

# DENNING ECOLOGY OF FEMALE AMERICAN BLACK BEARS IN SOUTH CENTRAL LOUISIANA

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**Abstract:** We examined the denning ecology of female American black bears (*Ursus americanus luteolus*) in the upper (Inland) and lower (Coastal) Atchafalaya River Basin of south central Louisiana. We attempted 101 den visits of 35 female bears during February–March, 1992–2000. We found dens on 28 of 56 (50%) Coastal and 44 of 45 (98%) Inland attempts. We determined reproductive status on 62 (61%) den visits, but our success differed between Coastal and Inland areas (43% and 84%, respectively). The distribution of litter sizes differed between areas. We did not detect any cub abandonment. Use distribution among den types (e.g., tree, snag, ground nest, slash, stump, log, and excavated) differed between areas. We found no evidence that the distribution of den security classes differed between parturient and barren females. Using the median location error of field trials with test transmitters (206 m) as our criterion, we classified bears as stationary during the denning season if the distances of 3 consecutive locations (a location set) from their centroid were each <206 m. Of 29 denned bears, 24 had  $\geq 1$  stationary location set (classified as denned), and 16 of 117 bear seasons outside of the denning period contained  $\geq 1$  stationary location set. We classified 10 of 23 Coastal females, 6 of 19 Coastal males, 2 of 4 Inland females, and 1 of 1 Inland males of previously unknown status as denned. Based on movement data, many Coastal bears, including adult females, remained active or only bedded for short periods during winter.

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**Key words:** American black bear, denning, litter size, location constancy, Louisiana, reproduction, *Ursus americanus luteolus*

Denning by black bears is hypothesized to be an adaptation to decrease stress during periods of inclement weather and food shortage (Lindzey and Meslow 1976, Johnson and Pelton 1980a), and is when parturition occurs (Alt 1983). After entering dens, bears cease all ingressive and eliminative functions and enter a lethargic or deep sleep (Nelson et al. 1973). Disturbance during the denning period may result in cub abandonment or reduce the survival probability of adult bears by increasing energy expenditure when food resources are scarce (Linnell et al. 2000). Because managers perceive denned bears, especially parturient females, to be vulnerable, adequate denning habitat and structures have been emphasized as important in managing black bear habitat (Johnson and Pelton 1981, Weaver and Pelton 1994, Linnell et al. 2000).

Researchers in the southeastern U.S. have reported black bears using a wide variety of den structures including trees, standing snags, ground nests, logs, stumps, piles of woody debris such as logging slash, and excavated areas beneath trees, logs, debris, or human structures (Johnson and Pelton 1981, Smith 1985, Hellgren and Vaughan 1989, Weaver and Pelton 1994). Of these, tree dens are considered the most secure (Johnson and Pelton 1981). Hence, bears using tree dens are presumed to realize increased survival for themselves and their offspring (White et al. 2001).

Denning is not, however, compulsory for all bears in some mild climates. Excluding parturient females, which must den to give birth, bears may remain active if sufficient food is available (Graber 1990). Winter-active bears have been reported for many southeastern black bear populations (Taylor 1971, Hellgren and Vaughan 1989, Wooding and Hardisky 1992, Weaver and Pelton 1994). These observations indicate that bears in milder climates may have winter behavioral options not available to bears in colder climates, where food may be more limited. Population-specific knowledge of bear behavior in winter is critical to understand the seasonal needs of bears and formulate appropriate management strategies.

To aid in conservation planning for the threatened Louisiana black bear (*U. a. luteolus*; U.S. Fish and Wildlife Service 1992), we investigated the denning habitat, denning frequency, and reproductive rates of bears in 2 isolated populations within the Atchafalaya River Basin, Louisiana. Our objectives were to document den structures used, determine if parturient females used more secure dens than other females, document reproductive output, and classify winter movement behavior (e.g., stationary or moving). Because of habitat differences between study areas (coastal swamps and mesic islands versus inland bottomland hardwood forests), known differences in movement dynamics (Wagner 1995) and mortality (Pace et al. 2000) between populations, and reported differences in den use among American black bear populations in the southeastern U.S., we compared aspects of denning ecology between our study populations.

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## STUDY AREA

We worked with 2 populations of bears located in 2 areas of south central Louisiana, referred to as Inland (approx 460 km<sup>2</sup> in size) and Coastal (approx 570 km<sup>2</sup> in size; Fig. 1). The Inland population was located primarily within the Morganza Spillway, a floodway developed by the U.S. Army Corps of Engineers to release floodwaters of the Mississippi River into the Atchafalaya Basin. Forested habitats within the floodway were primarily bottomland hardwood stands managed for timber production. Forest management prescriptions, especially even-aged management, may have influenced den tree availability. Agricultural fields within the Spillway were adjacent to the levees and Louisiana Highway 10, which bisected the Spillway near its northern end. Seasonal flooding occurred throughout the Inland area but was not severe during the term of this study. Large areas of slightly higher elevation were dry throughout winter, and flooded areas were generally <0.5 m deep.

The Coastal population was in an area consisting of small bottomland hardwood stands, baldcypress–water tupelo (*Taxodium distichum*–*Nyssa aquatica*) swamps, and coastal marshes that varied along salinity gradients ranging from fresh to saline (U.S. Army Corps of Engineers 1974). Wetland scrub habitats occurred in the transition zone between swamp and marsh. Bottomland hardwood stands were restricted to the borders of sugarcane fields protected from flooding by levees, and along spoil areas near waterways. Coastal habitats were highly interspersed and most contained open water, sloughs, bayous, and canals influenced by tidal fluctuations (Chabreck 1970). The Coastal area also contained 4 salt domes, characterized by upland cover types, rising >30 m above surrounding

deltaic plains (Evans et al. 1983). Most of the land area, excluding the salt domes and areas protected by levees, was inundated throughout most of the year. The water table was generally <0.2 m above the surface. Drier sites in the swamp and scrub habitats generally were those areas surrounding isolated groups of trees. Detailed habitat descriptions were provided by Nyland and Pace (1997).

## METHODS

We captured bears in leg snares or culvert traps following the methods detailed in Johnson and Pelton (1980b). We trapped from April to September during 1992–99, with trapping sessions ranging from 3 to 6 months. Trapping effort varied among years and between study areas, with Coastal receiving more effort during several years. Captured bears were immobilized with either a 2:1 mixture of ketamine hydrochloride and xylazine hydrochloride (4.4 mg/kg) or a 1:1 mixture of tiletamine hydrochloride and zolazepam (6.0 mg/kg). Bears were uniquely marked with ear tags, lip tattoo, and, beginning in 1997, with a passive injectable transponder (AVID Incorporated, Norco, California, USA). A first premolar was extracted for cementum annuli aging (Matson's Laboratories, Incorporated, Milltown, Montana, USA), and radiocollars with leather spacing material were attached to bears  $\geq 2$  years old (Advanced Telemetry Systems, Incorporated, Isanti, Minnesota, USA; Telemetry Systems, Incorporated, Mequon, Wisconsin, USA; Telonics, Incorporated, Mesa, Arizona, USA).

We attempted den visits for adult and subadult female bears during February and March from 1992 to 2000 to replace radiocollars, document den location and structure, and determine reproductive status. Conditions permitting, bears were immobilized in dens and the young sexed and weighed. We listened for nursing cubs at den sites we were not able to enter. To assess cub survival, selected litters after 1995 were radiotagged following the protocol of Higgins et al. (1997). Females were assigned to reproductive classes at den visits or from observations made after den emergence: solitary adult female, solitary subadult female, adult female with cub (born in current winter), subadult female with cub, adult female with yearling, and subadult or adult female of unknown condition. We tested for differences between areas in the proportion of den visits resulting in den observations using a  $\chi^2$  test and for differences between areas in female reproductive condition using Fisher's exact test. In these analyses, each den attempt represents the total number of field excursions we made attempting to assess the denning status of a female bear during 1 winter (bear-winter). Because sample sizes were small, data from adult and subadult females were pooled across years within areas for all analy-

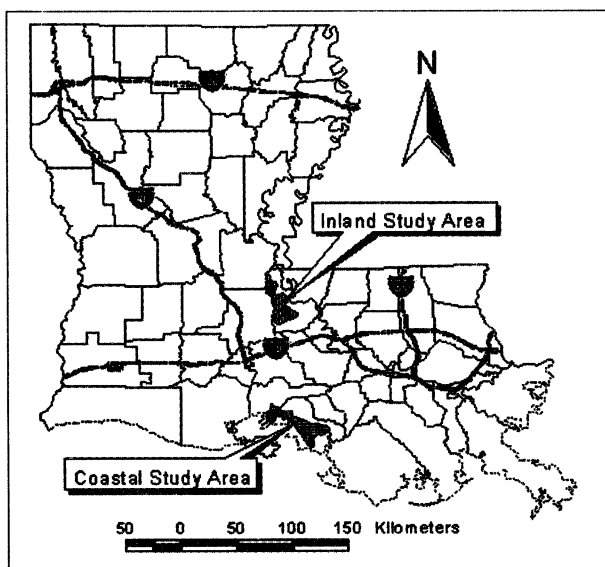


Fig. 1. Study areas in the Atchafalaya River Basin in south central Louisiana (1992–2000).

ses of den data. We assumed multiple observations of individuals across years were independent. A Type I error rate of 5% was used for all statistical tests.

We classified den types according to structure (e.g., ground den excavated beneath standing structure, ground nest, hollow log, slash pile, snag, stump, tree) and tested for differences in den types used between areas using Fisher's exact test. We also subjectively grouped structures into classes based on relative security from disturbance similar to McDonald and Fuller (1998). Tree and snag dens with elevated entrances were considered most secure, ground nests least secure, and the remainder were classified as moderate. We grouped bears of known reproductive condition into parturient or barren females and tested for differences in den security class within areas using Fisher's exact test.

Number, age (cub, yearling), and sex of offspring observed at the den site were recorded. Because sample sizes were small, we pooled litter sizes across years within areas for analysis. We assumed litter sizes were not different among years and that multiple litters born to the same female were independent. We used Fisher's exact test as evidence for differences in litter-size distribution (e.g., 1, 2, and 3 cubs) between areas.

Because we were sometimes uncertain if bears that moved away during our approach were denned and because some dens were inaccessible, we assessed denning remotely. We used aerial location constancy to classify the winter (November–April) movement of bears, including males, from 1992 to 1995 when den visits were unsuccessful or not attempted. Locations were obtained approximately weekly over the period considered. After 1995, bears were only located monthly, thus locations after 1995 were excluded from analyses. We characterized aerial tracking precision as the median deviation (distance error) obtained when locating test transmitters, placed at known locations, in 1994. Bears were considered stationary during the denning season if the distances of 3 consecutive locations (a location set) from their centroid were each less than the median distance error on test transmitters (206 m;  $n = 70$ ). We evaluated the technique by applying it to location sets of denned bears and location

sets outside the denning period.

## RESULTS

### Den Visits

We attempted den visits for 77% of bear-winters monitored (Table 1). We did not attempt to visit bears whose telemetry locations in the weeks prior to the period of den inspection indicated movement (19 adult and 1 subadult Coastal females, and 1 adult Inland female), or on bears located on inaccessible private lands (5 adult Coastal females and 1 adult Inland female). We observed 72 dens of 19 Coastal and 16 Inland female bears. We did not enter 17 dens because of safety concerns (i.e., anesthetic could not be safely administered to bear, bear appeared prepared to flee den, or den tree unsuitable for climbing).

Overall, 56% of attempted den visits were successful. A total of 15 dens were observed after the bear left the den site. Coastal females were more likely to move on our approach than Inland females (0.70 vs. 0.11;  $\chi^2 = 34.8$ , 1 df,  $P < 0.01$ ), and we were less likely to find Coastal dens once bears fled ( $n = 44$ ,  $P = 0.04$ ). We believe that Coastal bears fled when researchers were farther away than did Inland bears, resulting in only 28% of Coastal dens being observed if the bear fled versus 80% for Inland bears. Those factors resulted in den observation in only 50% of Coastal attempts compared to 98% of Inland.

The reproductive condition of bears leaving observed dens included 6 with cubs (all Coastal), 6 with yearlings (3 Coastal, 3 Inland), 1 solitary (Coastal), and 2 of unknown reproductive condition (1 Coastal, 1 Inland). Fourteen of 15 (93%) vacated dens were ground nests, and 1 was in a stump. Using aerial or ground telemetry, we verified the return of females with cubs to the area of the den following disturbance and detected no permanent cub abandonment. Of 17 radiotagged cubs representing 5 Coastal and 4 Inland litters, all were determined to be with the birthing female until den emergence. Several cub radiotags were recovered at the den site after the female emerged from the den, but we did not find any evidence

**Table 1. Den visits, den observations, and den season reproductive determinations of subadult and adult female black bears in the upper (Inland) and lower (Coastal) Atchafalaya River Basin (1992–2000).**

Study area	Age class	Bear den-years monitored	Den inspections attempted	Bears observed in dens	Dens observed	Reproductive condition determined
Coastal	Adult	75	51	17	27	24
	Subadult	6	5	0	1	0
	Subtotal	81	56	17	28	24
Inland	Adult	41	37+1 <sup>a</sup>	33	37	33
	Subadult	6	6+1 <sup>a</sup>	7	7	5
	Subtotal	47	43+2	40	44	38
	Total	128	101	57	72	62

<sup>a</sup> One unmarked bear was discovered in the den by a landowner; bear was subsequently inspected by project personnel.

of mortality. All others were determined to be with the female after den emergence.

We determined the reproductive condition of bears in 86% of dens observed in both areas. Because of the lower likelihood of observing Coastal dens, overall success in determining reproductive condition when den inspection was attempted was lower in the Coastal area than the Inland area (43% vs. 84%). Grouping bear visits that were not attempted because of movement prior to the den inspection period with unsuccessful den visits, Coastal bears accounted for 52 of 62 (84%) bear-winters of unknown reproductive status.

Seventeen of 38 (45%) Inland dens where the females reproductive condition was determined were occupied by solitary females, 15 (39%) by females with cubs, and 6 (16%) by females with yearlings. The reproductive condition of females in observed Coastal dens differed from Inland ( $n = 62$ ,  $P < 0.01$ ), with only 1 of 24 (4%) females solitary, 17 (71%) with cubs, and 6 (25%) with yearlings.

## Den Types

Den types were not observed in the same proportions between areas ( $n = 71$ ,  $P = 0.02$ ). Most dens in the Coastal area were ground nests, in contrast to Inland where the number of tree dens with elevated entrances (tree-elevated) and ground nests were about equal (Table 2). Dens in piles of logs and woody debris resulting from recent timber harvest or clearing were recorded in both areas, but 80% were Inland. We did not estimate the number of potential denning structures available in either area. However, because 93% of dens that were observed when the sow fled on our approach were ground nests, we believe that the majority of unsuccessful den visits were a result of bears abandoning ground-level dens. This was consistent with our observations of denned bear response to our presence. Bears in ground nests were generally aware of our presence and usually in a standing or sitting position

when we first observed them. In contrast, the majority of bears in other den types seemed oblivious to our presence and did not move until we approached to about 3 m.

We inspected den sites of 19 and 14 parturient females and 6 and 24 barren females in the Coastal and Inland areas, respectively (Table 3). We detected no differences among proportions of den security classes between parturient and barren for Inland females ( $n = 38$ ,  $P = 0.64$ ) or Coastal females ( $n = 25$ ,  $P = 0.83$ ).

## Litter Size

We determined litter size of 14 Coastal and 11 Inland litters. The distribution of litter sizes differed between areas ( $n = 25$ ,  $P = 0.05$ ). Mean litter sizes for the Coastal and Inland areas were 2.4 (SE = 0.17) and 1.5 (SE = 0.16), respectively. Observed frequencies of 1-, 2-, and 3-cub litters were 1, 6, and 7 for Coastal and 4, 6, and 1 for Inland.

## Location Constancy

We recorded 2,591 locations of 56 male and female bears from 1992 to 1995, forming 2,228 3-location sets, distributed across 193 bear-seasons (76 den season, Nov–Apr; 117 summer–fall, May–Oct). Three bear-winters with <3 locations were excluded from the analysis. In

**Table 3. Den security classes for dens used by parturient and barren subadult and adult female black bears in the upper (Inland) and lower (Coastal) Atchafalaya River Basin (1992–2000).**

Study area	Reproductive condition	Den security class		
		High	Moderate	Low
Coastal	Parturient	3	6	10 <sup>a</sup>
	Barren	1	1	4
Inland	Parturient	5	6	3
	Barren	6	10	8

<sup>a</sup> Includes 1 female whose reproductive status was determined after den emergence.

**Table 2. Percent of subadult and adult female black bear den types in the upper (Inland) and lower (Coastal) Atchafalaya River Basin (1992–2000), Tensas River Basin in northeast Louisiana (1988–91; Weaver and Pelton 1994), Great Dismal Swamp (GDS) in Virginia and North Carolina (1984–87; Hellgren and Vaughn 1989), Osceola (1983–85) and Ocala (1985–88) National Forests in Florida (Wooding and Hardisky 1992), White River National Wildlife Refuge in Arkansas (1993–95; Oli et al. 1997), and Big Island and Montgomery Island in Arkansas (1992–94; White et al. 2001). Percents were rounded to the nearest whole number; sample sizes (N) are indicated in bottom row.**

Den type	Study area						
	Coastal	Inland	Tensas	GDS	Florida	White River	Arkansas Islands
Excavated	5	2	0	48	0	0	0
Ground nest	57	28	14	44	100	2	8
Hollow log	5	0	0	0	0	0	0
Slash pile	7	19	27	0	0	8	75
Standing snag	0	12	0	0	0	0	0
Hollow stump	11	2	0	4	0	0	0
Tree, elevated entrance	14	30	59	4	0	90	16
Tree, ground entrance	1	7	0	0	0	0	0
N	28	43	22	23	14	51	12

testing the technique, we assumed bears were not stationary during the summer months. Accuracy of location sets to classify bear movement status both during and outside the denning period as stationary (bears with observed dens) or moving (summer locations) was 87%, overall. Thirteen percent of summer–fall bear-seasons were misclassified as stationary and 17% of bears observed in dens were misclassified as moving. Misclassified denned bears included 1 Coastal female with cubs, 1 barren Coastal female, 2 Inland females with yearlings, and 1 Inland female of unknown reproductive condition.

Based on location constancy, we classified 27 of 82 (62 female and 20 male) bear-winters where denning status was previously unknown. Twelve females (10 Coastal, 2 Inland) were classified as stationary for at least 1 location set (i.e., approximately 3 weeks) and 15 (13 Coastal, 2 Inland) were classified as moving. Seven males (6 Coastal, 1 Inland) were classified as stationary for at least 1 location set and 13 Coastal males were classified as moving. We believe winter movement determinations based on our decision rule conservatively estimate denning because in test comparisons we were more likely to classify stationary bears as moving than the opposite. Increasing the maximum distance above the median deviation increased the misclassification of summer–fall bear-seasons to unrealistic levels.

## DISCUSSION

High rates of tree den use have been reported in some southeastern U.S. black bear populations including White River National Wildlife Refuge, Arkansas (Smith 1985, Oli et al. 1997), Great Smoky Mountains National Park, Tennessee (Johnson and Pelton 1981), and the Tensas River Basin of Louisiana (Weaver and Pelton 1994). It has been hypothesized that tree or snag dens with elevated entrances are important to eastern black bear populations because they provide a well-insulated cavity (Johnson et al. 1978) and more protection from disturbance (Johnson and Pelton 1981, Alt and Gruttaduria 1984). Oli et al. (1997) suggested that using tree dens may afford parturient females more energy for activities associated with cub rearing by reducing the amount of energy expended for maintaining body temperature. If these assertions are correct, then we would expect bears, especially parturient females, to use tree-elevated or high security dens when possible. Because we did not measure den availability, we could not directly address den site selection. However, the proportions of high (tree-elevated), low (ground nest), and moderate (all others) den security classes used by parturient females in our study areas did not differ from barren females. These results suggest that security class of dens used was independent of birthing status, but some

caution should be used in interpreting this result. Our small sample sizes resulted in low power to detect differences.

The high proportion of ground nests we observed in the Coastal area was consistent with reports from other coastal plain populations in north central Florida (Wooding and Hardisky 1992) and the Great Dismal Swamp of Virginia and North Carolina (Hellgren and Vaughan 1989). Also, all bears observed in the Mississippi Alluvial Valley populations on Big Island and Montgomery Island in Arkansas used ground nests (White et al. 2001).

An absence of tree dens was thought to have influenced den types used in the Great Dismal Swamp and on Big Island and Montgomery Island in Arkansas (Hellgren and Vaughan 1989, White et al. 2001). Unlike the Coastal forests, most Inland forested lands known to be occupied by bears were managed for commercial hardwood production, potentially reducing the number of available tree-elevated or high security dens. However, Inland bears used and successfully gave birth in low and moderate security dens. Concealment, rather than energetics, may be the most important factor for black bear den site selection in southeastern coastal plain populations (Hellgren and Vaughan 1989), as most low and moderate security dens were located in thick cover.

Tree dens are not necessary for successful reproduction in Louisiana's mild climate if flooding and human disturbance are minimized. Our data were insufficient to test for differences in cub survival among den security classes or den types. However, in Minnesota and Massachusetts, areas with more severe winter weather, McDonald and Fuller (1998) were not able to detect any differences in cub survival rates among dens of 3 thermal efficiency classes. Their results suggest that cub survival is not reduced by use of open dens at ground level. We agree with Smith et al. (1994) that bears adapt to their environments and may use whatever materials are available for den construction.

Denned Coastal and Inland bears behaved differently when approached; Coastal bears were more likely to flee upon approach when occupying low security dens than Inland bears. Flushing of denned bears by researchers has been reported in most studies of black bear denning ecology in the Southeast (Hamilton and Marchinton 1980, Hellgren and Vaughan 1989, Weaver and Pelton 1994). Linnell et al. (2000) hypothesized that denned bears in milder climates lowered their threshold to disturbance because the energetic costs of den abandonment were lower. Our observations in the Coastal area support this assertion. However, Inland bears were more tolerant of intrusion in nearly the same climate. The Coastal terrain was more difficult to navigate and prevented us from approaching den sites as stealthily as was possible in the

Inland area. Our approach through thick cover around Coastal dens was noisy and probably contributed most to den abandonment.

Bear movement away from den sites raised our concern about potential cub abandonment. Many Coastal litters were examined in the den after the female fled, and in many cases she was not observed during the visit. Although some females with cubs changed den sites after our visit, we did not detect any cub abandonment as a result of our activities.

Coastal and Inland bears also differed in extent and probability of winter movement. Location constancy analyses indicated many Coastal bears and a small number of Inland bears continued to move throughout the denning period or only bedded for periods of <3 weeks. Additionally, some Coastal bears classified as stationary during the den season by our location constancy decision rule were stationary only briefly during November or December and began moving before our den visits in February. Distances between weekly winter locations were also greater for Coastal bears (R.O. Wagner and R.M. Pace, unpublished data). Winter-active black bears have been reported in many areas with mild climates (Hellgren and Vaughan 1989, Graber 1990, Weaver and Pelton 1994, Oli et al. 1997). Graber (1990) suggested winter dormancy may be elective for non-parturient females in mild climates where sufficient food is available throughout the winter. We did not measure winter food availability in our study areas, but we did observe fresh scats near winter bedding sites of many Coastal and Inland females with yearlings, as was also reported for bears in the Tensas River Basin (Weaver and Pelton 1994). Some winter foods were still available to bears during February and may have been sufficient to allow bears to remain active and forage while maintaining a positive energy budget.

We only detected 1 barren Coastal female through den season checks, suggesting most unsuccessful den visits were of barren females or females with yearlings. However, we concede that females with 1-cub litters could have carried the cub away from the nest on our approach (Erickson and Martin 1960). We do not believe this occurred in the majority of unsuccessful Coastal den visits, but we did record 1 instance where a female moved, undetected, away from a ground nest at our approach and was observed with 1 cub the following summer.

We detected litters at the majority of observed Coastal dens and they appeared larger, on average, than those observed Inland. We cannot explain the apparent difference in litter-size distribution between the Inland and Coastal populations. The age of females in the 2 study areas were similar and most bears in the Inland area appeared to be healthy, based on a subjective assessment of weight and body condition during den inspection. We believe the

apparent difference in litter size distribution between Inland and Coastal should be interpreted with caution, even though the significance level of the statistical test met our *a priori* level. We were unable to determine the reproductive condition of the female in 50% of Coastal den visits, and a small increase in the proportion of Coastal 1-cub litters would have changed our results.

## MANAGEMENT RECOMMENDATIONS

Availability of suitable dens does not appear to be a limiting factor in the 2 south central Louisiana black bear populations, and den trees are not required for successful reproduction. However, we do recommend protection of potential den trees within the Inland area because a large portion of the Inland population occupies a spillway designed to divert waters from the Mississippi River. No flooding occurred within the spillway during this study, but if waters were released into the spillway during the denning season, all litters in dens at ground level could be lost. Candidate den trees are defined in the U.S. Fish and Wildlife Service listing rule for the Louisiana black bear (U.S. Fish and Wildlife Service 1992) as baldcypress or water tupelo >91 cm diameter at breast height with a visible cavity, occurring in or along rivers, lakes, streams, bayous, sloughs, or other water bodies. We observed bear dens in many tree species including oaks (*Quercus* sp.), American elm (*Ulmus americana*), sweetgum (*Liquidambar styraciflua*), and water hickory (*Carya aquatica*). We recommend modification of this definition to include all tree species meeting the size and cavity criteria, regardless of location relative to water bodies.

We also recommend continued monitoring of both bear populations. Parameters necessary to model the dynamics of either of the populations, including cub and yearling survival and interbirth interval, are unknown. Studies designed to address these questions, as well as determine the cause of low reproductive output of Inland females, are needed.

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