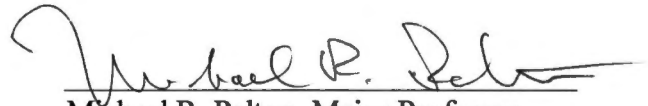
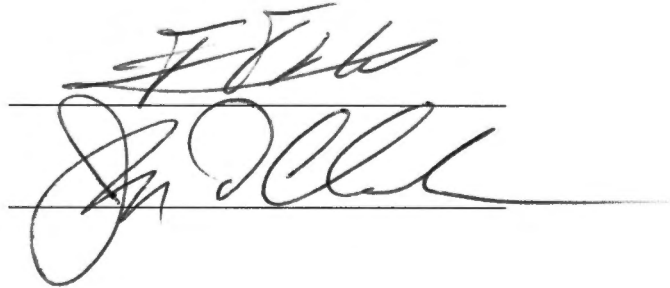


To the Graduate Council:

I am submitting herewith a thesis written by Richard A. Beausoleil entitled "Population and Spatial Ecology of the Louisiana Black Bear in a Fragmented Bottomland Hardwood Forest". I have examined the final 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:



Accepted for the Council:


Associate Vice Chancellor and
Dean of The Graduate School

**POPULATION AND SPATIAL ECOLOGY OF THE
LOUISIANA BLACK BEAR IN A FRAGMENTED
BOTTOMLAND HARDWOOD FOREST**

A Thesis

Presented for the

Master of Science Degree

The University of Tennessee, Knoxville

Richard A. Beausoleil

December 1999

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Thesis
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.B39

DEDICATION

This thesis is dedicated to two special people:

First, to my mother Nancy,
your inner strength is an inspiration
to me every day of my life.

Second, to my big brother Tony,
whose time on earth was much too short.
Your memory will remain with me forever.

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ABSTRACT

Forested lands in the Tensas River Basin have been reduced substantially. The Louisiana black bear (*Ursus americanus luteolus*), a threatened subspecies, occurs on some of the remaining bottomland forests, including several fragmented forested tracts in northeast Louisiana. Population estimates and an understanding of population dynamics are essential to manage this subspecies.

I investigated population and spatial ecology of black bears on small tracts of fragmented bottomland hardwood forest in northeast Louisiana from June 1997 to December 1998. The study area was privately owned by Deltic Farm and Timber Company and managed for agricultural and forest products.

I estimated population size using capture-resight and capture-recapture models, both within and across years. I used closed and open population models and incorporated several capture techniques to insure a robust design. I recorded 40 captures of 24 individual bears from 213 trap sites and collected 816 photographs from 198 remote camera sites. From those photographs, 193 (24%) were of bears with 63 (33%) wearing color-coded marks.

The population estimate was 47 using Bailey's binomial model (95% C. I. = 38 - 57), 45 using the Minta-Mangel estimator (95% C. I. = 35 - 67), 43 using the Bowden estimator (95% C. I. = 27 - 69), and Jolly-Seber produced an average estimate of 34 bears (95% C. I. = 5 - 44).

I collected 1,258 telemetry locations from 21 radio-collared bears (12F: 9M) between 23 June and 12 December 1998. Annual home range size (95% minimum convex polygon) for males and females averaged 7.0 km² and 4.2 km², respectively. Home range overlap among females was extensive, especially in the Bluecat tract. Each female's home range in Bluecat overlapped with at least 6 other female home ranges. Where overlap occurred, it ranged from <1 to 100% with 27 of 46 overlaps being over $\geq 50\%$.

I recorded dispersal patterns for 8 yearling bears (5M: 3F). All yearling females remained in the tract of capture, as did 1 male. Four yearling males dispersed to other tracts resulting in the death of 2 of those individuals. Eleven bears (8M: 3F) were documented moving between isolated woodlots on 81 occasions and 34 (42%) of these movements were between woodlots connected by a forested corridor. The remaining movements were between isolated tracts not connected by a corridor. However, 28 (35%) were between woodlots <0.5 km apart and 19 (23%) movements were made exclusively by males. I also recorded 28 observations of male ($n = 7$) and female ($n = 2$) bears in forested corridors. Twenty-three (82%) of these were made by male bears.

I also monitored natality and cub survival. Eight radiocollared bears and 1 free-ranging bear were observed with litters totaling 16 cubs. Five cub deaths were recorded. Three cubs (unknown sex) died of unknown natural causes, and 2 cubs (1M: 1F) died of unknown causes after translocation conducted by the USFWS. I recorded 3 other mortalities of bears during this study. Two males (1 adult, 1 yearling) were killed in collisions with automobiles and 1 juvenile male bear was poached.

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CHAPTER I

INTRODUCTION

GENERAL PROBLEM STATEMENT

The Louisiana black bear once occupied the bottomland hardwood forests of Louisiana, eastern Texas, southern Arkansas, and southern Mississippi (Hall 1981, U.S. Fish and Wildlife Service 1995). However, significant habitat reduction from timber harvest and conversion to agriculture, most notably for soybean production (Spencer 1981), has reduced available forest habitat and thus restricted the current range of this species to 3 core populations: the Tensas River Basin in northeast Louisiana and 2 areas of the Atchafalaya River Basin in southeast Louisiana (Pelton 1990, Pace et al. 1994) (Fig. 1). Additional disjunct populations may exist in the Mississippi River corridor (including regions of Loess Bluffs in the southwest and the adjacent Tunica Hills of Louisiana) (Shropshire 1991), and possibly in the lower East Pearl River and lower Pascagoula River basins, in southern Mississippi (Wooding et al. 1993, U.S. Fish and Wildlife Service 1995). Currently, the Louisiana black bear is limited to <20% of its historic range (Neal 1990) (Fig. 2). In Louisiana alone, the range of the black bear has been reduced by approximately 88%.

The Louisiana black bear is 1 of 16 subspecies of the black bear in North America, and 1 of 3 subspecies residing in the Southeast (Hall 1981). Griffith (1821) originally named the Louisiana black bear and Merriam (1893) used morphological characteristics of 5 skulls from Morehouse Parish to describe the taxon, giving the

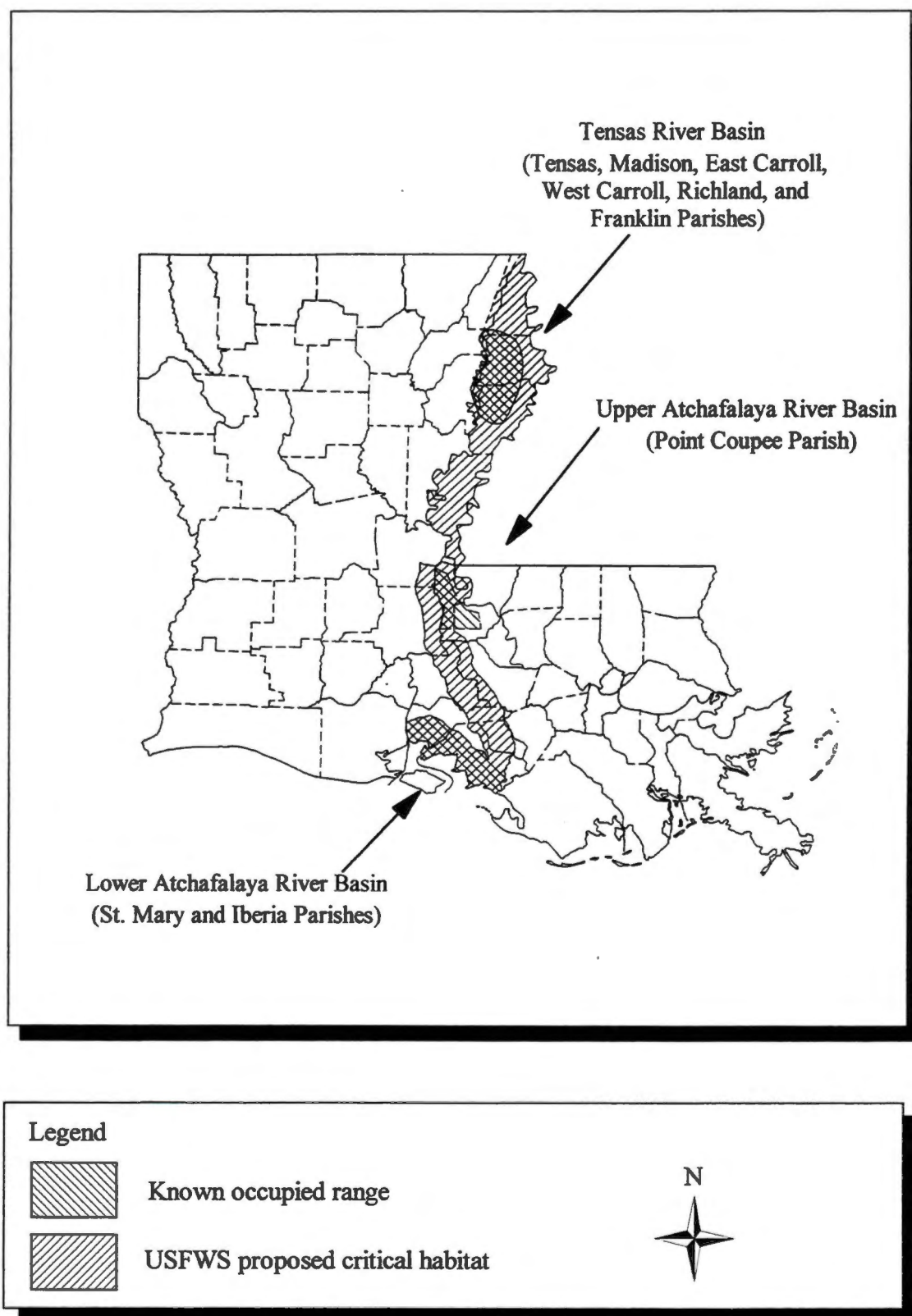


Fig. 1. Distribution of black bears in Louisiana (modified from Pace et al. 1994)

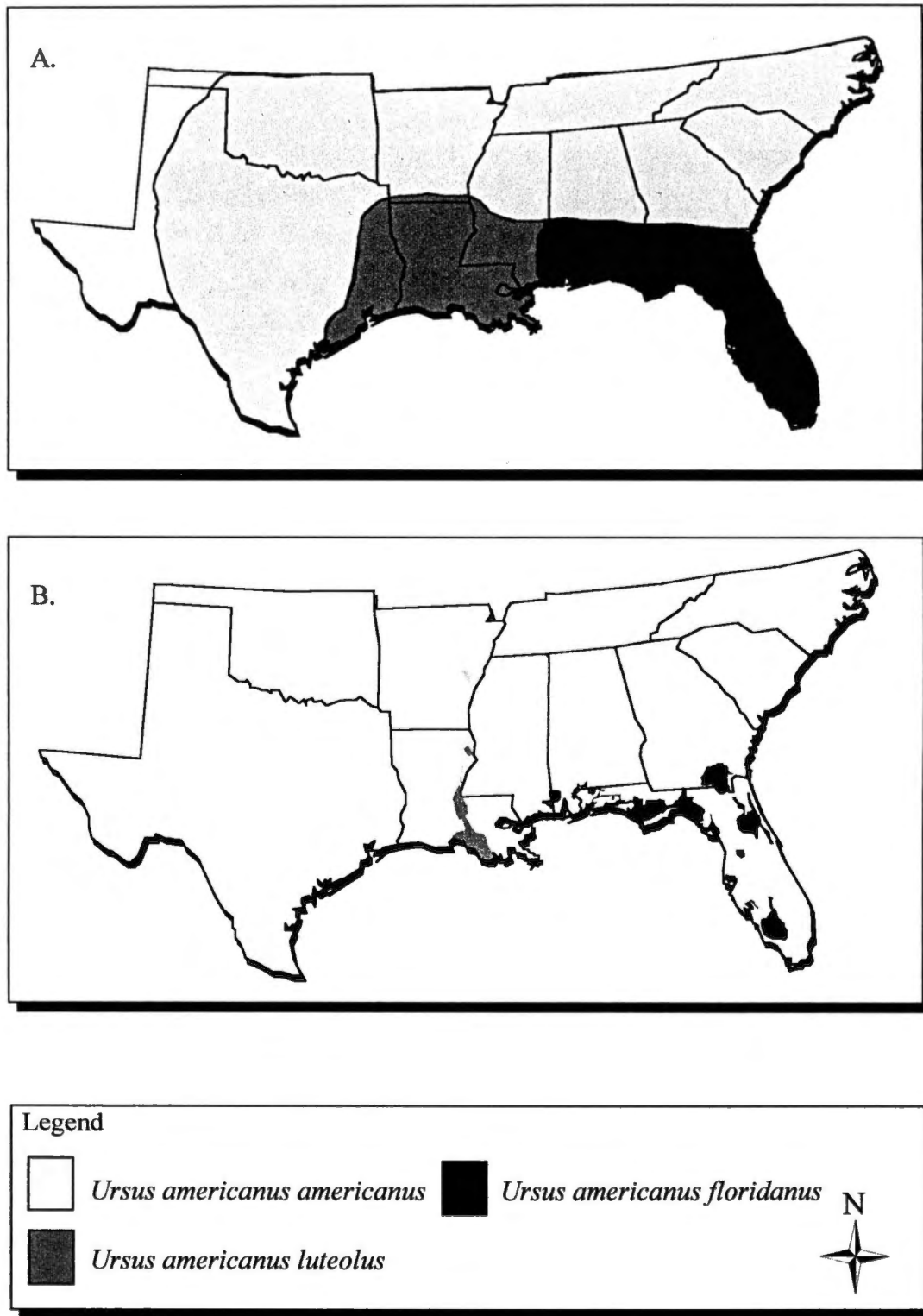


Fig. 2. Historic (A) and present (B) distribution of black bears in the Southeast (Modified from Pelton and van Manen 1994).

Louisiana black bear, or “yellow bear of Louisiana”, its subspecies status. Since then, there has been debate over the validity of that status (Pelton 1989). Questions regarding the status of the *luteolus* subspecies emanate mostly from a restocking program initiated by the Louisiana Department of Wildlife and Fisheries from 1964-1967 to augment the dwindling bear population in Louisiana. Taylor (1971) stated that 161 bears (41 adult males, 40 adult females, and 80 cubs or yearlings) were translocated from Cook County, Minnesota to 2 release sites in Louisiana. Thirty bears were released in the Tensas River Basin near the Tensas-Madison parish line, and 131 were released in the Atchafalaya River Basin between Lottie and Krotz Springs in Point Coupee parish (Lowery 1974). From those translocations, Lowery (1974) reported that there were 30 known mortalities, and 11 known out-of-state dispersals (7 to west Mississippi, 3 to east Texas, and 1 to southern Arkansas). The success of the translocation was deemed inconclusive (Taylor 1971, Nowak 1986) and genetic effects on the Louisiana black bear were considered statistically insignificant (Kennedy 1989, Miller 1995). Miller (1995) concluded that *U. a. luteolus* was more closely related to the Arkansas and Florida bear populations than it was to the Minnesota population that stocked the translocation effort. Comparative studies of bear morphometrics in the Southeast have concluded that *U. a. luteolus* is a morphologically distinct subspecies (Eason 1995).

Loss of habitat is the most critical issue facing black bear populations in the southeastern coastal plain (Pelton et al. 1999). Historically, there were over 101,000 km² of bottomland hardwood forests in the south; as of 1980, approximately 20,000 km² remained (The Nature Conservancy 1992) (Fig. 3). In Louisiana, it is estimated that

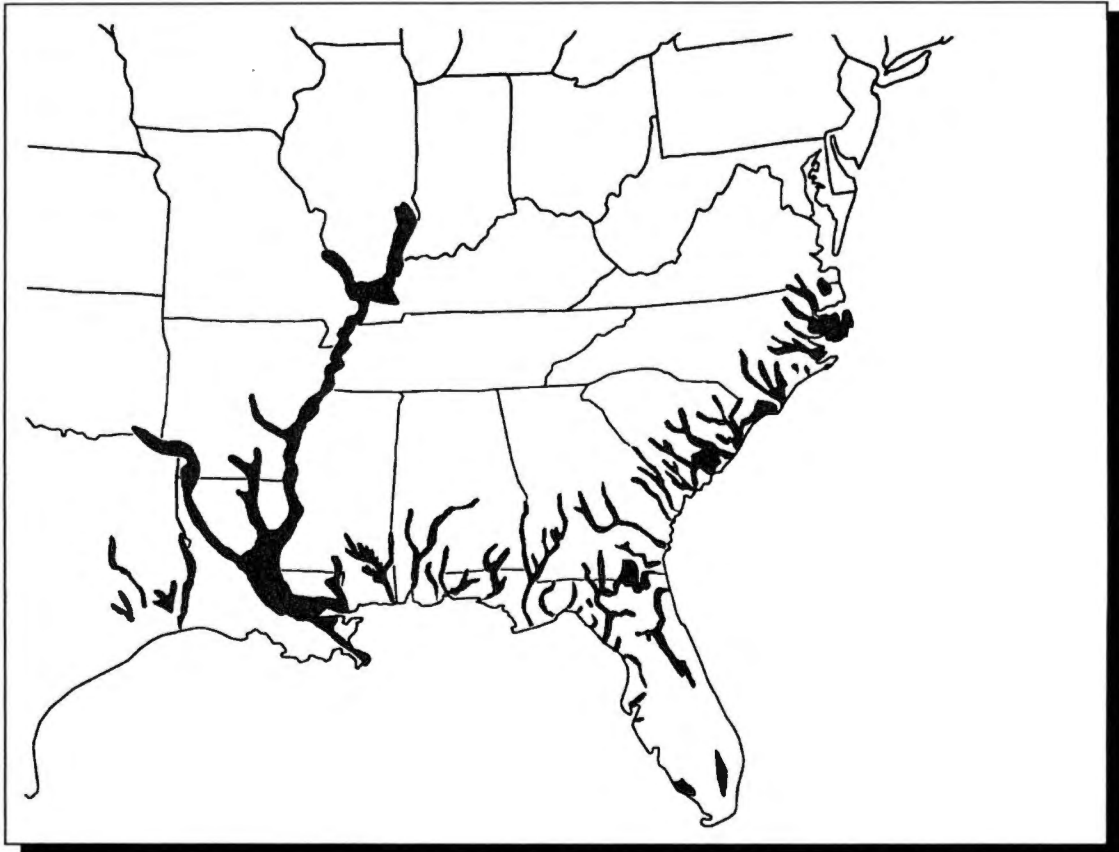


Fig. 3. Distribution of bottomland hardwood forests in the southeastern United States (modified from Schoenholz 1994).

92,758 km² (75%) of the state was forested in 1865 (Calhoun and Frois 1997). By 1880, the exploitation of timber resources had begun and agriculture production expanded (Wilds et al. 1996). Around 1920 the soybean was introduced and soon became the crop of choice for Louisiana farmers (Wilds et al. 1996). As of 1997, only 56,140 km² of forested land remained (Calhoun and Frois 1997).

A similar trend was observed in the Tensas River basin, which was almost all bottomland hardwoods (Lyttle and Sturgis 1939). By 1988, only 18% of the Tensas watershed remained forested (Gosselink 1988). The largest remaining contiguous bottomland hardwood habitat in northeast Louisiana is the Tensas River National Wildlife Refuge and adjacent Big Lake Wildlife Management Area that collectively occupy approximately 320 km².

The Tensas watershed is part of the original range of the red wolf (*Canis rufus*), Florida panther (*Puma concolor coryi*), and ivory-billed woodpecker (*Campephilus principalis*), all extirpated from Louisiana (Burdick et al. 1989). Although more resilient and adaptive than these species, the future of the Louisiana black bear is threatened by the continued loss of bottomland hardwoods (Mykytka and Pelton 1989, Weaver et al. 1990).

HISTORY

The Louisiana black bear was historically recognized as a game mammal. Swanton (1979) reported that Native Americans of the Southeast relied heavily on white-tailed deer (*Odocoileus virginianus*) and the black bear for subsistence. It is

believed that the black bear also provided native peoples with resources to be used within the tribal unit, as well as for trade (Swanton 1979). In the early 1800s the French pioneers also hunted bear in northeast Louisiana (Wilds et al. 1996). When brought to New Orleans, a tradesman could sell a bearskin or a gallon of bear oil for 1 dollar (Wilds et al. 1996), a significant sum at that time. At the turn of the twentieth century, hunters could legally kill 5 bears per year in Louisiana. By 1930, bears were considered a rarity and harvest was restricted to 1 bear per season (Taylor 1971). The hunting season was closed from 1964-1974 to accommodate the bear translocation program. From 1975-1987 a 9-day season was allowed and hunters were permitted to kill 1 bear annually, but cub harvest was prohibited (Weaver et. al 1990). The season has remained closed since the end of the 1987 season.

Louisiana black bears of the lower Mississippi River Valley are well represented in historic American literature. President Theodore Roosevelt (1908) documented his bear hunting experience near Panther Lake, along the Tensas Bayou, in October 1907 in an article titled "*In the Louisiana Canebrakes*". Earlier, in 1902, he hunted at a camp near northeast Louisiana where he brought prominent national attention to southern bears when he refused to kill a Louisiana black bear that was roped to a tree by fellow huntsman (Bourne 1992). The next day, 16 November, a cartoon titled "Drawing the Line in Mississippi" drawn by Clifford K. Berryman, appeared on the front page of *The Washington Post*. This article depicted the President, with his hand outstretched, refusing to shoot the roped bear. Subsequently, the bear became known as "Teddy's bear". Although the newspaper's caricature had political connotations, the "Teddy

bear” name was to prove significant. Shortly thereafter, Morris Michtom, a candy store owner, designed a stuffed bear to display in his store window, naming it “Teddy’s bear”. When residents began soliciting the sale of the bear, Mr. Michtom sought Roosevelt’s permission to use his name. After the President agreed, the production of the teddy bear began and a cultural icon was born (Bourne 1992).

William Faulkner also wrote about the Louisiana black bear in one of his best-known short novels, titled *The Bear* (Faulkner 1961), where he used the Louisiana black bear to symbolize the loss of wilderness, a disconnection with the land, and man’s ultimate “defeat” of nature.

JUSTIFICATION

The USFWS, acting under authority of the Endangered Species Act of 1973, listed the Louisiana black bear as a Threatened subspecies on 7 February 1992 (Federal Register 1992, 57[4]: 588-595). Habitat loss was cited as the primary factor in the listing decision. In 1993, the USFWS proposed to designate bottomland forests as critical habitat for the subspecies (Federal Register 58[230]: 63560-63569).

Approximately 5,059 km² of fragmented bottomland hardwood habitat in Louisiana was to be delineated as critical habitat if the rule were approved; much of the bottomland hardwood habitat in the Tensas River Basin would meet this criterion (Pace and Edwards 1996). However, because of a self-imposed moratorium on endangered species action, this rule has not been issued.

Louisiana black bear populations have diminished greatly because of anthropogenic activity. Basic ecological, taxonomic, and management information of black bears in the Tensas River Basin (Weaver 1990, Weaver et al. 1990, Weaver and Pelton 1994, Marchinton 1995, Anderson 1997, Beausoleil et al. 2000) and Atchafalaya River Basin (Nyland 1995, Wagner 1995), as well as status information (Hammond 1989) have only recently been reported. It is crucial that wildlife managers have an understanding of all ecological aspects of the Louisiana black bear, especially population status, so that this subspecies may be effectively managed and conserved. Population status is critical when developing strategies for recovery as outlined in section 2; articles 3 and 4, of the Louisiana Black Bear Recovery Plan (U.S. Fish and Wildlife Service 1995).

Weaver (1990) estimated that 60-100 bears may inhabit the entire Tensas River Basin and other researchers have reported that the bear population on the Deltic study area may be increasing. However, these population estimates were only speculative; no formal study of population estimation has been conducted in the Tensas River Basin or on the Deltic black bear population until the initiation of this study.

OBJECTIVES

Given the current understanding of black bear population dynamics in Louisiana the objectives of this study were:

- (1) to estimate the size of the black bear population on Deltic;
- (2) to estimate home range size and overlap;

- (3) to determine black bear movements between fragmented bottomland hardwood tracts and corridor use;
- (4) to document juvenile dispersal patterns and survival
- (5) to monitor natality and cub survival.

CHAPTER II

STUDY AREA

LOCATION

The Deltic study area comprised approximately 154 km² of the Tensas River Basin and occupied portions of Madison, East Carroll, West Carroll, and Richland parishes in northeast Louisiana (Fig. 4). Estimates of human population density in these parishes in 1996 were 8, 8, 13, and 4 humans per km², respectively (Calhoun and Frois 1997). Deltic was located approximately 45 km² west of Vicksburg, Mississippi and 71 km² east of Monroe, Louisiana. The study area was imprecisely bounded by Highway 17 to the west, Highway 80 to the south, Highway 65 to the east, and Highway 134 to the north. Within this boundary there was approximately 159 km of roads (0.25 km per km²), most notable were highways 577 and 579 which divided the forested woodlots (Fig. 5). Numerous gravel and dirt farm roads also traversed the study area. Three towns circumfused the Deltic study area: Tallulah, Delhi, and Epps, which lie southeast, southwest and northwest, respectively. Numerous other rural communities, private dwellings and agricultural fields were scattered throughout the landscape (Fig. 6).

Black bear habitat within the Deltic study area has been reduced to relatively small isolated tracts of bottomland hardwood forest surrounded by large expanses of agricultural land. Nowak (1986) reported that in 1984 approximately 61 km² of forested land existed on the Deltic study area; today there is < 32 km². The 4 major forested

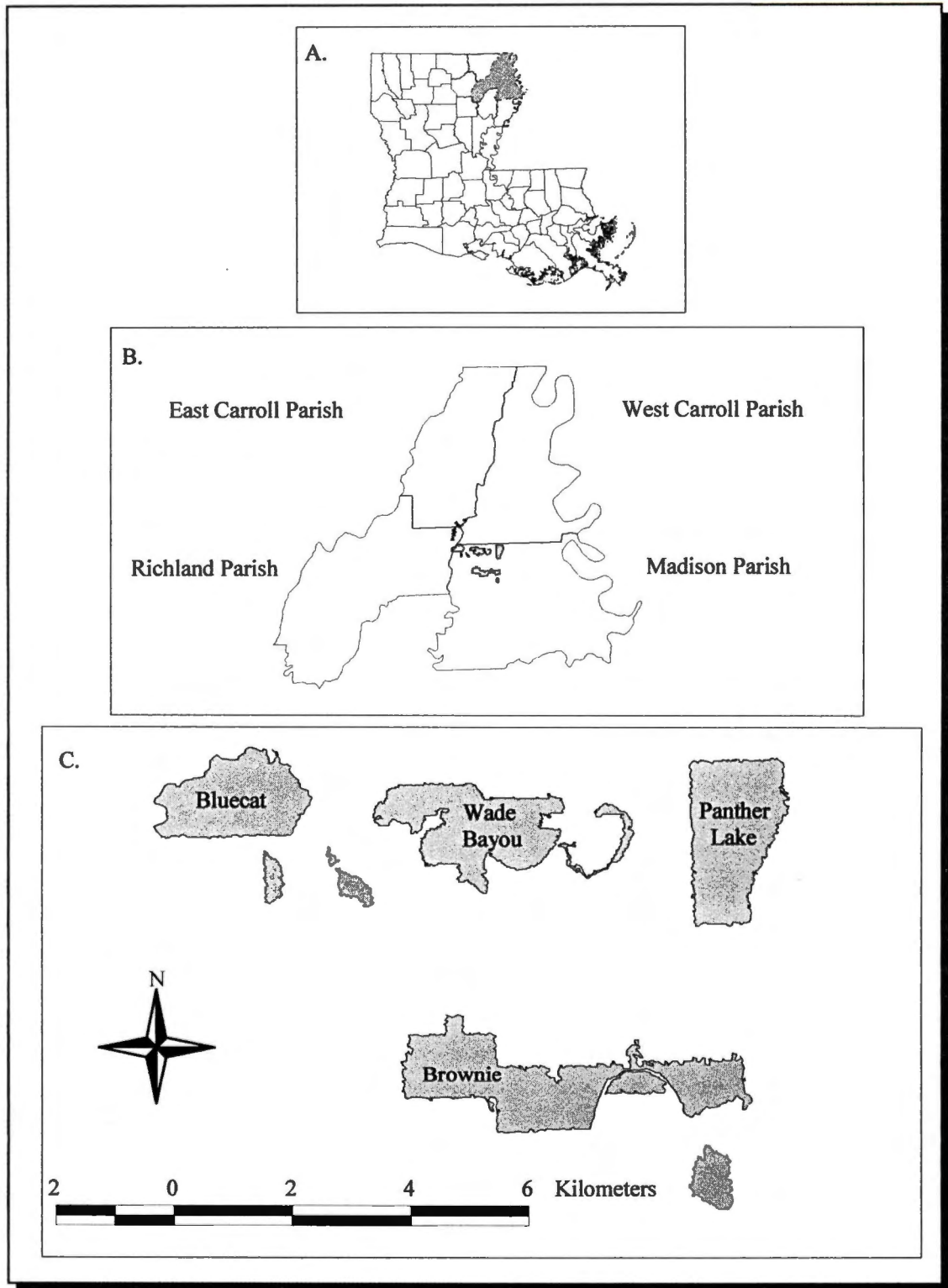


Fig. 4. Geographic location of the Deltic study area; the 4 parishes encompassing the study area (A), the study area within those parishes (B), and the distribution of the woodlots on the landscape (C), Tensas River Basin, northeast Louisiana, 1997-1998.

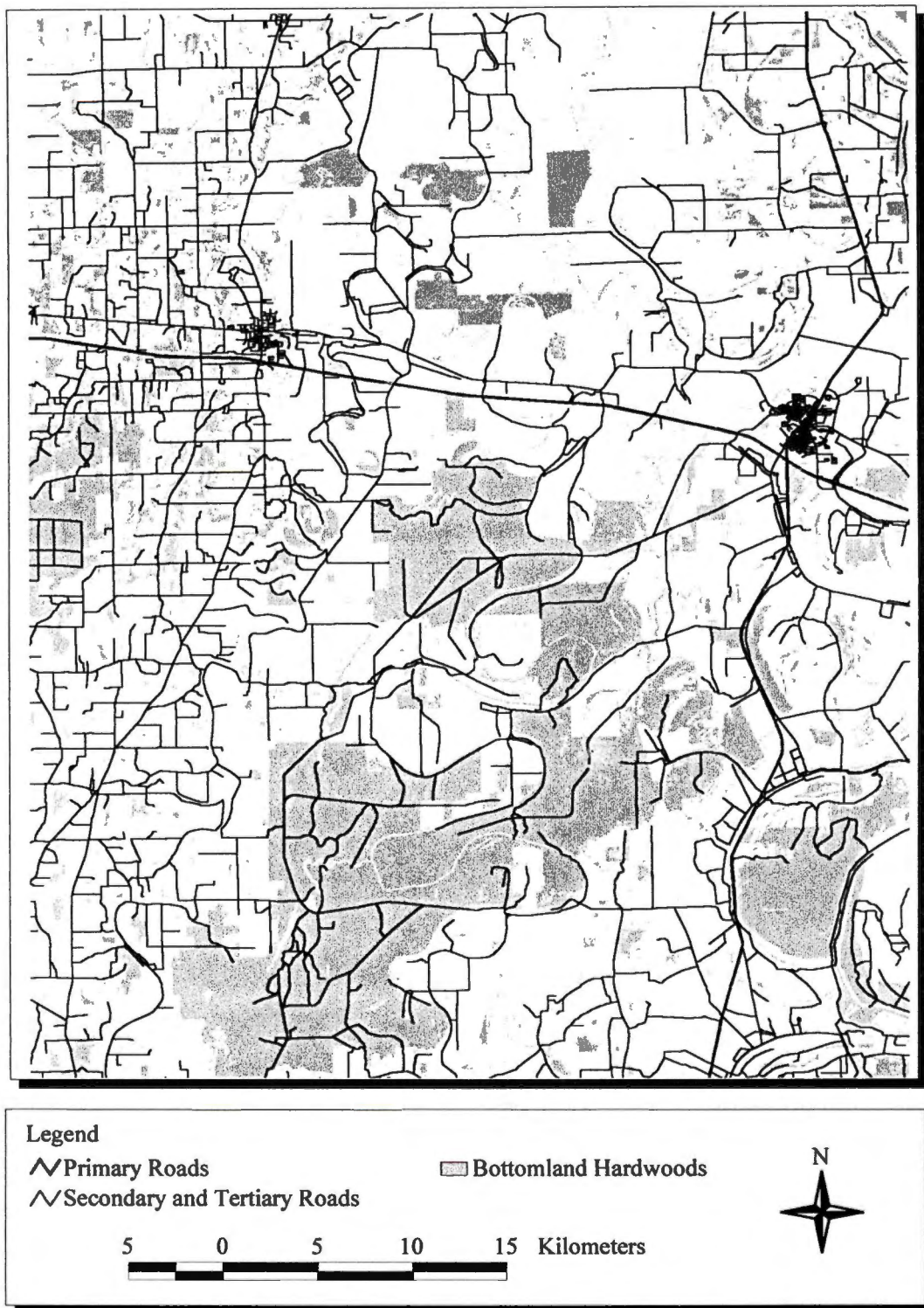


Fig. 5. Distribution of primary, secondary and tertiary roads on Deltic study area and vicinity, Tensas River Basin, northeast Louisiana, 1997-1998

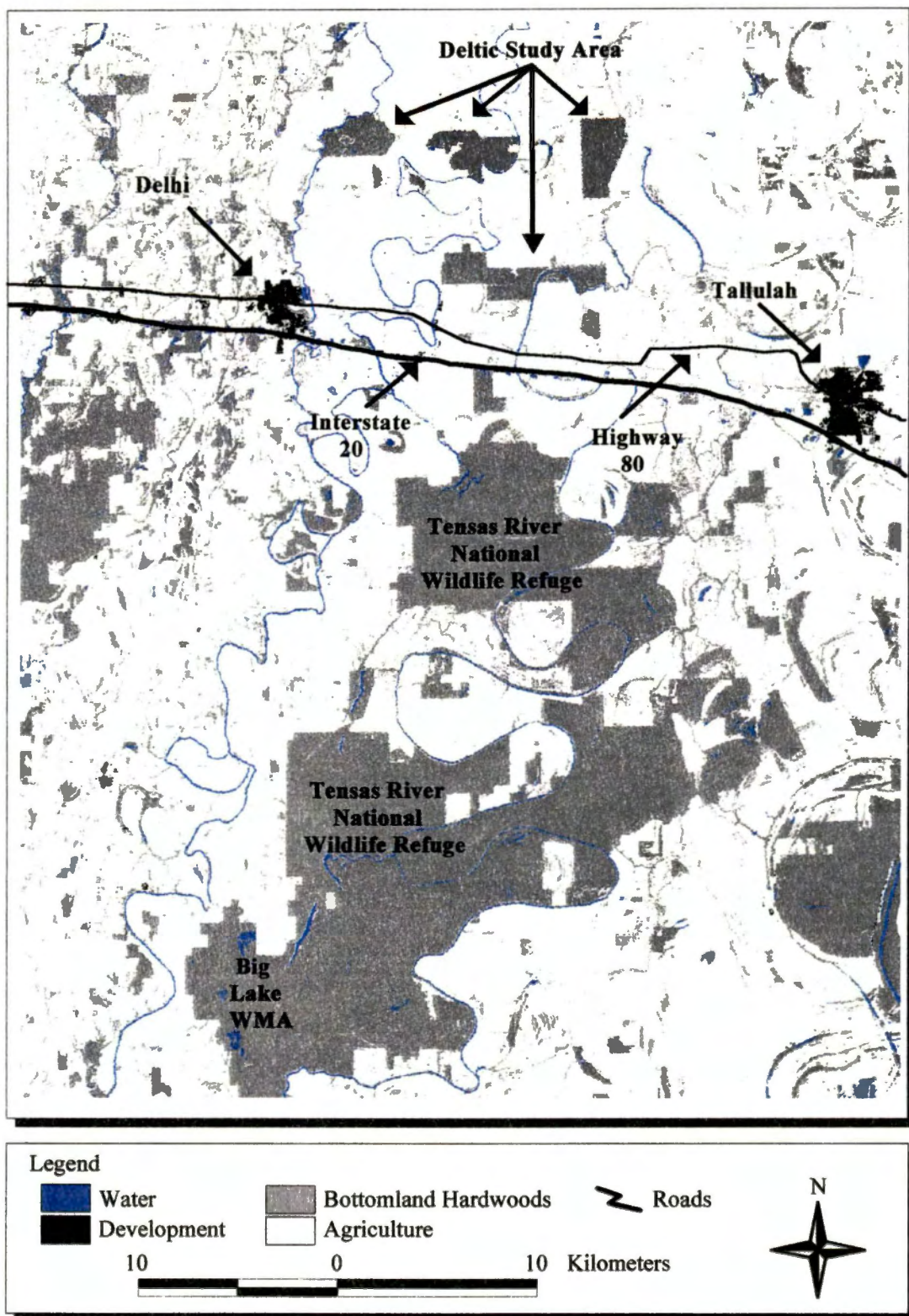


Fig. 6. Distribution of habitat associations surrounding the Deltic study site, Tensas River Basin northeast Louisiana, 1997-1998

tracts in the Deltic study area were Brownie (10.9 km²) (includes ~2.0 km² of land owned by the Talla Bena Plantation), Panther Lake (7.6 km²), Wade Bayou (6.8 km²), and Bluecat (5.9 km²) (Fig. 4). Other notable woodlots were the Carson Woods tract (0.4 km²) located immediately south (0.4 km) of the Bluecat tract, Lodge Lakes Woods, an assemblage of small woodlots (0.4 – 0.7 km²) just north (~1.5 km) of the Bluecat tract, and the Talla Bena South Woods tract (1.1 km²) located just south (0.9 km) of the Brownie tract. Numerous smaller woodlots (≤ 0.7 km²), woodland drainages, and cypress sloughs were also in the study area.

TOPOGRAPHY AND GEOLOGY

The Deltic study area is located in the physiographic province of the Mississippi alluvial plain. Elevation ranges from 19.8 – 27.4 m with the exception of an Indian mound that was 39.6 m (Marchinton 1995). Soils were Sharkey, Dundee-Sharkey, and Tensas-Sharkey associations, which formed from clayey alluvial sediments made by the Mississippi River (Allen 1993). These soils are characterized as generally level or gently undulating and poorly drained because of their clay or loam attributes (Weems et al. 1982). The soil is mainly used for agriculture, pasture, or woodlands and is considered fertile. However, permeability and drainage problems require extensive maintenance for agriculture that precludes their use in winter months.

Various water resources lie within the study area including Bayou Macon, Joes Bayou, Tensas River/Bayou, Bear Lake, and Roundaway Bayou, all flowing generally north to south. The course of the Tensas River is considered to be one of the earliest

meandering routes of the Mississippi River (Weems et al.1982). The Tensas River formed approximately 5,000 years ago as a result of a decreased gradient of the Mississippi River, caused by the postglacial rising of the sea level (Weems et al. 1982). The Arkansas River is said to have formed both Bayou Macon and Joes's Bayou about the same time period in an analogous process (Weems et al.1982).

CLIMATE

The climate in northeast Louisiana is influenced by its sub-tropical latitude, landmass to the north, and the Gulf of Mexico to the south. The warm and moist air from the Gulf influences the prevailing winds, which generally are from the south/southeast. Physical conditions are favorable for the development of isolated thundershowers. Periods of hot and dry weather are known to interrupt summer humidity, and winters are considered mild.

In 1997, mean summer high and low temperatures were 33.3 C and 21.1 C, whereas mean winter temperatures were 15.6 C and 5.6 C, respectively. Annual average precipitation in 1997 was 142.8 cm with most rainfall occurring in March (17.3 cm) and least in July (4.1 cm). In 1998, mean summer temperatures were 33.9 C and 22.8 C, whereas mean winter temperatures were 15.6 C and 5.0 C, respectively. Annual average precipitation in 1998 was 154.0 cm with most rainfall occurring in December (28.7 cm) and least in June (5.0 cm). In both years there was an average of 341 freeze-free days.

FAUNA

Northeast Louisiana supports a wide diversity of wildlife species. Within the Tensas River Basin, 227 bird, 78 fish, 45 reptile, 40 mammal, and 19 amphibian species have been documented. Game species taken by hunters and trappers include white-tailed deer, coyote (*Canis latrans*), bobcat (*Felis rufus*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), nutria (*Myocastor coypus*), river otter (*Lutra canadensis*), raccoon (*Procyon lotor*), opossum (*Didelphis virginianus*), swamp rabbit (*Sylvilagus aquaticus*), mink (*Mustela vison*), cottontail rabbit (*Sylvilagus floridanus*), fox squirrel (*Sciurus niger*), gray squirrel (*Sciurus carolinensis*), eastern wild turkey (*Meleagris gallopavo*), American woodcock (*Philohela minor*), mourning dove (*Zenaida macroura*), and numerous species of waterfowl.

Currently, the State of Louisiana lists 31 animal species as Threatened or Endangered including 11 birds, 2 fish, 7 reptiles, 8 mammals, and 3 invertebrates. Several of these species are considered extinct or nearly extinct in Louisiana: Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*), whooping crane (*Grus americana*), eskimo curlew (*Numenius borealis*), Ivory-billed woodpecker, red wolf, and Florida panther. The USFWS recognizes these extirpated species and lists 17 animal species including 7 birds, 2 fish, 3 reptiles, 2 mammals, and 3 invertebrates. Both lists include the official State mammal, the black bear.

FLORA

The forested habitat in northeast Louisiana is classified as bottomland hardwoods, composed mostly of the oak-gum-cypress forest type. Predominant overstory species in the Deltic study area were American elm (*Ulmus americana*), bald cypress (*Taxodium distichum*), sugar hackberry (*Celtis laevigata*), pecan (*Carya illinoensis*), sweetgum (*Liquidambar styraciflua*), green ash (*Fraxinus pennsylvanica*), and several species of oak including overcup oak (*Quercus lyrata*), Nuttall oak (*Quercus nuttali*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*) and red oak (*Quercus rubra*).

Understory species included palmetto (*Sabal minor*), switchcane (*Arundinaria gigantea*), greenbriar (*Smilax* spp.), blackberry (*Rubus* spp.), pokeweed (*Phytolacca americana*), elderberry (*Sambucus canadensis*), paw paw (*Asimina triloba*) and poison ivy (*Rhus radicans*). In Madison Parish, where most of the study area was situated, Rich and Thomas (1981) reported a checklist that contained 717 species of vascular plants.

The State lists 2 floral members as Threatened or Endangered; Louisiana quillwort (*Isoetes louisianensis*) is endangered and the earthfruit (*Geocarpon minimum*) is threatened. The USFWS also lists these species and includes 2 additional plants as endangered: pondberry (*Lindera melissifolia*) and American chaffseed (*Schwalbea americana*).

AGRICULTURE AND SILVICULTURE

Agriculture is the primary land use in northeast Louisiana. Between 1990 and 1998, primary crops in the 4 study area parishes included soybeans, cotton, rice, corn,

wheat, and sorghum (Table 1). These parishes averaged approximately 33% of the state's cotton production, 18% of the state's soybean production, and 9% of the state's rice harvested (Louisiana Cooperative Extension Service, unpublished data). During my study, these crops occupied approximately 72%, 60%, 48%, and 41% of the landbase in East Carroll, Madison, West Carroll, and Richland parishes, respectively. (Table 2). Aerial application of fertilizer, pesticides, and herbicides was common throughout the study area.

Timber was another important resource around the study area. In Madison parish, average landowner income from the sale of timber between 1992 and 1996 was \$1,048,515, whereas East Carroll, Richland and West Carroll parishes averaged \$598,889, \$367,300, and \$169,184 respectively (Marrugi and Bell 1997). In the same period, these 4 parishes averaged 0.4% of the State's timber sales, which averaged approximately 5.4 billion dollars (Marrugi and Bell 1997).

Table 1. Average land area (km²) occupied by 6 major agricultural crops in the 4 parishes surrounding the Deltic study area, northeast Louisiana, 1990-1998 (parenthesis in table show average percent of parish occupied by each crop) (Louisiana Agricultural Extension Service).

Crop	East Carroll (1,096 km²)	Madison (1,623 km²)	Richland (1,452 km²)	West Carroll (934 km²)	All Parishes (5,105 km²)
Soybeans	314 (29%)	405 (25%)	108 (7%)	81 (9%)	908 (18%)
Cotton	234 (21%)	231 (14%)	452 (31%)	221 (24%)	1,138 (22%)
Rice	67 (6%)	22 (1%)	55 (4%)	28 (3%)	172 (3%)
Corn	88 (8%)	234 (14%)	69 (5%)	16 (2%)	407 (8%)
Wheat	32 (3%)	43 (3%)	16 (1%)	21 (2%)	112 (2%)
Sorghum	25 (2%)	25 (2%)	14 (1%)	17 (2%)	81 (2%)
Total	759 (69%)	961 (59%)	714 (49%)	385 (41%)	2,819 (55%)

Table 2. Area (km²) occupied by 6 major agricultural crops in the 4 parishes surrounding the Deltic study area, Tensas River Basin, northeast Louisiana, 1997-1998 (parenthesis show the percent of parish area occupied by each crop) (Louisiana Cooperative Extension Service).

Crop	<u>East Carroll (1,096 km²)</u>		<u>Madison (1,623 km²)</u>		<u>Richland (1,452 km²)</u>		<u>West Carroll (934 km²)</u>	
	<u>1997</u>	<u>1998</u>	<u>1997</u>	<u>1998</u>	<u>1997</u>	<u>1998</u>	<u>1997</u>	<u>1998</u>
Corn	128 (12%)	206 (19%)	293 (18%)	356 (22%)	139 (10%)	254 (17%)	29 (3%)	48 (5%)
Cotton	157 (14%)	125 (11%)	193 (12%)	179 (11%)	357 (25%)	253 (17%)	174 (19%)	160 (17%)
Rice	69 (6%)	92 (8%)	14 (1%)	22 (1%)	22 (2%)	37 (3%)	32 (3%)	39 (4%)
Sorghum	29 (3%)	38 (3%)	19 (1%)	34 (2%)	10 (1%)	30 (2%)	17 (2%)	27 (3%)
Soybeans	378 (34%)	313 (29%)	408 (25%)	356 (22%)	171 (12%)	109 (8%)	100 (11%)	93 (10%)
Wheat	35 (3%)	15 (1%)	23 (1%)	22 (1%)	27 (2%)	16 (1%)	16 (1%)	29 (3%)
Total	796 (73%)	775 (71%)	950 (59%)	969 (60%)	368 (39%)	396 (42%)	726 (50%)	669 (46%)

CHAPTER III

METHODS

CAPTURE - RESIGHT

Trapping and Handling

Black bears were captured from 1 June through 15 September 1997, and 25 May through 9 September 1998 with Aldrich spring-activated foot snares (Aldrich Animal Trap Company, Clallam Bay, Washington). Trapsites were established along creek drainages and swamps, on known bear travel routes, and in areas with sign of bear activity.

Trail and modified cubby trapsets were used to capture bears (Clark 1991, Brandenburg 1996). Mobile home anchors or trees were used to secure snares. Bait consisted of bakery products (e.g., sweet rolls and doughnuts) laced with artificial raspberry, blueberry, or honey flavorings (Mother Murphy's, Greensboro, North Carolina.) to attract bears to trapsites. When a baited trap was raided by a bear >2 occasions without capture, unbaited traps were employed nearby (>15 m) while leaving the original baited trap in place. All traps were checked by 1100 daily.

Captured bears were immobilized with a mixture of Ketamine hydrochloride (200 mg/ml) (Ketaset, Burns Veterinary Supply, Incorporated, Farmers Branch, Texas), xylazine hydrochloride (100 mg/ml) (Rompun, Haver-Lockhart Incorporated, Shawnee, Kansas) and mepivacaine hydrochloride (20 mg/ml) (Carbocaine V, Winthrop

Laboratories, New York, New York). Drug was administered intramuscularly with a jab stick or blowgun (Dan-inject) at a dosage of 1 ml per 25.0 kg of estimated body weight. Liquamycin (LA-2000, Pfizer Animal Health, New York, New York) was administered at a dosage of 1 ml per 5 kg of body weight to bears that had fighting wounds or had sustained minor injuries. After immobilization, a wetting agent (Akwa Tears, Akorn Incorporated, Abita Springs, Louisiana) was applied to the bear's eyes to prevent desiccation. The bear's eyes were covered to protect them from insects and debris and to reduce visual stimuli.

A permanent identification number was tattooed on the inside upper lip of each bear using 0.8 cm numeric digits (Nasco, Fort Atkinson, Wisconsin) and animal tattoo ink (Ketchum Manufacturing, Ottawa, Canada). Numbered metal tags (Hasco Tag Company, Dayton, Kentucky), corresponding to the tattoo identification number, were placed in both ears of each bear. A radio-transmittable collar (Telonics Incorporated, Mesa, Arizona) was placed on all bears >1 year-old; leather spacers treated with linseed oil and measuring 12.5 cm long by 0.4 cm wide served as a breakaway function on each radiocollar.

The first upper premolar of each bear was extracted and later sectioned, and stained for age identification (Eagle and Pelton 1978) by cementum annuli analysis (Willey 1974). Bears were weighed with a spring scale and pertinent body measurements were recorded. Body temperature, respiration, and pulse were monitored throughout the immobilization. Descriptive information including general condition, reproductive status,

tooth wear, prominent scars or wounds, ectoparasite load, and anomalies were recorded for each bear.

Yohimbine hydrochloride (Lloyd laboratories, Shenandoah, Iowa), an antagonist for xylazine hydrochloride, was administered through the sublingual vein of the tongue or the femoral artery at a dosage of 1 ml per 25 kg of body weight. Bears were then monitored until recovery.

Marking, Cameras, and Resight

Population estimates using mark-recapture techniques are difficult to achieve because of trap response and heterogeneity biases (Pollock et al. 1990). Many authors have reported that capture-resight studies are a valuable and effective technique for estimating animal populations (Nichols et al. 1981, Pollock 1981, Minta and Mangel 1989, Garshelis and Coy 1994). Seber (1973) noted that the precision of an experiment can be increased using a sighting technique as a secondary capture method. Therefore, to reduce bias, I used a sighting method as a secondary capture technique using remote camera stations (Martorello et al. *in press*). Using a secondary capture technique changes the forces driving trap response and heterogeneity in capture probabilities (Pollock et al. 1990).

Garshelis and Coy (1994) compared mechanically activated camera stations to the motion-sensing units and reported that bears tampered with mechanical camera boxes more often and that they were less reliable because of moisture damage. However, an updated design using military ammunition boxes to house the camera unit was recently

developed and has proven resistant to moisture and bear damage (Martorello et al. *in press*).

The advantages associated with using manual remote camera stations are that a different sampling technique is used, which reduces bias in sampling, the technique is inexpensive, large areas can be sampled in a short period, and the method is simple and nonintrusive.

I marked each captured bear with a uniquely color-coded radiocollar and matching eartags (Fig. 7). An 18-oz vinyl fabric (Cooley Incorporated, Pawtucket, Rhode Island) used for sports products was used to color-code the hardware. By double-marking bears I decreased the probability that a marked bear would be overlooked or unrecognized should 1 of the marks be lost. Moreover, unique double-marking allowed identification of individuals, which enabled me to use different population estimators, thus providing a more robust population estimate.

The cameras used required manual film advance after a photograph was taken. Therefore, only 1 photo was possible between camera checks. Ideally, when bears pulled on the bait, and triggered the mechanism, the photograph taken displayed the bear's head and shoulder region revealing the color-coded hardware (Fig. 8 and Fig. C-1). All stations were baited with the same bait and lures used during the trapping period.

Subsequent to the 1997 and 1998 trapping seasons, 35 and 40 camera units were used to collect resight data, respectively. To facilitate independence of samples, camera stations were placed approximately ≥ 0.8 km apart throughout the study area, but were not placed at trap sites.

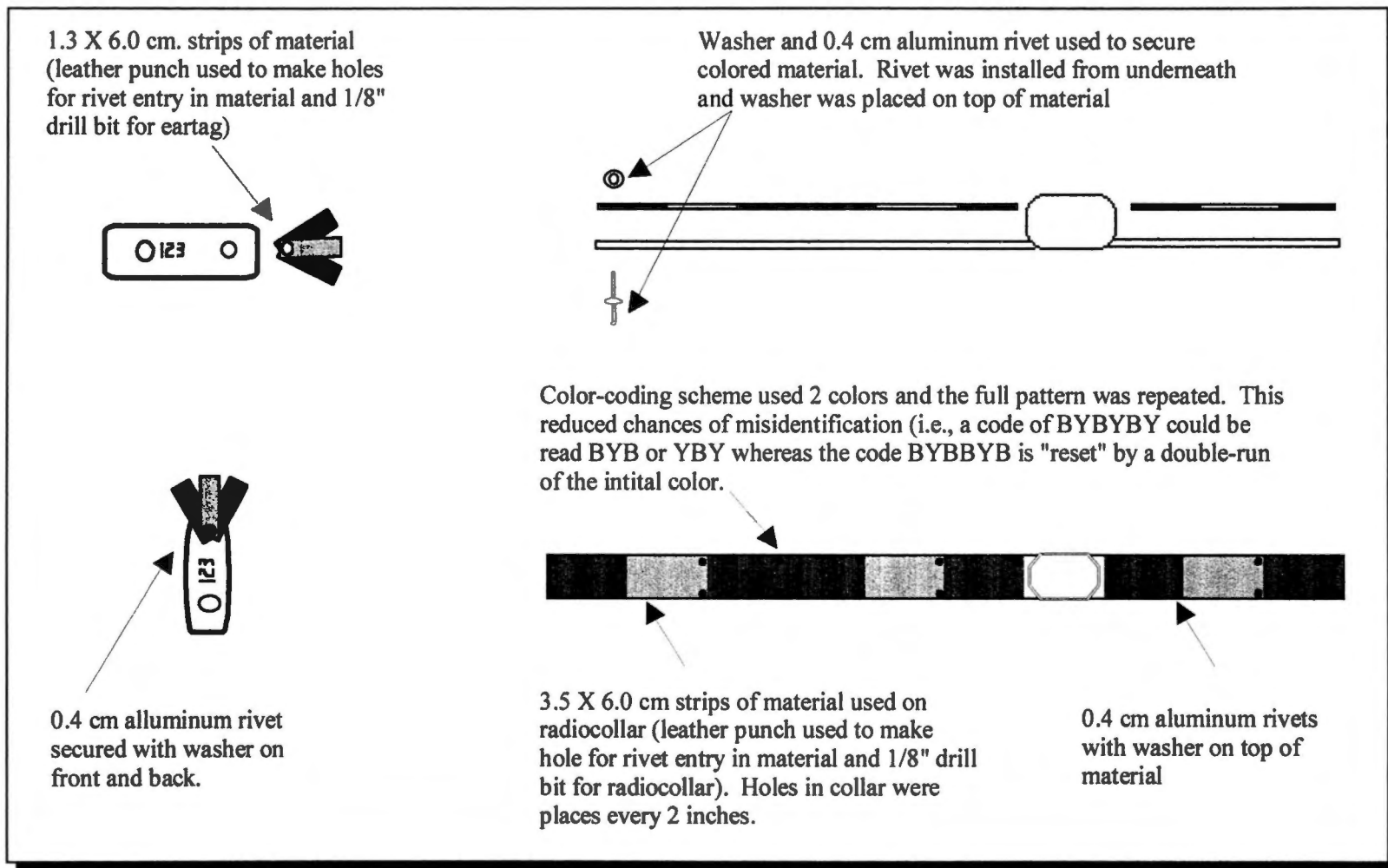


Fig. 7. Visual representation of the technique used to color-code the hardware for mark-resight study, Deltic study area, northeast Louisiana, 1997-1998.

Three photo sessions were conducted in 1997 and 2 in 1998. All tracts within the study area were concurrently monitored throughout all sessions. Average session length in both years was 28 days. After each session, cameras were relocated to a different site within the tract; 106 different camera stations were maintained in 1997 and 91 different stations in 1998. In both years, cameras were checked after 4 nights in the first 2 sessions, and after 7 nights during the third session in 1997; the longer interim in the third session was used to reduce conflict with deer hunting activity on the study area. However, because hunting pressure differed among forested tracts, some conflicts did occur; consequently, the third session was eliminated in 1998.

POPULATION ESTIMATION

There are many population models available to estimate wildlife population abundance. All models used for population estimation are restrictive in that certain assumptions must be made about the population being studied; compliance with particular conditions is essential for model integrity. Closed population models assume no births, immigration, death, or emigration during the sampling periods. Conversely, open population models allow for changes in composition of the study population between sample periods.

Pollock et al. (1990) described a capture-recapture scheme that allowed the combination of closed and open population models to be used for analysis; a design they called the “robust design”. Using this robust design, population estimates can be calculated within and across years. I designed the current study using this approach and

incorporated 3 closed population models for within-year estimates and 1 open model to estimate the population across years, incorporating data from previous studies on Deltic (Weaver, unpublished data, Marchinton 1995, Anderson 1997) (Fig. 9). By initiating a recapture technique (cameras) that was different from the capture method (snares), I attempted to reduce the amount of bias in the equal catchability assumption (Burnham and Overton 1979). Also, capture and resight sampling events were conducted separately, ensuring independence (Seber 1982).

For the within-year population models, I assumed both demographic and geographic closure because the sample periods were relatively short (~7 months each year) and natural barriers (i.e., agricultural fields, Interstate 20, Highway 80), were present which likely hindered movement. In 8 years of previous studies, only 1 bear has been documented leaving the study area (Anderson 1997). Also, the second sample immediately followed the first so no births occurred between sampling periods.

The loss or failure to accurately record marks can be detrimental to the closure assumption (Otis et al. 1978). If marks are lost, an overestimate of N will result. Double-marking bears with individually color-coded radiocollars and similarly color-coded eartags reduced the probability of this violation.

Based on previous studies on the Deltic study area, I expected low sample sizes and repeated camera sightings of individual bears. Therefore, I needed to use a model that would allow me to incorporate multiple resightings in my data analysis. Seber (1982) noted that a multiple resight model would accommodate small sample sizes and increase the precision of an estimate.

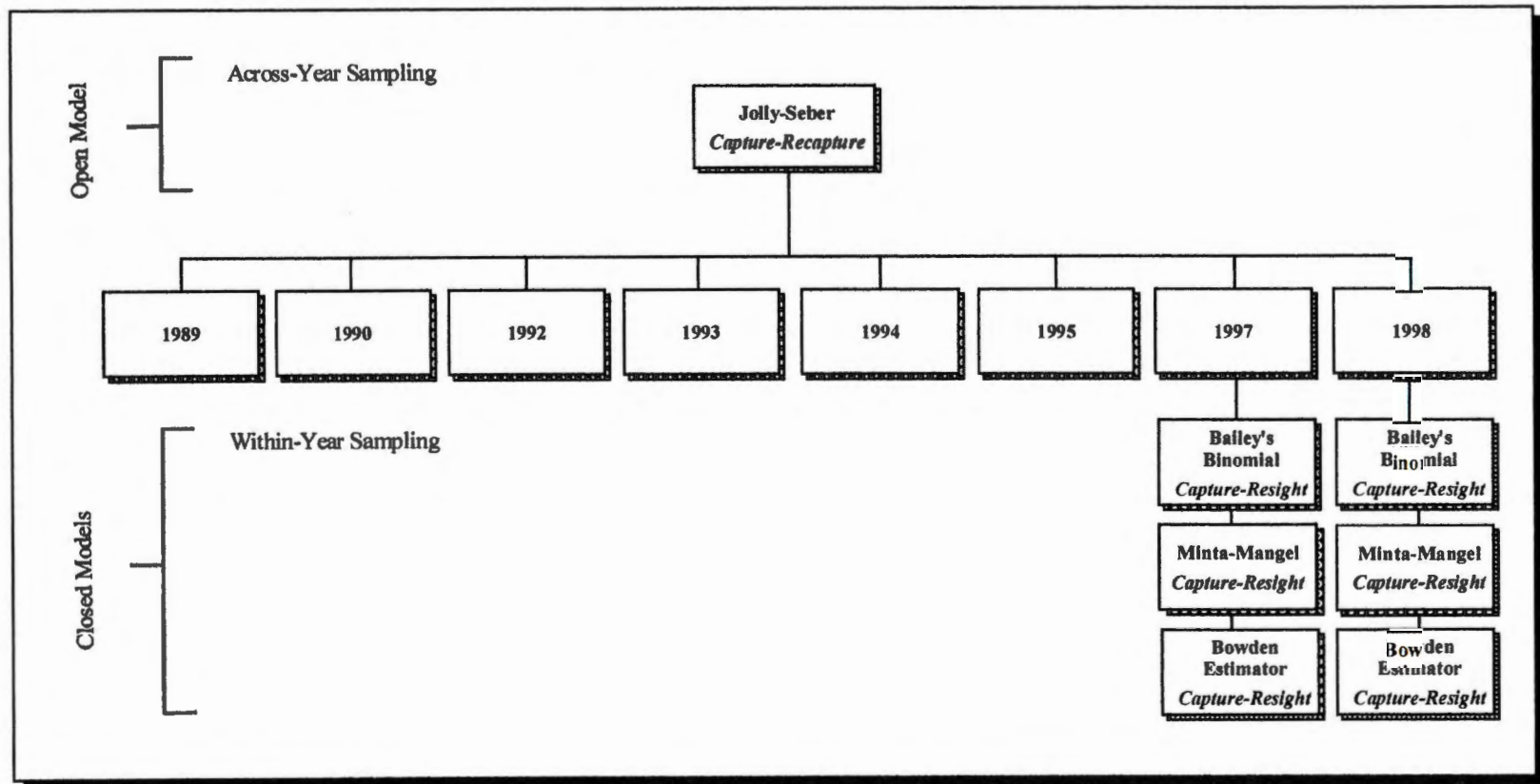


Fig. 9. Models used to estimate population size of black bears on the Deltaic study area, northeast Louisiana, 1989-1998

Lincoln-Peterson Model

Lincoln-Petersen estimator is a closed model that has been used extensively in population estimation, mostly in capture-recapture studies (Caughley 1977). With the Lincoln-Petersen estimator, the closure assumption can be relaxed if emigration occurs equally among marked and unmarked animals (Seber 1982). Chapman (1951) modified the Lincoln-Peterson model to accommodate low sample sizes, as in the Deltic study area. However, Robson and Reiger (1964) recommended that researchers not use the modified Lincoln-Petersen if the number of marked bears (m_2) in the second sample is < 7 . If there are ≥ 7 recaptures, a researcher can be confident that bias of N would be negligible 95 times out of 100. In the current study, all second year recapture data from 1988–1998 showed m_2 to be < 7 , therefore, Lincoln-Petersen was not employed as a method to estimate the Deltic population size.

Deltic Population Estimators

The 3 closed population models I used to estimate the Deltic population size were Bailey's Binomial model (Seber 1982), the Minta-Mangel model (1989), and Bowden's Estimator (Bowden and Kufeld 1995).

I also calculated a population estimate with the Jolly-Seber open model method (Jolly 1965, Seber 1965, Pollock et al. 1990). Because this model requires data from at least 3 sampling periods, I incorporated data from 3 previous studies; Weaver (unpublished data), Marchinton (1994), and Anderson (1997). These combined data

allowed analysis based on 9 capture periods over an 11-year interval. No trapping efforts were conducted in 1996 and only 2 bears were captured in 1991, but not as part of an organized trapping effort; therefore, both years were eliminated from analysis. The Jolly-Seber model allows for such discontinuous data.

Bailey's Binomial Model

Bailey's Binomial model, a variant of the Lincoln-Petersen estimator, was used to analyze capture-resight data. Bailey's binomial model uses a binomial distribution to account for repeat visitations by the same individual. The resight method accommodated within-year estimates and reduced the time period between mark and resight periods, thus minimizing violations to population closure. With Bailey's model, population size is estimated by

$$\hat{N}_b = \frac{n_1(n_2 + 1)}{m_2 + 1},$$

where $\hat{N}_b$ is the estimated population, n_1 is the number of bears marked in the initial sample, n_2 is the number of bears sighted in the second sample, and m_2 is the number of marked individuals that are resighted.

The approximate unbiased variance and associated 95% confidence intervals were calculated as follows:

$$\text{var}(\hat{N}_b) = \frac{n_1(n_2 + 1)(n_2 - m_2)}{(m_2 + 1)^2(m_2 + 2)},$$

and

$$95\%CI = (\hat{N}_b) \pm 1.96\sqrt{\text{var}(\hat{N}_b)}.$$

Assumptions of Bailey's Binomial model are: (1) the population is demographically and geographically closed, (2) animal marks are not lost, (3) all marks are noted and recorded, (4) the resight period is random, (5) there is equal resight probability among marked and unmarked animals, and (6) the marks do not affect future resight probability.

Minta-Mangel Model

The Minta-Mangel model, from program NOREMARK (Gary White, Department of Fisheries and Wildlife, Colorado State University), also provided within-year estimates but differed from Bailey's Binomial model in that it required animals to be individually identifiable during the resight period. This model uses a Monte Carlo simulation method to generate a maximum likelihood estimate of population size and incorporates an asymmetric confidence interval around that estimate. The Monte Carlo simulation is a randomization process that partitions resight frequencies of unmarked animals into frequencies similar to those of marked animals observed in the resight data, via the bootstrap procedure (Minta and Mangel 1989). The simulation I used performed 10,000 iterations. For this model, consider that there are 2 types of animals (type 1 = males and type 2 = females). Estimated population size is calculated by:

$$E\{\hat{N}_m\} = \sum_{m_1} \sum_{m_2} \Pr\{n_1 = m_1, n_2 = m_2\},$$

$$[B(m_1, m_2) + m_1 + m_2]$$

where $\Pr\{n_1 = m_1, n_2 = m_2\}$ is the product of 2 binomial expressions and

$$B(m_1, m_2) = \frac{[(n_1 - m_1)t_1 + (n_2 - m_2)t_2](m_1 + m_2)}{m_1 t_1 + m_2 t_2},$$

where n_1 is the number of marked animals of type 1, n_2 is the number of marked animals of type 2, m_1 is the number of marked animals sighted of type 1, m_2 is the number of marked animals sighted of type 2, t_1 is the number of photographs from animals of type 1, t_2 is the number of photographs from animals of type 2, N_1 is the number of type 1 animals in the population, N_2 is the number of type 2 animals in the population, and $\hat{N}_m$ is the estimated population size.

Assumptions of the Minta-Mangel model are: 1) animals are captured, marked, and randomly or systematically resighted, 2) the population is geographically and demographically closed, 3) tags are not lost and are properly recorded, 4) the initial captures are a random sample of the population, and 5) sampling events are independent.

Bowden's Estimator

The Bowden Estimator, also in program NOREMARK operates in a similar manner to the Minta-Mangel model regarding model assumptions and the individual identification of marked animals. However, confidence intervals are more conservatively constructed using an alpha level of 0.10. Also, sighting probabilities in Bowden's model can vary among individuals with regards to elements such as vegetational cover (Bowden

and Kufeld 1995). Furthermore, unidentifiable marked animals are incorporated into the model.

Population size is estimated with

$$\hat{N} = (\tilde{N} + s_y^2 / \bar{y}^2) / (1 + s_y^2 / n\bar{y}^2),$$

the variance is estimated with

$$\hat{V}(\hat{N}) = \hat{N}^2 \left(\frac{1}{n} - \frac{1}{\hat{N}} \right) \frac{s_y^2}{\bar{y}^2} \bigg/ (1 + s_y^2 / n\bar{y}^2)^2,$$

and confidence interval as,

$$\hat{N} \pm t_{1-\alpha/2, n-1} \sqrt{\hat{V}(\hat{N})},$$

where $\hat{N}$ is the estimated population size, s is the sighting probability, y_i is the number of sightings of the i^{th} animal, $\bar{y}$ is the mean number of times marked animals were sighted, $t_{1-\alpha/2, n-1}$ is the $1 - \alpha/2$ quantile of the Student's t distribution with $(n - 1)$ degrees of freedom.

Assumptions of the Bowden Estimator are: 1) marked animals are randomly selected from the population, 2) marked animals are individually identifiable, 3) all marks are recorded accurately, 4) all unmarked animals are recorded accurately, and 5) the sighting process is independent of the mark status of the animal.

Jolly-Seber Model

I also used the Jolly-Seber open population mark-recapture model, from program JOLLY (Pollock et al. 1990) to estimate the Deltic population across years. Five

different models are included in program JOLLY and chi-square goodness of fit tests allows determination of the most appropriate models for analysis. First, there is a general model (Model A) that allows capture and survival probabilities to vary over time. The second model (Model A') restricts additions to the population but allows deletions. Another model (Model 2) assumes equal survival rates between all marked and unmarked individuals. The fourth model (Model B) requires a constant survival rate throughout the study period. The last model (Model D) assumes that the survival and capture probabilities are constant throughout the study.

Population size is estimated by

$$\hat{N} = \frac{n_i M_i}{m_i}, \quad \text{and}$$

$$M_i = \frac{z_i n_i}{r_i + m_i} \quad \text{or} \quad M_i = \frac{z_i R_i}{r_i + m_i} \quad \text{if} \quad R_i < n_i,$$

where n_i is the number of animals captured in the i^{th} sample, m_i is the number of marked animals captured in the i^{th} sample, R_i is the number of marked animals released from the i^{th} sample, r_i is the number of animals released from the i^{th} sample that are recaptured in a subsequent sampling period, z_i is the number of animals caught before the i^{th} sample that are not caught in the i^{th} sample but are caught in a subsequent sampling period, $\hat{N}$ is the total number of animals in the population just before the i^{th} sample, and M_i is the total number of marked animals in the population just before the i^{th} sample (Pollock et al. 1990).

Assumptions of the Jolly-Seber model are: 1) the population is demographically and geographically open, 2) every animal has an equal probability of capture in the i^{th} sample, 3) every animal has an equal probability of survival from the i^{th} to the $i^{th} + 1$ sample, 4) marks are not lost and all marks are noted and recorded, and 5) all samples are instantaneous (Pollock et al. 1990).

RADIO TELEMETRY

I radiocollared 24 black bears between 23 June 1997 and 12 December 1998. Three bears dropped their collars within a few days of capture and were not monitored. I attempted to locate bears 3-5 times per week. Bears were located from roads and ATV trails with a model TR-4 receiver (Telonics Incorporated, Mesa, Arizona), a 5-element vehicular roof-mounted antenna (Wildlife Materials, Carbondale, Illinois), and a 2-element "H" antenna (Telonics, Incorporated, Mesa, Arizona).

Radiocollars used in this study were equipped with activity- and mortality-sensitive hardware (Mod-500, Telonics, Inc., Mesa Arizona). This allowed me to monitor survival and quickly locate a bear whose collar emitted a mortality signal. Radiocollars had an operational life of 30 months, but I used a leather spacer designed to break, so ideally the collar would remain on the bear for 18-24 months.

Telemetry stations were established at known locations that could be accurately identified on 1:24,000 United States Geological Survey (USGS) topographic maps. Station coordinates on ATV trails were determined using a Global Positioning System

(GPS). Each telemetry station was plotted and an identification number and Universal Transverse Mercator (UTM) coordinates were recorded.

Bear locations were determined through triangulation with ≥ 2 azimuths using the “loudest signal method” (Springer 1979, Mech 1983). Azimuths were selected based on the following criteria: (1) the angle between azimuths was between 45° and 135° , (2) all azimuths were collected in less than 20 minutes, and (3) signal strength was reliable.

Telemetry Error

Twenty-five radiocollars were placed throughout the study area at areas identifiable on a 1:24,000 scale map. I placed collars at various heights (i.e., on ground, 1m off ground, in trees), in various locations (i.e., creek drainages, forest interior, forest edges, corridors, and in fields) to simulate actual bear activity. I located collars during normal telemetric sampling at different times of the day and in different climatic conditions. Actual and estimated collar locations were plotted on maps and the distances between them were measured. Although several researchers placed test collars, I performed all telemetric duties independently.

Independence of Radio Locations

Bear movements likely depend on past experience; therefore, no 2 telemetry locations can be considered truly independent (Powell 1987, White and Garrott 1990, Clark 1991). Garshelis (1978) determined that a bear can usually move between any 2 points in its home range within approximately 6 hours. On Deltic, movements between

fragmented woodlots may have been restricted to the evening hours. Therefore, only locations recorded >12 hours apart were used in home range analysis.

Home Range Estimation

Telemetry data were entered into the software program TELEM 88 (Coleman and Jones 1988), using the bear identification number, date, station coordinates, and azimuths. The UTM coordinates were determined using 2 azimuths for each location.

To estimate annual home ranges I used the minimum convex polygon (Ackerman et al. 1990), adaptive kernel (Worton 1989), and harmonic mean (Dixon and Chapman 1980), methods in program CALHOME (Kie et al. 1994). The adaptive kernel and harmonic mean methods are nonparametric estimators for which the effect of outliers is small. For all methods 50, 75, and 95% contour levels were used to delineate core and overall home ranges for each bear. I calculated home ranges for all bears that had ≥ 30 locations.

Home Range Overlap

Using the 95% contour level of the minimum convex polygon estimate, I calculated home range overlap in program ARCVIEW[®] (ESRI, Redlands, California) by intersecting home ranges of 1 bear with all others overlapping home ranges. The overlap portion of any 2 home ranges was divided by each home range that produced it, resulting in a percent overlap for each bear. I calculated overlap for all female home ranges on the Bluecat and Brownie tracts.

Movements Between Isolated Forested Tracts

I radiocollared all animals >1 year-old and monitored their movements. When a radiocollared bear moved between 2 isolated forested tracts I recorded the bear's identification number, the date, the 2 tracts involved and in what direction movement occurred, and whether the 2 tracts were connected by a forested corridor.

Dispersal of Juveniles

I defined dispersal in this study as a movement from one isolated forested tract to another without return. I used radio telemetry to monitor juvenile dispersal patterns and survival. I compared male and female dispersal to determine if natal philopatry was exhibited within or among sexes. I provided a detailed account of movement patterns for all dispersing bears.

NATALITY AND MORTALITY

Natality and Cub Survival

Adult females in this study were monitored via radio telemetry to determine reproduction and survival. Reproductive condition and cubs present at capture were also recorded. When possible, I homed in on active radiocollared females and recorded offspring observed. Some den sites were visited to determine presence of cubs or yearlings and den selection. Dens were visited once the bear became stationary or radio

signals became inactive and were located by homing. Den chronology has been well documented in this population and was not monitored in this study.

Mortality

Radiocollars used in this study were equipped with mortality-sensitive hardware. The mortality signal was activated when the collar remained motionless for >2 hours. All causes of mortalities occurring on the study area were recorded and detailed accounts presented.

CHAPTER IV

RESULTS

CAPTURE - RESIGHT

Capture

A total of 3,525 trap nights from 213 trap sites (Fig. 10) resulted in 40 captures of 24 individual black bears (12F: 12M) (Table 3). In the 8 years of research prior to this study, 63 captures were made of 30 individual bears on the Deltic tracts. Upon completion of this study, 103 captures of 42 individual bears have been made (Table A-1). The age of marked bears in this study ranged from 0.5 to 16.5 years (Table 3). All trapsites in this study were maintained for an average of 16 trap nights and, on average, 20 trapsites were monitored simultaneously. Overall, trap success was 1.1% averaging 88 trap nights per capture, or 1 capture every 5 calendar days (Table A-2).

In 1997, 1,642 trap nights from 94 trap sites resulted in 12 captures of 10 individuals (6F: 4M) (Table 3). Of these 10 bears, 3 bears (2F: 1M) were captured in previous studies (Table A-1).

In 1998, 1,883 trap nights from 119 trap sites resulted in 28 captures of 20 individual bears (10F: 10M) (Table 3). Of the 20 captures in 1998, 10 (5F: 5M) were captured in previous studies and 6 (4F: 2M) were recaptures from 1997 (Table A-1).

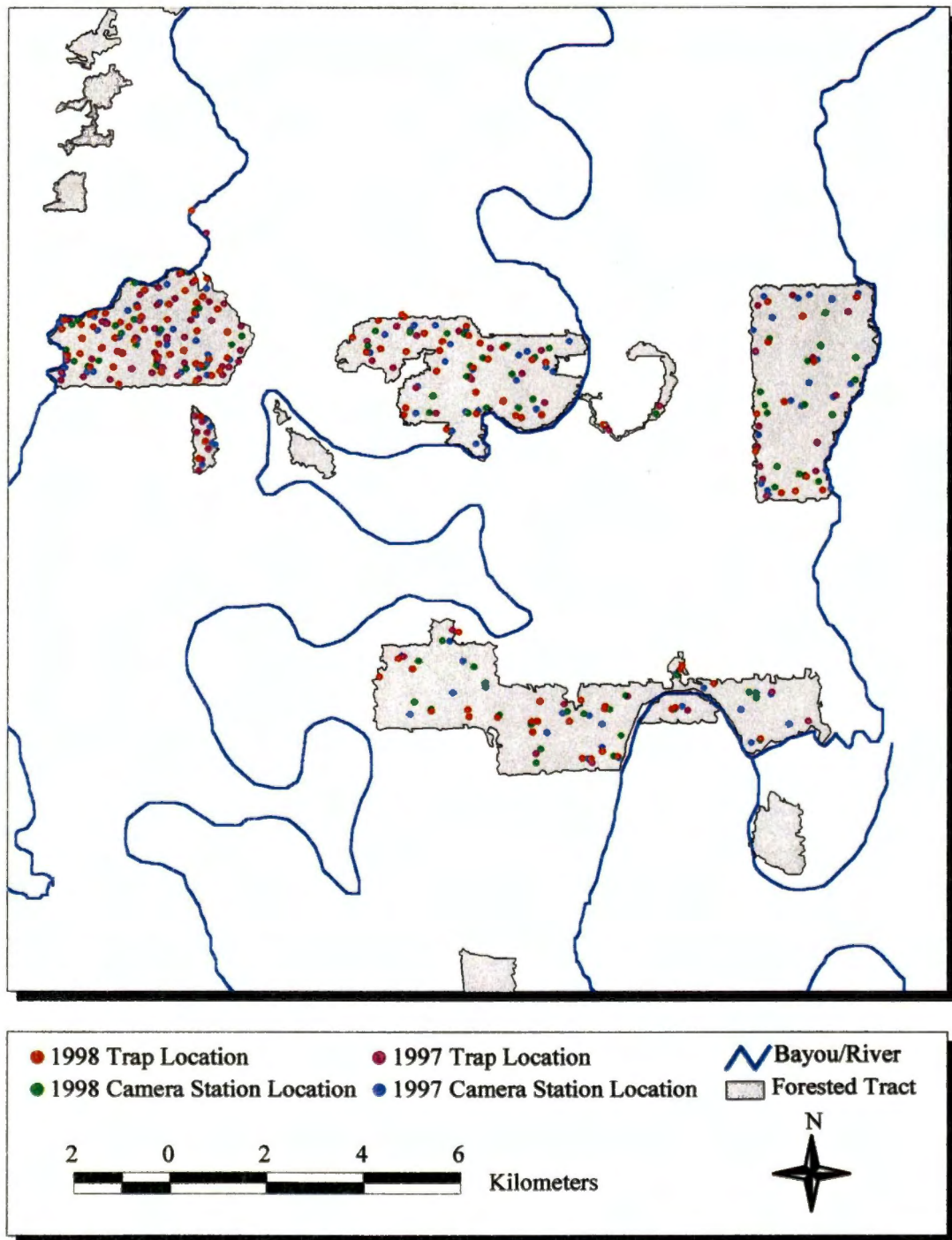


Fig. 10. Locations of traps and remote cameras used in mark-resight study, Deltic study area, northeast Louisiana, 1997-1998.

Table 3. Black bear trapping results for the Deltic study area, Tensas River Basin, northeast

Bear ID	Date	Location ^a	Sex ^b	Weight (kg)	Age (years)
122	29-Aug-98	Wade Bayou	M	162.0	11.5
124	01-Jun-98	Bluecat	F	96.8	12.5
128	12-Jun-98	Bluecat	F	83.3	16.5
	06-Aug-98	Bluecat		85.4	16.5
156 (375°)	14-Jun-98	Bluecat	F	56.3	9.5
162 (184°)	24 Aug-97	Carson Woods	F	49.9	5.5
190	23-Aug-98	Brownie	M	150.8	4.5
200	18-Aug-97	Brownie	F	55.8	5.5
	04-Jun-98	Brownie		56.3	6.5
202 (371°)	25-Jul-98	Panther Lake	F	60.75	4.5
213	17-Jun-98	Bluecat	M	164.3	11.5
226	23-Aug-98	Big Creek	M	119.3	4.5
228 (268°)	02-Jun-98	Bluecat	M	160.0	4.5
230 (263°)	06-Sep-97	Brownie	M	136.2	3.5
	26-Aug-98	Brownie		150.8	4.5
258	01-Sep-97	Bluecat	M	32.7	1.5
260	25-Jun-97	Wade Bayou	M	31.8	1.5
264	01-Jun-98	Bluecat	M	51.8	1.5

Table 3. (continued)

Bear ID	Date	Location ^a	Sex ^b	Weight (kg)	Age (years)
274	14-Aug-97	Bluecat	M	9.1	0.5
	08-Sep-97	Bluecat			0.5
	13-Sep-97	Bluecat			0.5
	25-May-98	Bluecat		36.0	1.5
	06-Jun-98	Bluecat			1.5
	10-Jul-98	Bluecat			1.5
	17-Jul-98	Bluecat			1.5
	02-Sep-98	Bluecat			1.5
	08-Sep-98	Bluecat		45.0	1.5
301	17-Aug-97	Carson Woods	F	56.3	4.5
	17-Aug-98	Bluecat		56.3	5.5
307	13-Jun-98	Bluecat	F	29.5	1.5
311	22-Jul-97	Bluecat	F	7.7	0.5
	14-Jun-98	Bluecat		24.8	1.5
314	01-Jun-98	Bluecat	F	63.0	4.5
	08-Jun-98	Bluecat			4.5
317	20-Aug-97	Bluecat	F	9.1	0.5
	27-May-98	Bluecat		33.8	1.5
	29-May-98	Bluecat			1.5
319	15-Sep-97	Brownie	F	67.2	4.5
360	25 May-98	Bluecat	M	48.6	1.5
362	4-Aug-98	Bluecat	M	108.0	4.5

^aSee figure 1 for locations of tracts^bM = male, F = female^cRe-issued this new lip tattoo number in the current study

Resight

A total of 4,995 camera trap nights were accumulated from 192 camera sites (Fig. 10). However, only 1,168 photographs were possible because cameras were checked every 4-7 days in 1997, and every 4 days in 1998. Each camera site was maintained for an average of 28 days and 816 (70%) photographs were taken. From those photographs, 193 (24%) were photographs of bears with 63 (33%) wearing color-coded hardware, and 123 (64%) were unmarked (Table 4). The remaining 623 photographs (76%) were of non-target species including 377 opossum (*Didelphis virginiana*), 94 raccoon (*Procyon lotor*), 9 southern flying squirrel (*Glaucomys volans*), 4 gray squirrel (*Sciurus carolinensis*), 3 common grackle (*Quiscalis quiscula*), 3 barred owl (*Strix varia*), 3 human (*Homo sapiens*), 2 eastern woodrat (*Neotoma floridana*), 1 white-tailed deer (*Odocoileus virginianus*), 1 northern cardinal (*Cardinalis cardinalis*), 1 bobwhite quail (*Colinus virginianus*), 1 yellow-billed cuckoo (*Coccyzus americanus*) 1 bat (undistinguishable spp.), 1 bird (undistinguishable spp.), 37 fallen branches, and 85 pictures with no animal visible.

From 19 September to 12 December 1997, 38 remote cameras were maintained simultaneously on all 5 tracts in the Deltic study area. A total of 2,811 camera trap nights were accumulated from 101 camera sites. Cameras were checked every 4-7 days in 1997 and 371 (61%) of 612 possible photographs were taken (Table 5).

From 14 September to 11 November 1998, 40 cameras were maintained simultaneously on all 5 tracts in the Deltic study area. A total of 2,184 camera trap nights

Table 4. Remote camera results for Deltic capture-resight study, Tensas River Basin, northeast Louisiana, 1997-1998.

Site	# Camera Locations	# Camera Nights	# Photos Possible	# Actual Photos	# Non-Target Species	Total # Bears	Total # Marked	Total # Unmarked	# Photos Censored ^a
Bluecat	56	1,288	298	259 (87%)	156 (60%)	103 (40%)	41 (40%)	60 (58%)	2 (2%)
Panther Lake	41	1,111	256	197 (77%)	186 (95%)	11 (6%)	5 (46%)	6 (55%)	0
47 Wade Bayou	42	1,110	262	125 (48%)	107 (86%)	18 (14%)	2 (11%)	16 (89%)	0
Brownie	42	1,119	265	167 (63%)	106 (64%)	61 (37%)	15 (25%)	41 (67%)	5 (8%)
Carson Woods	9	254	63	54 (87%)	54 (100%)	0	0	0	0
Panther Lake Drain	2	113	26	14 (54%)	14 (100%)	0	0	0	0
Total	192	4,995	1170	816 (70%)	623 (76%)	193 (24%)	63 (33%)	123 (64%)	7 (4%)

^a Mark status of the bear was undistinguishable

Table 5. Remote camera results for Deltic capture-resight study, Tensas River Basin, northeast Louisiana, 1997.

Site	# Camera Locations	# Camera Nights	# Photos Possible	# Actual Photos	# Non-Target Species	Total # Bears	Total # Marked	Total # Unmarked	# Photos Censored ^a
Bluecat	26	728	158	125 (79%)	89 (71%)	36 (29%)	3 (8%)	32 (89%)	1 (3%)
Panther Lake	24	677	144	113 (79%)	109 (97%)	4 (5%)	0	4(100%)	0
Wade Bayou	24	624	136	43 (32%)	34 (79%)	9 (21%)	0	9 (100%)	0
Brownie	21	556	121	76 (63%)	56 (73%)	20 (27%)	4 (20%)	14 (70%)	2 (10%)
Carson Woods	5	144	35	34 (97%)	34 (100%)	0	0	0	0
Panther Lake Drain	1	82	18	11 (61%)	11 (100%)	0	0	0	0
Total	101	2811	612	402 (66%)	333 (83%)	69 (17%)	7 (10%)	59 (86%)	3 (4%)

^a Mark status of the bear was undistinguishable

were accumulated at 91 camera stations. Cameras were checked every 4 days in 1998 and 414 (74.2%) of 558 possible photos were taken (Table 6).

POPULATION ESTIMATION

Population estimates from 1997 were between 24-72 individuals and from 1998 were between 28-47 (Table 7). However, with the closed population models, results from 1998 are considered to be more precise because both capture and resight frequencies increased, which reduced the confidence intervals giving a better representation of the population size.

Bailey's Binomial Model

In 1997, 2 marked bears were censored from resight data because they were removed from the population (M258 and M260). A total of 69 bear photographs were obtained, but 5 were censored because I was unable to distinguish the mark status of the bear. Therefore, 8 marked bears remained in the population and 4 (50%) were seen 7 times in the 64 photographs collected in resight data. In 1997, the Deltic population estimate using Bailey's Binomial Model was 70 bears (95% CI = 27 – 113).

In 1998, 123 bear photographs were obtained, but 4 photographs were censored because I was unable to determine the mark status of the bear. Although 24 bears were marked for this study, 3 animals were removed from the population. Bear M258 was killed by a vehicle collision, bear M260 was poached, and bear F162 was translocated by USFWS to TRNWR in March of 1998. Therefore, 21 bears were included in the

Table 6. Remote camera results for Deltic capture-resight study, Tensas River Basin, northeast Louisiana, 1998.

Site	# Camera Locations	# Camera Nights	# Photos Possible	# Actual Photos	# Non-Target Species	Total # Bears	Total # Marked	Total # Unmarked	# Photos Censored ^a
Bluecat	30	560	140	134 (96%)	67 (50%)	67 (50%)	38 (57%)	28 (42%)	1 (2%)
Panther Lake	17	434	112	84 (75%)	77 (92%)	7 (8%)	5 (71%)	2 (29%)	0
Wade Bayou	18	486	126	82 (65%)	73 (89%)	9 (11%)	2 (22%)	7 (78%)	0
Brownie	21	563	144	91 (63%)	50 (55%)	41 (45%)	11 (27%)	27 (66%)	3 (7%)
Carson Woods	4	110	28	20 (71%)	20 (100%)	0	0	0	0
Panther Lake Drain	1	31	8	3 (38%)	3 (100%)	0	0	0	0
Total	91	2184	558	414 (74%)	144 (35%)	124 (30%)	56 (45%)	64 (52%)	4 (3%)

^a Mark status of the bear was undistinguishable

Table 7. Black bear population estimates, Deltic study area, northeast Louisiana, 1997-1998.

Year	Model	Population Estimate	95% Confidence Interval
1997	Bailey's Binomial	70	27 – 113
	Minta – Mangel	72	53 – 99
	Bowden Estimator	58	24 – 133
	Jolly Seber Model A	24	4 – 44
	Jolly Seber Model B	56	12 – 99
1998	Bailey's Binomial	47	38 – 57
	Minta – Mangel	45	35 – 67
	Bowden Estimator	43	27 – 69
	Jolly Seber Model A	47	2 – 93
	Jolly Seber Model B	28	18 – 38

analysis. Thirteen (62%) of the 21 marked bears were observed on 53 occasions in resight photographs. Deltic's estimated population size using Bailey's Binomial Model in 1998 was 47 bears (95% CI = 38 – 57).

Minta - Mangel Model

Of the 4 bears resighted 7 times on Deltic in 1997, bears F317, F375, F311 were all sighted 1 time, and bear M263 was sighted 4 times. I censored 5 of the 69 photographs taken because I was unable to determine the mark status of the bear. In 1997 the Deltic population estimate using the Minta-Mangel model was 72 bears (95% CI = 53 – 99).

Of the 13 bears resighted 53 times on Deltic in 1998, bears F375, and M213 were both sighted 1 time, bears F371, M263, F200, and M122 were all sighted 2 times, bears F317, F314, and M190 were all sighted 3 times, bear F128 was sighted 4 times, bear M360 was sighted 5 times, bear F308 was sighted 7 times, and bear M274 was sighted 18 times. I censored 4 of the 123 bear photographs taken because I was unable to determine the mark status of the bear. In 1998, population size on Deltic using the Minta-Mangel Model was estimated to be 45 bears (95% CI = 35 – 67).

Bowden Estimator

This model used the same resight data listed used in the Minta-Mangel model above. In 1997 the estimate was 58 (90% CI = 24 – 133). In 1998, the Bowden Estimator produced an estimate of 43 bears (90% CI = 27 – 69).

Jolly-Seber Model

Models A, A', B, and D calculated population estimates for the Deltic study area. However, chi-square goodness-of-fit tests revealed that models A and B were most appropriate. Model D was least acceptable ($p = 0.05$) followed by model A' ($p = 0.12$).

Estimated population size from model A for 1998 was 47 bears (95% CI = 2 – 93) whereas model B was 21 bears (95% CI = 14 – 28). Both models depicted a gradual increase of bears since 1990 (Table 8).

RADIO TELEMETRY

Locations

I collected 1,258 location estimates of 21 radio-collared bears (12F: 9M) (Table 9). However, I censored animals that lost their radiocollars or had <30 locations. Therefore, 17 bears (12F: 5M) met criteria to be used in home range analysis and 714 of the 1,258 locations collected were used.

Telemetry Error

For the 25 test-collars I located, the mean error was 105.6 m with a standard deviation of 90.2 m and a range of 10-280 m. Sixty-percent of the locations were within 100 m of the actual location.

Table 8. Population estimates from Jolly-Seber models for the Deltic study area, Tensas River Basin, northeast Louisiana, 1989-1998.

Year	Model A ^a		Model A' ^b		Model B ^c		Model D ^d	
	N	95% CI	N	95% CI	N	95% CI	N	95% CI
1989	--	--	52	30 – 75	8	6 – 11	10	5 – 15
1990	7	4 – 10	45	29 – 60	10	7 – 13	12	6 – 17
1992	8	5 – 12	38	32 – 44	14	10 – 18	16	9 – 22
1993	16	5 – 26	62	22 – 101	18	10 – 26	17	10 – 24
1994	14	6 – 23	41	25 – 57	23	14 – 32	24	15 – 34
1995	21	8 – 35	49	25 – 74	40	11 – 68	23	14 – 32
1997	24	4 – 44	31	18 – 44	56	12 – 99	33	21 – 45
1998	47	2 – 93	32	17 – 47	28	18 – 38	44	28 – 60

^aModel A allows survival and capture probabilities to vary

^bModel A' allows deletions but not additions

^cModel B assumes constant survival rates throughout the study

^dModel D assumes constant survival and capture probabilities throughout the study

Table 9. Monitoring period and number of telemetry locations of black bears, Deltaic study area, northeast Louisiana, 1997-1998.

ID #	Sex	Monitoring Period	# Locations	# Independent Locations
122	M	29-Aug-98 to 10-Dec-98	30	19
124	F	01-Jun-98 to 09-Dec-98	63	39
128	F	12-Jun-98 to 09-Dec-98	66	41
184	F	24-Aug-97 to 10-Dec-97	56	31
190	M	23-Aug-98 to 24 Aug-98	2	---
200	F	18-Aug-97 to 10-Dec-98	121	73
213	M	17-Jun-98 to 15-Aug-98	17	9
226	M	23-Aug-98 to 08-Dec-98	23	---
258	M	01-Sep-97 to 21-Nov-98	52	31
260	M	25-Jun-97 to 29-Oct-97	72	47
263	M	06-Sep-97 to 02-Dec-98	80	48
264	M	01-Jun-98 to 14-Jun-98	6	---
267	F	14-Jun-98 to 09 Dec-98	59	35
268	M	02-Jun-98 to 10-Dec-98	48	35
274	M	25-May-98 to 09-Dec-98	69	45
301	F	17-Aug-98 to 09 Dec-98	38	30
307	F	13-Jun-98 to 09-Dec-98	64	39
317	F	27-May-98 to 09-Dec-98	73	41
319	F	15-Sep-98 to 09 Dec-98	101	67

Table 9. (continued)

ID #	Sex	Monitoring Period	# Locations	# Independent Locations
360	M	25-May-98 to 09-Dec-98	44	16
362	M	04-Aug-98 to 07-Dec-98	27	18
371	F	28-Jul-98 to 10-Dec-98	37	31
375	F	14-Jun-98 to 09-Dec-98	63	44

Home-Range Size

Annual home range size was different by sex. The average 95% minimum convex polygon annual home range size was 7.0 km² for males ($n = 5$) (Fig. 11) and 4.2 km² for females ($n = 12$) (Fig. 12). The 95% adaptive kernel and harmonic mean methods provided average male home ranges of 12.6 km² and 8.1 km² and average female home ranges of 7.1 km² and 4.8 km², respectively (Table 10).

Home-Range Overlap

Home range overlap was observed among females ($n = 12$) and males ($n = 4$), particularly in the Bluecat tract. I documented 26 different bears using the Bluecat tract (including cubs). All female bears in Bluecat that were used for home-range analysis ($n = 9$) exhibited extensive overlap (Table 11). Each female's home range overlapped with at least 6 other female home ranges. When overlap did occur, it ranged from <1 to 100% with 27 of 46 overlaps being over $\geq 50\%$. The most extensive overlap was observed from bear F128. Her home range overlapped with 8 other female home ranges and averaged 52% overlap (range 24 – 100%). The least extensive overlap was observed from bear F162 whose home range overlapped with 5 other female home ranges and averaged 11% (range 1 – 41%). However, the core of her home range was the Carson Woods tract; Bluecat comprised only 4% of her home range. In the Brownie tract, 2 female home range overlapped an average of 50% (range 42 – 59%). Overlap also was observed among male home ranges; it was greater than reported because 7 male home ranges were not presented due to low sample sizes. Of these 7, B122 used the Wade

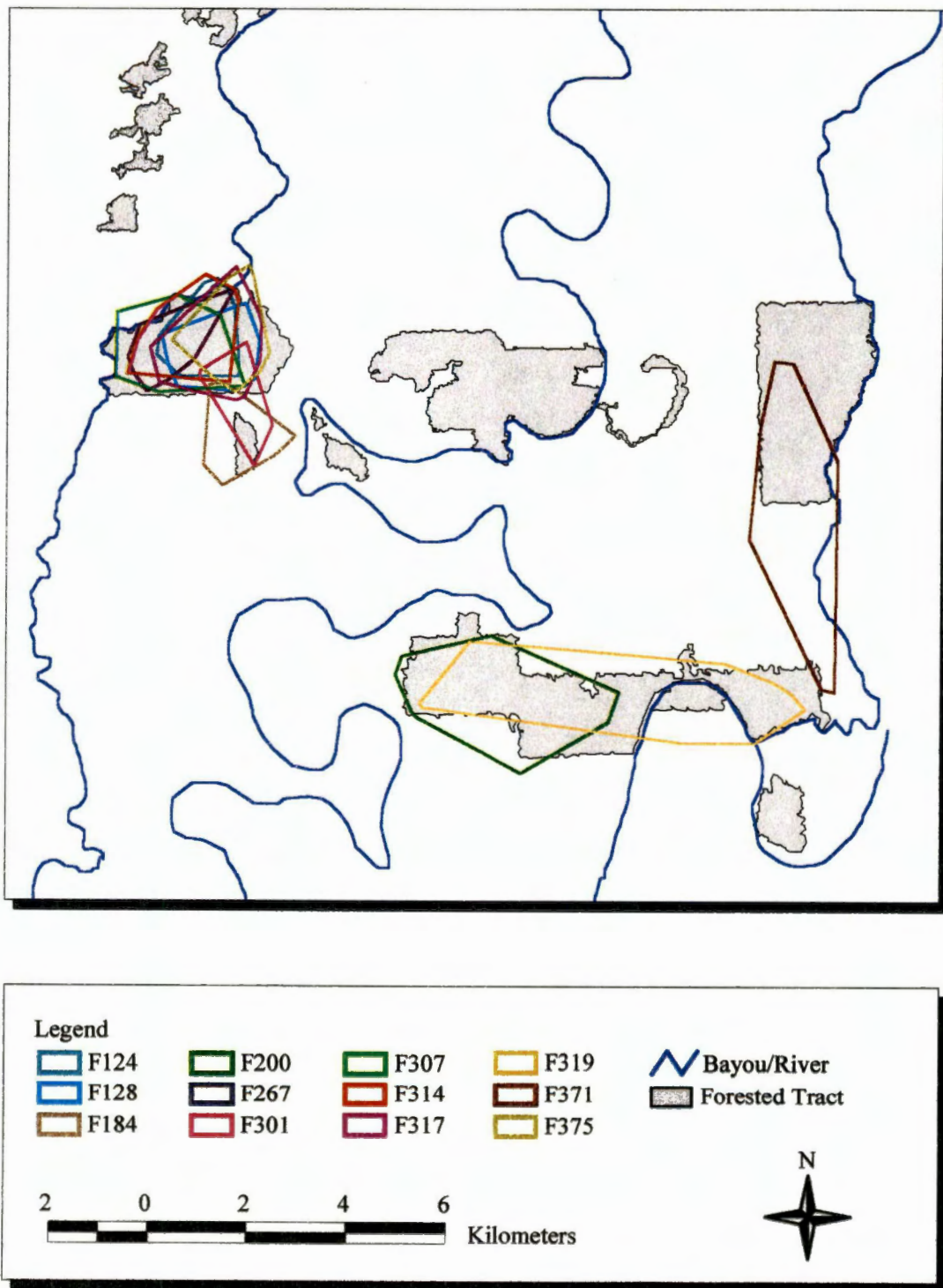


Fig. 11. Annual 95% minimum convex polygon home ranges of female black bears, Deltic study area, Northeast Louisiana, 1997-1998.

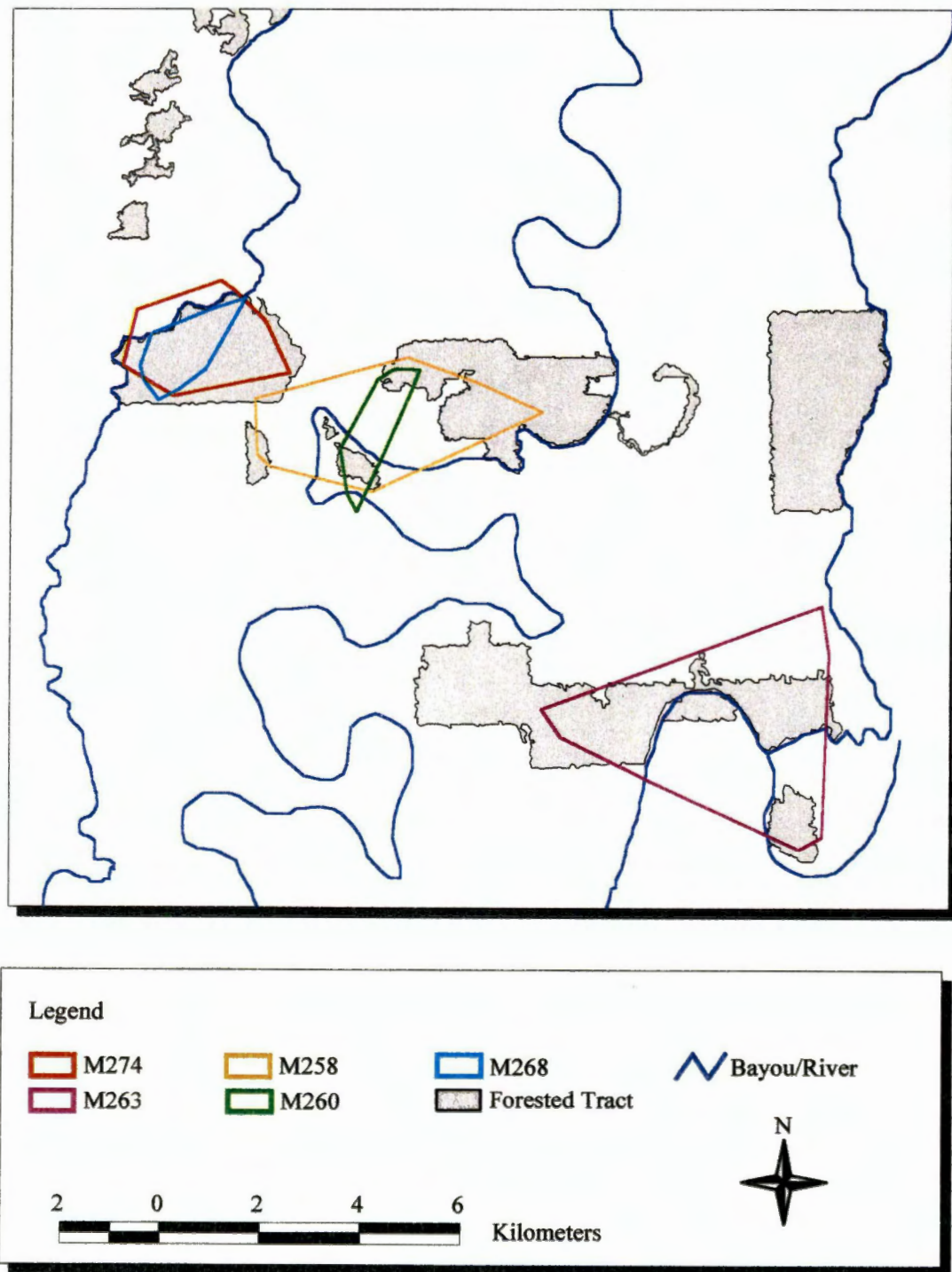


Fig. 12. Annual 95% minimum convex polygon home ranges of male black bears, Deltic study area, Northeast Louisiana, 1997-1998.

Table 10 . Annual home ranges of black bears using the adaptive kernel (AK), harmonic mean (HM), and minimum convex polygon (MCP) methods, Deltic study area, northeast Louisiana, 1997-1998

Bear #	Sex	# Locations	AK 95%	AK 75%	AK 50%	HM 95%	HM 75%	HM 50%	MCP 95%	MCP 75%	MCP 50%
124	F	39	3.1	1.6	0.6	2.0	0.9	0.3	2.3	1.4	0.4
128	F	41	3.7	1.7	0.9	2.3	1.1	0.5	2.5	1.6	0.7
184	F	31	4.0	1.3	0.6	1.5	0.6	0.2	2.2	0.8	0.3
200	F	73	12.4	4.5	2.3	8.5	4.2	1.7	7.5	5.7	3.9
268	F	35	4.5	1.4	0.5	1.9	0.8	0.2	2.0	0.9	0.2
301	F	30	3.0	1.2	0.4	1.1	0.6	0.2	1.8	0.9	0.3
307	F	39	6.5	2.6	0.8	3.1	1.4	0.4	3.8	2.1	0.8
314	F	39	5.1	1.8	0.4	3.1	1.2	0.3	3.3	1.1	0.2
317	F	41	4.4	3.2	1.4	2.5	1.6	0.6	3.8	2.7	1.6
319	F	67	18.2	7.1	2.9	21.2	5.2	2.3	10.6	4.4	2.0
371	F	31	15.8	5.8	2.4	7.5	2.3	1.2	7.7	2.1	0.7
375	F	44	4.6	1.9	1.0	3.2	1.4	0.5	2.8	1.8	0.8
Average female home range			7.1	2.8	1.3	4.8	1.8	0.7	4.2	2.1	1.0
258	M	31	14.9	5.0	1.7	7.2	2.3	1.1	9.4	3.2	0.9
260	M	47	4.1	1.2	0.4	3.5	0.8	0.3	1.9	1.0	0.5
263	M	48	27.0	7.5	2.3	19.9	6.9	1.8	15.6	5.0	1.1
268	M	35	4.5	1.4	0.5	1.9	0.9	0.2	2.0	0.9	0.2
274	M	45	11.5	4.5	0.9	7.0	2.9	0.9	5.0	1.6	0.8
Average male home range			12.6	4.1	1.3	8.1	2.9	1.0	7.0	2.5	0.8

Table 11. Annual home range overlap (percent) of females residing in the Bluecat tract, Deltic study area, northeast Louisiana, 1997-1998.

Bear #	Overlap (%) With Bear #									Average %
	124	128	162	267	301	308	314	318	375	
124		70	0	52	13	74	70	91	33	50
128	64		24	28	28	68	64	100	42	52
162	0	27		0	41	1	0	9	12	11
267	60	35	0		0	90	90	65	13	44
301	17	39	50	0		22	11	44	13	25
308	45	45	<1	47	1		68	58	27	36
314	48	48	0	55	6	79		70	33	42
318	55	66	5	34	21	58	61		56	45
375	33	42	<1	13	13	27	33	56		27

Bayou, Panther Lake and Brownie tracts, B264 used Bluecat, Panther Lake, and Brownie, B213 used Bluecat and the Lodge Lake Woods, B360 used Bluecat and Brownie, B362 used Bluecat and Carson Woods, and B190 remained in Brownie.

Movements Between Isolated Forested Tracts

From June 1997 to December 1998, 11 bears (8M, 3F) were documented moving between isolated woodlots on 81 occasions (Table 12). However, female movements between tracts did not occur unless the woodlots were connected with a forested corridor or the distance between woodlots was < 0.5 km.

I also recorded 28 observations of male ($n = 7$) and female ($n = 2$) bears in forested corridors. Twenty-three (82%) of these were made by male bears. Corridor locations were obtained along the Tensas Bayou ($n = 10$), Joe's Bayou ($n = 7$), Bayou Macon ($n = 4$), and Island Chute ($n = 6$) waterways. The corridors on Deltic had an average length of 6.2 km long, and had an average width of 66 m of vegetation on both sides (Anderson 1997).

Dispersal of Juveniles

I radiocollared 8 yearling black bears (5M: 3F) on the Deltic tracts. All female yearlings (F308, F311, and F317) remained in the tract of capture (Bluecat). Of the 5 males, 4 (M258, M260, M264, M360) dispersed to tracts other than the tract of capture. Bear M274 was the only yearling male that did not disperse from the capture location (Bluecat).

Table 12. Movements of radiocollared black bears between isolated forested tracts, Deltaic study area, Tensas River Basin, northeast Louisiana, 1997-1998.

Bear ID	Date	Movement Between Fragmented Tracts	Corridor Connection
M122	16-Sep-98	Wade Bayou to Panther Lake	Yes
	18-Sep-98	Panther Lake to Talla Bena South	Yes
	23-Sep-98	Talla Bena South to Brownie	Yes
	25-Sep-98	Brownie to Panther Lake	Yes
	05-Oct-98	Panther Lake to Brownie	Yes
	08-Oct-98	Brownie to Wade Bayou	No
	10-Oct-98	Wade Bayou to Bozeman	Yes
	15-Oct-98	Bozeman to Panther Lake	No
	27-Oct-98	Panther Lake to Wade Bayou	Yes
	16-Nov-98	Wade Bayou to Panther Lake	Yes
	26-Nov-98	Panther Lake to Wade Bayou	Yes
	01-Dec-98	Wade Bayou to Panther Lake	Yes
F124	None		
F128	21-Aug-98	Bluecat to Carson Woods	No ^a
	28-Aug-98	Carson Woods to Bluecat	No ^a
F184	11-Aug-97	Carson Woods to Bluecat	No ^a
	14-Aug-97	Bluecat to Carson Woods	No ^a
	16-Oct-98	Carson Woods to Bluecat	No ^a
	19-Oct-97	Bluecat to Carson Woods	No ^a
	27-Oct-97	Carson Woods to Bluecat	No ^a
	03-Nov-97	Bluecat to Carson Woods	No ^a
	01-Dec-97	Carson Woods to Bluecat	No ^a
M190	None		
F200	None		

Table 12. (continued)

Bear ID	Date	Movement Between Fragmented Tracts	Corridor Connection
M213	18-Jun-98	Bluecat to Lodge Lakes	Yes
	21-Jun-98	Lodge Lakes to Bluecat	Yes
M258	05-Sep-97	Bluecat to Bozeman	No
	16-Sep-97	Bozeman to Carson Woods	No
	21-Sep-97	Carson Woods to Wade Bayou	No
	25-Sep-97	Wade Bayou to Bozeman	Yes
	26-Sep-97	Bozeman to Wade Bayou	Yes
	30-Sep-97	Wade Bayou to Bozeman	Yes
	07-Oct-97	Bozeman to Lodge Lakes	Yes
	08-Oct-97	Lodge Lakes to Carson Woods	No
	13-Oct-97	Carson Woods to Bozeman	No
	29-Oct-97	Bozeman to Bluecat	No
	31-Oct-97	Bluecat to Carson Woods	No ^a
	02-Nov-97	Carson Woods to Bozeman	No
	05-Nov-97	Bozeman to Wade Bayou	Yes
	07-Nov-97	Wade Bayou to Bozeman	Yes
	11-Nov-97	Bozeman to Wade Bayou	Yes
	20-Nov-97	Wade Bayou to Brownie	No
M260	30-Jun-97	Wade Bayou to Bozeman	Yes
	15-Aug-97	Bozeman to Wade Bayou	Yes
	25-Aug-97	Wade Bayou to Bozeman	Yes
	27-Aug-97	Bozeman to Wade Bayou	Yes
M263	01-Oct-97	Brownie to Talla Bena South	Yes
	03-Oct-97	Talla Bena South to Brownie	Yes
M264	09-Jun-98	Bluecat to Bozeman	No
	14-Jun-98	Bozeman to Brownie	No

Table 12. (continued)

Bear ID	Date	Movement Between Fragmented Tracts	Corridor Connection
M268	05-Jul-98	Bluecat to Wade Bayou	No
	16-Sep-98	Wade Bayou to Talla Bena South	No
	03-Oct-98	Talla Bena South to Brownie	Yes
	20-Oct-98	Brownie to Wade Bayou	No
	21-Oct-98	Wade Bayou to Brownie	No
	06-Nov-97	Brownie to Wade Bayou	No
	16-Nov-98	Wade Bayou to Brownie	No
M274	None		
F301	25-Sep-98	Bluecat to Carson Woods	No ^a
	10-Oct-98	Carson Woods to Bluecat	No ^a
	25-Oct-98	Bluecat to Carson Woods	No ^a
	01-Nov-98	Carson Woods to Bluecat	No ^a
	06-Nov-98	Bluecat to Carson Woods	No ^a
	10-Nov-98	Carson Woods to Bluecat	No ^a
	11-Nov-98	Bluecat to Carson Woods	No ^a
	16-Nov-98	Carson Woods to Bluecat	No ^a
	19-Nov-98	Bluecat to Carson Woods	No ^a
	05-Dec-98	Carson Woods to Bluecat	No ^a
F308	None		
F311	None		
F314	None		
F317	None		
F319	None		

Table 12. (continued)

Bear ID	Date	Movement Between Fragmented Tracts	Corridor Connection
M360	16-Sep-98	Bluecat to Panther Lake	No
	21-Sep-98	Panther Lake to Brownie	Yes
	16-Oct-98	Brownie to Panther Lake	Yes
	07-Oct-98	Panther Lake to Brownie	Yes
	18-Oct-98	Brownie to Panther Lake	Yes
	29-Oct-98	Panther Lake to Brownie	Yes
	06-Nov-98	Brownie to Panther Lake	Yes
M362	08-Sep-98	Bluecat to Carson Woods	No ^a
	16-Sep-98	Carson Woods to Bluecat	No ^a
	18-Sep-98	Bluecat to Carson Woods	No ^a
	10-Oct-98	Carson Woods to Bluecat	No ^a
	15-Oct-98	Bluecat to Carson Woods	No ^a
	18-Oct-98	Carson Woods to Bluecat	No ^a
	25-Oct-98	Bluecat to Carson Woods	No ^a
	03-Nov-98	Carson Woods to Bluecat	No ^a
F371	31-Oct-98	Panther Lake to Brownie	Yes
	06-Nov-98	Brownie to Panther Lake	Yes
F375	None		

^aDistance between woodlots was less than 0.5 km

In 1997, 2 male yearlings dispersed from their tract of capture and both were killed. Bear M260 left Wade Bayou in late May and dispersed to the Bozeman tract where he remained until mid-August. He then returned to Wade Bayou and on 29 October 1997 I found evidence that bear M260 had been poached. Bear M258 left Bluecat in early September and spent the remainder of the month moving among 3 tracts (Bozeman, Wade Bayou, and Carson Woods). On 7 October, he dispersed to the Lodge Lakes area just north of Bluecat and then on 9 October he moved to Bozeman tract where he remained for the rest of the month. In November he visited the Carson Woods, Bozeman, Wade Bayou, and Brownie tracts. On 21 November bear M258 was killed on Highway 80 after being struck by a vehicle.

In 1998, 2 male yearlings captured in Bluecat dispersed to other tracts. Bear M360 left Bluecat in late June and dispersed to the Panther Lake tract. He remained in the Panther Lake vicinity until mid-September making several excursions to the Bear Lake area, just east of Panther Lake. Between late September and early November he made numerous trips between the Panther Lake and Brownie tracts and from mid-November through mid December, when the study ended, he remained in the Panther Lake tract. Bear M264 left Bluecat in early June and dispersed to the Brownie tract. Radio transmission was lost in mid-June.

Since 1992, 12 yearlings have been radiocollared and their movements monitored. Marchinton (1994) documented the dispersal of 1 bear (M182) from Bluecat to the Lodge Lakes Area and the Brownie tract. Bear M182 was later captured in 1994 in Panther Lake Drain, a small corridor connecting the Panther Lake and Wade Bayou

tracts, and subsequent radiotracking suggested that bear M182 did not return to the Bluecat tract (Anderson 1997). Anderson (1997) documented the dispersal of 3 bears (M210, M228, and M230) from Bluecat. He noted that after dispersing, bear M230 spent the winter in Wade Bayou, then moved to the Brownie tract in spring while M228 spent the winter in the Brownie tract and in spring returned to Bluecat. In the current study, both bears (bears M228 and M230) were recaptured in the Bluecat and Brownie tracts, respectively. Telemetry data in this study revealed that bear M230 continued to centralize his movements in Brownie. He made several short distance movements from Brownie to the Panther Lake tract and Talla Bena South woods, both connected by a wooded corridor. This suggests that bear M230 has settled into Brownie, also making his movements a true dispersal. However, bear M228 was captured and subsequently monitored in the Bluecat tract which suggests that bear M228 still resides in Bluecat and did not disperse from his natal tract.

NATALITY AND MORTALITY

Natality and Cub Survival

During this study 8 radiocollared bears and 1 free-ranging bear were observed with litters totaling 16 cubs (Table 13). Bear F162 lost a cub between 28 July and 05 August 1997. This bear also lost 2 cubs in 1996 (D. Anderson, USFWS, personal communication.). In both years the fate of the cubs was unknown. During winter 1997-1998, bear F162 produced 2 female cubs, making this the third consecutive year of cub production. This bear was later translocated by USFWS to TRNWR and only one cub is

Table 13. Natality, survival of cubs, and den type for 12 female black bears, Deltic study area, Tensas River Basin, northeast Louisiana, winters 1997 - 1999.

Bear #	# Cubs	Den Type	Survival / Comments
124	≥1	Tree	Not seen but cries heard during den visit
128	≥1	Ground	Not seen but cries heard during den visit
162	1 in 1997 2 in 1998	Ground Ground	cub died of unknown causes 1 cub dead after relocation to TRNWR
200	N/A	Tree	Not seen and no cries heard during den visit
301	1	Ground	Cub died after relocation to TRNWR
308	0	Ground	Yearling, seen in resight data in late fall
314	2 yearlings	Ground	All bears seen together in resight data in late fall
317	0	Ground	Yearling, seen in resight data in late fall
319	2	Tree	Also observed as yearlings in June still traveling with marked female
371	1	Unknown	Cub seen at capture and both seen in resight data in late fall
375	2 yearlings	Ground	Cubs not seen at capture
Unmarked	3	Unknown	Cub capture (F311), 2 additional cubs and adult female seen at trap site

confirmed to have survived. Bear F301 produced 1 male cub, which also died after translocation to TRNWR (D. Anderson, USFWS, personal communication).

Mortality

Since 1992, 8 bears (6 confirmed) have been reported as being killed by vehicle collisions on the Deltic study area. On 23 November 1997, a radiocollared yearling male (M258) was killed by a vehicle on Highway 80 on the Tendal bridge, just south of the Brownie tract. The Tensas River/Bayou makes a direct path from the Brownie tract to the Tendal bridge. It is likely that bear M258 used this riparian zone as a travel corridor. In July 1999 an adult male (M210) was killed in a vehicle collision on Highway 17. The bear had moved between the study area and isolated woodlots in the Big Creek - Holly Ridge area of Richland Parish.

A yearling male (M260) was poached around 29 October 1997. Project personnel found the radiocollar the bear was wearing along the west side of the Wade Bayou tract, approximately 2 m from the woodedge. The collar showed obvious sign of human tampering; the collar was cut with a knife, and the self-locking nuts that held the collar together were removed.

CHAPTER V

DISCUSSION

POPULATION ESTIMATION

Model Assumptions

Population size is an integral component of wildlife management, especially when the species is threatened or endangered. Because a census often cannot be accomplished, an estimate of the population size is derived by sampling and incorporating those data into a population model. When estimating animal populations, it is important to minimize model violations to reduce bias and increase precision (Pollock et al. 1990).

Population closure is a difficult model assumption to overcome or detect because bears have large home ranges and can disperse long distances in short time periods. However, with the level of fragmentation on the Deltic study area and of surrounding areas, it is likely that the closure assumption was met with a minimal amount of bias. The Deltic study area can be regarded as an “island” habitat surrounded by agriculture. Therefore, I assumed that immigration and emigration was negligible. No births took place during the sample and, because this population was protected, the chance of death was assumed to be equal among marked and unmarked animals. All 3 closed capture-resight models used in this study produced within-year population estimates for 1997 and 1998. Therefore, closure was assumed for a period of only 7 months each year.

Differences in capture probabilities due to individual heterogeneity and trap response are potential sources of bias in population studies. Heterogeneity due to social status, sex, and age is unlikely to be overcome because of the inherent characteristics of black bears. However, Seber (1982) and Pollock et al. (1990) report the effects of heterogeneity can be reduced by incorporating different capture techniques such as a capture-resight technique. Another way to reduce bias due to heterogeneity would be to calculate separate population estimates by sex and age groups (Pollock et al. 1990). However, this is not possible with small populations (Pollock et al. 1990). In this study I grouped sex and age classes to increase sample sizes. It is unlikely that the population estimate was greatly influenced because sex ratios of captured bears were equal and home ranges were comparable between sexes and among age classes. An increase in capture probability makes capture-recapture models more robust to model violations (Pollock et al. 1990).

Trap response bias likely occurred during this study. Pollock et al. (1990) defined trap response as variation in the probability of capture, in any sample, because of the animal's prior capture history. The Deltic bear population has been studied since 1988. This, coupled with the small population size and limited available habitat, probably contributed to some negative trap response. Because black bears have a great capacity for learning, some bears in the Deltic population likely learned to avoid capture, or become "trap smart".

To reduce the possible effects of trap response bias, I incorporated several capture techniques into the sampling design. A population estimate would not be

accurate if all animals in the population did not have the opportunity to be captured. Therefore, intensive trapping throughout the course of this study was a priority because I wanted to increase the probability that a bear would encounter a trap. I based my trap placement on average female home ranges from previous studies done on the Deltic study area so that numerous traps were placed within any given bears home range. I also altered the physical appearance of traps. Past research studies on Deltic used mostly trees to secure foot snares used at a trap site. I used trailer pins to secure the foot snare at 74% of the trap sites (all traps in 1998). The use of trailer pins allowed me to trap in areas that a bear may not associate with a typical trapset (i.e., a tree, bait, and a well-defined opening on 1 side of the tree). I also installed more than 1 snare at sites that were visited by a bear on more than 2 occasions without a capture. I left the newly installed snare unbaited in case a bear associated bait with a trap site. The second trap was placed at a distance so that 2 captured bears would not be able to injure each other.

Finally, I incorporated a resight technique as a secondary form of capture in the “recapture” phase of the study. The resight models used different sampling techniques for the 2 samples (capture-resight vs capture-recapture), which reduced the likelihood of trap response and effects of heterogeneity (Seber 1982). Because bears were attracted to the camera stations with bait, the second sample (cameras) may not have been completely independent of the first (snares). However, Pedersen (1995) studied the effects of temporal factors on trap response and concluded that “trap-wise” bears would not significantly affect the equal capture probability assumption when sampling periods were adequate in length and changes were made to trapsets during the sampling period.

Population Estimate and Density

Using the mid-range population estimates derived from the 3 within-year estimators, I indicated a black bear density of 1.43 bears/km² of forested land. As such, the Deltic population is the most dense population of black bears reported in the southeastern coastal plain (Table 14), and possibly throughout the species range. However, black bear abundance is low. Black bear density on the Deltic study area likely cannot be extrapolated to any other areas of occupied bear habitat in Louisiana or elsewhere. Deltic presents a unique situation in that the large expanses of agricultural crops were frequently used by bears, which likely increased the carrying capacity in the area. Anderson (1997) reported that 49% of the annual diet of black bears on Deltic consisted of agricultural crops (corn, wheat, and oats). Also, the Deltic tracts were heavily managed for timber, promoting a thick understory and ample soft mast food supply, especially in the Bluecat tract. Finally, the only notable disturbance on Deltic, other than occasional timber harvest, came during the hunting season. Therefore, human disturbance was relatively predictable and because hunters used ATVs for access, encounters were avoidable. Studies on Florida panthers indicated that predictable human disturbance may be compatible with endangered species management (Janis 1999). Most of the forested woodlots on the Deltic study area were gated to insure no uninvited guests hunted the woodlots. Approximately 75 people hunted the Deltic tracts at various times.

Table 14. Population densities and female survival rates of black bears in the southeastern coastal plain.

Locality	Bears / Km ²	Female Survival	Reference
Deltic, Tensas River Basin, Louisiana	1.43	1.00	This study
White River NWR, Arkansas	0.29	0.95 ^a	Smith 1985
White Rock, Arkansas	0.08	n/a	Clark 1991
Dry Creek, Arkansas	0.09	n/a	Clark 1991
Southeastern Georgia	0.34	n/a	Abler 1985
Gum Swamp, North Carolina	1.35	0.83	Martorello 1998
Big Pocosin, North Carolina	0.53	1.00	Martorello 1998
Camp Lejeune MCB, North Carolina	.02	0.71	Brandenburg 1996
Alligator River NWR, North Carolina	0.86	n/a	Allen 1999
Great Dismal Swamp, North Carolina-Virginia	0.58	0.84	Hellgren and Vaughan 1989

^a Male and female survival rate

RADIO TELEMTERY

Home Range Size and Overlap

The home range sizes reported in this study are small for black bears. The average home range size for males was likely affected by low sample sizes. If all 12 male home ranges had adequate sample sizes for analysis, the average size would have increased and likely reflected those reported by Marchinton (1995) and Anderson (1997). Home range size and shape are influenced by factors such as age, sex, habitat quality, and population density (Pelton 1982). It is likely that home range size on the Deltic study area was also influenced by the shape of the forested tracts.

I documented a minimum of 26 different black bears using the 6.4-km² Bluecat tract and Anderson (1997) recorded 30 bears using the Bluecat tract (both studies included cubs). The high degree of home range overlap I observed is likely related to the abundant agricultural food resources in areas adjacent to the forested tracts. Nonetheless, some competition for available resources may occur. Should the situation be compounded by a decrease in agricultural resources or an increase in population size it is unknown how this population would respond. Density-independent factors such as nutritional responses to a decrease in available food resources may result in delayed maturity in females, less frequent reproduction, or smaller litter sizes (Garshelis 1994). Density-dependent factors such as social regulation may result in breeding aggression, which is typically expressed by dominant males either killing cubs or becoming involved in competitive battles with other bears for breeding rights, and could also result in competition for space when defending high-value food sources (Garshelis 1994).

However, I did not directly observe either of these forces occurring in this population. The tolerance among individuals may be influenced by high-quality agricultural food items that are available throughout the summer and into the fall season. These circumstances may resemble the modified social behavior observed in brown bear (*Ursus arctos*) populations when salmon resources become abundant (Egbert and Stokes 1974). Another possible explanation for social tolerance may be a high degree of inter-relatedness among individuals within this population. However, no genealogical evidence is yet available to test this hypothesis.

Movements Between Isolated Forested Tracts

In this study, males made most of the movements between forested tracts. Most female bears were confined to a single forested tract. Thus, males seemed less affected by the fragmentation of the forested tracts on Deltic. Bears used forested riparian areas as corridors to move between isolated tracts of bottomland hardwood forests. Beier and Noss (1998) defined a corridor as “a linear habitat, embedded in a dissimilar matrix, that connects two or more larger blocks of habitat and that is proposed for conservation on the grounds that it will enhance or maintain the viability of specific wildlife populations in the habitat blocks”. The value of corridors has been debated in the literature because there is little evidence that animals actually disperse along corridors at higher rates than they do outside of corridors (Simberloff et al. 1992). However, Anderson (1997) suggested that corridors were an important habitat feature. Radiocollared bears traveled further away from forested tracts and were located in corridors more than expected in

proportion to occurrence in comparison to agricultural fields, which were a major food source (Anderson 1997). The observations made in this study corroborated the results of Anderson (1997), thus demonstrating the importance of corridors for this population. It is likely that corridors also were important for bears because they increased the available forested habitat by approximately 5%. Nonetheless, as human encroachment continues and land use changes, resources such as food, escape cover, and den sites may become more limited in the future.

Dispersal of Juveniles

Yearling dispersal is an important element of bear population dynamics and may influence a population's stability and its ability to increase (Garshelis 1994). In this study, 4 of the 5 radio-collared yearlings dispersed to other isolated forested tracts. These observations suggest that there is potential for population expansion if habitat was available or connected. Jonkel and Cowan (1971) speculated that juvenile dispersal may be correlated with population regulation (i.e, adult males are likely to discourage immigration and may encourage emigration). If so, this may explain why all dispersal was from an area with a high-concentration of bears to one that was lower. However, because of the relatively short-term nature of this study, some movements classified as dispersal may be only temporary movements. Because of the fragmented habitat on Deltec and the vagile nature of bears in general, dispersing juveniles will be vulnerable to mortality. Only 1 juvenile has been documented as successfully dispersing away from the

Deltic study area (Anderson 1997). In this study, 2 of the 4 dispersals resulted in mortality.

CHAPTER VI

MANAGEMENT IMPLICATIONS

POPULATION CONCERNS

Although the estimated density of bears on the Deltic study area is the highest reported in the Southeast, population abundance is low. To fully understand this population's dynamics, managers need long-term population data collected with standardized methodologies. A 2-year study on a single population is only a "snapshot in time" and provides little information about year-to-year variability. If management plans include conservation of this population, I recommend that wildlife managers continue to monitor the Deltic population. Perhaps the results of this study were acquired when all conditions were favorable and bear numbers were higher than normal. Successful conservation will depend on accurate long-term population monitoring programs and ongoing monitoring of habitat and human use.

Considering the Louisiana black bear is listed as Threatened on the Endangered Species List, connecting the Deltic and TRNWR populations may be a priority for state and federal agencies. Kennedy (1989) reported that a connection between Louisiana bear populations is necessary for long-term preservation. Only 4 km separates the Deltic and TRNWR populations. However, for exchange to occur, bears must cross Interstate 20, Highway 80, and railroad tracks that separate the 2 areas. The lack of frequent exchanges between the Deltic and TRNWR populations suggests that roads with high

traffic volume may be a hindrance to bear movements. In my study, bears moved between isolated forest tracts for distances greater than the distance separating the Deltic and TRNWR populations. Given the dispersal ability of the species, management efforts to encourage such movements through corridor development will likely be beneficial.

All bear studies on Deltic since 1988 have shown that corridors are important habitat features. Anderson (1997) showed that bears preferred wooded corridors over agricultural fields when outside a forested tract and that movement in corridors were further from forested tracts than in agricultural fields. Considering the extreme habitat fragmentation on Deltic, corridor protection, management, and construction is important. Although corridor parameters that would likely facilitate black bear movements have not been defined, the structure of the corridors already in place on Deltic may be used as a general standard. However, unless corridors are wide enough for interior protection, they may be influenced or even dominated by external forces (i.e., wind damage, nutrient deposition, herbicides, pesticides, weeds, predation) (Hobbs et al. 1990).

The use of highway underpasses to reduce vehicle-related mortality and habitat fragmentation is a management technique that is gaining attention (Waters 1988, Foster and Humphrey 1995, Land and Lotz 1996). Waters (1988) reported that black bears, wolves (*Canis lupus*), and coyotes (*Canis latrans*) crossed a fenced segment of the Trans-Canada Highway at will but used underpasses where they were convenient. In Florida, Foster and Humphrey (1995) documented large mammals, such as black bears and Florida panthers, using highway underpasses for travel. They inferred that the

underpasses effectively reduced mortality for some species while linking critical habitat, thus reducing the effects of fragmentation.

Harris (1984) recommended using existing river systems to establish connectivity between fragmented populations. On the Deltic study area, several river systems already have the potential to act as corridors and facilitate movement between the Tensas River Basin populations. These rivers travel under the existing roads (Interstate 20 and Highway 80) and railroad and may act as underpasses. Where the Tensas River crosses under Interstate 20 and Highway 80 is one such area. This area has been identified by the USFWS as a potential travel corridor and preliminary plans include widening it through reforestation. At the conclusion of this study, however, no definite plans had been made for plan execution. Other river systems such as Joe's Bayou and Bayou Macon could also perform a similar function.

Connecting the Deltic population with that of TRNWR may be an effective measure to conserve this small population. More ambitious efforts could include construction of corridors to the east of both Deltic and TRNWR, which would provide passage to the Mississippi River corridor and increase the likelihood of connection with White River National Wildlife Refuge to the north and the Atchafalaya River Basin to the south. An adult male bear captured on TRNWR in 1993 had eartags from an Arkansas study suggesting that this corridor may have the potential to offer the protective cover needed for dispersal to occur; however, it is uncertain that this was the definite route traveled. A Mississippi River connection also may encourage dispersal across the river

and into the state of Mississippi. Bears previously marked in Louisiana and Arkansas have been documented crossing the Mississippi River (Shropshire 1996).

Black bears on the Deltic study area have demonstrated the potential to increase their range. In the current study, an adult male was captured in the Holly Ridge-Big Creek area, just west of the study site. Personnel from USFWS also captured two adult males in the same vicinity in 1996 and 1997. It is important to note that all 3 bears were previously captured on the Deltic study area. Telemetry conducted in this study revealed several wooded areas in the vicinity of capture continued to be occupied by the remaining 2 radiocollared males. In fall 1998, a local sportsman who used an infrared camera unit to monitor deer activity, presented a picture of a female and cub in the Big Creek area. This evidence of reproduction suggests that protection of this habitat may be important.

The long-term viability of all isolated black bear populations in Louisiana, especially the Deltic population, likely will not be successful without management intervention. Although extensive land clearing has recently subsided in the Tensas River Basin, the amount of forest fragmentation has effectively created in an island-like setting. In 11 years of continuous research, only 1 subadult bear (M210) has been documented successfully dispersing from the Deltic to the TRNWR population (Anderson 1997); no other immigration or emigration has been documented between the 2 areas. However, some exchange from uncollared bears may occur. The theory of island biogeography (MacArthur and Wilson 1967) regarding issues of extinction and colonization on island habitats may be exemplified in the Tensas River Basin and can serve as a model for management on Deltic and TRNWR. This theory illustrated how smaller islands would

become extinct without supply from a mainland source. In this case, I suggest that the mainland source is TRNWR, which combined with Big Lake WMA, is tenfold in size compared to Deltic. Distance between the mainland and island populations is correlated with the rate of colonization of island habitats (MacArthur and Wilson 1967). The distance between the 2 areas mentioned in this study is not an issue of concern because only 4 km separates these populations. What is of concern is the barriers mentioned previously that limit dispersal. Without dispersal and successful exchange, population persistence and other aspects of metapopulation ecology (Hanski 1996) may be compromised and could result in local extinction of the Deltic population in the future. Therefore, if management plans are to address the issue of island biogeography, dispersal and exchange will likely need to be facilitated.

It is difficult to assess genetic integrity in a small black bear population. However, when speaking of an effective population size, Franklin (1980) recommends a minimum of 50 individuals for short-term survival and 500 individuals for long-term survival. Although the population estimate for the Deltic population was approximately 50 individuals, the effective population size is much different. If the age structure exhibited by my capture sample was indicative of the entire estimated population, then approximately 30% of the population would be excluded from the reproductive population, narrowing the effective size to 35. Most population geneticists agree that heterozygosity, or high genetic variation within populations, is positively correlated with fitness (Meffe and Carroll 1994). However, although genetics are important for

maintaining fitness and evolutionary potential, demographic aspects of the bear population on Deltic warrants a more immediate concern.

Because the bear population size within the Deltic tracts is estimated to be <100 individuals, the long-term viability of this population may be affected by forest management regimes. Any further reductions of forested habitat on Deltic would likely reduce the population and increase its susceptibility to stochastic events, inbreeding, and local extinction. Although not examined in this study, Deltic's management regime seems to have benefited bears on the study area. The selective cutting reduced long-term disturbance to bears, enhanced soft mast food production, and provided escape cover and ground denning sites. However, forest management appears to have recently intensified and more activity was noted in this study than in the past. Ideally, to minimize disturbance and accommodate bear movements in response to harvest activity, it may be beneficial to limit harvest activity by not cutting timber on 2 tracts concurrently, or, by not cutting a single tract in successive years, as Bluecat was in 1996 and 1997. Also, Deltic maintained small openings in the forest by disking, which encouraged the growth of early successional plant species that produce soft mast. They also planted fall foods such as oats and wheat to attract wildlife species like deer and waterfowl for hunting opportunities. These activities could be a valuable management technique as they may act as a buffer during poor mast crop years or during agricultural rotation years when corn may not be abundant.

Based on population estimates from the 2 Jolly-Seber models, the Deltic bear population appears to have increased since 1990. This increase may have been influenced

by the amount of agricultural grain crops, particularly corn, immediately surrounding these isolated forest tracts. In the 4 study area parishes, the average annual increase of from 1990-1998 was 56%, and in Madison parish alone there was a 41% increase. However, agricultural practices and crop rotation change over time and may not continue to benefit bears in the future. If bears in the Deltic population have to travel further or move more frequently to find late summer and early fall food items, an increase in mortality may result from vehicular collisions and bear-human conflicts. Managers may want to establish partnerships with other farming landowners, as they have with the Deltic Corporation, to ensure that crops favorable to wildlife continue to be planted on an annual basis. Economic incentives through conservation programs are one way to accomplish this goal.

Habitat issues will become more complex in the future with the establishment of the Poverty Point facility. Only Bayou Macon separates this recreational and residential lake area with the Bluecat tract, the tract most densely populated by black bears in the Deltic study area. Being immediately adjacent to the tract most densely populated by bears, it is reasonable to assume that this 685-ha complex will have a negative effect on the bear population through loss of habitat, decreased survival from roadkills, and an increase in human-bear conflicts. At the conclusion of the current study, all land clearing, burning, grading, and impoundment work had been completed at the site. Final construction activities have recently begun and were scheduled to be complete by summer 2000.

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APPENDICES

Appendix A. Compiled trapping results for Deltic study area, 1988 - 1998

Table A-1. Black bear trapping results for the Deltic study area, Tensas River Basin, northeast Louisiana 1988-1998.

Bear	Date	Location ^a	Sex ^b	Weight (kg)	Age (years)
101	29-Apr-88	Bluecat	F	73.5	N/A
104	30-Apr-88	Wade Bayou	F	88.5	N/A
106	01-May-88	Wade Bayou	M	104.0	3.5
	19-May-89	Bluecat		126.5	4.5
	23-Jul-92	Bluecat		122.5	7.5 $\pm$ 1
	20-Oct-93	Bluecat		163.5	8.5 $\pm$ 1
108	02-May-88	Bluecat	F	60.8	1.5
	29-Sep-90	Bluecat		60.8	3.5
	02-Jul-94	Bluecat		55.3	7.5 $\pm$ 1
110	03-May-88	Wade Bayou	M	180.0	N/A
	28-Apr-89	Wade Bayou		163.3	N/A
122	01-Dec-88	Bluecat	M	32.5	2.0
	09-Jun-89	Bluecat		38.5	2.5
	27-Sep-90	Bluecat		80.5	3.5
	29-Aug-98	Wade Bayou		162.0	11.5
124	02-Dec-88	Bluecat	F	43.5	4.0
	21-May-89	Bluecat		48.5	4.5
	28-Sep-90	Bluecat		64.5	5.5
	08-Jul-92	Bluecat		75.0	6.5
	20-Jul-93	Bluecat		68.0	7.5
	22-Jun-94	Bluecat		63.5	8.5
	01-Jun-98	Bluecat		96.8	12.5
126	21-May-89	Bluecat	F	29.0	N/A
	11-Jun-89	Bluecat		28.5	N/A
	23-Jun-94	Bluecat		59.0	Adult

Table A-1. (continued)

Bear	Date	Location ^a	Sex ^b	Weight (kg)	Age (years)
128	23-May-89	Bluecat	F	81.5	7.5
	09-Jun-89	Bluecat		82.0	7.5
	27-Sep-90	Bluecat		75.0	8.5
	30-Jun-92	Bluecat		81.0	10.5
	21-Jul-93	Bluecat		78.0	11.5
	01-Jul-94	Bluecat		68.0	12.5
	12-Jun-98	Bluecat		83.3	16.5
	6-Aug-98	Bluecat		85.4	16.5
149	28-Nov-90	Wade Bayou	M	60.0	2.5 $\pm$ 1
	26-Jul-92	Bluecat		70.5	4.5 $\pm$ 1
151	30-Nov-90	Wade Bayou	M	147.0	3.5
	20-Jun-92	Bluecat		159.0	5.5
153	21-Nov-91	Bluecat	M	72.5	N/A
156	17-Nov-91	Bluecat	F	47.5	2.5
	17-Jun-92	Bluecat		47.5	3.5
	08-Jul-92	Bluecat		47.5	3.5
	06-Oct-93	Bluecat		56.5	4.5
	26-Jun-94	Bluecat		53.1	5.5
	14-Jun-98	Bluecat		56.3	9.5
160	08-Jun-92	Bluecat	F	50.0	Adult
	17-Jul-92	Bluecat		43.0	Adult
162	05-May-93	Bluecat	F	26.5	1.5
	10-May-95	Bluecat		40.8	3.5
164	02-Jul-92	Bluecat	M	8.0	0.5
180	02-Jun-93	Panther Lake	F	59.0	10.5 $\pm$ 2
182	11-May-93	Bluecat	M	35.5	1.5
	15-Jul-94	Panther Lake Drain		70.1	3.5

Table A-1. (continued)

Bear	Date	Location ^a	Sex	Weight (kg)	Age (years)
184	14-Jul-93	Bluecat	F	18.0	1.5
	02-May-95	Bluecat		38.5	3.5
	24 Aug-97	Carson Woods		49.9	5.5
190	04-Jun-94	Wade Bayou	M	56.7	2.5
	23-Aug-98	Brownie		150.8	6.5
192	09-Jun-94	Wade Bayou	F	36.3	3.5
194	15-Jun-94	Wade Bayou	F	24.5	2.5
	21-Jul-94	Panther Lake Drain		28.6	2.5
196	27-Jun-94	Bluecat	F	46.3	4.5
200	17-Jul-94	Panther Lake	F	27.2	2.5
	16-May-95	Brownie		43.1	3.5
	18-Aug-97	Brownie		55.8	5.5
	4-Jun-98	Brownie		56.3	6.5
202	20-Jul-94	Panther Lake	F	11.3	0.5
	25-Jul-98	Panther Lake		60.75	4.5
210	11-May-95	Bluecat	M	24.9	1.5
	09-Sep-95	Bluecat		38.5	1.5
213	20-Jun-95	Bluecat	M	145.1	8.5
	17-Jun-98	Bluecat		164.3	11.5
226	26-Jun-95	Bluecat	M	72.6	2.5
	23-Aug-98	Richland Parish		119.3	5.5
228	13-Sep-95	Bluecat	M	49.9	1.5
	2-Jun-98	Bluecat		160.0	4.5
230	24-Oct-95	Bluecat	M	49.9	1.5
	06-Sep-97	Brownie		136.2	3.5
	26-Aug-98	Brownie		150.8	4.5

Table A-1. (continued)

Bear	Date	Location ^a	Sex ^b	Weight (kg)	Age
232	13-Mar-97	Richland Parish	M	95.3	3.5
258	01-Sep-97	Bluecat	M	32.7	1.5
260	25-Jun-97	Wade Bayou	M	31.8	1.5
264	1-Jun-98	Bluecat	M	51.8	1.5
274	14-Aug-97	Bluecat	M	9.1	0.5
	08-Sep-97	Bluecat			0.5
	13-Sep-97	Bluecat			0.5
	25-May 98	Bluecat		36.0	1.5
	06-Jun-98	Bluecat			1.5
	10-Jul-98	Bluecat			1.5
	17-Jul-98	Bluecat		45.0	1.5
	02-Sep-98	Bluecat			1.5
	08-Sep-98	Bluecat			1.5
301	17-Aug-97	Carson Woods	F	56.3	4.5
	17-Aug-98	Bluecat		56.3	5.5
308	13-Jun-98	Bluecat	F	29.3	1.5
311	22-Jul-97	Bluecat	F	7.7	0.5
	14-Jun-98	Bluecat		24.8	1.5
314	01-Jun-98	Bluecat	F	63.0	4.5
	08-Jun-98	Bluecat			4.5
317	20-Aug-97	Bluecat	F	9.1	0.5
	27-May-98	Bluecat		33.8	1.5
	29-May-98	Bluecat			1.5
319	15-Sep-97	Brownie	F	67.2	4.5
360	25 May-98	Bluecat	M	48.6	1.5
362	4-Aug-98	Bluecat	M	108.0	4.5

^aSee figure 1 for location of tracts^bM = male, F = female^cRe-issued this new lip tattoo identification number in the current study

Table A-2. Comparison of trap effort for the Deltic black bear study, northeast Louisiana, 1993-1998.

Year	Tract	Trap Nights	Bear Visits	Total Captures	Initial Captures	Recaptures	Trap Nights Per Capture	Success (%)
1993	Bluecat	186	73	7	3	4	26.6	3.8
1994	Bluecat	63	13	6	6	0	10.5	9.5
1995	Bluecat	94	15	10	8	2	9.4	10.6
1997	Bluecat	914	31	6	4	2	152.3	0.7
1998	Bluecat	780	52	21	6	15	37.1	2.7
1993	Brownie	47	2	0	0	0	-	0.0
1994	Brownie	45	7	0	0	0	-	0.0
1995	Brownie	15	2	1	0	1	15.0	6.7
1997	Brownie	194	6	3	1	2	64.7	1.6
1998	Brownie	410	18	3	0	3	136.7	0.7
1993	Panther Lake	37	2	1	1	0	37.0	2.7
1994	Panther Lake	47	1	2	2	0	23.5	4.3
1995	Panther Lake	16	2	0	0	0	-	0.0
1997	Panther Lake	178	1	0	0	0	-	0.0
1998	Panther Lake	196	3	1	0	1	196.0	0.5
1993	Wade Bayou	44	3	0	0	0	-	0.0
1994	Wade Bayou	81	3	3	3	0	27.0	3.7
1995	Wade Bayou	51	1	0	0	0	-	0.0
1997	Wade Bayou	197	6	1	1	0	197.0	0.5
1998	Wade Bayou	426	22	1	0	1	426.0	0.2

Table A-2. (continued)

Year	Tract	Trap Nights	Bear Visits	Total Captures	Initial Captures	Recaptures	Trap Nights Per Capture	Success (%)
1997	Carson Woods	104	3	2	1	1	51.5	1.9
1998	Carson Woods	57	1	0	0	0	--	0.0
1997	P. Lake Drain	55	0	0	0	0	-	0.0
1998	P. Lake Drain	14	1	0	0	0	--	0.0
1998	Big Creek	10	1	1	0	1	10	10.0
Total	Bluecat	2037	184	50	27	23	40.7	2.5
Total	Brownie	711	35	7	1	6	101.6	1.0
Total	Panther Lake	474	9	4	3	1	118.5	0.8
Total	Wade Bayou	799	16	5	4	1	159.8	0.6
Total	Carson Woods	161	4	2	1	1	80.5	1.2
Total	P. Lake Drain	69	1	0	0	0	--	0.0
Total	Big Creek	10	1	1	0	1	10	10.0
1993	All Tracts	314	80	8	4	4	39.3	2.6
1994	All Tracts	236	24	11	11	0	21.5	4.7
1995	All Tracts	176	20	11	8	3	16.0	6.3
1997	All Tracts	1642	47	12	7	5	136.8	0.7
1998	All Tracts	1893	97	28	22	6	67.6	1.5
Total	All Tracts	4261	268	70	52	18	60.9	1.6

Appendix B. Photograph from Deltic capture-resight study



Fig. B-1. Typical photograph of a bear (unmarked) visiting a remote camera station used in the mark-resight study to estimate the Deltic population size, Tensas River Basin, northeast Louisiana, 1997-1998

Appendix C. Methods and results of hair sampling for DNA analysis

Materials and Methods

Thirty-two barbed-wire hair traps were maintained simultaneously on the 5 major tracts on the Deltic study area between 16 September and 13 November 1998. Barbed-wire enclosures were constructed in a box-shaped pattern measuring approximately 3 meters square (Fig. C-1). I used 12½-gauge barbed-wire with 4-point, 14-gauge round barbs (Red-Brand, Keystone Steel and Wire Company, Peoria, Illinois). I strung and secured barbed-wire between trees with two 2.5 cm steel fence staples. Although similar studies used a single strand perimeter fence placed 30-50 centimeters above the ground (Woods et al. 1996, R. Grogan, personal communication). I experimented with the effectiveness of 2 strands placed at 38 and 76 cm above ground level. The placement of 2 strands allowed me to determine if bears were more likely to go under or over the lower strand. Bait (bakery products) was placed in a plastic bag and hung within the enclosure from a central limb using twine. Bait was laced with raspberry extract to lure bears into the enclosure. Bears left hairs on the barbed-wire when they crawled over or under the barbed-wire to retrieve the bait, or when they exited the enclosure, or both. Traps were checked and rebaited after 4 nights. Hair samples were collected from each barb and placed in an envelope that was labeled with the date, trap number, number of samples collected from that trap on that particular day, and whether the sample came from the lower or upper strand.

Hair samples collected were analyzed using a DNA fingerprinting technique based on microsatellite analysis (Paetkau and Strobeck 1994, McLellan et al. 1996). Essentially, DNA fingerprints from hair samples can be used as “marks”. When bears

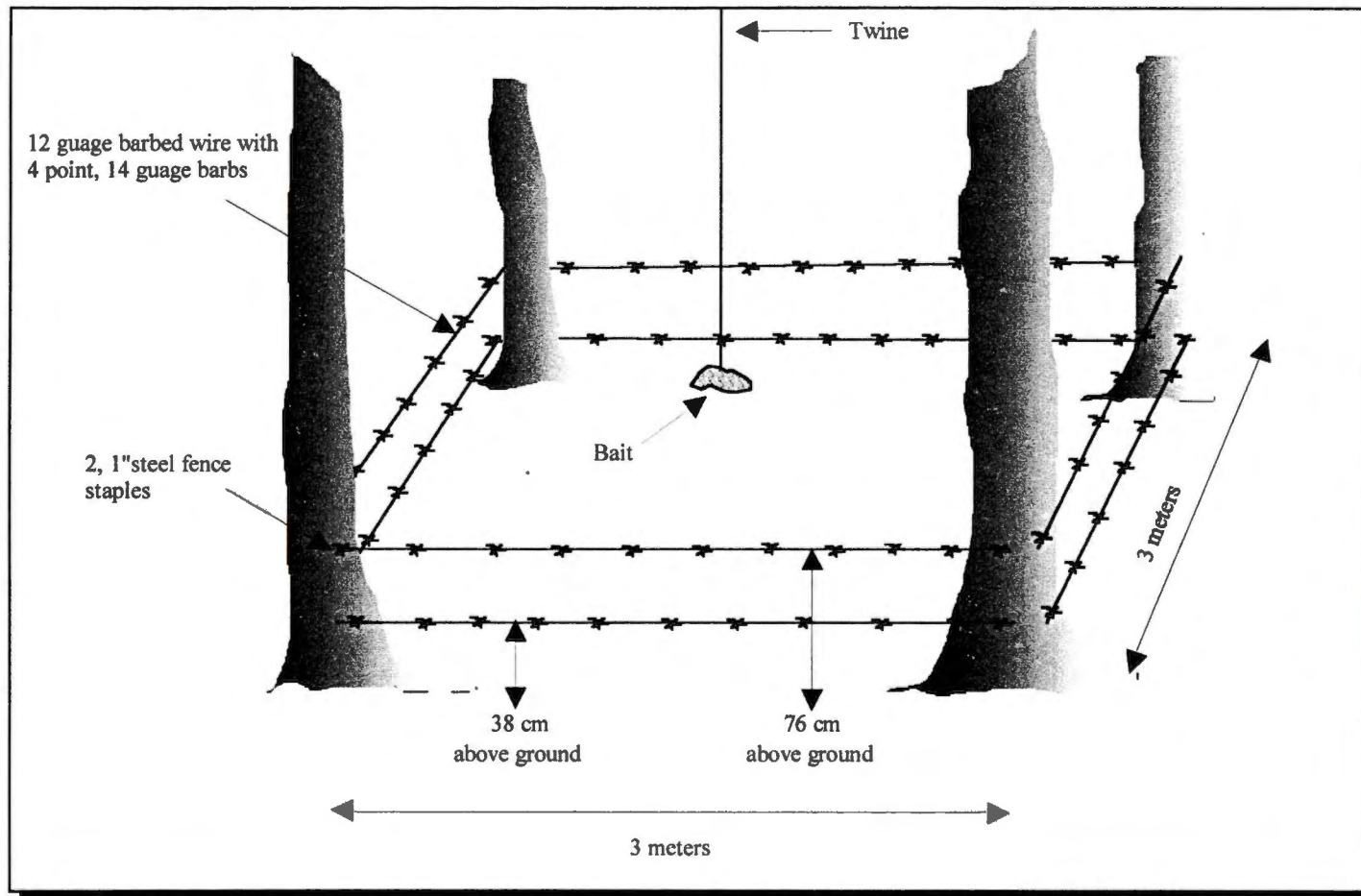


Fig.C-1. Schematic of barbed-wire hair trap used to collect hair samples for DNA analysis, Deltic study area, northeast Louisiana, 1997-1998.

were initially captured in a snare, a hair sample was taken and subsequently analyzed for its unique genetic identity. Later, using barbed-wire hair traps, hair samples were collected and later sent to a laboratory for analysis. From this information, individuals could be identified as being “captured” or “recaptured”. These data can then be incorporated into capture–recapture models. DNA marks have a distinct advantage over traditional marks; they cannot be lost or misidentified. Woods and Mclellan (1996) note “the probability of incorrectly identifying a black bear in a random sample is estimated to be 1 in 1.5 trillion”. Because no physical recapture is necessary and because this technique has never been used on the Deltic animal population, issues relating to trap response and individual animal heterogeneity (Carothers 1971, Pollock et al. 1990) was presumed to be negligible.

RESULTS

From 16 September to 13 November 1998, 32 barbed-wire hair traps were maintained simultaneously on all 5 Deltic tracts. A total of 195 hair samples were collected. From this total, 110 (56%) hair samples were obtained from 9 barbed-wire enclosures in Bluecat, 53 (27%) samples from 8 enclosures in Brownie, 22 (11%) samples from 7 enclosures in Wade Bayou, and 10 (5%) samples from 7 enclosures in Panther Lake. No samples were collected from 1 enclosure in Carson Woods. Of the 195 samples collected, 177 (91%) were collected from the lower wire and 18 (9%) from the higher wire.

Samples were sent to personnel at the Biological Resources Division of the United States Geological Survey in Leetown, West Virginia for DNA analysis. The

gene-sequence data will allow me to determine how many individuals were “captured” or “recaptured” and the sex of those individuals not initially captured with snares. Because of the popularity in this new technique and the time involved in preparing and analyzing hair samples, results were not available upon completion of this thesis and will be provided when the data become available.

Appendix D. Black bear observations on the Deltic study area

Table D-1. Summary of black bear observations on the Deltic study area, Tensas River Basin, Louisiana (June 1997-Dec 1998).

Date	Time	#Seen	Site	Comments
05-Jun-97	14:30	1	Panther Lake	Uncollared bear seen at edge of wheat field and forest edge on the west side of the tract, approximately 1.5 miles north of Donaldson Road.
23-Jun-97	15:30	1	Bluecat	Uncollared bear seen in the southwest portion of the tract on an ATV trail 50m from forest edge where corn was planted.
02-Jul-97	12:00	1	Bluecat	Uncollared bear seen at forest edge near corn field in Southeast corner.
14-Jul-97	13:00	2	Bluecat	Uncollared female and cub seen in the central portion of the tract. Both climbed a nearby tree.
15-Jul-97	09:30	1	Bluecat	Uncollared male seen crossing ATV trail about 30 m ahead of researchers. He was running on three legs, barely using his front left paw. Seen in central portion of tract.
23-Jul-97	12:00	4	Bluecat	Captured cub. Adult female also was observed at the trap site with two additional cubs. Seen in central west portion of tract.
28-Jul-97	11:15	2	Carson Woods	Bear #162. Homed in and observed her with a cub. Seen in the southwest corner of tract.
29-Jul-97	08:00	1	Bluecat	Observed bear #162 along the southeastern section of tract. She came out of the woods and entered the cornfield. Her cub was not seen.

Table D-1. (continued)

Date	Time	#Seen	Site	Comments
02-Aug-97	11:15	1	Bluecat	Collared bear #234. Observed while collecting telemetry locations. I walked in on him about 10 m from the forest edge. He was up in a tree in the southeastern portion of tract.
04-Aug-97	09:00	1	Bluecat	Uncollared male bear observed about 60 m from trap #24 in the central portion of the tract. He jumped into a creek drainage and crossed over to the other side and fled.
05-Aug-97	15:45	1	Carson Woods	Homed in on bear #162. Observed at close range. She was bedded down near the forest/corn edge on the southeast side of the tract. No cub was seen.
06-Aug-97	15:30	1	Carson Woods	Homed in on bear #162 to check on the status of her cub that hasn't been seen in last 2 sightings. No cub was observed.
11-Aug-97	10:00	1	Bluecat	Homed in on bear #162. She was in a large cypress tree and no cub was observed. She was in southeastern section of tract. (This bear was later confirmed to have lost her cubs 2 years in a row. She gave birth 3 consecutive years.
22-Aug-97	08:45	3	Bluecat	Uncollared female with two cubs observed. One of the cubs had color-coded ear tags; bear #238. Observed on west side of the duck levy.
29-Aug-97	2000	1	Bluecat	Uncollared male bear seen in field at the southeastern corner of the tract feeding in a cornfield that was cut 2 days prior.

Table D-1. (continued)

Date	Time	#Seen	Site	Comments
29-Oct-97	1100	1	Bluecat	Collared yearling bear seen in the southeast section of the tract. He was wearing a color-coded radio collar and was identified as bear #258.
08-Nov-97	0930	3	Bluecat	Large female bear seen in the central portion of the tract with 2 cubs. No tags were seen.
23-May-98	1415	3	Bluecat	Uncollared female and 2 yearlings observed in a small oat planting in the southeast corner of the tract, at the woodedge. Both yearlings stood up on their hind legs and all 3 scampered off into the woods heading northwest.
25-May-98	1330	3	Brownie	Collared bear (#319) seen with 2 yearlings in a soybean field on the south-central side of the tract. All 3 bears headed south. This bear was captured in Sept. 1997 and both cubs were observed.
01-Jun-98	0720	3	Bluecat	Female with 2 yearlings observed on the east side of the duck levy, about ½ mile from south end. All 3 stood up on their hind legs and then ran east into the woods. No marks could be seen.
11-Jun-98	0750	1	Bluecat	Uncollared male seen on the west side of the duck levy. He ran west to the east over the duck levy and passed within 15 yards of the moving ATV.

Table D-1. (continued)

Date	Time	#Seen	Site	Comments
11-Jun-98	0915	2	Bluecat	Two cubs of the year seen in the northeast section of the tract in a large clearing. The female was heard in the woods blowing and popping until the cubs ran into the woods. The cubs climbed a nearby tree but the female was never seen.
19-Jun-98	0825	1	Bluecat	Unmarked bear seen in the middle of the tract. It crossed about 30 yards ahead of me, running from the west to the east side of the trail.
29-Jun-98	1525	2	Wade Bayou	2 bears seen in the southwest portion of the tract. 1 bear was collared (#268). He was following a female and crossed from the south side of the trail to the north.
11-Jul-98	0755	1	Wade Bayou	Uncollared bear seen crossing the ATV trail. This may be the same bear seen with #268 on 29 June. It was sighted in the same area and was the same size.
14-Jul-98	0810	1	Wade Bayou	Collared bear (#268) seen in the southwest section of the tract. He crossed the ATV trail and headed east.
18-Sep-98	1430	1	Bluecat	Marked bear (#318) seen on the west side of the duck levy. She ran to the west.
22-Sep-98	1420	1	Bluecat	Bear seen at a barbed-wire hair trap in the center of the duck levy and heading north. No samples were collected at the trap. No marks could be seen.

Table D-1. (continued)

Date	Time	#Seen	Site	Comments
16-Oct-98	0735	1	Wade Bayou	Unmarked bear seen near a cane thicket on the east side of the tract. The bear ran east after taking notice of me.
23-Oct-98	1723	1	Bluecat	Marked bear (#318) sighted about 2/10 of a mile up west levy from the south end. She was in a clearing feeding on wheat and ran to the west after noticing me.
23-Oct-98	1725	1	Bluecat	Marked bear (#308) sighted about 1/2 mile up west levy from the south end. She ran to the west after taking notice.
03-Nov-98	1715	1	Bluecat	Marked bear (#318) sighted about 7/10 of a mile up west levy from the south end. She was feeding on wheat and ran to the west after taking notice.

VITA

Richard Anthony Beausoleil was born on 16 October 1968 in Salem, Massachusetts. He graduated from Salem High School in May 1986. In 1991, he enrolled at Essex Agricultural and Technical Institute in Hathorne, MA and received the Associate of Science degree in Horticulture in May 1993. That same year, he began his studies at the University of Massachusetts at Amherst and received a Bachelor of Science degree in Wildlife Biology/Conservation in May 1996. After summer and fall internships, working with moose in Minnesota and fox squirrels in Maryland, he began graduate school in Spring 1997 in the Department of Forestry, Wildlife and Fisheries at the University of Tennessee, Knoxville studying the federally Threatened Louisiana black bear. While preparing this thesis, he also trapped black bears in Great Smoky Mountains National Park in the summer of 1999. He was awarded the Master of Science degree in Wildlife and Fisheries Science in Fall 1999.

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