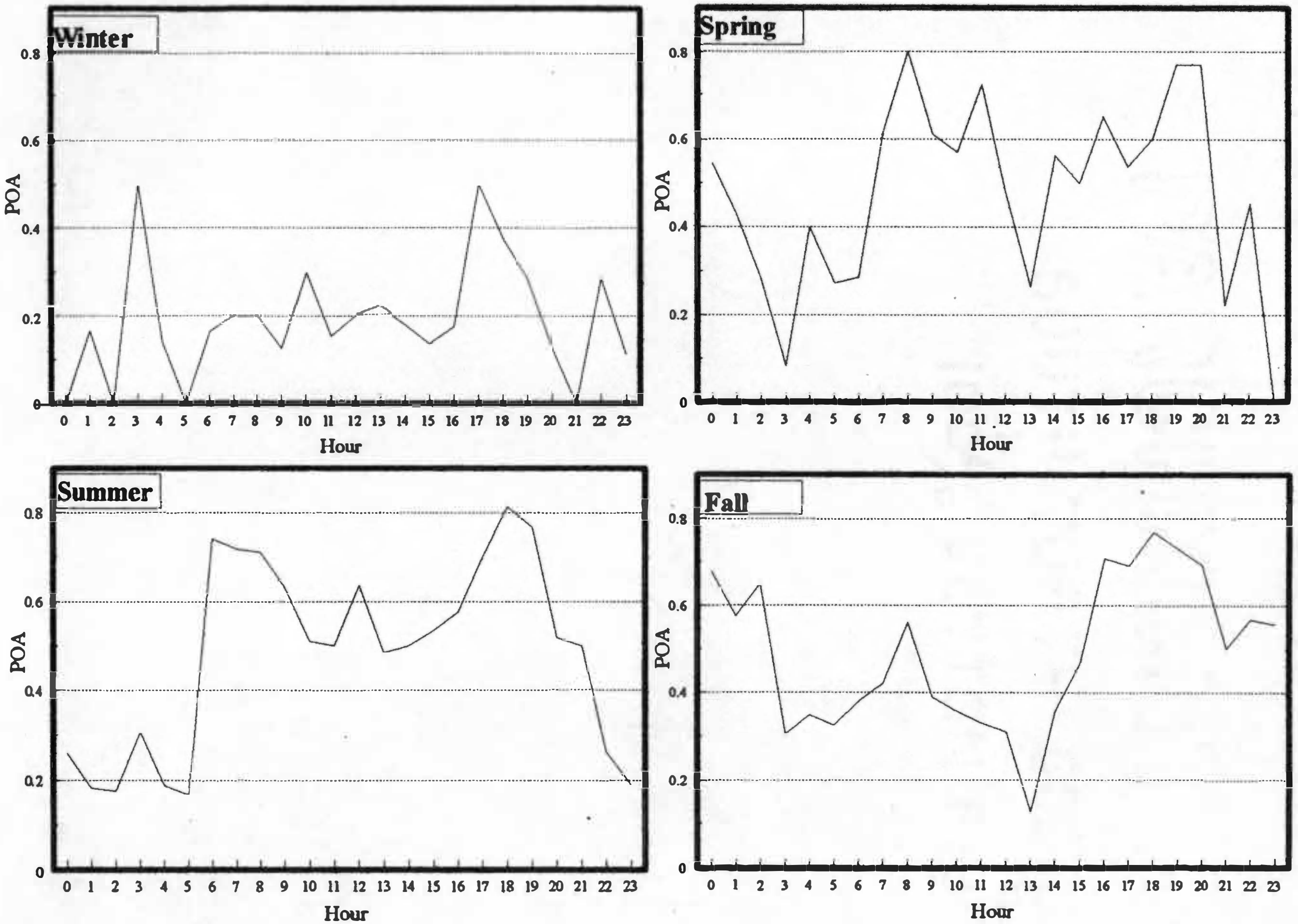

Fig. 4. Seasonal breakdown of hourly probability of activity for black bears, Deltic study area, Louisiana.

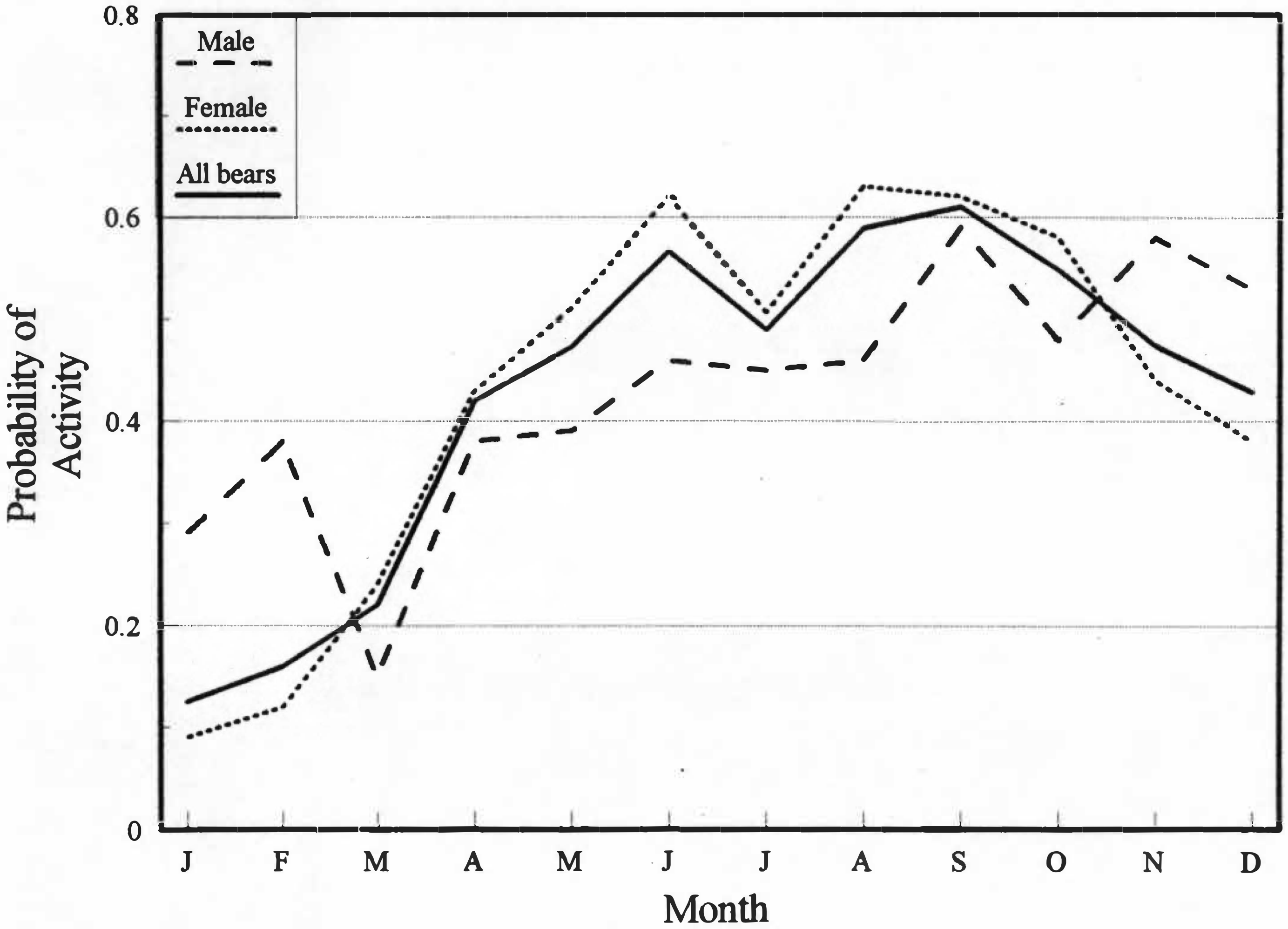

Fig. 5. Monthly probability of activity of male and female black bears, Deltic study area, Louisiana.

Table 6. Comparison of seasonal daily movement rates (m) of male and female black bears, Deltic study area, Tensas River Basin, Louisiana (1992-93).

	Winter		Spring		Summer		Fall	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Females								
F124	344	295	528	415	633	422	1543	1909
F128	682	517	594	355	870	466	1048	720
F156	232	229	188	162	1191	424	828	504
F160	213	167	675	435	1014	549	1646	1243
F180	--	--	--	--	1760	1112	1112	1455
F184	--	--	--	--	1104	747	1010	713
Mean	**374**	**369**	**499**	**384**	**981**	**624**	**1227**	**1238**
Males								
M106	3650	--	857	--	1846	1516	1458	1343
M149	--	--	898	754	1449	950	2065	1806
M151	--	--	--	--	1889	1771	2405	1626
M182	--	--	1383	1377	409	282	384	127
Mean	**3650**	**--**	**1100**	**944**	**1766**	**1443**	**1848**	**1616**
$\underline{P}$	0.11		0.24		0.03		0.02	

and subadults ($\underline{P}$ = 0.70).

Dispersal

Bear M182, the subadult male located in the Blue Cat-Lodge Lakes Complex area since May 1993, abruptly moved 12 km to the Brownie area in October 1993 where he remained until he lost his radio collar (December 1993). Early movement patterns suggest Blue Cat as the bear's tract of origin, with a gradual exploratory expansion of range later in the year (Fig. 6). Except for locations in Carson Woods and Wade Bayou Woods, the male's route between Blue Cat and Brownie was undocumented. A subadult female (F184) made an excursion to a bayou which was approximately 5 km south of Blue Cat, but returned to Blue Cat after less than a week.

BOTTOMLAND HARDWOOD HABITAT USE

Radio-collared bears were located in wooded areas more than expected in proportion to occurrence, whereas there were fewer locations than expected in nonwooded areas (χ^2 = 13.17, df = 1, $\underline{P}$ < 0.001).

Habitat Use Indices

Trap sites on Blue Cat were visited by bears more often than the other 3 tracts ($\underline{P}$ = 0.00039) (Table 7). The bear sign index showed a significant difference in bear sign among tracts ($\underline{P}$ = 0.032) (Table 8).

FIELD EXCURSIONS

For locations outside woodlots, male bears travelled further from forest edges than females ($\overline{X}$ = 0.43 km vs. 0.34 km, respectively). Males were found farther

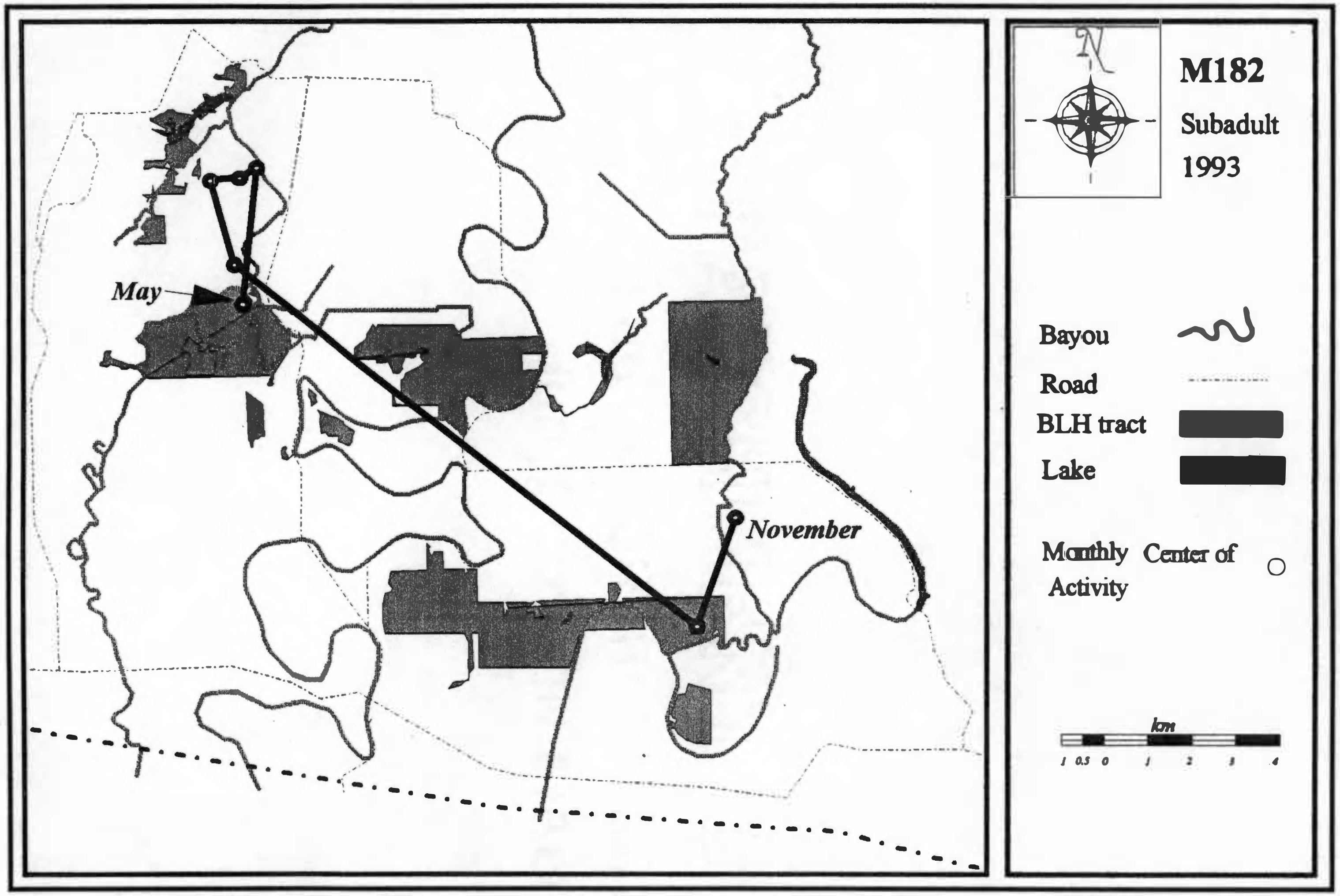

Fig. 6. Monthly centers of activity of black bear M182, Deltic study area, Louisiana (May-November 1993).

Table 7. Summary of Kruskal-Wallis analysis for bear activity at trap sites between bottomland hardwood tracts, Deltic study area, Tensas River Basin, Louisiana (1993).

Tract	No. of sites	Trap nights	Activity	Activity/TN
Blue Cat	19	186	73	0.392
Brownie	9	47	2	0.043
Panther Lake	7	37	2	0.054
Wade Bayou	9	44	3	0.068

Kruskal-Wallis Test (Chi-Square Approximation)
CHISQ = 18.240 DF = 3 Prob > CHISQ = 0.00039

Table 8. Summary of Kruskal-Wallis analysis for bear sign along habitat transects on bottomland hardwood tracts, Deltic study area, Tensas River Basin, Louisiana (1993).

Tract	No. of transects	Plots	Plots with sign	Sign/plots
Blue Cat	17	149	14	0.09
Brownie	27	195	4	0.02
Panther Lake	20	180	11	0.06
Wade Bayou	20	140	9	0.06

Kruskal-Wallis Test (Chi-Square Approximation)
CHISQ = 8.8016 DF = 3 Prob > CHISQ = 0.03205

from forest edges lines during both summers than at other times of the year.

Travel Corridors

Males were more likely than females to be found away from their tract of capture (including locations both in fields and on other tracts) (P < 0.03). Between 28.1% and 86.0% of locations for individual males were away from tract of capture ($\bar{x}$ = 64.2%, SD = 25.17) compared with a range of 2.9% to 52.2% for individual females ($\bar{x}$ = 15.5%, SD = 18.2) (P = 0.025). Travel between wooded tracts was much more common for males than for females (Table 9); only one female (F180) was ever found in a tract other than the tract of original capture.

DENNING AND REPRODUCTION

Denning Sites

All den sites were located in bottomland hardwood habitat. Of the 6 bears monitored during the winter of 1992-93 in the Deltic study area, 1 male and 2 females denned in hollow trees (Tables 10 and 11). The remaining 3 bears used ground nests, either brushpiles or open nests.

Denning chronology

Mean denning period for radio-collared bears during the winter of 1992-1993 was 71.1 days (N = 6, SD = 30.8). The length of the denning period was not different between sexes (P = 0.487).

Natality and survival

All females monitored (N = 4) had cubs during the winter of 1992-93, with

Table 9. Summary of locations for black bears, Deltic study area, Louisiana. 1992-1993.

Bear ID	Blue Cat	Brownie	Panther Lake	Wade Bayou	Field[a]	Other[b]
Female						
F124	163	0	0	0	6	19
F128	180	0	0	0	43	20
F156	151	0	0	0	20	24
F160	150	0	0	0	22	13
F180	0	0	24	1	5	15
F184	46	0	0	0	2	15
Total	690	0	24	1	98	106
Male						
M106	28	0	0	9	51	51
M149	67	0	0	8	9	17
M151	11	4	3	26	5	22
M182	9	4	0	1	18	24
Total	115	8	3	44	83	114

[a]Includes all agricultural areas.

[b]Includes all other bottomland hardwood fragments.

Table 10. Denning activity of radio-collared male black bears on the Deltic study area of Tensas River Basin, Louisiana (Winter 1992-1993).

Bear ID	Den type	Denning period	No. days denned
106	Ground	31 Jan-- 21 March[a]	52
149	Tree	06 Feb-- 11 Apr	64
		Mean	58

[a]Bear denned at first contact--may have begun denning earlier.

Table 11. Denning activity of radio-collared female black bears on the Deltic study area of Tensas River Basin, Louisiana (Winter 1992-1993).

Bear ID	Den type	Denning period	No. days denned	No. cubs
124	Tree	15 Jan--15 Apr	90	2
128	Ground	15 Jan--23 Feb	30[b]	3
156	Ground	06 Jan--05 May[a]	119	2
160	Tree	08 Jan--21 March[a]	72	1
Total cubs				8
Average denning period[c]			77	

[a]Bear denned at first contact--may have begun denning earlier.

[b]Nest abandoned.

[c]Average discounting F128: 93.7.

litter sizes ranging from 1 to 3 ($\bar{x} = 2$) (Table 11). One female (F128) abandoned her nest in February; the fate of the cubs was not determined.

MORTALITY

Two roadkills were reported in the study area in 1992 (T. Edwards, TRNWR, pers. commun). An untagged male (82 kg) was retrieved from Wade Bayou after being struck on Highway 579 in early February 1992. A tagged male (M153) was killed on Highway 577 near Blue Cat on 14 March 1992. A bear was reportedly struck by a vehicle on Highway 17 in December 1993, but was not recovered. No incidences of bear poaching in the TRB were reported during this period of study, but 3 bears were illegally shot on the TRNWR between 1988 and 1991.

CHAPTER V

DISCUSSION

TELEMETRY

Although activity signals of transmitters were considered accurate based on observation, errors were noted. For example, a female was observed moving across a field, but the tip switch collar of the bear continued to signal in the "inactive" mode until the bear climbed down a bank. Thus, it is possible that reported levels of activity may be underestimated. Similar problems were noted in using tip switch collars on cougars (Felis concolori) (J. Clark, Nat. Biol. Serv., pers. commun.)

Bayous seemed to be a source of significant signal bounce. Power lines and forest edges also appeared to distort or disrupt signals. Azimuths were taken 3-5 km from transmitters in many cases because of limited access and inclement weather. The larger, roof-mounted antenna produced stronger reception and more precise directionality than did the H-antennas. Because of limited access, however, H-antennas were often necessary for taking azimuths. I do not feel that the error rate observed with the test collars was high enough to adversely affect the overall conclusions.

HOME RANGE

Home range size and shape are determined in part by the capability of an area to provide the annual needs of bears (Hamilton 1978), but are also affected by other factors, including age, sex, season, and the population density (Pelton 1982).

Additionally, the quantity and quality of available food influences home range size (Jonkel and Cowan 1971, Hardy 1974, Alt et al. 1980, Amstrup and Beecham 1976, Eubanks 1976, Lindzey and Meslow 1977, Garshelis and Pelton 1980, Garris 1983, Garner 1986, Powell 1987). This study suggests that cover is also a determining factor in home range size and shape.

Though centered in Blue Cat, home ranges of females shifted between Fall 1992 and Fall 1993, reflecting the shift of corn crops from south of Blue Cat to north of Blue Cat (Fig. 7). Several studies have noted similar shifts in home range based on variation in food sources (Garshelis and Pelton 1980, 1981, Garner 1986).

Adult male bears on the Deltic study area occupy larger home ranges than do adult females; this is generally true for black bears elsewhere (Pelton 1982). Amstrup and Beecham (1976) suggested that the high mobility of males increased reproductive success, allowing males to find more females for mating; females, on the other hand, cover only the minimum area necessary to meet the requirements of maintenance. Alternately, Harestad and Bunnell (1979) suggested that males of dimorphic species use larger areas than females in order to fulfill greater metabolic requirements. Given the quantity of agricultural foods present throughout much of the year, it is likely that the hypothesis of Amstrup and Beecham is more applicable to bears in the Deltic study area.

Home ranges of bears, particularly those of females, appeared to be closely linked to forest cover. An analogous situation was found in a study on Long Island, Washington; the home ranges of male bears were not generally confined to the

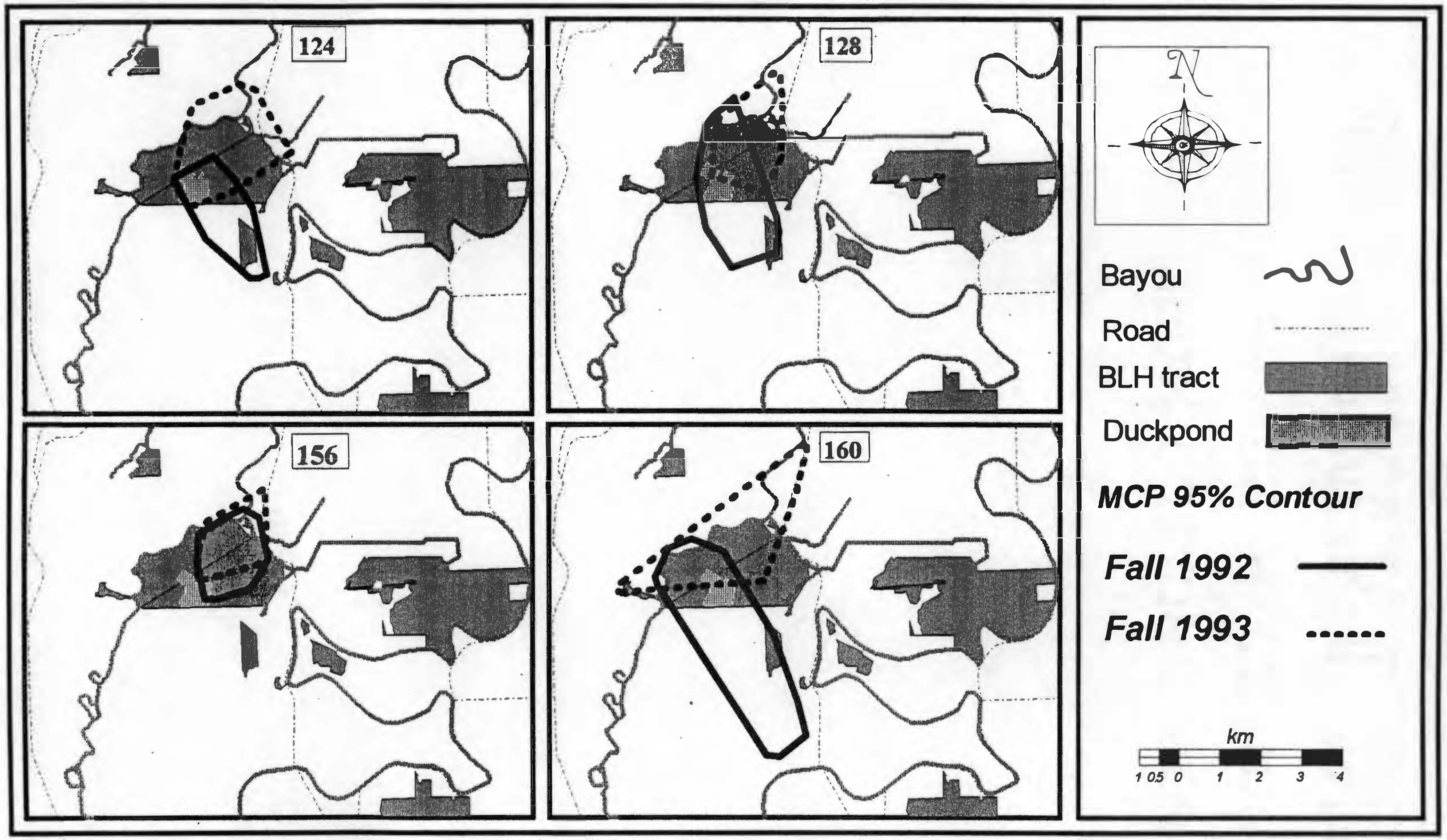

Fig. 7. Comparison of consecutive fall home ranges for female bears on Blue Cat, Deltic study area, Louisiana.

island, but home range configurations were directly or indirectly influenced by the configuration of the island (Lindzey 1976). The island analogy is appropriate for the fragmented habitat of the Deltic study area.

Extensive overlap between individual home ranges has been frequently observed among black bears (Sauer et al. 1969, Jonkel and Cowen 1971, Beeman 1975, Amstrup and Beecham 1976, Lindzey and Meslow 1977, Reynolds and Beecham 1980, Garshelis and Pelton 1981, Villarrubia 1982, Garner 1986), including bears in the Deltic study area. Core area overlap at seasonal food sources suggests intraspecific tolerance, at least seasonally. Home range overlap may, in some cases, indicate some amount of kinship among adult females and subadults (Garner 1986), but kin relationships of bears on the Deltic tracts were not clear enough to draw any conclusion. Powell (1987) noted that female bears in the Southern Appalachian Mountains exhibited greater home range overlap in more productive habitat and suggested that intrasexual territoriality among females implied that a limiting resources was being defended. In the Deltic study area, patchiness of the bottomland hardwood habitat (high density of bears), combined with extensive agricultural food resources (competition for food resources not intense), would seem to foster some degree of intraspecific tolerance. If home ranges overlap, temporal and spatial separation within overlapping areas may help prevent encounters between bears (Lindzey and Meslow 1977). Carr and Pelton (1984) noted strong mutual avoidance among bears in Great Smoky Mountains National Park. Jonkel and Cowen (1971) reported that whereas males and females travelled together during the breeding season, they maintained a distance of at least 50 m during the rest of the year. Reynolds and Beecham (1980) reported that female bears in Idaho concentrated in a portion of their range that minimized contact with other females.

ACTIVITY AND MOVEMENT

Bears were generally most active in early evening and mid morning, and least active around midnight and midday. Amstrup and Beecham (1976) and Reynolds and Beecham (1980) found bears in Idaho to be primarily diurnal throughout their active season. Lindzey (1976) reported black bears in Washington to be primarily diurnal; daytime activity was observed to be frequently interrupted for short periods of rest without sleeping. Deltic bears also appeared to have short rest periods during long periods of activity. Males in particular were found to show little movement or activity for hours or days, followed by a movement of several kilometers in the space of a few hours.

Both Garshelis and Pelton (1980) and Garner (1986) found that bears were mostly diurnal in the summer, and were mostly nocturnal during the fall. Bears became largely nocturnal in the fall on the Deltic study area. One possible explanation for this shift to night activity may be the increased human activity in the forest. Squirrel and deer hunters, often using ATVs, may cause bears to restrict activity to the quieter night hours. Garner (1986) hypothesized that males in Shenandoah National Park became more nocturnal when making excursions into farms, residential areas, and other human disturbance sites. Bears may also increase nocturnal activity in association with increased pre-denning foraging (Garshelis and

Pelton 1980).

Movement rates of males did not differ by season, possibly due to small sample sizes. Movements of adult males were greatest during the summer breeding season in Washington (Lindzey 1976) and Pennsylvania (Alt et al. 1980), whereas Reynolds and Beecham (1980) found no seasonal differences in movements between bears of either sex in Idaho. Deltic females moved farther in the fall, a period of pre-denning foraging, than during any other season. In the fall, all bears were found foraging in harvested corn fields, sometimes >1 km from forest cover.

Subadult male M182 dispersed from a tract with a high bear density to one with a relatively low bear density. It has been hypothesized that bears, particularly subadult males, are forced from a given population, perhaps as a means of population regulation (Jonkel and Cowen 1971, Young and Ruff 1982). Rogers (1987) found that subadult males in Minnesota more often dispersed voluntarily from the home range of their mother, whereas young females settled into part of their mother's home range. Reynolds and Beecham (1980) reported that dispersal of black bears primarily occurred in the 2.5-year-old age class. Adult males are likely to discourage immigration and settlement by transient subadults (Jonkel and Cowan 1971, Rogers 1976, Garner 1986); this could explain why M182 settled in a relatively unpopulated portion of the study area.

The results of this study demonstrate a tendency for males to travel farther from wooded cover than females during the summer breeding season (Amstrup and Beecham 1976). Males in this study used multiple woodlots far more frequently than females, and showed a generally higher mobility in many respects. For these reasons, I speculate that male movements, while influenced by habitat fragmentation patterns, were not inhibited by the level of fragmentation on the Deltic study area.

All bears were found in wooded corridors along bayous, possibly using these areas as staging areas for field excursions. Telemetry locations and visual observations indicated that wooded drainages were important travel corridors for movements between tracts. These drainages provide cover and may facilitate movements across agricultural lands (Weaver et al. 1990a). These drainages also may be important for dispersal outside the study area. However, several small communities were located to the south of the area, primarily along drainages. I speculate that human development along the bayous may discourage bears from using the drainages to cross I-20, effectively isolating the Deltic population from the habitat south of I-20, including TRNWR.

ROADS

Observations of bear tracks in the Deltic study area did not indicate habitual use of roads or ATV trails except in some thickly vegetated or inundated areas. Bears use foot trails as travel lanes in Shenandoah National Park (Garner 1986) and Great Smoky Mountains National Park (van Manen 1994), as well as in the coastal plain (Pelton, Univ. Tenn., pers. commun.)

Bears in the Deltic study area crossed secondary highways, usually at places in close proximity to cover such as a wooded drain or bayou. It is possible that I-20, a divided highway bordered by fences, constitutes a barrier between the Deltic study area and the TRNWR.

BEAR USE AND PATCH SIZE

Both the trap site and bear sign indices estimate relative density; Blue Cat was the only tract for which there was enough information to estimate true density. Blue Cat, the smallest of the 4 tracts, had an unusually high density of bears. Based on telemetry and direct observations, we determined that a minimum of 20 different bears (1993) regularly occupied this 5.5 km^2 wooded tract (3.6 bears/km^2). The ability of certain tracts to support high bear densities may be attributed to the availability of preferred agricultural crops. There are several possible reasons why Blue Cat and Wade Bayou appear to have more bears than the larger Brownie, which also was surrounded by agriculture. Certain natural foods were more abundant on Blue Cat than on Brownie (Table A-3), the most striking difference being pawpaw (Asimina triloba), which was much less common on Brownie (10% of sample plots) than on Blue Cat (53%). This disparity may be due to elevational differences, as Blue Cat is higher than Brownie and is less prone to flooding. Another potential factor is human use of tracts. Blue Cat is hunted by employees and guests of Deltic Farm and Timber, Inc., whereas Brownie is leased by a private hunt club, and thus may be subject to different and possibly more intensive management for hunting. Other habitat variables that might affect the suitability of habitat in the study area could not be discerned in this study.

All males were found in at least 2 of the 4 main bottomland fragments; 1 male was found in all 4. Males were also found in bayou corridors and small habitat fragments. By contrast, females were largely restricted to bayous and smaller fragments adjacent to their tract of capture. Bears, particularly males, appeared to need relatively small areas of contiguous woodland habitat for cover while utilizing food resources provided by extensive agriculture.

DENNING AND REPRODUCTION

Potential den sites in southeastern wetlands are limited by periodic flooding (Hamilton and Marchinton 1980, Hellgren and Vaughan 1989). However, Weaver and Pelton (1995) reported that availability of denning sites did not appear to be a limiting factor in the TRB.

Black bear ground nests were scooped-out shallow depressions, often lined with vegetation bitten off from around the nest site, and located on dry ridges or in flats. Nests are usually in areas of thick vegetation, which serve to conceal the nest. In some cases, bears construct dens inside brushpiles of logging slash (Weaver et al. 1990b). Black bear use of ground nests has been observed in other southeastern locations (Landers et al. 1979, Hamilton and Marchinton 1980, Johnson and Pelton 1981, Hellgren and Vaughan 1989). Tree dens were located in both living and dead trees, in cavities formed by rot introduced through either a broken trunk top or a broken limb. Tree dens were typically, but not exclusively, found in bald cypress in sloughs, lakes or other seasonally flooded areas (Weaver et al. 1990b). In the TRB, trees large enough and mature enough to contain usable cavities are almost always found in places inaccessible to logging. Tree dens have an advantage in that they seclude bears from disturbance more effectively than ground nests (Pelton et al.

1980). Smith (1985) reported that in a bottomland hardwood forest in Arkansas, females denned exclusively in tree dens, whereas males used both trees and ground nests. Weaver and Pelton (1995) reported that in a study in the TRB, 62% (N = 18) of bears used tree dens, whereas 48% (N = 14) used ground nests. All ground-nesting bears moved their den sites at least once, whereas the tree-denning bears stayed in the same locations throughout the denning period. I speculate that the ground-nesting bears were less secluded than tree-nesting bears and thus were more susceptible to disturbance. Two of the tree-denned bears were known to have used the same tree in previous years; this is not necessarily the case elsewhere. Lentz (1980) reported that bears on a north Georgia study area did not reuse dens during consecutive years. Weaver and Pelton (1995) found that between 1988 and 1990, only one monitored bear reused a den.

Black bears in the TRB denned for shorter periods than black bears in colder regions (Beecham et al. 1983, Kolenosky and Strathearn 1987, Schwartz et al. 1987), but denning periods were similar compared with black bears in Florida (Wooding and Hardisky 1992) and the coastal plain of Virginia (Hellgren and Vaughan 1987). Female denning periods were consistent with the 3- to 4-month minimum den period suggested by Wooding and Hardisky (1992).

Denning started later in this study compared with Weaver and Pelton (1995), who reported that in the TRB the onset of denning occurred from late November to early January. Emergence dates in this study were consistent with the late February to late April dates reported by Weaver and Pelton (1995).

Mean denning period for females in this study ($\overline{X}$ = 77 days, N = 4) was shorter than for females in Weaver and Pelton (1995) ($\overline{X}$ = 142 days, N = 9). Mean denning period of adult males for this study ($\overline{X}$ = 58 days, N = 2) was similar to the findings reported by Weaver and Pelton (1995) ($\overline{X}$ = 49 days, N = 7); overall denning period for this study was slightly shorter than Weaver and Pelton found ($\overline{X}$ = 71.1 days and $\overline{X}$ = 95 days, respectively).

MORTALITY

Adult black bears in the TRB have no natural predators, and non-human causes of mortality in the TRB are not known. Human-related mortality factors include vehicle collisions and poaching. Lindzey (1976) reported that most mortality of bears over 1 year of age on a study area in southwestern Washington appeared to be directly attributable to humans. Human-related mortality (particularly poaching) may have been the primary cause of death for bears in southeastern Arkansas (Smith 1984).

Roadkills on the Deltic study area occurred on secondary state highways. No vehicle collisions involving black bears have been reported along the stretch of I-20 bordering the Deltic study area and TRNWR. It is possible that males may be more at risk from vehicles because of their higher incidence of movement between tracts. In Florida, males were killed on roads more often than females, and males of dispersal age were killed more frequently than other age classes (Wooding and Brady 1987).

CHAPTER V

MANAGEMENT IMPLICATIONS

Bears appear to have little opportunity to move between the Deltic and TRNWR study areas. Movement throughout the Deltic study area is limited by human development, both residential and agricultural. Although males travel freely between tracts, females are generally based in one tract only.

Topographical maps and aerial photos indicate that approximately 10 km^2 of bottomland hardwood forest in the study area have been converted to agriculture since 1986, within the lifetime of some of the bears studied. Included in the clearing was habitat connecting Wade Bayou and Panther Lake Woods, and an extension of Brownie extending southward 2 km.

Although bear movement into the study area is not impossible, there was no direct evidence of immigration into the study area. This would suggest the possibility that the remnant bear population on the Deltic study area is isolated. However, in 1993 a male bear with Arkansas ear tags was captured on the TRNWR, so immigration is possible. Saunders et al. (1991) suggested that long-lived species may be persistent even in populations too small to be viable. The apparent health of this population is probably due in large part to the local agriculture. Protection of remaining forested habitat, including buffer strips around sloughs and bayous, is imperative for the long-term survival of this population. Any long-term plans must include reforestation of marginal farmland, and the reconnection of the Deltic and TRNWR areas for bear movements. Special attention should be given to possible links between the Deltic study area and the TRNWR.

RESEARCH IMPLICATIONS

Anecdotal evidence suggested possible future research topics. For example, bear tracks and local reports indicate that adult male bears would cross open fields, whereas smaller bears (presumably females and subadults) crossed fields at their narrowest point. Future research could address whether movement between fragments is influenced by the intervening distance, and whether males cross larger open spaces than females.

I could find no definite pattern to male movements between habitat fragments. A future study could decide whether males travel to other areas in response to shifting food sources, to avoid other males, or for other reasons.

A high priority should be to identify bear movements out of and into the study area, especially between the Deltic and TRNWR study areas. This information would be very useful in determining travel corridors to protect or reclaim.

An accurate population estimate for the TRB would be useful given the status of the Louisiana black bear as a threatened subspecies. Also important, and necessarily part of a long-term study, would be a relative population estimate that identified trends in local population growth.

A topic related to population estimation is cub survival. Females on the Deltic study generally have 2 or 3 cubs per litter. Knowing the survival rate of cubs in the TRB, and the mortality factors of cubs, would make it easier to accurately gauge population growth. A related topic pertains to subadult dispersal: do females disperse to tracts other than their tract of origin, and do any bears disperse to areas outside the study area?

This study indicated bear use of bottomland hardwood tracts is not directly proportional to the size of the tract. Knowing what factor(s) determine bear use of a particular habitat or tract would help managers make decisions about which tracts are most valuable as bear habitat or how to improve existing habitat.

CHAPTER VI.

SUMMARY AND CONCLUSIONS

1. Research was conducted on an approximately 350 km^2 study area in the Tensas River Basin, Louisiana, from May 1992 through December 1993. The purpose of the study was to determine movement characteristics of Louisiana black bears in fragmented bottomland hardwood habitat.

2. During the study, 18 captures were recorded in 565 trap-nights, for an average capture rate of 31.4 trap-nights per capture. Of the 12 bears captured, 10 were radio collared (4 M, 6 F). Two collared bears were subadults; the rest were adults.

3. Of the 6 bears monitored during the winter of 1992-1993, 1 male (50%) and 2 females (50%) denned in hollow trees; the remaining bears used brushpiles of open nests. All den sites were located on bottomland hardwood habitat. The mean denning period for bears ($\underline{N}=6$) during the winter of 1992-1993 was 71 days; the length of denning period was not different between sexes. All monitored females ($\underline{N}=4$) had cubs. Mean litter size was 2 cubs. One female abandoned her nest in February; her litter was not recovered.

4. A total of 3,748 telemetry locations were obtained from 10 bears during the course of the study. Analysis parameters narrowed the number of locations to 2,718, which were used for activity and movement analysis. Of these locations, 1,230 were considered independent for purposes of determining home range.

5. Mean overall home range estimate for males (52.3 km^2) was larger than the mean overall home range estimate for females (12.6 km^2). Seasonally, bear home ranges were largest during the fall. No size difference was found between home ranges of adults and subadults.

6. Home range shape appeared to be influenced by the configuration of available forest cover. The influence of cover was more apparent in the home ranges of females, which were centered on bottomland hardwood fragments and adjoining wooded drainages.

7. Extensive home range overlap among females suggested intraspecific tolerance. Patchiness of bottomland hardwood habitat, combined with abundant food resources, would seem to foster tolerance among female bears.

8. Bears were generally crepuscular. Seasonally, bears shifted from more diurnal in the summer to more nocturnal in the fall, with less clear patterns in the spring and winter. Between sexes, seasonal activity differed only in the summer, with males being more active than females.

9. Daily movement rates were greater for males than females. Male daily movement rates did not differ by season as expected; females travelled farther during the fall than during any other season.

10. All radio-collared males were found on more than 1 of the 4 bottomland hardwood tract during the study. Of the female bears, only 1was ever located on a tract other than the tract of capture. All black bears used wooded drainages; drainages appeared to be used to facilitate travel across the study area, and may act as

staging areas for foraging in agricultural fields. Observation of tracks did not indicate habitual use of roads or ATV trails except in thickly-vegetated or inundated areas.

11. Black bear use of bottomland hardwood habitat fragments did not increase proportionally to the size of the habitat fragment; the smallest tract appeared to have the largest bear number of bears using it, with an estimate of 20 bears, or 3.6 bears/km^2. Possible factors determining fragment use include human use of the habitat and varying natural food sources.

12. No mortality of adult bears was recorded during the study. However, two bears were killed in vehicle collisions in early 1992. A bear-vehicle collision occurred in December 1993, but no bear was recovered. No incidences of bear poaching were reported during the study.

13. Males were more likely to be found in agricultural fields than females, and were found farther from wooded cover than females during field excursions. All bears were found foraging in harvested corn fields during the fall.

14. The larger home ranges, higher movement rates and greater distance from cover suggest males to be more likely to leave or enter the Deltic study area than females. No instances of bears leaving or entering the study area were documented. Human development, including an interstate highway and several small communities, may inhibit movement between the Deltic study area and the less fragmented bottomland hardwood habitat of the TRNWR to the south. While movement between the Deltic tract and TRNWR is not impossible, several barriers could make such movement unlikely.

15. Based on home range size and movement patterns, I speculate that male bear movements, while influenced by habitat fragmentation patterns, were not inhibited by the level of fragmentation on the Deltic study area.

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APPENDICES

APPENDIX A: HABITAT SURVEY

HABITAT SURVEY

A grid system of transect lines was used to conduct a 1% sample of vegetation species composition. A grid pattern was used instead of a randomized sample in an attempt to map differences in habitat types. For 3 of the tracts, transect lines ran north-south (Panther Lake Woods was surveyed with east-west transects).

Plots were laid out along each transect. For 0.1 acre (0.04 ha) plot, ground cover was visually estimated as a percentage by species, and midstory and overstory species were tallied. Understory was considered as all anything 1.4 m or lower; midstory was between 1.4 m and 9 m, and overstory was above 9 m.

In most cases, we were unable divide the tracts into distinct habitat types. Except in a few flooded areas, overstory was a fairly uniform mixture of tree species. Ground cover was a mosaic too varied to be accurately mapped. Understory species composition varied with very minor fluctuations in elevation.

Principal overstory species were sweetgum (Liquidambar styraciflua), American elm (Ulmus americanus), pecan (Carya illinoensis), sugar hackberry (Celtis laevigata), green ash (Fraxinus pennsylvanica), and several species of red oaks (Quercus spp.). Baldcypress (Taxodium distichum) was a significant overstory component in permanently-inundated areas such as sloughs and bayous. Trees throughout the forest exhibit buttswell characteristic of a high water table.

Common midstory species included pawpaw (Asimina triloba), hawthorne (Crategeous spp.), flowering dogwood (Cornus florida), swamp privet (Forestiera acuminata), elm (Ulmus spp.), and hophornbeam (Ostrya virginiana). Switchcane

(Arundinaria gigantea), another important component, was generally confined to areas lacking overstory such as clearings and forest edges. Pawpaw, an important midstory food species for bears in the TRB (Weaver et al. 1990b), was widely available; it was especially prominent on Blue Cat and Wade Bayou (found in >50% of plots), which are relatively drier tracts than Panther Lake or Brownie.

Understory species included greenbriar (Smilax spp.), poison ivy (Rhus toxicodendron), palmetto (Sabal minor, trumpet vine (Campsis radicans), beggar lice (Desmodium spp.), Virginia creeper (Parthenocissus quincuefolia), and grape (Vitis spp). Most of the bottomland hardwood habitat in the Deltic study area were subject to seasonal flooding, inundating most trails and making some food resources (such as mast) inaccessible.

Several small logged clearings in western and central Blue Cat, eastern Wade Bayou, and central and northern Brownie support dense understory vegetation, notably blackberry (Rubus spp.), poison ivy, switchcane, and several vine species. Timber operations were conducted on Blue Cat, Wade Bayou, and Panther Lake tracts in Fall 1992, and while the understory in these areas was beginning to regenerate the following summer, relatively few bear food species were present.

Table A-1. Plant species in bottomland hardwood overstory as a percentage of occurrence in survey transects of four tracts, Deltic study area, Louisiana.

	Blue Cat	Brownie	Panther	Wade Bayou
Acer negundo	4.60	1.10	0.12	1.55
Acer rubrum	0.70	0.00	0.00	1.55
Carya illinoensis	19.10	23.00	9.72	1.55
Carya spp.	9.20	14.90	9.72	11.63
Celtis laevigata	18.40	11.50	13.89	10.08
Cornus florida	0.00	0.00	0.00	0.00
Diospyros virginiana	1.30	1.70	1.35	3.10
Fagus grandifolia	0.70	0.00	0.00	0.78
Fraxinus caroliniana	8.60	8.00	1.39	16.28
Gleditsia triacanthos	2.00	5.20	0.00	2.33
Liquidambar styraciflua	54.60	47.70	52.78	50.39
Nyssa sylvatica	2.00	0.00	0.00	0.00
Ostrya virginiana	2.60	8.60	0.00	0.00
Platanus occidentalis	1.30	2.30	0.00	0.00
Populus deltoides	0.00	1.10	1.39	1.55
Quercus alba	0.00	0.00	8.33	1.55
Quercus nigra	35.50	23.00	22.22	20.93
Quercus phellos	12.50	32.20	8.33	25.58
Quercus spp. (red oaks)	23.00	55.20	38.89	44.96
Salix nigra	0.00	0.00	1.45	7.75
Sassafras albidum	0.00	1.10	0.00	0.00
Taxodium distichum	1.30	0.60	2.78	4.65
Ulmus alata	2.00	0.00	0.00	0.78
Ulmus americana	14.50	17.20	41.67	13.18

Table A-2. Plant species in bottomland hardwood midstory as a percentage of occurrence in survey transects of four tracts, Deltic study area, Louisiana.

	Blue Cat	Brownie	Panther	Wade Bayou
Acer negundo	32.90	23.00	27.78	29.46
Acer rubrum	23.70	23.00	8.33	31.78
Aralia spinosa	2.60	4.60	6.94	0.78
Arundinaria gigantea	5.30	13.80	6.94	0.78
Asimina triloba	55.30	12.10	4.17	53.49
Berchemia scandens	3.30	6.90	4.17	5.43
Callicarpa americana	0.70	0.60	1.39	0.00
Carpinus caroliniana	1.30	0.00	5.56	6.20
Carya spp.	30.30	38.50	16.67	52.71
Carya illinoensis	0.00	0.60	0.00	0.00
Celtis laevigata	63.80	77.60	69.44	40.31
Cercis canadensis	12.50	5.70	0.00	3.88
Cornus florida	49.30	71.80	43.06	25.58
Cratageous spp.	44.10	51.70	38.89	3.88
Diospyros virginiana	4.60	10.30	8.33	13.95
Forestiera acuminata	3.30	71.30	36.11	10.08
Fraxinus caroliniana	26.30	39.70	11.11	33.33
Gleditsia triacanthos	2.00	1.10	1.39	3.88
Ligustrum sinense	3.90	1.10	0.00	0.00
Liquidambar styraciflua	21.10	42.00	55.56	37.98
Liriodendron tulipifera	1.30	1.10	0.00	1.50
Morus rubra	5.30	24.10	23.61	11.63
Nyssa sylvatica	2.60	4.00	1.39	5.43
Ostrya virginiana	36.80	61.50	1.39	5.43
Platanus occidentalis	0.70	0.60	0.00	0.00
Prunus serotina	3.30	0.00	2.00	1.55
Quercus alba	0.70	0.00	8.33	0.78
Quercus nigra	17.80	21.30	1.39	7.75
Quercus phellos	3.90	19.50	5.56	6.20
Quercus spp.	27.60	48.90	25.00	20.16
Rhus glabra	1.30	0.00	0.00	0.00
Salix nigra	0.70	0.60	2.78	2.33
Sambucus canadensis	0.00	0.60	1.39	0.78
Sassafras albidum	2.00	2.90	1.39	0.78
Taxodium distichum	0.00	1.10	1.39	3.88
Ulmus spp.	7.20	19.00	0.00	3.88
Ulmus alata	16.40	31.60	34.72	37.00

Table A-2. Continued.

	Blue Cat	Brownie	Panther	Wade Bayou
Ulmus americana	61.80	92.00	70.83	62.79
Vaccinium spp.	2.00	0.00	19.44	0.00
Vitis spp.	7.20	7.50	9.72	17.05
Zanthoxylum americana	2.60	0.00	0.00	0.00

Table A-3. Plant species in bottomland hardwood understory as a percentage of occurrence in survey transects of four tracts, Deltic study area, Louisiana.

	Blue Cat	Brownie	Panther	Wade Bayou
Acer negundo	9.20	1.70	2.78	0.00
Acer rubrum	6.60	1.70	2.78	4.65
Ampelopsis arborea	17.10	47.10	23.61	23.26
Arundinaria gigantea	8.60	9.20	5.56	2.33
Asimina triloba	53.30	10.30	1.39	46.51
Berchemia scandens	23.70	43.10	30.56	18.60
Callicarpa americana	4.60	0.00	4.17	10.08
Campsis radicans	44.70	58.60	43.06	17.05
Carya spp.	6.60	2.30	1.39	9.30
Celtis laevigata	24.30	7.50	20.83	5.43
Cercis canadensis	2.60	0.60	0.00	2.33
Cornus florida	15.10	2.30	2.78	9.30
Crategeous spp.	17.80	10.90	6.94	3.10
Desmodium spp.	46.70	24.10	5.56	4.65
Diosyros virginiana	3.90	1.70	2.78	6.98
Euonymus americanus	2.60	0.00	0.00	0.00
Forestiera acuminata	1.30	4.00	9.72	1.55
Fraxinus caroliniana	21.70	11.50	25.00	14.73
Gleditsia triacanthos	0.70	0.00	0.00	1.55
Gramaceae spp.	8.60	43.10	62.50	10.08
Juncus spp.	0.70	0.00	1.39	0.00
Ligustrum sinense	8.60	0.00	0.00	2.33
Liquidambar styraciflua	4.60	2.30	0.00	1.55
Lonicera japonica	3.90	2.90	16.67	2.33
Morus rubra	5.90	2.90	0.00	1.55
Nyssa sylvatica	1.30	1.70	1.39	0.78
Ostrya virginiana	6.60	0.60	0.00	0.00
Oxalis spp.	7.90	0.00	0.00	0.78
Parthenocissus quincuefolia	28.30	35.10	12.50	8.53
Passiflora lutea	25.70	12.10	6.94	2.33
Phytolacca americana	2.00	0.60	1.39	0.78
Plantago spp.	1.30	0.00	0.00	0.00
Prunus serotina	3.30	0.00	1.39	0.78
Quercus spp.	25.00	16.70	11.11	7.75
Rhus glabra	3.30	0.00	0.00	0.00
Rhus toxicodendron	75.00	86.80	81.94	65.89
Rubus spp.	32.90	32.20	37.50	8.53

APPENDIX B: DENNING CHARACTERISTICS

DENNING CHARACTERISTICS

M106 spent the winter in a semi-active state in a <0.01 km^2 patch of woods 3 km north of Blue Cat. This male was observed in a brushpile created by 2 felled tree tops. He was located in this spot from 31 January to 21 March, but may have moved to the patch earlier.

From 15 January to 15 April, F124 denned in a water oak snag located in a slough in the south-central area of Blue Cat. Two cubs were seen with her 23 March. She used this same tree in Winter 1991-1992 (Keith Weaver, USFWS, pers. comm.).

F128 denned in a ground nest that consisted of a low (0.5 m) earth mound, approximately 5.5 m in diameter with 4, 70-cm wide depressions. One depression was lined with palmetto fronds, vines, and oak leaves. The nest was within 5 m of the woods edge and was partially screened by saplings and vines. Three cubs were seen with her at this nest. On 4 February, the female moved 40 m along the wood's edge, making a nest of palmettos at the base of oak just inside the woods. Again, 3 cubs were seen with her. She abandoned this nest between 20 February and 24 February; the fate of the cubs is unknown. The bear was observed alone several times during the year. Biologist Tom Edwards (USFWS, pers. comm.) reported that this female also lost her cub in the spring of 1992.

M149 denned in a hollow overcup oak (Quercus lyrata) located in a drain in north-central Wade Bayou from 6 February to 11 April. Keith Weaver (USFS, pers. comm.) reported that the male used the same tree in previous winters.

F156 spent the winter in a ground nest on a <0.01 km^2 island in Cypress Bayou, northern Blue Cat. The island, which shows some evidence of old logging activity, is connected to land by a short (10 m) causeway (<4 m wide). This bear was either on or near the island prior to 6 January 1993, and left on 5 May 1993. In an effort not to disturb her, no attempt to cross to the island was made until after she left. No single nest could be identified, but several beds were found. This female was observed with 2 cubs on 19 June 1993. No cubs were observed at her capture on 6 October. One cub was seen with her as she fed on corn north of Blue Cat, 24 October 1993.

F160 was inactive in central Blue Cat when telemetry was resumed on 8 January 1993. Between 31 January and 6 February, F160 relocated approximately 100 m south to a 2-m tall hollow snag. The first den was not identified and the cause for the relocation is unknown. She left the den with one cub on March 21. No cub was seen when F160 was observed alone on the edge of a corn field on 16 September 1993.

APPENDIX C: HOME RANGE MAPS

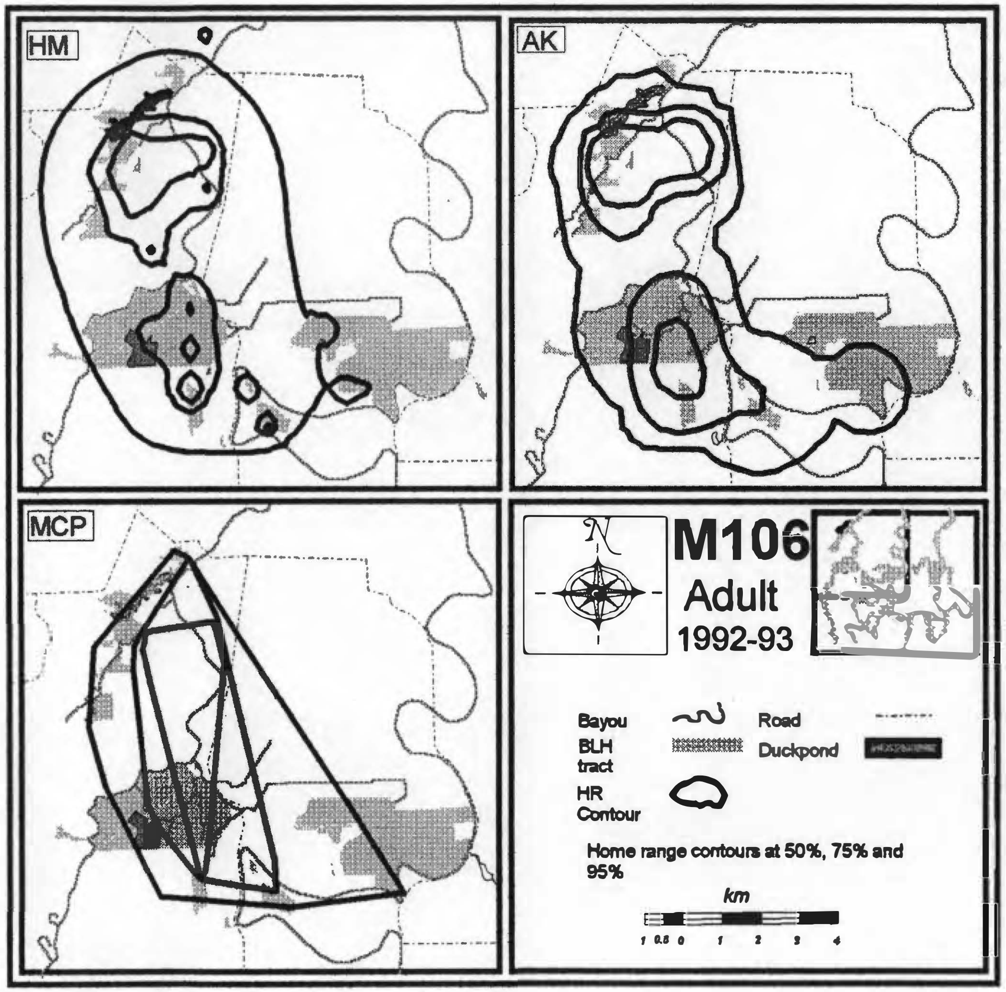

Fig. C-1. Estimated home range of black bear No. M106, Deltic study area, Louisiana (1992-1993).

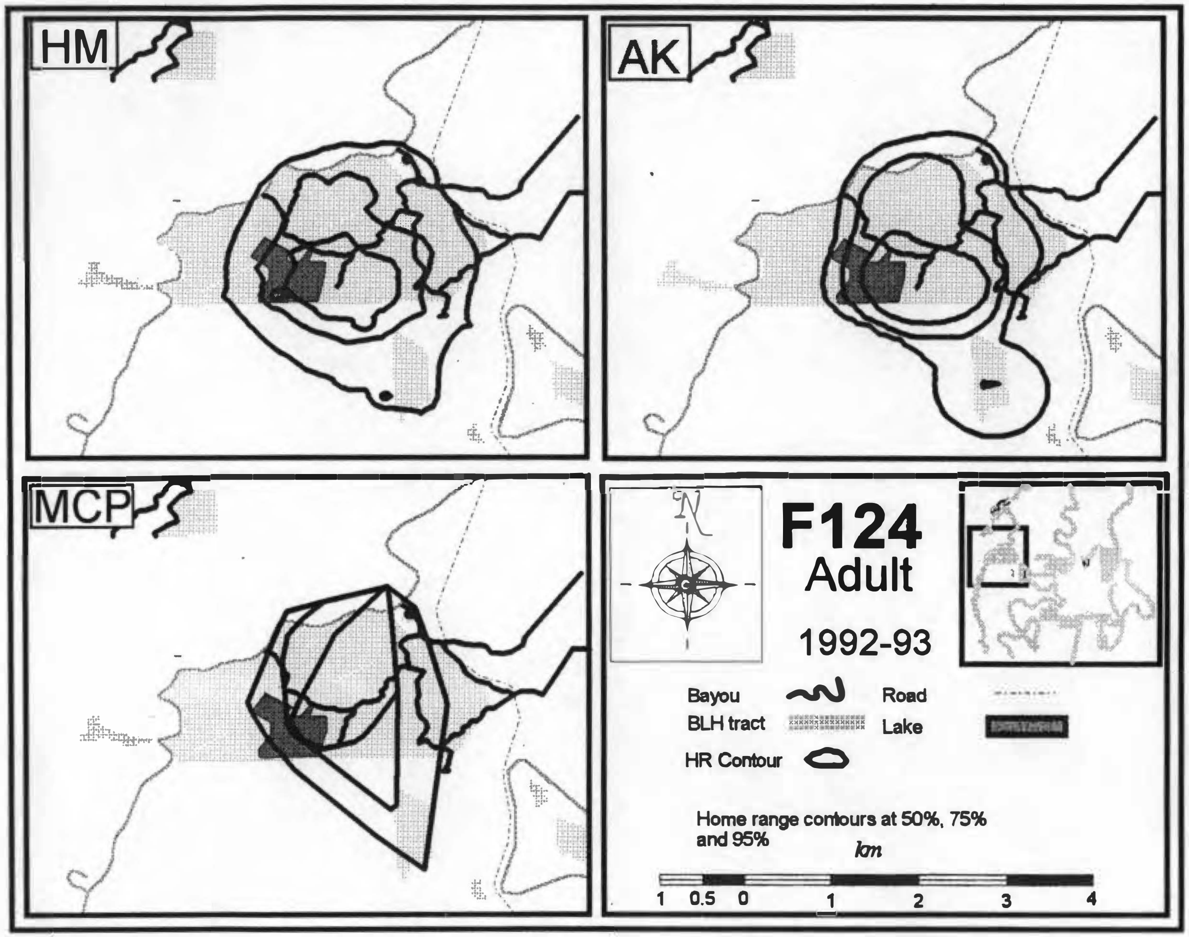

Fig. C-2. Estimated home range of black bear No. F124, Deltic study area, Louisiana (1992-1993).

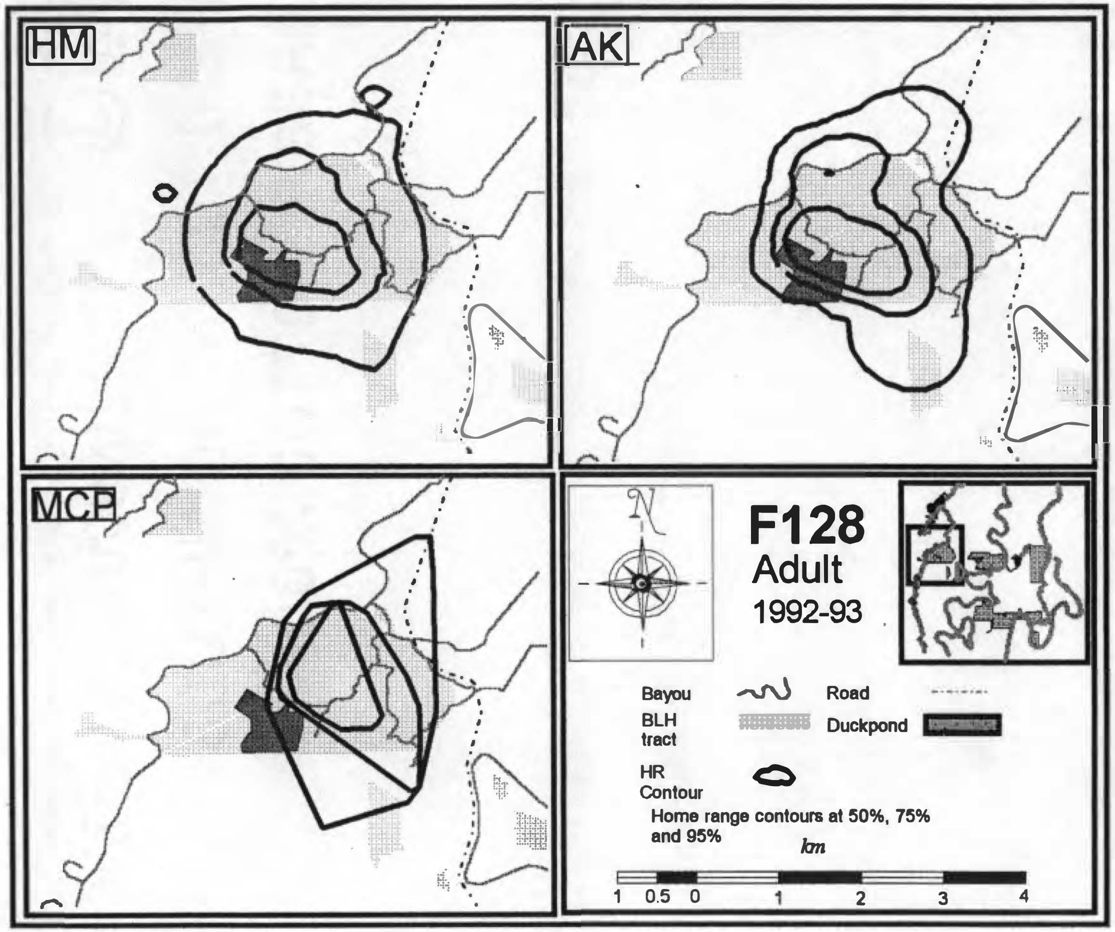

Fig. C-3. Estimated home range of black bear No. F128, Deltic study area, Louisiana (1992-1993).

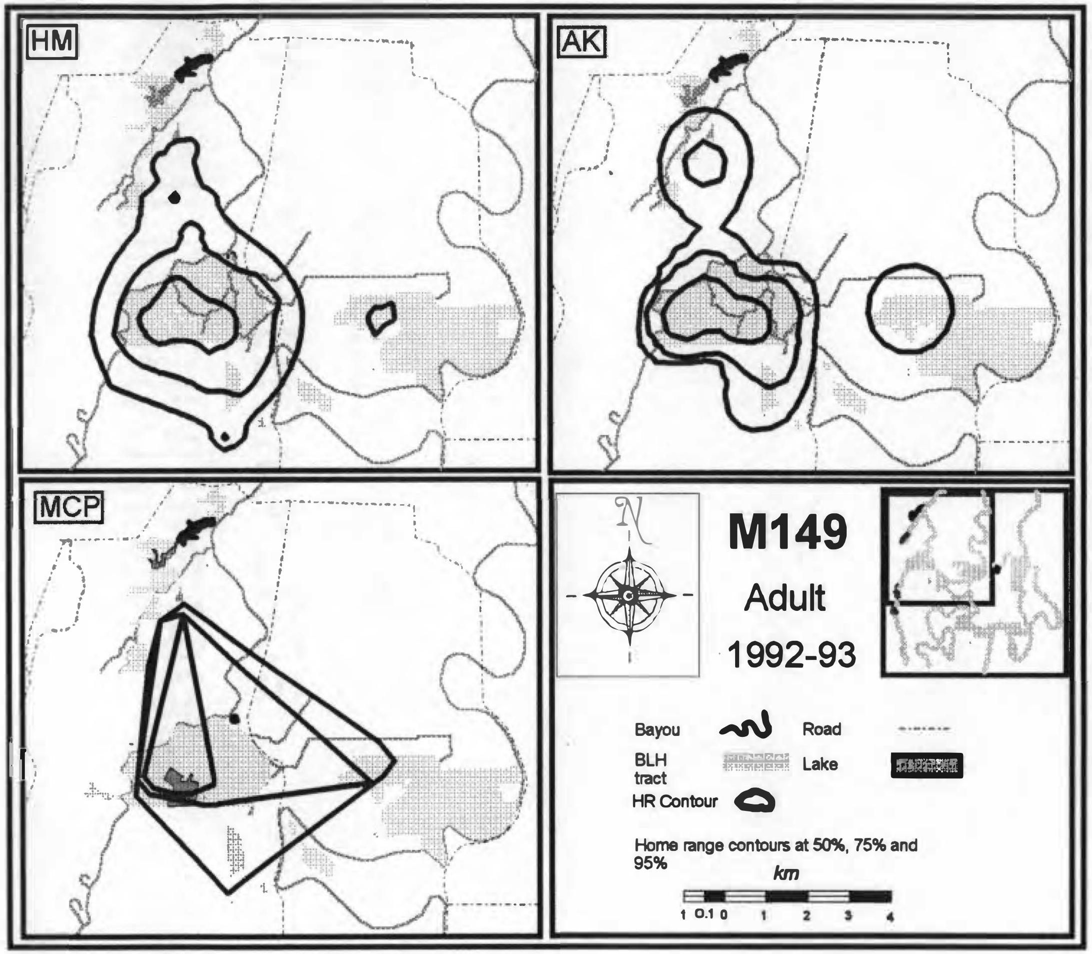

Fig. C-4. Estimated home range of black bear No. M149, Deltic study area, Louisiana (1992-1993).

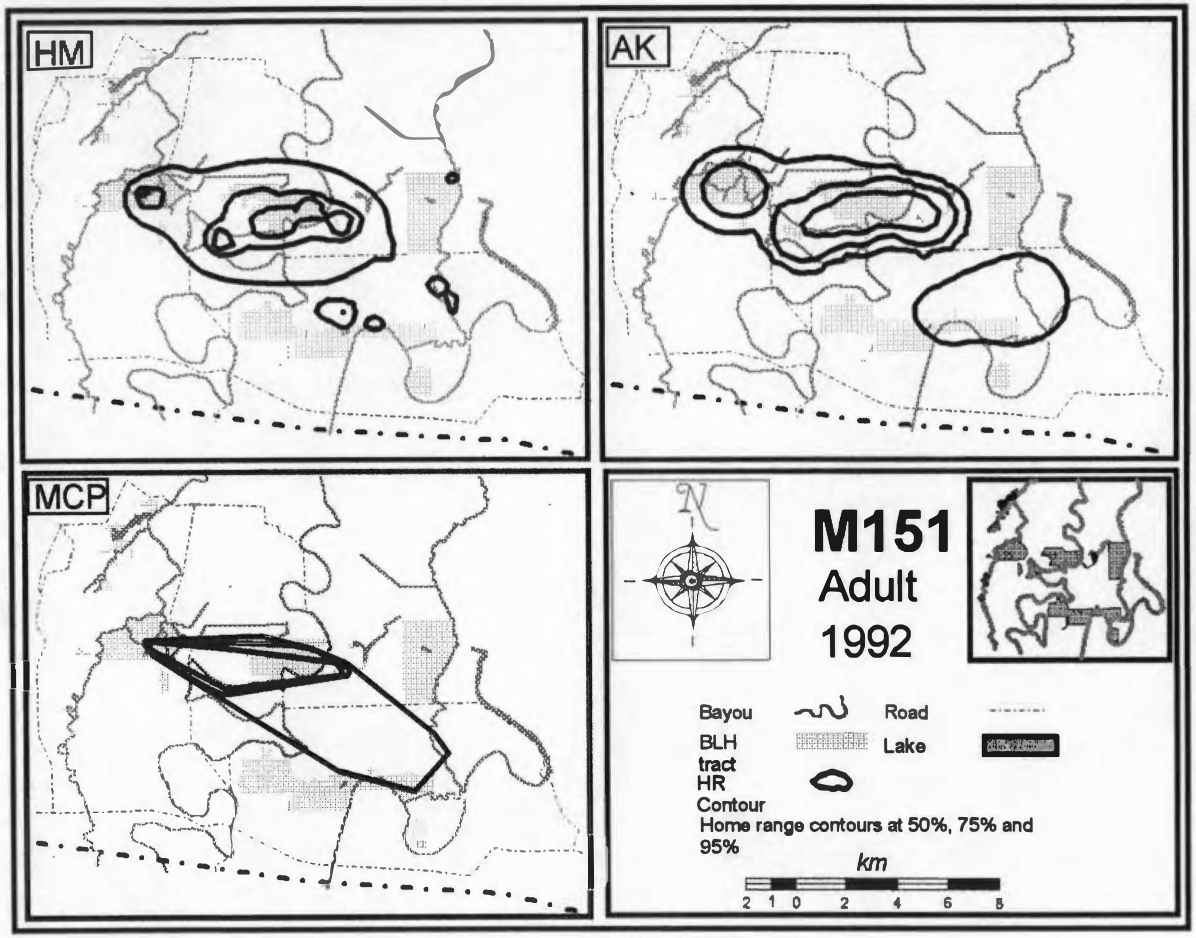

Fig. C-5. Estimated home range of black bear No. M151, Deltic study area, Louisiana (1992-1993).

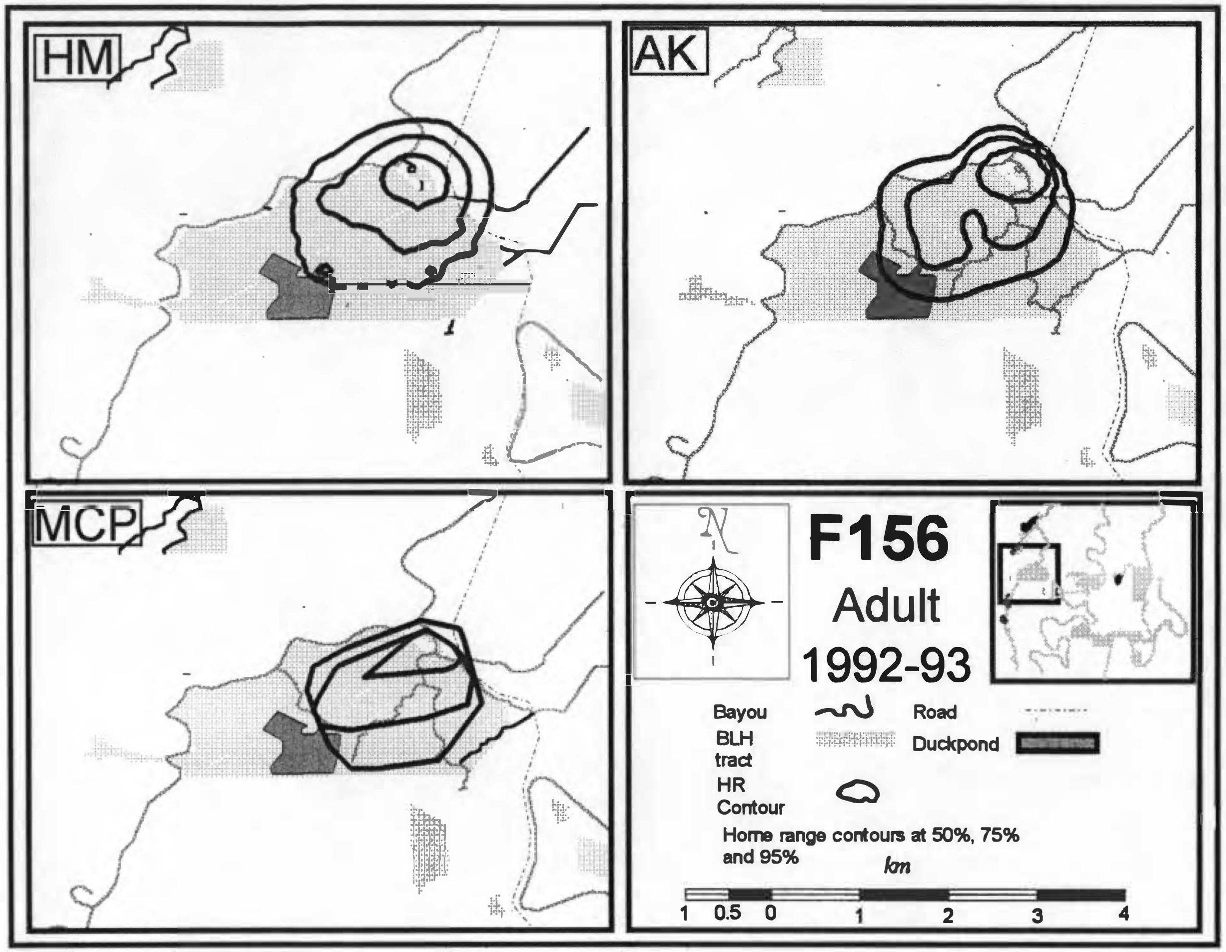

Fig. C-6. Estimated home range of black bear No. F156, Deltic study area, Louisiana (1992-1993).

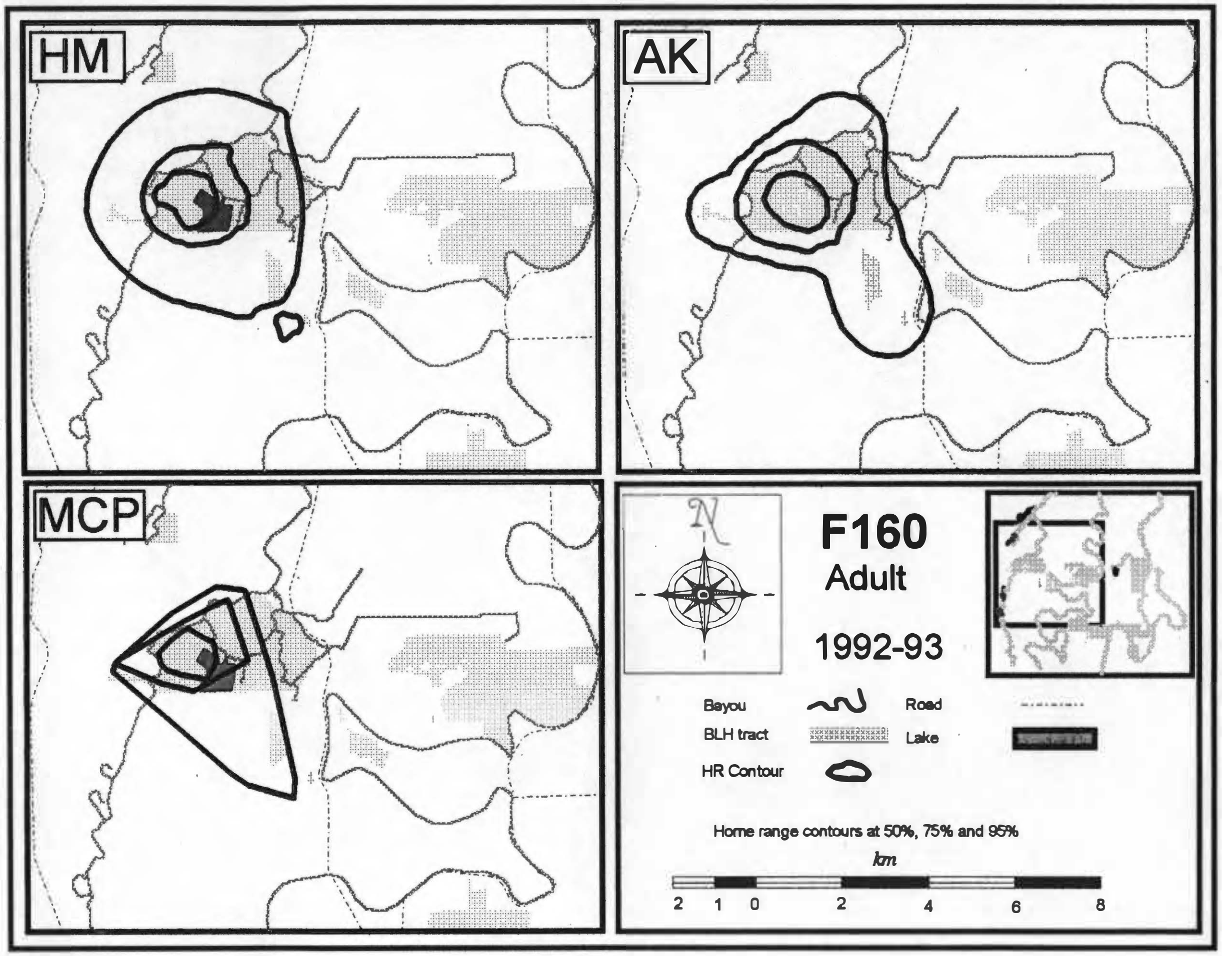

Fig. C-7. Estimated home range of black bear No. F160, Deltic study area, Louisiana (1992-1993).

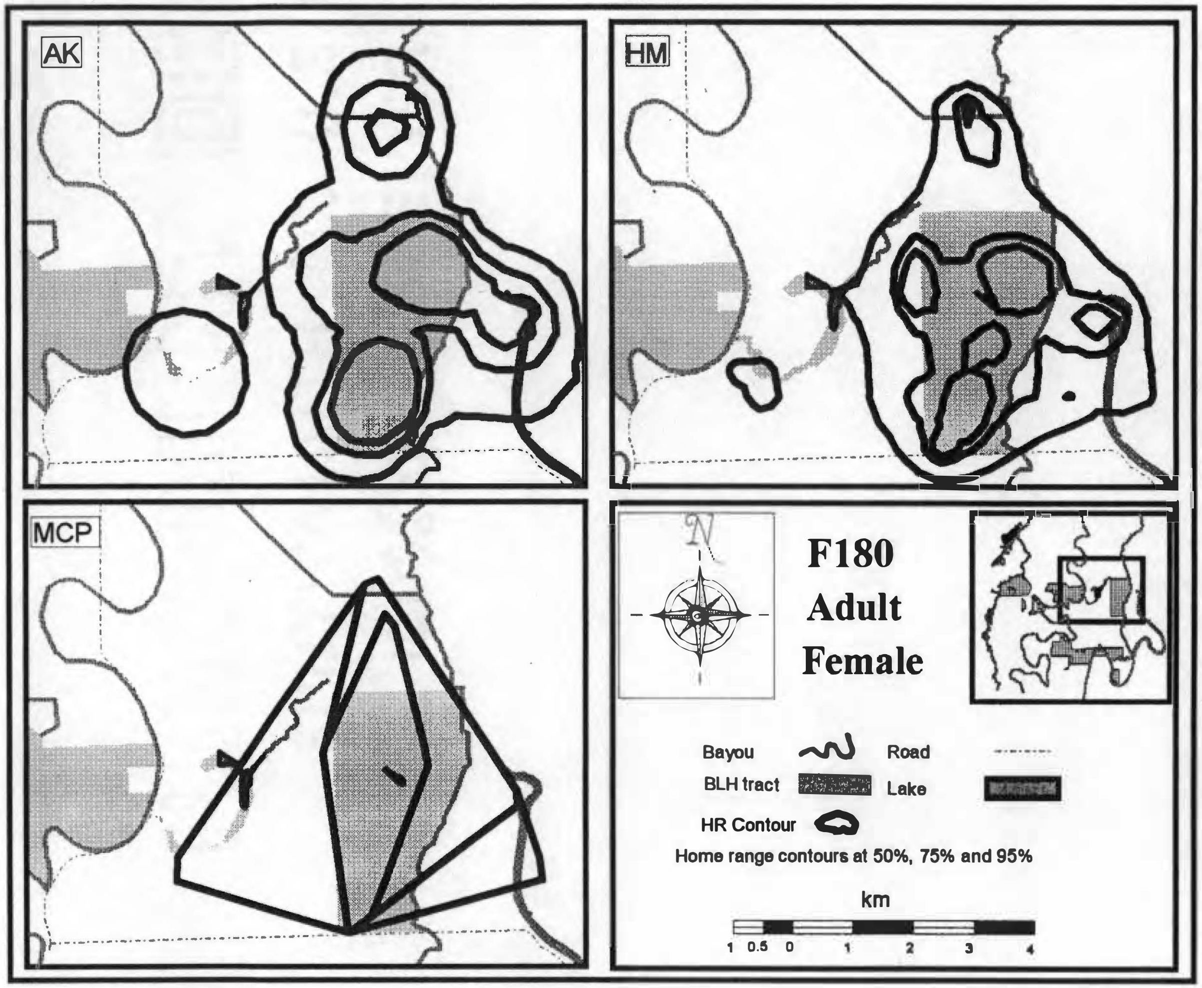

Fig. C-8. Estimated home range of black bear No. F180, Deltic study area, Louisiana (1993).

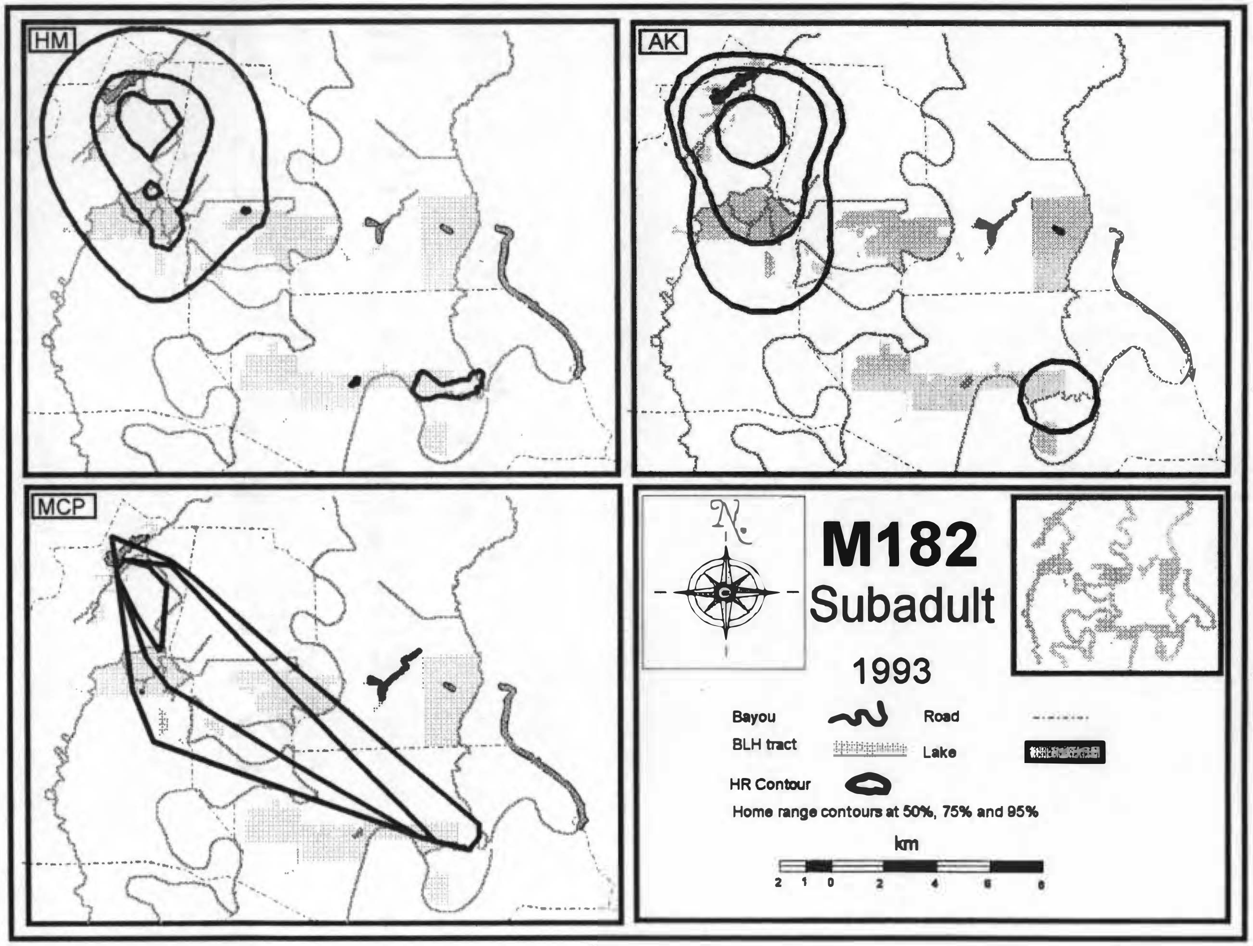

Fig. C-9. Estimated home range of black bear No. M182, Deltic study area, Louisiana (1993).

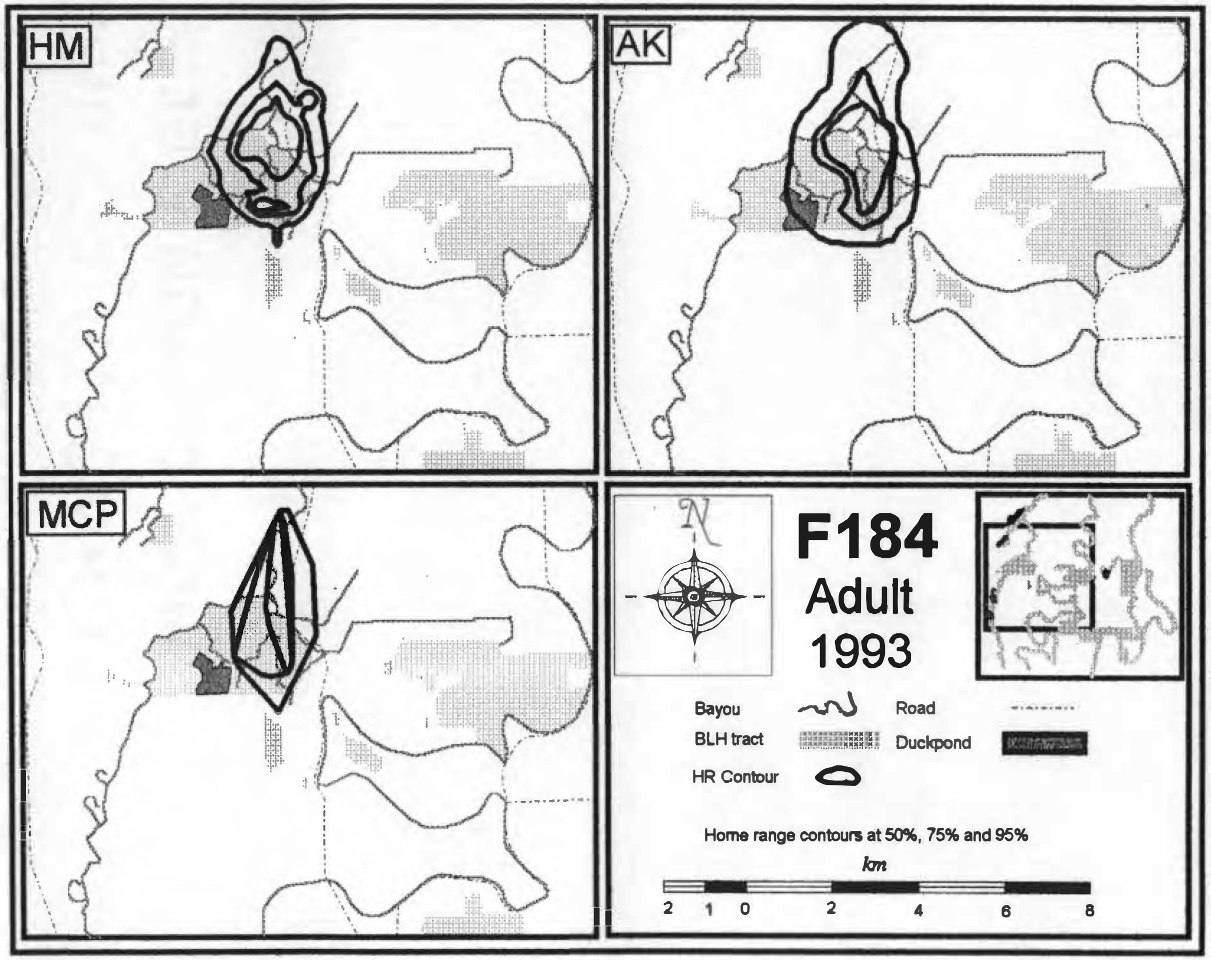

Fig. C-10. Estimated home range of black bear No. F184, Deltic study area, Louisiana (1993).

APPENDIX D: BEAR OBSERVATIONS

BEAR OBSERVATIONS

Bears were observed by researchers on 55 separate occasions; 13 of these involved multiple bears (Table D-1). Most sightings occurred in the Blue Cat area. In addition, farmers reported sightings of bears crossing fields in the Blue Cat and Panther Lake areas; several of these reports are also listed in Table D-1.

Table D-1. Summary of bear observations on the Deltic tracts of Tensas River Basin, Louisiana (June 1992-December 1993).

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22 June--Midafternoon--Cub in southeast part of Blue Cat.

22 June--Midafternoon--Three bears near greentree impoundment (duckpond), at south center of Blue Cat.

30 June–Morning--Large uncollared male, near trapped female (F128) at southern Blue Cat.

02 July--Morning--F160 ran from snare, then sat down to watch researcher rebait the trap. West end of Blue Cat.

06 July–Morning--Large bear found near snare. It moved off quickly.

08 July--Morning--F151 near trapped female (F124). The male was reluctant to leave the area despite the presence of 8 people and two attempts to dart him.

09 July--Midafternoon–Uncollared bear on duckpond levee.

09 July--Dusk--bear moving south from Blue Cat to tract south of Blue Cat (Carson Woods).

10 July--Morning--Uncollared bear walking across duckpond levee.

10 July--Afternoon--Small-medium sized uncollared bear climbed bank of Bayou Macon and crossed woods road.

11 July--Late Morning–Medium-sized (100-150lb) bear moving 30 yards in from woods edge on Blue Cat.

28 July--Afternoon--Uncollared bear in soybean field, moving towards a corn field, south-southeast of Blue Cat.

2 Aug--Morning--F128 west of duckpond, Blue Cat.

20 Sept--Early Evening--F128, northern portion of duckpond, Blue Cat.

01 Oct--Evening--F128 seen with a cub, feeding on corn left after harvest.

06 Nov--Afternoon--Two females, each with 3 cubs of the year, feeding in cornfield east of Carson Woods.

Table D-1 (Cont.).

06 Nov--2240 hrs--Cub of the year crossed turnroad southeast of Carson Woods.

15 Nov--0145--Large female, uncollared but tagged, over a mile south of Bluecat.

23 Nov--Midafternoon--Sow and 3 cubs, feeding on corn southeast of Blue Cat (East of Carson Woods).

24 Nov--Midafternoon--Sow and 3 cubs, feeding on corn southeast of Blue Cat (East of Carson Woods).

24 Nov--Midafternoon--F160 travelled northward from Carson Woods to Blue Cat.

25 Nov--Dusk--F160 moving south of Carson Woods.

11 January--1525 hrs--Uncollared sow and 2 cubs, on the west end of the duckpond, just inside the woodline, Blue Cat.

13 January--F124 seen on woodline north of duckpond, Blue Cat.

21 January--Early Afternoon--Sow and cub north of duckpond, Blue Cat.

1 February--Morning--Telemetry walk-in--F128 and 3 cubs of the year seen at nest, duckpond, Blue Cat.

9 February--Morning--Telemetry walk-in--F128 and one cub of the year seen, near nest, Blue Cat.

1 March--Morning--Telemetry walk-in--F106 in brushpile in < 1 ha woods north of Blue Cat.

6 March--Late Afternoon--Telemetry walk-in--F156 in nesting area on < 1 ha island off Bayou Macon, northern Blue Cat.

11 March--Morning--Telemetry walk-in--F128 seen on east-central Blue Cat.

17 March--Morning--Telemetry walk-in--F128 100 yards N of abandoned nest, Blue Cat.

24 March--Afternoon--Telemetry walk-in--F160 southeast of den, inside duckpond; 1 cub heard, Blue Cat.

Table D-1 (Cont.).

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23 April--Afternoon--Telemetry walk-in--F124 and 2 cubs, east of duckpond, 100m northeast of den tree, Blue Cat.

4 May--Noon--F160 on edge of woods inside duckpond, <50m from den, Blue Cat.

19 June--Morning--Telemetry walk-in--F156 with 2 cubs, in north central Blue Cat.

25 June--Morning--Reported: bear crossed field highway 577 at closest approach between Blue Cat and Wade Bayou.

1 July--Reported: large bear seen crossing cornfields north of Blue Cat.

9 July--Morning--Reported: bear crossing from Panther Lake drain to Panther Lake woods.

9 July--Late Morning--Reported: cub seen on west edge of Panther Lake woods.

19 July--Midmorning--Medium-sized tagged bear seen in western Blue Cat. It walked within 6 m of researchers.

27 July--Evening--Large bear moving into cornfield adjacent to Blue Cat. No ear tags were seen.

05 August--Late Evening--F184 on dirt road bordering Joe's Bayou, south of Carson Woods.

06 August--Late Morning--F184 in tree on Joe's Bayou, 3 km south of Carson Woods.

16 September--Late Morning--Reported: 3 bears in cornfield north of Blue Cat. Presence of collars not reported.

16 September--Evening--F160 on the edge of cornfield north of Blue Cat.

17 September--0115--Cub ran across turnroad, north of Blue Cat.

18 September--1420--Collared bear in cornfield north of Blue Cat.

21 September--Midday--Collared bear in corn field north of Blue Cat.

21 September--Evening--Cub running through cornfield to woodline on Bayou Macon.

Table D-1 (Cont.).

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21 September--Evening--F128 feeding in cornfield north of Blue Cat.

29 September--Reported:Bear crossed highway at Warden, northwest of Blue Cat. No collar reported.

5 October--1813--Small bear ran through cornfield into woods on Bayou Macon, north of Blue Cat.

5 October--1818--Uncollared bear on edge of cornfield, north of Blue Cat; walked with pronounced limp.

5 October--2018--F128 running from cornfield to woods bordering Bayou Macon, north of Blue Cat.

5 October--2057--Small bear ran into trees lining a drainage canal northwest of Blue Cat.

8 October--Early Evening--Bear in cornfield, holding up left front leg. Ate corn until researcher was within 50 yards, when bear ran into woods, still favoring leg.

16 October--Afternoon--F156 in cornfield; moved into woods immediately.

24 October--Midafternoon--F156 and 1 cub in cornfield north of Blue Cat.

16 November--Late Morning--Small bear in woods, 1 mile north on the west edge of Panther Lake Woods.

21 November--Morning--Reported: Collared female and 2 cubs feeding northeast of Duckpond.

21 November--Morning--Reported: Collared female and 2 cubs north of Duckpond.

24 November--Morning--Reported: Large, uncollared bear walking on Duckpond levee.

26 November--Reported: Bear with curled paw feeding in cornfield, north of Blue Cat; appeared to be in poor condition.

30 November--Midnight--Bear and two cubs in cornfield northeast of Blue Cat.

APPENDIX E: SPECIES LISTS, ABBREVIATIONS TABLE

Table E-1. Common and scientific names of plants noted on the Deltic study area.

Ash, green	Fraxinus pennsylvanica
Baldcypress	Taxodium distichum
Beech	Fagus grandifolia
Beggar lice	Desmodium spp.
Blackberry	Rubus spp.
Black Gum	Nyssa sylvatica
Box elder	Acer negundo
Cherry, black	Prunus serotina
Cottonwood	Populus deltoides
Devil's walkingstick	Aralia spinosa
Dogwood, flowering	Cornus florida
Elderberry	Sambucus canadensis
Elm	Ulmus spp.
Elm, American	Ulmus americana
winged	Ulmus alata
Goldenrod	Solidago spp.
Grape	Vitis spp.
Grass	Gramaceae spp.
Greenbrier	Smilax spp.
Hawthorne	Crategeous spp.
Hickory	Carya spp.
Hop Hornbeam	Ostrya virginiana
Ironwood	Carpinus caroliniana
Honeysuckle, Japanese	Lonicera japonica
Locust, Honey	Gleditsia triacanthos
Maple, red	Acer rubrum
Mulberry, French	Callicarpa americana
red	Morus rubra
Oak, red	Quercus spp.
white	Quercus alba
water	Quercus nigra
willow	Quercus phellos
Palmetto	Sabal minor
Passion-flower	Passiflora lutea
Pawpaw	Asimina triloba
Pecan	Carya illinoensis
Pepper vine	Ampelopsis arborea
Persimmon	Diospyros virginiana
Plantain	Plantago spp.
Poison ivy	Rhus toxicodendron
Pokeweed	Phytolacca americana

Table E-1 (Cont).

Privet	Ligustrum sinense
Privet, swamp	Forestiera acuminata
Rattan	Berchemia scandens
Redbud	Cercis canadensis
Rush	Juncus spp.
Sassafras	Sassafras albidum
Sparkleberry	Vaccinium spp.
Sugarberry	Celtis laevigata
Sumac, smooth	Rhus glabra
Strawberry bush	Euonymus americanus
Sweetgum	Liquidambar styraciflua
Switchcane	Arundinaria gigantea
Sycamore	Platanus occidentalis
Toothache-tree	Zanthoxylum american
Trumpet vine	Campsis radicans
Tulip poplar	Liriodendron tulipifera
Virginia creeper	Parthenocissus quincuefolia
Willow, black	Salix nigra
Wood sorrel	Oxalis spp.

Table E-2. Common and scientific names of animals mentioned in text.

Birds	
Bachman's warbler	Vermivora bachmanii
Ivory-billed woodpeckers	Campephilus principalis
Mammals	
Black bear	Ursus americanus americanus
Black bear, Louisiana	Ursus americanus luteolus
Cougar	Felis concolor
Coyote	Canis latrans
Florida panther	Felis concolor coryi
Raccoon	Procyon lotor
Red wolf	Canis rufus
White-tailed Deer	Odocoileus virginianus

Table E-3. Abbreviations used in the text.

AK	Adaptive kernal
ARB	Atchafalaya River Basin
ATV	All-terrain vehicle
BLWMA	Big Lake Wildlife Management Area
HM	Harmonic mean
MCP	Minimum convex polygon
NWR	National Wildlife Refuge
SAS	Statistical Analysis System
TRB	Tensas River Basin
TRNWR	Tensas River National Wildlife Refuge
USFWS	United States Fish and Wildlife Service

VITA

Forrest Buckley Marchinton was born in Athens, Georgia, on 2 December 1968. He graduated from Jefferson High School in 1987, and enrolled at the University of Georgia in the same year. He spent a year at Abraham Baldwin Agricultural College for a year in 1988-1989, before returning to UGA where he received an Bachelor of Science in Forest Resources (wildlife management concentration) in 1992. He began his thesis research in the Tensas River Basin in the spring of 1992 and was awarded an M.S. degree in Wildlife and Fisheries Science in the summer of 1995.