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Assessment of Water Resources and Watershed Conditions in Horseshoe Bend National Military Park, Alabama

Natural Resource Report NPS/SECN/NRR—2010/268

ON THE COVER
Tallapoosa River, Horseshoe Bend National Military Park
Photograph by: Michael Mallin

Assessment of Water Resources and Watershed Conditions in Horseshoe Bend National Military Park, Alabama

Natural Resource Report NPS/SECN/NRR—2010/268

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Executive Summary

The purpose of this report was to locate and examine existing information pertaining to the water quality in and around Horseshoe Bend National Military Park (HOBE NMP), assess the present and likely future water conditions of the park, and make recommendations to fill existing information gaps. Water quality and quantity, habitat issues, the potential for invasive species, trends in park resource use, and watershed influences and other stressors were addressed insofar as possible through available data and first-hand observations.

HOBE NMP is a small park (2,040 acres) with only one significant water body, a ~3.7-mile segment of the Tallapoosa River that flows through it and represents its most prominent natural feature. The park is named for a "horseshoe-like" bend in the river. The park also contains two springs, a small perennial stream, and several intermittent streams. The park's wetlands have not been well characterized, but they were recently delineated using GIS and occur as narrow fringes of swamp forest mostly along the river.

The middle Tallapoosa River basin, including the park, is a predominantly rural setting with mostly forested land cover. The park is located along the river between dams and hydropower facilities at two run-of-river impoundments, Harris Lake about 20 miles upstream, and Lake Martin's dam about 25 miles downstream. Since the upstream dam was constructed in 1980, the river segments downstream, including the park area, have been subjected to changes in river flow from as low as zero to 16,000 cfs. Thus, river flow is highly regulated, and the park has no control over river stage. The upper Tallapoosa River system also has been targeted as a potential source of potable water for Atlanta, GA.

Based on recently compiled species lists, the park contains a rich wetland plant flora. Fish species and herpetofauna also are well represented, but information is not available for microalgae (suspended or benthic) and little is known about benthic macroinvertebrates.

The larger Mobile River watershed, which contains the Tallapoosa River and HOBE NMP NMP, historically was home to many endemic species including fishes, mussels, aquatic snails, turtles, aquatic insects and crustaceans. During the past two centuries, watershed development has led to species extinctions at a rate unparalleled elsewhere in the mainland U.S., and various aquatic and wetland species are now threatened or endangered. The habitat fragmentation imposed by the Harris and Lake Martin dams, along with two other dams on the lower Tallapoosa River, have affected faunal diversity, species distributions, and fisheries. For example, shoals of the Tallapoosa River support populations of Cahaba lily (*Hymenocallis coronaria*), which has a limited distribution and requires swift current to flourish. This wetland plant has been eliminated from portions of its native range by impoundments, and is not listed among the park flora. Two protected mussel species, the finelined pocketbook (*Lamsilis atilis*) and the ovate clubshell (*Pleurobema perovatum*), are thought to be rare although present within park boundaries, but their ability to re-colonize the Tallapoosa, including park waters, is impeded by the impoundments along the river. Three of the four endemic fish species known from the Tallapoosa basin are on the park species list, including the lipstick darter (*Etheostoma chuckwachatte*), the Tallapoosa shiner (*Cyprinella gibbsi*), and the mottled sculpin (*Cottus bairdi*).

The Tallapoosa River serves as a transportation corridor for exotic species, and exotic animal and plant species, both terrestrial and aquatic, are a major concern for HOBE NMP. The aquatic invasive Asiatic clam, *Corbicula fluminea*, is assumed to be present in Park waters. Given its high growth and reproduction rates and its high tolerance for polluted environments, this species has the capacity to alter the aquatic food web of the river and to displace native bivalve molluscs.

There is a general dearth of information about the park's aquatic resources, with exception of a USGS stream flow station that tracks hydrologic conditions. Water quality data are available Auburn University's Alabama Water Watch for a short period of record. From these data, pH and dissolved oxygen were below acceptable conditions for Fish and Wildlife classification in 36% and 5%, respectively, of the samples collected, whereas turbidity was acceptable for maintenance of aquatic life. Limited nutrient data suggest mesotrophic (moderately productive) or eutrophic (nutrient over-enriched) conditions. The state environmental agency monitors some sites along the Tallapoosa River, not near the park, for mercury content in fish, and occasionally has reported fish consumption advisories. Data are lacking for fecal coliform bacteria, nutrient concentrations, chlorophyll *a* as an indicator of algal biomass, or toxic substances.

Present water quality concerns in the middle Tallapoosa sub-basin are sedimentation from increased clearcutting, pollution from agriculture and silvaculture, and atmospheric deposition of dust/particulates, toxic contaminants, and other pollutants from larger cities in the state and from Atlanta, Georgia. While the middle Tallapoosa sub-basin, at present, is only about 5% urbanized, the combined pressures of anticipated increased development in both the upper and middle basins are expected to increase land disturbance and water pollution including excessive suspended sediments, nutrients, fecal bacteria, and toxic substances. Although the overall potential for nonpoint source impairment in the middle sub-basin has been evaluated as low, more than half of the sub-watersheds in this sub-basin were estimated by the state environmental agency to have moderate potential of nonpoint source impairment because of runoff from forestry practices, clearcutting, and sedimentation.

Recommendations

The Tallapoosa River is the most prominent natural feature of HOBE NMP, yet the status of the park's water resources is very poorly known. The NPS is ill-equipped to protect its vitally important water resources from airshed and watershed pollution and other stressors because of the near-total lack of fundamental information on water quality conditions or aquatic community health. The following recommendations were developed considering these points. The first four recommendations concern water quality; the next six recommendations pertain to ecosystem and community health, including sampling programs for macroinvertebrates and fish, updated inventories of herpetofauna and wetland flora, and baseline inventories for suspended and benthic microalgae. The last recommendation covers action that is needed to strengthen public stewardship through education outreach.

Water Quality

As a short-term, high-priority action, a two-year water quality monitoring program should be established for at least two stations in the Tallapoosa River within the park. This program should be put in place on a biweekly (preferably, to capture effects of pollution from storm events) or monthly basis in order to establish and track water quality conditions in the Tallapoosa River within the park. Parameters measured should include, at a minimum, water temperature, pH, dissolved oxygen, suspended solids, turbidity, nutrients (TN, TP, nitrate, ammonium, BOD_5), fecal coliform densities, and chlorophyll *a* concentrations. The data should be evaluated with respect to published benchmarks for acceptable water quality.

Data should be collected at least once per year on toxic substance concentrations (PCBs, heavy metals, pesticides, pharmaceuticals) in sediments and fish or benthic faunal tissues.

The park should inventory changes in land use/land cover in the middle Tallapoosa basin, especially within ten miles of the park, including traditional categories but also septic tanks in new subdivisions, new highway projects, new shopping centers, and other potential sources of water pollution. The data should be used to create GIS maps of these sources, which can be upgraded over time to help the NPS track pollution and its impacts in park waters.

The smaller streams in the park should be assessed during high-precipitation periods to assess whether any of them are a source of suspended sediments and other pollution to the Tallapoosa River in the park area.

Ecosystem and Community Health

At least once per year during an appropriate seasonal timeframe, the macroinvertebrate communities in the park segment of the Tallapoosa River should be assessed in at least two stations. Benchmarks should consider published descriptions of healthy macroinvertebrate communities in warmwater streams. The data should be used to track stream ecological condition (rated from Excellent to Poor) over time.

At least once per year during an appropriate seasonal timeframe, the fish community in the park segment of the Tallapoosa River should also be assessed. The fish data should be used to develop an Index of Biotic Integrity and an Index of Well-Being for fish population health over time.

The park's wetland ecosystems should be assessed, and then updated at five-year intervals, for indices of diversity, function, and overall health.

An updated biological inventory should be completed for herpetofauna, and further updates should be completed at five-year intervals.

A baseline biological inventory is needed for the composition and abundance of microalgal assemblages. In at least two stations, triplicate samples should be collected monthly for suspended microalgae, and at least five samples should be collected bimonthly for benthic microalgae. Chlorophyll *a* concentrations should also be assessed for suspended microalgae. The data on suspended microalgae should be assessed over time to discern relationships with environmental conditions such as nutrient concentrations and turbidity. The benthic microalgal data should be use to develop a periphyton index of biotic integrity as another measure of ecosystem health for the Tallapoosa River in the park area.

A sampling program should be developed to establish present conditions and track changes in exotic invasive species affecting terrestrial as well as aquatic/wetland sources in the park. Assessment of exotic invasive species should be repeated at least at three-year intervals.

Groundwater and Air Quality

Groundwater resources of the park should be assessed through partnership with the USGS, including recharge/discharge areas, movement, and chemical quality.

Data are needed to assess the extent to which air pollution is affecting the park, and to forecast how increasing air pollution from major population centers will affect its waters and other natural resources. The park should install sampling devices to establish present air quality conditions and track air pollutants such as ammonium, particulates, and toxic substances (for example, mercury).

Education Outreach

HOBE NMP serves as an important greenspace. The park should strengthen its environmental education program to instruct visitors about the importance of greenspaces in ecosystem sustainability.

Acknowledgments

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Abbreviations

ADEM – Alabama Department of Environmental Management
AL – Alabama
AWW – Alabama Water Watch (volunteer program of Auburn University)
cfs – cubic feet per second
cfu – colony-forming units
DO – dissolved oxygen
ERMF – Environmental Research and Mapping Facility (of the University of Tennessee)
HOBE NMP – Horseshoe Bend National Military Park
m – meter
mgd – million gallons per day
mg/L – milligrams per liter (= parts per million)
µg/L – micrograms per liter (= parts per billion)
N – nitrogen: TN, total nitrogen
NCSU CAAE – North Carolina State University's Center for Applied Aquatic Ecology
NPS – National Park Service
NTU – nephelometric turbidity units
P – phosphorus: TP, total phosphorus; SRP, soluble reactive phosphate
park – Horseshoe Bend National Military Park
STORET – Storage and Retrieval Environmental Data System (of the U.S. EPA)
TWP – Tallapoosa Watershed Project (of Auburn University)
TMDL – total maximum daily load
TSS – total suspended solids
U.S. EPA – United States Environmental Protection Agency
USGS – United States Geological Survey

Park Description

Background

Location, Size, and Boundaries

Horseshoe Bend National Military Park (HOBE NMP), located in east central Alabama in Tallapoosa County (latitude 325833N, longitude 0854411W), is a small park (2,040 acres; *Figures 1, 2*) traversed by the Tallapoosa River, a tributary of the Mobile River. It is about 20 miles downstream from the Harris Dam at the outflow of the Harris Lake impoundment, and about 6 miles upstream from the Lake Martin impoundment. The park is easily accessible from State Highway 49, 5 miles south of New Site (population ~850) and ~12 miles north of Dadeville (population ~4,300). The largest nearby human population center is Alexander City (population ~16,000) about 13 miles west, adjacent to Lake Martin. Birmingham lies about 90 miles northwest, Montgomery is about 70 miles southwest, and Atlanta, GA is about 110 miles northeast.

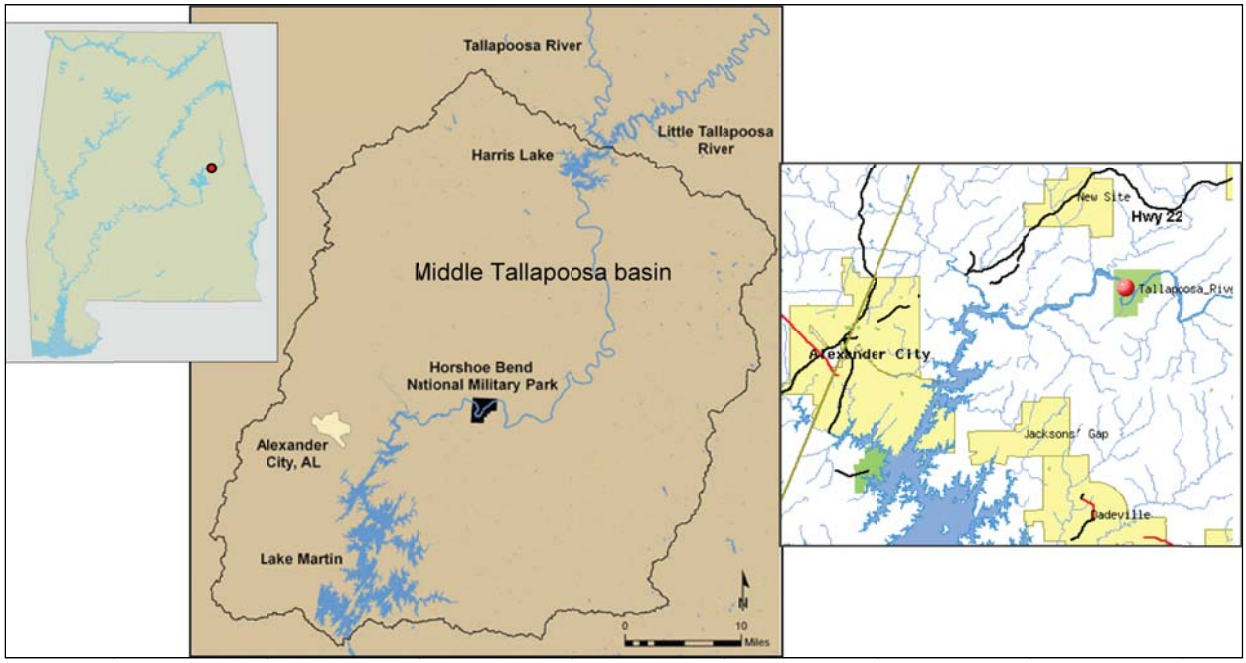

Figure 1. Location of HOBE NMP (left – red dot; right – green area with red dot) in east central Alabama, within the middle Tallapoosa sub-basin (designated sub-basin #03150109) between Harris Lake and Lake Martin (direction of water flow, from north to south). Maps from the CAAE (left – by S. Flood; middle – by M. Rothenberger) and from the U.S. Census Bureau (right – **http://tiger.census.gov**).

This park is under the jurisdiction of the NPS and is one of the four dedicated War of 1812 parks in the NPS system along with Fort McHenry National Monument in Baltimore, Perry's Victory & International Peace Memorial in Ohio, and Chalmette National Battlefield in New Orleans.

The park elevation ranges from ~540 feet to more than 600 feet on river hills (Dusi and Dusi 1997). The NPS currently maintains a Visitors Center and museum, a 2.8-mile nature trail, a 3-mile tour road, picnic areas, and the battlefield where the final battle of the Creek War was fought on 27 March 1814 (see below). The Park Superintendent has an office on-site

(http://www.nps.gov/HOBE NMP). Land use within park boundaries is primarily forested by upland and floodplain mixed hardwoods and pines. Grasslands and cleared grass fields associated with battlefields and park facilities can be found in the central regions of the park; the "Battlefield Area" has large open areas of well-mowed grasses interspersed with patches of mixed forest. In the visitors area, a paved road can be used to reach various observation posts; there is also a Battlefield Hiking Trail and a Nature Hiking Trail. A network of several miles of service roads traverse the non-visitors area.

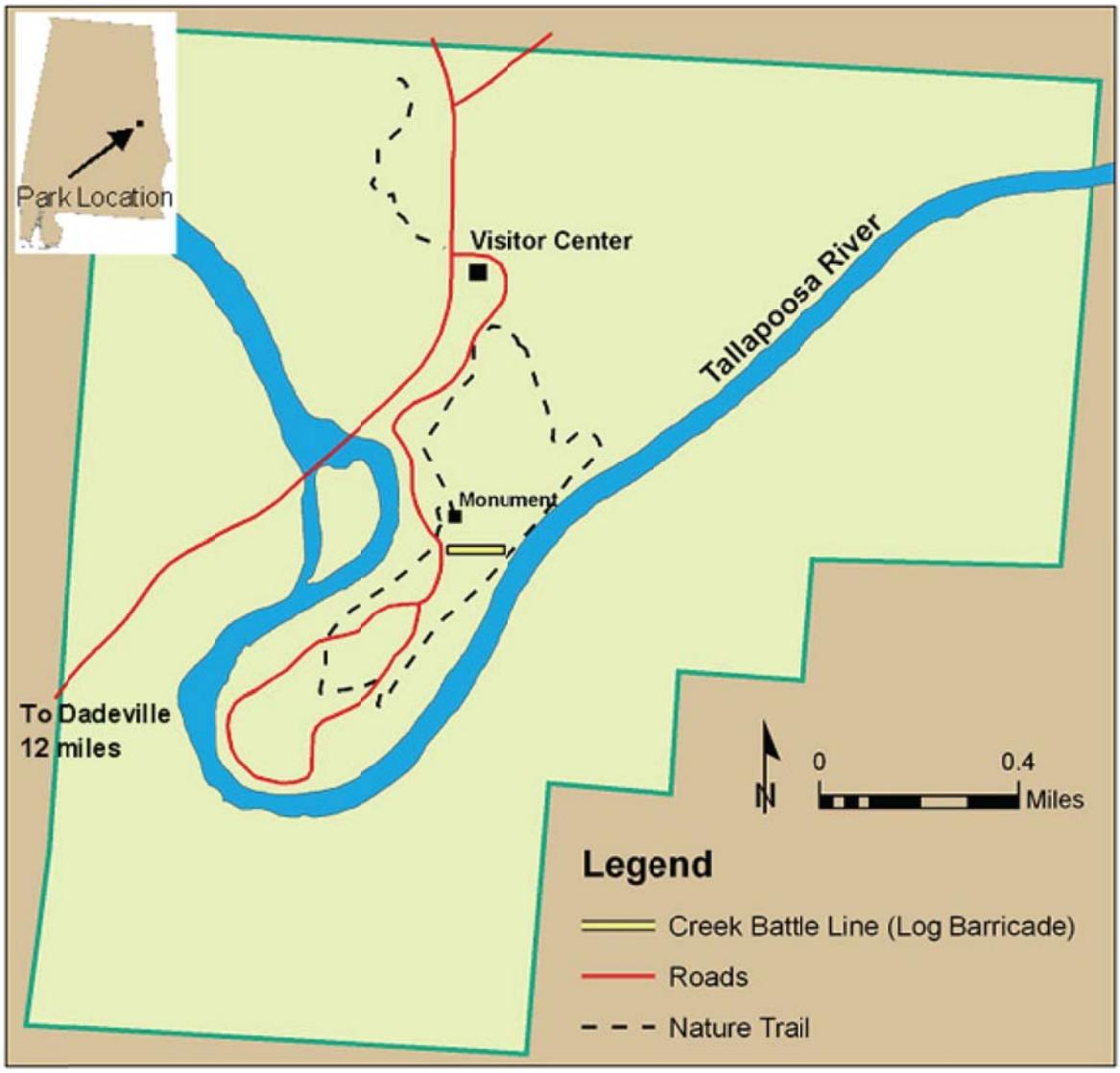

Figure 2. HOBE NMP (NPS map; green indicated the present-day park boundary).

History of the Park

The Creek War began as a civil war within the Creek (Muscogee) Native American nation, between the Upper Creeks who wished to strike against U.S. expansionists and return to a traditional way of life and the Lower Creeks who sought not to aggravate the U.S.

government and attempted to assimilate themselves into white culture. In February 1813, friction among the Creeks intensified when a group of Upper Creeks, known as the Red Sticks, killed seven frontier families after being told erroneous information, that the United States and the Creek Nation were already at war. After a Creek tribal council tried and executed the Creeks responsible for the killings, angered Red Sticks set out to destroy white settlements and opposing Creeks. Several months later at Burnt Corn Creek in Alabama, Red Sticks retaliated against a group of American soldiers and plundered their munitions. This exchange, later called the Battle of Burnt Corn, broadened the Creek Civil War to include American forces. Incited to fight, William Weatherford, a Red Stick leader, ordered his warriors to assault an American stockade, Fort Mims, on the Alabama River on 30 August 1813. Although Weatherford attempted to restrain his warriors, the Red Sticks killed about 500 people.

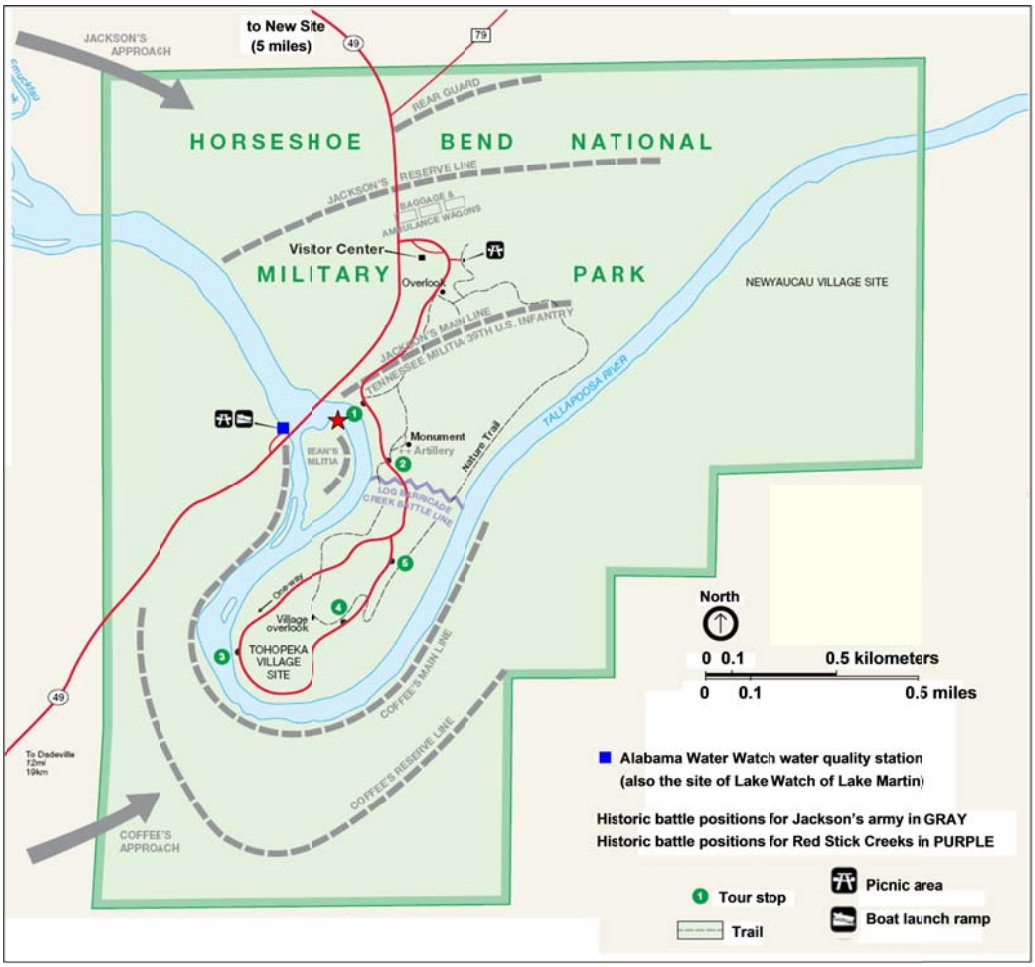

Figure 3. Map of the battle at Horseshoe Bend, 1814; the green border shows the boundaries of the present-day park. Also shown are park features and the Alabama Water Watch water quality sampling station. Modified from www.nps.gov/hobe.

Major General Andrew Jackson, an expansionist who saw the opportunity to secure Creek land, demanded "retaliatory vengeance" (Schafer 2003). In November of 1813, Jackson lead an advance on the Creeks, and ~500 Creeks were killed during the battles of Tallushatchee and Talladega in Alabama (*Figure 3, Plate 1*). Although the Creeks defeated Tennessee militiamen

in three minor engagements in January 1814, they finally were overcome in the Battle of Horseshoe Bend in March 1814. HOBE NMP preserves the site of Jackson's decisive victory in the Creek War of 1813-14, where nearly 900 of 1000 Creek Indians were killed. As DeVivo (2004) wrote, "Never before or since in the history of the United States have so many Native Americans lost their lives in a single battle. This battle ended, for all time, the power of the Creek Nation". Creek lands subsequently were added to the United States and opened for settlement.

Creation of the Park

HOBE NMP, including its museum and Visitor's Center, was dedicated March, 27, 1964 on the 150th anniversary of the Battle of Horseshoe Bend, culminating more than 50 years of effort. As early as August of 1907, Alabama state legislature voted to petition the United States Congress to establish Horseshoe Bend Battle Park to memorialize a battle site of "great patriotic and educatory value" (Cummings and Gebhard 1996). Congress voted in April 1914 to appropriate $5,000 to erect a small stone monument on the battleground, but petitions to establish a military park at the site were rejected in 1909, 1911, 1913, and 1914 because the "national significance" of the event was in doubt (Cummings and Gebhard 1996). During this same time period, a controversy erupted over who owned the battle site and who would control the region's emerging hydroelectric technology. Benjamin Russell, a local industrialist, began to build his own dam near Alexander City. In 1911, the Alabama Power Company, which planned to build its own dam on the river at Cherokee Bluff, brought suit against Russell and was successful at having construction stopped. In 1923, the Alabama Power Company purchased Horseshoe Bend from Russell. The company's president, Thomas Martin, whose great-grandfather had fought with Jackson's army in 1814, recommended to the Power Company's board of directors that no action on a dam should be taken until every effort to win congressional approval for a national park had been expended (Martin 1959).

After much research, Martin succeeded in convincing Congress of the significance of the battle. In July 1956, a bill to establish a national park at Horseshoe Bend was passed unanimously by the House and Senate, and the bill was signed into law by President Eisenhower in 1959. The Alabama state legislature provided $150,000 to purchase part of the 2,040 acres comprising the new park; the rest, about 560 acres, was donated by the Alabama Power Company; and the deeds for the land were presented to the Secretary of the Interior on 24 April 1959 (Cummings and Gebhard 1996).

Plate 1. View of the island (indicated by the red star in *Figure 3*) from the present-day park. Photo by M. Mallin.

Land Use / Land Cover in the Middle Tallapoosa Sub-basin

The middle Tallapoosa sub-basin, which includes HOBE NMP, has an area of 589.7 square miles and includes all lands and surface waters that drain to the Tallapoosa River between the confluence of the Tallapoosa and Little Tallapoosa Rivers and Martin Dam (*Figure 1*) (Alabama Department of Environmental Management [ADEM] 2005). North Carolina State University's Center for Applied Aquatic Ecology (NCSU CAAE) generated a new land use-land cover map for this sub-basin using the following procedure. The sub-basin boundary (8-digit Hydrologic Unit Code) Geographic Information System (GIS) data layer was provided by the US Geological Survey (USGS), and National Land Cover data for 2001 (most recent dataset available) were downloaded from the USGS Seamless Data Distribution System (http://seamless.usgs.gov/). Using the Spatial Analyst extension of ArcGIS9.1, the land use classification system was modified to include eight general categories: (1) urban areas, (2) row crop agriculture, (3) animal agriculture, (4) forests, (5) grasslands, (6) water, (7) wetland, and (8) barren/disturbed. Once the grid was reclassified, the Spatial analyst "tabulate area" function was used to calculate the area of each land class within the sub-basin surrounding HOBE NMP (Table 2). This analysis indicated that the park is in a predominantly rural setting consisting mostly of forested land cover (~70%), which helps to provide favorable conditions for good water quality (ADEM 2005; *Table 1, Figure 4*). The remainder is mostly grassland (~9%), pasture/hay agriculture (~9%), urban

development (5%), and water (~5%), with wetlands comprising only about 1.4% of the land cover. This information can serve as a baseline from which to assess future watershed changes that may affect the park's natural resources.

Table 1. Area and percent cover of each land use class in the middle Tallapoosa sub-basin (03150109), from analysis by the NCSU CAAE. National Land Cover data for 2001 were downloaded from the USGS Seamless Data Distribution System (http://seamless.usgs.gov/).

Land Cover Type	Urban	Pasture/ Hay	Row Crops	Forest	Grassland	Water	Wetland	Barren	Total
Miles^{w}	79.6	147.6	0.3	1,094.4	146.6	77.9	22.7	20.1	1,589.7
km^2	206.3	382.7	0.8	2,835.2	379.8	201.9	58.8	52.1	4,117.4
% of Total	5.0%	9.3%	0.02%	68.9%	9.2%	4.9%	1.4%	1.3%	100%

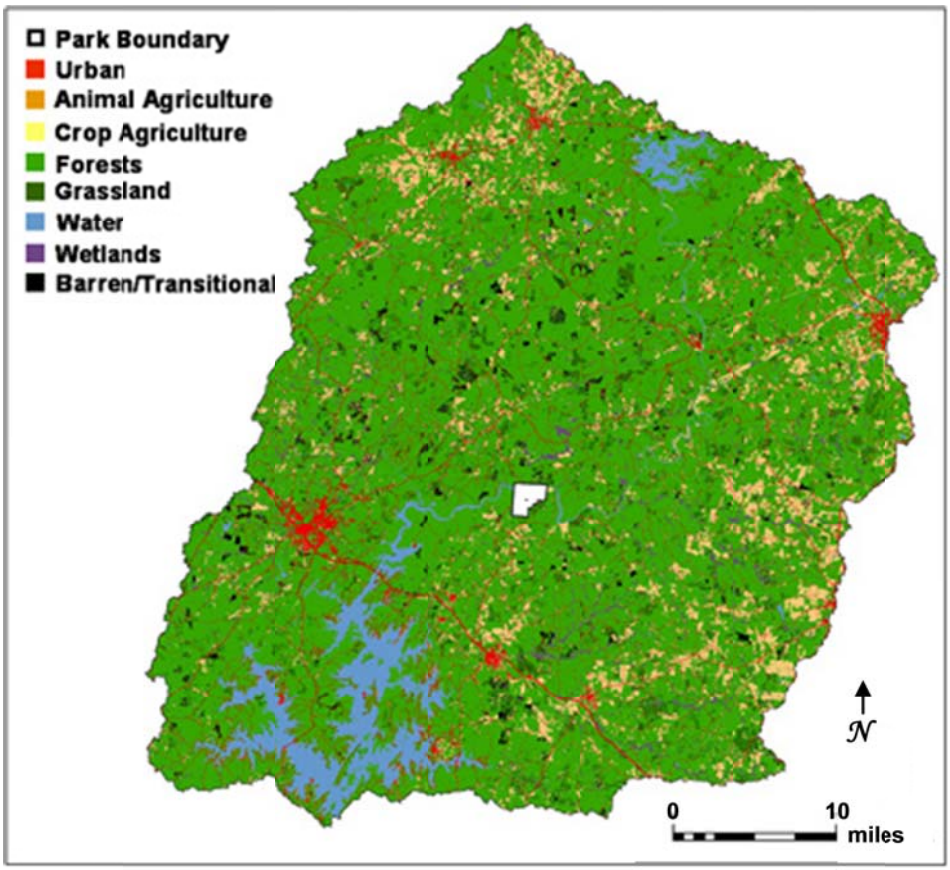

Figure 4. Land use / land cover (2001) in the middle Tallapoosa sub-basin (03150109) that includes HOBE NMP (area in white). Prepared by the NCSU CAAE.

Environmental Research and Mapping Facility (ERMF) at the University of Tennessee – Chattanooga (2007) was retained by the NPS to develop and maintain a GIS base map for HOBE NMP (*Figure 5*). ERMF conducted data surveys, field data collection, and additional file processing and development to derive geospatial files and metadata. Tasks included verification of digitized topographical map components and development of distinct data layers including contours, the river and creeks, structures, paved roads, dirt roads, monuments, and the park boundaries. Primary forest distributions were developed. Existing fire management maps were digitized to show 26 burn units within the park. Distinct data layers were also developed for the visitor center/administration building, maintenance building, three houses, a boat ramp, two picnic shelters, three interpretative shelters, a barricade location, water-sewage-electrical lines, hiking trails (~3 miles), dirt fire roads (~12 miles), wooden fencing, three drilled water wells, USGS boundary markers, and interpretative stops along the main tour road within the park. The information as well as scanned historical documents are available on an autorun compact disc application.

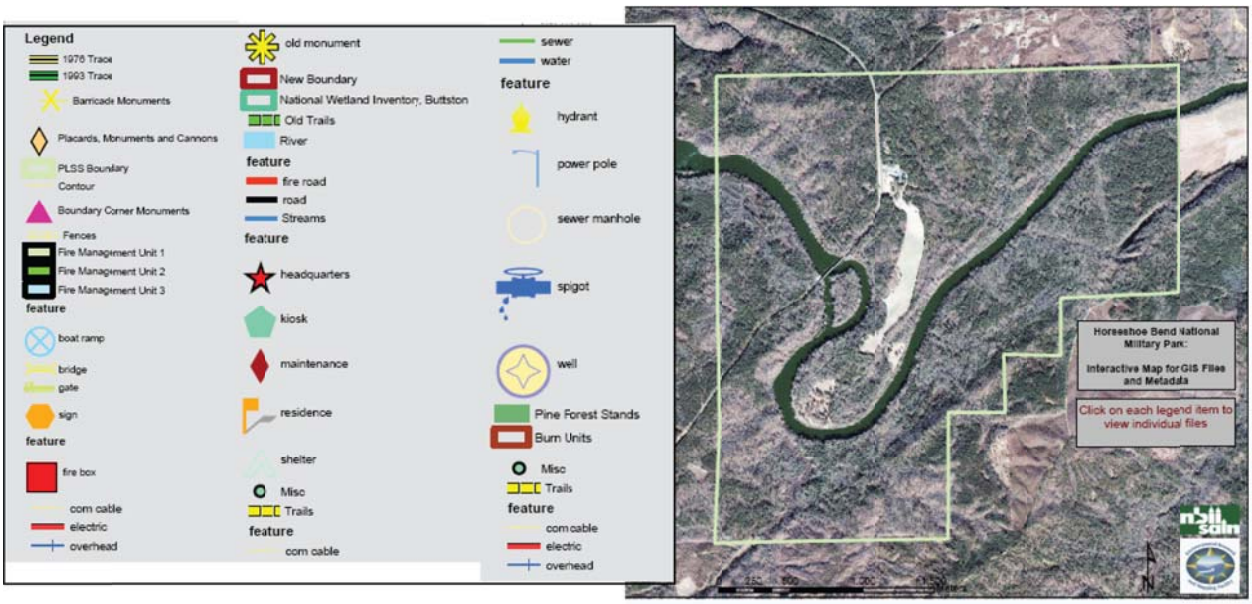

Figure 5. The interactive map for GIS files and metadata, created by the Environmental Research and Mapping Facility (ERMF 2007) at the University of Tennessee - Chattanooga.

Hydrologic Information

The climate in the park area is moist and temperate (mean annual temperature, 61°F), with mean annual precipitation ranging from 49 to 53 inches, with minimal snowfall (USGS 1997). A dry season typically occurs from mid-summer to late fall, whereas maximal precipitation and flow occur during March.

Surface Waters

The Tallapoosa River is a major tributary within the Mobile River Basin (44,000 mi^2 or 113,959 km^2), which is the 6th largest river basin in the U.S. From its headwaters in northwest Georgia

(four counties west of Atlanta), the Tallapoosa River flows for 195 miles (314 km) south-southwest through Alabama (16 counties) until it joins the Coosa River near Montgomery, AL to form the Alabama River. In Alabama, the Tallapoosa River basin (4,680 mi^2 or 12,121 km^2) lies within the Piedmont (with HOBE NMP) and Coastal Plain physiographic provinces (*Figure 6*). The reach of the Tallapoosa River that runs through HOBE NMP is located between two dams and hydropower facilities, the R.L. Harris Dam (~20 miles upstream from the park near Linville, AL, built and operated by the Alabama Power Company) and Martin Dam near Alexander City (*Figure 1*), and, as a result, is strongly flow-regulated. Peak power generation activities at Harris Dam result in two high-water events per day, causing river levels to fluctuate as much as 5-6 feet (DeVivo 2004). Since the dam's construction in 1980, the river segments downstream, including the park area, have been subjected to changes in river flow from as low as zero to 16,000 cfs (American Rivers 2003). In addition to changes in water level, the dam affects both in-stream flow and water temperature patterns. The park has no control over the sometimes-extreme artificial flow regime. Moreover, the Tallapoosa River system has been targeted as a potential source of potable water for Atlanta, GA through interbasin transfer (North Georgia Draft Water Supply and Water Conservation Management Plan 2003; DeVivo 2004).

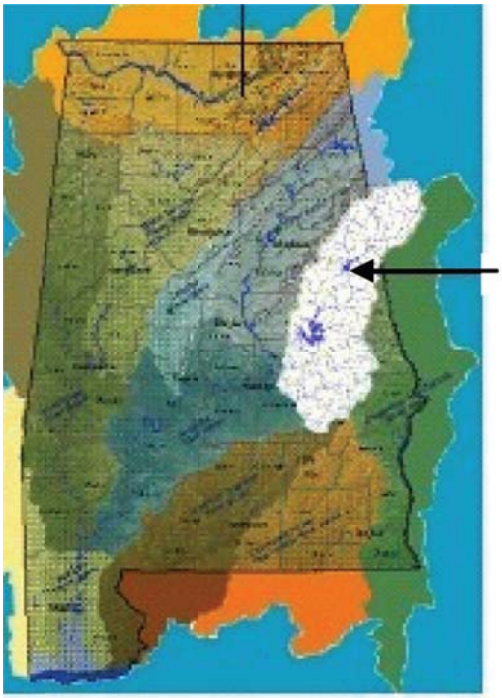

Figure 6. Location of the Tallapoosa watershed (white, arrow) in Alabama and Georgia (from the AL Water Watch Program, Auburn University Fisheries Dept. (www.twp.auburn.edu/).

A ~3.7-mile segment of the Tallapoosa River winds through the park. In this area the river is a relatively deep channel marked by several shoals, habitat features that characteristically support high faunal diversity (Irwin and Freeman 2002) (cover photo). The USGS maintains a gaging station on the Tallapoosa River, designated as the Horseshoe Bend site in Tallapoosa County, AL (USGS 02414715, Tallapoosa River near New Site, AL [Horseshoe Bend]; hydrologic unit 03150109; latitude 32.9772, longitude -85.7397; drainage area, 2,058 square miles; gage 528.6

feet above sea level). Data collected include river discharge in cubic feet per second, and stage (http://water.usgs.gov/waterwatch/) (*Table 2, Figure 7*). Annual flow at this cite has averaged 3,254 cfs during the 21-year period from 1986-2007; gage height averaged 3.94 feet based upon eight years of available data (1991-1993, 1998-1999, 2002-2004).

Table 2. USGS data for mean annual discharge at HOBE NMP during the period of complete available records (1987 – 2007).

Water Year	00060 Discharge (cfs)
1987	2,572
1988	1,461
1989	3,213
1990	4,903
1991	2,792
1992	3,314
1993	4,428
1994	3,122
1995	3,153
1996	5,065
1997	3,981
1998	5,003
1999	2,146
2000	1,556
2001	3,105
2002	1,585
2003	5,852
2004	2,473
2005	4,658
2006	2,517
2007	1,423

The Tallapoosa River is the major perennial water body within HOBE NMP, and the park's major natural feature. This fifth order stream has a rock, silt, sand and gravel bottom interspersed with patches of organic matter. Some riffle areas occur, as well as areas of woody debris (*Plate 2*). Other surface water resources in the park include two small springs: One emerges from a hill about 0.5 mile from the top of Battlefield Hill, to the east (#1, *Plate 3*). A second small, spring originates from a series of seeps near the second hill of the battlefield, and then becomes a small unnamed perennial stream near visitor's Stop 1 (#2, *Plate 4*). ERMF (2007) mapped the locations of various other small streams in the park (*Figure 8*) that are intermittent (J. Cahill, HOBE NMP, pers. comm.).

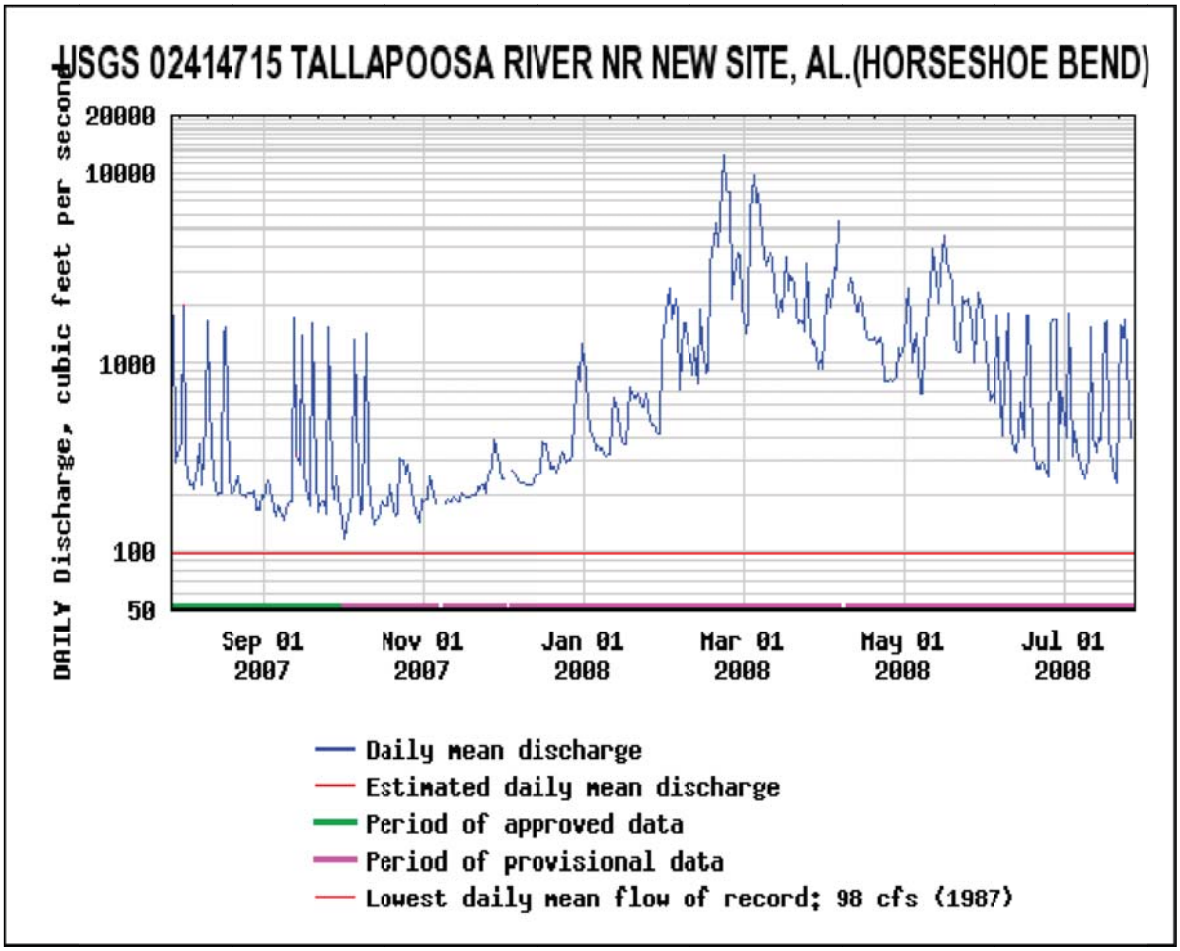

Figure 7. Daily discharge at the USGS stream flow gaging station at New Site, AL, near HOBE NMP during September 2001 – 1 July 2007, showing extremely low flow during a late summer - fall drought period, and maximum flow in early spring.

Plate 2. Left: Tallapoosa River bridge, viewed from HOBE NMP; right: Remains of old covered bridge next to the Tallapoosa River bridge, showing rock substrata. Photos by J. Burkholder and M. Mallin.

Plate 3. Small spring at HOBE NMP to the east of Battlefield Hill. Photo by M. Mallin.

Plate 4. A second small spring in the park (left) that becomes a small perennial tributary stream (right) to the Tallapoosa River. Photos by M. Mallin.

Geology, Soils, and Groundwater Resources

The park lies within the southern boundary of the Northern Piedmont Upland physiographic region, and consists of metamorphic and igneous rocks of Paleozoic to Precambian age (USGS 1997). The bedrock materials are granite, gneiss, and schist, and the soils are well-drained reddish loam or clay. Porous-media and fracture-conduit aquifers occur in the Tallapoosa River basin (Journey and Atkins 1996, USGS 1997). The porous-media aquifers are shallow and typically consist of unconsolidated or poorly consolidated sediments. Most groundwater in the Piedmont Geological Province, which includes HOBE NMP, occurs in these aquifers, within soil, alluvium, and saprolite derived from rocks of various age. Fracture-conduit aquifers are deeper and form in areas of igneous and metamorphic rocks, and generally have lower storage capacity. In these aquifers groundwater mostly moves through fractured or broken rock, and through openings between cleavage plains. Water quality is generally evaluated as "good", although data are not available for HOBE NMP. On the park grounds is a well house and a well that is welded shut, as the park is now supplied by water from the nearby town of New Site.

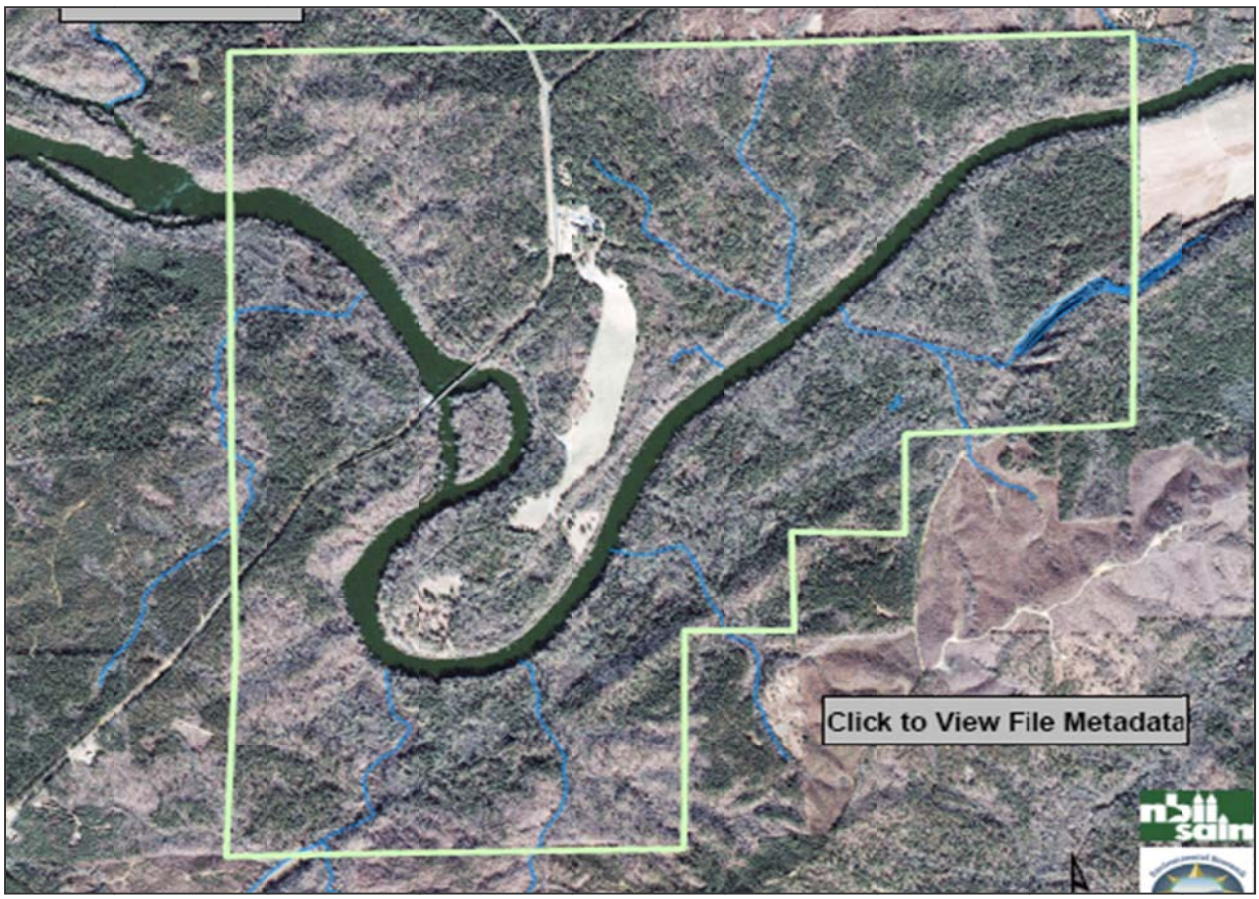

Figure 8. ERMF's (2007) map of streams in the park (boundary in green), most of which are intermittent (J. Cahill, pers. comm.).

A second small spring in the park (left) that becomes a small perennial tributary stream (right) to the Tallapoosa River. Photos by M. Mallin.

The estimated groundwater use in the Tallapoosa River basin is ~14 mgd. Of this total, about 41% has been used for public water supply, 32% for domestic water supply, 24% for agricultural use, and 3% for self-supplies industrial and commercial activities (USGS 1997). Groundwater levels fluctuate in response to natural and anthropogenic processes, such as seasonal changes in rainfall, interaction with the surface-water system, and groundwater withdrawal. Annual low water levels generally occur in the fall after the dry summer, and annual high water levels occur in the early spring because of recharge following rainfall during the winter (USGS 1997).

Groundwater levels in the middle Tallapoosa River basin fluctuate in response to natural and anthropogenic processes such as seasonal changes in precipitation, interactions with surface waters, and groundwater withdrawals (USGS 1997). Based upon long-term water level data measured biannually for four wells in fracture-conduit aquifers during 1968-1993, significant year-to-year or long-term changes in the average water level of the aquifer were not apparent. The data suggested that mean annual recharge and discharge are similar, with minimal permanent changes in aquifer storage.

Wetlands

Wetlands are defined as transitional lands between terrestrial and permanent (deeper) standing-water habitats (Cowardin et al. 1979). The water table in wetlands is at or near land surface, or the land is covered at times by shallow water. In the Tallapoosa River basin, most wetlands are forested floodplain systems, maintained by the natural flooding regime of rivers and streams (ADEM 2005). This description is characteristic of the woody wetlands in HOBE NMP, which occur as narrow fringes along the Tallapoosa River (*Figure 9*). More than 20% of the vegetative cover in these wetlands consists of forest or shrub vegetation (*Plate 5*). The wetlands have not been well characterized, but a recent survey of plant species indicates that there is a rich diversity of wetland and aquatic plant species in the park (below).

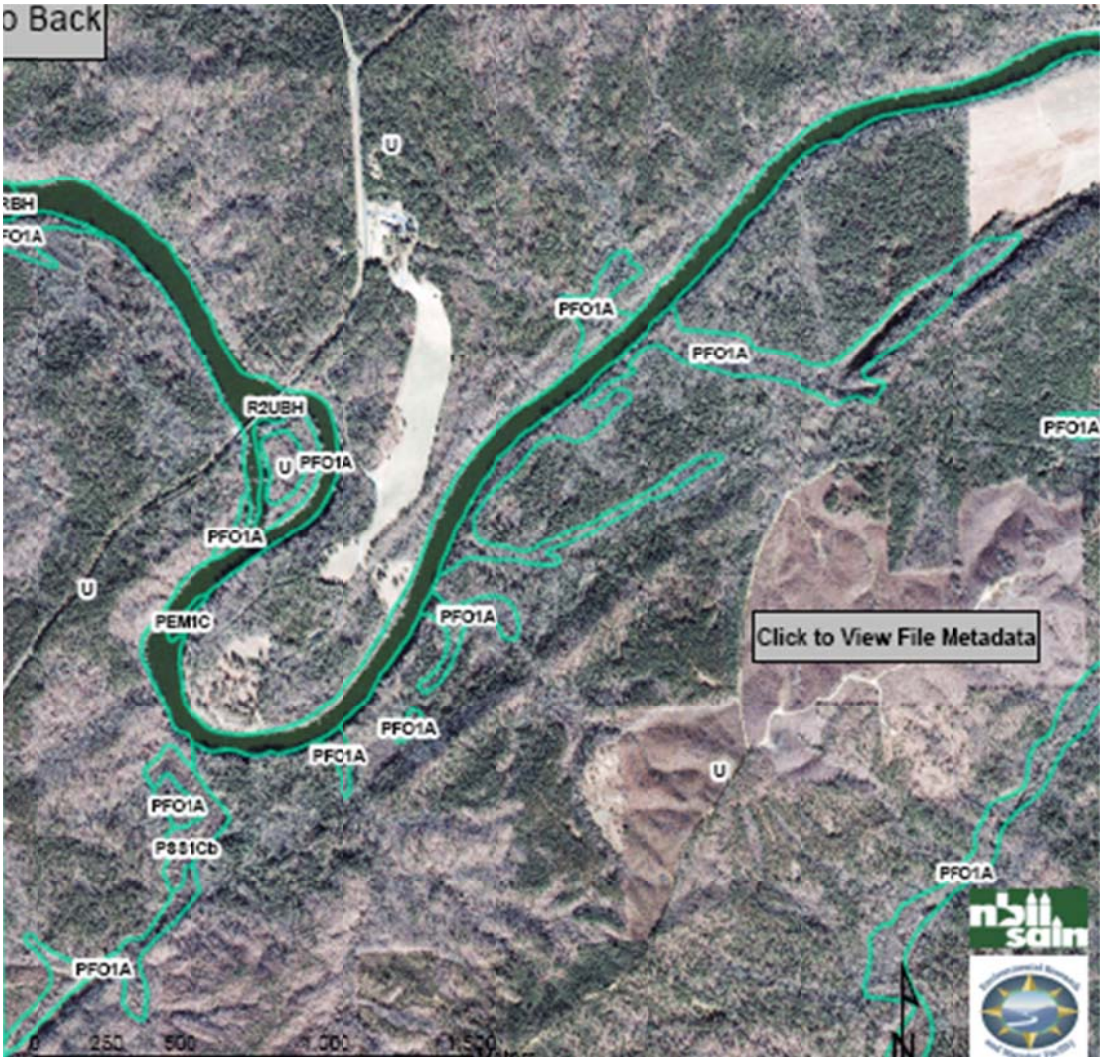

Figure 9. Locations of wetlands in the park (delineated by green lines – see Figure 5; ERMF 2007).

Plate 5. Riparian area with woody swamp wetland along the Tallapoosa River. Photo by M. Mallin.

Biological Resources

The larger Mobile River watershed which contains the Tallapoosa River and HOBE NMP provides a variety of habitats for plants and animals, and its isolation by time and geological events such as the last ice age resulted in a relatively high number of endemic species. It is uncertain as to how many of these species may have occurred in the park, but considering wetland and aquatic fauna, historically endemic fauna of the Mobile River watershed included 40 fishes, 33 mussels and 110 aquatic snails, as well as various turtles, aquatic insects and crustaceans.

As in other regions, dams have strongly affected faunal diversity, species distributions, and fisheries in southeastern U.S. rivers (Neves and Angermeier 1990, Lydeard and Mayden 1995).

Four dams have been constructed on the Tallapoosa River, including one upstream from the park (R.L. Harris Dam) and three downstream (Lake Martin Dam, Yates Dam, Thurlow Dam). Thus, fragmentation effectively has completely altered both upstream and downstream influences upon the aquatic communities in-between, to the extent that the Tallapoosa was listed in the top ten most endangered rivers in 2003 (American Rivers 2003). Within this broader context of the Mobile River watershed, the following information is specific to the park.

Microalgae

There apparently are no published studies of the phytoplankton assemblages or benthic microalgae in the Tallapoosa River. Some unpublished water quality and phytoplankton biomass records (the latter, as chlorophyll *a*) are available for the Tallapoosa River near HOBE NMP and for the Harris and Martin reservoirs, which are located above and below the park (*Figure 1*). Mean chlorophyll *a* concentrations in the Tallapoosa River at US Highway 280 were 7 µg/L in 2003 and 4 µg/L in 2004 (ADEM 2005). Mean chlorophyll *a* concentrations (photic zone composite samples collected monthly from April through October) at several locations of Harris Reservoir were highest (5-15 µg/L) among the mainstem Tallapoosa River reservoirs, and trophic site index (TSI) values derived from chlorophyll *a* concentrations in Harris Reservoir were at or below the mid-eutrophic range (ADEM 2000, Wetzel 2001). With the exception of the eutrophic upper portion of Martin Reservoir, mean annual chlorophyll *a* concentrations in Martin Reservoir were much lower (3-5 µg/L) than those of Harris Reservoir, and TSI values were often in the oligotrophic to mesotrophic range (ADEM 2000, Wetzel 2001).

Terrestrial Vegetation

The park is near the northern boundary of longleaf pine, and historically the floodplains and drainages consisted of mixed hardwoods, while patches of longleaf pine grew along the ridgetops. The hillsides and ridgelines also had a climax beech (*Fagus* spp.)-oak (*Quercus* spp.)-hickory (*Carya* spp.) forest, mixed with ash (*Fraxinus* spp.), walnut (*Juglans* spp.), and chestnut (*Castanea* spp.) (DeVivo 2004). Since the battle of 1814, the vegetation was altered extensively by human settlement, logging, and the introduction of exotic species until the park was established in 1959 (NPS 2000). Many agricultural fields are now managed in loblolly pine or are undergoing ecological succession, and some of the park is also maintained through mowing as open grasslands. The present-day forest type is primarily mixed hardwood with floodplains, drainages, and hillsides consisting of hickory, oak, ash, walnut, and chestnut (*Castanea* spp.) (DeVivo 2004). Drier areas and ridge tops are dominated by loblolly pine, and the open under-story is dominated by sapling elms, blueberries, silver bells, muscadines, and ferns (NPS 2000).

The NPS (2008) listed 7 species of ferns (primitive vascular plants, order Polypodiales) and ~700 (704) species of higher vascular plants that are known or suspected to be in the park. HOBE NMP contains many species of plants endemic to the Piedmont region and to the Southeastern and Southern Coastal Plains. Southern pine beetles (*Dentroctnus frontalis*) have done considerable damage to the pine species, and many trees lie on the forest floor because of beetle damage and windfall from Hurricane Opal (October 1995) (Dusi and Dusi 1997).

Wetland and Aquatic Vascular Plants

About half (9) of the fern species (primitive vascular plants) that are known or suspected to be in the park (NPS 2008) occur in wetland habitats (*Table 3*).

Table 3. Wetland fern species in the park (NPS 2008).

Species	Habitat
Broad beechfern (Phegopteris hexagonoptera or Thelypteris hexagonoptera)	moist woodlands
Cinnamon fern (Osmunda cinnamomea)	swamps, stream banks, shores
Chainfern (Woodwardia areolata)	acidic bogs, wet woods
New York fern (Thelypteris noveboracensis)	moist, humus-rich, deciduous woods
Royal fern (Osmunda regalis)	swampy areas, fens, damp woodlands
Sensitive fern (Onoclea sensibilis)	open swamps, marshes, low woods
Southern lady fern (Athyrium asplenioides)	stream and pond banks

Survey information indicates that the park has a rich diversity of wetland species (NPS 2008). About 48% (198) of the 412 species of higher vascular plants that are known or suspected to be in the park are wetland and aquatic vascular plants (listed in Godfrey and Wooten 1981a,b; *Table 4*). Only two species (hornleaf riverweed, *Podostemum ceratophyllum*; and watershield, *Brasenia schreberi*) are predominantly aquatic (*Plate 6*). Hornleaf riverweed is the most highly modified angiosperm known in aquatic environments (Sculthorpe 1967), whereas watershield can be amphibious (facultatively wetland species), existing on moist soils without overlying water. Thus, nearly all of the 198 species are wetland rather than aquatic in habit. Three other species, daisy fleabane (prairie or rough fleabane, *Erigeron strigosus*), littlehip hawthorn (*Crataegus spathulata*), and spotted St. Johnswort (*Hypericum punctatum*), were listed by the U.S. Department of Agriculture as having a fairly high probability of being found in wetlands (see http://plants.usda.gov/java/profile? symbol=HYPU).

Plate 6. *Podostemum ceratophyllum* and *Brasenia schreberi*, two aquatic plants on the NPS (2008) list. Photos: *Podostemum* – NCSU CAAE; *Brasenia* – http://www.ct-botanical-society.org/galleries/brasenia schr.html (by Eleanor Saulys, with permission).

Table 4. Wetland and aquatic plant flora (basis: Godfrey and Wooten 1981a,b) that are known in the park, including indication of exotic or non-native species ([e]) and weedy species ([w]) (NPS 2008).

Alder (brook-side alder, hazel alder) (*Alnus serrulata*)
Allegheny (ringen) monkey flower (*Mimulus ringens*)
American bladdernut (*Staphylea trifolia*)
American burnweed (*Erechtites hieraciifolia*)
American bur-reed (*Sparganium americanum*)
American elder (*Sambucus canadensis*)
American elm (*Ulmus americana*)
American (Canada) germander (wood sage) (*Teucrium canadense*)
American holly (*Ilex opaca*)
American hornbeam (*Carpinus caroliniana*)
American hornbeam (*Carpinus caroliniana*)
American pokeweed (common pokeweed, inkberry) (*Phytolacca americana*)
American snowbell (*Styrax americana*, or *S. americanus*)
American sycamore (*Platanus occidentalis*)
American (common) water willow (spike justicia) (*Justicia americana*)
American witchhazel (*Hamamelis virginiana*)
Angelicatree (devil's walkingstick) (*Aralia spinosa*)
Apios americana (groundnut, potatobean) (*Apios americana*)
Ashleaf maple (box elder) (*Acer negundo*)
Atamasco lily (*Zephyranthes atamasca*)
Azure bluet (*Houstonia caerulea*)
Bahiagrass (*Paspalum notatum* var. *saurae*) [e]
Beach false foxglove (*Agalinis fasciculata*)
Bedstraw (catchweed bedstraw, cleaves, cleaverwort) (*Galium aparine*)
Bigroot morning glory (man-of-the-earth) (*Ipomoea pandurata*)
Bitternut hickory (*Carya cordiformis*)
Black gum (*Nyssa sylvatica*)
Black-seed (Rugel's) plantain (*Plantago rugelli*)
Black willow (*Salix nigra*)
Blisterwort (little leaf buttercup) (*Ranunculus recurvatus*)
Blue mistflower (horseweed) (*Conoclinium coelestinum*, or *Eupatorium coelestinum*)
Blue (mad dog) skullcap (*Scutellaria laterifolia*)
Blueeyed grass (bur-cucumber) (*Sicyos angulatus*)
Blunt spikerush (*Eleocharis obtusa*)
Bog hemp (small-spike false nettle) (*Boehmeria cylindrica*)
Bristlestalked sedge (*Carex leptalea*)
Bristly buttercup (*Ranunculus hispidus*)
Broadleaf cattail (cattail) (*Typha latifolia*)
Broadleaf uniola (Indian wood-oats) (*Chasmanthium latifolium*)
Bullbrier (common catbrier, common greenbrier) (*Smilax rotundifolia*)
Bulrush (woolgrass) (*Scirpus cyperinus*)
Butterweed (*Packera glabella*)
Button eryngo (button snakeroot, Yuccaleaf eryngo) (*Eryngium yuccifolium*)
Buttonbush (*Cephalanthus occidentalis*)
Cahaba lily (Carolina, shoals, or water spiderlily) (*Hymenocallis carolina*)
Calico aster (*Aster lateriflorus*)
Camphor pluchea (camphor weed) (*Pluchea camphorata*)
Canada lettuce (Canada woodnettle) (*Laportea canadensis*)
Canadian honewort (honewort) (*Cryptotaenia canadensis*)
Canadian (early) lousewort (*Pedicularis canaden*
Cardinal flower (*Lobelia cardinalis*)
Carolina elephantfoot (leafy elephantfoot) (*Elephantopus carolinianus*)
Carolina jessamine (evening trumpetflower) (*Gelsemium sempervirens*)
Carolina lily (*Lilium michauxii*)
Cat greenbrier (*Smilax glauca*)
Chervil (hairy-fruit chervil) (*Chaerophyllum taintu*
Chestnut oak (*Quercus prinus*)
Chinese (Japanese) honeysuckle (*Lonicera japo*
Chinese (common Chinese) privet (*Ligustrum sinense*) [e,w]
Climbing hempvine (climbing hempweed) (*Mikan scandens*)
Climbing milkweed (honeyvine) (*Cynanchum lae*
Coastalplain blue-eyed grass (*Sisyrinchium fusca* or *S. arenicola*)
Common (eastern) cottonwood (*Populus deltoide*
Common (wooly) dutchmanspipe (*Aristolochia tomentosa*)
Common fox sedge (*Carex vulpinoidea*)
Common goldstar (eastern yellow-star grass) (*Hypoxis hirsuta*)
Common honeylocust (*Gleditsia triacanthos*)
Common meadowbeauty (handsome Harry) (*Rhexia virginica*)
Common (eastern) persimmon (*Diospyros virgini*
Common (lamp) rush (*Juncus effusus*)
Common sheep (sheep, or red) sorrel (*Rumex acetosella*) [e]
Common trumpetcreeper (cow-itch, trumpet cree (*Campsis radicans*)
Compact dodder (*Cuscuta compacta*) [w]

Table 4. (Continued).

Crested yellow orchid (*Platanthera cristata*, or *Habenaria cristata*)
Crimsoneyed (swamp) rosemallow (*Hibiscus moscheutos*)
Cross-vine (trumpet-flower) (*Bignonia capreolata*, or *Anisostichus capreolata, A. crucifera*)
Curley dock (curly, narrowleaf, or sour dock) (*Rumex crispus*) [e]
Cutleaf (green-head) coneflower (*Rudbeckia laciniata*)
Dallas (water) grass (*Paspalum dilatatum*) [e]
Desert false indigo (desert indigobush, dullleaf indigo (*Amorpha fruticosa*)
Devil's-darning needles (virgin's bower, Virginia bower (*Clematis virginiana*)
Ditch stonecrop (Virginia penthorum) (*Penthorum sedoides*)
Dogfennel (*Eupatorium capillifolium*)
Dotted smartweed (*Polygonum punctatum*)
Downy lobelia (*Lobelia puberula*)
Drooping melonnettle (Guadaloupe cucumber) (*Melothria pendula*)
Drummond St. Johnswort (nits and lice) (*Hypericum drummondii*)
Dwarf huckleberry (*Gaylussacia dumosa*)
Dwarf St. Johnswort (*Hypericum mutilum*)
Eastern poison ivy (poison ivy) (*Toxicodendron radicans*)
Eastern smooth beardtongue (*Penstemon laevigatus*)
Elliott's blueberry (*Vaccinium elliottii*)
Entireleaf (ivyleaf) morning glory (*Ipomoea hederacea*)
Fescue sedge (*Carex festucacea*)
Flypoison (*Amianthium muscitoxicum,* or *A. muscaetoxicum*)
Fringed loosestrife (fringed yellow-loosestrife) (*Lysimachia ciliata*)
Fringetree (white fringetree) (*Chionanthus virginicus*)
Giant cane (*Arundinaria gigantea*)
Globe flatsedge (*Cyperus globulosis*, or *C. ovularis*)
Greater bladder sedge (*Carex intumescens*)
Green adder's-mouth orchid (*Malaxis unifolia*)
Green ash (*Fraxinus pennsylvanica*)
Green dragon (*Arisaema dracontium*)
Green woodland orchid (or small green woodland orchid) (*Platanthera clavellata*, or *Habenaria clavellata*)
Helmet flower (*Scutellaria integrifolia*)
Hornleaf riverweed (threadfoot) (*Podostemum ceratophyllum*)
Iceweed (Virginia or white crownbeard) (*Verbesina virginica*)
India (Indian) heliotrope (*Heliotropium indicum*) [e]
Indian cucumber (*Medeola virginiana*)
Indian Jack-in-the-pulpit (Jack-in-the-pulpit) (*Arisaema triphyllum*)
Ironweed (tall or giant ironweed) (*Vernonia altissi*
or *V. gigantea*)
Jewelweed (spotted touch-me-not) (*Impatiens capensis*)
Joe Pye weed (trumpetweed) (*Eupatorium fistulo*
Johnson grass (*Sorghum halepense*) [e]
Jumpseed (Virginia smartweed) (*Polygonum virginianum* or *Tovara virginiana*)
Juniper leaf (*Polypremum procumbens*)
Lanceleaf (small) greenbrier (*Smilax smallii*)
Late eupatorium (lateflowering thoroughwort) (*Eupatorium serotinum*)
Laurel oak (*Quercus laurifolia*)
Leathery rush (*Juncus coriaceus*)
Limestone meadow sedge (*Carex granularis*)
Lizard's tail (*Saururus cernuus*)
Longleaf spikegrass (longleaf woodoats) (*Chasmanthium sessiliflorum* or *Uniola sessilifl*
Longroot smartweed (*Polygonum coccineum*)
Marsh parsley (*Cyclospermum leptophyllum*, or *Apium leptophyllous*)
Marsh primrose-willow (marsh seedbox) (*Ludwig palustris*)
Maryland meadowbeauty (*Rhexia mariana*)
Mountain (piedmont) azalea (*Rhododendron canescens*)
Muscadine (muscadine grape) (*Vitis rotundifolia*)
Needle-tip blue-eyed grass (*Sisyrinchium mucro*
Nodding ladies'-tresses (white nodding ladies-tresses) (*Spiranthes cernua*)
Obedient-plant (false dragon-head) (*Draco-cephalum virginianum*, or *Physostegia virginia*
Orange coneflower (*Rudbeckia fulgida*)
Oriental ladysthumb (bristled knotweed (*Polygor caespitosum* var. *longisetum*) [e]
Partridgeberry (*Mitchella repens*)
Pecan (*Carya illinoinensis,* or *C. illinoiensis*)
Philadelphia daisy (*Erigeron philadelphicus*)
Pickerelweed (*Pontederia cordata*)
Pignut hickory (*Carya glabra*)
Plume thistle (*Carduus spinosissimus*, or *Cirsiun horridulum*)
Poor-joe (rough buttonweed) (*Diodia teres*)
Possumhaw (*Ilex decidua*)
Post oak (*Quercus stellata*)
Potato dwarfdandelion (tuber dandelion) (*Krigia dandelion*)

Table 4. (Continued).

Pretty verbena (purpletop, or purpletop vervain) (*Verbena bonariensis*) [e]	Sweetbay (*Magnolia virginiana*)
Rattail smutgrass (*Sporobolus poiretii* or *S. indicus*)	Sweetgum (*Liquidambar styraciflua*)
Red maple (*Acer rubrum*)	Sweetscented joepyeweed (*Eupatorium purpureu*
Red mulberry (*Morus rubra*)	Trumpet honeysuckle (*Lonicera sempervirens*)
Reflexed flatsedge (*Cyperus refractus*)	Tulip poplar (tuliptree or yellow poplar) (Liriodendron tulipifera)
River birch (*Betula nigra*)	Two wing silverbell (*Halesia diptera*)
Rosepink (squarestem rosegentian) (*Sabatia angularis*)	Virginia bugleweed (Virginia water horehound) (*Lycopus virginicus*)
Roundhead rush (*Juncus validus*)	Virginia buttonweed (*Diodia virginiana*)
Sampson's snakeroot (*Psoralea psoralioides*)	Virginia dayflower (*Commelina virginica*)
Saw greenbrier (*Smilax bona-nox*)	Virginia sweetspire (*Itea virginica*)
Scaldweed (*Cuscuta gronovii*) [w]	Virginia wild rye (*Elymus virginicus*)
Shallow sedge (*Carex lurida*)	Water oak (*Quercus nigra*)
Sharpwing monkey flower (*Mimulus alatus*)	Watershield (Schreber watershield) (*Brasenia schreberi)*
Silky dogwood (*Cornus amomum*)	Waxyleaf (meadow-rue) (*Thalictrum revolutum*
Silver maple (*Acer saccharinum*, *A. saccharinum* var. *floridanum*)	Weakstalk bulrush (*Schoenoplectus purshianus*)
Smooth white oldfield aster (*Symphyotrichum racemosum,* or *Aster brachypholis, A. racemosus, A. fragilis*)	White avens (*Geum canadense*)
Southern catalpa (*Catalpa bignonioides*)	Whiteleaf leather flower (*Clematis glaucophylla*)
Southern magnolia (*Magnolia grandiflora*)	Whorled marsh pennywort (*Hydrocotyle verticillai*
Southern annual saltmarsh aster (*Symphyotrichum divaricatum*, or *Aster exilis*	Willow oak (*Quercus phellos*)
Southern rein orchid (*Habenaria flava*)	Winged elm (*Ulmus alata*)
St. Andrew's cross (*Hypericum hypericoides*)	Wingstem (*Verbesina alternifolia*)
Stiff dogwood (*Cornus foemina*)	Winter grape (*Vitis baileyana*)
Strawcolored flatsedge (strawcolor nutgrass) (*Cyperus strigosus*)	Woodland bluegrass (*Poa sylvestris*)
Swamp chestnut oak (*Quercus michauxii*)	Woodvamp (*Decumaria barbara*)
Swamp sneezeweed (swamp sunflower) (*Helianthus angustifolius*)	Wrinkleleaf goldenrod (*Solidago rugosa*)
	Yaupon (*Ilex vomitoria*)
	Yellow crownbeard (*Verbesina occidentalis*)
	Yellowroot (*Xanthorhiza simplicissima*)

Benthic Macroinvertebrates

Information is lacking on benthic macroinvertebrates within park waters. The invertebrate fauna in the section of the middle Tallapoosa River, which includes HOBE NMP, is not well characterized (Johnson 1997). Within the larger Mobile River basin, as mentioned, historically there was once a rich and diverse benthic macroinvertebrate fauna including various endemic species, some of which are now extinct. A decade ago the U.S. Fish and Wildlife Service (1998) reported that the basin still contains 33 mussels and 110 aquatic snails as well as numerous insects and crustaceans. About 30 mussel species inhabit the Tallapoosa River Basin, but native mussels are becoming rare in the middle reach of the Tallapoosa mainstem which includes HOBE NMP (ADEM 2005).

Amphibians and Reptiles

HOBE NMP is located along the boundary between the Piedmont and Coastal Plain and, as a result, resident herpetofauna (amphibians and reptiles) include species characteristic of both physiographic provinces (Tuberville et al. 2005). Tuberville et al. (2005) conducted a two-year survey of herpetofauna in national parks of the Southeast for the NPS; subsequently, the NPS (2008) developed a more comprehensive list of herpetofauna that are known or suspected to be

in the park (*Table 5*). Based upon NPS (2008), HOBE NMP contains 63 native species of reptiles and amphibians, including 30 amphibians (19 frogs and toads, 11 newts and salamanders) and 33 reptiles (9 turtles, 8 lizards, 17 snakes + 1 variety), as well as 2 exotic snake species (*Table 5*). In a comparison of 16 parks, Tuberville et al. (2005) noted that larger parks had higher species richness, which would suggest that because of its small size, HOBE NMP is a more fragile ecosystem (*Figure 10*).

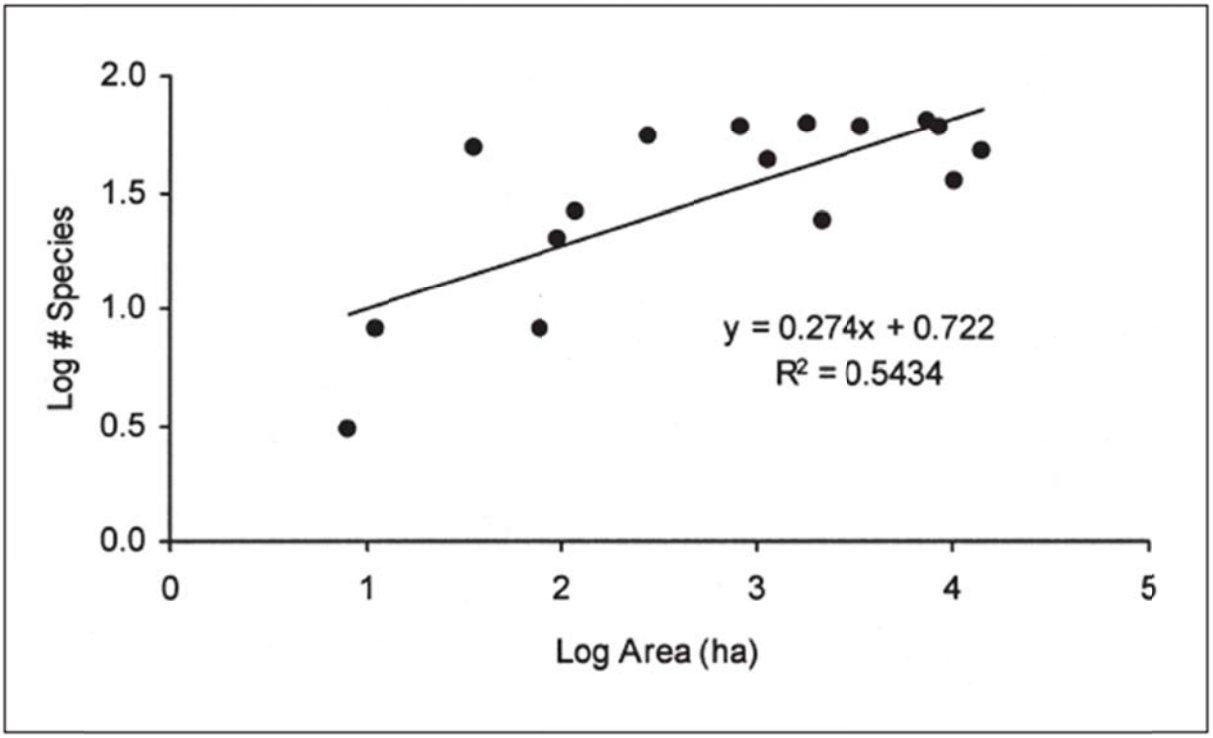

Figure 10. Relationship between land area (hectares) and species richness, excluding exotic (introduced) species, among 16 parks within the Southeast Coast Network of the NPS, including HOBE NMP, showing the strong positive linear relationship between (log-transformed) land area and species richness (P = 0.001). From Tuberville et al. (2005), with permission from Southeastern Naturalist.

Table 5. Herpetofauna of HOBE NMP, documented from field surveys, museum specimens, literature records, and reliable personal communications (NPS 2008).

AMPHIBIANS

Frogs and Toads

American bullfrog (*Rana catesbeiana*)
American toad (*Bufo americanus*)
Barking treefrog (*Hyla gratiosa*)
Bird-voiced treefrog (*Hyla avivoca*)
Cope's gray (tree) frog (*Hyla chrysoscelis*)
Eastern narrow-mouthed toad (*Gastrophyrne carolinensis*)
Eastern spadefoot (*Scaphiopus holbrookii*)
Florida (southern) leopard frog (*Rana sphenocephala*)
Fowler's toad (*Bufo fowleri*)
Gray treefrog (*Hyla versicolor*)
Green frog (*Rana clamitans*)
Green treefrog (*Hyla cinerea*)
Mountain chorus frog (*Pseudacris brachyphona*)
Pickerel frog (*Rana palustris*)
Southern cricket frog (*Acris gryllus*)
Southeastern (upland) chorus frog (*Pseudacris feriarum)*
Spring peeper (*Pseudacris crucifer*)
Wood frog (*Rana sylvatica*)
Woodhouse's toad (*Acris crepitans*)

Newts and Salamanders

Dusky (northern dusky) salamander (*Desmognathus fuscus*)
Eastern mud (mud) salamander (*Pseudotriton montanus*)
Eastern newt (*Notophthalmus viridescens*)
Marbled salamander (*Ambystoma opacum*)
Mole salamander (*Ambystoma talpoideum*)
Northern slimy (slimy) salamander (*Plethodon glutinosus*)
Red salamander (*Pseudotriton ruber*)
Southern two-lined salamander (*Eurycea cirriger*
Spotted salamander (*Ambystoma maculatum*)
Three-lined salamander (*Eurycea guttolineata*)
Three-lined salamander (*Gyrinophilus porphyritic*

REPTILES

Lizards

Broad-headed (broadhead) skink (*Eumeces laticeps*)
Eastern fence lizard (*Sceloporus undulatus*)
Five-lined skink (*Eumeces fasciatus*)
Green anole (*Anolis carolinensis*)
Ground (little brown) skink (*Scincella lateralis*)
Mole skink (*Eumeces egregius*)
Six-lined racerunner (*Cnemidophorus sexlineatus*
Southeastern five-lined skink (*Eumeces inexpect*

Snakes (** = exotic introduced)

Brown (DeKay's, northern brown) snake (*Storeria dekayi*)
Coachwhip (*Masticophis flagellum*)
Common gartersnake (*Thamnophis sirtalis*)
Common kingsnake (*Lampropeltis getula*)
Copperhead (*Agkistrodon contortrix*)
Cottonmouth (*Agkistrodon piscivorus*)
Eastern racer (racer) (*Coluber constrictor*)
Eastern rat (rat, Texas) snake (*Elaphe obsoleta*)
Eastern worm snake (*Carphophis amoenus*)
Gray rat snake (*Elaphe obsoleta spiloides*)
Midwest worm snake (*Carphophis amoenus helenae*)
Northern copperhead (*Ankistrodon contortrix mokasen*)
Northern watersnake (*Nerodia sipedon*)
Plain-bellied watersnake (*Nerodia erythrogaster*)
Queen snake (*Regina septemvittata*)**
Red-bellied snake (*Storeria occipitomaculata*)
Ring-necked snake (*Diadophis punctatus*)
Rough green snake (*Opheodrys aestivus*)**
Southern copperhead (*Agkistrodon contortrix contortrix*)
Timber rattlesnake (*Crotalus horridus*)

Turtles

Common (eastern) box turtle (*Terrapene carolina*)
Common (eastern) mud turtle (*Kinosternon subrubrum*)
Common musk turtle (*Sternotherus odoratus*)
Common slider (slider) (*Trachemys scripta*)
Common snapping turtle (*Chelydra serpentina*)
Eastern river (river) cooter (*Pseudemys concinna*
Gulf Coast spiny softshell turtle (*Apalone spinifera aspera*)
Loggerhead musk turtle (*Sternotherus minor*)
Spiny softshell turtle (*Apalone spinifera*)

Fish

The middle 50-mile reach of the Tallapoosa River from Harris Dam to the inflow of Lake Martin, which includes the section within HOBE NMP, is the only remaining Piedmont large-river habitat remaining in the state of Alabama. It represents one of the longest and highest-quality segments of Piedmont River habitat remaining in the Mobile River drainage (Lydeard and Mayden 1995 (*Plate 7*). Recent information from the NPS (2008) indicates that there are 26 species of fish in park waters (*Table 6*). This region of the Tallapoosa River has shown a decline in some species such as the speckled chub (*Macryhybobsis aestivalis*), bullhead minnow (*Pimephales vigilax*), madtom catfish (*Noturus* spp.), and redhorse suckers (*Moxostoma* spp.) (Freeman et al. 2001), and none of these species are present in the Park (NPS 2008). There has been no fisheries management plan for the Park (DeVivo 2004), but the ADCNR conducts annual creel surveys at the park boat ramp.

Table 6. Fish species known to be in the park (NPS 2008; ** = exotic species).

Alabama shiner (*Cyprinella callistia*)	Green sunfish (*Lepomis cyanellus*)
Banded sculpin (*Cottus carolinae*)	Logperch (*Percina caprode*s)
Blackspotted topminnow (*Fundulus olivaceus*)	Mosquitofish (western mosquitofish) (*Gambusia affinis*)**
Blacktail redhorse (*Moxostoma poecilurum*)	Pretty shiner (*Lythrurus bellus*)
Bluegill (*Lepomis macrochirus*)	Redeye bass (*Micropterus coosae*)
Brown bullhead (*Ameiurus nebulosus*)	Rough shiner (*Notropis baileyi*)
Central stoneroller (*Campostoma anomalum*)	Southern brook lamprey (*Ichthyomyzon gagei*)
Channel (graceful) catfish (*Ictalurus punctatus*)	Speckled darter (*Etheostoma stigmaeum*)
Common carp (or European carp)** (*Cyprinus carpio*)	Speckled madtom (*Noturus leptacanthus*)
Creek chub (*Semotilus atromaculatus*)	Spotted bass (*Micropterus punctulatus*)
Flathead catfish (*Pylodictis olivaris*)	Striped shiner (*Luxilus chrysocephalus*)
Golden redhorse (*Moxostoma erythrurum*)	Warmouth (*Chaenobryttus gulosus*)
Golden shiner (*Notemigonus crysoleucas*)	White crappie (*Pomoxis annularis*)

Plate 7. Snag along the Tallapoosa River at HOBE NMP. Such structures provide critical habitat for beneficial aquatic life. Photo by M. Mallin.

Birds

Recent checklists of birds found in HOBE NMP indicate that there are ~120 species of birds located within the park boundaries (Dusi and Dusi 1997; NPS 2008) (*Table 7*). Some species, such as the spotted sandpiper (*Actitis macularia*) and the Nashville warbler (*Vermivora ruficapilla*), have been seen only rarely (once or twice) within park boundaries. Ten species are known to be associated mainly with aquatic habitats.

Table 7. Bird species that have been observed in the park (past ~decade; Dusi and Dusi 1997, NPS 2008).

Species associated with aquatic habitats

Belted kingfisher (*Ceryle akyon*)
Fish crow (*Corvus ossifragus*)
Great blue heron (*Ardea herodias*)
Great egret (*Casmerodius albus*)
Green heron (*Butorides striatus*)
Little blue heron (*Egretta caerulea*)
Red-winged blackbird (*Agelaius phoeniceus*)
Ring-billed gull (*Larus delawarensis*)
Spotted sandpiper (*Actitis macularla*)
Wood duck (*Aix sponsa*)

Other species (** = exotic species; note that the report authors also saw house sparrows in the park)

Acadian flycatcher (*Empidonax virescens*)
American crow (*Corvus brachyrhynchos*)
American goldfinch (*Carduelis tristis*)
American kestrel (*Falco sparverius*)
American pipit (*Anthus rubescens*)
American robin (*Turdus migratorius*)
American redstart (*Setophaga ruticilla*)
Barn swallow (*Hirundo rustica*)
Barred owl (*Strix varia*)
Black-and-white warbler (*Mniotilta varia*)
Blackburnian warbler (*Dendroica fusca*)
Black-throated green warbler (*Dendroica virens*)
Black vulture (*Coragyps atratus*)
Blue-gray gnatcatcher (*Polioptila carulea*)
Blue-gray gnatcatcher (*Polioptila carulea*)
Blue grosbeak (*Guiraca caerulea*)
Blue jay (*Cyanocitta cristata*)
Broad-winged hawk (*Buteo platypterus*)
Brown-headed cowbird (*Molothrus ater*)
Brown-headed nuthatch (*Sitta pusilla*)
Brown thrasher (*Toxostoma rufum*)
Carolina chickadee (*Poecile carolinensis*)
Carolina wren (*Thyrothorus ludovicianus*)
Chimney swift (*Chastura pelagica*)
Chipping sparrow (*Spizella passerina*)
Cedar waxwing (*Bombycilla cedrorum*)
Chuck-will's-widow (*Caprimulgus carolinensis*)
Common grackle (*Quiscalus quiscala*)
Common loon (*Gavia immer*)
Common yellowthroat (*Geothlypis trichas*)
Cooper's hawk (*Accipiter cooperii*)
Dark-eyed junco (*Junco hyemalis*)
Downy woodpecker (*Picoides pubescens*)
Eastern bluebird (*Sialia sialis*)
Eastern kingbird (*Tyrannus tyrannus*)
Eastern meadowlark (*Sturnella magna*)
Eastern phoebe (*Sayornis phoebe*)
Eastern (rufous-sided) towhee (*Pipilo erythrophthalmus*)
Eastern screech owl (*Otus asio*)
Eastern wood-pewee (*Contopus virens*)
Evening grosbeak (*Coccothraustes vespertinus*)
European starling (*Sturnus vulgaris*)**
Field sparrow (*Spizella pusilla*)
Fox sparrow (*Passerella iliaca*)
Golden-crowned kinglet (*Regulus satrapa*)
Gray catbird (*Dumetella carolinensis*)
Great crested flycatcher (*Myiarchus crinitus*)
Great horned owl (*Bubo virginanus*)
Hairy woodpecker (*Picoides villosus*)
Hermit thrush (*Catharus guttatus*)
Hooded warbler (*Wilsonia citrina*)
House finch (*Carpodacus mexicanus*)
House sparrow (*Passer domesticus*)**
House wren (*Troglodytes aedon*)
Indigo bunting (*Passerina cyanea*)
Kentucky warbler (*Oporonis formosus*)
Least flycatcher (*Empidonax minimus*)
Louisiana waterthrush (*Seiurus motacilla*)
Magnolia warbler (*Dendroica magnolia*)
Mourning dove (*Zenaida macroura*)
Nashville warbler (*Vermivora ruficapilla*)
Northern bobwhite (*Colinus virginianus*)
Northern cardinal (*Cardinalis cardinalis*)
Northern flicker (*Colaptes auratus*)
Northern harrier (*Circus cyaneus*)
Northern mockingbird (*Mimus polyglottos*)
Northern parula (*Parula americana*)
Northern rough-winged swallow (*Stelgidopteryx serripennis*)
Northern waterthrush (*Seiurus noveboracensis*)
Orange-crowned warbler (*Vermivora celata*)
Orchard oriole (*Icterus spurius*)
Ovenbird (*Seiurus aurocapillus*)
Palm warbler (*Dendroica palmarum*)
Pileated woodpecker (*Dryocopus pileatus*)
Pine siskin (*Carduelis pinus*)
Pine warbler (*Dendroica pinus*)
Prairie warbler (*Dendroica discolor*)
Prothonotary warbler (*Prothonotaria citrea*)
Purple finch (*Carpodacus purpureus*)
Purple martin (*Progne subis*)
Red-bellied woodpecker (*Melanerpes carofinus*)
Red-breasted nuthatch (*Sitta canadensis*)
Red-eyed vireo (*Vireo olivaceus*)

Table 7. (Continued).

Red-headed woodpecker (*Melanerpes erythrocephalus*)	Veery (*Catharus fuscescens*)
Red-shouldered hawk (*Buteo lineatus*)	White-breasted nuthatch (*Sitta carolinensis*)
Red-tailed hawk (*Buteo jamaidensis*)	White-eyed vireo (*Vireo griseus*)
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	White-throated sparrow (*Zonotrichia albicollis*)
Ruby-crowned kinglet (*Regulus calendula*)	Wild turkey (*Mealeagris gallopavo*)
Ruby-throated hummingbird (*Archilochus colubris*)	Winter wren (*Troglodytes troglodytes*)
Rusty blackbird (*Euphagus carolinus*)	Wood thrush (*Hyloclichla mustelina*)
Scarlet tanager (*Piranga olivacea*)	Worm-eating warbler (*Helmitheros vermivorus*)
Song sparrow (*Melospiza melodia*)	Yellow-bellied sapsucker (*Sphyrapicus vatius*)
Summer tanager (*Piranga rubra*)	Yellow-billed cuckoo (*Coccyzus americanus*)
Swainson's warbler (*Limnothlypis swainsonii*)	Yellow-breasted chat (*Icteria virens*)
Tufted titmouse (*Parus bicolor*)	Yellow-rumped warbler (*Dendroica coronota*)
Turkey vulture (*Cathartes aura*)	Yellow-throated vireo (*Vireo flavifrons*)
	Yellow-throated warbler (*Dendroica dominica*)

Mammals

A recent list compiled in 2003, together with information from NPS (2008), indicates that excluding domestic horses and cattle, there are 38 species that occur or probably occur in the park (*Table 8*). Five species (American beaver, marsh rice rat, muskrat, northern river otter, swamp rabbit) make extensive use of aquatic habitats, and mink consume fish as food. Many species use swamp forest wetlands as habitat, as well.

Table 8. Mammals of HOBE NMP (NPS 2008; a ≡ species that make extensive use of aquatic habitats or consumes fish as food; b ≡ species that probably occur in the park according to D. Webster's (UNC Wilmington) survey in 2003, but not reported by NPS (2008); c ≡ exotic introduced species that is present or suspected to be present in the park.

American beaver (*Castor canadensis*) [a]	Long-nosed (nine-banded) armadillo (*Dasypus novemcinctus*)
Bee shrew (least shrew, little short-tailed shrew) (*Cryptotis parva*)	Long-tailed weasel (*Mustela frenata*) [b]
Bobcat (*Lynx rufus*) [b]	Marsh rice rat *(Oryzomys palustris*) [a]
Common gray (gray) fox (*Urocyon cinereoargenteus*)	Mink (*Mustela vison*) [a,b]
Cotton mouse (*Peromyscus gossypinus*)	Mole shrew (northern short-tailed or short-tailed shrew (*Blarina brevicauda*)
Coyote *(Canis latrans*)	Muskrat (muskbeaver) (*Ondatra zibethicus*) [a,b]
Eastern chipmunk (*Tamias striatus*)	Northern raccoon (*Procyon lotor*)
Eastern cottontail (*Sylvilagus floridanus*)	Northern river (river) otter (*Lutra canadensis*) [a]
Eastern gray (gray) squirrel (*Sciurus carolinensis*)	Norway rat (*Rattus norvegicus*) [b,c]
Eastern harvest mouse (*Reithrodontomys humulis*) [b]	Pine (woodland) vole (*Microtus pinetorum*) [d]
Eastern mole (topos) (*Scalopus aquaticus*)	Red fox (*Vulpes vulpes*)
Eastern red (red) bat (*Lasiurus borealis*)	Southeastern shrew (*Sorex longirostris*)
Eastern woodrat (*Neotoma floridana*)	Striped skunk (*Mephitis mephitis*)
Evening bat (*Nycticeius humeralis*)	Swamp rabbit (*Sylvilagus aquaticus*) [a,b]
Feral dog (*Canis familiaris*) [c]	Virginia opossum (*Didelphis virginiana*)
Feral cat (*Felis catus*) [c]	White-footed mouse (*Peromyscus leucopus*)
Feral horse (*Equus caballus*) [c]	White-tailed deer (*Odocoileus virginianus*)
Golden mouse (*Ochrotomys nuttalli*)	Woodchuck (*Marmota monax*)
Hispid cotton rat (*Sigmodon hispidus*)	Woodland vole (*Microtus pinetorum*) [b]
House mouse (*Mus musculus*) [b,c]	

The park has no terrestrial mammal species that are considered to be imperiled by the U.S. Fish and Wildlife Service. The Alabama Department of Conservation and Natural Resources has

evaluated one species, the long-tailed weasel, as rare (S3). Three carnivorous species that historically were known in the area (American black bear, *Ursus americanus*; mountain lion, *Puma concolor*; red wolf, *Canis rufus*) have been extirpated from the region; several reports by local citizens of mountain lions have not been substantiated. In contrast, the long-nosed (nine-banded armadillo (*Plate 8*) and the coyote have emigrated into the park and the surrounding area (Howell 1921 vs. Choate et al. 1994).

Concerns related to mammals include over-population of deer and turkeys on the north side of the river, and possibly over-hunting of these species on the south side of the river because of illegal poaching and dog hunting (DeVivo 2004). Feral pigs have not been reported in the park, and beaver damage to trees or water flow alteration has been minimal (J. Cahill, pers. comm.).

Plate 8. A long-nosed (nine-banded) armadillo in the park. The status of this species is unknown; increasing populations may be invasive or natural range extension, and impacts have not been assessed (DeVivo 2004). Photo by M. Mallin.

Rare and Threatened Species

The larger Mobile River watershed which contains HOBE NMP has been described as "an ecosystem in trouble" with respect to rare and threatened species (U.S. Fish and Wildlife Service 1998). During the past two centuries, human development of the watershed has led to species extinctions at a rate now unparalleled elsewhere in the mainland U.S.; nearly 50% of U.S.

species extinctions in the past 100 years have occurred in the Mobile River basin (U.S. Fish and Wildlife Service 1998). At least 16 endemic mussels and 38 endemic aquatic snails are now believed to be extinct, mostly within the past few decades (U.S. Fish and Wildlife Service 1998). The watershed has 32 aquatic/wetland animal and plant species that are protected under the Endangered Species Act of 1973, including 2 plants, 2 turtles, 10 fish, 17 mussels, and 1 snail. At least 62 other species are regarded as imperiled including plants, insects, crustaceans, snails, mussels, fishes and turtles.

Shoals of the Tallapoosa River support populations of the Cahaba lily (*Hymenocallis coronaria*, also called the Carolina spiderlily, the shoals spider-lily, the spider lily, and the water spider lily) (*Plate 9*). This plant is federally listed as a species of concern (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q0ZP), and is found in the central portion of the Tallapoosa River of Alabama (including the park), Georgia, and South Carolina. It requires swift current to flourish. This wetland plant has been eliminated from portions of its native range by impoundments (Irwin and Freeman 2002).

Although presently not known to be within the park boundaries (NPS 2008), the federally threatened terrestrial wildflower species little Amphianthus (*Amphianthus pusillus*) and the federally endangered terrestrial species relict trillium (*Trillium reliquum*) both occur near the park within the central Tallapoosa River basin (ADEM 2005).

The larger Mobile River basin is reported to contain two protected mussel species, *Lampsilis atilis* (the finelined pocketbook) which is federally listed as threatened) (*Plate 10*), and the ovate clubshell (*Pleurobema perovatum*) which is federally listed as endangered (Storey et al. 2003). These species most commonly are found in small stream riffles withmoderate to high flow velocities (Gangloff 2003).

They are assumed to be rare although present within park boundaries (DeVivo 2004). Impoundments along the river are considered to be a major impediment to their ability to re-colonize the Tallapoosa, including waters within park boundaries (DeVivo 2004).

At least four endemic fish species (*Etheostoma chuckwachatte*, the lipstick darter; *Cyprinella gibbsi*, the Tallapoosa shiner; *Etheostoma tallapoosae*, the Tallapoosa darter; and *Cottus bairdi,* the mottled sculpin; Freeman et al. 1997) are present in the Tallapoosa River basin (e.g. *Plate 11*). However, the fish species list from the NPS (2008) for HOBE NMP does not include these four species.

Plate 9. The Cahaba lily (Carolina spiderlily or shoals spider-lily). Inset photo by Chris Oberholster, the Nature Conservancy, with permission – http://www.nature.org/initiatives/freshwater/work/cahabariver.html. Background photo by Greg Evans, with permission – http://www.pbase.com/stoneraven/image/32506776).

Plate 10. The protected mussel species, *Lampsilis atilis* (fine-lined pocketbook), that may be in the park. Photos by M. Gangloff. Reprinted with permission of the Auburn Univ. Aquatic Invertebrates Collection.

Plate 11. The Tallapoosa shiner, 1 of 4 fish species endemic to the Tallapoosa River in the reach that includes HOBE NMP, but not reported in the park by NPS (2008). Photo by Patrick E. O'Neill, courtesy of the Geological Survey of Alabama – copyrighted from "Fishes of Alabama and the Mobile Basin". See http://www.outdoor alabama.com/fishing/freshwater/fish/other/minnow/ shiner/tallapoosa).

Invasive Species

Exotic plant and animal species, both terrestrial and aquatic, are a major concern and have affected many areas within HOBE NMP. Terrestrial exotic plant species include terrestrial species such as tree of heaven (*Ailanthus altissima*), mimosa (*Albizia julibrissin*), chinaberry (*Melia azedarach*), Japanese honeysuckle (*Lonicera japonica*), kudzu (*Pueraria montana*), and sandburs (*Cenchrus longispinas*) that continue to expand and invade new areas (DeVivo 2004). Some of these invasive plants, such as honeysuckle and kudzu, can serve as ladder fuels and increase fire danger (DeVivo 2004). Eleven exotic wetland plant species also occur in the park, one of which (Chinese privet) is also considered a weedy nuisance plant (*Table 4*). The southern pine beetle, *Dentroctonus frontalis*, is considered the most destructive forest insect pest in the southeastern U.S. (Clarke 1995). This species occurs within the park and is a potential threat to internal pine stands, as well as those on neighboring lands (Clarke 1993).

The exotic invasive Asiatic clam, *Corbicula fluminea*, is assumed to be present in the system and potentially competing with native mussels (DeVivo 2004, NPS 2008; *Table 5, Plate 12*). This species, with high growth and reproduction rates, has the capacity to alter aquatic food webs and to displace native bivalve mollusc species (Stites et al. 1995). It also appears to be more adaptable to polluted environments than many native bivalves (Jenkinson 1979).

Plate 12. The exotic invasive species *Corbicula fluminea* (photo: Noel Burkhead, with permission).

Assessment of Park Water Resources

Water Quality Standards

The park segment of the Tallapoosa River is classified by the ADEM for designated use for Fish and Wildlife (ADEM 2004; http://www.adem.state.al.us/waterdivision/WQuality/WQUseClass.htm, http://www.epa.gov/waterscience/standards/wqslibrary/al/al_4_wqs-archive.pdf). The description for the Fish and Wildlife use classification states that the "best usage of waters [is for] fishing, propagation of fish, [other] aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food-processing purposes" (ADEM 2004). For this designated use, the state has ambient water quality standards for common water quality parameters such as dissolved oxygen (DO), pH, turbidity, fecal bacteria, and enterococci bacteria (*Table 9*).

Table 9. In-stream water quality standards for non-coastal surface waters with designated use as Fish and Wildlife (ADEM 2004).

Parameter	Acceptable Conditions
Temperature	Maximum shall not exceed 90oF [32oC]; maximum in-stream temperature rise above ambient due to the addition of artificial heat by a discharger shall not exceed 5oF
DO	For a diversified warmwater biota, including game fish, daily concentrations For a diversified warmwater biota, including game fish, daily concentrations shall not be less than 5 mg/L at all times, except that under extreme conditions due to natural causes, it may range between 5 mg/L and 4 mg/L, provided that water quality is favorable in all other parameters.
pH	Sewage, industrial wastes, or other wastes shall not cause the pH to deviate more than 1 unit from the normal or natural pH. The pH should be greater than 6.0 and less than 8.5.
Turbidity	There shall be no turbidity of other than natural origin that causes substantial visible contrast with the natural appearance of waters or interfere with any beneficial uses. In no case shall turbidity exceed 50 Nephelometric units [NTU] above background. Background is interpreted as the natural condition of the receiving waters, without influence of human or human-induced causes.
	Shall not exceed a geometric mean (g.m.) of 1,000 colonies [cfu] per 100 mL, nor exceed a maximum of 2,000 colonies per 100 mL in any sample. The geometric mean shall be calculated from no less than five samples collected over a 30-day period at intervals not less than 24 hours. For incidental water contact during June through September, water quality is acceptable when a survey by controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform densities do not exceed 200 colonies per 100 mL.
Toxic, color-producing, odor-producing, and other deleterious substances from wastes	Only such amounts, whether alone or in combination with other substances or wastes, as will not cause acute or chronic toxicity to fish, wildlife, and [other] aquatic life, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, or adversely affect the aesthetic value of the water.

Other recommended guidelines for acceptable water quality have been published by the U.S. EPA (2000, 2002), Mallin (2000), and Mallin et al. (2006) (*Table 10*). The Clean Water Act requires the U.S. EPA to develop criteria (i.e. recommendations) for water, designed to protect aquatic life. The criteria are supposed to reflect accurately the up-to-date scientific knowledge.

Whereas the State of Alabama has imposed regulations, a U.S. EPA water quality criterion is not a regulation; it does not impose legally binding requirements on the U.S. EPA or the states. States have discretion to adopt approaches that differ from the U.S. EPA water quality criteria, but these criteria are meant to provide useful guidance.

Table 10. Summary of Alabama state standards for acceptable water quality in waters classified as Fish and Wildlife designated use (ADEM), and of conditions for acceptable water quality recommended by other sources. See *Table 12* and text description for more information on available data.

Parameter	ADEM	Other Recommendation(s) or Guideline(s)	HOBE NMP
General Water Quality Parameters			
DO	≥ 5 mg/L; or ≥ 4 mg/L in extreme conditions	≥ 4 mg/L (U.S. EPA 2000)	Limited data - some violations (down to 3.4 mg/L)
pH	> 6.0, < 8.5	> 6.5, < 9.0 (U.S. EPA 2000)	From limited data, pH as low as 6.0
Turbidity	< 50 NTU above background	---- (also see total suspended solids)	Data not available
Fecal Coliforms	< 1,000 cfu/ 100 mL (g.m.); < 2,000 cfu/ 100 mL in any sample	400 for data collected with insufficient frequency to calculate g.m.s by the State's criteria (general recreational use - U.S. EPA 2003)	Data not available
Nutrients	----	< 100 µg/L for total phosphorus and for inorganic nitrogen nitrate+nitrite, and/or ammonium) to discourage noxious algal blooms (Mallin 2000)	Data not available except for total N (suggest excessive conditions)
Biochemical oxygen demand	----	Less than 3.0 mg/L as the 5-day biochemical oxygen demand (BOD_5) (Mallin et al. 2006)	Data not available
Total suspended solids (TSS)	----	≤ 25 mg/L, and < 10 mg/L increase from a sudden spike (U.S. EPA 2000)	Limited data - TSS < 25 mg/L
Toxic metals (µg/L)			
Aluminum	Equations*	CMC 750, CCC 87 (U.S. EPA 2000, 2002**	Data not available
Cadmium	"	CMC 2, CCC 0.25 (U.S. EPA 2000, 2002)**	"
Chromium III	"	CMC 570, CCC 74 (U.S. EPA 2000, 2002)**	"
Chromium IV	"	CMC 16, CCC 11 (U.S. EPA 2000, 2002)**	"
Copper	"	CMC 13, CCC 9 (U.S. EPA 2000, 2002)**	"
Lead	"	CMC 65, CCC 2.5 (U.S. EPA 2000, 2002)**	"
Mercury	"	CMC 1.4, CCC 0.77 (U.S. EPA 2000, 2002)**	"
Nickel	"	CMC 470, CCC 52 (U.S. EPA 2000, 2002)**	"
Zinc	"	CMC 120, CCC 87 (U.S. EPA 2000, 2002)**	"

* Dissolved concentrations; equations have been developed that express the total recoverable concentration depending upon the water hardness or pH.

** Water quality guidelines (reference condition, 25th percentile – also see Byrne 2004). CMC ≡ the criterion maximum concentration; CCC ≡ the criterion continuous concentration, within a pH range of 6.5-9.

Surface Water Quality

The park's sewage is treated on-site with septic tanks. Park sewer lines for septic tanks, which previously caused problems from leakage, recently were replaced and aboveground storage tanks were replaced with double-wall containers.

The Tallapoosa River Basin Management Plan (ADEM 2005) described water quality and general habitat concerns identified by stakeholders for various segments of the Tallapoosa River and certain tributaries within the Middle Tallapoosa watershed, including microbial pathogen contamination, erosion and siltation, clay turbidity, nutrient over-enrichment, excessive phytoplankton biomass (as chlorophyll *a*) in impoundments. Water quality and habitat integrity measures within the middle Tallapoosa sub-basin were evaluated as generally achieving use classification standards (ADEM 2005), likely reflecting the fact that land use is mostly forested. However, supporting data for this evaluation are, and were, extremely sparse. The results from a Tallapoosa River basin surface water quality assessment (ADEM 2000), now dated by nearly a decade, rated the overall potential for nonpoint pollution source impairment as low, based on estimates of sedimentation rates, animal unit densities, and pastureland. One smaller watershed within the middle Tallapoosa sub-basin (03150109040, located above HOBE NMP) was listed as a priority NPS-watershed because of a "fair" assess-ment rating caused by erosion and sedimentation from silvacultural practices (ADEM 2005).

The USGS collected data in the Tallapoosa River in the park for water temperature and conductivity on 18 dates and 16 dates, respectively, from 1986 to1996 (station 02414715; *Tables 11* and *12, Figure 11*). Also a little more than a decade ago, the NPS (1997) inventoried the data available on surface water resources and water quality near and within HOBE NMP to provide a base for comparison with subsequent conditions. The effort included examination of the STORET water quality database, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), water gages (GAGES), and water impoundments (DAMS). The analysis located no industrial/ municipal dischargers upstream from the park, no drinkingwater intakes, one water gage (USGS), and no water impoundments. In addition, the NPS sampled nine stations in the park for several water quality parameters during the mid-1990s as a one-date sampling effort (*Tables 11-13, Figure 11*). One station within the park boundary (boat ramp on the Tallapoosa River at State Route 49) was sampled during the mid-1990s with a longer record, from Jan 1994 through Apr 1997. At that station on two dates, the DO concentration was at or below the 4 mg/L U.S. EPA criterion for protection of freshwater life (U.S. EPA 2000). Also at that station, on 24 dates during 1966-1997 the pH was at or below the U.S. EPA (2000) criterion for protection of freshwater life ($\leq$ 6.5).

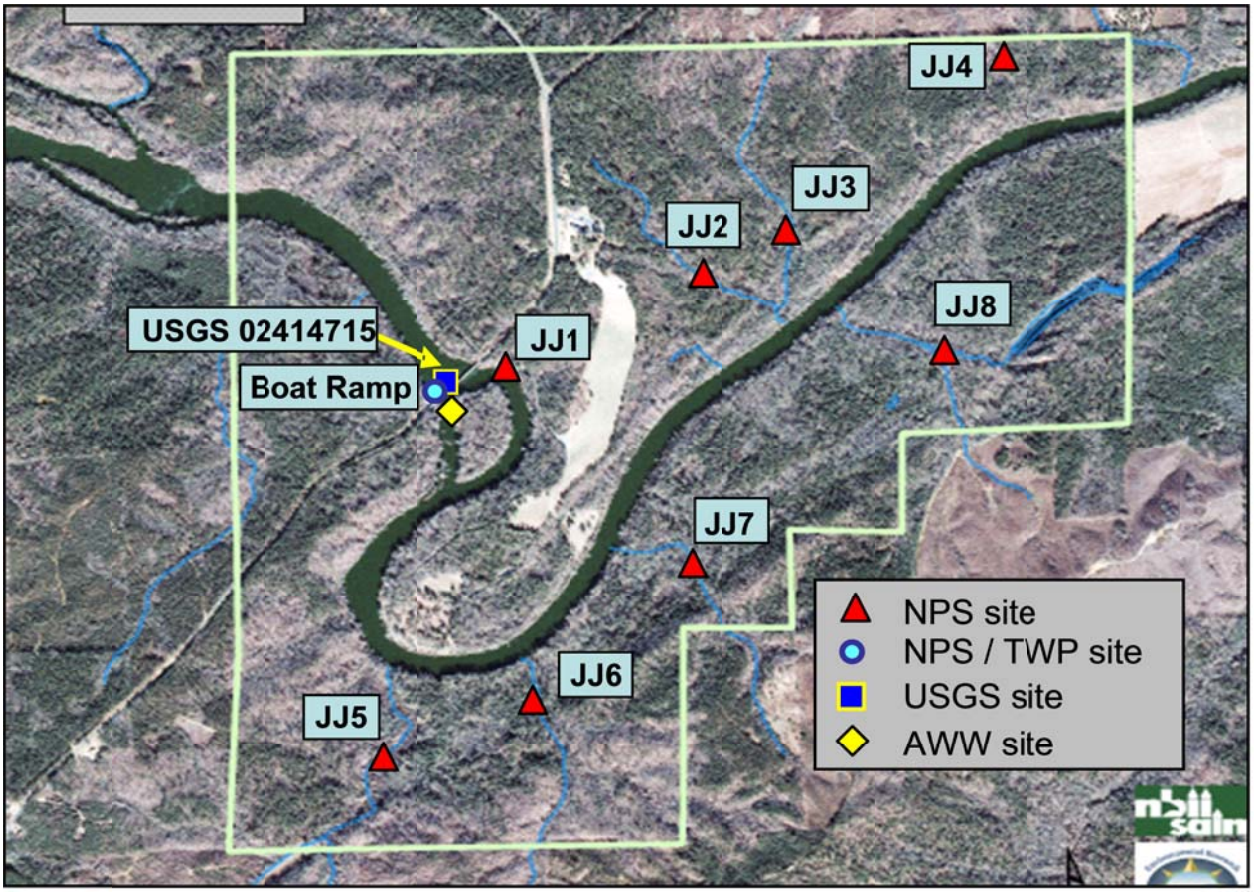

Figure 11. Water quality sites in the park with data collected between 1986 and 1996 (USGS), 1994 - 1997 (NPS), 1993 - present (Boat Ramp station - Alabama Water Watch, AWW), and 2004-2006 (Tallapoosa Watershed Program, TWP). Map modified from ERMF (2007).

Table 11. Locations of water quality sampling sites at HOBE (1986-1996, except Boat Ramp site sampled from 1993-present).

Site	Latitude	Longitude
USGS 2414715	32.9772	-85.7397
Boat Ramp: NPS, TWP	32.9761	-85.7411
AWW	32.975	-85.7403
NPS JJ1	32.9766	-85.7376
NPS JJ2	32.9813	-85.7316
NPS JJ3	32.9819	-85.7271
NPS JJ4	32.9882	-85.7197
NPS JJ5	32.9615	-85.7438
NPS JJ6	32.9741	-85.7371
NPS JJ7	32.9716	-85.7272
NPS JJ8	32.9769	-85.7218

Table 12. Dates of water quality sampling, and parameters sampled in surface waters of the park.

Station	Duration	*n*	Parameters
USGS #02414715	1986 - 1996	16-18	Water temperature, conductivity
Alabama Water Watch (AWW) Boat Ramp, site #07001001	Jun 93 - present (data available through Feb 07)	127	Water temperature, salinity, alkalinity, hardness, turbidity, pH, DO
NPS (Boat Ramp - HOBE NMP 0011)	Jan 94 - Apr 97	37-38	Air temperature, water temperature, total alkalinity, hardness (Ca+Mg), turbidity, pH, DO
NPS JJ1 - JJ6	16 Aug 96	1	Water temperature, specific conductance, alkalinity ($CaCO_3$), hardness (carbonate; Ca+Mg), pH
NPS JJ7 - JJ8	16 Aug 96	1	Alkalinity ($CaCO_3$), hardness (carbonate; Ca+Mg), pH
Tallapoosa Watershed Project (TWP) Just downstream from Boat Ramp station - Auburn Univ. R-3 Talla-poosa R., Horseshoe Bend	Feb 04 - Dec 05	29	Total phosphorus (TP), soluble reactive reactive phosphate (SRP) total nitrogen (TN), TSS

Table 13. Previous water quality conditions in the Tallapoosa River at HOBE NMP, sampled by the NPS (NPS 1997; includes 12 sampling dates in 1994, 10 in 1995, 10 in 1996, and 4 in 1997). Note that the numbers underlined in bold indicate violations of the state water quality standard.

Parameter	Date	*n*	Mean (range)	Medi
HOBE NMP 0011 (Tallapoosa River at the Boat Ramp station in HOBE NMP)				
Temperature (^oC)	Jan 94 - Apr 97	38	18.3 (4.0 - 30.0)	18.0
DO (mg/L)	Jan 94 - Apr 97	37	8.43 (**3.40** - 11.00)	9.00
pH	Jan 94 - Apr 97	38	6.75 (**6.00** - 7.10)	7.00
Alkalinity (mg/L as $CaCO_3$)	Jan 94 - Apr 97	38	17.24 (10.00 - 25.00)	17.50
Total hardness (mg/L as $CaCO_3$)	Jan 94 - Apr 97	38	17.1 (10.0 - 40.0)	20.0

More recent water quality data characterizing aquatic resources in HOBE NMP are almost completely lacking, even for the Tallapoosa River, except for the Boat Ramp site. Volunteers associated with Auburn University's Alabama Water Watch (AWW; https://aww.auburn.edu/) have collected water quality data near the Boat Ramp station in HOBE, but on the edge of the island in the middle of the river downstream from the boat ramp. Parameters measured include water temperature, pH, DO, alkalinity, hardness, salinity, and turbidity, at coordinates N32.975 and W85.74028 (site # 07001001) within HOBE NMP since June 1993 (data available through January 2006; *Figures 12-14*). Based on monthly averages, pH and DO concentrations were below the 6.5 pH minimum and the 5 mg DO/L minimum for acceptable habitat (Fish and Wildlife classification) in 36% and 5%, respectively, of the total samples. Turbidity was well below the state standard of 50 NTU throughout the sampling period. Data are lacking for fecal

coliform bacteria, nutrient concentrations, chlorophyll *a* as an indicator of algal biomass, or toxic substances. Byrne (2004) reported an overall "potential red flag" for the Tallapoosa River segment in the park considering pH and total and fecal coliforms.

The Tallapoosa Watershed Project (TWP) at Auburn University obtained monthly nutrient data (total phosphorus [TP], soluble reactive phosphorus [SRP], total nitrogen [TN], and total suspended solids [TSS]) for a two-year period (January 2004 - January 2006) at the Boat Ramp station (*Table 14*). The data for TP indicate mesotrophic (moderately productive) conditions (Wetzel 2001; ~20-80 µg/L), whereas TN concentrations throughout 2005 - winter 2006 are very high (eutrophic to hypereutrophic range; Wetzel 2001), suggestive of problems with N over-enrichment. TSS data depict moderately turbid conditions (U.S. EPA 2000, 2002) throughout the sampling period.

Groundwater Quality

Data are lacking for groundwater quality in HOBE NMP. The park has a well house by the maintenance yard, and a well that is no longer in use (welded shut; J. Cahill, pers. comm.).

Potential Sources of Pollutants

The middle Tallapoosa River sub-basin includes a total of 84 NPDES dischargers (66 industrial, 18 municipal; ADEM 2006). The five major NPDES dischargers in the sub-basin 03150109 have a combined permitted flow of 13.8 mgd (ADEM 2006). Data are not available as to whether these point sources have affected HOBE NMP, but sewage spills, for example, have affected tributaries close by in the sub-basin (e.g. *Plate 13*).

Nonpoint source pollution from airsheds and land occurs from human activities such as urban development, agriculture, silvaculture, various other industries, and other land use practices. It is the major source of pollution in many U.S. watersheds, and can carry toxic substances, suspended sediments, excessive nutrients, and microbial pathogens into receiving waters (e.g. U.S. EPA 2001, Burkholder et al. 2006). Local nonpoint pollution sources in the watershed include suburban/urban runoff and air pollution from the small population centers and agricultural and silvacultural operations upstream from the park. The upper watershed has been used for agriculture, gold mining and, more recently, for timber production and harvest. Concern has been raised that water quality in the middle Tallapoosa sub-basin may be adversely affected by agricultural runoff from upstream livestock and chicken production (DeVivo 2004, ADEM 2005). In addition to non-point water and air pollution from local sources, toxic contaminants, dust/particulates, and other pollutants may be carried into the park area and upstream Tallapoosa waters from larger cities in the state, and from Atlanta, GA, by prevailing winds. Moreover, the risk of foliar ozone injury to plants at HOBE NMP has been evaluated as high (DeVivo 2004), and is considered to affect both wetland and terrestrial species.

The overall potential for nonpoint source impairment in the middle Tallapoosa River sub-basin has been evaluated as low, based upon estimates of sedimentation rates, animal unit densities, and pasture land (ADEM 2000). However, more than half of the 22 sub-watersheds in the middle basin were estimated to have moderate potential of NPS impairment because of runoff from forestry practices, clearcutting, and sedimentation. Accordingly, pollution from increased industrial development of the Tallapoosa watershed is a park concern, as is clearcutting for timber and for development (*Plate 14*).

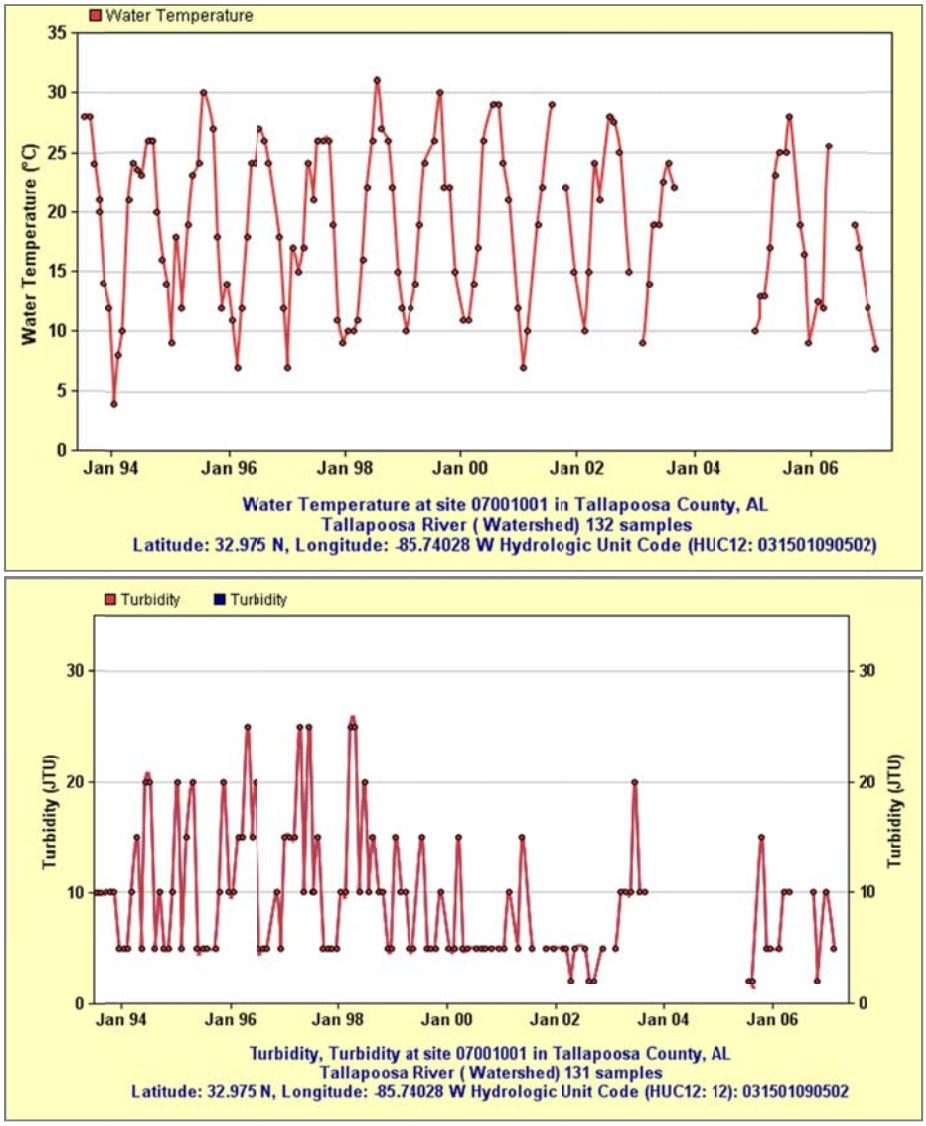

Figure 12. Water temperature and turbidity (upper and lower panels, respectively) in the Tallapoosa River at HOBE NMP (Boat Ramp station, Jul 1993 - Feb 2007) from a monthly sampling program by volunteer citizens in the Alabama Water Watch.

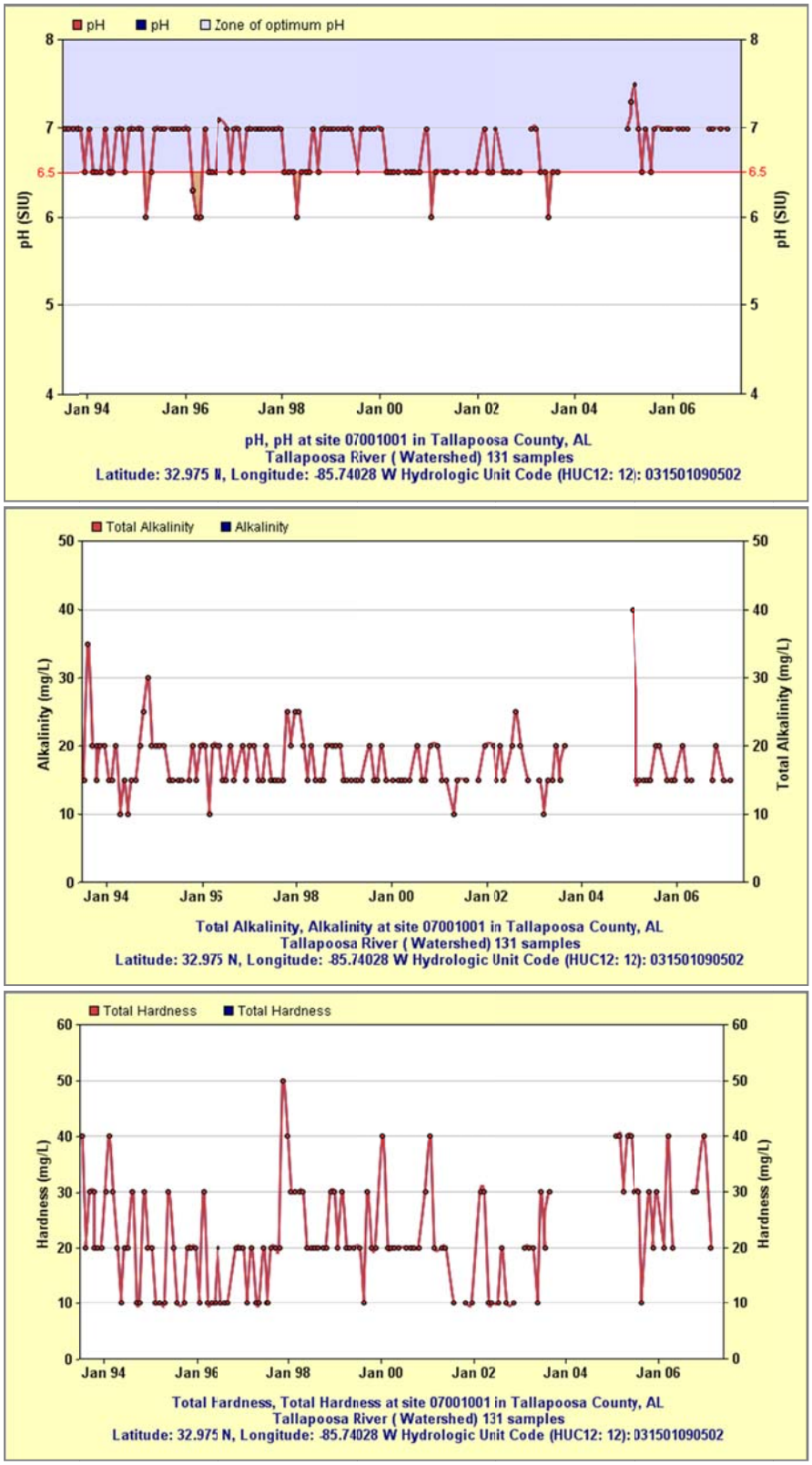

Figure 13. Water pH, alkalinity, and hardness (upper, middle, and lower panels, respectively) for the Tallapoosa River at HOBE NMP (Boat Ramp station, Jul 1993 - Feb 2007) from a sampling program by volunteer citizens in the Alabama Water Watch.

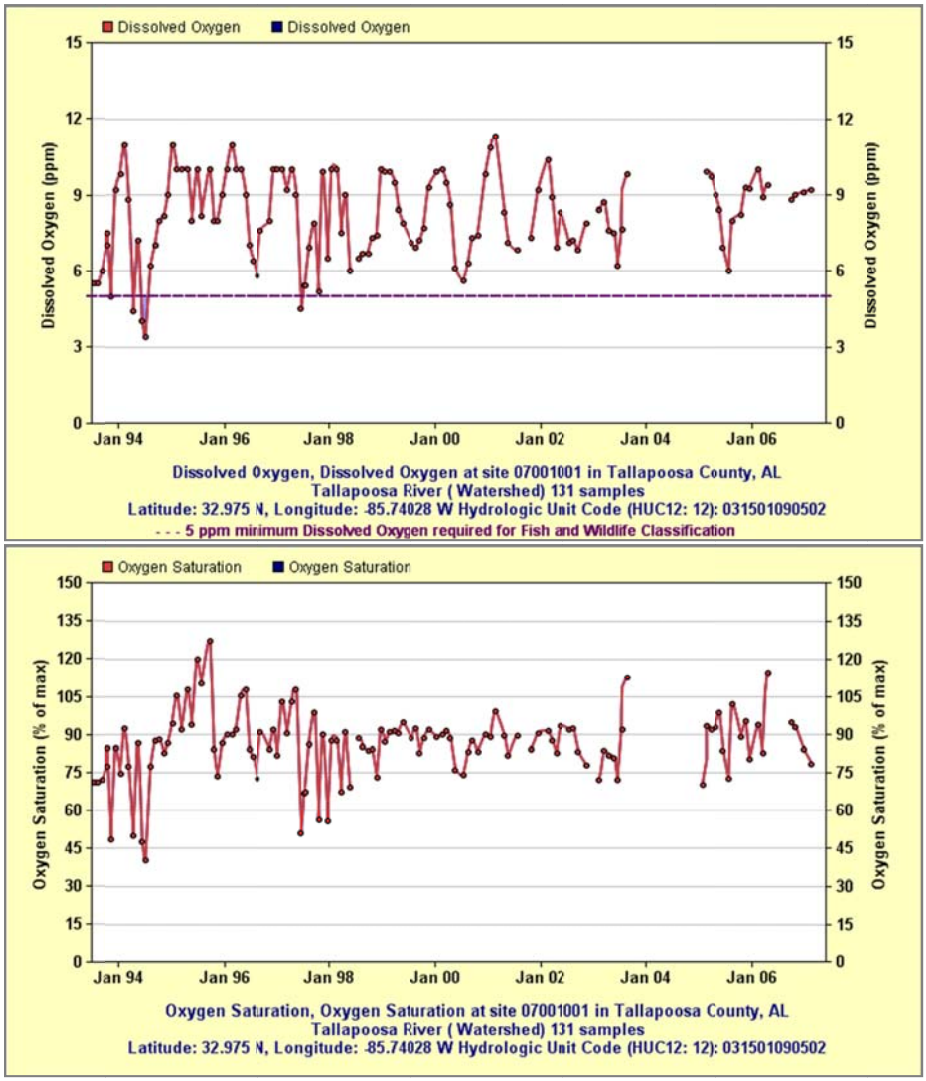

Figure 14. Dissolved oxygen as concentration and percent saturation (upper and lower panels, respectively) for the Tallapoosa River at HOBE NMP (Boat Ramp station, Jul 1993 - Feb 2007) from a sampling program by volunteer citizens in the Alabama Water Watch.

Table 14. Seasonal mean nutrient concentrations, based upon monthly data (1993 - 2006, n = ~160), at the Boat Ramp station within the park. Data were collected in association with the Tallapoosa Watershed Project at Auburn University.

Season/Year	TP (µg/L)	SRP (µg/L)	TN (µg/L)	TSS (mg/L)
Winter 2004	21	2	3,890	9.9
Spring 2004	25	2	4,980	14.0
Summer 2004	19	3	6,320	12.2
Fall 2004	22	4	6,770	14.1
Winter 2005	28	5	12,250	11.5
Spring 2005	37	2	13,920	10.6
Summer 2005	71	5	55,930	10.0
Fall 2005	24	2	15,350	14.2
Winter 2006	31	4	16,840	12.5

Plate 13. Dead fish, part of a fish kill from a raw sewage spill at Wadley, AL on a tributary of the Tallapoosa River in the middle basin. Photo by Joey Hodges, reprinted with permission from The *Randolph Leader Newspaper*, 9 July 2008.

Plate 14. A fresh clearcut about 0.5 mile from HOBE NMP, November 2006. Photo by M. Mallin.

A total maximum daily load (TMDL; U.S. EPA, 1991) was developed in 2002 for the Tallapoosa River (4.3 mile length) within Cleburne County in the upper Tallapoosa basin based upon low DO and organic enrichment (indicated from data on biochemical oxygen demand) as recounted in impaired stream reports from 1996-2000 (ADEM 2002). Two major point sources of pollution were identified as the city of Heflin wastewater treatment plant, and the Tyson poultry industry. While the impaired stream segment is separated from the park by a considerable distance (*Figure 15*), this illustrates the point that additional watershed development nearer to the park is of concern because it has the potential to adversely affect water quality.

Other Issues of Concern

Changing Land Use, Population Growth, and Pollution

Land use affecting HOBE NMP includes both the immediate area and the watershed upstream that drains into it. In 2000 the human population of the middle Tallapoosa sub-basin was ~129,000. While the middle sub-basin changed very little from 1991-2000 (increase of 0.8%), the upper basin is developing more rapidly and increased in population by ~10%, including influx from the Atlanta, GA area. The state of Alabama is expected to experience a ~21% population increase from 2000-2025 (Source: Center for Business and Economic Research, University of Alabama). While the middle sub-basin, at present, is only ~5% urbanized, water

quality is impaired in various stream segments in the Tallapoosa basin (ADEM 2002,2005), and the combined pressures of increased development in the upper and middle basins are expected to increase land disturbance and water pollution including excessive nutrients, fecal bacteria, toxic substances, and suspended sediments.

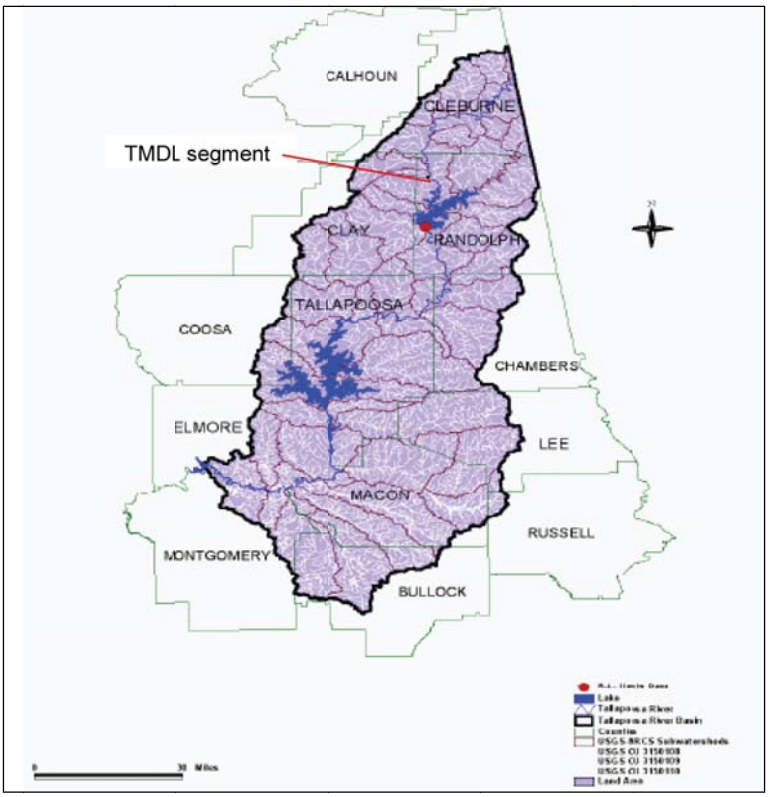

Figure 15. The segment in the upper Tallapoosa basin, in Cleburne County, where the TMDL was developed (ADEM 2002). Star = location of HOBE NMP; scale = 30 miles.

The state environmental agency monitors some sites along the Tallapoosa River, not near the park, for mercury content in fish, and occasionally has reported fish consumption advisories.

Air Quality

Information is not available about air quality in the park. Nevertheless, although HOBE NMP is relatively remote from major population centers, its airshed can be affected by pollution and poor air quality from Birmingham (90 miles northwest) and Montgomery (~70 miles southwest). For example, the American Lung Association rated Birmingham (years 2004-2006) among the five worst cities in the nation for fine particulate pollution (Bouma 2008; American Lung Association – see http://lungaction.org/reports/sota07_cities.html).

In addition, the park occasionally can be affected by smoke from wildland fires considerable distance away. The National Weather Service (http://www.srh.noaa.gov/bmx/significant_events/2007/weather_review.php) reported that significant wildland fires which developed across southern Georgia and northern Florida in mid-April through May of 2007 pushed a smoke plume into central Alabama. The resulting hazy and smoky conditions lasted several days.

Park Land and Water Use Issues

Stormwater runoff from impervious surfaces can lead to increased pollutant loadings to the Tallapoosa River, the small perennial tributary stream, and the intermittent streams in the park. The parking lot in the visitors' area drains into the Tallapoosa River, so that during high-use periods, precipitation events would be expected to add pollutants to the river. Even so, the relatively small impervious surface area likely is not a problem to the river in terms of pollutant runoff.

Both surface water and groundwater are plentiful in the park region, and present as well as anticipated use of water at the Park and in the surrounding area should not cause problems for water resources.

Physical changes to the landscape are affecting water quality in the Tallapoosa watershed (ADEM 2002, 2005), but physical alterations from active construction and other land disturbance is not occurring in the park. The various trails that are used by visitors may be worn over time and should be surveyed periodically to check for overuse and deterioration.

Synopsis of Stressors to Aquatic Resources at HOBE NMP Tallapoosa River and Wetlands

The present and potential stressors that are affecting or may affect KEMO NBP are summarized in *Table15*. A highly artificial flow regime has been imposed in the middle Tallapoosa River by hydroelectric operations, which periodically would be expected to cause sudden, extreme stress and elimination of aquatic life. The dams also have fragmented the river habitat for natural migration and breeding patterns of fish and mussels. A rich wetland flora is present in the park. Data on the Park flora and fauna consist mostly of lists of species that are known or suspected to be present. Among the latter species is the exotic invasive Asian clam (*Corbicula fluminea*), which may have displaced native bivalve molluscs.

Table 15. Current and potential stressors that are affecting or may affect HOBE NMP (ND ≡ no data to make judgment; --- ≡ not applicable; EP ≡ existing problem; PP ≡ potential or pending problem).

Stressor	Surface Waters	Groundwater	Airshed	Forest	Human Health
Acidification	EP	ND	PP	PP	PP
Algal blooms	PP	---	---	---	NP
Toxic algae	ND	---	---	---	NP
Encroaching development (clearcutting, etc.)	ND (PP)	ND (PP)	ND (PP)	ND (PP)	NP
Erosion (including dust)	ND (PP)	ND	---	ND (PP)	---
Excessive nutrients	EP	ND	PP	---	NP
Exotic invasive species*	EP	---	---	EP	ND (PP)**
Fecal bacteria, other microbial pathogens	ND (PP)	ND	ND	ND	PP
Habitat disruption	EP	ND	---	EP	---
Hypoxia	EP	---	---	---	---
Metals contamination	ND (PP)	ND (PP)	ND (PP)	---	ND (PP)
Other toxic substances	ND (PP)	ND (PP)	PP	ND (PP)	PP
Ozone pollution	ND	---	PP	PP	PP
Particulate matter pollution	ND (PP)	ND	PP	---	PP
Sedimentation	ND (PP)	---	---	---	PP
Trash/refuse pollution	PP	---	---	PP	---
Water demand	PP	PP	---	---	PP

* Suspected for aquatic resources; known for terrestrial resources.
** Includes consideration of West Nile virus, carried by mosquitoes and known to be in the area.

Based on very limited data, the river in the park area is moderately nutrient-enriched and may be sustaining noxious algal blooms. Sub-optimal pH and DO concentrations have been documented and likely stress beneficial aquatic life. The park's aquatic resources may also be affected by water quality degradation related to airshed pollution (ozone, other pollutants), agriculture, and land clearing. For example, agricultural impacts may have resulted in local extirpations of herpetofauna (Tuberville et al. 2005). The park's sewage is treated in on-site septic systems and

is not assessed as a threat to surface-or groundwater quality. Data are not available for microalgal abundance/composition, fecal bacteria densities, or toxic substances.

Drinking Water

Drinking water for the park is supplied by the town of New Site. The water is chlorinated and, thus, not a risk from fecal bacteria.

Groundwater

Groundwater resources in the park appear to be plentiful, but data are not available to assess groundwater quantity or quality.

Recommendations for Addressing Impairments, Potential Impacts, and Water Bodies

General Comments

Government-managed lands comprise 29% of the U.S. land area (Gibbons et al. 1997), including more than 32 million hectares set aside within the National Park System (Stohlgren et al. 1995). Thus, the National Park System is a major factor in the potential for this nation to protect natural lands and biodiversity. The parks and their natural resources are supposed to be "protected lands" for present and future generations of U.S. citizens, but external encroaching stressors from watershed development and habitat fragmentation are seriously threatening these critically important refuge areas, including HOBE NMP. Another major threat is the lack of fundamental data to evaluate present status. Such data are needed to guide improved management strategies to protect these important national resources.

Water – namely, the Tallapoosa River – is the most prominent natural feature of HOBE NMP, yet its status is very poorly known. Although the park is still within a relatively undisturbed, forested sub-basin of the watershed, the NPS is ill-equipped to protect its vitally important water resources from airshed and watershed pollution and other stressors because the stressors, for the most part, are outside of NPS control. In addition, there is a near-total lack of fundamental information on water quality conditions or aquatic community health. More fundamentally, very few data are available on aquatic resources, mostly limited to surveys of known or suspected species occurrence. The following recommendations were developed considering these points.

Specific Recommendations

Water Quality

- A two-year water quality monitoring program should be established for at least two stations in the Tallapoosa River within the park. This program should be put in place on a biweekly (preferably, to capture effects of pollution from storm events) or monthly basis to track water quality conditions in the Tallapoosa River within the park. Parameters measured should include, at a minimum, water temperature, pH, DO, suspended solids, turbidity, nutrients (TN, TP, nitrate, ammonium, biochemical oxygen demand as BOD5), fecal coliform densities, and chlorophyll a concentrations. This effort should be repeated every five years. Bench- marks for acceptable water quality should consider the information contained in Table 11.

- Data should be collected at least annually on toxic substance concentrations (PCBs, heavy metals, pesticides, pharmaceuticals) in sediments and fish or benthic faunal tissues.

- The park should inventory changes in land use/land cover in the middle Tallapoosa basin, especially within ten miles of the park, including traditional categories but also septic tanks in new subdivisions, new highway projects, new shopping centers, and other potential sources of water pollution. The data should be used to create GIS maps of these sources, which can be upgraded over time to help the NPS track pollution and its impacts in park waters.

- The smaller streams in the park should be assessed during high-precipitation periods to assess whether any of them are a source of suspended sediments and other pollution to the Tallapoosa River in the park area.

Ecosystem and Community Health

- At least once per year during an appropriate seasonal timeframe, the macroinvertebrate communities in the park segment of the Tallapoosa River should be assessed in at least two stations, following the protocol in Barbour et al. (1999). Benchmarks should consider published descriptions of healthy macro- invertebrate communities in warmwater streams (e.g. Barbour et al. 1999, GA 2007). The data should be used to track stream ecological condition (rated from Excellent to Poor) over time.

- At least once per year during an appropriate seasonal timeframe, the fish community in the park segment of the Tallapoosa River should be assessed, following the protocol outlined in Barbour et al. (1999). The fish data should be used to develop an Index of Biotic Integrity and an Index of Well-Being for fish population health over time (Barbour et al. 1999).

- A sampling program should be developed to establish present conditions and track exotic invasive species affecting terrestrial as well as aquatic/wetland sources in the park. Assessment of exotic invasive species should be repeated at least at three-year intervals to enable detection of species that may rapidly invade.

- The park's wetland ecosystems should be assessed at five-year intervals for indices of diversity, function, and overall health.

- An updated biological inventory should be completed for herpetofauna, following the protocol outlined in Tuberville et al. (2005).

- A baseline biological inventory is needed for the composition and abundance of microalgal assemblages. In at least two stations, triplicate samples should be collected monthly for suspended microalgae, and at least five samples should be collected bimonthly for benthic microalgae following protocols in Wetzel and Likens (2001). Chlorophyll concentrations should also be assessed for suspended microalgae (protocol in Wetzel and Likens 2001). The data on suspended microalgae should be assessed over time to discern relationships with environmental conditions such as nutrient concentrations and turbidity. The benthic microalgal (periphyton) data should be used to develop an index of biotic integrity (e.g. following Hill et al. 2000) for the Tallapoosa River in the park area.

Groundwater and Air Quality

- Groundwater resources of the park should be assessed through partnership with the USGS, including recharge/discharge areas, movement, and chemical quality.

- Data are needed to assess the extent to which air pollution is affecting the park, and to forecast how increasing air pollution from major population centers will affect its waters and other natural resources. The park should install sampling devices to establish present

air quality conditions and track air pollutants such as ammonium, particulates, and toxic substances (for example, mercury).

Education Outreach

- HOBE NMP serves as an important greenspace. The park should strengthen its environmental education program to teach visitors about the importance of greenspaces in ecosystem sustainability.

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