

# Assessing American black bear habitat in the Mobile–Tensaw Delta of southwestern Alabama

Kent R. Hersey<sup>1,2</sup>, Andrew S. Edwards<sup>1,3</sup>, and Joseph D. Clark<sup>4</sup>

<sup>1</sup>Department of Forestry, Wildlife, and Fisheries, 274 Ellington Plant Sciences Building, University of Tennessee, Knoxville, TN 37996, USA

<sup>4</sup>U.S. Geological Survey, Southern Appalachian Field Branch, 274 Ellington Plant Sciences Building, University of Tennessee, Knoxville, TN 37996, USA

**Abstract:** American black bears (*Ursus americanus*) have been extirpated from all but a few areas in southwestern Alabama, and the remaining habitat is being rapidly lost to development. Remnant bear populations exist near extensive (>125,000 ha) bottomland hardwood forests in the Mobile–Tensaw Delta (MTD), but those bottomland areas are rarely used by bears. Reintroduction of black bears to the MTD may improve viability of the remaining bear populations in southwestern Alabama. To evaluate the suitability of this area for bears, we compared habitat conditions at the MTD with similar alluvial habitats at White River National Wildlife Refuge (White River NWR), where bears are numerous. We measured overstory, midstory, and understory vegetation in the MTD and on the North and South management units at White River NWR. We used principal components analysis and principal variable selection to identify 9 variables associated with 5 principal components (hard mast, soft mast, cavity tree availability, large tree availability, and total basal area) that best explained variation among study areas. Differences among the study areas were associated with hard mast, soft mast, and cavity tree availability ( $P \leq 0.001$ ). Hard and soft mast production in the MTD was lower than at White River NWR, but we believe it was adequate. However, suitable den trees, which may be a critical habitat component given the duration and severity of winter flooding, appeared to be lacking in the MTD.

**Key words:** Alabama, Florida black bear, habitat, Mobile–Tensaw Delta, reintroduction, *Ursus americanus*, White River

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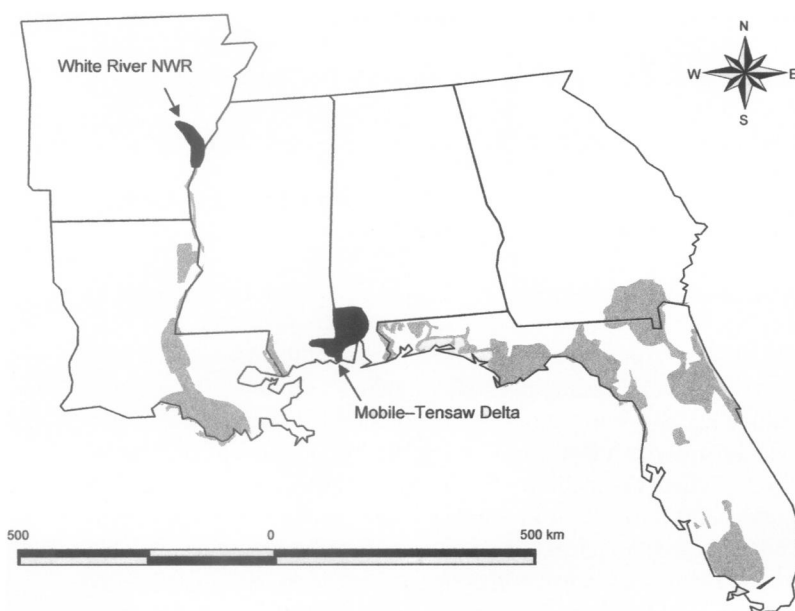
In southern Alabama, American black bears (*Ursus americanus*) were formerly common and many were killed by hunters during the late 1800s (Howell 1921). By the early 1900s, however, black bears were extirpated in Alabama except for in swamps and lowlands of the southernmost counties (Howell 1921). Edwards (2002) found that breeding females existed in only a few, small, isolated uplands in southwestern Alabama that were rapidly being lost to residential housing development. Despite extensive surveys during 1998–2000, Edwards (2002) found no evidence that bears inhabited seasonally flooded bottomland hardwood forests in the MTD and

hypothesized that winter flooding and removal of den trees by loggers excluded bears from the MTD. Because of that flooding, however, the extensive bottomlands in the MTD (>125,000 ha) may be protected from urban sprawl that threatens the upland bear population and, as such, may represent the only secure habitat for future black bear populations in the region.

Bear reintroduction has been proposed for the MTD, and successful restoration has occurred elsewhere in the southeastern US (Smith and Clark 1994, Eastridge and Clark 2001, Eastridge 2001, Reagan et al. 2001). Bears from adjacent declining populations in Alabama might be translocated, or additional bears from elsewhere within the range of the subspecies might be reintroduced, thereby helping bolster the viability of the remnant population. Additionally, demographic and genetic linkages with other black bear populations might be created (Fig. 1, Clark et al. 2002). Because bears currently are not present in the MTD, however,

<sup>2</sup>Present address: State of Utah, Department of Natural Resources, Division of Wildlife Resources, 1594 West North Temple, Suite 2110, Salt Lake City, UT 84114, USA; kentersey@utah.gov

<sup>3</sup>Present address: Pheasants Forever, 1212 Jackson Boulevard, Rochester, IN 46975, USA



**Fig. 1.** Proximity of the Mobile-Tensaw Delta to adjacent Florida black bear populations (gray shaded areas) and to White River NWR (from Pelton and van Manen 1997).

it is important to identify possible habitat deficiencies before reintroduction takes place.

In contrast to the MTD, White River NWR in eastern Arkansas is also seasonally flooded, but bears are numerous (Smith 1985, Bowman et al. 1996, R. Eastridge, Arkansas Game and Fish Commission, Little Rock, Arkansas, USA, unpublished data). Climate, species composition, and flood frequency and duration in White River NWR are similar to that in the MTD. Our goal was to compare habitat features of White River NWR where bears occurred with those features in the MTD where bears were absent, regardless of the reason for extirpation. In so doing, we intended to identify possible habitat deficiencies in the MTD prior to any reintroduction effort.

## Study areas

### Mobile-Tensaw Delta

The southwestern Alabama study area was centered on the MTD (approximately 80,500 ha). The MTD extends from Jackson, Alabama, on the Tombigbee River and Claiborne, Alabama, on the Alabama River southward to Interstate Highway 65 and includes parts of Baldwin, Clarke, Mobile, Monroe, and Washington counties (Fig. 2). The MTD is formed by the confluence of the Alabama and Tombigbee rivers, which combine to form the Mobile River, which in turn divides into

major distributaries, the Middle and Tensaw rivers. Over 80% of the study area was privately owned, most of which was intensively managed for timber production. The remainder of the study area was located on the publicly owned Upper Delta Wildlife Management Area. Vegetation associations consisted of seasonally flooded bottomland hardwoods and permanently flooded swamp forests. Overstory species included bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), laurel oak (*Quercus laurifolia*), Nuttall oak (*Q. nuttallii*), overcup oak (*Q. lyrata*), water oak (*Q. nigra*), willow oak (*Q. phellos*), red maple (*Acer rubrum*), American elm (*Ulmus americana*), and water hickory (*Carya aquatica*). Understory species included deciduous holly (*Ilex decidua*), dwarf

palmetto (*Sabal minor*), switchcane (*Arundinaria gigantea*), pepper-vine (*Ampelopsis arborea*), poison ivy (*Toxicodendron radicans*), greenbriers (*Smilax* spp.), grapes (*Vitis* spp.), and blackberries (*Rubus* spp.). Outside the study area, upland pine and mixed hardwood-pine forests prevailed.

The MTD is temperate rainforest (Bailey 1995); climate is subtropical and characterized by long, hot, humid summers and short, mild winters (National Oceanic and Atmospheric Administration [NOAA] 1978). Mean daily temperatures ranged from 2 to 16°C in January and from 21 to 34°C in July (NOAA 2000). Annual mean precipitation for the study area was 158 cm (NOAA 2000). Winter and spring were the wettest seasons, with March precipitation averaging 16.8 cm (NOAA 2000). Flooding occurred during late winter and early spring, with greatest flood frequency during March.

Elevations in the MTD range from 0.6 to 15.2 m above mean sea level. Sluggish streams, marshes, swamps, and lakes are numerous. Soils are mainly Ultisols, Spodosols, and Entisols and are wet, acidic, and nutrient-poor (Bailey 1995). Silty soils mainly occur in lower areas whereas sands prevail in hilly areas (Bailey 1995).

### White River National Wildlife Refuge

White River NWR (65,000 ha) includes portions of Arkansas, Desha, Monroe, and Phillips counties in eastern

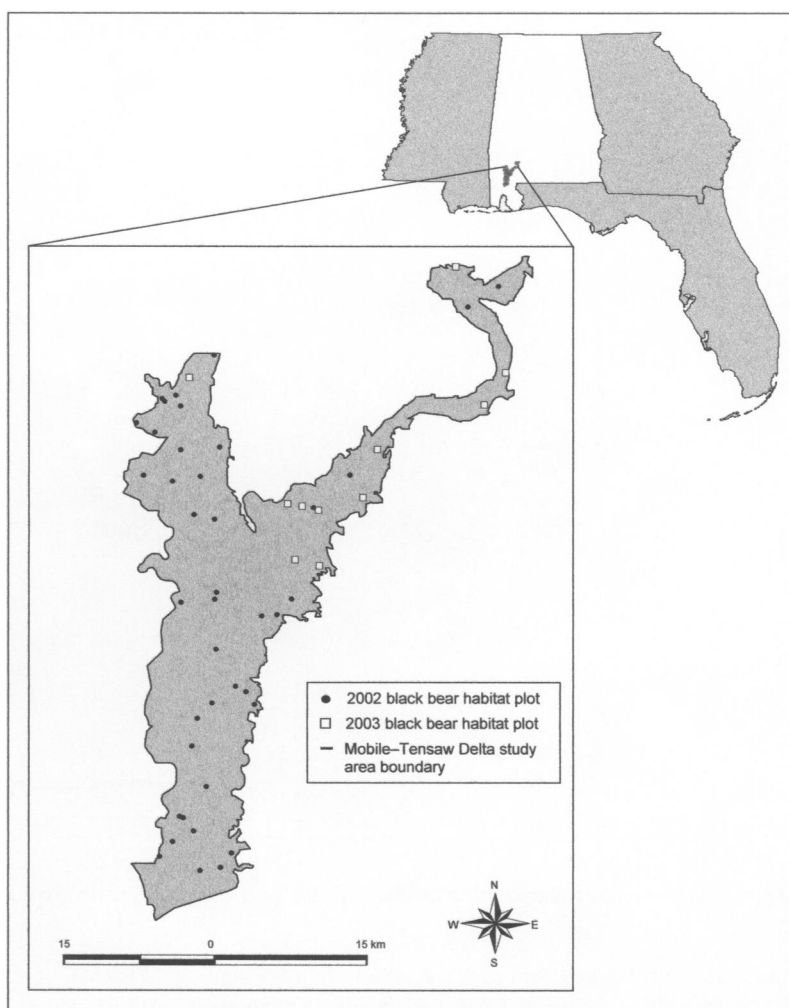
Arkansas (Fig. 3). White River NWR is located in the Lower Mississippi Alluvial Valley and is the largest tract of bottomland hardwoods under single ownership in the United States. The refuge encompasses 145 km of the White River and has >300 lakes and ponds interconnected by a matrix of streams, bayous, and sloughs. Vegetation associations were similar to those of the MTD, consisting of seasonally flooded bottomland hardwoods and permanently flooded swamps. Outside the refuge, land use was dominated by rice and soybean agriculture.

White River NWR is divided into North and South management units. The South Unit (43,000 ha) has been under federal ownership since the establishment of the refuge in 1935. Bear densities were higher in the southern portion of the refuge (Smith 1985, Bowman et al. 1996). The North Unit (22,000 ha) was acquired from Potlatch Timber Company in 1993. Timber on the North Unit had been selectively harvested 3 times since 1970 (J. Denman, US Fish and Wildlife Service, St. Charles, Arkansas, USA, personal communication, 2002).

Climate is similar to southwestern Alabama with long, hot, humid summers and short, mild winters (NOAA 1978). Mean daily temperatures ranged from  $-1$  to  $10^{\circ}\text{C}$  in January and from  $22$  to  $34^{\circ}\text{C}$  in July (NOAA 2000). Annual mean precipitation at White River NWR was 131 cm (NOAA 2000). Like southwestern Alabama, winter and spring were the wettest seasons with March precipitation averaging 14.2 cm (NOAA 2000).

Most of the area is flat, with slopes averaging  $<13$  cm/km (Bailey 1995). Elevations at White River NWR range from 40.8 to 48.2 m above mean sea level. Flooding from the White River annually inundated about 75% of the refuge during winter and spring. Soils are a mosaic of Inceptisols in alluvial bottomlands; Alfisols occur in areas of loess and Mollisols are found in swamp areas (Bailey 1995).

At White River NWR, vegetation occurred along a continuum of decreasing flood tolerance from the lowest to the highest elevations (Fredrickson and Heitmeyer 1988, Smith 1996, Richardson 2000). In the wet areas,



**Fig. 2. Mobile-Tensaw Delta study area and plot locations, southwestern Alabama, 2002–2003.**

bald cypress, water tupelo, and overcup oak dominated. At moderately wet sites, Nuttall oak, green ash, sweet pecan (*Carya illinoensis*), and water hickory were more prevalent. On the drier sites, red maple, sweetgum, cherrybark oak (*Q. pagoda*), and willow oak were dominant. Annual flooding limited understory density, but heavy seedbanks were present. Common understory species included deciduous holly, green ash, overcup oak, American elm, sugarberry, swamp privet (*Forestiera acuminata*), and buttonbush (*Cephalanthus occidentalis*).

## Methods

### Vegetation plots

Bowman (1999) developed a habitat suitability index (HSI) model for black bears in Mississippi based on



**Fig. 3. White River National Wildlife Refuge and plot locations, Arkansas, 2000–2003.**

measures of hard and soft mast production. Bowman (1999) found that soft mast basal area, hard mast canopy cover (i.e., hard mast basal area/total basal area), and hard mast basal area of mature trees were the best indicators of black bear habitat suitability in Mississippi. In addition to such mast production data, we collected data on canopy closure, horizontal cover, and den availability because all have been shown to be important habitat components for black bears (Landers et al. 1979, Hamilton and Marchinton 1980, Smith 1986, Hellgren and Vaughan 1989, Oli et al. 1997, Dobey et al. 2002). Forest inventory data were also collected at White River NWR in conjunction with its timber management program (J. Denman, US Fish and Wildlife Service, St. Charles, Arkansas, USA, unpublished data). We established sampling protocols that enabled us to calculate variables used in Bowman's (1999) HSI model and also use existing White River NWR data.

Consistent with White River NWR forest inventory data, we used a cluster sampling structure to sample habitat in the MTD. Each plot consisted of 5 subplots

(Fig. 4). Although systematic sampling was used at White River NWR, randomized sampling was conducted in the MTD because we were unsure of the number of plots we would need to sample. We used random plots so the entire study area would be evenly sampled (i.e., unbiased) regardless of the cutoff point. We used the running mean approach to assess sampling effort in the MTD (Mueller-Dombois and Ellenberg 1974). We established random plots in the MTD with ArcView® Version 3.2 (Environmental Systems Research Institute Redlands, California, USA) prior to field work and worked systematically to sample those points over a 2-year period.

Data collected at each subplot were averaged by plot. Subplots in the MTD were located 100 m from the central plot in each direction (north, south, east and west), whereas satellite plots at White River NWR were located 80.5 m (i.e., 4 chains; 1 chain = 66 ft) away from the central plot in each cardinal direction. We used 100 m in the MTD because those points were easier to locate with our global positioning system than were points

80.5 m from the central plot, and because it was unlikely that the increased distance between subplots would bias the combined plot mean (Fig. 4).

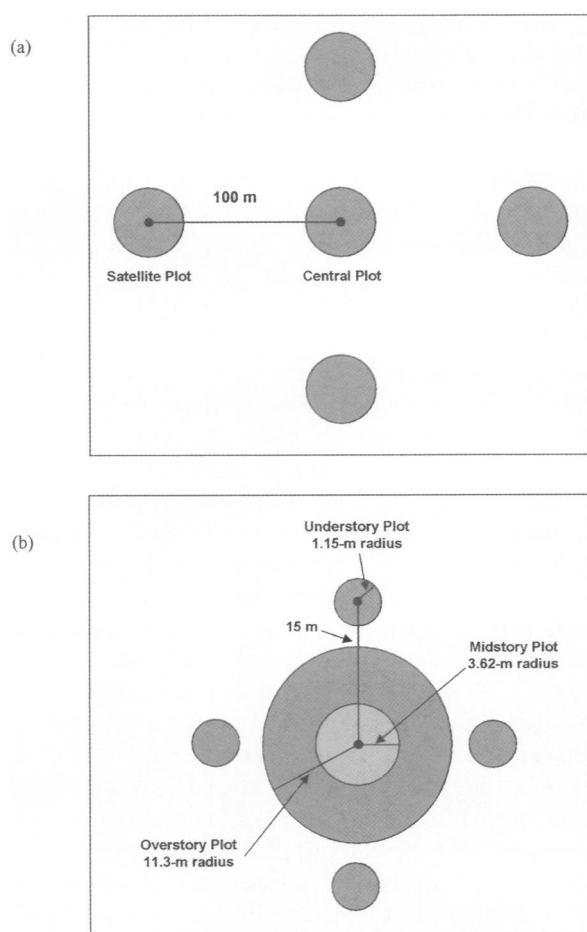
At White River NWR, subplots that were located in water bodies (e.g., lake, river) were not sampled. In the MTD, we moved central plots in a cardinal direction to the closest bank so none of the subplots would be affected by water. That was done to maximize our sampling effort given the extended length of time required to reach many of the plots, again assuming this procedure produced no biases.

At each subplot, we recorded the cover type (oak-mixed hardwoods, cypress-tupelo, or disturbed) and collected data on canopy closure, overstory, midstory, horizontal cover, understory, and den tree availability. We estimated canopy closure using a Model A spherical densiometer (Lemmon 1956) by taking 4 densiometer readings per subplot, 1 in each cardinal direction. We multiplied the readings by a correction factor of 1.04 to estimate the percent of overhead area not occupied by the canopy (Lemmon 1956), using the difference between this value and 100 as an estimate of overstory density.

We sampled the overstory within 11.3-m radius plots (0.04 ha, Bowman 1999), recording species and diameter at breast height (DBH) for each live tree  $\geq 12.7$  cm DBH. We sampled the midstory within 3.62-m radius plots (0.004 ha, Bowman 1999), recording all live vegetation  $\geq 1.5$  m in height not included in the overstory plot. Data were recorded as a stem count by species. All vines above the required height also were included on the midstory plots.

We used a cover pole (Nudds 1977, Griffith and Youtie 1988) to estimate the density of horizontal cover. We took 4 cover-pole readings at each subplot, 1 in each cardinal direction. Each reading was taken 15 m away, with the observer standing at the plot center. We then sampled the understory at 4 locations per subplot, 1 in each cardinal direction. Each understory plot was located 15 m from the plot center and was 1.15 m in radius (0.0004 ha, Bowman 1999). We recorded the percent cover of all hard or soft mast vegetation  $< 1.5$  m in height.

Trees were the primary den type for black bears at White River NWR (Smith 1986), but they must be large and contain a cavity of sufficient size to be suitable. Therefore, we searched for large trees within 100-m  $\times$  100-m plots (1 ha) in the MTD and within 80.5-m  $\times$  80.5-m plots (0.65 ha) at White River NWR; these tree searches were centered on each of the subplots. We considered all trees  $\geq 84$  cm DBH (Johnson 1978) to be potential den trees. We recorded species, DBH, presence of a cavity, and visible bear sign (such as claw marks)



**Fig. 4.** Black bear habitat sampling plot structure used in the Mobile-Tensaw Delta study area, Alabama, 2002–2003: (a) cluster sampling structure and (b) overstory, midstory, and understory plots comprising each subplot.

for each tree. If a cavity was present, we recorded the size of the opening (0–15 cm, 15–30 cm, or  $> 30$  cm) and height above ground. Tree counts were then rescaled into densities (e.g., 2.5 trees/hectare).

We calculated total basal area, soft mast basal area, soft mast canopy cover (soft mast basal area/total basal area), hard mast basal area, hard mast basal area of mature trees, hard mast canopy cover, canopy closure, den tree availability, and horizontal cover. Total basal area was used to determine whether overall stand stocking differed among study areas, and we used canopy closure as an index of understory growth. We assessed den tree availability using 3 variables: number of large trees, number of large trees with the presence of

any cavity, and number of large trees with a cavity suitable for a bear (large opening, above flood line). The number of large trees with a cavity suitable for a bear was a measure of current den availability, whereas the other 2 variables represented future den availability. Finally, we measured horizontal cover at 4 height strata (0.0–0.5 m, 0.5–1.0 m, 1.0–1.5 m, and 1.5–2.0 m); cover is a critical habitat component for bears in the southeastern US (Landers et al. 1979, Hamilton and Marchinton 1980, Hellgren and Vaughan 1989, Telesco 2003).

### Study area comparisons

We defined our study areas as White River North, White River South, and the MTD. We separated White River NWR into 2 strata because of possible differences in habitat based on past management practices and because bear densities were lower in the northern section of the refuge (Smith 1985, Bowman et al. 1996). To reduce the large suite of habitat variables, we performed a principal components analysis on the correlation matrix using robust methods and a Varimax rotation (Johnson 1998). We used an eigenvalue cutoff of 0.7 (W. Seaver, University of Tennessee, Knoxville, Tennessee, USA, personal communication, 2003) to determine important principal components and used factor loadings to identify variables associated with each component. The significant principal components were then used in a principal variable selection to identify the principal components that contributed most to differences among study areas based on changes in  $R^2$ .

We used pairwise randomization tests (Edgington 1995) based on 10,000 Monte Carlo simulations to examine the selected principal components in multivariate and univariate frameworks using study area as the dependent variable and the selected principal components as the independent variables. We chose to use randomization tests because the original variables were not normally distributed and because randomization tests do not require that assumption to be met. For multivariate comparisons, we used Hotelling's  $T^2$  test statistic with Bonferroni procedures ( $\alpha_{\text{Overall}} = 0.05$ ,  $\alpha_{\text{Individual}} = 0.05/3$  or 0.017) to determine which pairings of study areas were different. If differences between areas were detected, we individually compared principal components using the Student's  $t$  test statistic with the Bonferroni adjustment.

Finally, we used Bowman's (1999) HSI values for bottomland hardwoods and clearcuts (0.88 and 0.28, respectively) combined with the percent of each cover type to obtain overall HSI scores for each study area. We defined bottomland hardwoods as oak-mixed hard-

woods or cypress-tupelo cover types. We pooled disturbed cover types and clearcuts.

### Results

We estimated that the MTD was comprised of 65.1% oak-mixed hardwoods, 18.8% cypress-tupelo, and 16.1% disturbed cover types, resulting in an HSI score of 0.79. White River North was comprised of 93.8% oak-mixed hardwoods and 6.2% disturbed, whereas the White River South was comprised of 99.3% oak-mixed hardwoods and 0.7% disturbed, resulting in overall HSI scores of 0.85 and 0.88, respectively.

We measured overstory, midstory, and understory at 51 plots in the MTD during summer 2002 and 2003 (Fig. 2), whereas we and refuge personnel collected data at 93 plots (39 on the North Unit and 54 on the South Unit; Fig. 3) in White River NWR from June 2000 to December 2002 and during summer 2003. Unusual spring and summer flooding during 2003 inundated much of the MTD, limiting our ability to evenly sample the entire area, particularly in the southern portion. Means did not differ between 2002 and 2003, suggesting that the data were not biased because of the flooding.

Seven principal components accounted for 95.0% of the variation in the data. The first component (horizontal cover) contained all 4 horizontal cover variables (Table 1). The second component (hard mast) contained hard mast basal area, hard mast basal area of mature trees, and hard mast canopy cover, and the third component (soft mast) contained soft mast basal area and soft mast canopy cover. The fourth component (cavity tree availability) included number of large trees with any cavity and number of large trees with a cavity suitable for a bear. The fifth, sixth, and seventh components consisted of single variables: canopy closure, large tree availability, and total basal area, respectively.

Principal variable selection indicated that 5 principal components (hard mast, soft mast, cavity tree availability, large tree availability, and total basal area) best explained the variation among the study areas (combined  $R^2 = 0.46$ , Table 1). Those 5 principal components differed ( $\alpha_{\text{Individual}} = 0.017$ ) between the MTD and White River North ( $T^2 = 29.54$ ; 5, 29.4 df;  $P = 0.001$ ) and the MTD and White River South ( $T^2 = 92.49$ ; 5, 60.6 df;  $P < 0.001$ ). We found no difference between White River North and South units ( $T^2 = 15.55$ ; 5, 57 df;  $P = 0.020$ ; Table 2). The MTD had lower values for the hard and soft mast principal components ( $t = 2.47$ – $3.79$ ,  $P = <0.001$ – $0.015$ ) than the North Unit, but we found no differences between cavity tree availability, large tree

**Table 1. Habitat variables associated with each principal component obtained from the principal components analysis and associated  $R^2$  with each principal component.**

Principal component	Associated variables	$R^2$	Change in $R^2$
Hard mast	Hard mast basal area	0.24	0.24
	Hard mast basal area of mature trees		
Soft mast	Hard mast canopy cover	0.37	0.12
	Soft mast basal area		
Cavity tree availability	Soft mast canopy cover	0.43	0.06
	Number of large trees with any cavity		
Large tree availability	Number of large trees with a cavity suitable for a bear	0.45	0.02
	Number of large trees		
Total basal area	Total basal area	0.46	0.01
Canopy closure	Canopy closure	0.47	0.01
Horizontal cover	Horizontal cover (0.0–0.5 m)	0.47	0.00
	Horizontal cover (0.5–1.0 m)		
	Horizontal cover (1.0–1.5 m)		
	Horizontal cover (1.5–2.0 m)		

availability, and total basal area ( $t = 0.49$ – $2.15$ ,  $P = 0.028$ – $0.627$ ). We found lower values for hard mast, soft mast, and cavity tree availability principal components ( $t = 2.71$ – $5.70$ ,  $P \leq 0.001$ ) in the MTD than at White River South, but no differences between large tree availability and total basal area ( $t = 1.07$ – $1.14$ ,  $P = 0.253$ – $0.287$ ).

## Discussion

Our estimates of food resources at White River were much higher than at the MTD, suggesting that habitat in the MTD may not be suitable. However, Tensas River National Wildlife Refuge in Louisiana is comprised of similar alluvial bottomland cover types, has a viable bear population (Boersen et al. 2003), but has a hard mast basal area of mature trees of  $6.98 \text{ m}^2/\text{ha}$  (from Shropshire 1996), only slightly higher than in the MTD ( $5.39 \text{ m}^2/\text{ha}$ ). Thus, food resources in the MTD may be adequate to support black bears. Interestingly, HSI scores for food resources in the MTD were only slightly lower than at White River NWR. However, HSI models are relative rather than absolute measures of habitat suitability, and markedly lower but adequate food

**Table 2. Pairwise randomization test statistics and  $P$ -values (Hotelling's  $T^2$  test for overall and Student's  $t$  tests for individual variables) for comparisons of principal component values for the Mobile-Tensasaw Delta, Alabama and White River North and White River South, Arkansas ( $\alpha_{\text{Overall}} = 0.05$ ,  $\alpha_{\text{Individual}} = 0.05/3$ ).**

Principal component category	Mobile-Tensasaw Delta vs. White River North	Mobile-Tensasaw Delta vs. White River South	White River North vs. White River South
Overall	29.54 (<0.001)	92.49 (<0.001)	15.55 (0.020)
Hard mast	2.47 (0.015)	5.70 (<0.001)	2.24 (0.031)
Soft mast	3.79 (<0.001)	3.80 (<0.001)	0.70 (0.490)
Cavity tree availability	2.15 (0.028)	2.71 (0.001)	0.75 (0.492)
Large tree availability	1.68 (0.099)	1.07 (0.291)	2.23 (0.030)
Total basal area	0.49 (0.634)	1.14 (0.253)	0.68 (0.504)

resources in the MTD would properly result in only a slightly lower HSI score.

Differences in forest management on the 3 study areas likely explain observed differences in food availability (Table 3). Clearcutting was used extensively to harvest timber in the MTD, and clearcut stands often were colonized by sweetgum, an invasive, shade-intolerant species. Regrowth of sweetgum contributes to total basal area, but it is not a mast species and its presence decreases the amount of hard and soft mast available in the MTD. In contrast, selective thinnings and uneven-aged regeneration methods designed to facilitate oak regeneration were used at White River South (J. Denman, US Fish and Wildlife Service, St. Charles, Arkansas, USA, personal communication, 2003). Consequently, hard and soft mast measures there were higher. Prior to 1993, White River North was managed such that only trees  $\geq 66 \text{ cm}$  DBH were harvested (J. Denman, personal communication, 2003). Thus, hard mast species, generally being larger than soft mast species, were often removed at White River North, explaining why we found higher point estimates for hard mast variables (the  $P$ -value approached statistical significance) at White River South. Conversely, soft mast species were rarely harvested, explaining why we were unable to detect any difference between soft mast at White River North and South, but found more soft mast on the North unit than in the MTD.

Cover type differences between the 3 areas also may contribute to differences in food availability. We found more disturbed areas (clearcuts) in the MTD than on either management unit at White River NWR. Those

**Table 3. Habitat variable means and 95% confidence intervals for the Mobile-Tensaw Delta, Alabama, and White River North and White River South study areas, Arkansas, 2002–2003.**

	Mobile-Tensaw Delta		White River North		White River South	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Total basal area (m <sup>2</sup> /ha)	30.46	26.43–34.48	25.23	20.63–29.83	26.08	22.17–29.99
Hard mast basal area (m <sup>2</sup> /ha)	6.50	4.86–8.14	10.89	9.01–12.76	14.61	13.01–16.20
Hard mast basal area of mature trees (m <sup>2</sup> /ha)	5.39	3.93–6.86	9.17	7.50–10.85	12.26	10.83–13.68
Hard mast canopy cover (%)	27.78	21.77–33.79	43.10	36.23–49.98	57.63	51.78–63.47
Soft mast basal area (m <sup>2</sup> /ha)	1.41	0.38–2.45	4.93	3.75–6.11	4.60	3.59–5.60
Soft mast canopy cover (%)	7.56	3.71–11.41	19.02	14.61–23.42	17.12	13.38–20.87
Large trees (trees/ha)	0.91	0.58–1.25	0.91	0.41–1.40	1.91	1.55–2.28
Large trees with any cavity (trees/ha)	0.13	0.02–0.23	0.16	0.01–0.32	0.38	0.26–0.49
Large trees with a cavity for a bear (trees/ha)	0.00	0.00–0.09	0.11	0.00–0.24	0.28	0.19–0.38

clearcuts contained few overstory trees to contribute to food resources. However, those areas contained thick understory and midstory vegetation and could prove to be important sources of soft mast for bears in the MTD. Additionally, the cypress-tupelo cover type was extensive in the MTD and only occurred at White River NWR along river margins. Cypress-tupelo swamps, although potentially good denning habitat, contained few hard or soft mast species.

We located many large trees with cavities suitable for bears at White River South ( $\bar{x}$  = 0.28 trees/ha) and North ( $\bar{x}$  = 0.11 trees/ha), but we were unable to find any such trees in the MTD. Differences in densities of those trees reflect differing management practices on the 3 study areas. The MTD is mostly privately owned, and many landowners use their forests as a source of income. Those landowners view large trees showing signs of rot or decay as unhealthy (poor growing stock, poor genetic quality) and consequently remove them (D. Powell, Mobile Forest Products, Mobile, Alabama, USA, personal communication, 2003). In contrast, selective thinning and uneven-aged regeneration methods at White River South resulted in the retention of substantial numbers of large-diameter-class trees (66–100 cm; J. Denman, personal communication, 2003). At White River North, diameter-limit cutting methods resulted in only large trees being removed. Contrasting forest management practices explain why we observed higher numbers of large trees (the *P*-value neared statistical significance) at White River South than White River North, but found no difference in large tree availability between the MTD and the White River North. However, because trees with large cavities were not actively being removed from the stands as in the MTD, we detected no differences in densities between White River North and South.

### Management implications

A striking difference between the MTD and White River NWR was density of large trees with cavities suitable for a bear. Although not true for all wetland types (White et al. 2001, Hightower et al. 2002), availability of adequate den sites can be critical in forested wetlands where flat terrain and seasonal flooding reduces availability of safe ground dens (Oli et al. 1997). Tree dens are likely preferred by bears over other den types (Hamilton and Marchinton 1980, Weaver and Pelton 1994), and bears make extensive use of tree dens in bottomland hardwoods subject to flooding (Smith 1986, Weaver and Pelton 1994, Anderson 1997, Oli et al. 1997, Dobey et al. 2002). By using tree dens, bears increase energy savings, minimize likelihood of disturbance, and may enhance neonate survival (Johnson et al. 1978, Johnson and Pelton 1981). Although management practices used at White River NWR may be economically infeasible on private lands, availability of den sites in the MTD would greatly improve if landowners could be convinced to leave a few large, low-value (poor growing stock, low-value species) trees. This could be accomplished in the time required for tree cavities to form (8–30 years, Carey and Sanderson 1981) because some large trees already are present and tree growth in the MTD is rapid (Mader 1990). A limited number of elevated sites exist at the MTD where flooding does not or rarely occurs (Hersey 2004), and such elevated areas have been used for ground denning by bears in other bottomland habitats (White et al. 2001). Researchers at Felsenthal National Wildlife Refuge in Arkansas have had success reintroducing bears via artificial den structures (Wear 2003). Although those structures were placed on the ground, it may be possible to place them in trees, above flood stage. In areas with limited den sites,

it is likely that den reuse would be high (Alt 1984, Schwartz et al. 1987, Hayes 1990).

In the near term, we feel that a reintroduction or translocation could be successful in the MTD if suitable den sites can be provided. However, food resources are relatively low at the MTD and home ranges of reintroduced bears may be large. Ultimately, bear movements and population viability will be the best measures of habitat quality in the MTD.

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