A State of Knowledge of the Natural, Cultural, and Economic Resources of the Greater Mobile-Tensaw River Area

Natural Resource Report NPS/NRSS/BRD/NRR—2016/1243
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A State of Knowledge of the Natural, Cultural, and Economic Resources of the Greater Mobile-Tensaw River Area

Natural Resource Report NPS/NRSS/BRD/NRR—2016/1243

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Abstract

From the convergence of the Alabama and Tombigbee rivers in southern Alabama, arise the sister Mobile and Tensaw Rivers, and one of the great natural and cultural wonders of North America. The Greater Mobile-Tensaw River Area has been called “America’s Amazon” because of its obvious natural bounty, wondrous complexity, and profound diversity. Dramatic bluff lands and pinelands plunge down to the Mobile-Tensaw Bottomlands and Delta comprised of ever-changing levees, islands, channels, and bayous. The region’s unique geology and hydrology underpin its dynamic biotic systems as, likewise, do associated ecological processes that range from the lingering influences of ancient and far-off continental glaciation to the daily rise and fall of tides and changes in water salinity. Flora and fauna of the area are at once fragile and bountiful—the area contains many endangered, threatened, and special concern species, but also tree species diversity that ranks among the highest in North America, a diverse assemblage of freshwater crustaceans, over 200 species of birds, and likely the greatest turtle diversity in the world. The Greater Mobile-Tensaw River Area is steeped in human history, as well, from the originating Native American tribes and the mysteries of their ancient mounds awaiting exploration; through the area’s critical role in European settlement of America and, later, the American Civil War; through today’s cultural and economic vibrancy of its adjacent urban center, Mobile. Here people’s lives are woven among the dynamic rhythms of the area’s lands and waters. Yet, much remains elusive about how the area’s places are connected ecologically, socially, and economically. This holistic volume combines science, natural and cultural history, economics, and personal reflection to call attention to the connectivity of the area, to acknowledge challenges from human encroachment, and to serve as a foundation for a discussion of shared ecological, cultural, and economic stewardship of the Greater Mobile-Tensaw River Area.
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List of Acronyms

ADCNR—Alabama Department of Conservation and Natural Resources
IUCN—International Union for the Conservation of Nature
NHL—National Historic Landmark
NNL—National Natural Landmark
NOAA—National Oceanic and Atmospheric Administration
NPS—National Park Service
USDA—United States Department of Agriculture
USEPA—United States Environmental Protection Agency
USFWS—United States Fish and Wildlife Service
USGS—United States Geological Survey
Foreword

Edward O. Wilson, Museum of Comparative Zoology, Harvard University

Mobile-Tensaw River Delta, Alabama. Photograph courtesy of Hunter Nichols.

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The greater Mobile-Tensaw River area, containing the Delta and the Red Hills immediately to the north, is both uniquely beautiful and one of the least known natural areas in America. Although located on the flat Gulf of Mexico plain, its habitats match—or exceed—in diversity those in any of America’s established national parks. In the Red Hills, ridges with remnant longleaf pine savannas drop to deep, cool ravines that harbor relict “ice-age” floras left behind during the retreat of the last continental glacier. Southward they give way to the Mobile-Tensaw Delta, second largest delta in America after the Mississippi, enclosed by the two powerful rivers feeding between them, inward from shoreline bluffs, a labyrinth of streams, oxbow lakes, freshwater and brackish marshes, flooded woodland, and raised islets of secure ground. The Delta is a miniature wilderness. Even with a boat, map, and GPS, travel is difficult.

The Delta may also be the easiest natural land in America in which to get lost. Yet at the same time it is the most accessible of any known wildland. Its bayfront border, lined with a causeway, can be reached by automobile from downtown Mobile in 15 minutes.
Because of the great variety of the habitats in which they live, and their still mostly undisturbed condition, the fauna and flora of the greater Mobile-Tensaw River area may well be most diverse of comparable geographical areas in North America. The 28+ species of oaks in the Red Hills, for example, is evidently a national record. The number of turtle species is one of the highest in the world. The full roster of plants and animals includes many endangered species. Others are certain to exist still unknown to science.

The pre-European human history of the Mobile-Tensaw Delta has also just begun to yield its secrets. Archaeological evidence exists of settlements that go back thousands of years, with a likelihood of inception during the Late Archaic Period, at least 6000 years before the present. The best and most striking settlement in Lower Alabama is the Delta’s Bottle Creek site, which was occupied between AD 1250 and 1550. Still mostly unexcavated by archaeologists, it contains a high mound facing a plaza, along with smaller residential mounds scattered about. The largest of its kind on the central Gulf Coast, it appears to have been the headquarters of elites who controlled the population for miles inside the Delta and to the Gulf.

And there is substantial history as well. Through the 1820s at the edge of the Tensaw River, Blakeley, a frontier boomtown flourished, only to be dispersed following two yellow fever epidemics. It was then replaced by Fort Blakeley, the site of the last major battle of the Civil War, fought unknowingly on the same day as Lee’s surrender at Appomattox. The Confederate ramparts still stand, untouched to the present day. I am personally involved a bit in these battlements, since one of my great-grandfathers, a Confederate artilleryman, escaped capture by fleeing across the Delta to reach his home in Mobile.

Actually, my attachment to this immediate area runs even more deeply. When I was a boy, living in Mobile and also nearby Brewton, Alabama, I fell in love with what has come to be called “America’s Amazon.” I was predisposed to do so because Mobile was my ancestral home. My forebears were among the settlers of Mobile County and adjacent Baldwin County during the American era, from its 1819 statehood. They all worked close to and around the Delta, variously as merchants, marine engineers and bar pilots on the Bay. One couple helped establish the doomed community at Blakeley. After its abandonment, they moved with their infant daughter to the village of Mobile.

The Delta had a powerful influence on my development as a scientist. As I roamed around its edges, collecting butterflies and snakes, I dreamed of someday taking an expedition into the interior to discover all of the insects and other animals. Now I understand that it will take a lot of expeditions.

Remarkably little has changed in the Red Hills and Mobile-Tensaw Delta since my boyhood in the 1940s. Industries and housing are pressing in on the habitable edges, and the pollution of the river waters is rising inexorably. The populations of Mobile and the Bay coasts are growing and spreading rapidly. Yet for a while longer this small wilderness will persist, a priceless window on deep history, and a national treasure at multiple levels.

The value of the greater Mobile-Tensaw River area is great, unique, and if lost cannot be recreated. Is there any other place in America where residents and visitors can live in a modern city and yet travel into an authentically wild area within an hour? Or where students can experience a natural subtropical environment along with unaltered historical sites spanning 500 years in a single day’s excursion?
INTRODUCTION

Alligator, Mobile-Tensaw Delta, Alabama. Photograph courtesy of Hunter Nichols.
1. Introduction

Gregory A. Waselkov, University of South Alabama; C. Fred Andrus, University of Alabama; Glenn E. Plumb, National Park Service

This report is the product of a cooperative effort between the University of South Alabama, the University of Alabama, and the National Park Service through the Gulf Coast Cooperative Ecosystem Studies Unit, a consortium that facilitates cooperative science and scholarship between federal agencies and regional universities. The principal goal of contributors to this report is to share with the public the state of our knowledge on the natural, cultural, and economic resources of the greater Mobile-Tensaw River area. As defined for this project, this area encompasses the large landscape and watershed that includes the Mobile-Tensaw Delta.

Alabama and the National Park Service have a strong history of cooperation via parks, national natural landmarks, national historic landmarks, national historic sites, and community assistance programs. One National Natural Landmark (Mobile-Tensaw River Bottomlands) and 6 National Historic Landmarks (Fort Morgan, Mobile City Hall and Southern Market, USS Alabama, USS Drum, Government Street Presbyterian Church, and Bottle Creek Archeological Site) are located in or near the greater Mobile-Tensaw River area. The National Natural and Historic Landmarks programs are administered by the National Park Service. Designation as National Landmarks recognizes and encourages the conservation of sites that contain outstanding natural and cultural resources regardless of landownership type. These are the only programs of national scope that recognize the best examples of natural and cultural resources and values in both public and private ownership. Partnerships among public and private land stewards allow participants to share information, solve problems cooperatively, and conserve outstanding sites that illustrate the rich and diverse tapestry of the country’s natural and cultural landscapes. Integration of knowledge about and stewardship of natural and cultural landscapes is crucial to preserving the ecological and cultural integrity of our communities.

We have convened 35 contributing authors in an unprecedented effort to assess the state of our knowledge on key natural, cultural, and economic conservation resources for the Mobile-Tensaw Delta, lower Alabama and Tombigbee rivers, and adjacent contributing watersheds, bluffs, and pinelands. The area under consideration begins at the head of Mobile Bay and extends north through the deltaic floodplain, including locally rising watersheds and streams, and the forests sheltering those watersheds and streams, up through the Red Hills region that overlooks the northern extent of the Delta. This area—the greater Mobile-Tensaw river area—includes approximately the northeastern quadrant of Mobile County, the northwestern quadrant of Baldwin County, most of southern Clarke County, the southeastern corner of Washington County, the westernmost section of Escambia County, and the southwestern quadrant of Monroe County.

The 23 chapters of this wide-ranging report will, we hope, enhance understanding and stewardship of these natural and historic landmarks, and aid planning by the citizens and State of Alabama and its partners. Among the contributors are many preeminent specialists who know their corners of the greater Mobile-Tensaw River area better than anyone else. Here they introduce us to their topics in plain English and share information not generally available outside of the technical literature. Every chapter illustrates the area’s rich natural and cultural diversity, and identifies challenges and opportunities to preserve the integrity and economic viability of these resources. This report highlights the history of the Delta, its communities and habitats, from the Delta’s geological origins through changes in land use by humans from earliest to modern times. We have endeavored to share with readers an up-to-date picture of the greater Mobile-Tensaw River area that can contribute to the area’s biological health and sustainability by enhancing understanding and stewardship of its resources, and inform conservation planning by Alabama and its partners.
2. A Brief History of the Mobile-Tensaw River Bottomlands National Natural Landmark

Glenn E. Plumb, National Park Service

The National Natural Landmarks Program

The National Natural Landmarks (NNL) Program was established by the Secretary of the Interior in 1962, under authority of the Historic Sites Act of 1935 (16 USC 461 et seq.), to identify and encourage the preservation of the full range of geological and biological features that are determined to represent nationally significant examples of the nation’s natural heritage. Potential sites are evaluated by qualified scientists and, if determined nationally significant, recommended to the Secretary of the Interior for designation. Once a landmark is designated it is included on the National Registry of Natural Landmarks, which currently includes nationally significant geological and biological features in 48 states, American Samoa, Guam, Puerto Rico, and the US Virgin Islands.

National Natural Landmarks are nationally significant sites owned by a variety of land stewards, and their participation in the NNL program is entirely voluntary. National Natural Landmark designation is not a land withdrawal, does not change the ownership of a site, and does not dictate use, activity, or land acquisition (NPS 2009). Of the nearly 600 NNLs designated to date and listed on the Registry, approximately one half are administered solely by public agencies (e.g., federal, state, county, or municipal governments), nearly one third are owned entirely by private parties, and the remaining are owned or administered by a mixture of public and private owners. For the many natural landmarks that are privately owned or not managed for public access, owner permission must be obtained prior to visitation. Designation in no way confers any right of public access. The National Park Service (NPS) administers the NNL program and works in partnership with landmark owners to encourage and advocate for conservation of landmark resources. Upon landowner request, the NPS can also provide assistance for landowner conservation efforts.

The Mobile-Tensaw River Bottomlands National Natural Landmark

During the early 1970s, Richard Goodwin and William Niering from Connecticut College conducted a review of important inland wetlands of the United States (see Goodwin and Niering 1975). By early 1972, this comprehensive national study involved discussion with Walter Beshears of the Alabama State Department of Conservation and Natural Resources (Vance 1972; Mount 1973) regarding important inland wetlands of Alabama. Beshears had previously co-published an overview of Alabama’s estuarine areas (Beshears and Bird 1959), including the Mobile-Tensaw River Bottomlands. Available records indicate that by the early 1970s, it was Mr. Beshears who first suggested to Goodwin and Niering that the Mobile-Tensaw River Bottomlands be considered for designation as an NNL (Vance 1972; Mount 1973; Goodwin and Niering 1975). In response to this suggestion, Richard Vance, Park Naturalist with the Natchez Trace Parkway, visited the area with Dr. M.W. Galland and Douglass Freeman on June 6, 1972, and engaged in additional correspondence with Dr. Arthur Garrett from the University of South Alabama and Mrs. Verda D. Horne of Fairhope, Alabama (Vance 1972). In a short report Vance (1972) described the highlights of the Mobile-Tensaw River Bottomlands and wrote that, “The area has problems. However, the tremendous amount of nationally significant natural values offset most of the encroachments. Also, there are many influential groups and people who are working to preserve this area.” He further concluded that, “It is my recommendation that this site is eligible for inclusion in the National Registry of Natural Landmarks.”

Following Vance’s 1972 visit, the National Park Service requested a formal evaluation by Dr. Robert H. Mount, Professor of Zoology-Entomology at Auburn University, who had visited the area on numerous occasions. On June 28, 1973 Mount toured the area by boat with Dr. James Harper of Auburn University, and subsequently made contact with the 4 largest landowners in the area (Scott Paper Company, International Paper
Company, Baer and Company, and Alabama Public Lands Division). Mount also consulted with faculty colleagues from Auburn University, Mrs. Mary Ivy Burks (Executive Secretary of The Alabama Conservancy), and Mrs. Verda D. Horne (Conservation Chairman of the Alabama League of Women Voters). In his written report, Mount (1973) included detailed descriptions of the location, size, ownership, land use, natural resource values, and threats to integrity of the area. He concluded that:

The delta of the Mobile bay drainage is one of the most important wetland areas in the country. It contains a variety of habitats, ranging from mesic floodplains and freshwater swamps to open, brackish-water marshes. Despite man’s intrusions into the area and his depositions of pollutants in the streams that furnish its water, the delta still retains many of its natural values. The area is, in my opinion, of considerable national importance. Its designation as a Registered Natural Landmark will enhance efforts being made to protect it from further degradation. Numerous references and knowledgeable people were consulted during the study of the Mobile Bay delta and in the preparation of this report. All of the individuals with whom I talked concurred with the opinions expressed herein.

In April 1974, at its 70th meeting at Washington D.C., the Department of Interior Advisory Board on National Parks, Historic Sites, Building and Monuments (hereafter, “Advisory Board”) identified 35 sites across the United States eligible for designation as Registered Natural Landmarks. Those identified included 3 sites in Alabama: Beaverdam Creek Swamp, the Dismals, and the Mobile-Tensaw River Bottomlands (NPS 1974a). On April 24, 1974 Lady Bird Johnson, Acting Chairman of the Advisory Board and wife of President Lyndon Johnson, formally wrote to the Secretary of Interior to recommend these 35 sites for official designation (NPS 1974a). She further informed the Secretary of Interior, by a separate letter in that same capacity, “The Board recommends that the National Park Service conduct further study to determine the best means of protecting the ecological values of this site” (NPS 1974b). The NPS undertook a “Study of Alternatives, Mobile-Tensaw River Bottomlands” (NPS 1979) focused on two purposes:

- to evaluate resource significance through development of a resource base, including maps, and report sections delineating natural resources, cultural resources, water and air quality, land use and ownership, socioeconomic environment, and regional context; and
- to delineate preservation/management alternatives in terms of specific institutional arrangements required to protect and properly utilize values of the area.

The study involved extensive stakeholder consultation with federal, state, county, and non-governmental organizations, including specific contact with the Director of the Alabama Division of Game and Fish, and the Commissioner and Assistant Commissioner of the Alabama Department of Conservation and Natural Resources. Other agencies and organizations contacted by the NPS included Alabama Air Pollution Control Commission; Alabama Coastal Area Board;
Alabama Cooperative Extension Service; Alabama Water Improvement Commission; US Department of Agriculture Forest Service; Department of Defense, Department of the Army; Corps of Engineers-Mobile District; Environmental Protection Agency; Mobile Bureau of Environmental Health; South Alabama Regional Planning Commission; University of South Alabama; and 5 Alabama non-government organizations (The Alabama Conservancy, Birmingham; Baldwin County Wildlife Association, Robertsdale; Baldwin County Wildlife and Conservation Association, Bay Minette; Mobile Audubon Society, Mobile; and the Mobile County Wildlife Association, Mobile).

The NPS released the “Study of Alternatives, Mobile-Tensaw River Bottomlands” as a public document in 1979, which at the time was the first integrated synthesis of natural resource, cultural resource, and socio-economic information for the area (NPS 1979). The report included detailed and summary state-of-the-knowledge information, tables, figures, and maps, as well as key findings about resource status/condition. According to this report (NPS 1979):

While the delta still retains its natural values to a significant degree, threats to the integrity of the natural environment do exist. If these threats are left unchecked, it is very likely that the significant natural values would be lost, and the integrity upon which the Secretary originally based his determination of national significance would be destroyed.

The report identified the major threats to the areas as:

1. existing industrial development along the west bank of the Mobile River with further expansion planned northward and along the Tensaw River, which would produce cumulative degradation;
2. cumulative effects of pollution from silt, agricultural chemicals, and to a lesser degree industrial waste as an ongoing problem;
3. potential widespread expansion of timber harvesting practices;
4. uncontrolled wildlife harvest that reduces some species; and
5. cumulative effects from dredging and spoilage.

The report included descriptions of potential alternatives and various methods of preserving the resources of the Mobile-Tensaw River Bottomlands NNL. These potential alternatives included (NPS 1979):

1. maintaining the status quo, with no change in ownership and management;
2. imposing state regulation, with no change in ownership and management;
3. creating a state park in the core area of the Mobile-Tensaw River Bottomlands;
4. creating a state park under state management;
5. designating an Area of National Concern, with a core area of federal ownership and mixed state and federal management;
6. establishing a US Fish and Wildlife Service (USFWS) Refuge for most of the Mobile-Tensaw River Bottomlands NNL;
7. establishing an NPS preserve, wherein hunting and fishing and other uses would continue under state management; and
8. establishing a mixed NPS/USFWS approach.

While the report articulated potential alternatives for long-term management of the resources in the landmark area, it did not recommend any alternative for further action by any agency. According to National Natural Landmarks Program authorities, no further NPS action regarding the proposed alternatives was taken on the report following release. The site remains a designated landmark and NNL Program staff have maintained contact with various landowners at the site over time. Recently, in an effort to digitize all landmark boundaries nationwide, the NNL Program has augmented the descriptions by Mount (1973) and NPS (1979) with aerial photo interpretation and, as a consequence, clarified that the designated Mobile-Tensaw River Bottomlands NNL includes approximately 178,000 acres (720 km²) (Figure 2-1; NPS 2011).

Summary

It has been over 40 years since the Mobile-Tensaw River Bottomlands was championed by Alabama citizens and scientists as an area of national significance leading to National Natural Landmark designation. Since this designation, Alabama conservation agencies, Alabama academic scientists and scholars, Alabama public and private conservationists, and popular media have continued to highlight the extraordinary values and characteristics of the Mobile-Tensaw River.
Figure 2-1. Boundary delineation of the Mobile-Tensaw River Bottomlands National Natural Landmark. Source: National Park Service (2011), as informed by Mount (1973).

MOBILE-TENSAW RIVER BOTTOMLANDS NATIONAL NATURAL LANDMARK
Baldwin, Mobile, and Washington Counties, Alabama

Calculated Acreage: 178,828.6

Data Source:
NPS NNL Data
Map Produced Jan 2016 by National Park Service
Intermountain Region Geographic Resources Division
Bottomlands as a place of local, regional, national, and international significance. As denoted in a 2011 NNL Program Brief (NPS 2011), the Mobile-Tensaw River Bottomlands NNL a) remains an expansive wetland and bottomland forest ecosystem of mixed ownership and jurisdictions originating near the confluence of the Alabama and Tombigbee Rivers and extending southward for about 60 km (37 mi) to the head of Mobile Bay; and b) continues to be one of the most important wetlands in the nation. The area combines a variety of habitats, ranging from mesic flood plains and freshwater swamps to open, brackish water marshes, with a network of interconnecting streams and lakes and interspersed low, forested islands. It is an important habitat for wildlife, and the vastness of the delta and its limited accessibility continues to support its basic integrity. Significant reptiles include the American alligator (*Alligator mississippiensis*), the federally endangered Alabama red-bellied turtle (*Pseudemys alabamensis*), and the delta map turtle (*Graptemys nigrinoda delticola*). Diversity of birdlife is exceptional, including the Swallow-tail Kite (*Elanoides forficatus*) and the Mississippi Kite (*Ictinia mississippiensis*), as well as abundant waterfowl, such as the rare mottled duck (*Anas fulvigula maculosa*). Mammals include beaver, raccoon, river otter, and deer. The area is also one of the few locations in Alabama where the Florida black bear (*Ursus americanus floridanus*) can be found.

This chapter briefly summarizes the history of the designation of the Mobile-Tensaw River Bottomlands NNL and subsequent further study by the NPS. It is part of a comprehensive multidisciplinary report through the Gulf Coast Cooperative Ecosystem Studies Unit that is intended to inform enduring NPS responsibilities to monitor the condition and encourage and support the conservation of this landmark site.

**Acknowledgments**

The author gratefully acknowledges Heather Eggleston and Carolyn Davis of the National Park Service, National Natural Landmarks Program, and David Morgan, PhD, National Park Service, Southeast Archeological Center, who helped locate key documents and provided manuscript review.
Mobile-Tensaw Delta, Alabama. Photograph courtesy of Hunter Nichols.
3. Geology of the Lower Mobile River Basin

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Shaped like a dowsing rod pointing south to the ocean, the Tombigbee and Alabama river valleys merge into the extensive Mobile River Valley, which forms a delta at the head of Mobile Bay (a bayhead delta). The location and morphology of the Valley is controlled, in part, by tectonic events related to the creation of the Gulf of Mexico. Over the past few hundred thousand years, the valley experienced multiple episodes of erosion and deposition related to climate cycles and associated fluctuations in sea level that repeatedly exposed and inundated the continental shelf of the northern Gulf of Mexico. Reconstructing the paleogeography of the Mobile Bayhead Delta over the last 9000 years shows that it is highly sensitive to small increases in the rate of sea level rise, which calls into question the sustainability of the bayhead delta’s current extent in the face of global warming.

Geologic Setting of the Lower Mobile River Basin

The extensive Mobile River Basin (41,600 mi² [107,700 km²]) is made up of the Tombigbee and Alabama rivers (Figure 3-1). The basin extends across the broad flat coastal plain in Mississippi and Alabama and into the rugged southern Appalachian Mountains of Alabama, Tennessee, and Georgia in the north, including the Appalachian Plateaus, Valley and Ridge, and Piedmont and Blue Ridge provinces (Figure 3-1). The Appalachian Plateaus are composed mainly of limestone, sandstone, and shale and make up the northwestern part of the basin. The Valley and Ridge is made up of a series of northeast trending subparallel ridges of erosion resistant sandstone and chert, separated by valleys of less resistant shale and carbonate rocks (Raymond et al. 1988). The Piedmont and Blue Ridge, in the northeastern part of the basin, is characterized by igneous and metamorphic rocks with elevations reaching greater than 3000 ft (910 m) above sea level. More than half of the Mobile River Basin is in the Coastal Plain, which is primarily unconsolidated or poorly consolidated sands, gravels, clays, and limestones.

In the lower coastal plain, the floodplains of the Tombigbee and Alabama rivers widen dramatically

![Figure 3-1. Geologic map showing the different geologic provinces (arrows) and the scale of the Mobile River drainage basin, which comprises the Tombigbee and Alabama river valleys (above). Location of the Mobile River Basin is shown in the lower image. (Modified after Moore 1971 and Planert et al. 1993).](image-url)
from around 2.5 to 7 km (1.6 to 4.3 mi) just upstream from where they merge forming the Mobile River (Figure 3-2). Downstream from that junction the Mobile River Valley is extremely straight, trends to the north, and is consistently around 12 km (7.5 mi) wide to Mobile Bay, a distance of 37 mi (60 km; Figure 3-2). The general morphology and location of the Mobile Valley has been attributed, in part, to geologic events dating back to the initial formation of the Gulf of Mexico (Planert et al. 1993). The continental crust extended (stretched) in this area during the breakup of the super continent Pangea, around 180 million years ago, forming a rift basin that was periodically connected to the ocean during Jurassic time (160 to 140 million years ago; Salvador 1987). The arid climate and restricted basin resulted in persistent evaporation of sea water and deposition of salt up to 3300 ft thick (1000 m) (Wilson 1975; Miller 1982). The salt was subsequently buried beneath denser sediment and its buoyancy helped to promote movement, which resulted in the formation of a variety of complex structures including salt domes positioned between 1000 and 6000 ft (300 and 1800 m) from the surface. The Mobile Graben, a low area between two normal faults, is another structural element related to salt movement (Figure 3-1). The sides of the Mobile Valley and Bay generally line up with the north trending faults that mark the eastern and western boundaries of the Mobile Graben and the eastern extent of the salt basin (Figure 3-1; Moore 1971). Many geologists have hypothesized that movement along the faults within this system resulted in the confluence of the Alabama and Tombigbee rivers and formation of the broad Mobile Valley and Bay (Murray 1960; Tanner

Figure 3-2. Digital elevation model of the Lower Mobile River Basin. Resolution for areas outside and inside the black box is 1 arc-second and 1/3 arc-second, respectively. Data are from the National Oceanic and Atmospheric Administration’s National Centers for Environmental Information, formerly the National Geophysical Data Center.
While the location of the valley may be a product of the structural geology of the area, the depth of the valley and the sediments that fill it are largely controlled by fluctuations in sea level.

Late Quaternary Sea Level Fluctuations and River Erosion

High magnitude (330 ft [100 m]) sea level cycles of 20,000- to 100,000-year duration have been the pattern for at least the last million years. The main cause for these sea level fluctuations is the expansion and retreat of glaciers. During the last glacial maximum 21,000 years ago, water was stored on the continents in glaciers and massive ice sheets, which lowered sea level to 394 ft (120 m) below present and caused northern ice sheets to reach 1.8 mi (2.9 km) in thickness. As the climate warmed, glaciers and ice sheets melted and their water returned to the oceans. Currently we are experiencing a sea level highstand and there is relatively little glacial ice covering the planet. During the last comparable event, around 120,000 years ago, global mean sea level reached +4 to +9 m (+13 to +30 ft) (Cuffey and Marshal 2000; Lambeck et al. 2012; Kopp et al. 2013; Simms et al. 2013). Evidence of this previous highstand is preserved as a 120,000-year-old beach ridge on the back side of Fort Morgan Peninsula that averages 4 to 5 m (13 to 16 ft) in elevation (Figure 3-2) (Otvos and Howat 1992; Rodriguez and Meyer 2006). Given that the seaward edge of the continental shelf offshore Alabama is 141 ft (43 m) below sea level, Mobile Bay and the continental shelf were exposed during most of the last sea level cycle (Figure 3-3) and for many of the sea level cycles during the past 1 million years. When the continental shelf was exposed, the Mobile River extended across the 46-mi (74-km) wide shelf, which influenced the morphology of the lower Mobile River Valley.

At the coast, rivers erode valleys when sea level fall exposes a surface with a steeper gradient than the river profile, such as the apex of the coastal prism, which is the transition between the flat coastal plain and steeper continental shelf (Helland-Hansen and Martinsen 1996). For the Mobile River system, the gradient of the continental shelf is about 4 times the coastal plain gradient. As a river crosses that apex, a knickpoint forms, which is defined by a sharp change in river slope. The river gradient will equilibrate by the process of landward knickpoint migration, which erodes the apex (Schumm et al. 1984; Schumm and Brackenridge 1987). The knickpoint moves upstream only several miles for small, high gradient fluvial systems, whereas large, low gradient fluvial systems, like the Mobile River, adjust their profiles over 100 mi (160 km) upstream (Blum and Törnqvist 2000). The great landward extent of the valley, in part, is due to the apex of the coastal prism being exposed during multiple sea level cycles, and the Mobile River eroding to adjust its profile.

Evidence for multiple cycles of valley incision are preserved at the valley edge as a series of downward stepping terraces above the present floodplain (Figure 3-2; Smith 1997), and in the valley-fill stratigraphy as multiple stacked erosional surfaces (Greene et al. 2007). The topography of those terraces show relict channels, point bars, and scroll bars and the terraces are remnants of former higher elevation floodplains. Each terrace represents an episode of floodplain deposition followed by river erosion. The downstream gradient of terraces on the western side of the valley is extremely low, less than 1.32 ft/mi (0.25 m/km), similar to the modern downstream gradient of the lower Mobile River floodplain of less than 0.53 ft/mi

![Figure 3-3. Sea level curve for the northern Gulf of Mexico after Anderson et al. (2004).](image-url)
(0.10 m/km), suggesting that the current morphology of the lower Mobile River has been repeated multiple times in the past.

High resolution seismic data and cores from Mobile Bay and the Mobile Bayhead Delta show multiple stacked erosional surfaces that formed by river processes during periods when sea level was lower and the area was exposed (Figure 3-4; Greene et al. 2007). The most recent episode of river erosion began as the climate was progressing towards the last glacial maximum and the inner continental shelf was exposed, which resulted in incision to 20 m (66 ft) below sea level at the modern bayhead delta location. The resulting erosional surface is clearly defined in cores as a sharp contact between recent mud and older highly compacted and oxidized sand and clay. Oxidation results from sediment being exposed to air for a long period. The increase in sediment compaction across the erosional surface makes it easy to image and map regionally with seismic data (Rodriguez et al. 2008). That mapping shows the area is defined by multiple channels that extend onto the continental shelf. Similar to the valley terraces, each erosional surface represents an episode of river incision followed by deposition. The more recent valleys generally reoccupied earlier valley positions, which further supports the interpretation that the modern morphology of the lower Mobile River is a reflection of previous cycles.

Transgression and Valley Fill

The last deglaciation, from around 21,000 to 6000 years ago, caused sea level to rise approximately 330 ft (100 m) and the shoreline to move landward. Because the bases of valleys have a gradual slope, rising sea level penetrates many miles into the coastal plain during inundation. As a result, drowned river mouth estuaries, such as Mobile Bay, form. Mobile Bay is restricted from marine influence at its mouth by Dauphin Island in the west, and Morgan Peninsula in the east. The middle part of Mobile Bay is a large (400 mi² [1036 km²]) and relatively shallow (10 to 13 ft [3 to 4 m]) basin where thick (up to 65 ft [20 m]) gray mud is deposited. The Mobile River forms a bayhead delta where it meets the bay and is the main source of freshwater into the estuary. During...
sea level rise, the estuary and bayhead delta depositional environments move landward up the valley and a record of this is left behind in the stratigraphy of the estuary as thin bayhead delta deposits overlain by thick middle bay deposits.

Before Mobile Bay existed, that area was occupied by the bayhead delta and/or the river floodplain depositional environment. Radiocarbon dates from cores collected in upper and lower Mobile Bay show that the estuary formed sometime between 8900 and 8100 years ago (Rodriguez et al. 2008) and the entire modern extent of the estuary inundated rapidly during a 100-year period (Rodriguez et al. 2010). The low gradient of the Mobile River Basin and a brief increase in the rate of sea level rise 8200 years ago are likely causes for the high rate of flooding and rapid formation of Mobile Bay. This increase in rate of sea level rise occurred in response to the abrupt drainage of glacial lakes Agassiz and Ojibway (Alley and Ágústsdóttir 2005; Kendall et al. 2008), which also caused marine inundation in Sabine Lake, Galveston Bay, Corpus Christi Bay, and Baffin Bay (Anderson and Rodriguez 2008; Rodriguez et al. 2010).

Mobile Bayhead Delta

The Mobile Bayhead Delta extends 28 mi (45 km) from the first distributary channel in the lower Mobile River valley to the upper bay. The Mobile River bifurcates into the Mobile and Tensaw distributary channels less than 5 mi (8 km) downstream from where the Tombigbee and Alabama rivers merge (Figure 3-2). Those two main distributary channels of the delta discharge into the western (Mobile) and eastern (Tensaw) sides of Mobile Bay. The delta plain contains numerous highly sinuous distributary channels, levees, interdistributary bays, and delta lobes.

The bayhead delta has existed at its modern location since around 9800 years ago. This conclusion is based on a 62 ft- (19 m-) long core collected from the delta front (Rodriguez et al. 2008). At the base of the delta, the core sampled 29.5 ft (9 m) of delta plain clay and silt with abundant organic material such as wood and leaf litter. Overlying delta plain deposits, the core sampled 23 ft (7 m) of delta-front sand with abundant shell material. Delta plain below delta front environments shows that the bayhead delta’s movement landward in response to sea level rise outpaced sedimentation. Over millennial time scales, the old delta plain, seen at the base of the core, accumulated at a decelerating rate from 0.18 to 0.05 inch/yr (4.6 to 1.3 mm/yr) and the delta front accumulated at 0.05 inch/yr (1.3 mm/yr), about the same as sediment accumulation rates in the middle of Mobile Bay (0.07 inch/yr; 1.8 mm/yr) (Rodriguez et al. 2008). These sedimentation rates are less than the present rate of relative sea level rise measured at Dauphin Island, 0.12 inch/yr (3 mm/yr); however, sediment accumulation rates at decadal time scales are over twice the millennial rate (Smith et al. 2013). This higher rate of recent sedimentation is due, in part, to anthropogenic modifications to the delta system, importantly, construction of the causeway in the 1920s that restricts sediment and water exchange with Mobile Bay (Smith et al. 2013).

The rapid transition from bayhead delta to estuary that occurred around 8200 years ago in the area of modern Mobile Bay demonstrates that bayhead deltas are highly sensitive to increases in the rate of sea level rise. During sea level rise, bayhead deltas, in general, are predisposed to episodes of rapid landward retreat as a result of the dendritic morphology of their river valleys (Simms and Rodriguez 2014). Tributary junctions, such as the one that exists below the modern Mobile Bayhead Delta location (Figure 3-4; Greene et al. 2007), act as pinning points for the transgressing shoreline. This is mainly due to sharp increases in valley gradient and decreases in valley width across tributary junctions. With accelerating sea level rise, the Mobile Bayhead Delta will likely stabilize at the next tributary junction located 35 mi (56 km) upstream from the modern bayhead delta front where the Alabama and Tombigbee rivers merge. The timing for this next (final?) bayhead delta backstepping event is uncertain.
4. Hydrology and Water Quality in the Mobile-Tensaw Delta

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The Mobile-Tensaw River Delta (hereafter, “the Delta”) is the terminus of a river system with the 4th largest discharge to a coastal area in North America (Wilson and Iseri 1969). The Mobile River, which flows into the Delta from the north, is relatively short, only 50 mi (80 km) long. However, it is formed from the merging of two large rivers, the Alabama and Tombigbee, which drain (with their tributaries) the eastern and western subbasins of the total Mobile River Basin. At 44,000 mi² (114,000 km²) this basin is the 6th largest in the US and the largest east of the Mississippi River that drains into the Gulf of Mexico (Atkins et al. 2004; Ward et al. 2005). It covers most of Alabama, parts of Mississippi and Georgia, and a small portion of Tennessee. Therefore, the Delta receives water and materials that emerge from this expansive river system and serves as a critical buffer between it and coastal areas to the south, including Mobile Bay (Figure 4-1). Geomorphology, hydrology, and water quality of the Delta are highly influenced by features of the upgradient landscape and river systems of the Mobile River Basin.

Water that reaches the Delta travels through a landscape that exhibits great geologic and physiographic diversity. The northeastern portion of the basin presents higher elevations and very old rock (Cambrian and Precambrian) formations. In the lower half of the Mobile Basin, water flows through geologically younger, unconsolidated sediments. This geologic diversity produces, in many cases, differing amounts of runoff and distinct chemical compositions of water, which contribute to the high biological diversity in the basin (Ward et al. 1991, 1992).

Abundant rainfall and runoff in the basin supply the Delta with ample water each year. Indeed, it is this abundance within the basin that ultimately creates the vast wetland landscape we now observe as the Delta. Long-term average rainfall throughout the basin is

Figure 4-1. Mobile River Basin and river network. (Courtesy of Grover Ward and Amelia Ward, University of Alabama; image credit: Sarah Mattics, University of South Alabama.)
relatively evenly distributed across seasons, although low rainfall summer seasons are well known. Typical summer precipitation is the result of convectional rainfall, but heavy rainfall from tropical storms and hurricanes often produce large amounts of rain in normally drier summer months. Over the long term, these heavy rainfall years even out seasonal rainfall variability. Rainfall and runoff are not evenly distributed across the basin. The Delta and coastal areas typically receive average annual precipitation of 60 to 64 inches (150 to 160 cm), whereas further north in the basin annual rainfall amounts range from 52 to 58 inches (130 to 150 cm) (Johnson et al. 2002). Not surprisingly, annual runoff values are higher near the coast (26 inches [66 cm]) relative to areas further north within Alabama (Johnson et al. 2002).

**Geomorphology**

Flow from the major tributaries is responsible for sustaining the highly diverse landscape within the Delta. Published values for the size and areal coverage vary somewhat, depending on boundary definitions employed, but the Delta is about 45 mi (72 km) long, from 6 to 16 mi (10 to 26 km) wide and 300 to 400 mi² (780 to 1040 km²) in area. The US Department of Commerce (1979) estimated the area as 185,000 acres (750 km²), identifying 20,000 acres (80 km²) of open water; 10,000 acres (40 km²) of marsh; more than 70,000 acres (280 km²) of swamp; and more than 85,000 acres (340 km²) of bottomland forest. Fortunately, federal, state, and private conservation efforts have resulted in a large amount of land now protected and managed (Smith 2014).

The Delta is considered geologically to be a drowned alluvial plain and valley, one of several along the northern Gulf Coast (Smith 1988; Kindinger 2015). However, only the Mobile and Pascagoula rivers exhibit well-developed alluvial plains. Because the lower Alabama and Tombigbee rivers flow through a relatively flat landscape, these channels exhibit broad meanders, and water in river channels in such terrain frequently overtops river banks. Water elevations from the confluence of the Alabama and Tombigbee rivers to Mobile Bay decline by roughly 0.16 ft/mi (3 cm/km; Smith 1988). Thus, over time, flood flows moving south to Mobile Bay have carved a complex network of interconnected channels, described as a distributary network.

The Mobile-Tensaw River distributary network conducts water through 7 major channels. South of the confluence of the Alabama and Tombigbee rivers, the Mobile River splits to form the Tensaw River, which runs along the eastern side of the Delta, and the Mobile River, which runs along the west side. The Tensaw River branches several times, forming Middle, Raft, Blakeley, and Apalachee rivers. Eventually 5 channels reach upper Mobile Bay. Spanish River, which drains Grand Bay, one of the larger floodbasins, receives water from Raft River before reaching Mobile Bay (Figure 4-2).

The Delta landscape is a complex of terrestrial landforms and aquatic habitats, created by thousands of years of geological, fluvial, and geomorphic interactions. Smith (1988) provided detailed analyses of the many geomorphology components of the Delta landscape; the more important ones are noted below. In addition to active distributary channels, other major landscape components include islands, floodbasins, levees, bays, abandoned channels, lakes, sloughs, and bayous. Levees, observed frequently along distributary channels, develop as a result of the capture of sand and silt suspended in flood waters that overtop river banks and build in height over time from repeated flooding.

Floodbasins, a major landscape component of the Delta, are large areas of floodplain forest surrounded by distributary channels and their associated levees. These basins receive flood water when levees are overtopped, or receive inflow through breaches (crevasse channels) when water levels are below the height of the levee. Much of the inflowing water will later drain back through these breaches into distributary channels, or over low points in levees. These landscape units typically contain a network of stream channels that permit drainage out of the floodbasin after flood events. Examples include Gravine Island and the Mifflin Lake basin.

Within the Delta, relict stream and abandoned river channels are common landscape features. Former channels once carried river water, but flood waters cut new routes and left them abandoned. Sedimentation at the terminal ends has isolated them from riverine flow, creating floodplain lakes that retain stream channel shapes. Notable examples include Tensaw Lake, Mifflin Lake, Stiggins Lake, Big Chippewa Lake, and Little Chippewa Lake.

Many shallow basins, termed bays, exist at the southern end of the Delta. Strictly speaking, bays are restricted to embayments at the terminus of the Delta
impacted by tidal fluxes. For example, Grand Bay, Pole Cat Bay, Chacaloochee Bay, and Bay Minette are actually relict floodbasins that have been inundated by rising sea level. Stream channels that are a) tributaries to bays or inundated floodbasins and b) subject to tidal influences are termed bayous (e.g., Bayou Sara and Catfish Bayou).

**Delta Movement during the Holocene**

The Delta has been in its present location for roughly the last 4000 years, but over geological time has migrated north and south from its present location coincident with the rise and fall of sea level (Hummel and Parker 1995). Sea levels 30,000 to 35,000 years before present were thought to be similar.
to present day levels. However, from 16,000 to 18,000 years before present, global sea level was 427 ft (130 m) lower than at present (Milliman and Emery 1968). During the last glaciation, the Gulf of Mexico shoreline was perhaps 60 mi (100 km) south of its present position (Smith 1988). After glaciers began melting and prior to 7000 years before present, the head of the Delta system lay in what is now southern Mobile Bay, extending out onto the continental shelf. As is the case currently, the Delta contained a distributary network of channels, the larger of which flowed through an area now occupied by the Fort Morgan Peninsula and another through present-day Main Pass. Tributaries that currently flow directly into Mobile Bay would have discharged instead into the main stem of the Mobile River. At this time, the Mobile River was perhaps 100 to 125 ft (31 to 38 m) lower than at present (Smith 1988), having downcut through sediments of Miocene, Pliocene, and Pleistocene age. River-derived sediments and ocean sediment deposits sustained terrestrial habitats as the Delta migrated. As glaciers melted, sea levels rose more rapidly, and by 7000 years before present the water in the main channel of the Mobile River flowed through what is now Mobile Bay, likely flanked by marshlands and perhaps a wide bottomland floodplain forest.

By 6000 years before present, rising sea levels (to a point 15 ft [5 m] below current level) caused a northward migration of the Delta as more than 75% of Mobile Bay was inundated with seawater and filled with sediment (Smith 1988). Approximately 4000 years ago sea levels stabilized, Mobile Bay assumed its current location, and the southern edge of the Delta was established. The landforms, bays, bayous, and distributary drainage pattern we now observe in the Delta are, thus, the result of a river valley slowly drowned as a result of sea level rise. As the southern edge of the Delta disappeared due to inundation by the more saline waters of Mobile Bay, typical deltaic landforms developed at its northern edge.

**Hydrology**

The mean annual discharge of water into the Delta is approximately 62,100 ft³/s (1760 m³/s). That discharge is made up of the Mobile River (95%) and several small independent tributaries (Loyacano and Busch 1979). The total flow of the Mobile River is derived from the Alabama River (52%) and the Tombigbee River (48%) (Johnson et al. 2002).

Inflows vary substantially, both seasonally and annually. Analyses of United States Geological Survey (USGS) discharge data for 1976 to 2014 from gauges at Coffeeville Lock and Dam (Tombigbee River) and Claiborne Lock and Dam (Alabama River) were combined to estimate mean flow into the Delta (Figure 4-3). Highest average monthly flows occur from January to April each year, typically exceeding 95,000 ft³/s (2700 m³/s). Discharge falls rapidly over the late spring and early summer, reaching flows less than 25,000 ft³/s (710 m³/s) in August through October. Detailed and accurate knowledge of hydrological characteristics is one of the most important physical features of aquatic ecosystems. This is important for wetlands because the biological structure of the system is determined by the quantity, quality, and timing of water movement through the system. Unfortunately, knowledge of wetland hydrology lags well behind that of other

![Figure 4-3. Monthly mean, minimum, and maximum discharge (in ft³/s or cfs) into the Mobile River based on summation of discharge from lower Alabama and lower Tombigbee rivers, 1976-2014. (Courtesy of Grover Ward and Amelia Ward, University of Alabama; image credit: Sarah Mattics, University of South Alabama.)](image-url)
aquatic systems, and the larger and more complex the wetland, the more difficult it is to determine sources, routing, and losses of water. The complex topography and diversity of land and water features in the Delta make an accurate estimate of inflow and water routing challenging because so many measurements are required to characterize the many braided channels, bays, and off-channel lakes where water is naturally stored. Also, due to low elevation gradients overland flow typically occurs during floods, but direct measurement of this movement is difficult to obtain.

USGS gauging stations on the lower Alabama and Tombigbee rivers have been in operation for several decades and provide flow and other data necessary to compute riverine flow, nutrient, and other material input to the Mobile River. Two other gauging stations located within the Delta, with shorter periods of record but still useful for these calculations, are on the Mobile River at Bucks, Alabama, 31 mi (50 km) north of Mobile Bay, and on the Tensaw River near Mt. Vernon, Alabama, east of the Mobile River.

An accurate hydrological budget for the Delta first requires an accurate measurement of combined flows from the Alabama and Tombigbee rivers as an estimate of the total water input to the Delta from the Mobile River Basin. Gauges on the lower Alabama and Tombigbee rivers provide the long-term flow record needed for these estimates. A second requirement for a robust hydrological budget is quantification of flow through the Mobile River, on the western edge of the Delta, as well as the Tensaw River that flows along the eastern boundary. All other distributary channels within the Delta receive the majority of their flow from these two major rivers. However, flow measurements and calculations for these rivers are confounded for several reasons. Accurate estimates of flow require a substantial period of record, but flow records from gauges on the Mobile River near Bucks and the Tensaw River near Mt. Vernon have only been in place for 12 years. The most difficult estimates to acquire are for flow during floods, when water overtops river banks. In addition, measuring the quantity and distribution of overland flow (flow outside river channels) across the Delta would be technically difficult. Lastly, flow calculations must account for the fact that tidal fluxes in Mobile Bay impact the measurement of river flow even at the northern end of the Delta.

O’Neil (2007) examined data from the Tensaw River (Mt. Vernon) and Mobile River (Bucks) gauges for years 2003 to 2006 to construct a preliminary water budget for the Delta. Not surprisingly, not all of the water flowing from the Alabama and Tombigbee rivers could be accounted for by summing data for flows in the Mobile and Tensaw rivers. Indeed, approximately 12.5% of the annual input of water from the Alabama and Tombigbee rivers was not measured as flow through the channels of the Mobile or Tensaw rivers. This analysis suggested that when the combined flow of the Alabama and Tombigbee rivers was less than 130,000 ft³/s (3700 m³/s), flow values in the Mobile and Tensaw rivers were similar to the summed flow of these two rivers. However, flows greater than 130,000 ft³/s (3700 m³/s) did not result in similar flows. O’Neil hypothesized that the “missing” discharge likely originated in the lower Alabama River, and during flood events likely flowed overland to the south where it entered the Tensaw River, completely missing the two river gauges. Given the geomorphic structure of the Delta, this idea is plausible.

Overland flow in the Delta appears to be an annual occurrence. Analysis (for this report) of USGS flow data for the lower Alabama and Tombigbee rivers over the period 1976 to 2014 revealed that flows greater than 130,000 ft³/s (3700 m³/s) occur every year. On average, flows of this magnitude or greater occur 48 days per year, ranging from a low of only 6 days in the drought years of 1988 and 2007 to a high of 134 days in 1983.

Hydrological Alterations
Humans frequently modify hydrologic patterns in wetlands and rivers. Such modifications often impact water movement, and especially hydrologic connectivity with adjacent ecosystems. Over the decades, several bridges and roadways across the Delta and Mobile Bay have been constructed. Bridge supports tend to obstruct downstream flow as well as seawater exchange between the Delta and Mobile Bay. However, the most significant obstruction to connectivity between the Delta and Mobile Bay is the Mobile Bay Causeway (US Highway 90/98). Constructed in 1926 as the first direct road connection between Mobile and Baldwin counties, it consists of a series of raised earthen embankments and concrete bridges, and it served as the primary transportation artery over Mobile Bay until the Interstate 10 Jubilee Parkway (locally known as the “Bayway”) was completed in 1978. The causeway’s embankments have impeded the exchange of water between Mobile Bay and the
lower Delta, largely by reducing the cross-sectional area through which higher salinity estuarine water can flow from Mobile Bay into the lower reaches of the Delta. The loss of hydrological connectivity (between the Delta and Mobile Bay) reduced the salinity of important nursery habitats (e.g., Chocolatta Bay and Tensaw River). As a result, species composition of fish, crustaceans, and shellfish communities has been altered within these habitats. Lowered salinity resulted in loss of nursery habitat and population densities for commercially important species, such as Blue Crab, white shrimp, and southern flounder (Rozas et al. 2013).

**Water Quality**

The Mobile River delivers 95% of the freshwater input to the Delta and Mobile Bay from the merged flows of the Tombigbee and Alabama rivers (Schroeder and Wiseman 1999). It is also a primary nutrient source to both (Pennock et al. 1999). Reported high levels of nitrate input from Midwestern agricultural areas into the Mississippi River that cause “dead zones” in the northern Gulf of Mexico (e.g., Rabelais et al. 2002) have stimulated interest in nitrogen dynamics in other watersheds and riverine-dominated estuaries of the northern Gulf Coast. Compared to other watersheds that have been studied across the US, the Mobile River Basin appears to be nitrogen retentive. Total nitrogen exported from the Basin (i.e., discharged into the Mobile River), based on nitrogen flux from the lower Tombigbee and Alabama rivers, is about 5 to 7% of total nitrogen input to the Basin, whereas other watersheds typically export 25 to 30% of basin inputs to coastal areas (Carey et al. 2003). Nitrogen retention mechanisms within the Mobile River Basin have not been well studied. However, nitrogen is likely retained in forest soils, as well as in floodplains and other features of large rivers (Tatariw et al. 2013). The Delta, which receives nutrients from this vast upgradient river system via the Mobile River, also likely functions as a nutrient retention and transformation zone between the Mobile River and Mobile Bay, thus lessening nitrate-nitrogen export to Mobile Bay and fragile coastal areas.

Although the Mobile River Basin is noted for its nitrogen retention capabilities, human activities threaten to saturate them, which would result in greater export of nitrogen, and possibly other nutrients, to the Delta and coastal areas. The Delta is the last nutrient retention defense before Mobile Bay; thus, if more nutrients are exported into the Delta from upgradient rivers, then more pressure is put on retention mechanisms within the Delta.

Over 95% of both nitrogen and phosphorus inputs to the Mobile River Basin derive from nonpoint sources, with major contributions from animal wastes, row crops, and urban areas (Atkins et al. 2004). A comparison of nutrient flux from the lower Alabama and Tombigbee rivers shows that export of nitrate-N, ammonium-N, and orthophosphate-P (soluble reactive phosphorus) into the Delta is generally higher from the Tombigbee River than from the Alabama River, western and eastern subbasins of the Mobile River Basin, respectively (Table 4-1). Also, in both rivers, nitrate-N flux is higher than ammonium-N flux and, thus, represents a higher proportion of overall dissolved inorganic nitrogen transported into the Delta, based on minimum to maximum ranges of each over multiple years.

A few recent studies have investigated nutrient concentrations within the Delta (Valentine and Sklenar 2006; O’Neil 2007). O’Neil (2007) reported turbidity, suspended solids, and total nitrogen are reduced in Tensaw Lake and the Tensaw River channel compared to Mobile, Alabama, Tombigbee, and Middle rivers. These data suggest that these components are filtered out of overland flow in the eastern Delta. Nevertheless, concentrations for chlorophyll

<table>
<thead>
<tr>
<th>Nutrient</th>
<th><strong>Alabama River</strong></th>
<th><strong>Tombigbee River</strong></th>
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<tbody>
<tr>
<td></td>
<td>Min (kg/yr)</td>
<td>Max (kg/yr)</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>1540 (3395)</td>
<td>7160 (15,785)</td>
</tr>
<tr>
<td>Orthophosphate-P</td>
<td>594 (1310)</td>
<td>3861 (8512)</td>
</tr>
</tbody>
</table>
total nitrogen, and suspended solids collected from the Mobile River (western Delta), Middle River, Tensaw Lake, and Tensaw River (all sites north of Interstate 65 in the northern part of the Delta) (O’Neil 2007) indicate ongoing mesotrophic to mesoeutrophic conditions (Wetzel 2001). Values for total phosphorus from those same sites suggest mesoeutrophic to hypereutrophic conditions—in other words, highly enriched and productive environments. Concentrations of soluble nutrients important to plant growth, such as orthophosphate-P, ammonium-N, and nitrate-N, were low (orthophosphate-P was undetectable) to moderate. The combination of somewhat modest concentrations of dissolved nutrients, but relatively high concentrations of nutrients in particulate form (chlorophyll $a$, total nitrogen, and total phosphorus), suggests rapid uptake of soluble inorganic nutrients by phytoplankton, other microbes, and plants that occupy the diverse habitats within the Delta. This mechanism likely retains nutrients and also lessens nutrient transport downgradient to southern parts of the Delta and Mobile Bay.

Comparisons of nutrients in dissolved and particulate forms just north and south of the causeway, in the southern reaches of the Delta (Valentine and Sklenar 2006), revealed slightly higher values than in northern parts of the Delta (O’Neil 2007). Since the two studies were completed several years apart, these differences may reflect inter-annual variability of nutrients in general in the Delta. Alternatively, areas of the Delta near the causeway, the city of Mobile, and other urban developments may be affected by human activities that increase nutrients proximate to those activities. The lower part of the Delta is also influenced by interactions with water in Mobile Bay, including saltwater intrusions that may affect nutrient dynamics.

In addition to nutrients described above, the Delta receives inputs of other types of chemicals. Pesticides are widespread in streams and rivers in the Mobile River Basin, but in relatively low concentrations, with heavily used atrazine, simazine, metolachlor, tebuthiuron, and 2,4-D (the herbicide Dichlorophenoxyacetic acid) most frequently detected (Atkins et al. 2004). Trace elements most frequently detected in fish tissue collected from sites throughout the Mobile River Basin suggest that aluminum, boron, copper, iron, manganese, selenium, strontium, and zinc are most likely to bioaccumulate in riverine fish (Zappia 1998).

Within the Delta, most detection of trace metals, including toxic ones, occurred in the Mobile River on the western side of the Delta (O’Neil 2007). Titanium, arsenic, nickel, antimony, and lead were most frequently encountered. However, all pesticides and herbicides analyzed in the overlying water were below detection limits, and the only pesticide or herbicide detected in sediments was 2,4-D. Off-channel lakes and embayments are sinks for metals because of higher organic matter and low flushing rates. Highest levels of the toxic trace metals cadmium and mercury occurred in sediments in Cedar Creek and Tensaw Lake, which are not in the main river channels of the Delta. Black water streams also accumulate metals because of higher acidity, increased organic matter, and low flushing rate.

**Summary**

The Delta is one of the most important and valuable natural resources in the US. It has existed for tens of thousands of years, and currently receives water, sediments, and solutes from a substantial area of Alabama and adjoining states via the river system of the Mobile River Basin. Sea level changes and water flow from the basin have over time carved an extensive and complex riverscape of channels, lakes, bays, bayous, and bottomland forests, which both harbor extensive wildlife resources and act to sequester sediments, nutrients, metals, and pesticides draining from the basin upstream. It is important to recognize that human activities in the Mobile River Basin have profound impacts on the Delta downstream. We do not currently have a thorough understanding of the rates of water and material flow in the Delta nor of the myriad roles of biota in mitigating nutrient and other chemical inputs that otherwise would be transported into Mobile Bay. Without this knowledge, fully effective management of the Delta will remain elusive.
BIOTIC LANDSCAPE

Green tree frog, Mobile-Tensaw Delta, Alabama. Photograph courtesy of Hunter Nichols.
5. **Paleobotany and Paleoclimate**

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Paleobotanical assemblages can be valuable resources for understanding how modern terrestrial plant communities developed, but they are only now being analyzed with modern techniques in the greater Mobile-Tensaw River area. This oversight is due to the historical perception that this region is nearly devoid of fossil plant localities, despite being underlain by massive layers of sediments deposited over the last 40 million years (Graham 1999a). Ongoing research shows that this view is mistaken and that plant fossils can be obtained through persistent search. Although much of this work is in early stages, some important findings are summarized here. This treatment focuses on the fossil leaf and seed record, which is congruent with the stratigraphically limited pollen data.

The plant fossil record in the greater Mobile-Tensaw River area begins with Eocene Epoch deposits (approximately 40 million years ago) along the bluffs in Monroe County, and extends into the last interglacial (approximately 85 thousand years ago) in Mobile County. This record is spotty, with the more recent floras the best studied. Therefore, this account starts with the youngest sites and works backwards.

**Mobile River Terrace (Late Pleistocene—85,000 to 82,000 Thousand Years Ago)**

Pleistocene (ice age) terrace deposits resulting from sea level fluctuations are common around the greater Mobile-Tensaw River area, but their ages are disputed (Heinrich 2009). However, plant fossils from a terrace deposit along the Mobile River near Bucks, north of Mobile, have been reliably dated using optically stimulated luminescence (Stults and Axsmith 2009). This technique, which determines age by measuring radiation accumulated in mineral crystals since their time of burial (Wallinga 2008), provides an estimate of 83,000 years ago for this deposit, which correlates with the last warm episode (interglacial) before the final glacial advance of the Pleistocene.

Common plant fossils from this deposit include members of the birch family (Betulaceae), including *Betula nigra* (river birch) and *Carpinus caroliniana* (ironwood), and several oaks, including *Quercus lyrata* (overcup oak), *Q. michauxii* (swamp chestnut oak), and *Q. virginiana* (Virginia live oak). Other fossils include *Carya aquatica* (water hickory), *Liquidambar styraciflua* (sweetgum), *Nyssa aquatica* (water tupelo), *Pinus elliotii* (slash pine), and *Vitus rotundifolia* (muscadine grape) (Figure 5-1; Stults and Axsmith 2009). All of these plants are still common in the modern greater Mobile-Tensaw River area, which indicates that this region did not experience the extensive community reorganizations that occurred in more northern areas during the Pleistocene glaciations (Delcourt and Delcourt 1993).

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**Figure 5-1.** Representative plant fossils from a Pleistocene terrace deposit in Mobile County: A) seed cone of *Pinus elliotii* (slash pine); B) fruit of *Liquidambar styraciflua* (sweetgum); C) acorn of *Quercus lyrata* (overcup oak); D) leaf of *Betula nigra* (river birch); E) leaf of *Vitus rotundifolia* (muscadine grape).
The Citronelle Formation Flora (Late Pliocene—3.4 to 2.7 Million Years Ago)

The Citronelle Formation underlies much of the northern Gulf of Mexico Coastal Plain, extending from east Texas to the Florida panhandle (Matson 1916; Otvos 1998). Edward Berry (1916) long ago described 18 plant fossil taxa from sites near Citronelle in Mobile County and along Perdido Bay in Baldwin County. He attributed most of the fossils to species still living in the region, or considered them their immediate ancestors. One interesting exception is the strange horned fruit of the floating aquatic plant *Trapa* (water caltrop), which is extinct in North America but common in Africa and Eurasia. Little additional work was done until we reinitiated study of the Citronelle flora. In addition to refining original identifications, our investigations have revealed more than 50 plant taxa. These findings are filling a major gap in the fossil record, as floras of this age are rare throughout the continent.

Berry’s (1916) conclusion that the Citronelle flora is dominated by plant groups still important in the region today is supported by our reinvestigations (Figure 5-2) (Stults et al. 2002; Stults 2003, 2011; Stults and Axsmith 2009, 2011a). Some of the most abundant taxa include several oaks: *Quercus falcata* (southern red oak), *Q. virginiana* (Virginia live oak), and *Q. laevis* (turkey oak). Several species of hickory are also abundant, with *Carya aquatica* (water hickory) being most common. *Platanus occidentalis* (American sycamore), *Planera aquatica* (water elm), and *Betula nigra* (river birch) are also common at some localities. The conifer *Taxodium distichum* (bald cypress), which is still an important tree of wetland habitats, occurs at all localities (Stults et al. 2011).

The Citronelle Formation flora also includes regionally extinct forms, in addition to *Trapa*. Some of these reveal the remarkable biogeographical fact that plant communities of eastern North America are closely related to those of eastern Asia, despite the thousands of kilometers separating them today (Manos and Meireles 2015). This knowledge indicates that the forest types of these areas once extended more widely across the Northern Hemisphere. During the Oligocene Epoch (approximately 35 million years ago), climates became cooler and drier following the warmer temperatures of the Eocene. This trend continued with minor interruptions through the Miocene and Pliocene, resulting in loss of deciduous forests in many areas. Such relictual forests now occur only in areas wet and warm enough to sustain them.

The fossil record indicates that floral similarity between eastern North America and easterb Asia was even greater in the past, as many plants now considered Asian endemics (e.g., *Ailanthus* [tree of heaven] and *Ginkgo*) were once present in North America but became extinct here (Manchester 1999). A striking example from the Citronelle Formation includes discovery of fossil leaves and fruits of *Pterocarya* (wingnut), a member of the walnut family (Juglandaceae) represented today by 4 species in Asia. Nuts of *Pterocarya* bear 2 wings for wind dispersal. *Pterocarya* fossils are common in Oligocene and Miocene localities in North America, Europe, and Asia. Citronelle Formation *Pterocarya* fossils represent the last occurrence of this genus in all of North America.
Another remarkable find is a fruit of *Begonia* (Stults and Axsmith 2011b). Although commonly known as a tropical houseplant, *Begonia* is one of the most species-rich flowering plant genera. Yet the Citronelle Formation *Begonia* is the only fossil record for this genus.

One of the most surprising findings from our Citronelle Formation research involves the pines (Stults et al. 2011). The genus *Pinus* is composed of two subgenera, *Haploxylon* (soft or white pines) and *Diploxylon* (hard or yellow pines), distinguishable by leaf anatomy and pollen. Pines dominate many of the forests of the greater Mobile-Tensaw River area today, and they are all *Diploxylon* species. *Pinus palustris* (long leaf pine), *P. taeda* (loblolly pine), and *P. elliottii* (slash pine) have particular ecological and economic significance. The only *Haploxylon* pine in eastern North America today is *Pinus strobus* (eastern white pine), which is common in the northeast, but occurs in the southeast only in the Appalachian Mountains. Today, *Haploxylon* pines are completely absent from Alabama. Based on the similarity of the Citronelle Formation broadleaf flora to that of today, we anticipated a similar pattern with the pines, especially considering that their abundant, robust needles and cones have excellent fossilization potential. However, Berry (1916) reported only one possible needle fragment and a seed from his original collections, and we encountered none during our first several years of collecting. A few pine needle clusters (fascicles) were eventually found at one site, but based on their structure (5 needles/fascicle, small fascicle base) they clearly represent a *Haploxylon* pine similar to *Pinus strobus*. We also found that that *Haploxylon* pine pollen grains dominate all of the pollen assemblages (Stults, Axsmith, and Liu 2010). These findings demonstrate that the current exclusive dominance of *Haploxylon* pine species in the greater Mobile-Tensaw River area developed relatively recently—sometime between 3 million years ago and 85,000 years ago. Such findings underscore the unique and sometimes surprising contributions that paleobotany can make to our understanding of the floristic history of a region. Examples of regionally extinct taxa from the Citronelle Formation can be seen in Figure 5-3.

The abundance and quality of the Citronelle Formation plant fossils makes them suitable for a variety of quantitative techniques for estimating the climate under which they grew (Stults 2011; Stults and Axsmith 2015). Such an effort is especially interesting for the late Pliocene, a time of recent global warmth that interests researchers using fossil assemblages as models for possible future climate change (Lunt et al. 2012). Quantitative paleoclimate methods using plant fossils fall into two broad categories: a) those using specific structural features of leaves (physiognomy) as paleoclimate indicators (Yang et al. 2011); and b) estimates based on climate tolerances of the nearest living relatives of the fossils (Utescher et al. 2014). Physiognomic methods are based on the proposition that leaf features (e.g., size, presence of teeth along the margins) are adaptations to specific climatic conditions. Nearest-living-relatives approaches assume that the climatic requirements of fossil plants were similar to those of their nearest living relatives. Two climate reconstruction analyses based on physiognomy and two based on nearest-living-relatives analyses were performed on the Citronelle Formation fossils. Surprisingly, a synthesis of the results suggests that late

![Figure 5-3. Representative regionally extinct Citronelle Formation plant fossils: A) fruit of *Trapa alabamensis* (water caltrop); B) fruit of *Begonia*; C) fruit of *Pterocarya* sp. (wingnut); D) leaflet of *Pterocarya*; F) fascicle of white pine.](image-url)
Plicente mean annual temperature (18°C [64°F]) was similar to modern levels or even slightly lower, and annual precipitation levels (1190 to 1250 mm [46.9 to 49.2 inch]) were lower despite the global warmth of that time (Stults 2011; Stults and Axsmith 2015).

Some other proxies correlated with climate can be estimated using plant fossils. For example, atmospheric carbon dioxide (CO₂), which is a greenhouse gas associated with warming climates, can sometimes be estimated from fossil plants. This estimate is possible because many plants reduce the numbers of gas exchange openings (stomata) on their leaves to minimize water loss as atmospheric CO₂ levels increase. Individual species response to increasing atmospheric CO₂ can be determined from historical herbarium specimens (i.e., dried leaf collections) for the industrial revolution until now, during which time atmospheric CO₂ levels increased from 280 ppm (parts per million) to the current value of 400 ppm. Stomatal openings are sometimes well preserved on fossil plants, and these can be counted and compared with the calibrated data set based on the modern plants, thus providing an estimate of the atmospheric CO₂ concentration when the fossil plant lived (Woodward 1988). Using this procedure on Taxodium distichum (bald cypress) leaves from the Citronelle Formation, the atmospheric CO₂ level during the late Pliocene was about 351 ppm, which is higher than the pre-industrial value, but lower than current levels (Stults et al. 2011). This observation suggests that the late Pliocene warm interval may have been caused by elevated CO₂, but other factors may also have contributed to greater climate sensitivity (Lea 2015).

Mauvilla Flora (Late Miocene—7.3 to 6.8 Million Years Ago)

The greater Mobile-Tensaw River area is underlain by massive layers of sediment from the Miocene Epoch, but they are mostly poorly dated and few fossils of any kind have been described from them. This lack of fossils is unfortunate as the Miocene included important events like the continuation of post-Eocene cooling and the expansion of grasslands (Graham 2011). One important exception to this dearth of Miocene fossils is the Mauvilla fauna, which was discovered on private land along Chickasaw Creek in Mobile County (Isphording and Lamb 1971). The mammals have been described in detail and include horses, peccaries, rhinos, and many others. Several of the mammal taxa are age diagnostic and indicate an age range of 6.8 to 0.3 million years ago (Hulbert and Whitmore 2006).

The original account of the Mauvilla site mentioned wood fragments, but no other plants (Isphording and Lamb 1971). We have discovered a layer above the mammal fossils that also includes abundant seeds and leaves. Although in early stages of investigation, this flora includes many taxa still common in the area today, including the conifers Chamaecyparis thyoides (Atlantic white cedar) and Taxodium distichum (bald cypress), Cyrilla (titi), Nyssa (tupelo), several Quercus (oak) species, Sambucus (elderberry), and Vitis (grape). Regionally extinct taxa have also been recovered, including Trapa and fragments of the conifer Podocarpus, which is now mainly a Southern Hemisphere genus. New taxa are still being found, and we anticipate that this flora will soon be sufficiently well known to allow climate analyses like those done for the Citronelle Formation flora. Examples of Mauvilla plant fossils can be seen in Figure 5-4.

Figure 5-4. Representative Mauvilla site plant fossils: A) branches of Chamaecyparis thyoides (Atlantic white cedar); B) seeds of Vitis sp. (grape); C) pit of Nyssa sp. (tupelo); D) immature acorn (Quercus sp.).
Bucatunna Formation (Early Oligocene—30.5 to 30.3 Million Years Ago)

Early Oligocene plant fossils have recently been collected from the Bucatunna Formation in southeastern Monroe County, Alabama. This discovery is exciting because early Oligocene plant fossil sites are rare throughout the entire US, and this epoch was important for the onset of globally cooler temperatures following the extreme warmth of the Eocene, as mentioned above (DeVore and Pigg 2010).

Numerous leaves and fruits have been collected from the Bucatunna Formation, but are not yet well identified. At least 10 different leaf types are present, including some with affinity to the Lauraceae (laurel family) and Fagaceae (beech, chestnut, oak family). Although hundreds of leaves have been collected, only one has marginal teeth, which is remarkable since a high proportion of leaves with smooth margins is typically correlated with warmer climates (Chen et al. 2014). In this instance, however, we suspect that this flora represents a specialized, marginal marine coastal community. Examples of Bucatunna Formation plant fossils can be seen in Figure 5-5.

Gosport Formation, Claiborne Group (Middle Eocene—41 to 38 Million Years Ago)

The oldest plant fossils from the greater Mobile-Tensaw River area come from Eocene outcrops of the Gosport Formation, which is part of the Claiborne Group of formations, at the bluffs of Claiborne landing in southern Monroe County (Berry 1924). Based on recent studies at Claiborne Group sites in Kentucky and Tennessee (Dilcher 2000; Dilcher and Lott 2005; Devore and Pigg 2010; Wang et al. 2013), we know that many of Berry’s early identifications were incorrect. The flora now includes taxa related to modern plants in the region today, like *Nyssa* (tupelo), and *Gordonia* (loblolly bay). However, there are many extinct forms with affinities to species today in Central America, South America, Europe, Africa, and Asia. It would be interesting to make additional collections at the bluffs at Claiborne for updated comparisons with the Kentucky and Tennessee sites, but the fossiliferous layer is now inaccessible due to extensive slumping of overlying sediments.

Summary

It is now evident that the greater Mobile-Tensaw River area contains significant plant fossil resources. Recent studies of the plant fossil sites briefly described here are helping unravel the evolution, biogeography, and climate of this important floristic region. Although in early stages of investigation, two important generalizations are possible. First, plant communities have been remarkably stable, with a few interesting exceptions, since the late Miocene Epoch (approximately 7 million years ago), and probably for much longer. This plant community stability is likely due to relative climatic stability imposed by proximity to the Gulf of Mexico. Second, the marshy and deltaic environments common today have been typical of this region for millions of years (Noss et al. 2015). The Pliocene Citronelle flora is now well documented, and future work will focus on the Pleistocene, Miocene, Oligocene, and Eocene floras and their paleoclimate implications.

Figure 5-5. Representative Bucatunna Formation fossils: A) elongate leaf morphotype; B) ovoid leaf morphotype; C) fruit with persistent sepals; D) rare leaf with toothed margin.
Landscape ecology addresses ecological processes and effects within a context of broad spatial landscape patterning, including effects of dynamic spatial heterogeneity on biotic and abiotic processes, the role and consequences of periodic disturbance within and beyond a range of normal variability, and the role of habitat fragmentation on species and ecological processes (Turner 1989; Turner et al. 1989). The components of an area’s disturbance regime include the frequency, return interval, size, intensity and severity, and residuals (see White and Pickett 1985; Turner et al. 1998; Turner 2010). While some scientific literature exists about some of these specific elements and components of the landscape and disturbance ecology of the greater Mobile-Tensaw River area, there is yet no published description of the area’s overarching and integrated large-scale landscape and disturbance ecology. This chapter offers an initial synthesis of how large landscape and disturbance ecology of the greater Mobile-Tensaw River area are organized and expressed according to geologic/geomorphic, hydrologic/precipitation, and pyric patterns and processes.

Overview of Ecosystems of the Greater Mobile-Tensaw River Area

Before delving into the specific geologic, hydrologic, and pyric patterns and processes that underpin the landscape and disturbance ecology of the greater Mobile-Tensaw River area, we should step back and acknowledge the area as the largest inland delta complex in the United States, at the base of the nation’s 4th largest river system (Sturm et al. 2006). The greater Mobile-Tensaw River area has, by far, the largest discharge (79,300 ft³/s [2250 m³/s]) of any Gulf of Mexico river system east of the Mississippi River embayment, representing 35 times the discharge of all the other eastern Gulf Coast river systems combined (Tetra Tech 2012). The area lies at the intersection of the greater longleaf pine savanna ecosystem, which is unusually high in herbaceous diversity, and the eastern broadleaf forest, which is high in tree diversity (Sorrie and Weakley 2001; Thorne 2008; Kartesz 2015a; Weakly 2015). For the purposes of this synthesis we characterize the greater Mobile-Tensaw River area as part of the East Gulf Coastal Plain ecoregion, with a dizzying array of complex and heterogeneous ecosystems organized within 3 primary systems, as follows (Bailey et al. 1994; Comer et al. 2003).

1) Southern Sandy and Sandy-loam Pinehills, Plains, and Savannas

These ecosystems, which correspond to NatureServe’s East Gulf Coastal Plain Interior Upland Longleaf and East Gulf Coastal Plain Near-Coast Pine Flatwoods, develop over fluvial sediments, generally Miocene to Pleistocene in depositional origin. There are myriad divisions within this category, including steephead seeps, xeric uplands, pine plains and hills, flatwoods, and bogs.

2) Floodplain

This ecosystem includes deltaic and riparian zone floodplains and all estuarine areas, with two major divisions:

- Brown water (redwater) stream floodplains and riparian zones, which correspond with NatureServe’s East Gulf Coastal Plain Large River Floodplain Forest and East Gulf Coastal Plain Freshwater Tidal Wooded Swamp, and North Central Gulf of Mexico Salt and Brackish Tidal Marsh. These areas have high flow, high conductivity and fine grain sediment loads, and slightly acidic to nearly neutral pH. This division includes deepwater swamps; bottomland hardwood levees and terraces; transitional “bay” tidal forests; freshwater to brackish water marsh; and submerged and floating-emergent vegetation on the edges of stream channels and in deeper pools of “dead” channels and lakes.
Blackwater stream floodplains and riparian zones, which corresponds with NatureServe’s Southern Coastal Plain Blackwater River Floodplain Forest, East Gulf Coastal Plain Small Stream and River Floodplain Forest and East Gulf Coastal Plain. These areas arise in the immediate coastal plain, with low conductivity and naturally very low, large-grained sediment loads. They are highly acidic and poorly buffered. This division includes blackwater swamps and drains, white cedar swamps, blackwater streamside scour zones and meadows, and submerged and floating-emergent vegetation zones.

3) Riparian Zone Bluffs, Coves, and Large-scale Erosional Cuestas

These ecosystems correspond to NatureServe’s Southern Coastal Plain Mesic Slope Forest and Southeastern Coastal Plain Cliff and Southern Coastal Plain Limestone Forest. They are typically areas of relatively high relief (shaped by the interaction of uplift of ancient seabeds with small-scale and large-scale fluvial processes) with complex mineralogy and multiple layers of highly exposed strata. These areas are generally occupied by highly diverse broadleaf forests characterized by some 25 species of oaks, 7 species of magnolias, high shrub and tree diversity, and widespread occurrence of “disjunct” Appalachian species (e.g., beech and basswood).

Geological and Geomorphological Patterns and Processes

The Mobile-Tensaw Delta and the lower Alabama River and its tributaries slice through unusually complex and highly exposed Cenozoic marine-origin formations, overlain with sandier Pliocene-Pleistocene alluvium (Smith 1988; Smith 1997). This process has resulted in surrounding zones of high relief, with steep riparian bluffs, coves, and—in the Red Hills region—large-scale erosional cuestas, occasionally with sharp drops of several hundred feet to the river bed. Such features are highly unusual in the Southern Coastal Plain and are believed to have been shaped by the interaction of uplift of ancient seabeds and large- and small-scale fluvial processes. There is much speculation on the cause of the uplift, but it appears to be the result of active tectonics that produce the highest rate of elevational change (approximately 4 mm/yr [0.2 in/yr]) of any place in the Southeastern coastal plain (King and Beikman 1978; Leopold et al. 1992; Shumm et al. 2000). This vertical relief, and the complex mineralogy associated with it, has had a profound effect on the ecosystems surrounding the Delta and also on the development of the river and Delta itself as it winds through these steep headlands. As is the case with other rare areas of high relief or unusual soil characteristics within the coastal plain (e.g., the Apalachicola bluffs region), this combination of factors has resulted in areas with both high total species diversity and unusual floral and faunal endemism, perhaps because these areas offered multiple habitat niches and remained relatively stable during past climate change events (Graham 1999b; Fetter 2014; Noss et al. 2015).

The Delta is a fluvially dominated system with high rates of discharge and high rates of sediment loading comparable to other Appalachian-origin rivers in the eastern US (Watson et al. 1986; Smith 1988; Isphording et al. 1996). Thus, it is generally considered a “prograding” system, with its potential to move southward and seaward influenced by rates of sea level rise. Like the Bay below it, the Delta developed over a Pleistocene river valley incised in Mobile Bay some 100 ft (30 m) below current sea level (Smith 1988; Greene et al. 2007). The surrounding headlands show successive layers of Pliocene/Pleistocene alluvium laid over a Miocene basement of marine sediments (Smith 1988; Greene et al. 2007). The prehistoric river may have originally drained much of the Appalachians now drained by the Tennessee and other rivers. For most Appalachian slopes, sediment loss was an order of magnitude higher during the Pleistocene than today, so it is reasonable to assume that the pre-Holocene Alabama River had discharge rates and sediment loads much higher than at present (Delcourt and Delcourt 1987; Montgomery and Wohl 2003).

Isphording et al. (1996) and Smith (1988) hypothesize that the Deltaic floodplain rose rapidly with the increase in sea level after the last low-stand 18,000 years before present. In essence, the intersection of Delta and Bay appears to have remained relatively stable for many thousands of years, in spite ongoing sea level rise (estimated at 8 to 11 inch [20 to 28 cm] per century) (Penland and Ramsey 1990; Williams et al. 1999). As Isphording (1996) describes, neither the Bay nor the Delta seem to have existed much northward of where they are now, at least since the last interglacial. Rodriguez et al. (2010) provide a more
complex assessment of how bayhead deltas across the northern Gulf of Mexico may have stepped back in response to brief and rapid changes in sea level.

In spite of high sediment loads, it is important to note that the Delta has low trap efficiency. That low efficiency results because this delta is constrained by high headlands on either side and cannot create new, lower-elevation deltaic lobes that are more efficient sediment traps. Most sediment capture in the greater Mobile-Tensaw River area occurs only during select overbank flood events, whereas the lower Mississippi Delta can spread freely and often “moves” sideways in search of lower elevation paths to the ocean. As a result, only about 30% of the suspended sediments entering or originating in the Delta actually settle there; most are discharged into the Bay and Gulf (Isphording 1996; Rodriguez et al. 2008). For this reason, Isphording (1996) suggests the Delta has been spared much of the contamination that might otherwise have occurred as a result of mid- and late-20th-century agricultural and industrial water-borne pollution (with some significant localized exceptions). Many of these contaminants are bound up in fine-grained and highly charged sediments that settle out into the Bay, where they have limited availability to the food chain. Essentially, the only way to broadly increase the Delta’s trap efficiency is to raise sea level, which lifts more sediment out of the channels and brings it into contact with the Delta’s floodplain and filtering vegetative structures. This appears to partially explain why the Delta continues a very slow progradation southward and seaward in spite of current sea level rise. It may also suggest that the Delta’s floodplain and its natural communities can respond to and survive a significant degree of sea level rise.

**Hydrologic and Precipitation Patterns and Processes**

The greater Mobile-Tensaw River area has a distinctly seasonal climate, with large variation in average daily temperatures from season to season, but with an unusually long growing season, typically 300 days. The northern Gulf Coast receives more rainfall than any other major region of the country. The city of Mobile receives more rainfall than any other metropolitan area in the US, at 67 inches (170 cm) annually, almost twice as much rainfall as Seattle. This rainfall rate is high even in comparison to many other areas of the humid southeast US. (Rainfall on the Atlantic Coastal Plain, for example, is typically under 50 inch/yr [130 cm/yr]). While heavy rainfall events are common, sometimes with 5 inches (13 cm) or more in a day, rainfall is well distributed throughout the year (with rainfall peaks in early spring and again in midsummer). Mobile also ranks high in the number of days per year with at least 0.1 inch (0.25 cm) of rain. This typical abundance of rainfall has, not surprisingly, shaped the area’s geography, promoted the development of extensive and diverse stream and wetland habitats, and is critical to the area’s biological diversity and productivity. It is also worth noting that high water availability can control and even limit the expansion and distribution of ecological communities, just as lack of water does in drier environments. High water availability also makes the area highly sensitive to small changes in rainfall, stream inflow, groundwater levels, and water tables.

High precipitation generates high rates of freshwater inflow from both local, coarse-grained, low-conductivity blackwater systems and regional fine-grained, high-conductivity redwater rivers (Ward et al. 2005). Tidal and biological connectivity to the Gulf of Mexico creates estuarine conditions virtually throughout the region’s waterways, with seasonal estuarine processes that create a freshwater-dominated Delta system during months with high freshwater runoff (January through April) and an increasingly brackish-water system during the months with lower runoff (July through November) (Schroeder and Wiseman 1999; Valentine and Sklenar 2006; O’Neil 2007; Goecker et al. 2009; TetraTech 2012). In the southernmost sections of the Delta floodplain, hydroperiod and water levels are influenced more by tidal head than by river head. All but the very largest riverine flood events quickly disperse and attenuate in the broad lower floodplain and in Mobile Bay, typically raising water levels by inches rather than feet (Tetra Tech 2012; USGS 2015).

Freshwater flood levels and impacts steadily increase upstream in the Delta floodplain, in the Alabama and Tombigbee rivers, and in the surrounding blackwater streams. Unusually active tectonics for the coastal plain have promoted a high relief coastal zone and undulating to steep riparian and streamside zones, exposing complex geological strata and encouraging unusual fluvial geomorphologic processes (Byrnes et al. 2013). The Delta is embedded in a region where long-term climate dynamics have been relatively stable compared to much of North America, resulting in the persistence of species (aquatic and terrestrial) eradicated by climate fluctuations in other parts of eastern
North America (Delcourt and Delcourt 1987; Graham 1999b; Sorrie and Weakly 2001; Stults et al. 2009; Noss et al. 2015). Periodic tropical disturbances such as hurricanes can alter the composition of ecosystems, though perhaps not as significantly as floods and fires (Isputherland 1996; Park et al. 2007; Smith et al. 2013). Gilliam and Platt (2006) discuss the role large tropical weather disturbances can have on longleaf ecosystems and indicate that a loss of such disturbances, which result in more open canopy conditions, could reduce biodiversity.

High water tables in the Delta and in various kinds of perched wetland and flatwoods in the uplands have a significant impact on the oxidation-reduction (redox) potential of soils, limiting not only the growth rate but also the kinds of plant communities that occur there. Because of this, changes of elevation of a few centimeters can have dramatic effects on floral and faunal communities, much greater than changes in elevation of hundreds of feet in montane communities (Noss et al. 2015). Likewise, seemingly minute increases or decreases in water levels can play a significant role in the success or failure of species and communities within and around the Delta.

Mature bald cypress (*Taxodium distichum*) are the signal trees of the Delta and are ecologically restricted to wet or frequently flooded sites. But seed germination and seedling growth requires moderately dry and highly aerobic topsoils, which occur in the Delta only after an extended period of low water and low water tables. Such a period may occur seasonally every year in some areas, or once every few years in others. The frequency of these occurrences can be dramatically altered either by timber harvest (which results in longer hydroperiod and significantly higher water tables throughout the year) or by changes in seasonal flow variability of adjacent streams, either through increased runoff from development or through seasonal manipulation of flow rates by upstream dams. Under such conditions, swamp tupelo (*Nyssa aquatica*), whose seedlings are more tolerant of flooding, can displace cypress. In many areas of the Delta, flow rate manipulation appears to have been used to promote pure stands of swamp tupelo, which are preferred for paper pulp processing (Messina and Connor 1998; Evans et al. 2013).

Even more dramatic consequences of hydrological alteration affect the blackwater streams and pitcher plant bogs surrounding the Delta. Unlike the interior of the Delta, where water conditions are primarily controlled by inflow from hundreds of miles upstream or by tidal inflow, water quality on most of the Delta’s blackwater streams is determined by local conditions and hydrological connectivity to the surrounding uplands. Relatively small changes in freshwater inflow as a result of house construction, road building, or groundwater pumping can result in rapid loss of stream head and rapid replacement by siltier waters from the Delta’s redwater systems, or more saline tidal waters. Such changes can dramatically alter floral and faunal communities. In the longleaf forests above these blackwater streams, mesic flatwoods and pitcher plant bogs exhibit extraordinarily high diversity (up to 60 species/m² [6 species/ft²]) in part because the plants have carefully partitioned habitat as a result of minute (1 cm [0.4 inch]) changes in depth to the water table. Road building and house construction can severely impair the sheet-flow hydrology that feeds these highly diverse wetland systems, resulting in the loss of hundreds of species of plants and insects from relatively small areas.

Interactions of tidal and freshwater influences are vital to the ecosystems in this region. Virtually every waterway from the Gulf of Mexico to the first dams on the Alabama and Tombigbee rivers, almost 100 water miles (160 km) inland from Mobile Bay, are tidally influenced, and influenced by saline density currents much of the year. While tidal dynamics are moderate compared to many sites fronting the Atlantic or Pacific, large-scale wind-driven water level “set-ups” in the Gulf can greatly amplify daily tidal fluctuations, and do so throughout the year. Though the brief surges associated with tropical systems are most notorious, non-tropical set-ups can last for days or sometimes weeks and often have more impact (Schroeder and Wiseman 1999).

The Delta is often described as a seasonal estuary. It is a freshwater system while evaporation and transpiration are low and inflow from upstate is high. Because the Delta estuarine system dissipates its freshwater inflows over a large floodplain and bay system, the hydrological head of the Gulf plays a significant role in determining hydroperiods and flood levels, mitigating the effect of flood and drought on water levels. Less often the opposite happens: dramatic increases and decreases in water levels occur that are larger than those attributable to drought and flood. The estuary becomes more brackish as inflow from upstate decreases in summer and fall, and evaporation
and transpiration increase. This seasonal transition to a brackish system greatly alters the aquatic community, mixing marine predators (e.g., tarpon, speckled trout) and prey species (e.g., shrimp, anchovies) with freshwater species such as bream and bass (Lowe et al. 2009; Norris et al. 2010; Carassou et al. 2011; Lowe et al. 2011; DeVries 2013; Rozas et al. 2013). Seasonal transitions may also play a role in mediating dominance in the herbaceous and woody plant communities in the lower Delta (Myers and Ewel 1990; Light et al. 2002).

In the lower Delta, hydroperiods are less significant than changes in conductivity as a result of tidal influence. Moving upstream in the Delta floodplain, and along the river and local stream channels, the influence of tidally influenced conductivity declines and the impact of hydroperiod increases. As is typical of estuarine systems, the tidal head forms persistent density currents in the channel thalwegs—heavier saltwater currents that have the appearance of a saltwater wedge as they move up the channels (Schroeder and Wiseman 1999). During floods, these density currents may be restricted to the deepest channels in the lowermost Delta. As the hydrological head of the river decreases in late summer, the saltwater wedge penetrates as far as the dams upstream (and likely once went even farther north) and mixing of fresh and salt water increases throughout the water column. In the lower Delta, the entire water column typically becomes brackish in fall. This is a critical breeding and development time for many marine and estuarine fauna—ranging from white shrimp to speckled trout—which take advantage of the increased salinity to forage and develop in the midst of the complex and productive structure of Delta vegetation, shell reefs, and organic soils.

Hurricanes and wind may also play a role in community structure, at least temporarily, and occasionally with long-term impacts. Wind impacts to terrestrial systems (e.g., downed timber) are perhaps most obvious, but the most significant impacts are usually the result of wind-forced water surges. These brief but dramatic rises and falls in sea level can be devastating to human structures, and can lead to higher salinities. In most cases, impacts on the ecosystems are generally short-lived (Park et al. 2007), but under the right conditions hurricanes can significantly rearrange sediments and even influence geomorphology. In 1979 Hurricane Frederic, a moderately large storm, rapidly drained the bay by removing loose sediments (Isphording 1996). While hurricanes apparently play a significant role in sediment accumulation in Mobile Bay salt marshes, floods seem to play a more important role in the Delta itself (Smith et al. 2013). Small magnitude but long duration wind-forced changes in water levels may play an equally large role in community structure. In winter they can expose mud flats for weeks, and in spring and summer they can result in weeks of much higher than normal tides that flood usually dry habitats. Flooded or exposed, these are exceptionally productive habitats for mudflat crustaceans and mollusks, as well as shorebirds and even fish, including the threatened Gulf sturgeon (Peterson and Peterson 1979; Randall et al. 2006).

Droughts are perhaps equally significant, resulting in dewatering of fresh groundwater throughout the Delta and longer term elevation of salinity high up in the Delta. These drought effects, in turn, can increase habitat and access to vegetative and hard structure for estuarine-dependent species like white shrimp. At the same time they can reduce gross productivity, slow down eutrophication of some water bodies, and slow the regeneration and advance of trees and shrubs into freshwater marshlands (Rozas et al. 2012; Rozas et al. 2013).

Hydrological and landscape continuity is unusually important in this region. Water quality and productivity in the Delta is the product of the myriad streams surrounding it, and the hydrology of these streams is linked to percolation and water retention rates of the surrounding uplands. Development can compromise the surrounding landscape’s ability to serve as a water reservoir, resulting in greater runoff immediately following rains and less residual freshwater days after a rain. Cycles of flood and drought are amplified. Because the blackwater streams surrounding the Delta serve as important biological refugia and nurseries, loss of connectivity between the Delta’s brown water aquatic habitats and these blackwater streams can directly impact the Delta’s biological diversity.

Fire
Oddly enough, the area’s high rainfall is also responsible for the ecosystem’s long and critical association with fire. Thunderhead development and rains during the growing season on the Gulf Coast are inevitably accompanied by lightning. The highest flash density of lightning in North America (and one of the highest

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densities in the world) occurs in a narrow band around the Gulf Coast and in the Florida peninsula (Noss 2013).

Given this high frequency of ignition, the only limit to the frequency of fire historically was the availability of combustible fuel. Because of high rainfall, fuel loads (flammable vegetation) could build up quickly on most sites. Longleaf pine itself, along with the oil-rich herbaceous grassland community it supported, is responsible for “nursing” ignition, increasing the chances that fires would occur. Within the longleaf pine forest ecosystem surrounding the Delta, fire return intervals were typically from 1 to 3 years. Because of their high frequency, fires were usually only of moderate intensity, and the vegetative community recovered rapidly, often in a matter of days. In these areas, virtually all species were fire tolerant, or even fire dependent (Myer and Ewell 1990; Jose et al. 2006; Palmquist et al. 2014). Many species in these plant communities (e.g., wiregrass, multiflowered calopogon orchid, toothache grass, American chaffseed) flower only after growing season fires. These frequent fires restricted development of common tall shrubs, vines, and trees, which opened up space for an unusual diversity of plant species, up to 60 species/m² (6 species/ft²) and 140 species per 1000 m² (10,800 ft²) in some cases (Peet and Allard 1993). These frequently burned habitats represented some of the densest concentrations of plant diversity on the planet (Peet et al. 2014).

Even with abundant lightning, large-scale landscape connectivity is critical to fire-maintained ecosystems, and fragmentation of the landscape is unusually devastating. Only one well-timed lightning strike was necessary when fires burned uninterrupted “river-to-river.” Today roads, fields, exurban and suburban development, and active fire suppression limit the spread of any one strike. Some researchers estimate that tens of thousands of acres of relatively unbroken pyrogenic landscapes may be required to support natural fire frequencies with lightning as the sole source of ignition (Lindenmayer and Fischer 2006; Bailey et al. 2007). Otherwise, prescribed burns must be used to supplement or supplant natural sources and spread of ignition. The relationship of fire ecology to pre-Columbian cultures is controversial and complex, but along the Gulf Coast, at least, natural fire frequency is so high, limited not by ignition but rather by the availability of fine fuels, that additional ignition by humans is not thought to have had a major impact on ecosystems (see Frost 1993; Noss 2013; Ryan et al. 2013).

On moister north- or east-facing slopes, and on slopes and banks immediately surrounding streams, fire return intervals and fire intensity would have been somewhat less, typically once every 5 to 25 years (Harper 1943; Myers and Ewell 1990; Frost 2000; Frost 2006). These areas also typically overlap exposures of multiple geological strata, each supporting a unique chemical and sedimentary signature, which allowed development of a very different forest community, one more resembling the Appalachian forests of central North America. Higher content of magnesium and calcium and a higher redox potential encourage colonization by plant species seldom encountered in the more common, coarse-grained acidic soils. Broadleaf trees (e.g., oaks, magnolias, hickory, beech) dominate the canopy, with a wide assortment of shrubs and ephemeral herbaceous plants that respond to brief, seasonal exposure to sunlight. In areas of full habitat development, along the lower Alabama River at the top of the Delta, tree species diversity may be higher than almost any place else in North America, with some 25 species of oaks, 7 species of magnolias, and many other species occupying a very small area. There is indication that the Red Hills of southwest Alabama support the highest oak diversity (28+ oak species) for North America (Kartesz 2015b). But even in these habitats, occasional fire trickling in from the adjacent longleaf forests is necessary to maintain diversity, and loss of connectivity between these areas and the surrounding longleaf ecosystem has resulted in decline in oak regeneration and the decline or loss of many other species (Adams 1992; Barnes and Van Lear 1998).

While fire was critical right up to the banks of the Delta, fires within the Delta would likely have been rare. Fires would certainly have occurred in cypress-tupelo swamps, and may be necessary for their long-term health and reproduction, but the return interval would have been measured in centuries (Messina and Conner 1998). White cedar swamps, a subcomponent of blackwater swamps, require catastrophic fires, with a return interval of 50 to 100 years, for regeneration. Lack of fire and loss of connectivity to longleaf uplands is likely responsible for the continued loss of this ecosystem (Laderman 1989; Messina and Conner 1998; Atkinson et al. 2003). Fire may have played a more frequent role in the development of freshwater and brackish water marsh habitats (Myers and Ewell 1998).
1990; Noss 2013), though there has been little effort to identify long-term fire trends in the lower Delta. A fairly well-documented history exists of recent anthropogenic burning in the Delta marshes from the 19th through the first half of the 20th century. But it’s harder to imagine how these islands of wet marshes, fragmented and isolated by deep swamps or rivers, would have ignited naturally with much frequency. The decline of the Delta’s once abundant canebrake habitats raises other questions about the possible interaction of fire and periodic flooding and the loss of connectivity to longleaf pine ecosystems, particularly along the riverine corridors of the northern Delta and the lower Alabama River (Noss 2013).

Heterogeneity within and between upland and wetland landscape communities is promoted and mediated by fire, which makes continuity between communities and across broad landscapes particularly important. Because of this fire dependency, a self-maintaining landscape would require tens of thousands of acres of relatively unbroken, fire-maintained forest or savanna, with connectivity to surrounding habitats where fire return intervals may be longer. Because of fragmentation, sources of ignition must be artificially introduced into ecosystems and the fires managed on a regular basis. Even with artificial prescribed fire regimes, relatively large unbroken landscapes are needed to manage fire intensity and frequency. Loss of connectivity between longleaf uplands and surrounding broadleaf and wetland communities has resulted in greatly reduced fire frequencies in those areas. These “ecotonal” marginal areas are integral to the existence of many, if not most, of the listed endangered, threatened, and special concern species (e.g., Red Hills Salamander, Reticulated Flatwoods Salamander, American chaffseed, pot of gold lily, Wherry’s pitcher plant).

**Vulnerabilities and Challenges**

The movement of wildlife from floodplain to uplands and back again has already been compromised by residential and commercial areas, roads, and other developments. Many endangered or rare species are highly dependent on continued connectivity between uplands and wetlands (e.g., indigo snakes, black bear, freshwater turtles, numerous bird species). The 3 counties surrounding the Delta support what is likely the greatest turtle diversity in the world. But protecting the Delta alone, without giving attention to the surrounding upland habitat, will have no benefits for the turtles. Some of these turtle species are primarily upland species and use the Delta rarely or not at all. Most of those that do are threatened above all by loss of suitable upland (non-flooded) habitat for egg laying and hatchlings. A great number are lost while trying to lay eggs on the grassy highway medians that run through the Delta (Nelson 2003).

While there are many uncertainties associated with region-specific impacts of climate change, we may be able to assess the relative vulnerability of the Delta and surrounding region based on previous climate fluctuations. The Gulf of Mexico’s stabilizing influence on the climate of the area is often cited as one of the reasons for the persistence of Miocene, Pliocene, and Pleistocene floral and faunal elements that have disappeared from much of the country (Graham 1999b; Noss et al. 2015). Evidence exists that this Delta may also be somewhat buffered from sea level rise. Unlike the sediment-limited estuarine systems across much of the Gulf Coast, this Delta’s primary floodplain has a sediment surplus to bank on as sea level rises. As such, it appears to be better equipped than most estuaries to handle moderate levels of sea level rise, even at levels higher than in the past century. Less clear, however, is the rate or degree of sea level rise that will begin to overwhelm the potential increase in trap efficiency.

Sea level rise, even at existing moderate levels, is much more likely to impact anthropogenic features in and around Delta, which have no built-in adaptations to sea level rise. Ancient and historic features, such as shell middens, the Mississippian mounds, colonial and Civil War sites, and even the modern city of Mobile, continue to subside and face severe erosive events as sea level continues to rise. Efforts to conserve and preserve these features will have to take this challenge into account. Also more likely to be impacted are the unusually rich natural communities on the margins of the Delta and its feeder streams and uplands. Blackwater streams and basins and their surrounding floodplain communities, for example, might normally rise with sea level to occupy slightly higher elevations. But residential and urban development is concentrated along the blackwater streams, so there are fewer and fewer areas where these communities can go. For this reason, remaining undeveloped uplands surrounding these blackwater streams should be prioritized for conservation.
7. Ecoregional Basis for Biodiversity Richness and Endemism

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The greater Mobile-Tensaw River area is one of the most biologically rich and ecologically diverse regions of its size in the Southeast, and possibly in all of temperate North America. Within this area is a dazzling range of ecological conditions, from sunny fire-dominated woodlands to blackwater swamp forests to steep shady ravines (Duncan 2013). This diverse collection of highly productive ecosystems sustains such a profusion of species that some refer to it as “America’s Amazon.” There is no single reason for why this region is so rich. Instead, the influences of 3 forces have shaped this region’s biological diversity: the intermingling of 3 distinct biogeographic realms, a benevolent climate, and the unstoppable forces of ecological change. This chapter explores how these forces created the greater Mobile-Tensaw River area and its diverse landscape.

Biogeographic Realms

The biogeographic realms shaping the greater Mobile-Tensaw River area are the Gulf of Mexico, the Atlantic Coastal Plain, and the waters of the Mobile River Basin. The Gulf is a warm ocean basin fed by a continuous stream of warm, clear waters from the Caribbean Sea. Along the northern coast these waters are infused with a broth of nutrient- and sediment-laden freshwater spilling off of the rainiest region of temperate North America (Gore 1992; Oey et al. 2005). The resulting mixture supports a flourishing array of marine ecosystems, many of whose species migrate into the Mobile River Delta to breed or mature (Wallace 1997).

The Atlantic Plain physiographic region, in which the greater Mobile-Tensaw River area is embedded, extends from New England to the Yucatan Peninsula (USGS 2010). The region is composed of ancient marine sediments exposed as sea levels gradually receded from a highstand peaking 145 million years ago (Lacefield 2013). Across this plain are sedimentary bands, each of which is composed of semi-consolidated or unconsolidated materials distinct in their structure, chemistry, and erodibility (Osborne et al. 1989; Lacefield 2013). The surface waters of the lower Alabama and Tombigbee river areas have weathered and sliced into these sediments to create a topographically complex landscape, despite being dubbed a “plain” (Lacefield 2013). Any change in elevation, aspect, and soil type alters the sunlight, groundwater, and nutrients available for plant growth. Subsequently, tremendous ecosystem diversity is sustained across the Atlantic Plain and represented in the greater Mobile-Tensaw River area (Duncan 2013).

The third biogeographic realm shaping the greater Mobile-Tensaw River area is the waters of the Mobile River Basin. The Mobile River Basin drains a majority of Alabama, and minor portions of Mississippi, Tennessee, and Georgia (Metee et al. 1996). Due to the interaction between the Southeast’s benevolent climate and the southern Appalachian Mountains, the basin has been the origin point for hundreds of freshwater species, especially mussels, snails, fishes, and crayfishes. Consequently, the Mobile River Basin is a global hot spot for aquatic biodiversity (Boschung and Mayden 2004; Williams et al. 2008; Duncan 2013). Many of its species, including basin endemics and more widespread species, inhabit the waters of the greater Mobile-Tensaw River area (Boschung and Mayden 2004; Schuster and Taylor 2004; Williams et al. 2008).

Climate

The region’s generous climate is the second force shaping the biodiversity of the greater Mobile-Tensaw River area. The region receives plentiful rainfall and sunlight relative to most other regions of North America (Chen and Gerber 1990; Chaney 2007). This combination of moisture, light, and heat sustains high rates of primary productivity in terrestrial and aquatic systems, and sustains globally significant floral and faunal diversity. The only temperate region on earth with comparable biological productivity and biodiversity is Southeast Asia (Duncan 2013).

Frequent lightning along the Gulf Coast (Chen and Gerber 1990) is another climatic feature promoting biological diversity in the greater Mobile-Tensaw
River area. Lightning-generated fires regularly purge ecosystems of shrubs and trees that would otherwise usurp the light needed by the region’s great diversity of wildflowers and grasses. The most celebrated pyrogenic ecosystem is the longleaf pine woodland, but fire played a crucial role in many of the greater Mobile-Tensaw River area’s ecosystems (Duncan 2013).

**Ecological Change**

The third force shaping the greater Mobile-Tensaw River area is ecological change. Landscapes subjected to a moderate degree of change—whether on a regular or irregular basis—often sustain a greater diversity of species than more stable landscapes (Krebs 2009). Examples abound across varied time scales. As anglers can attest, daily tides facilitate the mingling of both freshwater and marine species in the lower Delta. Seasonal changes in freshwater, sediments, and nutrients flushing through the greater Mobile-Tensaw River area cause the expansion and retreat of the Delta’s marshland (Smith 1988). Many aquatic species correspondingly migrate in and out of the Delta, including crustaceans, fishes, and even a population of the West Indian manatee (Pabody et al. 2009). High above these waters, the proliferation of spring plant growth feeds a profusion of insects, which is fuel for birds arriving from the tropics. The onset of winter dormancy in the greater Mobile-Tensaw River area’s forests forces a nearly complete turnover in the bird species present between summer and winter.

Changes over the intervals of years and decades also sustain high levels of biological diversity. The original fire-return interval for the longleaf pine woodlands and other fire-dependent ecosystems of the greater Mobile-Tensaw River area is not known for certain, but was likely 1 to 3 years (Frost 2006). Hurricanes periodically blow down trees *en masse* in forests and woodlands, thereby creating space for opportunistic species to temporarily thrive and increasing the chance of intense wildfires (Liu et al. 2007).

Geologic and climate change over the millennia has also enriched the greater Mobile-Tensaw River area’s biological diversity. During the Pleistocene (2.6 million years ago to 11.7 thousand years ago) there were dramatic fluctuations in sea level and climate (Lacefield 2013). During cold glacial periods, northern species colonized the Southeast, and relict populations persist in places sheltered from wildfire and the summer sun (Duncan 2013; Lacefield 2013). Fluctuating sea levels during the Pleistocene have been implicated in promoting the evolution of new fish species along the coastal plain (Near et al. 2003).

**Subregions Within the Greater Mobile-Tensaw River Area**

Three factors, as described above—the intermingling of 3 biogeographic realms, a benign climate, and the pervasiveness of ecological change—have created subregions within the greater Mobile-Tensaw River area with distinct ecologies and unique amalgamations of species. An effective tool for classifying such subregions throughout North America was developed by the US Environmental Protection Agency and other entities in an effort to classify lands based on physiography, geology, soils, flora, fauna, and other variables (Commission for Environmental Cooperation 1997). Known as the ecoregion approach, lands are classified in a 4-tiered hierarchy.

Level IV ecoregions are the most specific tier of classification (Griffith et al. 2001a) and the remainder of this chapter explores their occurrence in the greater Mobile-Tensaw River area. Generally, ecoregions are described in terms of their historical condition (5000 to 200 years ago), instead of their current condition, which is often radically different due to anthropogenic forces on the landscape. The importance and effect of these latter influences are discussed briefly at the end.

1) **Gulf Barrier Islands and Coastal Marshes Ecoregion**

The lower Delta is a labyrinth of shallow bays, channels, marshes, and low-lying forests all belonging to the Gulf Barrier Islands and Coastal Marshes Ecoregion (classification number 75k). Herbaceous growth, including grasses, irises, lilies, rushes, arums, and other non-woody plants crowd the shallow waters and adjacent low-lying lands. Trees tolerant of waterlogged soils survive at slightly higher elevations. This ecoregion is found intermittently from Louisiana through the Florida Panhandle, and in Alabama it includes salt marshes and barrier island ecosystems.

This ecoregion includes the most dynamic of the greater Mobile-Tensaw River area’s ecosystems, given that the abiotic factors controlling it vary daily and seasonally in dramatic fashion, and consequently species diversity is quite high. Each day the rising tide pushes back against the riverwater to bring salt-laden waters and marine animals into the lower Delta.
Alabama coast receives one high and one low tide each day and water levels change hourly. The magnitude of tidal change within a daily tidal cycle can range from 67 cm to 3 cm (26 to 1.2 inches) at the mouth of the Delta, depending on the lunar phase (NOAA 2015). Winds and extremes in atmospheric pressure can augment or dampen these extremes (Smith 1988). Due to elevation gradients within the lower Delta, some areas are rarely inundated, others are rarely exposed, while many areas fall somewhere in between (Smith 1988). Consequently, variation in elevation, tidal magnitude, and exposure to saltwater govern the composition of plant communities in the lower Delta. Some areas are dominated by tall grasses, others by floating plants, and still others only by submerged vegetation (Duncan 2013).

There are also dramatic seasonal changes in the lower Delta. From winter through spring, high volumes of cold nutrient- and silt-laden freshwater pour through the Delta’s channels. Where fresh silt accumulates, new marshland appears in the late spring when temperatures warm, the flooding subsides, and plant growth peaks (Finch 1999a; Duncan 2013). From late spring into late fall discharge from the basin wanes (with the exception of the occasional tropical cyclone), and marine waters have more sway in the lower Delta. During this time juvenile crabs, shrimps, fishes, and other saltwater species use the lower Delta as a nursery. Higher salinities brought by high tides and waves generated by the daily sea breeze cause seasonal dieback of freshwater marshes in vulnerable areas (Finch 1999a; Duncan 2013).

2) Floodplains and Low Terraces Ecoregion
Upper delta ecosystems are the heart of the greater Mobile-Tensaw River area, including its river channels, oxbow lakes, ponds, swamps, and floodplain forests (Griffith et al. 2001b). This is the Floodplains and Low Terraces Ecoregion (the two Level IV ecoregions comprising the upper portions of the Delta, Southeastern Floodplains and Low Terraces [65p] and Floodplains and Low Terraces [75l], are treated here together). Trees are the dominant vegetation due to being beyond the reach of the salty tides. Historically, bald cypress populated many of the shallower areas where seasonally low water levels allowed seedlings to establish. But logging and upstream dams vastly reduced the extent of cypress swamps. In their place are stands of fast-growing swamp and water tupelo (Finch 1999b; Griffith et al. 2001b; Duncan 2013).

At slightly higher elevations throughout this ecoregion are floodplain forests. During winter and spring, they are flooded with muddy river water for weeks or months. Tree species composition varies depending on the depth and duration of flooding, but all are lush and diverse because water is always available and nutrient-rich silt is deposited each year (Sharitz and Mitsch 1993). Many trees support epiphytic orchids, ferns, and bromeliads. Aquatic wildlife is abundant, and diversity of fishes, reptiles, and amphibians is world renowned (Duncan 2013). Terrestrial mammals are abundant when water levels are low, and birds are plentiful in migration and during the summer. The region’s productivity nurtured the rise of Bottle Creek, one of the most important pre-Columbian southeastern Native American cities (Brown 2003a). With notable exceptions endemism to the upper and lower Delta seems to be minimal. Most species in these ecosystems are widespread, due in part to the periodic mixing of aquatic and semi-aquatic species along the coastal plain whenever sea levels dropped during the Pleistocene’s interglacial periods.

3) Southern Pine Plains and Hills Ecoregion
The uplands bordering the Delta host radically different ecosystems that collectively are part of the Southern Pine Plains and Hills (65f) Ecoregion. Sediments here are clays and well-drained sands, weathered remains of marine sediments deposited in the past 23 million years (Osborne et al. 1989; Griffith et al. 2001b). The resulting topography is predominantly broad hills and level plains, but small streams create narrow riparian zones and ravines (Duncan 2013).

Prior to European-African settlement, this landscape was dominated by the longleaf pine woodland, a savanna ecosystem with scattered pines. Abundant light striking the ground, combined with frequent rain, sustained hundreds of herbaceous plant species, and subsequently supported a great diversity of vertebrates, particularly amphibians and reptiles (Frost 2006; Means 2006; Finch et al. 2012). This savanna-woodland ecosystem is the most biologically diverse ecosystem in North America outside of the wet tropics (Finch et al. 2012).

The longleaf woodlands were sustained by the frequent recurrence of low-intensity wildfires that killed fire-intolerant broadleaf trees and shrubs continuously attempting invasion from nearby riparian ecosystems (Frost 2006; Duncan 2013). Within this ecosystem, plant community composition varied with...
subtle changes in drainage patterns (Peet 2006). More
dramatic topographic changes created other ecosystems, including the seepage bogs famed for a diversity
of carnivorous plants (Peet 2006; Duncan 2013).

Endemism to this ecoregion is high, but given its
great expanse across the Southeast, most species
have historic distributions extending beyond the
greater Mobile-Tensaw River area. But given the near-
complete loss of this ecosystem to land use change
(Frost 2006), every surviving population of longleaf-
associate species has great conservation value. It is
worth mentioning that the width of the Mobile River
Delta, and even that of the swamps and floodplain
forests of the Tombigbee and Alabama rivers to the
north, were range expansion barriers to many small
vertebrates. More than a few taxa are found only to
the west or east of these river systems (Mount 1975).

4) Buhrstone/Lime Hills Ecoregion
At the very northern margin of the greater Mobile-
Tensaw River area is a region known as the Red Hills.
This area of steep hills and deep ravines belongs to the
Buhrstone/Lime Hills (65q) Ecoregion. Like much of
the greater Mobile-Tensaw River area, these ecosys-
tems have received little scientific scrutiny and new
discoveries should be expected. The hills exist due to
Eocene and Oligocene marine deposits of claystone,
sandstone, and limestone that are more resistant to
erosion than the softer sediments of the surrounding
region (Osborne et al. 1989; Lacefield 2013). In addi-
tion, a salt dome known as the Hatchetigbee Dome has
added to the high relief of the region and contributed
mineral springs to the landscape (Lacefield 2013).
The unique soils and extreme topography of the
Red Hills relative to the surrounding plains sustains
species usually found farther north and above the Fall
Line, at the extreme inland limits of the Coastal Plain
(Mount 1975; Boschung and Mayden 2004). Due to
its uniqueness and geographic isolation, this ecoreg-
ion may harbor more endemic species than any other
within the greater Mobile-Tensaw River area. The best
known example of this endemism is the ecoregion’s
flagship species, the Red Hills Salamander.

The Red Hill’s original ecosystems included pyro-
genic broadleaf and longleaf pine woodlands on the
hilltops, ravine forests on the steep slopes, and ripar-
ian forests along the small and large streams of the
region (Mount 1975; Griffith et al. 2001b). Because the
ravines are sheltered from the sun and receive ground-
water from the slopes above, they remain moist and
cool throughout the summer, thus providing refuge
from wildfires and the harsh summer sun for many
heat- and fire-intolerant plant species more abundant
at northern latitudes. Some are relict populations that
established in the Pleistocene. Ironically, they grow
alongside representatives of tropical plant families
that adapted to the warm temperate zone climate, but
also cannot tolerate wildfire (Duncan 2013).

Anthropogenic Change
While the forces that created the ecosystems of the
greater Mobile-Tensaw River area are grand and
enduring, they alone cannot sustain the region’s biodi-
versity in the face of anthropogenic change. Much has
been lost already. An earthen causeway interrupts the
natural exchange of fresh and salt water in the lower
Delta. Cities and farms far to the north send pollut-
ants into the waters feeding the Delta. Dams upstream
interrupt the migrations of fishes and distort the natu-
ral hydrology. The overharvest of plants and animals
has weakened or extirpated many populations. Many
exotic invasive species have permanently established
and have reshaped the greater Mobile-Tensaw River
area’s ecology. Two centuries of land use change have
reduced the greater Mobile-Tensaw River area’s natu-
ral upland ecosystems to an assortment of slivers and
small patches. Sea level rise over the next century
will cause retraction of marshland in the lower Delta.
Fortunately, remedies and mitigations exist, but only
for a public willing to protect the greater Mobile-
Tensaw River area from these threats.
8. Vegetation Communities

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This chapter provides a glimpse of the vegetation communities of the greater Mobile-Tensaw River area, first through review of the historical observations of William Bartram and Charles T. Mohr, then through more contemporary works. It concludes with brief discussions of the Delta today, and how to access it.

William Bartram’s Lyrical Descriptions

William Bartram, in his famous Travels (1791) through the southern British colonies of eastern North America, arrived in Mobile in July 1775 after a 2-year trek from Savannah, Georgia. Eager to experience and explore the Delta that he had hurriedly crossed, he immediately returned east in a “trading boat” to “Taensa” (now Lower Bryant’s Landing in northern Baldwin County, Alabama), then procured a “light canoe” to travel upriver. There he found river cane (Arundinaria gigantea) growing “to a great height and thickness” and discovered a new species of evening primrose (Oenothera grandiflora), “perhaps the most pompous and brilliant herbaceous plant yet known to exist.” Over 100 years later—after the seeds that Bartram collected that day and sent to England had spread widely across Europe—this primrose formed the basis for Hugo de Vries’ critical studies of plant mutations (Cleland 1935; Davenport 2011).

Continuing upriver, Bartram paddled through “high forests and rich swamps” with “the Canes, and Cypress trees of an astonishing magnitude, as were the trees of other tribes.” Then leaving the river channel “and penetrating the awful shades,” he passed through “stately columns of the Magnolia grandiflora…. What a sylvan scene is here!..I recline on the verdant bank, and view the beauties of the groves”: red buckeye (Aesculus pavia), bottlebrush buckeye (A. parviflora), Carolina laurel cherry (Prunus caroliniana), oakleaf hydrangea (Hydrangea quercifolia), dahoon holly (Ilex cassine), pyramid magnolia (Magnolia pyramidata, which he described here as a new species), odorless wax-myrtle (Morella inodora), Carolina buckthorn (Frangula caroliniana), two-winged silverbell (Halesia diptera), crossvine (Bignonia capreolata), coral honeysuckle (Lonicera sempervirens), and Eastern gum bully (Sideroxylon lanuginosum).

Bartram canoed to the head of the Delta, the confluence of the Tombigbee and Alabama rivers and the Cutoff. He ascended the Tombigbee River and, “just within its capes,” entered “a large lagoon, or capacious bay of still water,” many acres in extent and dominated by American lotus (Nelumbo lutea). He described fully its leaves, flowers, and fruits, even the sweet taste of its seeds.

Finally, Bartram stopped at a bluff and, opposite it, “a district of swamp or low land, the richest I ever saw. . . . [A]s for the trees I shall forbear to describe them, because it would appear incredible” that the bald cypress (Taxodium distichum), green ash (Fraxinus pennsylvanica), American sycamore (Platanus occidentalis), Eastern cottonwood (Populus deltoides), sweetgum (Liquidambar styraciflua), “and others, are by far the tallest, straitest and every way the most enormous that I have seen or heard of.” He was equally impressed by the sizes of the canes, “thirty or forty feet [9 to 12 m] high, and as thick as a man’s arm.”

Descriptions of Charles T. Mohr

More than a century after Bartram’s short visit—and after 40 years’ study—Mobile pharmacist and botanist Charles T. Mohr described the vegetation of the Delta in much greater (though less poetic) detail in his life’s work, Plant Life of Alabama (Mohr 1901). I cannot improve upon Mohr’s work. So for the rest of this treatment, I will use his words to describe the vegetation communities of the Delta, while providing modern nomenclature (Kral et al. 2011; Alabama Plant Atlas 2015) and additions as needed.

1) Cypress Swamps

Mohr was one of the last botanists to visit and describe unaltered cypress swamps in the Delta, what he termed “paludial arboreal associations” or “cypress brakes.” Mohr (1901) described them thusly:

The bottom lands of the Mobile River and the islands in the delta . . . are covered with a high forest of deciduous trees, common to them and the lowlands of the same character along the Tombigbee and Alabama rivers. . . . Where
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the banks are almost perpetually submerged they are covered with cypress. This largest of the Atlantic forest trees was formerly found in the upper part of the river delta in great perfection. The mighty trunks rise to a total height of from 100 to 120 feet [30 to 37 m] and over, with a diameter, measured above the buttresses which expand the bases, of from 3 to over 5 feet [0.9 to 1.5 m] . . . The assemblage of these monarchs of the forest in the compact cypress brake, surrounded by the peculiar cone-shaped excrescences (cypress knees) rising from their roots 1 to 2 feet [0.3 to 0.6 m] and more above the dark unruftled surface of the water, presents a feature in the arboreal flora . . . at once strange and imposing. In these brakes the tupelo gum (Nyssa aquatica) is the only associate of the cypress, which it rivals in size, and the Carolina swamp ash (Fraxinus caroliniana) is the only tree of small size thriving in the gloomy shade beneath these trees.

2) Wet Hardwood Sites

Mohr (1901) went on to describe the plant associations on slightly higher ground:

In the mire of the swamps above the level of long-continued overflows, a variety of hardwood trees mingle with the cypress and finally supersede it on ground slightly above the ordinary water level [Figures 8-1 and 8-2]. Black gum [Nyssa biflora], water oak [Quercus nigra], water hickory [Carya aquatica], green ash [Fraxinus pennsylvanica], more rarely Southern red oak [Quercus falcata], [American] elm [Ulmus americana], [Eastern] cottonwood [Populus deltoides], and overcup oak [Quercus lyrata] . . . form the high forest overshadowing the smaller trees, of which the most conspicuous are planer tree [Planera aquatica], red maple [Acer rubrum], [Eastern] hop-hornbeam (Ostrya virginiana), [and several species of hawthorn (Crataegus)].

In addition, Mohr (1901) noted American snowbell (Styrax americanus), devilwood (Cartrema americana), possum-haw (Ilex decidua), Georgia holly (Ilex longipes), and parsley hawthorn (Crataegus marshallii) “form the shrubby undergrowth. The handsome [two-wing] silverbells, the dahoon holly, and the swamp dogwood (Cornus foemina) occupy the dried outskirts of these swamps.”

In the depths of these “drier” swamps, Mohr (1901) found that cabbage palm (Sabal palmetto) “reaches its perfection, the trunk[s] rising from 2 to 3 feet [0.6 to 0.9 m] above the ground, the fan-shaped leaves with their stalks 8 to 10 feet [2.4 to 3 m] long. Black willow (Salix nigra) and cottonwood cover the recent alluvium.” And deeper in these swamps are sensitive fern (Onoclea sensibilis), royal fern (Osmunda spectabilis), Virginia chain fern (Anchistia virginica), green arrow-arum (Peltandra virginica), and swamp spider-lily (Hymenocallis occidentalis).

In the extremely rich and diverse habitats of these swamps, Mohr (1901) found that the shallow pools were filled with awl-fruit sedge (Carex stipata), common fox sedge (Carex vulpinoidea), rice cut-grass (Leersia oryzoides), white cut-grass (Leersia virginia), dense-flower smartweed (Persicaria glabra), and lizard’s-tail (Saururus cernuus). Eastern mosquito fern (Azolla caroliniana), the liverwort Riccia, and water

Figure 8-1. Cypress-gum-pine border, Byrnes Lake Boat Landing north of Spanish Fort. (Photo credit: Lawrence Davenport.)
spangles (*Salvinia minima*) float on the water’s surface.

3) Grass Beds

In another section of his introduction to *Plant Life of Alabama*, Mohr (1901) described the “limnaean” vegetation of the Delta:

> The still waters of the estuary of [the] Mobile River and of the larger streams emptying into the upper part of the bay, fresh, except at long intervals, when it is slightly brackish, harbor a number of submerged species, forming in their dense mass subaquatic meadows.

He listed the following species as constituting these “meadows” or grass beds: horned pondweed (*Zannichellia palustris*), wigeon-grass (*Ruppia maritima*), coon’s-tail (*Ceratophyllum demersum*), curly pond-weed (*Potamogeton crispus*), small pondweed (*Potamogeton pusillus ssp. pusillus*), water-thread pondweed (*Potamogeton diversifolius*), long-leaf pondweed (*Potamogeton nodosus*), clasping-leaf pondweed (*Potamogeton perfoliatus*), Eurasian water milfoil (*Myriophyllum spicatum*), leafy bladderwort (*Utricularia foliosa*), long-beak buttercup (*Ranunculus longirostris*), grassleaf arrowhead (* Sagittaria graminea*), American lotus, American eelgrass (*Vallisneria americana*), and Canadian waterweed (*Elodea canadensis*). To Mohr’s list I would add sago pondweed (*Stuckenia pectinata*) and turtle grass (*Thalassia testudinum*), while emphasizing the dominance of American lotus in some areas. See Raines (2015) for a recent description of the latter.

4) Open River Marshes

In his portrait of the Delta, Mohr (1901) also painted its open river marshes (Figures 8-3, 8-4, 8-5):

> The islands in the lower part of the delta and the low banks of the streams in the tidewater region are covered with deep and extensive open marshes, the soft silt of which, rich in humus,
supports an association of paludial plants (halophytes), which take root firmly in the soil, their mostly strong, interlacing rhizomes forming a dense sod, resisting the action of waves and winds. Reed-like grasses, large rushes, and tall umbelliferous plants are the most conspicuous features of this association.

Here he included common reed (Phragmites australis), salt-meadow cordgrass (Spartina patens), big cordgrass (Spartina cynosuroides), annual wild rice (Zizania aquatica), water millet (Zizaniopsis miliacea), switchgrass (Panicum virgatum), maiden-cane (Panicum hemitomon), broadleaf cattail (Typha latifolia), soft-stem bulrush (Schoenoplectus tabernaemontani), river bulrush (Bulboschoenus fluviatilis), saw grass (Cladium jamaicense), jointed flatsedge (Cyperus articulatus), spotted water hemlock (Cicuta maculata), stiff cowbane (Oxypolis rigidior), and water parsnip (Sium suave). To Mohr’s list I would add the Caribbean-based Southern cattail (Typha domingensis), which is now well established in certain Delta marshes.

Mohr further noted basic successional trends in these marshes, with wild rice, soft-stem bulrush, and broadleaf cattail being “among the first [plant species] to gain a firm hold on the muddy shoals, constantly formed by the deposits of silt with which the turbid waters are charged.” He also added the following graminoids to his growing list: red-root flatsedge (Cyperus erythrorhizos), straw-color flatsedge (Cyperus strigosus), rusty flatsedge (Cyperus odoratus), sallow sedge (Carex lurida), green-white sedge (Carex albo-lutescens), broad-wing sedge (Carex alata), Southern cutgrass (Leersia hexandra), purple bluestem (Andropogon glaucopsis), angle-stem beaksedge (Rhynchospora caduca), and short-bristle horned beaksedge (Rhynchospora corniculata). Plus he added the following more broad-leaved herbs and shrubs: saltmarsh
morning glory (*Ipomoea sagittata*), broadleaf Indian-plantain (*Arnoglossum ovatum*), Virginia saltmarsh-mallow (*Kosteletska virginica*; Figure 8-6), small-head dill’s-daisy (*Boltinia diffusa*), giant ironweed (*Vernonia gigantea* ssp. *gigantea*), bull-tongue arrowhead (*Sagittaria lancifolia* ssp. *media*), giant arrowhead (*Sagittaria montevidensis*), saltmarsh loosestrife (*Lythrum lineare*), pickerel-weed (*Pontederia cordata*; Figure 8-7), pale dock (*Rumex altissimus*), creeping burhead (*Echinodorus cordifolius*), broadleaf arrowhead (*Sagittaria latifolia*), and Southern seaside goldenrod (*Solidago sempervirens* var. *mexicana*).

Mohr (1901) ended his lengthy discussion of the Delta’s open river marshes by noting, “The dark waters of ditches and shallow pools at the outskirts of these marshes are filled with the floating stems of” floating primrose-willow (*Ludwigia peploides* spp. *glabrescens*) “and bordered by” floating marsh-pennywort (*Hydrocotyle ranunculoides*), whorled marsh-pennywort (*Hydrocotyle verticillata*), cursed buttercup (*Ranunculus sceleratus*), threadleaf mock bishopweed (*Ptilimnium capillaceum*), and sticky joint-vetch (*Aeschynomene viscidula*). Other plants noted were marsh spikerush (*Eleocharis palustris*), three-rib arrowgrass (*Triphlochis striata*), needle-pod rush (*Juncus scirpoides*), many-head rush (*Juncus polycarpous*), hairy-pod cowpea (*Vigna luteola*), and climbing hempweed (*Mikania scandens*). Pea-tree (*Sesbania herbacea*) and bagpod (*Sesbania vesicaria*) “occupy almost alone the alluvial banks bordering the swamps, covered with the debris left behind after every overflow.”

**5) Dry Edges and Beaches**

Mohr (1901) also described the littoral zone, extending along the eastern shore of Mobile Bay to the beaches of the Fort Morgan Peninsula and Dauphin Island. Surprisingly, he offered few details of the Bay and its dry edges, except for the sand-stabilizing presence of Brazilian bay-hops (*Ipomoea pes-caprae* ssp. *brasiliensis*). Other vines and low-lying shrubs are
trumpet-creeper (Bignonia capreolata), beach morning glory (Ipomoea imperati; Figure 8-8), marsh false bindweed (Calystegia sepium ssp. limnophila), rough cocklebur (Xanthium spinosa), common partridge pea (Chamaecrista fasciculata), and dwarfed Chinese Tallowtrees (Triadica sebifera).

6) Shell Hammocks

Finally, Mohr (1901) noted shell hammocks near the sea and along the Delta’s “narrow tortuous marine channels.” These “heaps of bivalve shells, frequently many yards in length and from 6 to 15 feet [1.8 to 4.6 m] and over in height,” are “the accumulation of refuse from the food supply which served a race of men unknown to history.” Dominant plants on Delta shell mounds are live oak (Quercus virginiana), Southern magnolia (Magnolia grandiflora), pignut hickory (Carya glabra), Carolina buckthorn (Frangula caroliniana), red buckeye (Aesculus pavia), and Carolina wolfberry (Lycium carolinianum). Growth of the last 2 species may have been encouraged by Mohr’s “race of men unknown to history,” with the first being used as a fish poison and the second one for food (Raines 2014).

Later Studies

Later workers have not improved on the work of Mohr, especially in his detailed knowledge of Delta plant associations and dynamics. Four years after his death—which came, sadly, just 2 weeks before the publication of Plant Life of Alabama—Roland M. Harper was named botanist for the Geological Survey of Alabama. During his long (1905-1966) and fruitful association with the Survey, Harper published over 600 letters, scientific articles, and books. (For a synopsis and analysis of Harper’s works, see Davenport and Hubbs 1995). While several of these (Harper 1913, 1920, 1943) deal with Alabama’s forests and plant associations, none offers the details provided by Mohr.

Harper’s first treatment (Harper 1913) is admittedly superficial or “broad brush,” based on 3 train rides along the Louisville & Nashville Railroad across the lower end of the Delta. He listed only the main tree species seen from the train car windows: bald cypress, black willow, cottonwood, American elm, sweetbay, red bay (Persea pubescens), sweetgum, red maple, black gum, tupelo gum, and green ash.

Harper’s second treatment (Harper 1920), based on the same railroad trips, contains a few more details, especially among the shrubs, vines, and herbs. His third treatment (Harper 1943), again devoted to trees, includes details from a 1927 trip from Mount Vernon, in north Mobile County, near the Delta’s upper end. Here he divides those trees into larger and smaller, upper and lower, corresponding largely with Mohr’s designations of wet hardwood sites and “cypress brakes.”

E. Lucy Braun, the dominant plant ecologist of her generation, used even broader strokes. In her masterpiece, Deciduous Forests of the Eastern United States, Braun (1950) made no specific reference to the Delta, even though she relied heavily on the works of Mohr and Harper in describing the forest vegetation of the Southeast. The same is true of Christensen (1988); while providing detailed accounts of the vegetation zones of the Southeastern Coastal Plain, he used no examples from the Mobile-Tensaw Delta. And in the most recent treatment, Sharitz and Mitsch (1993) pull...
details and plant lists from many solid sources. But again, they make no specific reference to the Delta.

**The Delta Today**

Today, the Delta remains an unbroken cypress-tupelo swamp, as described so enthusiastically by Bartram. And its edge habitats and marshes still support the plant communities depicted by Mohr. But a number of changes must be noted.

Although some champions remain in isolated places, the huge trees celebrated by Bartram are gone, logged out during the past 150 years. The same is true of the equally celebrated cane brakes. While cane itself remains in the Southeast, the number and size of individuals is much diminished, as is the importance of cane brakes as a distinct ecosystem (Platt and Brantley 1997).

The completion of the Causeway across the lower Delta in 1926, cutting east-west across the north-south flow of water, has modified salinity regimes, such that some vegetation zones have been enhanced and others diminished. Additionally, many grass beds along Mobile Bay’s eastern shore have suffered heavy silt loads from construction projects (Raines 2014).

**Access**

The vegetation zones of today’s Delta can be readily visited by water and land. Public and private boat landings allow access to both the eastern and western portions, with the Five Rivers Delta Resource Center (near Spanish Fort) in the middle (Figure 8-9). Also highly recommended are the boardwalk/trail from Bayfront Park in Daphne (Figures 8-10, 8-11, 8-12) and the E. O. Wilson Boardwalk at Historic Blakeley State Park (Figure 8-13).

![Figure 8-9. Water’s edge, Byrnes Lake Boat Landing north of Spanish Fort. (Photo credit: Lawrence Davenport.)](image)

![Figure 8-10. The Jackson Oak, Village Point Park Preserve, Daphne. (Photo credit: Lawrence Davenport.)](image)
Figure 8-11. Warning sign, Village Point Park Preserve, Daphne. (Photo credit: Lawrence Davenport.)

Figure 8-12. American alligator, *Alligator mississippiensis*, viewed from boardwalk, Bayfront Park, Daphne. (Photo credit: Lawrence Davenport.)
Figure 8-13. E. O. Wilson Boardwalk, Historic Blakeley State Park, Spanish Fort. (Photo credit: Lawrence Davenport.)
9. Exploring the Unknown—The Insects of the Mobile-Tensaw River Delta

John W. McCreadie and Peter H. Adler, University of South Alabama

Who will inherit the earth? In many ways, evolution has answered this question: the insects. In a world rich with life, 60% of all known species are insects, currently numbering more than 1 million (Adler and Foottit 2009). The reigning kings of biodiversity, beetles, account for well over one third of all insect species. Even within the beetles, a single group, the weevils, includes 3 to 4 times as many species as all species of birds and mammals combined.

The Mobile-Tensaw River Delta (hereafter, as the locals call it, “the Delta”) is a relatively pristine, roughly 1000 km² (390 mi²) area of subtropical wetlands about 60 km (37 mi) long and 16 km (10 mi) wide, stretching from the confluence of the Alabama and Tombigbee rivers south to the head of Mobile Bay. The Delta is one of the nation’s largest river deltas. A staggering 15% of the contiguous nation’s water runs through it. Much of the area remains in a natural state, which is remarkable given that the Southeast has relatively little land under federal or state protection (Loomis and Echowhawk 1999).

The Delta is suspected of being a hotbed of insect biodiversity—“suspected” because we actually know little about the insects of the Delta. Consisting of bottomland hardwood forests interlaced with large rivers, streams, canals, bayous, and marshes, the Delta is challenging to traverse; movement often is possible only by boat. Such an inaccessible habitat has protected its denizens and shrouded many of the smaller creatures, such as the insects, in mystery.

In our investigations of the insects of the Delta, we initiated an inventory and established an arthropod museum to house reference specimens. To introduce the insect biodiversity of the Delta, we provide preliminary accounts of a small selection of insect groups.

What Is Known of Insects in the Delta?

Little has been published on the insects of the Delta. This is both exciting and daunting, since almost everything we learn about the insects in the Delta is new. Apart from a US Department of Agriculture (USDA) report on the control of tent caterpillars in the 1970s (Abrahamson et al. 1982), the first paper published on insects in the Delta concerned a curious insect known as a water scorpion (Figure 9-1; Ihle and McCreadie 2003). This stealth predator hides in the vegetation of calm waters, waiting for prey to wander by. Water scorpions with barnacles attached to them attest to the intermingling of freshwater and saltwater near the

Figure 9-1. The water scorpion Ranatra with a barnacle attached to its thorax. (Photo credit: Laura T. Miller, West Virginia Deptartment of Agriculture.)
southern border of the Delta. We also have published a study on larval dragonflies (McCreddie et al. 2005), several new distribution records, and a couple of new species descriptions. No doubt a number of insects collected from the Delta are spread across collections and museums in North America. However, museum specimens typically are encountered only by systematists working on specific taxonomic groups, and the information is not easily tracked by nonspecialists. Hence, we are in a better position to discuss what we do not know about the insects of the Delta than what we do know.

The Total Insect Bio-inventory Project of the Mobile-Tensaw Delta

Nearly all that is known about the insects of the Delta has been gathered under the umbrella of the Total Insect Bio-inventory Project of the Mobile-Tensaw Delta. This project was initiated and developed by J.W. McCreddie and P.H. Adler in 2000, largely with funds provided by the Alabama Center for Estuarine Studies. The Total Insect Bio-inventory Project’s primary long-term goal is to produce a robust inventory of the insect fauna in the Mobile-Tensaw Delta over the course of a 20- to 30-year survey. In our endeavor to catalog as many species as possible, we have enlisted the help of more than 60 collaborators from around the world. Because the Southeast has less protected land than most other areas in the United States and is facing the potential battering effects of climate change, the need for a bio-inventory of the relatively pristine Delta wetlands is particularly urgent.

Sampling and Collecting

Our interests cover the insects of both aquatic and terrestrial environments. Accordingly, collecting for the Total Insect Bio-inventory Project has taken two basic forms: Malaise traps (Figure 9-2) for terrestrial insects and large hand-held nets for aquatic species.

We have found Malaise traps to be an efficient means of collecting insects in the Delta. Four collecting sites in the lower half of the Delta were established in unique topographical or vegetational areas to a) maximize the number of species collected and b) eventually examine the effects of landscape features on insect biodiversity and community structure. Each site had 1 Malaise trap initially (for incidence data), and later 4 traps (25 m [82 ft] apart) to permit estimations of relative abundance of each species per site. This arrangement prevented complete loss of data from a site if individual traps were destroyed by storms. We also established 20 sites for sampling aquatic insects along a north-south axis across the Delta, each in a habitat with unique aquatic vegetation (e.g., submergent vegetation, debris) and microhabitat (e.g., slow lotic, fast lotic, bayou). At each site, five 5-min bankside samples were obtained using a mesh net (Ihle and McCreddie 2003; McCreddie et al. 2005).

Search methods also include ad hoc examinations of specific habitats, such as animal burrows, which rely on an investigator’s knowledge of the group of interest. Although these methods typically lack repeatable selection protocols, and data are not easily quantifiable, they can add significantly to the number of species discovered.

To process collected material, personnel at the University of South Alabama place fully labeled samples in vials of 80% ethanol and send them to Clemson University, where material is sorted to family by students with appropriate taxonomic training. Insects such as calyptrate flies are dried chemically with

Figure 9-2. Malaise trap, the primary means of collecting insects in the Delta. (Photo credit: John W. McCreddie, University of South Alabama.)
hexamethyldisilazane (Brown 1993), which also preserves DNA (deoxyribonucleic acid; Koch et al. 1998), should contemporary or future workers wish to perform molecular analyses. Dried specimens are pinned appropriately and a collection label affixed to the pin. Other groups of insects, such as Doli- chopodidae, Psychodidae, Simuliidae, and Tipulidae, are retained in ethanol vials. To accommodate representative specimens collected in the Delta, the University of South Alabama Arthropod Depository was established in 2001.

Insects

Most of the insects identified from the Delta reflect our own interests, such as the dragonflies (Odonata) and true flies (Diptera); our choice of collecting methods; and, most importantly, the availability of expert taxonomic collaborators. More than 50,000 insects have been sorted to the family level, and thousands await identification by a willing specialist. We have collected groups for which there are no active specialists to identify the specimens. For some groups, therefore, we have long lists of families, genera, and species, but for other groups we have no identified specimens. Given these constraints, insects in 108 families, 366 genera, and more than 800 species have been identified, entered into a database, and curated in the University of South Alabama Arthropod Depository.

1) Odonata—Damselflies and Dragonflies

One charismatic order of insects is the Odonata, which includes nearly 5700 species in the world, over 460 in North America, and 170 in Alabama. The aquatic larvae (Figure 9-3) and terrestrial adults of all species are highly specialized predators. Monthly samples taken for 1 year from Delta streams and rivers more than 10 m (33 ft) wide yielded 1151 larvae in 4 families, with 16 species, or 9.2% of all odonate species known from Alabama (McCreadie et al. 2005). The number of species decreased with proximity to Mobile Bay, possibly because of increasing salinity. The most common species was Erythemis simplicicollis (Say), the eastern pondhawk, representing 34% of all collected specimens, followed by Enallagma signata (Hagen), the orange bluet, at 21%. The most infrequently collected species—represented by a single specimen—was Nasiaeschna pentacantha (Rambur), the Cyrano darner. Subsequent to our regimented larval collections, we added 4 more species—Enallagma pollutum (Hagen), Ischnura kellicotti (Williamson), Ischnura pronata (Hagen), and Arigomphus pallidus (Rambur)—to the list of odonates in the Delta, bringing the total to 20 species.

2) Diptera—Flies

The true flies of the order Diptera are a highly diverse group. They represent about 10% of the planet’s biodiversity, making these small and often overlooked insects one of the most species-rich groups of organisms in the world (Brown 2005; Adler and Foottit 2009; Courtney et al. 2009). In the Delta, we have collected more than 185 genera and 400 species of flies, at least 6% of which are new species. Many additional species are state records for Alabama and often represent the northernmost or southernmost distribution records. Thus, the Delta appears to be a “hot spot” for fly biodiversity. We feature 10 families of flies to provide an indication of the extent of the Delta’s biodiversity.
Anthomyiidae (Figure 9-4)
The nearly 2000 anthomyiid flies of the world are diverse in their habits. Some species, the so-called “root maggots,” develop in roots and stems, whereas others live in flowers and leaves, some feed on kelp along the seashore, some are fungivores, and still others are scavengers, parasites, and commensals in the nests and burrows of animals. Thus far, 21 specimens have been submitted for identification. Eleven genera and 12 species have been collected, among which are 1 new species and 11 state records, including the southernmost record for *Eustalomyia vittipes* (Zetterstedt), a species also found in the Old World.

Another anthomyiid in the Delta is *Delia platura* (Meigen), the seedcorn maggot. As a seed feeder, this cosmopolitan species can be a sporadic pest of agricultural crops, such as corn and soybeans.

Calliphoridae (Figure 9-5)
The blow flies, best known as ubiquitous colonizers of carrion and excrement, also include parasites of birds, mammals, and earthworms. They number more than 1520 species in the world. The conspicuous, shiny blue and green flies that appear almost immediately around dead animals have great value as forensic indicators, providing insights into time since death. Five species were found among 48 specimens in our Delta collections, of which 73% were *Lucilia coeruleiviridis* (Macquart), the green bottle fly. The sex ratio of green bottle flies in our samples was strongly skewed: 33 females to 2 males.
Ceratopogonidae (Figure 9-6)
Biting midges, no-see-ums, punkies, wings-with-teeth — the numerous vernacular names for these blood-sucking flies allude to their tiny size and the annoying biting habits of the female flies, primarily in the genus *Culicoides*, which attack humans. The family contains an enormous number of species, with about 6000 described and many more remaining to be discovered. The females of the majority of species feed on insect blood. To date, 53 species in 15 genera have been collected in the Delta, including 3 new species and 2 state records. Another 3 genera and 33 species have been collected from Baldwin and Mobile counties adjacent to the Delta. One new species, *Brachypogon laneae*, a member of a group that feeds on the blood of other flies, already has been described from the Delta (Swanson and Grogan 2011).

Chironomidae (Figure 9-7)
The nonbiting midges are among the most common and ubiquitous flies in the world, totaling more than 7200 described species. The larvae develop in aquatic habitats, such as streams, rivers, ponds, and lakes, and in organically rich terrestrial habitats, such as soil. Most species feed on detritus and small organisms, but some are predaceous. Chironomids are frequently used in water quality assessments. Some species are vulnerable to degraded aquatic environments, but others are remarkably tolerant, including the bloodworms—species with hemoglobin—that can achieve enormous populations in poorly oxygenated habitats. The adults are small, delicate, mosquito-like flies often found dead in light fixtures. They take water and sugary substances, such as insect honeydew. A meager sample of chironomids from the Delta yielded 46 species, of which at least 13% are new to science and 46% are state records.
The Chironomidae represent one of the richest dipteran families in the Delta, and continued identification will drive the species list far higher.

**Dolichopodidae (Figure 9-8)**
Members of the family Dolichopodidae—long-legged flies—are typically metallic with long legs and almost comically oversized male genitalia. Most adults are predaceous and usually inhabit humid terrestrial environments. Larvae are found in a wide range of habitats, such as tree holes, sap flows, streams, and plant stems. The family is quite large, with more than 7300 species known in the world. Our collections of Dolichopodidae from the Delta have yielded more than 90 species, of which 14 are new to science. Only 9 species of long-legged flies were known in the state of Alabama before 2000 (Pollet et al. 2004).

**Muscidae (Figure 9-9)**
The family Muscidae is far more diverse than suggested by its two most notorious synanthropic members, the house fly (*Musca domestica* L.) and the stable fly (*Stomoxys calcitrans* L.). The world’s 5200-plus species represent a wide variety of larval habitats, including carrion, decaying vegetation, soil, bird nests, and freshwater. Adults of some species have evolved piercing-cutting mouthparts to take vertebrate blood. Among a sample of 97 adults collected in Malaise traps in the Delta, 10 genera and 17 species were identified, including 2 probable new species. The most frequently collected muscid, representing one quarter of the identified specimens, was the widespread *Coenosia lata* (Walker), followed by *Neodexiopsis major* (Malloch; 14%).
Psychodidae (Figure 9-10)
The tiny moth flies are familiar to most people as denizens of bathrooms and communal showers where they breed in accumulated organic matter in drains. The annoying bathroom species belies a far richer taxonomic and ecological diversity of moth flies associated with a variety of wet habitats. More than 3000 species have been described for the world. Adults are largely nocturnal. Collections in the Delta have yielded 18 species in 10 genera, including 2 new species and 2 state records. More than 20 additional species have been found in adjacent areas of Baldwin and Mobile counties, suggesting the aquatic environment of the Delta supports a substantial psychodid fauna.

Simuliidae (Figure 9-11)
The pesky gnats known as black flies or buffalo gnats are small, compact flies that conjure the image of lilliputian American bison. The females of about 90% of North American species take a blood meal; only birds and mammals serve as hosts. Black flies breed exclusively in flowing freshwater and are best represented in mountainous areas, where the elevational gradient offers a variety of riverine habitats. Given the elevational monotony of the Delta, we would expect few species. Our Malaise trap samples bear this out, yielding only 3 species (about 1%) of the 255 simuliid species known from North America (Adler et al. 2004). One species feeds on the blood of mammals, and the other 2, including the notorious turkey gnat, *Simulium meridionale* (Riley), take the blood of birds. Remarkably, one of these species is new to science—an early season, Coastal Plain endemic that was chromosomally investigated by one of our graduate students (Gleason 2012). An additional 5 species...
have been collected as larvae from streams and rivers flowing into the Delta in Baldwin and Mobile counties.

**Tachinidae (Figure 9-12)**
Flies in the family Tachinidae constitute the second most species-rich group of Diptera, approaching 10,000 described species in the world and more than 1340 in North America. The larvae of all species of tachinids are parasitoids of insects, with scattered examples of species attacking a spider, centipedes, and scorpions.

A preliminary sorting of our Malaise trap collections revealed 19 genera, 29 species, and 7 state records, including the northernmost record for *Ormia dominicana* (Townsend). This pale brownish-orange tachinid is a parasite of *Orocharis luteolira* (Walker), the false jumping bush cricket; the fly locates its host acoustically based on the mating song (Lehmann 2003).

**Tipulidae (Figure 9-13)**
Delicate, long-legged flies of the family Tipulidae *sensu lato*—the crane flies—are one of the most species-rich families of insects on Planet Earth (although some specialists recognize the superfamily Tipuloidae and split the Tipulidae into 4 families). More than 1610 species of crane flies are found in North America, representing about 10.5% of the world’s total (de Jong et al. 2008). They are well represented in our Delta samples, with 31 species in 16 genera so far recorded. Our most commonly collected species was *Erioptera caliptera* (Say), the larvae of which live in damp soil.

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**Figure 9-12.** A member of the large family of parasitoid flies (family Tachinidae). (Photo credit: Steve A. Marshall, University of Guelph.)

**Figure 9-13.** A typical crane fly (family Tipulidae). (Photo credit: Steve A. Marshall, University of Guelph.)
Summary—More than 800 Species and Counting

With a modest total of 800-plus species recorded thus far, our goal to inventory the insects of the Delta continues. Lest the ultimate objective be misinterpreted, we emphasize that the inventory is not an endpoint, but rather a starting point for understanding, protecting, conserving, managing, and even harvesting the riches of the Delta’s insect fauna.

Acknowledgments

Large surveys of organisms, especially of arthropods, are possible only because of the specialized knowledge and enthusiasm of specialists. We are grateful for the contributions to this effort by the following scientists: D. Ackland (Anthomyiidae), J. A. Cammack (Calliphoridae), G. Curler (Psychodidae), J. Epler (Chironomidae), W. L. Grogan and D. A. Swanson (Ceratopogonidae), R. Hurley (deceased) and J. B. Runyon (Dolichopodidae), A. Pont (Muscidae), D. M. Wood (Tachinidae), and C. W. Young (Tipulidae). We are indebted to S. A. Marshall for generously allowing us to use his photographs of representative flies. We thank E. Benton and W. K. Reeves for their dedication to sorting material to family level and coordinating identifications with many of the specialists.
Vector-borne diseases are afflictions caused by a pathogen carried from one host to the next by another living organism. The agent of disease, often called the pathogen, is adapted to thrive not only within the body of its host, but also within the body of its carrier, called the vector. The vector acquires the pathogen from the host, usually through the act of biting and blood feeding. The term “Vector-borne disease system” refers to all of the elements (both living and non-living) that influence the cycle of transmission of a vector-borne disease. It most often includes the pathogen, its vectors, various hosts, the habitat where transmission occurs, and the weather and climate that influence the habitat and biologies of hosts and vectors.

Vector-borne diseases can be caused by a wide variety of organisms. Malaria, for example, is caused by a protozoan (animal-like single-celled organism), Lyme disease by a bacterium, yellow fever by a virus, and dog heartworm by a roundworm. Organisms that transmit vector-borne diseases are as diverse as pathogens and include mosquitoes, ticks, sand flies, kissing bugs, mites, lice, and fleas, among many others (Mullen and Durden 2009). In the greater Mobile-Tensaw River area, the most important vector-borne diseases of humans are viruses transmitted by mosquitoes.

Yellow Fever and the Greater Mobile-Tensaw River Area

The greater Mobile-Tensaw River area, particularly the port of Mobile, occupies a special place in the history of vector-borne diseases. Originally located at Twenty-seven Mile Bluff, the city of Mobile was relocated in 1711 to its current location partly due to recurring epidemics of yellow fever. Unfortunately, the early Mobilians did not escape yellow fever by relocating their city (Figure 10-1). At that time the idea that mosquitoes could carry yellow fever, or other diseases, was not fathomed by the medical community, much less the average person. Not until more than 100 years later did scientists and physicians begin to understand the association between mosquitoes and human disease, and then only imperfectly. Like malaria, yellow fever was thought to be caused by “bad air” that emanated from rotting vegetation abounding in marshes and swamps.

Josiah Nott, a prominent physician in Mobile was one of the first to notice how the spread of yellow fever in a community coincided with the mosquito season (Nott 1848). Dr. Nott likened the spread of the disease to the behavior of the mosquito moving through the landscape. While Nott’s writings fell short of stating that mosquitoes actually carry a pathogen, the philosophical link was established between mosquitoes and disease.
This important first step fostered a scientific atmosphere that eventually led to experiments in Havana, Cuba, in 1901 that demonstrated how yellow fever was transmitted by mosquitoes. An attendant of those experiments was William Crawford Gorgas, another prominent Mobilian, who would eventually become Surgeon General of the US Army. After the conclusion of the Yellow Fever Commission in Havana, Gorgas was charged with overseeing sanitation during construction of the Panama Canal (1904 to 1914). Having observed first-hand the experiments proving that mosquitoes transmit yellow fever, Gorgas used this knowledge to implement the first widespread sanitary programs to protect humans from mosquito-borne diseases. By draining swamps, fumigating living quarters, and destroying mosquito breeding sites, Gorgas’s sanitarians protected laborers constructing the Panama Canal from yellow fever and malaria, diseases that had thwarted a French attempt to build the canal 2 decades earlier (Dolan and Silver 1968).

**Vector-borne Diseases and the Greater Mobile-Tensaw River Area Today**

Today yellow fever and malaria, the scourges of Old Mobile, are no longer found in the US. An effective vaccine for the yellow fever virus was developed in 1937, and a widespread yellow fever vaccination program, coupled with the new science of mosquito control, led to eradication of yellow fever from the US and many other parts of the developed world. Malaria was also eradicated from the US, although much later than yellow fever. No vaccine exists for malaria. Thus the National Malaria Eradication Program, which commenced operations in 1947, utilized application of DDT (dichlorodiphenyltrichloroethane) and the draining or removal of mosquito breeding sites to eliminate malaria as a significant public health problem in the continental US by 1949. Although these immensely important diseases are no longer a threat in Alabama, several other vector-borne diseases are still found in the region, some of which have a profound impact upon human health.

**1) Eastern Equine Encephalitis**

Eastern equine encephalitis—sometimes known as “EEE” or “Triple E”—is probably the most important vector-borne disease in the greater Mobile-Tensaw River area (Mullen and Hribar 1988). The disease is caused by a virus transmitted by certain mosquito species that thrive in wooded swamps, such as those that dominate much of the Mobile-Tensaw Delta. Cases of Eastern equine encephalitis occur throughout the eastern United States, from Maine to southeastern Florida, most commonly in low-lying areas where swamps and swamp-inhabiting mosquitoes are found. The mosquito species *Culiseta melanura* is the most important vector of Eastern equine encephalitis virus, although it very rarely bites humans or other mammals. *Culiseta melanura* predominantly bites songbirds, such as the familiar northern cardinal. When *Culiseta melanura* bites an infected songbird, the virus in the bird’s blood passes to the mosquito. Inside the body of the mosquito the virus must pass from the digestive tract into the body cavity, and then to the salivary glands. During this process the virus encounters multiple transmission barriers that it must be adapted to pass, otherwise the mosquito will not transmit the virus when it bites another animal.

Although birds are not particularly affected by Eastern equine encephalitis, the virus can be deadly to humans and horses. In symptomatic cases of Eastern equine encephalitis the fatality rate is greater than 50%. Since *Culiseta melanura* rarely bites humans or other mammals, other mosquito species, such as *Coquillettidia perturbans*, which bite both birds and mammals, are important as vectors of the virus to humans and domestic animals (Figure 10-2). Species such as *Coquillettidia perturbans*, which carry a pathogen from the reservoir host to humans or other animals that are adversely affected by a pathogen, are sometimes called “bridge vectors.” Many other mosquito-borne viruses that affect humans, such as West Nile virus and St. Louis encephalitis, have transmission cycles similar to that of Eastern equine encephalitis, with birds as the natural host for the virus. The bird and mosquito species important in transmission usually differ from one virus to the next.

**2) Tensaw Virus**

Another mosquito-borne virus found in the greater Mobile-Tensaw River area that warrants mention is Tensaw virus, named after the Tensaw River, which flows through western Baldwin County before reaching Mobile Bay. Tensaw virus was discovered during extensive mosquito-borne virus investigations in Baldwin County during the 1950s and 1960s by teams of scientists from the Centers for Disease Control and Prevention (Stamm 1958; Sudia et al. 1968). In that era, very little was known about the transmission cycles of mosquito-borne diseases. Many of today’s basic concepts concerning mosquito-borne virus
Transmission were established during those studies in southern Alabama, which were conducted in response to outbreaks of Eastern equine encephalitis at farms near swamplands bordering tributaries of the Tensaw River. Thousands of mosquitoes were captured, identified, and tested for mosquito-borne viruses. In addition to the virus that causes Eastern equine encephalitis, the scientists discovered, characterized, and named viruses that were previously unknown.

Tensaw virus is not known to cause disease in humans, but it can be lethal in certain rodents (Coleman 1969). Foxes, rabbits, and some rats are probably important hosts of Tensaw virus (Südia et al. 1968; Bigler et al. 1975), although relatively little is known about the ecology of this virus. The mosquito *Anopheles crucians* is considered the most important vector of Tensaw virus in the southern US (Calisher et al. 1986). This mosquito is abundant in swamplands of the Deep South, and is one of the more common species in the greater Mobile-Tensaw River area. *Anopheles crucians* mainly bites mammals, but will also bite herons and other wading birds.

### Tick as Vectors of Human Pathogens

Several tick species that are vectors of human pathogens occur in the greater Mobile-Tensaw River area. These include the Gulf Coast tick (*Amblyomma maculatum*), the lone star tick (*Amblyomma americanum*), and the deer tick (also known as black-legged tick, *Ixodes scapularis*) (Figure 10-3). These ticks transmit a variety of human diseases, including Lyme disease (*Borrelia burgdorferi*), Rocky Mountain spotted fever (*Rickettsia rickettsii*), southern
tick-associated rash illness (*Borrelia lonestari*), and American boutonneuse fever (*Rickettsia parkeri*). Some of these tick-borne diseases—particularly Lyme disease and Rocky Mountain spotted fever—have long been associated with the northern and western US, and doctors in those areas are accustomed to diagnosing and screening patients for the pathogens. Many physicians in the southern US, however, are unaccustomed to diagnosing tick-borne diseases, so many cases of tick-borne diseases, such as Lyme disease, are undiagnosed and unreported in the region (Clark et al. 2014).

Small mammals, especially rodents, are the most important wild reservoir hosts of tick-borne diseases in the US (Mullen and Durden 2009). Rodent species, such as the white-footed mouse, deer mouse, meadow vole, and woodrat, are important hosts for the pathogens and important hosts for the tiny tick larvae—often called seed ticks—that transmit the pathogens. Seed ticks that feed on an infected wild animal can pick up pathogenic organisms from the animal’s blood. The blood-fed seed tick drops off the host animal and sheds its exoskeleton to grow to the next (larger) stage, called the “nymph”, another immature stage in the life cycle of ticks (Figure 10-4). As with mosquito-borne diseases, the pathogenic organism replicates in the body of the blood-fed vector tick. The next time the tick, now a nymph, bites an animal it has the potential of transmitting the pathogen to its new host, which could be a human, dog, deer, or other animal.

Nymphs are only about half the size of the adult tick (Figure 10-4), so they are more likely to be overlooked during tick checks than adult ticks. Since ticks usually need to be attached for more than 24 hours before infecting their host, the duration of tick attachment is an important factor determining risk of transmission. This is one reason that infected nymphal ticks are more dangerous to humans than adult ticks, which are larger and more easily found on the body.

**Concluding Thoughts**

Some vector-borne diseases such as dengue and West Nile virus are clearly associated with the “peri-domestic” landscape (Mullen and Durden 2009). This is primarily because mosquitoes that transmit these diseases, such as *Aedes aegypti* and *Culex quinquefasciatus*, proliferate in urban and suburban environments. The larvae of these mosquitoes are not found in swamps or ponds, but have adapted to man-made objects, such as unkempt birdbaths, discarded tires, old paint cans, flower pots, and other artifacts that can hold water and fallen leaves or other organic debris that are the food of the mosquito larva. Humans create larval habitat for the vectors of West Nile virus, dengue, and yellow fever, so these diseases are most common in populated areas. Many other serious vector-borne diseases, such as Eastern equine encephalitis and Lyme disease, are transmitted by vector species that do not prosper in populated areas, but instead thrive in wild habitats. As humans encroach upon, invade, and otherwise alter habitats where the vectors of arthropod-borne diseases are most abundant, we increase our risk of exposure to these pathogens (Weaver 2005).

Much research is still needed to fully document and understand the importance of vector-borne diseases in the greater Mobile-Tensaw River area. It is overwhelmingly likely that undiscovered vector-borne diseases are currently circulating in the wetlands of the region. Tensaw virus, for example, was discovered in this
hot spot of biodiversity, during studies investigating other mosquito-borne diseases. Advances in molecular biology and techniques for detection of novel pathogens will certainly yield new species of vector-borne pathogens. Studies that focus on the ecology of the potential vectors and reservoirs of these pathogens are needed to help better understand this unique aspect of the greater Mobile-Tensaw River area.
11. Freshwater Mollusks of the Greater Mobile-Tensaw River Area

Michael M. Gangloff, Appalachian State University

The freshwater mollusk fauna of the greater Mobile-Tensaw River area is among the least frequently collected mollusk assemblages in Alabama and the southeastern United States. The vast majority of mollusk habitats in this region occur within the principal rivers. Difficulties involved with sampling mollusks from these deep, swift rivers make them unforgiving places to conduct mollusk surveys (Figure 11-1). Since most mollusk habitats in these large rivers exist at depths that preclude effective hand or mask-and-snorkel sampling, much of our knowledge about this system's historical mollusk assemblages has been gleaned from dead shells collected on gravel bars or archeological middens.

During the past 20 years the region has received more attention from freshwater biologists employing scuba to survey mussel and snail populations in the deeper reaches of the lower Alabama, Mobile, and lower Tombigbee rivers, and from surveys of tributaries in Baldwin, Clarke, Mobile, Monroe, and Washington counties. Recent work has produced a more complete, if largely qualitative, picture of this region’s freshwater mollusk resources. This chapter describes the region’s likely historical assemblage structure, identifies the key freshwater mollusk populations in this system, and notes threats to those populations.

Geographical Scope

Mollusk habitats in the greater Mobile-Tensaw River area include the Alabama, Mobile, and Tombigbee rivers upstream to the confluences of Big Flat Creek with the Alabama River and Santa Bogue and Satilpa creeks with the Tombigbee River. The upstream boundaries of this reach coincide with the locations of the Claiborne and Coffeeville locks and dams on the Alabama and Tombigbee rivers, respectively (Williams et al. 2008). Major tributaries of the Alabama River in this reach include Big Flat, Halls, Holly, Limestone, Majors, Pigeon, Pine Log, Randons, Reedy, and Wallers creeks and Little River (Figure 11-2). Bassett, Bilbo, Jackson, Leatherleaf, Lewis, Limestone, Salt, Santa Bogue, Satilpa, and Tauler creeks are major tributaries to the Tombigbee River (Figures 11-3 through 11-6). The Alabama and Tombigbee rivers join east of Calvert, Alabama to form the Mobile River. The Mobile River is characterized by a wide floodplain interwoven with distributary or slough channels (Williams et al. 2008). Named distributary channels of the Mobile River include the Middle and Tensaw rivers.

Historical Surveys

Early freshwater mollusk biologists working in Alabama were dissuaded from working in much of the greater Mobile-Tensaw River area by the remote and inaccessible nature of its rivers. Much of what we know of the region’s mollusk fauna prior to the 1950s comes from specimens recovered from ancient Native
American middens, as well as from material collected by early workers including H. H. Smith and R. L. Howard from small streams (McGregor and Dumas 2010; Peacock et al. 2014; see Author’s Note). Archeological excavations near the salt springs in southern Clarke County, a historically important natural and economic resource from prehistoric times until fairly recently, revealed a long-standing Native American presence in the region. McGregor and Dumas (2010) documented a species-rich historical freshwater mussel fauna (19 species, including 4 taxa currently listed as threatened or endangered by the US Fish and Wildlife Service) in the lower Tombigbee River, near the confluence of Salt Creek in southern Clarke County. Interestingly, the majority of individuals in middens appear to be species that are numerically dominant in recent surveys (McGregor and Garner 2006; Peacock et al. 2014).

Between 1964 and 1976, Royal Sutkiss at Tulane University collected mussels from sites across the Alabama River drainage. These collections include material from 11 sites primarily in the lower Alabama River, as well as from the Tensaw River, the Big Flat and Bear Creek tributaries, and at least one oxbow lake (see Author’s Note). Other collections from this time period are sporadic, but together with archeological material provide a glimpse of the region’s pre-impoundment mollusk fauna.
Recent Surveys
The era of recent mollusk surveys in the lower Tombigbee and Alabama river drainages began in the 1980s with review of numerous freshwater mussel and snail taxa for protection under the Endangered Species Act. In 1989 the US Fish and Wildlife Service added the Heavy Pigtoe (*Pleurobema taitianum*), Southern Combshell (*Epioblasma penita*), and Stirrupshell (*Quadrula stapes*) mussels to the Endangered Species List (USFWS 1989). In 1990 the USFWS listed the Inflated Heelsplitter mussel (*Potaamilus inflatus*) as threatened, and in 1991 the recently rediscovered Tulotoma Snail (*Tulotoma magnifica*) was listed as endangered (USFWS 1990, 1991, 1993). These actions necessitated additional surveys for these taxa across their historical ranges in the Mobile Basin (Pierson 1991).

Initially, mollusk surveys in the lower Alabama River were conducted by USFWS and Alabama Department of Conservation and Natural Resources (ADCNR) personnel. But survey needs quickly exceeded existing personnel and fiscal resources, so biologists with other agencies, universities, utilities, and private stakeholders joined the effort. Following the rediscovery in 1982 of *Tulotoma magnifica* in the Coosa River near Wetumpka, Alabama Power Company and USFWS began surveys in shoal habitats in the Alabama, Cahaba, and Coosa rivers to assess remaining populations. These surveys later revealed that the distribution of *Tulotoma magnifica* populations extended downstream to the tailwaters of Claiborne Lock and Dam (USFWS 2011). Although no populations of Tulotoma Snail were found in the lower Alabama River downstream of Claiborne, these and other surveys during the 1980s and 1990s provide additional
data about freshwater mollusk assemblages in this reach (Pierson 1991; see Author’s Note).

During the last 25 years, freshwater mollusk surveys in the region have targeted tributaries of the lower Alabama and Tombigbee drainages (McGregor et al. 1999), and the lower main stem Alabama, Mobile, and Tombigbee rivers (Hartfield and Garner 1998; Miller 2000; McGregor and Garner 2006). Recent focused mussel surveys have examined portions of Big Flat (Gangloff et al. 2009) and Bassett creeks (Gangloff 2011), as well as streams on the Stimpson Wildlife Sanctuary in Clarke County, administered by Alabama Division of State Lands (Gangloff et al., unpublished data, unreferenced). These surveys were conducted in association with research on small dams (Gangloff et al. 2009, 2011), infrastructure maintenance (Gangloff 2011), and biodiversity inventories (see Author’s Note).

Mollusk Assemblage Structure

Because they occupy linear habitats (i.e., stream drainage networks), freshwater mollusk distributions are highly constrained and predictable. Water chemistry parameters, including dissolved oxygen, pH, and concentrations of Ca²⁺ and other cations, influence the shell building and waste excreting abilities of freshwater mollusks. Low pH and cation concentrations apparently exclude most native freshwater mollusks from blackwater streams draining poorly buffered strata (e.g., Citronelle Formation) in the southeastern quadrant of the greater Mobile-Tensaw River area. In contrast, larger streams draining portions of the Coastal Plain in northern Clarke and Monroe counties intersect limestone outcroppings, and are consequently well-buffered and hence more conducive to shell growth. Mussel assemblages typical of well-buffered Gulf Coastal tributary streams commonly include thin-shelled taxa (subfamily Lampsilinae) in the genera *Lampsilis* and *Villosa* spp.

Although unionid assemblages in large river systems in the Mobile Basin may share numerous species with tributary assemblages, heavy-shelled taxa (subfamily Ambleminae) are far more abundant in faster-water main channel habitats. Main channel habitats are dominated by species like *Elliptio crassidens*, *Plectomerus dombeyanus*, *Quadrula asperata*, and *Regenaia ebena*. In contrast, thinner-shelled taxa (subfamily Anodontinae) are generally the primary taxa found in off-channel slough and oxbow habitats (although the thick-shelled taxa *P. dombeyanus* and *Glebula rotundata* may also occur in these habitats) (Williams et al. 2008; Haag 2012).

Integrating results of recent surveys and studies of prehistoric middens reveals that as many as 74 species of freshwater pearly mussels (Bivalvia: Unioniformes: Unionidae and Margaritiferidae), clams (Sphaeriidae), and gastropods historically occurred in this portion of the Mobile Basin (Tables 11-1 and 11-2). This is a substantial portion of the approximately 65 freshwater mussel and 125+ gastropod taxa known from the Mobile Basin (Garner et al. 2004; Williams et al. 2008; Johnson et al. 2012).
Table 11-1. Systematic list of freshwater bivalve taxa collected, conservation status (S-Stable, FC-Federal species of Concern, FT-Federally Threatened, FE-Federally Endangered, I-Introduced, EX-Extinct, SC-Special concern, U-Unknown/non-assessed), and habitats occupied (B-Backwater/slough, M-Main stem Alabama, Mobile, and/or Tombigbee rivers, T-Tributaries) during historical (1900-1990) and recent (1990-2015) freshwater mollusk surveys in the greater Mobile-Tensaw River area (main stem Alabama, Mobile, and Tombigbee rivers and tributaries in Baldwin, Clarke, and Washington counties, Alabama). Taxonomy follows Turgeon et al. (1998), Williams et al. (2008), and Campbell and Lydeard (2012).

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Status</th>
<th>Habitat</th>
<th>Historical</th>
<th>Recent</th>
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<td>Cyprinidae</td>
<td><em>Corbicula fluminea</em></td>
<td>Asian Clam</td>
<td>I</td>
<td>B, M, T</td>
<td></td>
<td>X</td>
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<tr>
<td>Margaritiferidae</td>
<td><em>Margaritifera mariannae</em></td>
<td>Alabama Pearlshell</td>
<td>FE</td>
<td>T</td>
<td></td>
<td>X</td>
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<tr>
<td>Pisidiidae</td>
<td><em>Margaritifera mariannae</em></td>
<td>Alabama Pearlshell</td>
<td>FE</td>
<td>T</td>
<td></td>
<td>X</td>
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<td>Pegaciidae</td>
<td><em>Pegacia griffini</em></td>
<td>Griffini's Pearlshell</td>
<td>FT</td>
<td>M</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Paphuriidae</td>
<td><em>Paphurius galeatus</em></td>
<td>Galeatus' Pearlshell</td>
<td>FT</td>
<td>M</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Unionidae</td>
<td><em>Amblema plicata</em></td>
<td>Three-ribbed Pearlshell</td>
<td>FE</td>
<td>M</td>
<td></td>
<td>X</td>
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<tr>
<td>Cypridae</td>
<td><em>Cyprina parva</em></td>
<td>Small Pearlshell</td>
<td>SC</td>
<td>M</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Unionidae</td>
<td><em>Unio pictorum</em></td>
<td>Painted River Mollusk</td>
<td>FT</td>
<td>M, T</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Historical and Recent columns indicate presence during the specified time periods.
Table 11-1. Systematic list of freshwater bivalve taxa collected, conservation status (S-Stable, FC-Federal species of Concern, FT-Federally Threatened, FE-Federally Endangered, I-Introduced, EX-Extinct, SC-Special concern, U-Unknown/non-assessed), and habitats occupied (B-Backwater/slough, M-Main stem Alabama, Mobile, and/or Tombigbee rivers, T-Tributaries) during historical (1900-1990) and recent (1990-2015) freshwater mollusk surveys in the greater Mobile-Tensaw River area (main stem Alabama, Mobile, and Tombigbee rivers and tributaries in Baldwin, Clarke, and Washington counties, Alabama). Taxonomy follows Turgeon et al. (1998), Williams et al. (2008), and Campbell and Lydeard (2012), cont.

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Status</th>
<th>Habitat</th>
<th>Historical</th>
<th>Recent</th>
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<tr>
<td><strong>Unionidae, cont.</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Obovaria unicolor</td>
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<td>Alabama Hickorynut</td>
<td>S</td>
<td>M</td>
<td>X</td>
<td></td>
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<tr>
<td>Plectomerus dombeyanus</td>
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<td>Bankclimber</td>
<td>S</td>
<td>B, M</td>
<td>X</td>
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<td>Pleurobema perovatum</td>
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<td>Ovate Pigtoe</td>
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<td>Pyganodon grandis</td>
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<td>Giant Floater</td>
<td>S</td>
<td>B, M, T</td>
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<tr>
<td>Quadrula apiculata</td>
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<td>M</td>
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<td>Alabama Orb</td>
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<td>Pistolgrip</td>
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<td>Reginaia ebena</td>
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<td>Pondhorn</td>
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<td>Paper Pondshell</td>
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<td>Villosa lienosa</td>
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<td>Little Spectaclecase</td>
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<td>Villosa vibex</td>
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<td>Southern Rainbow</td>
<td>S</td>
<td>T</td>
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</table>

**Total Taxa** 52 38
Table 11-2. Systematic list of freshwater gastropod taxa collected, conservation status (S-Stable, V-Vulnerable, FC-Federal species of Concern, FT-Federally Threatened, FE-Federally Endangered, U-Unknown, E-Endangered), and habitats occupied (B-Backwater/slough, M-Main stem Alabama, Mobile, and/or Tombigbee rivers, T-Tributaries) during historical (1900-1990) and recent (1990-2015) freshwater mollusk surveys in the greater Mobile-Tensaw River area (main stem Alabama, Mobile, and Tombigbee rivers and tributaries in Baldwin, Clarke, and Washington counties, Alabama). Taxonomy and status rankings follow Johnson et al. (2013).

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific name</th>
<th>Common Name</th>
<th>Status</th>
<th>Habitat</th>
<th>Historical</th>
<th>Recent</th>
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<td>Amnicolidae</td>
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<td>Cochliopidae</td>
<td>Pseudotryonia grahamae</td>
<td>Salt Spring hydrobe</td>
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<td>T</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Hydrobiidae</td>
<td>Birgella subglobosus</td>
<td>Globe Siltsnail</td>
<td>S</td>
<td>M</td>
<td>X</td>
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<td>Tulotoma Snail</td>
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<tr>
<td></td>
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<td>Round Mysteysnail</td>
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<td>B</td>
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</tbody>
</table>

Total Taxa 21 10
Freshwater Bivalves

Freshwater bivalves comprise the majority of the freshwater mollusk species found in the greater Mobile-Tensaw River area. Freshwater pearly mussels (Order Unionoida) have the greatest number of species (50+ taxa), but have also likely experienced some of the most dramatic range shifts in this region. The other major group of freshwater bivalves, fingernail clams (Family Pisidiidae), is poorly known from this region, with few collections from Clarke, Mobile, and Washington counties.

Most recently, the region has been invaded by the Asian clam (*Corbicula fluminea*). Populations of this viviparous and highly tolerant bivalve are now found throughout the main stem lower Alabama River and many of its larger, permanent tributaries (McGregor et al. 1999; McGregor and Garner 2006). Estuarine bivalves, including members of the families Dreissenidae (*Mytilopsis leucophaeata*) and Rangidae (*Rangia cuneata*), occur in the lower reaches of the system in sections inundated by the salt wedge (Chadwick and Feminella 2001).

1) Cyrinidae

The freshwater bivalve family Cyrinidae has one representative in the study area, the introduced Asian Clam, *Corbicula fluminea*. This species was likely introduced deliberately from Asia into streams in the Pacific Northwest of North America in the early part of the 20th century. It has subsequently colonized much of North America, including much of the southeastern US. First collected from Alabama in the late 1960s, the species has become one of the more common and widespread bivalves in the region (Jenkinson 1979; see Author’s Note). Although numerous workers have speculated that Asian clams may impact native bivalves, there is little empirical evidence of competitive exclusion or other direct impacts.

2) Margaritiferidae

The freshwater bivalve family Margaritiferidae is represented in the study region by a single species, *Margaritifera marrianae* (*Alabama Pearlshell*), which occurs in small tributaries of the Alabama and Escambia rivers draining the Red Hills region of south Alabama (see Author’s Note). Populations are known from the Big Flat and Limestone creek watersheds. This species was added to the Endangered Species List by USFWS in 2012 (USFWS 2012a).

3) Pisidiidae

Fingernail clams (formerly Sphaeriidae) are very poorly surveyed throughout much of the southeastern US, and therefore their taxonomy, distribution, and ecological associations are poorly known. The 6 records of sphaeriid taxa from the greater Mobile-Tensaw River area were all collected during historical surveys (Table 11-1). There are no records of fingernail clams subsequent to 1970, but populations of most fingernail clam taxa likely remain extant in the region.

4) Unionidae

Historically the lower Alabama, Mobile, and lower Tombigbee rivers likely supported as many as 50 species of Unionidae. Although numerous species have apparently been extirpated from the lower Alabama and lower Tombigbee rivers as a result of hydropower and navigation projects, recent surveys suggest as many as 30 species remain extant in the main stem Alabama River and its tributaries (McGregor and Garner 2006; Gangloff et al. 2009). Unionid assemblages in the lower main stem Tombigbee River are somewhat less diverse, with populations of 20 taxa reported during recent surveys.

Surveys by Royal Sutkiss from 1964 to 1976 revealed specimens of 24 freshwater mussel taxa in the main stem Alabama River and in Big Flat Creek, including records for 2 species currently listed as federally threatened (*Hamiota perovalis* and *Medionidus acutissimus*) (Williams et al. 2008; see Author’s Note). Specimens of federally endangered *E. penita*, *Pleurobema decimus*, and *P. taitanum* have been reported from prehistoric middens near the Salt Creek saltworks, so presumably these taxa were once extant in the nearby Tombigbee River (McGregor and Dumas 2010). No recent collections of these taxa have been made from the study area and they are presumed to be locally extirpated.

Tributary freshwater mussel assemblages in the greater Mobile-Tensaw River area are typically quite different from assemblages found in river habitats, although some taxa—including *Lampsilis straminea*, *L. teres*, *Potamilus purpuratus*, and *Quadrula rumphiana*—commonly occur in both habitat types. In Big Flat and Bassett creeks, *Quadrula asperata*, *Lampsilis straminea*, and *Villosa lienosa* are among the more numerous taxa, although these systems support at least 15 other mussel species (Figure 11-7).
Impounded reaches of the Alabama and Tombigbee rivers support species-poor mussel assemblages comprised of species that are tolerant of the slower flows, softer substrates and lower dissolved oxygen concentrations that typify these altered habitats. Although many unionids common in impoundments are thin-shelled taxa (e.g., *Pyganodon grandis*, *Utterbackia imbecillis*), some heavy-shelled taxa including *Quadrula apiculata* and *Plectomerus dombeyanus* are also common in impounded habitats (Figures 11-8 and 11-9).

5) Estuarine Bivalves

Euryhaline bivalves (including *Mytilopsis leucophaeta*, *Polymesoda caroliniana*, and *Rangia cuneata*) are poorly sampled in the greater Mobile-Tensaw River area. They are likely present throughout the lower reaches of the Mobile River and its tributaries, though not reported to date in the Alabama or Tombigbee rivers. However, as sea levels continue to rise and the floodplain of the Mobile River subsides as a result of upstream (impoundment-driven) sediment capture, these taxa will likely become more common (and may replace unionids) in deeper, main channel habitats expected to experience the greatest degree of salt wedge intrusion.

Freshwater Gastropods

A total of 22 primarily freshwater gastropod taxa have been reported from the greater Mobile-Tensaw River area (Table 11-2). Of these, 21 taxa were documented during historical (pre-1995) surveys, whereas recent surveys have revealed populations of only 10 taxa. This discrepancy is likely due to so few recent surveys targeting freshwater gastropods in this region. More focused surveys will probably reveal that this region still harbors a substantial
portion of its native freshwater gastropod fauna and may help clarify taxonomic issues associated with several unresolved taxa.

1) **Pebble Snails (Amnicolidae, Cochliopidae, and Hydrobiidae)**

The greater Mobile-Tensaw River area has a surprisingly high diversity of hydrobiid snails, with representatives of 5 genera present. Of these, only *Pseudotryonia grahamae*, the endemic Salt Springs Hydrobe, appears to be a high conservation priority taxon (Table 11-2). However, specimens of *Amnicola* and *Somatogyrus* collected from the region have not yet been ascribed to any known taxon. Careful genetic and morphological studies are needed to resolve the taxonomic affinities of these populations.

2) **Pleuroceridae**

Compared to other parts of the Mobile Basin, the lower Alabama River area has relatively few pleurocerid species. *Elimia taitiana* appears to be the most widespread taxon in smaller tributary streams, including Limestone Creek (Figure 11-5). *Pleurocera vestitum*, a large silt-tolerant pleurocerid, occurs in slow-moving main channel and backwater habitats (Table 11-2). *Elimia olivula*, a species currently being considered for protection under the Endangered Species Act, occurs in the main stem Alabama River near Claiborne, as does *Leptoxis picta*, a federally endangered pleurocerid that occurs in the tailwaters of Claiborne Lock and Dam and few other places on earth (Garner et al. 2004; see Author’s Note).

3) **Viviparidae**

The *Tulotoma Snail* (*Tulotoma magnifica*), the only high-conservation priority viviparid snail extant in the greater Mobile-Tensaw River area, was initially described from material collected near Claiborne, Alabama. Presumed extinct until rediscovered in the Coosa River and several tributaries during the late 1980s, recent surveys detected a small population downstream of Claiborne Lock and Dam (Hershler et al. 1990; USFWS 2011). This discovery, along with detection of additional populations and evidence of population growth, led USFWS to downlist *T. magnifica* from endangered to threatened. Other viviparid taxa in the lower Alabama River are include *Campeloma limum* and *C. regularae* (see Author’s Note). The systematics and distribution of *Campeloma* spp. remain unclear and the genus needs genetic and morphological study.

4) **Pulmonate Snails (Lymnaeidae, Physidae, and Planorbidae)**

Pulmonate snails lack gills and respire via pallial lungs. This allows them to tolerate low dissolved oxygen habitats, including ponds, sloughs, and marshes. Because they are relatively tolerant of environmental conditions that would be lethal to gilled snails (e.g., *Elimia*, *Leptoxis*), few pulmonates are considered conservation priorities. However, there have been few recent collections of any members of these 3 families from the greater Mobile-Tensaw River area (see...
Author’s Note). Future researchers should make an effort to document their occurrence and collect specimens whenever possible.

**Current Status and Threats to Mollusk Resources**

Comparisons between recent and historical survey data, combined with insights from studies of shells in Native American middens, suggest that greater Mobile-Tensaw River area mussel (and likely snail) populations have changed over the past several centuries. Although much of this change is likely due to widespread impoundment and dredging of large river habitats, there is some evidence that the activities of Native Americans may have altered mussel assemblages well before the arrival of Europeans. For example, Peacock et al. (2005) reported noticeable changes to the composition of freshwater mussel assemblages in prehistoric middens, which they attributed to the advent of subsistence agriculture and possible changes in water quality.

Among many threats to native mollusk assemblages in the greater Mobile-Tensaw River drainage, the most pressing come from 3 sources. First, the construction, maintenance, and operation of large dams upstream in the Mobile Basin for navigation, flood control, and power generation are chronic stressors to main stem river and tributary mollusk populations (Williams et al. 1992; USFWS 2000; Williams et al. 2008). Water levels in the Alabama River downstream of Claiborne Lock and Dam fluctuate by as much as 3 m (10 ft) daily and these changes have dramatic effects on mollusk populations. Tributary confluences may be inundated by rising waters and then rapidly dewatered during power generation events. Additionally, impounded habitats are more likely to support populations of non-native unionids, like *Anodonta suborbiculata* and *Ligumia subrostrata*, and may facilitate the stepping-stone advance of these taxa into native habitats.

Second, land use at much finer scale including management of upland and riparian forests, exurban and infrastructure development, and the construction of small earthen impoundments in headwaters may affect mollusk habitats and populations. However, evidence that these factors are impacting freshwater mollusk populations is sparse and there have been no studies to the author’s knowledge that have quantified effects of land use on stream habitats or sensitive mollusk populations in this region of the Gulf Coastal Plain. Interestingly, recent surveys in Big Flat Creek, just downstream of Rikard’s Mill, revealed a species-rich mussel assemblage (Gangloff et al. 2009, 2011). This phenomenon appears to be relatively widespread in southeastern Coastal Plain and Piedmont streams and suggests that some structures (notably older historic dams) may counterintuitively improve unionid habitat in some streams (Gangloff 2013).

Third, long-term stressors, including the effects of climate change and sea level rise, may reduce the downstream limits of freshwater mollusk habitat in the lower Mobile Basin. Although the effects of climate change have been poorly studied in this system, their consequences for freshwater resources likely pose the single greatest threats to biodiversity in this sparsely developed region of Alabama.

Information gaps simultaneously represent the largest but most easily addressed threats to freshwater mollusk diversity in the greater Mobile-Tensaw River area. Numerous systematic questions need to be resolved, including determination of the taxonomic affinities of several gastropod and unionid taxa (see Author’s Note). Additionally, the US Fish and Wildlife Service is currently reviewing the need to protect several mollusk taxa found in the greater Mobile-Tensaw River area under the Endangered Species Act (Figure 11-10). Although the region’s larger streams have been well-covered by qualitative surveys (e.g., Hartfield and Garner 1998; McGregor and Garner 2006), smaller streams have been far less extensively surveyed and many streams or localities have only been surveyed once during the past 45 years. It seems reasonable to assume that numerous additional populations and taxa remain undiscovered in the greater Mobile-Tensaw River area. Moreover, there have been few attempts to use quantitative or occupancy-based surveys to understand how local or landscape-scale habitat parameters influence the diverse array of freshwater mollusk assemblages present in the greater Mobile-Tensaw River area. Finally, establishment of permanent monitoring sites, both in high diversity mollusk habitats and in systems that support unique taxa (e.g., *Pseudotryonia grahamei*), to assess temporal changes to population and assemblage structure will help ensure the persistence of this region’s unique mollusk resources.
Author’s Note
Museum records for freshwater mollusks collected from localities within the greater Mobile-Tensaw River area, as described in this chapter, can be found in DOI: 10.13140/RG.2.1.1931.6241 at the author’s page on the ResearchGate website (https://www.researchgate.net/profile/Michael_Gangloff/contributions). The author gratefully acknowledges the museums involved: the Auburn University Natural History Learning Center and Museum, the Mississippi Museum of Natural Sciences, and the Florida Museum of Natural History at the University of Florida.

Figure 11-10. Anodontoides radiatus from a tributary of the Alabama River in Wilcox County. This species occurs in small, sandy streams on the Coastal Plain from the Mississippi Drainage east to the Apalachicola Drainage in Florida and is currently being considered for federal protection by the US Fish and Wildlife Service. (Photo credit: Michael M. Gangloff, Appalachian State University.)
12. Crustaceans

James A. Stoeckel and Brian S. Helms, Auburn University

This chapter reviews the current status of crustaceans in the greater Mobile-Tensaw River area, drivers and stressors impacting them, and key stewardship needs.

Current Knowledge—Natural, Cultural, and Economic Importance

The lower Alabama River, lower Tombigbee River, and Mobile-Tensaw Delta host a diverse assemblage of freshwater crustaceans notable for their ecological and economic importance. In the freshwater, non-tidal portions of the system, the crustacean macro-invertebrate fauna is dominated by crayfish. As tidal influences and salinity increase in the Mobile-Tensaw Delta, fiddler crabs gradually replace crayfish as the dominant, semi-terrestrial burrowing crustacean and Blue Crabs (Callinectes sapidus) replace crayfish as the dominant aquatic crustacean. Finally, as the Mobile-Tensaw Delta empties into Mobile Bay, a wide range of crabs, prawns, and shrimps depend on estuaries as critical habitat for various life history stages.

1) Crayfish

Global crayfish diversity peaks in North America with over 350 species (Taylor et al. 2007). Within North America, Alabama has the highest number of crayfish species of any state or province (86 species, plus several undescribed forms), presumably due to geologic diversity and isolation of major drainage basins (Ortmann 1905, 1931; Hobbs 1969; Schuster et al. 2008; Smith et al. 2011). Crayfishes are found in a range of aquatic and terrestrial habitats, including streams, lakes, wetlands, and terrestrial burrows. They play instrumental roles in community dynamics, with strong effects on other organisms, and can influence ecological function via herbivory, predation, organic matter breakdown, and sediment processing (Creed 1994; Lodge et al. 1994; Momot 1995; Charlebois and Lamberti 1996; Usio 2000; Helms and Creed 2005; Twardochleb et al. 2013).

In the Mobile-Tensaw Delta, 6 genera are represented by 34 species (Table 12-1, Figure 12-1). Procambarus is the most diverse genus with 17 species. Procambarus spp. in the greater Mobile-Tensaw River area often inhabit slow-moving surface waters, including ditches, swamps, and sluggish streams, and can be locally abundant (Penn 1956; Smith et al. 2011). Several species are largely confined to the lower Alabama (P. bivittatus, P. clemmeri, P. evermanni, P. lagniappe, P. lecontei, P. penni, and P. shermani).

Many crayfish found in the Mobile-Tensaw Delta show moderate to strong propensity for burrowing, including all 5 species of Cambarus. Fallicambarus is also highly adapted to a subterranean existence, with a vaulted carapace, spatula-like legs, and reduced eyes, antennae, and abdomen. While the Cambarus species can be found in a wide range of habitats, the 3 species of Fallicambarus found in the Mobile-Tensaw Delta are often associated with pitcher-plant bogs, pine flatwoods, swamps, and seepage areas of tributaries (Fitzpatrick 1987; Graydon 2009).

Some of the more intriguing crayfishes are the dwarf crayfishes represented by species in the genus Cambarellus. The 3 species found in the Delta are generally rare with highly restricted distributions inhabiting oxbow lakes, heavily vegetated pools, ditches, and other sluggish aquatic habitats (Stites et al. 2014). These animals are particularly small, with the Least Crayfish being one of the smallest crayfishes in North America (less than 25 mm [1 in] as adult). Nearly nothing is known about their biology.

Crayfishes also have a rich cultural and culinary history in Alabama. The Red Swamp Crawfish (Procambarus clarkii) and the White River Crawfish (P. zonangulus) are the 2 primary species cultured for consumption (Smith et al. 2011). Although the native range of both species is unclear, it is generally agreed that P. clarkii is native to at least far southern Alabama, potentially north to the Fall Line. As of 2012, there were 12 commercial farms in Alabama, producing slightly over $2.3 million in sales (USDA 2014). Average Alabama farm yields are around 1000 pounds per acre (0.1 kg/m²) (Masser et al. 1997). Crawfish farms are often rice-crayfish-soybean polycultures, with crayfish inhabiting rice fields that are gradually flooded during the warm spring months (Walls 2009).
Table 12-1. Crayfish found in the Mobile-Tensaw Delta (MD), lower Alabama River (AL), Lower Tombigbee (LT), and adjacent local watersheds. “AFS Status” is conservation status as assessed by the American Fisheries Society (Taylor et al. 2007) and “AL Priority” is conservation priority assigned by the Alabama Department of Conservation and Natural Resources.

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<th>Common Name</th>
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<th>LT</th>
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<td>Procambarus vioscai paynei</td>
<td>Payne's Creek Crayfish</td>
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Animals are harvested from December through June (Masser et al. 1997).

2) Crabs
Several species of fiddler crab are found in the Mobile Tensaw Delta. All are semi-terrestrial and breathe air. Some like *Uca minax* (Red Jointed Fiddler Crab) are found in freshwater and low salinity tidal marshes, whereas others like *U. longisignalis* (Gulf Mud Fiddler Crab) prefer moderate to high salinity habitats beyond the Delta. Males are easily recognized by an enlarged claw, which they wave back and forth to entice females into a nearby burrow for mating. Though not valued as a food item by humans, they are eagerly consumed by fishes, birds, and small mammals. Fiddlers also play an important role as ecosystem engineers, modifying their physical habitat through burrowing and feeding activities. Burrows are constructed for shelter, protection from predators, and reproduction. In large fiddler crab colonies, burrow density can reach 300/m² (28/ft²), resulting in 120 to 160 cm³ of sediment/m² (0.7 to 0.9 inch³ of sediment/ft²) excavated per day, thoroughly mixing the top 8 to 15 cm (3 to 6 inch) of sediment (McCraith et al. 2003). Burrowing activity can strongly influence transfer of energy and nutrients in marshlands, bringing increased organic material to the surface and fostering growth of marsh grasses, while speeding decomposition of plant material via stimulation of microbial communities (Katz 1980; Montague 1980; Daiber 1982; Bertness 1985).

Blue Crabs (*Callinectes sapidus*) are also found in low to high salinity habitats but, unlike fiddler crabs, live primarily in water. Blue Crabs of both sexes are eagerly sought by commercial

and recreational fishermen. In Alabama, annual harvest increased from less than 1 million pounds (0.45 million kg) before 1940 to a peak of 4.2 million lb (1.9 million kg) in 1984, before decreasing to an average of 2 million lb (0.9 million kg) per year—with a dockside value approximately $2 million—since 2000 (VanderKooy 2013; Audubon Nature Institute [date unknown]).

3) Shrimp
The young of many marine crustaceans are also found in the low salinity, estuarine habitats of the Delta and upper Mobile Bay. Shrimp are of particular importance, with the Brown Shrimp (Penaeus aztecus) designated as Official State Crustacean of Alabama in March 2015. Brown Shrimp, White Shrimp (P. setiferous), and Pink Shrimp (P. duorarum) are all harvested by the Alabama shrimp fleet. The Alabama shrimp fishery began in the early 1900s and peaked in the 1980s with an estimated 2000 commercial shrimp licenses issued. Commercial shrimping remains a valuable industry with 17.7 million lb (8 million kg) landed in 2014 (dockside value greater than $57 million). Recreational shrimping is also a popular hobby and family tradition with greater than 1000 recreational fishing licenses issued to Alabama citizens every year (Alabama Gulf Seafood 2015).

Key Drivers and Stressors
Due in part to their complex life cycles, crustaceans in the greater Mobile-Tensaw River area are affected by many environmental drivers and stressors, which we review here.

1) Connectivity
One of the most important factors impacting crustaceans is status of habitat connectivity (Pringle 2003). A lack of connectivity (i.e., habitat fragmentation) is considered one of the leading causes of global species loss (Fischer and Lindenmayer 2007), particularly when associated with limited resource use or restricted gene flow (Fahrig 2003; Omerod 2003). Many species of crayfish, particularly endemic species, may have low dispersal rates, which increases their susceptibility to loss of connectivity (Bubb et al. 2006; Helms et al. 2015). Connectivity between favorable habitat patches is essential for population persistence (Figure 12-2). Discontinuities such as culverts, road crossings, and dams either physically restrict movement of individuals or create vast areas of inhospitable habitat, both of which can isolate populations, with detrimental effects (Hartfield 2010; Adams 2013; Foster and Keller 2011). Further, connectivity between terrestrial and aquatic habitats is critical for many burrowing crayfish species. For C. diogenes, a species that moves between open water and terrestrial

Figure 12-2. Connectivity between aquatic and semi-terrestrial habitats is critical for crayfishes. Many species burrow exclusively in terrestrial environments, either in floodplains (A) or isolated wetlands (B). These primary burrowers rely on subsurface groundwater and move from subterranean to terrestrial habitats and to some degree from terrestrial to surface water habitats depending on species and life stage. Some species burrow in close proximity to surface water (C), often with direct connections to surface water. These secondary burrowers can freely move between terrestrial, subterranean, and surface water habitats. Other species spend their entire life cycle in surface water (D). Thus, maintaining hydrologic connectivity and protecting isolated wetlands is a fundamental component to successful crayfish conservation.
burrows, decreased crayfish burrow abundance in terrestrial floodplains is associated with increased stream incision (Helms et al. 2013). For other burrowers, particularly those that inhabit bogs, wet meadows, and swamps (e.g., *Fullicambarus* species), draining of wet fields and similar environs is a major threat (Graydon 2009; Stites et al. 2014), as these activities lower the local water table and increase the prevalence of inhospitable habitats.

For other crustacean taxa, critical connectivity occurs at the interfaces between fresh, brackish, and saltwater habitats. A little known crustacean group, formerly abundant in the Gulf of Mexico coastal drainages, is the freshwater prawn or River Shrimp (*Paleomonidae, Macrobrachium* spp.). Six species are known from the US, all dependent on freshwater-brackish connections. *Macrobrachium ohione* (Ohio Shrimp, Figure 12-3), once supported a valuable US fishery as late as the 1930s (Mermilliod 1976; Bowles et al 2000), but numbers have since plummeted, presumably due to damming of large river systems and loss of connectivity with brackish estuaries. River Shrimp adults live in freshwater, but females must migrate downstream to deliver larvae that require saline habitats for proper development (Oliver and Bauer 2011; Oliver et al. 2012). Juveniles then migrate upstream to freshwater habitats (Figure 12-4), but this migration may be impeded by dams (Olivier et al. 2013). Still present in the lower Mississippi and Atchafalaya river systems of Louisiana, Ohio Shrimp were reported from the Alabama River as late as 1971 (Bowles et al. 2000), but are now extremely rare or absent from the Mobile-Tensaw Delta.

Marine shrimp (*Penaeidae, Penaeus* spp.) are dependent on saltwater-brackish connections (Figure 12-4). Mating, spawning, and development of early planktonic larval stages occur in offshore marine habitat. Post-larvae utilize shoreward currents and a combination of light and salinity cues to migrate to brackish estuaries that serve as vital nursery areas of all 3 species. Brown Shrimp post-larvae typically migrate to estuaries in the spring, White Shrimp in the summer, and Pink Shrimp in the winter. Growth and survival of post-larval shrimp are severely limited if they fail to reach estuarine nurseries. Once in the nurseries, post-larvae metamorphose into the juvenile stage, which feed and grow in the estuaries. Late-stage juveniles then migrate back to the open ocean to complete their life cycle (Matthews et al. 1991; Howe et al. 1999). Availability of high quality estuarine habitat and strong connectivity between Mobile Bay estuaries and the Gulf are vital for maintaining healthy populations of these highly valued species.

Blue Crabs and fiddler crabs are also dependent on connectivity between Mobile Bay estuaries and offshore marine environments (Figure 12-4). Blue Crab females migrate out of brackish estuaries and into high salinity offshore waters to hatch their eggs. Upon hatching, the free swimming zoea (larvae) feed in offshore water before metamorphosing into megalopae and migrating back to estuaries, where they settle out and metamorphose into juveniles. Settlement in Mobile Bay occurs from June through November, peaking from July through mid-October (Morgan et al. 1996). Males typically spend their entire juvenile and adult lives in estuaries, while adult females will migrate back to offshore waters (VanderKooij 2013). Fiddler crab females are triggered by a combination of tide and moon phase to migrate from estuaries to nearshore areas where their eggs hatch. The resultant planktonic larvae migrate to high salinity offshore waters and then back to estuaries, where, similar to Blue Crab, the megalopae stage settles and

Figure 12-3. Ohio Shrimp (*Macrobrachium ohione*) male (left) and female (right). This species is now rare to absent in the Mobile-Tensaw Delta. (Photo credit: Ray Bauer.)
metamorphoses into juvenile crabs in brackish water estuaries.

2) Habitat Type

Crayfishes in general depend on a variety of habitat types, ranging from gravel, cobble, and boulder to sand and detritus substrates. Many crayfishes in the greater Mobile-Tensaw River area are associated with sandy stream bottoms. For example, the Lagniappe Crayfish (P. lagniappe), appears to require cool water flowing over firm sand substrates, a habitat preference shared with some other Procambarus and all the Orconectes species in the area (McGregor et al. 1999). Also of particular importance in the Mobile-Tensaw Delta is the presence of submerged woody debris and aquatic vegetation that crayfishes use for spawning, feeding, and refuge. The importance of such habitat is evident in the preponderance of species (e.g., many Procambarus spp., Cambarellus spp.) generally found in slow streams, vegetated sloughs, vernal pools, and even roadside ditches (Hobbs 1981; Walls 2009). Depletion of aquatic vegetation and woody debris can drastically affect crayfish populations (Taylor et al. 2007). Similarly, vegetated brackish habitats, such as marshes and areas containing submerged aquatic vegetation, are very important for young-of-year crab and shrimp (Orth and van Montfrans 1990; Heck et al. 2001; Rozas et al. 2013).

3) Sedimentation

One of the more pervasive threats to freshwater crayfishes is sedimentation from sources such as land clearing, road runoff, and new construction. About 15% of stream miles assessed in the US are considered threatened or impaired by suspended sediments (USEPA 2013). Sedimentation can increase emigration, clog gills, reduce growth, and alter the interactions of aquatic organisms, as well as bury critical habitats (Newcombe and MacDonald 1991; Wood and Armitage 1997). Fortunately, none of the watersheds in the lower Alabama and Tombigbee rivers and Mobile-Tensaw Delta are listed by the US Environmental Protection Agency (USEPA) as significantly impaired from sediment (USEPA 2015).

4) Dissolved Oxygen

As evidenced by their preferred habitats and known natural history, the crayfish inhabiting the Mobile-Tensaw Delta generally are relatively tolerant of low dissolved oxygen. Sensitivity to low dissolved oxygen is...
species specific, with lower-lethal limits ranging from 0.4 to 2.6 mg/L (0.4 to 2.6 parts per million) depending on the species. Distributions are typically driven by sublethal concentrations that are much higher than lower-lethal concentrations (Nyström 2002). Since many of the lowland streams in the Mobile-Tensaw Delta naturally have low dissolved oxygen, the animals inhabiting these systems have adapted to these conditions. In fact, crayfish can respire out of water as long as their gills—which do not collapse in open air like those of most aquatic animals—retain some moisture (McMahon 2001). If aquatic dissolved oxygen concentrations fall below certain thresholds, many species (e.g., *P. clarkii*) will climb to the surface via woody debris or banks, perching sideways to take advantage of atmospheric oxygen (Nyström 2002).

Blue Crabs and shrimp are highly mobile and typically move out of an area when dissolved oxygen levels decline to dangerous levels. This phenomenon, long recognized in Mobile Bay (Loesch 1960; May 1973; Tatum 1982), is termed a “jubilee,” as large numbers of crabs and shrimp migrate to the shores to escape low-oxygen water. Jubilees attract large crowds of people and result in popular celebrations in Mobile Bay (e.g., see City of Fairhope [date unknown]). However, low dissolved oxygen concentrations can occasionally result in massive mortality, especially if crabs are trapped in cages when the events occur (May 1973; VanderKooy 2013). Fiddler crab adults are primarily terrestrial, breathing air from the atmosphere, and thus are less affected by dissolved oxygen than Blue Crabs and shrimp.

5) Temperature and Salinity
Thermal tolerance of Blue Crabs is dependent on salinity, with crabs becoming less tolerant of temperature extremes as salinity decreases (Tagatz 1969; Holland 1971; for summary, see Perry and VanderKooy 2015). The optimal range for Blue Crabs has been estimated at 0 to 27 parts per thousand salinity and 10 to 35°C (50 to 95°F) (Copeland and Bechtel 1974).

6) Freshwater Inflow
Freshwater inflow appears to be the most important driver of Blue Crab population dynamics in most, if not all, of the northern Gulf of Mexico watersheds, including the greater Mobile-Tensaw River area (VanderKooy 2013). Both juvenile abundance and commercial landings of adults tend to be high in wet years, but decrease in dry years.

7) Chemical Pollutants
Crustaceans are susceptible to a range of metals, plasticizers, herbicides, and pesticides (Krebs et al. 1974; Millikin and Williams 1984; Oehlmann et al. 2009), with metal toxicity frequently increasing with decreasing salinity (Hall and Anderson 1995). Non-lethal effects of metals (e.g., copper) and herbicides (e.g., metolachlor) on crustaceans include reduced chemosensory function and subsequent fitness (Wolf and Moore 2002; Olsen 2011; Blinova and Cherkashin 2012). Because they are important food items for various predators (Grimes et al. 1989), crustaceans can accumulate and transfer toxins such as PCBs (polychlorinated biphenyls) from contaminated sediments to aquatic, terrestrial, and avian food webs.

Oil and natural gas pollution comes from a combination of natural seeps (Farrington and McDowell 2013), localized oil spills, and large industrial accidents such as the Deepwater Horizon spill in 2010. Although coastal oil spills garner significant publicity, recent evidence suggests that the major proportion of petroleum spills occur inland (Yoshioka and Carpenter 2002). With increasing demand for petroleum, as well as new and existing pipelines in Alabama, inland oil pollution is potentially a concern for crustaceans living in the freshwater/riverine portions of the Mobile-Tensaw Delta. Crude oil and biodiesel chemicals are sensory pollutants to crayfish that bind and otherwise damage chemoreceptors, thus decreasing their ability to forage, mate, and avoid predators (Jurcak et al. 2015). Oil pollution is also a potential problem for life stages of other crustacean species that are dependent on estuarine and saltwater portions of Mobile Bay. Oil can have a variety of negative effects ranging from physical clogging and morphological damage to gills (Perry and VanderKooy 2015) to decreased survival and reproductive effects (Anderson 2010). Planktonic crab larvae drifting near the surface are particularly susceptible to hydrocarbon pollutants due to photo-induced toxicity. When exposed to polycyclic hydrocarbons in the presence of solar ultraviolet radiation, planktonic crab larvae exhibit much higher mortality than when exposed in the absence of ultraviolet radiation (Peachey 2005; Alloy et al. 2015). Burrowing crustaceans may be affected by oil residues buried beneath salt marsh sediments decades after a spill (Culbertson et al. 2007).
Resource Conservation Implications

For many of the crayfish in the greater Mobile-Tensaw River area, there is a general lack of species-specific life history, distribution, habitat requirements, and other ecological information. Thus hindered, management recommendations are often not targeted, but instead are based on generalities or incomplete data. Additional survey and taxonomic work is also needed for many crayfish taxa. For burrowing species, particularly *Fallicambarus* species, maintenance of the native vegetation structure and hydrologic regime of coastal plain swamps, wetlands, and pitcher plant bogs is critical, including the use of prescribed fire. Once critical biological and distributional limits are recognized for all pertinent species, better informed guidelines can be implemented for resource conservation.

The protection and maintenance of natural flows, seasonally flooded areas, groundwater fluctuations, and general hydrologic connectivity are of considerable importance to the conservation of crustaceans in the greater Mobile-Tensaw River area. This is pertinent in terms of future construction of dams, impoundments, road crossings, and bridges (e.g., Rozas et al. 2013). Maintenance of salinity gradients is also paramount. Alterations in freshwater inflow/saltwater intrusion patterns, as a result of water withdrawal for agricultural and industrial uses and global climate change, can potentially have devastating effects. Large groundwater withdrawals have been reported in the coastal zones of Baldwin and Mobile counties (Twilley et al. 2001). Such changes in supply, coupled with changes in rainfall patterns (e.g., drought), are viewed as a major threat to the sustainability of the Blue Crab fishery of Alabama (Perry and VanderKooy 2015).

Most people are generally familiar with crabs, shrimp, and crayfish. However, many are shocked to learn that there is more than one “type” of each of these animals, and even more surprised upon learning about the levels of Alabama’s aquatic biodiversity. Public knowledge of the natural heritage associated with our native crustaceans is critical to their conservation. Conveying the ecological, commercial, and cultural value of these animals is the essential first step towards effective management and conservation.
This chapter describes the fishes of the greater Mobile-Tensaw River area, including the diverse habitats available, impacts of salinity to species makeup, threats to fish diversity and populations, and resource conservation implications.

**The Landscape for Fishes**
Aquatic habitats in the greater Mobile-Tensaw River area (hereafter “the Delta”) are diverse and complex, ranging from large-riverine habitat upstream, to complex braided river channel, bayou, creek, and marsh habitat downstream. Approximately 10 km (6 mi) below the confluence of the Alabama and Tombigbee rivers, the Mobile River divides into two main channels, the Mobile River and the Tensaw River. Between them are the braided streams, swamps, marshes, and lakes of the Delta (Figure 13-1). The upper Delta is dominated by vegetation typical of lower coastal plain swamps (Figures 13-2, 13-3). Submerged vegetation—important as fish habitat—is dynamic, and density and coverage can vary widely through time.

Backwater areas can have highly variable productivity and physical/chemical conditions, such as low dissolved oxygen and low pH, which can be stressful to fishes. Water chemistry and clarity in the main channels are strongly influenced by river discharge, limiting growth and development of submerged vegetation. Further downstream in the lower Delta, terrestrial and marsh vegetation shift to grasses, sedges, and shrubs (Figures 13-4 and 13-5). Aquatic plants are a mixture of native
species, such as American eelgrass and widgeongrass, and non-native invasive species such as Eurasian watermilfoil, hydrilla, water hyacinth, and common salvinia (Table 13-1). This complex vegetative mosaic, as well as physical/chemical characteristics of the water (e.g., depth, flow, clarity, pH, dissolved oxygen), supports the diversity of fishes in the Delta.

**Fishes in the Greater Mobile-Tensaw River Area**

The Alabama River drainage reportedly supports 184 native fishes, including 33 endemics (Boschung and Mayden 2004; Freeman et al. 2005). While the overall biota of the Delta has been relatively less studied than other large river systems (McCreadie et al. 2005), several studies of its fish assemblages do exist, most notably two recent books on the fishes of Alabama (Mettee et al. 1996; Boschung and Mayden 2004). According to Mettee et al. (1996), the Delta and freshwater tributaries to Mobile Bay contain 131 species, 30 of which are marine. While marine species may be restricted to estuarine areas for much of the year, they can make large-scale movements into freshwater; similarly, freshwater species can make large-scale movements into water with higher salinities. Clearly, this area possesses an extremely diverse and dynamic fish species assemblage (Table 13-1).

Fishes of the Delta can be broadly classified into 3 groups, as described below: freshwater and estuarine species, marine migrants, and anadromous and catadromous species.

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*Figure 13-3. Cypress root habitat—a lowland swamp and marsh habitat. Note the high water marks on the cypress trunks. During high water events, this lowland forest is flooded, creating important habitat for many aquatic species. (Photo credit: Dennis DeVries and Russell Wright).*

*Figure 13-4. Lower delta habitat—extensive shallow water marshes with both emergent and submersed vegetation are the primary habitat type in the lower Delta just above the causeway, at the head of Mobile Bay. (Photo credit: Dennis DeVries and Russell Wright).*
1) Freshwater and Estuarine Species

Freshwater fishes, those found in inland freshwater systems, are resident throughout the Delta. The particular species of freshwater fish present in an area varies with ambient salinity levels and specific habitat. Species with low tolerance to elevated salinity (e.g., minnows) are limited to strictly freshwater areas, whereas those with broad salinity tolerance (e.g., many of the *Lepomis* sunfishes) can be found throughout the region. Similarly, tolerance to reduced dissolved oxygen can provide an advantage for species in backwater or isolated water habitats that often experience oxygen depression. Fishes such as bowfin and gars (*Lepisosteidae*) that are capable of aerial breathing are common in backwaters. Large-river species such as paddlefish, Alabama sturgeon, southeastern blue sucker, smallmouth buffalo, blue catfish, and flathead catfish inhabit the main channels, as well as the reservoirs and oxbows of the river and Delta. Some of these fishes undertake extensive spawning and feeding migrations within the river and Delta systems. For example, paddlefish tend to migrate to the oxbows of the river and backwaters of the Delta as feeding habitat in summer, to Mobile Bay in the winter, and back up the river in the spring to spawn (Mettee et al. 2009). Construction of dams on the lower Alabama and lower Tombigbee rivers has altered critical habitat and blocked migration routes, changes that have contributed to decline of some large-river forms and imperilment of the Alabama sturgeon (*Parauka* 2004) (Figure 13-6).
Of the freshwater fishes native to the Delta, large-mouth bass is the most extensively studied. Large-mouth bass are native to eastern North American freshwater systems from southern Canada to northern Mexico (Figure 13-7). Populations are common in oligohaline portions of estuaries throughout the northern Gulf of Mexico and along the Atlantic Coast from Florida to Massachusetts. Largemouth bass are among the warmwater game-fish species most sought after by US freshwater anglers (US Department of the Interior, US Fish and Wildlife Service, and US Department of Commerce, US Census Bureau 2011). This freshwater species is common in the reservoirs of the lower Alabama River, and also abundant throughout the Delta. Largemouth bass beyond the early fry stage can tolerate salinity over 10 part per thousand (ppt), while eggs and larvae are killed by salinity exceeding 4 ppt (Tebo and McCoy 1964). Since salinity rarely exceeds 4 ppt in the Delta during the spring spawning season, juvenile largemouth can recruit past this vulnerable stage except during periods of extreme drought, when salinity can exceed 4 ppt.

Largemouth bass in the lower Delta exhibit adaptations to life in this environment. Rather than growing as large as those in strictly freshwater environments, Delta largemouth bass tend to store high amounts of fat, consistent with a strategy to withstand periods of high salinity and temperature during late summer (Glover et al. 2013). Estuarine resident fishes include primarily small-bodied species, such as killifishes (Fundulidae) and silversides, well adapted to withstand the extremes of living at the edge of marshes where the physical/chemical environment can vary dramatically.

2) Marine Migrants

Marine migrants include species that use the estuary primarily as a nursery area and species that move in
and out of the Delta to feed on abundant prey as salinity varies seasonally. Species such as southern flounder, spot, and Gulf menhaden spawn in coastal marine waters and their eggs and larvae are carried into the estuary (Figure 13-8). Juveniles may spend months to a few years in the estuaries before migrating out to the bays and near coastal waters. These larval and juvenile fishes colonize the entire lower Delta, often thriving in waters with no measurable salinity. Other marine migrants only move into the Delta and up the Mobile River when salinity peaks during late summer. Movement of spotted seatrout and red drum into the Delta support active fisheries (Figure 13-9).

Other fishes may be found many kilometers upstream, including Atlantic needlefish, striped mullet, and several species of sharks and rays. In fact, prior to construction of dams on the lower Alabama River, striped mullet were common in the Cahaba River where they contributed to local harvest and recreational fishing (Boschung and Mayden 2004).

3) Anadromous and Catadromous Species

The 3rd group of fishes that inhabits this diverse ecosystem comprises the anadromous and catadromous species. Alabama shad, Gulf sturgeon, and striped bass are examples of anadromous species that migrate up the river to spawn. The only catadromous species is the American freshwater eel, which spends the majority of its life in freshwater and migrates to the ocean to spawn. All of these highly migratory fishes have experienced population declines in the Mobile drainage since construction of dams on the lower Alabama and lower Tombigbee rivers.

Figure 13-7. Large largemouth bass—this example of a largemouth bass from the Mobile-Tensaw Delta weighs more than 2.3 kg (5 lb). Largemouth bass support a tremendous recreational fishery, but rarely reach this size in the Delta. (Photo credit: Dennis DeVries and Russell Wright).

Figure 13-8. Southern flounder—collected in the Delta. This species has a complex life history. Spawning in offshore coastal waters, their eggs and larvae are then carried into the coastal estuary. Juveniles can live in very low salinities and will remain in the estuary for months to years. (Photo credit: Dennis DeVries and Russell Wright).
Salinity

The Delta’s diversity of fish species is due in large part to the mixing in this area of freshwater, estuarine, and marine habitats. Whereas species in inland lakes are restricted to freshwater, and species in the open gulf or ocean are restricted to high salinity, fishes in the Delta can choose from a variety of salinities and a variety of habitats, both of which can vary seasonally and across years.

The mixing of marine and fresh water in the Delta creates a system that is spatially and temporally dynamic with respect to salinity. Salt concentration is a critical factor limiting survival and growth of fishes. In spatial terms, salinity levels tend to be highest in downstream areas closest to Mobile Bay; however, salinity also tends to be elevated further north on the west (Mobile River) side of the Delta due to the clockwise gyre of water flow in Mobile Bay, an effect compounded by the deepened and maintained shipping channel. Because salt water is denser than fresh water, salinity also tends to be greater at depth, forming saline wedges along the bottom that move northward counter to the flow of the river. Salinity also exhibits strong seasonal variations. As river discharge decreases during late summer, salinity in the lower Delta increases. Elevated salinity can limit distributions of freshwater species, as the concentration exceeds their physiological tolerances, while allowing marine species to move further inland.

Threats to Fishes in the Lower Alabama River and Mobile-Tensaw River Delta

The Delta faces a number of threats that directly influence the diversity of fishes found there. Increasing human population is a key factor that simultaneously influences many other effects. Between 1990 and 2007, Baldwin County experienced a 75% increase in its population; in Mobile County there was a 7% increase. These rates of increase are likely to continue through at least 2025 (Mobile Bay National Estuary Program 2008).

1) Human Development and Habitat Loss

Development associated with human population increase poses substantial threats to fish populations. Although occurring nearly 100 years ago, construction in 1926 to 1927 of a causeway across the downstream end of the Delta, at the northern end of Mobile Bay, has had a variety of impacts on the Delta, some only recently identified. Most obvious is altered water flow and altered water connectivity between the Delta and Mobile Bay. Rather than flowing as a sheet between the two as in the past, water is now funneled through four 400-m (1300-ft) wide culverts, which has altered energy and nutrient transfer between these areas (Goecker et al. 2009) and possibly led to increased sedimentation north of the causeway (Valentine et al. 2004; Valentine and Sklenar 2006; see also Isphording et al. 1996 for an alternative perspective). A further implication of this reduced connectivity is the potentially reduced nursery function of the Delta (Rozas et al. 2013). Given the amount of time the causeway has been in place, fishes have clearly adapted to its presence. But it is important to be aware of these effects, particularly as human population density and development continue to increase.

Another impact of increased human development is change in land use and land cover in and surrounding the Delta (Ellis et al. 2011). Among many changes in land cover through time, impervious surfaces have
increased, natural habitats lost or degraded, and forests reduced.

Additional habitat losses have taken place in riverine reaches upstream of the Delta due to dredging and relocation of dredge spoils. Recent collections by Haley and Johnston (2014) indicate changes from historical baseline data, suggesting that loss of habitat is affecting the presence of species in riverine areas (Haley 2012; Haley and Johnston 2014). They also presented evidence for homogenization of the fish assemblage across the greater Mobile-Tensaw River area in recent collections.

2) Mercury Pollution
Mercury deposition in the Delta has been documented in several fish species, as well as in sediments, and has been traced primarily to atmospheric input (Bonzongo and Lyons 2004; Warner et al. 2005). Consumption advisories are regularly issued for many fish species in the region due to mercury (Alabama Department of Public Health 2015). Methylmercury concentrations in fishes have been shown to differ across the length of the Delta between piscivore species (e.g., largemouth bass and southern flounder), and between predators and prey (e.g., bluegill and Blue Crab; Farmer et al. 2010).

3) Tropical Storms
Although tropical storms are natural phenomena, they can still represent a threat to fishes in the study area. Several large hurricanes have impacted this area in recent years, including hurricanes Frederic in 1979, Ivan in 2004, and Katrina in 2005. Their impacts on fishes have not been well studied, given the difficulty in sampling after such storms. However, data on Hurricane Ivan demonstrated major changes in water levels and salinity during landfall, followed by high community metabolism in the afternoon and low dissolved oxygen levels the following morning (Park et al. 2007), all factors thought to have strong impacts on fishes. Isphording (1994; cited in Baya et al. 1998) estimated that Hurricane Frederic removed nearly 300 million metric tons (660 billion lb) of sediment from the Delta and bay, providing a “natural cleansing” to the area.

4) Invasive Species
The impacts of a growing suite of invasive species represent an important potential threat to fishes in the study area that must be addressed. Those impacts may be less evident than for threats described previously as the threats to fishes may be less direct, making eventual outcomes difficult to correlate and predict. Invasive species significant to fishes in the area include a number of plants (Eurasian watermilfoil, hydrilla, water hyacinth, common salvinia), invertebrates (the Amazonian apple snail, Asiatic clam, a subtropical water flea), and fishes (common carp, grass carp). Invasive plants most certainly influence habitat available for fishes (see, for example, Crowder and Cooper 1982 on freshwater systems). In some cases, the impacts of invasive invertebrates and other fishes, such as common carp, occurred long ago and are thus well established. Other invasives have arrived relatively recently and their effects have not yet been quantified (e.g., DeVries et al. 2006; Martin et al. 2012).

5) Climate Change
Finally, at the broadest level, climate change is a major driving force that is likely to exert a strong influence on fishes in the rivers and Delta. Climate change models predict not only increased temperatures for coastal and estuarine areas, such as the Delta, but also a suite of other effects, such as increased rates of sea level rise; increased intensity and frequency of coastal storms and hurricanes; and changes in freshwater inputs, sedimentation, nutrient input, and resulting estuarine productivity (Scavia et al. 2002; Nelson et al. 2013; Rybczyk et al. 2013). Increased temperatures will directly affect the metabolic rates of ectotherms. But the indirect effects of changes in salinity patterns (due to changes in freshwater inflows), precipitation, and storm frequency are more complex and difficult to predict. In addition, effects of climate change may enhance the ability of invasive species to enter the system, further complicating predictions (Rahel and Olden 2008). Given the complexity of these systems, we may never accurately predict these system-wide effects. If we are to begin generating testable predictions, additional research is needed to identify those factors most important to system dynamics.

Resource Conservation Implications
Conservation and management of the tremendous diversity of fishes of the Delta involves common sense, as well as some significant changes in human behavior. For example, rapid development in Mobile and Baldwin counties highlights the need to protect the riparian zones in the watershed as a whole, and specifically in local watersheds that drain directly into the Delta. Sediment has been recognized as one of the
Figure 13-10. Excessive sediment from erosion is considered among the most important non-point source pollutants in Alabama. This is an example of a failed attempt to control erosion at a construction site in Baldwin County. Note the collapsed silt fences. (Photo credit: Dennis DeVries and Russell Wright).

Figure 13-11. Sunset on the Mobile-Tensaw River Delta. (Photo credit: Dennis DeVries and Russell Wright).

most significant nonpoint source pollutants impacting aquatic environments (Figure 13-10). In the face of growing demands on water upstream, it is not only important to maintain the quality of water entering the rivers and the Delta, but the quantity and timing of critical flows must also be maintained. Without sufficient and well-timed freshwater input, salinity will encroach inland, compromising production and survival of sensitive species.

Increasing the connectivity of the upper portions of the Mobile Basin watershed with the Delta and with the Gulf of Mexico is important for restoration of the most imperiled species. Fish populations that have suffered the greatest decline in this system are those whose historic migration patterns have been impeded or blocked entirely by the presence of upstream dams. Providing greater connection to critical habitats by facilitating fish movement, using either existing lock-and-dam structures or by developing new passage technologies, could help restore these once abundant populations and increase the flow of nutrients and materials in the ecosystem.

While we cannot alter large-scale effects of climate change at the regional level (e.g., sea level rise), it is possible to monitor changes in habitat and adopt better management approaches. Increased salinity further upstream, greater storm impacts, and the potential for greater colonization by tropical species are potential threats to native species. Routine monitoring to detect the presence and determine the spread of current and new invasive species is important, whether they are climate influenced or not.

Clearly the fishes of the greater Mobile-Tensaw River area are important to the ecological function of the system. Many of these populations are important commercial and recreational species that support economically significant industries. We must take the correct management and conservation steps to preserve this diverse community of fishes for future generations (Figure 13-11).
This chapter describes the conservation status of reptiles and amphibians in the greater Mobile-Tensaw River area. We follow the lead of the US Fish and Wildlife Service by using “species” broadly to include both species and subspecies (USFWS 2015a). As an example, for Coal Skinks (*Plestidon anthracinus*), we count 2 “species”: Northern Coal Skinks (*P. a. anthracinus*) and Southern Coal Skinks (*P. a. pluvialis*). This approach takes full advantage of the knowledge gleaned from conservation genetics.

Reptile Conservation

Alabama contains roughly one third of the reptile species found in the contiguous 48 states (ADCNR 2014a). This reptile richness is a result of Alabama’s subtropical climate, diverse geography, and extensive riverine system (Mittermeier et al. 2015). Lack of glaciation during the Pleistocene also contributed to the proliferation of Alabama’s flora and fauna (ADCNR 2014a). Over 90% of Alabama’s lizard species, 75% of its snake species, and nearly 70% of its turtle species are documented, likely to occur, or once occurred in the greater Mobile-Tensaw River area (Table 6; Guyer et al. 2015 and Guyer et al., forthcoming).

One of those species, Southern Black-knobbed Map Turtle (*Graptemys nigrinoda delticola*), is endemic to Alabama.

Globally, 1 in 5 species of reptile is at risk of extinction, with freshwater ecosystems, such as those found in the greater Mobile-Tensaw River area, having one of the highest proportions of at-risk species (Bohm et al. 2013). Top threats to reptile conservation are habitat loss and harvesting, with harvest of freshwater and marine reptiles of particular concern (Bohm et al. 2013). Reptile conservation is further burdened by agriculture, aquaculture, urban development, and pollution (Bohm et al. 2013), along with exotic invasive species, pollution/contaminants, disease, parasitism, and climate change (Gibbons et al. 2000).

Public perception of reptiles poses yet another challenge to their conservation. These animals are often vehemently feared or disliked—frequently resulting in indiscriminant killing—and their importance in natural systems is underappreciated. It is unfortunate that public support for species conservation often depends on their perceived aesthetic quality or value to humans. Despite reptiles serving as important components in the food web as both predator and prey, as well as their ecosystem services in the form of rodent and insect control, they do not garner levels of public support enjoyed by other taxonomic groups, such as birds or mammals.

Ironically, those who do value reptiles can sometimes be the same ones contributing to their decline. Over-collection and wildlife trafficking of herpetofauna significantly impact population levels. Penalties for wildlife smuggling often do not outweigh the monetary profits and other benefits received from committing those crimes. Threats to reptiles of the greater Mobile-Tensaw River area are not substantially different from those faced by reptiles worldwide. However, the level of habitat loss here, coupled with high species diversity, makes the greater Mobile-Tensaw River area an important conservation priority.

1) Many Species of Conservation Concern

Twenty-three percent of reptile species found in the greater Mobile-Tensaw River area are classified as Species of Greatest Conservation Need by the Alabama Department of Conservation and Natural Resources (2014a; Table 14-1) and approximately 11% are listed as Endangered or Threatened under the federal Endangered Species Act. The latter includes the Alabama Red-bellied Cooter (*Pseudemys alabamensis*), officially designated as Alabama’s state reptile in 1990. In addition, Eastern Diamondback Rattlesnakes (*Crotalus adamanteus*), Southern Hognose Snakes (*Heterodon simus*), and Alligator Snapping Turtles (*Macrochelys temminckii*) are classified as Under Review under the Endangered Species Act.

Southern Hognose Snakes have not been documented in Alabama since 1970 and this species is possibly extirpated (Guyer et al., forthcoming). Despite the release of Eastern Indigo Snakes (*Drymarchon couperi*;
Table 14-1. Reptile and amphibian species documented (D), likely to occur (L), or previously occurring (i.e., extirpated [E]) in the greater Mobile-Tensaw River area and their federal, state, and International Union for Conservation of Nature (IUCN) classifications (See Table 14-2).

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<tr>
<th>Class</th>
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<th>Common Name - Species</th>
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</table>
Table 14-1. Reptile and amphibian species documented (D), likely to occur (L), or previously occurring (i.e., extirpated [E]) in the greater Mobile-Tensaw River area and their federal, state, and International Union for Conservation of Nature (IUCN) classifications (See Table 14-2), cont.

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Table 14-1. Reptile and amphibian species documented (D), likely to occur (L), or previously occurring (i.e., extirpated [E]) in the greater Mobile-Tensaw River area and their federal, state, and International Union for Conservation of Nature (IUCN) classifications (See Table 14-2), cont.

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</table>
Table 14-1. Reptile and amphibian species documented (D), likely to occur (L), or previously occurring (i.e., extirpated [E]) in the greater Mobile-Tensaw River area and their federal, state, and International Union for Conservation of Nature (IUCN) classifications (See Table 14-2), cont.

<table>
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<th>Class</th>
<th>Order</th>
<th>Scientific Name - Species</th>
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Table 14-2. Federal, State, and International Union for Conservation of Nature (IUCN) classification definitions for reptiles and amphibians.

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<td>Listed Endangered—a species in danger of extinction throughout all or a significant portion of its range.</td>
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<td>Listed Threatened—a species likely to become endangered within the foreseeable future throughout all or a significant portion of its range. (SA = due to similarity of appearance.)</td>
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<td>C</td>
<td>Candidate—a species under consideration for official listing for which there is sufficient information to support listing.</td>
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<td>UR</td>
<td>Under Review—species that have been petitioned for listing and for which a 90-day finding has not been published or for which a 90-day substantially has been published but a 12-month finding have not yet been published in the Federal Register. Also includes species that are being reviewed through the candidate process, but the Candidate Notice of Review has not yet been signed.</td>
</tr>
<tr>
<td><strong>State (ADCNR 2014a, 2014b and 2015)</strong></td>
<td>P1</td>
<td>Priority 1/Highest Conservation Concern—species critically imperiled and at risk of extinction/eradication because of extreme rarity, restricted distribution, decreasing population trend/population viability problems, and specialized habitat needs/habitat vulnerability. Immediate research and/or conservation action required.</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>Priority 2/High Conservation Concern—species imperiled because of 3 of 4 of the following: rarity; very limited, disjunct, or peripheral distribution; decreasing population trend/population viability problems; specialized habitat needs/habitat vulnerability. Timely research and/or conservation action needed.</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>Priority 3/Moderate Conservation Concern—species with conservation problems because of insufficient data or because of 2 of 4 of the following: small populations; limited, disjunct, or peripheral distribution; decreasing population trend/population viability problems; specialized habitat needs/habitat vulnerability due to natural/human-caused factors. Research and/or conservation action recommended.</td>
</tr>
<tr>
<td></td>
<td>P4</td>
<td>Priority 4/Low Conservation Concern—species that are secure, yet conservation concerns exist because of 1 of 4 of the following: relative abundance; limited, disjunct, or peripheral distribution; decreasing population trend/population viability problems; specialized habitat needs/increasing habitat vulnerability due to natural/human-caused factors. Research on specific problem suggested.</td>
</tr>
<tr>
<td></td>
<td>P5</td>
<td>Priority 5/Lowest Conservation Concern—species that are demonstrably secure, with size of population stable/increasing, geographical distribution stable/expanding, population trend/population viability stable/increasing, relatively limited habitat vulnerability due to natural/human caused factors, or an unusual visitor to the state. No specific monitoring or conservation action needed.</td>
</tr>
<tr>
<td></td>
<td>SP</td>
<td>Species Protected—species protected by Regulation 220-2-.92 (Nongame Species Regulations), which prohibits the take or attempt to take, capture, kill, possession, sale, trade or offer for anything of monetary value of nongame wildlife species or any parts thereof listed in the regulation, unless allowed by permit.</td>
</tr>
<tr>
<td><strong>IUCN (2012 and 2015)</strong></td>
<td>CE</td>
<td>Critically Endangered—a taxon that meets any of the criteria for Critically Endangered and is facing an extremely high risk of extinction in the wild.</td>
</tr>
<tr>
<td></td>
<td>DD</td>
<td>Data Deficient—a taxon is data deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>Endangered—a taxon that meets any of the criteria for Endangered and is facing a very high risk of extinction in the wild.</td>
</tr>
<tr>
<td></td>
<td>LC</td>
<td>Least Concern—a taxon that has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened. Widespread and abundant taxa are included in this category.</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>Not Evaluated—a taxon that has not yet been evaluated against the criteria.</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>Nearly Threatened—a taxon that does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.</td>
</tr>
<tr>
<td></td>
<td>VU</td>
<td>Vulnerable—a taxon meets any of the criteria for Vulnerable and that is facing a high risk of extinction in the wild.</td>
</tr>
</tbody>
</table>
Federally Threatened) at 9 locations in Alabama in the 1970s and 1980s (Speake and Smith 1987; Speake et al. 1987), recent surveys produced no confirmed sightings of this species (Hart 2002) and it also is believed to be extirpated in the state. However, in 2010 and 2011 Eastern Indigo Snakes were released in Conecuh National Forest in Covington County, a county that neighbors Mobile County to the east. The hope is that a breeding population will become established in the area (Godwin et al. 2011). The greater Mobile-Tensaw River area contains unique and high quality habitat in the Perdido River Longleaf Hills Tract (a state-owned preserve) in Baldwin County that could well serve both Eastern Indigo Snakes and Southern Hognose Snakes for reintroduction efforts (Guyer et al., forthcoming).

2) Rattlesnakes

The longest-running rattlesnake roundup (1960 to present) occurs annually in the City of Opp, Alabama (City of Opp 2015), where members of the public provide the snakes used each year at the festival. In 2015, 88 Eastern Diamondback Rattlesnakes were on display (Elofson 2015). The rodeo is a 2-day event that includes handling and racing Eastern Diamondback Rattlesnakes and selling Eastern Diamondback Rattlesnake meat at concession stands. No snakes are killed at the event. The city’s Planning Director said the rodeo generated considerable revenue from the more than 20,000 people in attendance—more than triple the current population of Opp—during the 2012 festivities (Johnson and Wallace-King 2012). For decades, gassing of burrows was the principal method used to collect large numbers of Eastern Diamondback Rattlesnakes for purposes such as rattlesnake rodeos. This practice was made unlawful in 2009, but Guyer et al. (2015) fear decades of use may have left an “environmental legacy . . . across southern Alabama,” referring to the time that will be required to recover from this overharvest.

Eastern Diamondback Rattlesnakes are a Priority 2 species (Table 14-1), of high conservation concern in the State of Alabama, and, as such, their take should be prohibited along with Priority 1 species and all other Priority 2 species. However, they are not afforded the same protection due to political resistance and attitudes of the general public (Guyer et al. forthcoming). In fact, unlimited harvest is allowed.

The City of Opp Rattlesnake Rodeo is endorsed as a family-friendly event that promotes rattlesnake conservation. Alternative ways to promote Eastern Diamondback Rattlesnake conservation to the public would be to display captive-raised individuals. While Opp is not in the greater Mobile-Tensaw River area, its close proximity makes it likely that many of the Eastern Diamondback Rattlesnakes over the years have come from the study area. Simple conservation measures, such as limiting or prohibiting harvest of this species from the wild, can go a long way to conserve Eastern Diamondback Rattlesnakes in the greater Mobile-Tensaw River area and throughout the state.

3) Turtles

Twenty years ago, Lydeard and Mayden (1995) wrote a paper exalting the biodiversity of Alabama, giving particular attention to turtles. Alabama boasts remarkable turtle diversity (Table 14-1). It claims over half of US freshwater turtle species (Lydeard and Mayden 1995) and, in global analyses, ranks second in turtle species richness (Buhlmann et al. 2009; Mittermeier 2015).

Lydeard and Mayden (1995) noted that insufficient protections were in place to conserve the biota of Alabama and urged “recognition, protection, and recovery of critical habitat, particularly for hot spots such as the aquatic systems of Alabama.” The State of Alabama provided a conservation mechanism for turtles with enactment in 2012 of a prohibition on the commercial harvest of wild freshwater turtles, their eggs, and turtle parts on both public and private lands. Turtle harvest in Alabama and other states in the US spiked in recent years due to the market for turtle meat in Asia, where native turtle populations have plummeted due to unsustainable harvest. Alabama Department of Conservation and Natural Resources Administrative Code Chapter 220-2, however, allows up to 2 turtles per day to be taken from the wild for personal use.

Administrative Code Chapter 220-2 also allows turtle farming, provided the proper permits are acquired and turtles from the wild are not used in propagation. Currently, there are 6 permitted turtle farmers in the state (Mark Sasser, biologist for the Alabama Division of Wildlife and Freshwater Fisheries, personal communication, unreferenced), with snapping turtles, sliders, and softshells being common exports. In fact, unlimited harvest is allowed.
4) American Alligators
In addition to these steps taken for turtle conservation, Alabama showed leadership in conservation of American Alligators (*Alligator mississippiensis*). When this species was at the brink of extinction earlier in the 20th century, Alabama was the first state to put in place protective measures. From 1938 until 2006, nearly 70 years, alligator hunting was banned in the state (Felsher 2014). Today sustainable alligator hunting is allowed, which boosts Alabama’s economy through the sale of licenses and other associated hunting costs.

5) Changing Public Attitudes
The 20th century saw a shift in public attitudes toward predators, from viewing them as vermin to an appreciation of their value as components of ecosystems, particularly their role as managers of prey populations. Herpetologists have hoped for similar shifts in attitudes toward reptiles and such changes have already begun. For example, the State of Georgia used to host 3 rattlesnake rodeos, but the Fitzgerald Rattlesnake Roundup was rebranded as the Fitzgerald Chicken Festival and the rattlesnake roundup in Claxton, which ran for more than 4 decades, became instead a wildlife festival in 2012. If the words of Lydeard and Mayden are further heeded, rigorous conservation efforts in the greater Mobile-Tensaw River area can be similarly effective in protecting species like the Eastern Diamondback Rattlesnake, restoring species such as Eastern Indigo Snakes and Southern Hognose Snakes, and further spotlighting Alabama as a leader in reptile conservation.

**Amphibian Conservation**
Just as the greater Mobile-Tensaw River area is of high value for reptile conservation, so it is for amphibian conservation. Given that amphibians are one of the most threatened vertebrate groups in the world and are declining at an alarming rate (Stuart et al. 2004; IUCN 2008), identifying and protecting areas of high species richness and endemism is the most efficient approach to stemming the tide of global amphibian declines (Margules and Pressey 2000; Sarkar et al. 2006; Apodaca 2010). The southeastern United States provides the best opportunity to pursue this approach in North America. The region is a world hot spot for amphibians (Duellman 1999; Apodaca 2010; Jenkins 2015), with over 140 described species, various evolutionarily significant lineages (Rissler and Smith 2010), and 23 genera, including a high number of endemics.

The State of Alabama contains at least 73 species of amphibians, with a handful of additional possibilities (roughly one third of US amphibian diversity). The greater Mobile-Tensaw River area contains an astounding 53 species (excluding 2 extirpated species; Table 14-1). While other regions in North America may boast higher total numbers of amphibian species due to narrow endemics (e.g., the Southern Appalachians), the greater Mobile-Tensaw River area includes sites with the highest total amphibian richness on the continent (Apodaca 2010; Jenkins et al. 2015).

This incredible richness is due to a coalescence of historical influences and more recent habitat availability. Environmental niche modeling has revealed that the climate in this area is ideal for a high number of amphibians (Apodaca 2010), and predicted climate changes do not appear to substantially alter the projected species composition (Apodaca, unpublished data, unreferenced). Additionally, the Alabama River drains more than 110,000 km² (42,000 mi²)—including everything from 1st-order streams to expansive floodplains—providing both the various habitats required to host such a vast number of native amphibians and a barrier large enough to promote vicariance. In fact, the greater Mobile-Tensaw River area lies within the most prominent “suture zone,” a hot spot for phylogeographic breaks, for amphibians in North America (Rissler and Smith 2010). At least 3 pairs of amphibian sister species likely speciated entirely due to the Alabama River system.

For several other species, the river represents the eastern or western fronts of their range (Soltis et al. 2006). From a conservation standpoint, this historical anomaly offers the possibility to preserve a high amount of amphibian diversity in a relatively small geographic area. Given that several amphibian species have significant phylogeographic breaks at or near the greater Mobile-Tensaw River area, it is also an opportunity to preserve a significant amount of genetic diversity, thus giving them the necessary evolutionary capacity to respond to ongoing and future threats, such as chytrid fungi (*Batrachochytrium dendrobatidis* and *B. salamandrivorans*) and global climate change.

1) Red Hills Salamander
The greater Mobile-Tensaw River area contains several globally imperiled and declining species, including the Federally Threatened Red Hills Salamander (*Phaeognathus hubrichti*) and 7 state-listed species (Table
14-1). Perhaps the most charismatic member of this group is the highly imperiled Red Hills Salamander. This unique species, the only member of its genus, is endemic to a narrow band within 6 counties in south Alabama. In fact, it is the only terrestrial vertebrate completely endemic to the State of Alabama. In 2000, the Red Hills Salamander was officially designated as Alabama’s state amphibian. The majority of known populations of Red Hills Salamanders reside near the eastern bank of the Alabama River. Consequently, preservation efforts in the study area provide the best chance to conserve habitat for the long-term protection of this species (Apodaca 2010).

2) Mississippi Gopher Frogs and Reticulated Flatwoods Salamanders

Protected habitats in the greater Mobile-Tensaw River area would also provide an excellent opportunity to reintroduce 2 of the most endangered amphibians in the world—Mississippi Gopher Frogs (*Lithobates sevosus*) and Reticulated Flatwoods Salamanders (*Ambystoma bishopi*)—both of which are known from only a handful of localities in the wild and are both historically found in the greater Mobile-Tensaw River area. Mississippi Gopher Frogs are currently found at only one pond in southern Mississippi, and in any given year may have less than 100 surviving adults (Richter et al. 2003). Reticulated Flatwoods Salamanders are found in only a small portion of their original range and the number of relatively healthy populations is likely in the single digits. Both of these amphibian species have active captive breeding programs, and would be excellent candidates for reintroduction activities in the greater Mobile-Tensaw River area. Such efforts are vitally important to the continued survival of these species.

3) Threats to Amphibians

The greater Mobile-Tensaw River area is certainly not immune to the myriad threats to biodiversity in the Southeast. Similar to the threats facing reptiles in the greater Mobile-Tensaw River area, chief threats to amphibians here include habitat loss, conversion, and fragmentation. The 3 aforementioned imperiled amphibian species are glaring examples of the effects that habitat loss can have on the region’s amphibians. The limited dispersal ability of herpetofauna previously mentioned makes many species especially susceptible to habitat loss and fragmentation, which exposes them to the perils of small populations and eventually the extinction vortex (Frankham 2010). Accordingly, any successful amphibian conservation plan for the greater Mobile-Tensaw River area should consider conservation corridors, as well as large portions of ideal habitat.

4) Economic and Cultural Value of Amphibians

It is easy to overlook the economic and cultural value of amphibians. However, in many parts of the southeastern US, and certainly in many ecosystems within the greater Mobile-Tensaw River area, amphibians are the most abundant vertebrates (Burton and Likens 1975; Jaeger 1979; Hairston 1987; Welsh and Droeg 2001). This abundance makes them exceptionally important components of the ecosystem and cornerstones of many food webs and communities (Hairston 1987; Welsh and Droeg 2001). This value is especially true in wetland and floodplain communities, which play a disproportionately important role in the health and functioning of ecosystems (Gibbons et al. 2006).

Economically and culturally, amphibians play a significant role in fully functioning wetland ecosystems, particularly among those ecosystem services considered most valuable: biodiversity support, water quality improvement, and carbon management (Zedler and Kercher 2005; Hocking and Babbit 2014). The economic value of such services throughout the greater Mobile-Tensaw River area undoubtedly reaches into the tens of millions of dollars per year.

Thwarting Extinction

The US has witnessed the extinction of numerous species, lineages, and unique species assemblages over the past centuries. Without drastic actions, extinction rates may climb sharply at the end of this century (Pimm et al. 1995; Mace et al. 2005). Alabama has the dubious distinction of leading the continental US in number of extinctions (Stein 2002), largely due to human-caused impacts to its vast network of rivers and accompanying habitats. Additional protection in the greater Mobile-Tensaw River area would be a tremendous first step in a quest to thwart the continuing loss of biodiversity in the southeastern United States, and would serve as a vital component of global efforts to stem amphibian biodiversity loss worldwide.
15. Avifauna of the Lower Alabama River and Mobile-Tensaw Delta

Joel A. Borden and C. Smoot Major, University of South Alabama

Birds are the most abundant and diverse terrestrial vertebrate group on Earth. At over 10,000 species, and counting, they comprise a third of all terrestrial vertebrate species (Pough et al. 2013). Alabama has over 400 species of birds that are either full-time residents or part-time migrants (Alabama Ornithological Society 2015). This chapter reviews the avifauna of the greater Mobile-Tensaw River area, beginning with a review of species present, those at risk, and those who migrate through, and closing with a discussion of conservation implications.

Significance to Avifauna of the Greater Mobile-Tensaw River Area

The greater Mobile-Tensaw River area, including the Mobile-Tensaw Delta, supports high biodiversity (over 200 species) and provides critical habitat for avian populations across the Eastern Gulf Coastal Plain and much of the Eastern Deciduous Forest ecoregions. This area, from the Red Hills in Monroe County to the vast expanse of braided streams, bottomland hardwood forests, and coastal marshes that straddle Baldwin and Mobile counties, is an often harsh and ever-changing environment for plants and animals that call this watershed home.

Habitat diversity, environmental patchiness, and natural- and human-induced disturbance define this highly dynamic ecosystem. The ecosystem plays a crucial role as an avian breeding ground, plus serves as a migratory stopover for refuge and refueling and as a major flyway of the Central Gulf Coastal Region (Orme et al. 2005). In particular, the annual flood cycle is a key component and ecological driver of biodiversity in the region. Flooding is common; it occurs primarily during winter and early summer prolonged rain events that inundate small streams and rivers with high degrees of variation in intensity and periodicity (US Army Corps of Engineers 2015). Variations such as these have been linked to patterns in primary productivity in other dynamic river delta systems (Junk et al. 1989; Høberg et al. 2002; Tockner and Stanford 2002; Lindholm et al. 2007).

As part of the Eastern Gulf Coastal Plain ecoregion, the greater Mobile-Tensaw River area is a portion of 1 of 6 “biodiversity hot spots” in the United States (Chaplin et al. 2000). Many taxa endemic to this ecoregion are restricted to cypress-dominated and pine-dominated wetlands and uplands, which characterize much of lower Alabama. Pine-dominated wetlands and uplands, which are now reduced to less than 5% of their original coverage, have become two of the most endangered ecosystems in North America (Noss and Peters 1995). Thus, in keeping with statewide declines in biodiversity, the Eastern Gulf Coastal Plain is also considered to be a “species endangerment hot spot” (Flather et al. 1998).

Figure 15-1. Purple Gallinule hatchling. (Photo credit: Kathy Hicks).
Moreover, the Mobile-Tensaw deltaic system is of evolutionary significance. As reviewed by Soltis et al. (2006), the Delta and surrounding regions constitute a major phylogeographic break, which has acted as a significant barrier to gene flow resulting in distinct evolutionary lineages on either side of the Delta. This “hybridization” of community types, in part, explains the high degree of endemic species and biodiversity observed in southern Alabama. The Delta is also subject to considerable disturbances, both human-induced (e.g., eutrophication, development, industrial pollution) and natural (e.g., tropical storms, drought, flooding events). In fact, the high biodiversity of this region seems largely driven by disturbance.

**Species Overview**

The greater Mobile-Tensaw River area plays a major role in the function of this section of the Gulf Coast, which is distinguished by some of the world’s most productive estuarine and coastal marine communities, providing habitat for waterfowl, wading birds, migratory songbirds, birds of prey, and both game and non-game species. Notable species within the avian community are the marsh (wetland grasses) birds, such as the Clapper, King, Virginia, Black, and Yellow Rails; Common and Purple Gallinules (Figure 15-1); the American Coot; Red-winged Blackbird and Boat-tailed Grackle. These species require large expanses of marsh that provide cover for predator avoidance and nesting, and habitat for prey (Dunn and Alderfer 2011).

Huge annual flights of waterfowl also utilize marsh and forested backwaters of the greater Mobile-Tensaw River area during migration and as overwintering sanctuaries. These species include Green-winged and Blue-winged Teal (Figure 15-2), Mallard, Gadwall, American Wigeon, Northern Pintail, Northern Shoveler, Canvasback, Redhead, Ring-necked Duck, Wood Duck (Figure 15-3), Greater and Lesser Scaup, Bufflehead, and Hooded and Red-breasted Merganser (Dunn and Alderfer 2011).

Perhaps, the most conspicuous group is the long-legged wading birds. These species lurk stealthily around the edges of river channels and across vast mud flats looking for prey as varied as insects, fish, frogs, snakes, hatchling alligators, and rodents. Included in this group are the Great Blue Heron, Great Egret,
Snowy Egret, Tricolored Heron, Little Blue Heron, Reddish Egret (Figure 15-4), Black-crowned and Yellow-crowned Night-Heron, Green Heron (Figure 15-5), and Least Bittern (Gill 2007; Dunn and Alderfer 2011).

Another group reliant on this region are migratory songbirds that inhabit bottomland deciduous forests. Among these are warblers (Prothonotary [“swamp canary”] (Figure 15-6), Yellow-throated, Prairie, Northern Parula, Yellow-rumped, Black-and-white (Figure 15-7), American Redstart, Northern Waterthrush, Common Yellowthroat, and Kentucky, to name just a few); vireos (Red-eyed, White-eyed, Yellow-throated, and Blue-headed), wrens (Carolina, House, Winter, Sedge, and Marsh), Carolina Chickadee (Figure 15-8), Tufted Titmouse, and flycatchers (Eastern Phoebe, Eastern Kingbird, Eastern Wood-Pewee, Acadian, Great-crested, and Least) (Dunn and Alderfer 2011). These species are ecologically important to the greater Mobile-Tensaw River area because they “repackage” energy, in the form of small arthropods, into a larger meal for raptors, small mammals, snakes, and other predators (Gill 2007; Pough et al. 2013).

Upland species inhabiting pine savannas and oak-hickory forests also play a crucial role in the ecological stability of this region (Gill 2007). The sparrows (Chipping, Savannah, Field, Grasshopper, Henslow’s, Song, White-crowned [Figure 15-9], and White-throated) disperse seeds and fall prey to small mammals, as well as to Cooper’s Hawks, Sharp-shinned Hawks, American Kestrels, and Merlins (Gill 2007; Dunn and Alderfer 2011).

Primary cavity nesters—the woodpeckers—are critical as “keystone species” within the greater Mobile-Tensaw River area. The term keystone species is defined as a species that has a disproportionately large effect on its environment relative to its population size. If a keystone species is removed from its habitat, many other species would likely decline or disappear altogether (Pough et al. 2013). These diligent excavators provide relatively safe and secure nesting opportunities for not only their offspring, but other species’
Figure 15-6. Prothonotary Warbler. (Photo credit: Kathy Hicks).

Figure 15-7. Black-and-White Warbler. (Photo credit: Kathy Hicks).
Figure 15-8. Carolina Chickadee. (Photo credit: Kathy Hicks).

Figure 15-9. White-Crowned Sparrow. (Photo credit: Kathy Hicks).

Figure 15-10. Pileated Woodpecker. (Photo credit: Kathy Hicks).
offspring as well (Martin et al. 2004). They also help disperse fungal infection throughout forested habitats which aids in softening dead standing timber (Jackson and Jackson 2004). This softened wood is prized by many other species as prime nesting habitat (Gill 2007). Species as varied as Wood Ducks, American Kestrels, Tree Swallows, Carolina Chickadees, Eastern Screech-Owls, Prothonotary Warblers, and Brown-headed Nuthatches use abandoned woodpecker nests to raise their young. Many of these secondary cavity nesters are dependent on the 6 species (Northern Flicker, Pileated [Figure 15-10], Red-headed, Red-bellied, Downy, and Hairy) of woodpeckers for nesting sites as these are often the most secure sites within these habitats for raising their young (Gill 2007).

At the top of the “food chain” are the apex predators. These are also known as birds of prey or simply raptors. The greater Mobile-Tensaw River area has many species of raptors that play a significant role in reducing the size of prey populations, as well as increasing the health of those species by removing weaker individuals. These include the Bald Eagle, Red-tailed hawk, Red-shouldered hawk, Northern Harrier, Osprey (Figure 15-11), Horned Owl, Barred Owl (Figure 15-12), Mississippi Kite, Swallow-tailed Kite (Figure 15-13), and Peregrine Falcon. These birds feed on an incredible assortment of prey, from insects like dragonflies to fishes, snakes, songbirds, waterfowl, and small mammals. As in all ecosystems, top predators are important as a “top down” control that prevents prey species from destroying habitat resources for other species (Steinmetz et al. 2003).

**Species of Special Concern**

Of the 19 species listed under “High Conservation Concern” by Mirarchi et al. (2004a), 17 utilize the Mobile-Tensaw Delta on a seasonal basis, if not year-round. Conservation biologists use several parameters to designate a species’ current conservation status (Table 15-1). NatureServe (2015) documents conservation status at 3 geographic scales: global (G), national (N), and state (S), with severity of concern indicated from 1 to 5, G1 being the rarest to G5 the most secure, for example. State-ranked species
are further characterized as breeding (B) or non-breeding (N). Lastly, the International Union for the Conservation of Nature Red List rates species of “Least Concern” (LC) and “Near Threatened” (NT) (IUCN 2012; Table 15-2).

Nine species considered of “High Conservation Concern” in Alabama (Table 15-3) are highly dependent on wetland habitats: Least Bittern, Reddish Egret, American Black Duck, Swallow-tailed Kite, Northern Harrier, Black and Yellow Rails, White Ibis (Figure 15-14), and American Oystercatcher. The other 9 species of high concern (Table 15-4) prefer upland habitats adjacent to swamps and bottomlands of the Mobile-Tensaw Delta. These include the southeastern subspecies of American Kestrel, American Woodcock, Short-Eared Owl, Wood Thrush, Worm-Eating Warbler, Swainson’s Warbler, Kentucky

![Swallow-tailed Kite](image)

**Figure 15-13. Swallow-tailed Kite. (Photo credit: Kathy Hicks).**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Ranking Criteria Definition for NatureServe</th>
</tr>
</thead>
<tbody>
<tr>
<td>GX</td>
<td>Presumed Extinct (species)/Eliminated (ecological communities and systems) — Species not located despite intensive searches and virtually no likelihood of rediscovery. Ecological community or system eliminated throughout its range, with no restoration potential.</td>
</tr>
<tr>
<td>NX</td>
<td>Possibly Extinct (species)/ Eliminated (ecological communities and systems) — Known from only historical occurrences but still some hope of rediscovery. There is evidence that the species may be extinct or the ecosystem may be eliminated throughout its range, but not enough to state this with certainty.</td>
</tr>
<tr>
<td>SX</td>
<td>Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.</td>
</tr>
<tr>
<td>G2</td>
<td>Imperiled—At high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors.</td>
</tr>
<tr>
<td>N2</td>
<td>Vulnerable—At moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors.</td>
</tr>
<tr>
<td>S2</td>
<td>Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.</td>
</tr>
<tr>
<td>G3</td>
<td>Secure—Common; widespread and abundant.</td>
</tr>
</tbody>
</table>

Table 15-1. Ranking species is conducted by NatureServe on Global (G rank), National (N rank), and a State rank (S rank) and are considered very reliable by most scientists, government agencies, and conservationists (NatureServe 2015).
### Table 15-2. Species rankings for the IUCN red list (IUCN 2012).

<table>
<thead>
<tr>
<th>Status</th>
<th>Abbreviation</th>
<th>Status Description For the IUCN Red Book List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinct</td>
<td>EX</td>
<td>A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon’s life cycles and life form.</td>
</tr>
<tr>
<td>Extinct in the Wild</td>
<td>EW</td>
<td>A taxon is Extinct in the Wild when it is known only to survive in cultivation, captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon’s life cycle and life form.</td>
</tr>
<tr>
<td>Critically Endangered</td>
<td>CR</td>
<td>A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild.</td>
</tr>
<tr>
<td>Endangered</td>
<td>EN</td>
<td>A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.</td>
</tr>
<tr>
<td>Vulnerable</td>
<td>VU</td>
<td>A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.</td>
</tr>
<tr>
<td>Near Threatened</td>
<td>NT</td>
<td>A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.</td>
</tr>
<tr>
<td>Least Concern</td>
<td>LC</td>
<td>A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.</td>
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<tr>
<td>Data Deficient</td>
<td>DD</td>
<td>A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.</td>
</tr>
<tr>
<td>Not Evaluated</td>
<td>NE</td>
<td>A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.</td>
</tr>
</tbody>
</table>

### Table 15-3. High conservation state of Alabama concern wetland species within the greater Mobile-Tensaw River area.

<table>
<thead>
<tr>
<th>Birds</th>
<th>Natural Heritage Rank</th>
<th>Red Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least Bittern</td>
<td>G5, S2N, S4B</td>
<td>LC</td>
</tr>
<tr>
<td>Reddish Egret</td>
<td>G4, S1B, S3N</td>
<td>NT</td>
</tr>
<tr>
<td>American Black Duck</td>
<td>G5, S2B, S5N</td>
<td>LC</td>
</tr>
<tr>
<td>Swallow-Tailed Kite</td>
<td>G5, S2</td>
<td>LC</td>
</tr>
<tr>
<td>Northern Harrier</td>
<td>G5, S3N</td>
<td>LC</td>
</tr>
<tr>
<td>Black Rail</td>
<td>G3-G4, S2N</td>
<td>NT</td>
</tr>
<tr>
<td>Yellow Rail</td>
<td>G4, S2N</td>
<td>LC</td>
</tr>
<tr>
<td>White Ibis</td>
<td>G5, S2B, S3N</td>
<td>LC</td>
</tr>
<tr>
<td>American Oystercatcher</td>
<td>G5, S1</td>
<td>LC</td>
</tr>
</tbody>
</table>

### Table 15-4. High conservation state of Alabama concern for species inhabiting uplands adjacent to swamps and bottomlands of the greater Mobile-Tensaw River area.

<table>
<thead>
<tr>
<th>Birds</th>
<th>Natural Heritage Rank</th>
<th>Red Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Kestrel</td>
<td>G5, S3B, S5N</td>
<td>LC</td>
</tr>
<tr>
<td>American Woodcock</td>
<td>G5, S3B, S5N</td>
<td>LC</td>
</tr>
<tr>
<td>Short-Eared Owl</td>
<td>G5, S2N</td>
<td>LC</td>
</tr>
<tr>
<td>Wood Thrush</td>
<td>G5, S5</td>
<td>LC</td>
</tr>
<tr>
<td>Worm-Eating Warbler</td>
<td>G5, S4B</td>
<td>LC</td>
</tr>
<tr>
<td>Swainson's Warbler</td>
<td>G4, S4B</td>
<td>LC</td>
</tr>
<tr>
<td>Kentucky Warbler</td>
<td>G5, S4B</td>
<td>LC</td>
</tr>
<tr>
<td>Bachman's Sparrow</td>
<td>G3, S3</td>
<td>NT</td>
</tr>
<tr>
<td>Seaside Sparrow</td>
<td>G4, S2</td>
<td>LC</td>
</tr>
</tbody>
</table>
Warbler, Bachman’s Sparrow, and Seaside Sparrow. Additionally, 48 of 53 species (90%) listed under “Moderate Concern” in Alabama have been encountered in the greater Mobile-Tensaw River area. Essentially half of all bird species found in Alabama utilize this region, making it a critical ecological corridor for avian population stability (Mirarchi et al. 2004; NatureServe 2015).

Neotropical Migrants
Since the inception of the Alabama Breeding Bird Atlas, an estimated 36 out of 102 (35%) species that breed throughout the greater Mobile-Tensaw River area are Neotropical migrants, birds that breed in North America but migrate to Central and South America to overwinter (Alabama Ornithological Society 2015). An additional 25 species use it as a major migration route on their journey north. Without the varied and rich habitats of the greater Mobile-Tensaw River area, these species would surely be subject to increased predation and starvation due to the lack of sufficient mature hardwood bottomland and upland pine forests.

Migration Corridor
The greater Mobile-Tensaw River area also serves as an uninterrupted corridor for the movement of species in and out of the Central Gulf Coastal Region. Because of its long, unbroken tracts of bottomland forests, the greater Mobile-Tensaw River area acts as a flyway for a multitude of avian species. With places to hide, rest, and feed, this area is essential for species making the long, arduous journey from Central and South America through the southeastern US and on to the heart of North America to breed (Fitzpatrick 2004; Gill 2007).

Impacts of Birding
The US Fish and Wildlife Service has estimated that birders contribute $85 billion in overall economic output per year, with $13 billion going toward state and federal income taxes (Gill 2007). With such a great diversity of bird species throughout the greater Mobile-Tensaw River area, birders are attracted here from all over the globe. Enthusiasts spend considerable amounts of money boosting economies in large cities and small communities just to see a Bald Eagle, Swallow-tailed Kite, Prothonotary Warbler, Great Egret, or Osprey for the first time. Most birders are nature enthusiasts who are awed by the great diversity of our planet and wish to contribute to its maintenance for future generations.

Conservation Implications
While every state has witnessed species extinctions, such losses have not occurred uniformly across the nation. States exhibiting high numbers of extinctions tend to boast high overall numbers of species and fragile ecosystems with at-risk flora and fauna and/or intense human impact. Unfortunately for Alabama, all 3 of these scenarios apply. According to data collected by the nation’s Natural Heritage programs and The Nature Conservancy, Alabama is the most extinction-prone state of the mainland United States, with 96 documented species extinctions to date (Stein et al. 2000; NatureServe 2015).

Because of its ancient and complex geological terrain spanning 3 major river basins, Alabama is home to more species of animals and plants than any other state east of the Mississippi River. An estimated 10 to 20% of all species known to occur in Alabama are in peril due to ever-increasing pressures associated with increased incidence of disturbance, both natural (e.g.,
hurricanes, flooding events) and human-induced (e.g., eutrophication, development, industrialization, oil spills) (Stein et al. 2000; Brawn et al. 2001).

We have already lost one bottomland hardwood inhabitant, Bachman’s Warbler (GH-Global Rank “Possibly Extinct,” SX-State Rank “Extinct,” LE-USFWS “Endangered,” CR-IUCN Red List “Critically Endangered”), to clearcutting of the tupelo gum-cypress swamps and severe reduction of natural cane-brakes along river levees. And we likely have lost another, the Ivory-billed Woodpecker (G1, SX, LE, CR), the largest woodpecker in North America, which has certainly been extirpated or driven into extinction altogether. Along with these two losses, dozens more species have seen precipitous declines in both numbers and distribution (Anderson 1996; Mirarchi et al. 2004a; Gill 2007).

Measurable reductions in biodiversity around the globe have been attributed to many factors, including fragmentation of undeveloped land for farming, logging, and suburban development, and invasive species (Murcia 1995; Dobson 2000; Stein et. al. 2000; Wittenberg and Cock 2001). Loss of habitat diversity has also been implicated in species declines throughout the world (Dobson 2000; Stein et al. 2000). The disappearance and degradation of wetlands, as well as changes in stream hydrology through dredging and channelization, have also resulted in losses in diversity and trophic structure (Russell et al. 2002; Ryan et al. 2002; Semlitsch 2003).

Changes in hydrodynamics, through channelization and increased sedimentation caused by poor soil conservation, have altered natural flood cycles of the Mobile-Tensaw Delta and surrounding uplands. Moreover, poorly managed private lands leased for silviculture and a reduction in riparian zones have diminished available habitat necessary for spring migration and nesting that affect species of high and moderate concern. Neotropical migrant species impacted by these conditions include, but are not limited to, Swainson’s Warbler, Cerulean Warbler, Kentucky Warbler, Worm-eating Warbler, Wood Thrush, Prothonotary Warbler, Northern Parula, and Louisiana Waterthrush (Ward 1989; Naiman and Décamps 1997; Paetzold et al. 2005; Gill 2007).

Habitat fragmentation has also been cited as a major cause of population decline in wetland species, upland pine savanna specialists, and large, contiguous mature forest nesters (Askins 1995). Small habitats generally lack enough space, food, nesting sites, or refuge from predators to support sustainable populations (Wilcove et al. 1998; Robinson et al. 1995).

One problem in particular for small woodland species is the need for large areas of mature forest. Most of our mature hardwood and pine forests have been relegated to thin strips that are mostly (if not entirely) edge habitat. These edge habitats, the physical boundary between one habitat type and another, tend to be hotter and dryer than suitable habitats in larger forests. Such environmental shifts increase time spent on eggs rather than foraging, thereby reducing parental energy stores.

Predation also tends to be higher along edges. Not only are adults, their eggs, and offspring preyed upon by mammalian, reptilian, and raptorial predators, but obligate brood parasites, especially Brown-headed Cowbird and occasionally Yellow-billed Cuckoo, are more common within edge habitats (Robinson et al. 1995). While these species do not eat eggs or hatchlings, they are responsible for dramatic declines in populations of vireos, warblers, flycatchers, and other Neotropical migrants that are forced to nest close to forest edges. Brood parasites do not build their own nests. Instead they lay one of their eggs in an established vireo or warbler nest. The parasite’s egg hatches first and its larger hatchling either pushes the remaining eggs and/or hatchlings out of the nest or demands more food from the host parents. Thus, parasitic behavior decreases resources available to the host’s offspring and greatly reduces survivorship (Robinson et al. 1995; Payne 1998; Davies 2000).

Summary

Birds are an incredibly important component of the greater Mobile-Tensaw River area ecosystem. Many of these species are imperiled due to habitat loss or degradation through reduction in riparian zones, fragmentation of large, contiguous forest tracts, and reduction of wetlands from development. It is imperative that this diverse and ecologically important area is managed for the use and enjoyment of future generations of scientists and nature enthusiasts alike. The Mobile-Tensaw Delta has been called “a jewel in the crown of North America” and “an American Amazon” by noted biologist, scholar, and native Alabamian, E. O. Wilson (EO Wilson Biodiversity Foundation [date unknown]). We would do a great disservice to the generations yet to come should we fail to protect its beauty and diversity.
Biotic Landscape - Chapter 16

16. Mammals

Troy L. Best, Auburn University

Modern research (Mirarchi 2004; Mirarchi et al. 2004a, 2004b; Best and Dusi 2014) has recently augmented standard listings and summaries about the mammals of southern Alabama by Howell (1909, 1921), Holliman (1963), and Mount (1984, 1986). At present, the mammalian fauna of the greater Mobile-Tensaw River area contains 9 taxonomic orders represented by 22 families and about 58 species. This chapter reviews mammals living in or extripated from the greater Mobile-Tensaw River area.

Overview

Of the 58 species of the greater Mobile-Tensaw River area, most are rodents (20 species), carnivores (14), and bats (12) (Table 16-1). Some species have been extirpated in Alabama (red wolf, cougar), are of questionable occurrence (jaguarundi), are known from the region only by a few historical records (southeastern pocket gopher, little brown myotis, marsh rabbit), or are officially listed as endangered (West Indian manatee, gray myotis, red wolf).

Opossums, Manatees, and Armadillos

Virginia opossums, West Indian manatees, and nine-banded armadillos are the only representatives of their taxonomic orders in the greater Mobile-Tensaw River area (Didelphimorphia, Sirenia, and Cingulata, respectively). Virginia opossums (Figure 16-1) occur statewide in all terrestrial habitats, but they favor floodplains and swamps. Hedges, piles of wood, fence rows, stream banks, and other habitats provide cover in suburban areas. These opportunistic omnivores consume insects, carrion, fruits, garden vegetables, foods discarded by humans, and food left outside for pets. Virginia opossums are a common roadkill on our streets and highways (McManus 1974; Best and Dusi 2014), as are nine-banded armadillos (Wolfe 1968; McBee and Baker 1982; White 1992; Best and Dusi 2014). Until the 1980s, nine-banded armadillos were known only from southern Alabama, but by the mid-1990s they had extended their range across the state and well into Tennessee. Insects, especially beetles and ants, are common items in their diet; they also eat millipedes, centipedes, earthworms, snails, eggs, amphibians, reptiles, birds, baby mammals, carrion, fruits, and berries. Although they consume many harmful insects, nine-banded armadillos often are not welcome because of damage they cause to vegetable gardens and flower beds.

West Indian manatees are warm-season residents in and around Mobile Bay. They have been observed as far north as Claiborne Lock and Dam (Carmichael RH, et al., in litteris, unreferenced) on the Alabama River, about 8 km (5 mi) upstream from Claiborne, Monroe County. These large, streamlined aquatic mammals have flippers instead of front legs, no hind legs, and a flattened-spatulate tail (Husar 1978). Their closest relatives are elephants (Proboscidea) and

![Figure 16-1. Virginia opossum (Didelphis virginiana) is a common species in the greater Mobile-Tensaw River area of Alabama. (Photo credit: Troy L. Best.)](image-url)
Table 16-1. Mammals of the greater Mobile-Tensaw River area of Alabama (Best and Dusi 2014) and a qualitative estimate of their current status in the region.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Species</th>
<th>Current Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didelphimorphia (American Opossums)</td>
<td>Didelphidae (American Opossums)</td>
<td>Virginia opossum (<em>Didelphis virginiana</em>)</td>
<td>Common</td>
</tr>
<tr>
<td>Sirenia (Dugongs, Manatees, and Sea Cows)</td>
<td>Trichechidae (Manatees)</td>
<td>West Indian manatee (<em>Trichechus manatus</em>)</td>
<td>Endangered</td>
</tr>
<tr>
<td>Cingulata (Armadillos)</td>
<td>Dasypodidae (Armadillos)</td>
<td>Nine banded armadillo (<em>Dasypus novemcinctus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td>Rodentia (Rodents)</td>
<td>Sciuridae (Squirrels)</td>
<td>Eastern gray squirrel (<em>Sciurus carolinensis</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern fox squirrel (<em>Sciurus niger</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Southern flying squirrel (<em>Glaucomys volans</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern chipmunk (<em>Tamias striatus</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td>Castoridae (Beavers)</td>
<td>American beaver (<em>Castor canadensis</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td>Geomyidae (Pocket Gophers)</td>
<td>Southeastern pocket gopher (<em>Geomys pinetis</em>)</td>
<td>Rare</td>
</tr>
<tr>
<td></td>
<td>Cricetidae (New World Rats and Mice, Voles, Hamsters, and Relatives)</td>
<td>Woodland vole (<em>Microtus pinetorum</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Common muskrat (<em>Ondatra zibethicus</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern woodrat (<em>Neotoma floridana</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Golden mouse (<em>Ochrotomys nuttali</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cotton deermouse (<em>Peromyscus gossypinus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White-footed deermouse (<em>Peromyscus leucopus</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td>Muridae (Old World Rats and Mice)</td>
<td>Oldfield deermouse (<em>Peromyscus polionotus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern harvest mouse (<em>Reithrodontomys humulis</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marsh oryzomys (<em>Oryzomys palustris</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hispid cotton rat (<em>Sigmodon hispidus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td>Myocastoridae (Coypus)</td>
<td>Coypu (<em>Myocastor coypus</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Lagomorpha (Hares, Pikas, and Rabbits)</td>
<td>Leporidae (Rabbits and Hares)</td>
<td>Swamp rabbit (<em>Sylvilagus aquaticus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern cottontail (<em>Sylvilagus floridanus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marsh rabbit (<em>Sylvilagus palustris</em>)</td>
<td>Rare</td>
</tr>
<tr>
<td>Soricomorpha (Shrews, Moles, Desmans, and Relatives)</td>
<td>Soricidae (Shrews)</td>
<td>Southern short tailed shrew (<em>Blarinia carolinensis</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>North American least shrew (<em>Cryptotis parva</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td>Talpidae (Moles)</td>
<td>Southeastern shrew (<em>Sorex longirostris</em>)</td>
<td>Common</td>
</tr>
<tr>
<td>Carnivora (Carnivores)</td>
<td>Family Felidae (Cats)</td>
<td>Bobcat (<em>Lynx rufus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cougar (<em>Puma concolor</em>)</td>
<td>Extirpated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jaguarundi (<em>Puma yagouaroundi</em>)</td>
<td>Questionable</td>
</tr>
<tr>
<td></td>
<td>Canidae (Wolves, Dogs, Foxes, and Jackals)</td>
<td>Coyote (<em>Canis latrans</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red wolf (<em>Canis rufus</em>)</td>
<td>Extirpated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gray fox (<em>Urocyon cinereoargenteus</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td>Ursidae (Bears and Giant Pandas)</td>
<td>American black bear (<em>Ursus americanus</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td>Mustelidae (Weasels, Badgers, and Otters)</td>
<td>North American river otter (<em>Lontra canadensis</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long-tailed weasel (<em>Mustela frenata</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>American mink (<em>Neovison vison</em>)</td>
<td>Common</td>
</tr>
</tbody>
</table>
Table 16-1. Mammals of the greater Mobile-Tensaw River area of Alabama (Best and Dusi 2014) and a qualitative estimate of their current status in the region, cont.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Species</th>
<th>Current Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora (Carnivores), cont.</td>
<td>Mephitidae (Skunks and Stink Badgers)</td>
<td>Striped skunk (<em>Mephitis mephitis</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern spotted skunk (<em>Spilogale putorius</em>)</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Procyonidae (Raccoons, Ringtails, and Coatis)</td>
<td></td>
<td>Raccoon (<em>Procyon lotor</em>)</td>
<td>Common</td>
</tr>
<tr>
<td>Artiodactyla (Even-toed Ungulates)</td>
<td>Suidae (Swine)</td>
<td>Wild boar (<em>Sus scrofa</em>)</td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td>Cervidae (Deer, Elk, Caribou, and Moose)</td>
<td>White-tailed deer (<em>Odocoileus virginianus</em>)</td>
<td>Common</td>
</tr>
</tbody>
</table>

hyraxes (Hyracoidea) (Best and Dusi 2014). They have no predators, but scars from propellers and keels of boats are evidence that humans may have a significant impact on populations (Hartman 1979). West Indian manatees are nearly completely herbivorous and usually forage on vegetation in shallow coastal freshwater and saltwater habitats (Husar 1978). Causes of death associated with humans include collisions with boats; drowning in fishing nets; ingestion of fishing hooks, fishing lines, and wire; and entrapment in locks, dams, and large pipes (Husar 1978; Best and Dusi 2014). West Indian manatees are solitary or occur in pairs (often a female and her young) or in small groups; larger groups may form near warm springs in inland waterways during winter (Husar 1978; Hartman 1979). In autumn, many of Alabama’s West Indian manatees migrate along coastal waterways to warm water springs near Crystal River, Citrus County, Florida (Carmichael RH, et al., *in litteris*, unreferenced).

**Rodents**

Of the 4 species of squirrels, 3 (eastern gray squirrel, eastern fox squirrel, southern flying squirrel) are common in the greater Mobile-Tensaw River area, but the eastern chipmunk is rare at this southern edge of its geographic range (Hall 1981; Best and Dusi 2014). American beavers (Castoridae) are common, but local populations may be reduced or removed by humans when they become a nuisance because they construct dams across streams and damage trees. The family Geomyidae is represented only by the southeastern pocket gopher, at the western edge of its geographic range (Merriam 1895; Harper 1952; Hall 1981). Southeastern pocket gophers are associated with rolling topography, sandy soils, longleaf pines (*Pinus palustris*), and turkey oaks (*Quercus laevis*). They also inhabit highway right-of-ways, parks, lawns, golf courses, orchards, cemeteries, and pasturelands. Their burrowing mixes and aerates the soil, and their burrows provide shelter for a variety of organisms (Best and Dusi 2014).

The most diverse family of rodents in North America and in the greater Mobile-Tensaw River area is Cricetidae. Each of the 10 species in this family occupies one or more habitats in the area, from aquatic and marshy (golden mouse, common muskrat, marsh oryzomys), to woodlands (woodland vole, eastern woodrat, cotton deermouse), to fallow agricultural fields and grasslands (white-footed deermouse, oldfield deer-mouse, eastern harvest mouse, hispid cotton rat). Although most are active at night, some also are active during daylight (woodland vole, common muskrat, hispid cotton rat). Most species use underground burrows or nests in vegetation for protection from environmental extremes, to escape from predators, to rest, and to rear young. In a study of small mammals in the upper Mobile-Tensaw Delta, Gay (2006) reported that the cotton deermouse (37 individuals), marsh
oryzomys (25), and hispid cotton rat (1) were the only rodents he encountered during intensive sampling in spring and summer of 2004 and 2005.

Eastern woodrats are somewhat exceptional for their elaborate denning sites (middens) constructed mainly of branches, twigs, and leaves, although they can also incorporate bones, cattle dung, aluminum cans, and shotgun shells. These middens may be 2 to 4 m (7 to 13 ft) wide and 1 m (3 ft) tall, built under rocky outcrops, in brush piles, at the base of large trees, in trees, or in abandoned buildings and motor vehicles. Middens may be maintained, modified, and occupied by generations of eastern woodrats, and they also are used as shelter by many kinds of animals (Best and Dusi 2014).

**Hares, Pikas, and Rabbits**

Three species of rabbits (swamp rabbit, eastern cottontail, marsh rabbit) occur in southern Alabama. The marsh rabbit has not been recorded from the greater Mobile-Tensaw River area, but is included here because of reported occurrence in southern Baldwin County (Hall 1981). Marsh rabbits occupy damp or swampy lowlands, marshes, and brackish-water areas (Chapman and Willner 1981; Chapman and Litvaitis 2003), all habitats present in the greater Mobile-Tensaw River area. Swamp rabbits primarily occur in swamps, floodplains, marshes, and lowlands, where they may construct shelters in vegetation, or they may use holes in the ground or in trees. Diet includes a variety of plants. Swamp rabbits are excellent swimmers and will readily take to water to avoid predators (Chapman and Feldhamer 1981; Chapman and Litvaitis 2003).

Eastern cottontails occupy diverse habitats, including urban areas, agricultural fields, hedgerows, shrublands, grasslands, swamps, and forests. Diet varies seasonally and consists of a variety of plant material, including woody and herbaceous species. Eastern cottontails are an important food for many raptors and mammalian carnivores. Shelters made by clearing sites under vegetation, especially under clumps of grasses, are used for shelter and hiding from predators (Chapman et al. 1980; Chapman and Litvaitis 2003).

**Shrews, Moles, Desmans, and Relatives**

Three species of shrews (southern short-tailed shrew, North American least shrew, southeastern shrew) and 1 species of moles (eastern mole) occur in the greater Mobile-Tensaw River area. All are common, but few are observed due to their small size, concealment in surface and subsurface habitats, and secretive nature. Southern short-tailed shrews occur in fallow agricultural fields, roadsides, grasslands, brushy areas, cane bottomlands, swampy areas, hardwood and mixed pine-hardwood forests, and dense thickets. Diet includes vegetative matter, slugs, snails, fungi, earthworms, insects, centipedes, spiders, and eggs of turtles (Genoways and Choate 1998; McCoy 2001).

North American least shrews often inhabit dry grassy, weedy, and brushy fields, but they may be present in marshes, woodlands, and forests with maples, oaks, and pines. Diet includes fungi, earthworms, centipedes, snails, slugs, spiders, and some plant material (Whitaker 1974).

Southeastern shrews occur in moist to wet areas, usually bordering marshes, swamps, or rivers. They also may be common in fallow or planted fields, dry upland hardwoods, planted pines, and dry sandy areas. Diet includes vegetation, slugs, snails, spiders, centipedes, and insects (French 1980a; 1980b).

Eastern moles inhabit moist, loamy, or sandy soils, and they are rare or absent in soils with dense clay, stones, or gravel. Woodlands and floodplains along rivers and streams are frequently occupied, but they may occur in grassy habitats and cultivated fields. Diet includes earthworms, insects, and some plant material (Arlton 1936; Yates and Schmidly 1978).

**Bats**

In southern Alabama, some species of bats are active throughout most of the year (e.g., eastern red bat, hoary bat, Seminole bat, Brazilian free tailed bat), including warm nights in winter. Some migrate (e.g., eastern red bat, gray myotis), and some become torpid or hibernate (e.g., big brown bat, Rafinesque’s big-eared bat [Figure 16-2], tri-colored bat). Of the 12 species of bats occurring in the greater Mobile-Tensaw River area, 7 are common, 4 are rare (hoary bat, northern yellow bat, Rafinesque’s big eared bat, little brown myotis), and 1 is endangered (gray myotis). There have been reports of parasites and rabies in bats with geographic distributions that include southern Alabama (e.g., White 1959; LaVal 1967; Best et al. 1993; Hilton and Best 2000; Hester and Best 2007). In the most thorough study of the region’s bats, Kilgore (2008) compiled data on relative abundance of 7 species of bats occupying different-aged forest stands.
in the Mobile-Tensaw Delta: Seminole bat (51 individuals), tri-colored bat (49), evening bat (32), eastern red bat (22), southeastern myotis (15), Rafinesque’s big eared bat (4), and hoary bat (2). Two other species (Brazilian free-tailed bat, big brown bat) are common in the region, but they often roost in buildings and other human-made structures, which were uncommon in Kilgore’s (2008) study area. In addition, Brazilian free-tailed bats fly high and fast (Wilkins 1989; Harvey et al. 2011; Best and Dusi 2014), possibly at altitudes much higher than where Kilgore (2008) obtained bats for his study.

Carnivores

Six families of carnivores represented by 14 species occur in the greater Mobile-Tensaw River area. Although carnivores are active during day and night, they generally are secretive and not easily observed (for example, the long-tailed weasel \([\text{Mustela frenata}]\), Figure 16-3). Common species such as bobcats, coyotes, gray and red foxes, North American river otters, American minks, striped skunks, and raccoons are seen more often as roadkills on highways than alive. The cougar has been extirpated in Alabama and the native subspecies \((\text{Puma concolor cougar})\) is believed to be extinct throughout its range in eastern North America (USFWS 2015b). There are many reports of tracks and sightings of cougars in Alabama, including a report of a breeding pair in northern Baldwin County in 1984 (Mount 1984), but whether these individuals are from a natural population or released captives is unknown (Best and Dusi 2014). Large black cats also have been reported throughout Alabama, but those large cats are not black cougars. During studies of geographic variation in cougars (Gay and Best 1995, 1996a, 1996b), no black...
cougar was observed among hundreds of specimens examined from throughout North and South America.

The occurrence of the jaguarundi in Alabama is questionable because no specimen from the state has been examined. Sightings may have been of escaped or released individuals, or of some other species of mammal (e.g., large domestic cat).

The last red wolf was killed in Alabama in 1917 (Nowak 1972), but the last record for Baldwin and Mobile counties was in 1894 (Howell 1921). Red wolves are critically endangered; the species now exists in the wild only as a re-introduced population in eastern North Carolina (e.g., Phillips et al. 2003).

Prior to the mid-1900s, American black bears probably occurred statewide in Alabama. Tracks, sightings, and other evidence indicate that a few individuals or small populations now exist throughout eastern and southern parts of the state. Currently, the only breeding populations appear to be in northeastern Alabama and in the greater Mobile-Tensaw River area (including parts of Baldwin, Clarke, Escambia, Mobile, and Washington counties). Diet is primarily vegetation, but insects, reptiles, birds, and mammals also are consumed opportunistically. In spring American black bears consume new growth of vegetation and winter-killed carrion. In summer they eat herbaceous vegetation and fruits, and in autumn they feed primarily on fruits and nuts. Adults have few predators, but young may be preyed upon by bobcats, coyotes, and other American black bears. Most mortality is caused by humans through shooting, trapping, and collisions with vehicles (Best and Dusi 2014).

Even-toed Ungulates
In the 1500s, Spanish explorers introduced wild boars into what is now the southeastern United States, from their native range in northern Africa, Europe, and Asia. Feral swine now occur statewide in Alabama and they are the most destructive invasive species in the state. They are omnivorous and will consume almost any type of plant or animal materials, including agricultural crops, food discarded by humans, carrion, small mammals, birds, turtles, snakes, and amphibians. By rooting large areas they have widespread negative impacts, including destruction of crops, property, archeological deposits, native fauna, and natural vegetation, as well as the disruption of soils, seed banks, tree roots, and natural succession.

In Alabama, humans are the only significant predators of adult feral swine (Sweeney et al. 2003; Best and Dusi 2014).

The white-tailed deer is a prized game species in the greater Mobile-Tensaw River area and throughout most of its geographic range. This species inhabits most terrestrial habitats, from fallow agricultural fields to dense forests. Diet includes agricultural crops (e.g., corn, wheat, soybeans, alfalfa, fruit trees), grasses, forbs, fruits, mushrooms and other fungi, and succulent leafy vegetation; acorns are readily consumed when available. White-tailed deer may cause significant damage to agricultural crops, orchards, nurseries, and ornamental plants in yards and gardens. In Alabama, they are the most economically important game species, with 300,000 to 500,000 white-tailed deer harvested each year (Smith 1991; Best and Dusi 2014). White-tailed deer cause considerable property damage through collisions with vehicles on roads, especially in rural areas.

Ever-increasing Threats
The greater Mobile-Tensaw River area is home to a biologically diverse fauna that is subject to ever-increasing threats from encroachment by humans, loss of habitats, changes in global climate, invasions by exotic species, and other environmental pressures. With about 58 species of mammals, the greater Mobile-Tensaw River area contains one of the richest mammalian faunas in Alabama. Increases in populations of humans and their associated domestic species (e.g., dogs, cats, cattle); construction of commercial and residential structures and paving of highways and parking lots; extension of power grids, utilities, and pipelines; applications of pesticides, fertilizers, and other chemicals; destructions of local flora and fauna by exotic species (e.g., wild boars); and other perturbations of this ecosystem, although of less consequence when assessed individually, add up to significant changes in our natural world. When coupled with what may seem to be incremental increases in global temperatures and changes in weather patterns, we should expect eventual reductions in some populations and loss of some species of mammals in the greater Mobile-Tensaw River area.

Mammalian species especially vulnerable to human-made environmental changes in the greater Mobile-Tensaw River area include the West Indian manatee, southeastern pocket gopher, marsh rabbit, Brazilian
free tailed bat, Rafinesque’s big eared bat, gray myotis, little brown myotis, American black bear, North American river otter, long tailed weasel, American mink, eastern spotted skunk, and white tailed deer. Personnel of local, state, and national agencies and organizations, landowners and land managers, and other informed citizens must work together if we are to preserve our natural heritage for future generations.
CULTURAL LANDSCAPE

Alabama River, Dallas County, Alabama. Photograph courtesy of Hunter Nichols.
The other chapters in this volume illustrate many ways in which the greater Mobile-Tensaw River area is exceptional—ecologically, biologically, and geologically. Superlatives also apply culturally, in the myriad ways humans have adapted to, made use of, and lived within this unique environment. For a millennium or more this area was a fulcrum of cultural interaction, a major node on overland and canoe trails emanating from the continental interior and coastal societies to the east and west.

**Bottle Creek**

The most significant site at this intersection was the complex of monumental and residential earthworks known as the Bottle Creek site (1BA2 [Smithsonian-trinomials to identify archeological sites are provided]) (Bigelow 1853; Jones and DeJarnette 1933; Waselkov 1993; Brown 2003a). As 1 of only 2 prehistoric-era National Historic Landmark properties in the state (Moundville is the other), Bottle Creek originated around AD 1250, and is characterized by a plaza and at least 20 mounds built atop a seasonally inundated island (Figure 17-1). There is no other site like it in scale on the central Gulf Coast, and no other coeval mound complexes (of any scale) within the greater Mobile-Tensaw River area.

Bottle Creek served as principal town for the Pensacola culture, which spanned the greater Mobile-Tensaw

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**Figure 17-1.** Topographic map of the Bottle Creek mounds (1BA2) (Waselkov 1993). Since creation of this map, several additional mounds have been discovered. (Image credit: Sarah Mattics, Center for Archaeological Studies, University of South Alabama.)
River area, westward along the Mississippi coast, and eastward along the Florida panhandle (Stowe 1985; Fuller and Brown 1995; Brown 2003a). The Pensacola culture, like other chiefly societies that flourished circa AD 1200 to 1550, was organized internally by social inequality that is partly reflected in the Bottle Creek settlement pattern. Five large mounds—the biggest one being a flat-topped pyramidal earthwork standing 16 m (52 ft) high—enclose an open plaza. The mounds themselves were platforms for residences occupied by members of a hereditary elite who served as sociopolitical and religious community leaders. Surrounding the plaza and its ring of large mounds were numerous, smaller residential mounds that arose gradually from the accretion of household refuse. Inhabitants of these residential mounds are thought to have served as retainers to the elite of the central mounds.

No matter their social rank, all of the site’s occupants consumed the same kinds of foods, with a heavy emphasis on corn (maize, Zea mays), brackish water clams (Rangia cuneata), and vast quantities of seasonally available small schooling fish of the Clupeidae family, like shad (Alosa sapidissima) and menhaden (Brevoortia patronus) (Quitmyer 2003; Scarry 2003a, 2003b). Corn was brought to the site off the cob, as shelled kernels, perhaps as tribute from the lowest social class living elsewhere, presumably at the non-mound sites of this era scattered throughout the greater Mobile-Tensaw River area (Brown 2003b). Internal social differences are further suggested by differences in ceramic vessels resulting from food preparation by nobility at the residential mounds, slated for consumption by the paramount elites on the larger mounds (Johnson 2003). The presence of yaupon holly (Ilex vomitoria) at the accretional mounds provides a clue to elite religious activities at the complex, as yaupon leaves were used to brew the caffeinated Black Drink—principal ritual beverage of Pensacola and other similar Mississippian cultures.

Use of the Bottle Creek site declined by AD 1550, although the cause of this eclipse is unknown. Cycles of social formation and dissolution were a regular part of the Southeastern cultural landscape throughout the first half of the 2nd millennium AD, due to a variety of interacting social and environmental factors. Moreover, we now know that diseases introduced to the region by European explorers of the 16th century devastated indigenous populations and contributed to the collapse of chiefly power structures and cessation of monumental earthen construction (Dobyns 1983; Ramenofsky 1987).

Short-term and long-term processes that led to the genesis of Bottle Creek remain murky. Indeed, the archaeology of the greater Mobile-Tensaw River area is very poorly understood. The few research projects undertaken there offer us a patchwork of vignettes scattered across a multi-millennial timeline (Figure 17-2). Consider, for example, what we do not know about Bottle Creek. The place surely was occupied seasonally because of the Delta’s regular, predictable inundation every spring (Curren 1976; Knight 1984; Brown 2003b). Where did the site’s occupants reside during those inhospitable months? A partial answer may be found at the Crossroads Mounds site (1BA356), which consists of 3 small earthen mounds arranged in an approximate equilateral triangle, perched on the eastern bluffs overlooking the Tensaw River on land owned by the US Army Corps of Engineers (Figure 17-3). Two private archeological companies have conducted surveys in the vicinity of the site in the last 2 decades (Mozingo and Whitley 2000), but the age of this site remains uncertain. It may be affiliated with the Pensacola culture, and thus linked to Bottle Creek, or the site may predate Bottle Creek by as much as 1100 years. Similarly, Bottle Creek’s chiefly rulers are thought to have dominated non-mound and single-mound Pensacola centers in Mississippi and northwest Florida (Knight 1984; Bense 1994, p 234-8; Blitz and Mann 2000), yet insufficient research has occurred to test that hypothesis. Thus it remains unclear if Bottle Creek represents the apex of a 3-tier or 2-tier settlement system, or if it sits in isolation as Moundville’s “gateway” community near the Gulf Coast (Brown 2003b).

A systematic and thorough exploration of such ancient social dynamics is one area of research that will prove fascinating in the years ahead. Future research should include a consideration of Bottle Creek’s relationship with the next closest society of comparable size and age—Moundville, located in the Black Warrior River valley—particularly with respect to architecture and other types of evidence unavailable in prior years. It also should consider how Bottle Creek articulated with the non-mound habitation sites found throughout the Mobile-Tensaw Delta and surrounding uplands. Studies conducted already provide some tantalizing clues. Many researchers, for instance, suspect that the Bottle Creek complex was a
Moundville development or intrusion (e.g., compare DeJarnette 1952; Sears 1977; Brose et al. 1983; Fuller and Brown 1998, p 88; Brown and Fuller 1999; Brown 2003b; Fuller 2003). This argument is based mostly on comparable early ceramic types and the lack of a significant older occupation at Bottle Creek. Intriguingly, a study of animal remains at Bottle Creek identified a single snail (*Elimia hydei*) endemic to the Black Warrior River valley (Quitmyer 2003), which conjures an image of this tiny mollusk clinging to a southbound dugout canoe traveling down the Tombigbee River to the Mobile-Tensaw Delta.
Figure 17-3. Field Sketch of the Crossroads Mound (1BA356) when initially recorded in 1998 by Richard S. Fuller, David W. Morgan, and Jack W. Morgan (on file at the US Army Corps of Engineers, Mobile District Office). This is one of the only sites in the area besides Bottle Creek (1BA2) that exhibits multiple platform mounds, but its age and relationship to the larger mound complex remains unclear.
Little Lizard Creek

To date, excavations at just a few archeological sites in the estuary proper—Little Lizard Creek (1BA195) and D’Olive Creek (1BA196 and 1BA251)—afford us a view of Pensacola culture life outside the mound center (Curren 1976; DeJarnette and Nielsen 1976; Knight 1984; Morgan 2003a). Information from older Late Woodland period (circa AD 400 to 1200) sites (Shorter 1999; Detwiler 2000; Morgan 2001, 2003a; Dumas 2007) suggests a great deal of continuity in the ways the inhabitants of the greater Mobile-Tensaw River area exploited the Delta estuary and adjacent uplands. During the Late Woodland period, people lived at small villages or hamlets in the estuary during the summer and early fall, and in the uplands on a seasonal or permanent basis. While in the Delta, they collected clams (Rangia cuneata comprised 99% of the mollusks eaten at Little Lizard Creek) and netted a specific suite of seasonally abundant, small freshwater and brackish water fishes (7 taxa at Little Lizard Creek; 98% of the fish vertebrae recovered are smaller than 6 mm [0.2 inch] in diameter). Turtles were also favorite targets, and medium-sized mammals making use of the forested wetlands, such as raccoon, were probably collected opportunistically. Fruits, nuts, and wild and domesticated indigenous plants complemented the animal portion of the diet. Corn was grown in minor amounts for the first time in the greater Mobile-Tensaw River area after circa AD 400, probably in small garden plots in and among dwellings, and became a food staple after circa AD 900 (Curren 1976; DeJarnette and Nielsen 1976; Knight 1984; Gremillion 1993; Detwiler 2000; Morgan 2001, 2003a, 2003b; Scarry 2003a, 2003b).

Notable against this backdrop of almost 1100 years of continuity are subtle variations in fish and clam exploitation that tell us a great deal about prehistoric life. For instance, around AD 1100, roughly coincident with the initiation of mound construction at Bottle Creek, clam sizes in the midden at the Little Lizard Creek site shrank significantly, suggesting people were taking smaller and smaller animals, intensifying pressure on clam beds to a point where clam populations were unable to reach their prior size before being harvested (Morgan 2003a). This hypothesis matches data drawn from the oldest Pensacola culture clam refuse at Bottle Creek (Quitmyer 2003). Around this same time corn shifted from a minor dietary component to a dominant cultigen at Pensacola culture sites throughout the greater Mobile-Tensaw River area. It is probably no coincidence that these two subsistence intensifications occurred at a time of population growth, influx, and reorganization accompanying the genesis of Bottle Creek.

Earliest Human Use of the Greater Mobile-Tensaw River Area

Some of the biggest gaps in our understanding of the ways humans used the greater Mobile-Tensaw River area relate to the periods preceding the Late Woodland. Not surprisingly, we know the least about the oldest inhabitants of southwest Alabama. We suspect people entered the greater Mobile-Tensaw River area approximately 12,000 years ago, as we know they did elsewhere in the Southeast (Anderson and Sassaman 1996). But, aside from isolated stone projectile points or knives found on the hills overlooking tributary creeks, no archeological sites from these early years have yet been identified (Trickey and Holmes 1971). The most ancient archeological sites within the estuary were destroyed as rivers meandered over thousands of years, or now lay deeply buried under later flood deposits within the Delta or submerged off our present coast by early Holocene climate change and rising seas (Trickey and Holmes 1971; Curren 1976).

The oldest human occupations documented in the Delta date to the Late Archaic and come primarily from shell middens on the south side of Tensaw Lake, specifically sites named Bryant’s Landing 3 and 4 (1BA176 and 1BA175, respectively; Figure 17-4) (Trickey and Holmes 1971). The Late Archaic period (circa 4000 to 1400 BC) in the Southeast in general represents a culmination of trends from the preceding 4 millennia: populations expanded, regional differentiation continued, and social complexity became increasingly elaborated. Mound construction occurred at a scale never before seen in North America, and some Late Archaic sites are considerably bigger than those of prior eras. Inter-community exchange heightened noticeably as large quantities of non-utilitarian goods were moved great distances. The increasingly specialized Late Archaic tool kit reflects their ability to exploit virtually all available major food resources. In the upland Southeast by 2000 BC, exploitation of wild plant foods resulted in domestication of several weedy species, providing important additions to the subsistence regime (Cowan 1985; Ford 1985a, 1985b; Yarnell and Black 1985; Smith 1989, 1992a, 1992b, 1995; Yarnell 1989, 1993; Watson 1991; Chapman and Watson 1993; Scarry 1993).
The Late Archaic in the greater Mobile-Tensaw River area presumably parallels these trends observed elsewhere, although we have few data from which to draw conclusions. People first began using the Bryant’s Landing 4 site for clam exploitation around 2100 BC. Other people took up residence at the site in the Gulf Formational period (the Bayou La Batre culture), the Middle Woodland period (Porter Hopewell culture), the Late Woodland period (Tate’s Hammock, Coden, and Tensaw Lake cultures), and the Mississippi period (Pensacola culture). This is one of the most archeologically informative sites recorded in the Mobile-Tensaw Delta to date because of its long use and stratigraphic layering. (Photo credit: David W. Morgan.)

Evidence from the Early Gulf Formational (circa 1400 BC to AD 100) has been revealed by excavations at the Coon Neck site (1BA290), located on Douglas Lake in the northeast portion of the delta (Stowe 1990), and at the View Point site (1BA281) on the southeastern shore of Mobile Bay (Stowe 1990; Fuller 1998, p 7). The former site, which rests atop an old terrace and dates roughly to the 14th century BC, has fiber-tempered pottery, steatite vessels, stone points, and other features. The latter site, which is very similar in its overall layout and characteristics, may represent an earlier phase of occupation.

In the greater Mobile-Tensaw River area, the Late Archaic is often interpreted as ending around 1400 BC with the introduction of fiber-tempered ceramics. To highlight the transition to a ceramic technology, the time between Late Archaic and Woodland periods in the South has been dubbed Gulf Formational (circa 1400 BC to AD 100). Sites of this time period can be difficult to distinguish from Late Archaic sites without excavation. Gulf Formational sites tend to be smaller, were used less intensively, and lack evidence for long-distance inter-community material exchange. Settlement patterns generally remained the same, and there were few elaborations to tool assemblages, treatment of the dead, or other aspects of material culture. Pottery became increasingly diverse in terms of vessel forms (and presumably functions) and decorative treatment.
and other tools. View Point had a buried peat layer, which has since eroded into the bay. Fuller (1998, p 7) reported a calibrated radiocarbon date for the peat layer in the 1200s BC. Collections at low tide by avocational archaeologists produced several hundred sherds of grit-tempered pottery, a minor amount of fiber-tempered pottery, stemmed projectile points/knives, ground and polished stone objects, and steatite vessel fragments.

By the Late Gulf Formational period (circa 700 to 100 BC) 4 major pottery traditions had spread across the Southeast. The Gulf Tradition is represented in the greater Mobile-Tensaw River area by Bayou La Batre culture, with sites in the Delta and as far north as the lower Tombigbee drainage (Bense 1994, p 127; Brown 2004a). Most of what we know about it relates to its pottery, which consisted chiefly of grit tempered vessels, often adorned with small feet (called “podal supports”), either left plain or decorated with stabbing and drag incisions or dentate rocker stamping (Wimberly 1953, 1960; Bense 1994, p 124-30; Fuller 1998; Brown 2004a). Excavations are limited to units dug in several stratified sites, including the Blakeley site shell middens (IBA229) at the head of Mobile Bay (Stowe 1977); Bryant’s Landing 3 and 4 (Trickey and Holmes 1971); the Griffin site (ICK45) in Clarke County (Chase 1972; Brose et al. 1983); the Bayou La Batre Shell Midden (1MB12-14) (Wimberly 1960, Table 18); and on the eastern bluffs of the delta at the Hamilton Creek site (IBA354) (Morgan 2003a). Research at these sites has focused on pottery and stone tool types, with little attention devoted to questions of estuarine-adaptation, settlement pattern, subsistence, mortuary ritual, or social organization.

**Life in the Greater Mobile-Tensaw River Area during the Woodland Stage**

Our portrait of prehistoric life in the greater Mobile-Tensaw River area in the subsequent Woodland stage is somewhat more detailed. There are several hallmarks of life in the region during the Woodland period, spanning *circa* 100 BC to *circa* AD 1000. One was the use of pottery for cooking on a daily basis, as well as accompanying innovations in pottery manufacturing and decoration. Another was the gradual introduction of corn, and a third was a change in stone technology, including introduction of the bow and arrow from the Plains. All of these changes influenced technological, economic, political, and social developments in the Southeast.

The Woodland stage in the Mobile-Tensaw River Basin begins with what is considered the Middle Woodland period (AD 100 to 400) elsewhere in the Southeast. It is distinguished from the Late Gulf Formational by the general trends noted above, and because of a noticeable increase in interregional exchange and interaction related to the Hopewell Interaction Sphere. Beginning in the 1st century AD, new sacred information, iconography, and artifacts diffused throughout eastern North America from several core areas in the Ohio and Illinois river valleys. Hopewellian traits disseminated as far north as southern Ontario and Maine, south down the Atlantic Coast to middle Florida, and west to Kansas City. Unlike Archaic cultural elaborations, which were gradual and encompassed all aspects of life, the Middle Woodland Hopewell phenomenon appears to have been restricted mainly to religious, ceremonial, and mortuary activities. In the core areas of the Midwest the Hopewell concept may well have been holistically transformative, but in the greater Mobile-Tensaw River area, on the southeastern Hopewell periphery, these religious paraphernalia appear to have been incorporated into otherwise local traditions.

In the Hopewell core, elaborate mortuary ritual included crypt burials or pit tombs in earthen mounds, with one or multiple bodies placed with specialized grave goods obtained through long-distance exchange. Burials often were associated with charnel houses, designed to house the dead and ritual participants, built on earthen platforms or enclosed by geometrical earthworks. Based on burial analysis, Hopewell is thought to represent a “big person” society, in which charisma and ability, structured within a kin and lineage system, enabled certain individuals to acquire and conspicuously redistribute wealth, thereby enhancing their own and their lineage’s prestige and social status. A kin-group’s achieved rank was ephemeral and could shift with the death of individual leaders. Each Hopewell community appears to have been autonomous, with no overarching political structure (Service 1962; Dragoo 1963; Sahlins 1963, 1968, 1972; Caldwell and Hall 1964; Prufer 1964; Brown 1979; Goad 1979; Seeman 1979a, 1979b, 1992; Braun 1986; Webb and Snow 1988; Clay 1992; Pacheco 1996).

On the Gulf Coast, evidence of the Hopewell Interaction Sphere takes the form of small conical mounds, usually 1 to 2 m (3 to 7 ft) tall and about 15 m (49 ft) in diameter, with northwest Florida and the greater
Mobile-Tensaw River area being the two areas most heavily influenced and perhaps interconnected (Brose 1979; Walthall 1990, p 156; Brown 2004a). The local manifestation in the greater Mobile-Tensaw River area, and extending into the lower Tombigbee valley, is the Porter culture. Walthall (1990, p 155-65) suggested that Porter people employed two settlement types and two distinct modes of burial. There were short-term occupations within the Delta, bay, and coast focused on exploitation of the estuary and represented by shell middens, such as Bryant’s Landing 4 (Trickey and Holmes 1971). And there were upland communities, such as Porter Village (1CK21) and McVay Village (1CK1), which focused on hunting and collecting plant resources from adjacent swamps (Wimberly 1960). The latter sites cover several hundred square meters and, unlike the lowland sites, contain middens bearing sparse numbers of mollusks but relatively abundant quantities of stone artifacts. It is unclear if these upland sites were seasonal or longer-term occupations.

Porter Hopewell burials were interred within habitation sites and within burial mounds away from residential areas (Walthall 1990, p 160). The best known of the mound sites is McQuo-rquodale (1CK25), north of the Delta, near modern day Jackson, Alabama (Wimberly and Tourtelot 1941; Walthall 1990, p 158). There Porter people constructed a conical mound, about 1 m (3 ft) high and 20 m (66 ft) in diameter, that covered a smaller earthen platform. Ten individuals were buried in the mound/platform with copper adornments, galena and mica, ground stone celts, and other exotic, non-local materials. Sites along the lower Tombigbee River contain fewer burials placed on the ground before being covered with dome-shaped mounds (Brown 2004a). In contrast, at places like Porter Village and the Blakeley site burials were found within the middens, seemingly with no or few exotic funerary goods (Moore 1905; Stowe 1977).

The influence of Hopewell ideology waned across the Southeast after AD 400, while other aspects of life continued much as they had in prior centuries. With the loss of this shared ideology, it is perhaps no surprise that the Late Woodland period is characterized by greater regional variability. Gulf Coast societies continued to interact on a local level, with the Weeden Island culture adapting and evolving from the prior Porter culture in the greater Mobile-Tensaw River area, and the Santa Rosa-Swift Creek culture developing in the Florida panhandle. Many aspects of the preceding Porter and Swift Creek cultures continued, including modes of settlement, subsistence, and mortuary ritual. Some well-known examples are the elaborate Kolomoki and McKeithen mound complexes to the east in southwest Georgia and the Florida panhandle (Sears 1956; Milanchich et al. 1984; Milanich et al. 1997; Williams and Elliot 1998). Within the greater Mobile-Tensaw River area, Late Woodland mortuary ritual on the coast is represented by small sand mounds, such as those at Seymour’s Bluff (Figure 17-5), many of which are now lost to development (Moore 1905; Fuller 1998; Morgan 2005).

Figure 17-5. Example of a small, circa AD 400 to 700 Weeden Island pot excavated from the Late Woodland period Seymour (Parkway) Mound (1BA80) complex in the 1930s by the Alabama Museum of Natural History. This is 1 of 3 whole vessels believed to have been unearthed by David L. DeJarnette and John L. Bruckner, along with a crew of 6 men, who dug a test trench into mound 1BA80 in 1937. Their photo catalog labels (1933.010.366, 1933.010.367, and 1933.010.368) cause some ambiguity as the 1933 prefix appears to reference the year the museum director, Walter B. Jones, visited the site. The 1937 acquisition date is likely correct, as Jones made only surface collections while DeJarnette and Bruckner’s methods would have been more likely to yield intact vessels. (Image credit: Eugene Futato, Office of Archaeological Research, Moundville, Alabama.)
Judging from the variability in Late Woodland pottery styles, there appear to have been many cultures on the central Gulf Coast, and “influences seem to have come from all directions simultaneously, as very different groups chose to occupy the Mobile Basin” (Brown 2004a). The lower Tombigbee people who worked the salt springs of Clarke County seem relatively distinct in terms of pottery and, thus, may have been newcomers from the Alabama and Coosa river valleys (Brown 2004a; Dumas 2007). Small Weeden Island sites became common along tributaries in the Florida panhandle around AD 700, and this has led to speculation that intensification of corn horticulture prompted a population expansion and migration into the greater Mobile-Tensaw River area (Milanich et al. 1997; Lolley 2003). Local traditions continued, represented by relatively numerous Tates Hammock phase (AD 400 to 750) clam shell midden deposits in the Delta and oyster midden deposits on the Bay (Figure 17-6). Similar sites are known from the subsequent Coden (AD 750 to 1100) and possibly Tensaw Lake (AD 850 to 1100) phases (Fuller 1998; Brown 2004a).

**Summary**

Archeological research in the greater Mobile-Tensaw River area has created a chronological and spatial framework that can now support more robust anthropological inquiries about early Native American residents. Where researchers have looked beyond basic culture history, at places like Bottle Creek, they are revealing the intricate and complex lives of the region’s original inhabitants.

But there is so much more to be learned. Exciting patterns in the archeological data are materializing that merit intensive scrutiny and the application of new analytical techniques in the years ahead. For instance, evident in the greater Mobile-Tensaw River area are vacillations between periods of great inter-regional interaction and status building with periods of regionalism and egalitarian social organization, a pattern seen elsewhere in the Southeast. It will be fascinating to search for the reasons for these long-term patterns as they were expressed in southwest Alabama. Viewed from a geographical perspective, the greater Mobile-Tensaw River area appears to have been a prehistoric cultural frontier, a fulcrum on which societies to the east and west met in a precarious balance. How did local peoples mediate that frontier? Notions of creolization may be worth applying to such pre-modern culture contact situations.

The greater Mobile-Tensaw River area’s past affords an ongoing opportunity to address the most contemporary of issues, as the archeological record has the unique ability to let us study human behavior across thousands of years against the backdrop of this particular natural environment. Climate change, immigration, population growth, resource depletion, and social inequality are just some of the issues to which these data can speak.
Hernando de Soto’s failed effort to conquer southeastern North America for Spain had broad and long-lasting repercussions for the region’s indigenous peoples and their environment. Even though the climactic battle at Mabila, where Chief Tascalusa ambushed and nearly destroyed the conquistadors in 1540, took place probably some distance north of our study area (Knight 2009), native societies peripheral to the invasion route experienced population declines, collapse of chiefly power structures, an end to earthen platform mound construction, and abandonment of many agricultural fields, towns, and hunting territories. Over the following century and a half, descendants of the Mississippian peoples reorganized their societies and landscapes in novel ways that enabled them to withstand later colonizing efforts by Europeans.

Evidence of the Earliest Mobilians
Archeological surveys have identified clusters of small sand burial mounds in the upper Delta and adjacent uplands that date to the late 16th and early 17th centuries (Stowe 1978, 1981, 1982; Brose et al. 1983; Fuller et al. 1984; Butler et al. 1997; Fuller and Brown 1998, p 146-7). Neither these mounds nor their associated village sites have yet been scientifically investigated. However, second-hand Spanish accounts between 1675 and 1693 reported many towns crowded into the lower Alabama River area (Waselkov and Gums 2000, p 7). Among these relocated nations—refugees fleeing home lands further north to escape slaving raids by interior tribes (Ethridge 2010)—were the Mobilians, who moved south to the Mobile-Tensaw Delta sometime in the mid-17th century (Knight and Adams 1981; Lankford 1983; Goddard et al. 2004). Mobilians discouraged a Spanish emissary from visiting their towns in 1686 due to a drought “so severe that although they had cultivated the ground they had secured no crop and all had dried and for many days they had sustained themselves on shellfish” (Boyd 1937).

Establishment of the Louisiane Colony and Old Mobile
When a French expedition arrived on the Gulf Coast in 1699 to establish the Louisiane colony, colonists quickly established military and trade connections with the Mobilians and the Tomés, whose villages occupied high bluffs on the west banks of the upper Mobile and lower Tombigbee rivers, respectively. Mobilian and Tomé women cultivated extensive fields of maize, beans, squash, and other cultigens on the east banks of those rivers, on natural levees bordering the bottomland islands of the delta. However, as native populations declined rapidly in following years from exposure to newly introduced Old World diseases, French colonists reclaimed abandoned fields and the rich soils of former Indian settlements for their plantations (Figure 18-1; Potter and Waselkov 1994; Waselkov 1997; Waselkov and Gums 2000, p 7-21).

After an initial tentative settlement on Biloxi Bay, in 1702 the French established Mobile as their colonial capital, at Twenty-seven Mile Bluff on the Mobile River, just downstream from the largest Mobilian village. With its formal European-style town grid covering about 40 ha, Old Mobile, as it came to be known after abandonment in 1711, was the first colonial town in the northern Gulf Coast (preceded only by failed settlement attempts by Luna in 1559 and LaSalle in 1685, and by the successful Spanish military outpost at Pensacola in 1698). This important archeological site has been intensively studied since 1989 (Waselkov 1991, 2002, 2005; Moussette and Waselkov 2013, p 376-92), and has been determined eligible by the Secretary of the Interior for designation as a National Historic Landmark (NPS 2001). The French selected this location for their capital for many of the same reasons that led the Mobilians, and before them the Mississippian at Bottle Creek, to settle near the heart of the Mobile-Tensaw Delta. With the confluence of 2 major river systems not far to the north, this place controlled major canoe routes into the heart of the continent. And Delta soils were the most productive, by far, for agriculture in the entire region, since silt naturally deposited by flooding annually renewed soil fertility. Less appreciated by the French was the continuing sacred significance of the Bottle Creek mound site to the Mobilians. In a brazen act of desecration, early in 1702 Governor Iberville’s
brother, Jean Baptiste Le Moyne de Bienville, paid a Mobilian a musket . . .

. . . to show him the place where their gods are.

. . . It took a search to locate them on a little hill among the canes, near an old village that is destroyed, on one of these islands. The gods were brought here. They are 5 images—a man, a woman, a child, a bear, and an owl—made of plaster . . . We have them at the settlement. The Indians who see them here are amazed at our boldness and amazed that we do not die as a result.

Iberville determined to take these statues, stolen from a temple atop one of the small mounds on the periphery of Bottle Creek, to France, although he considered them “not particularly interesting” (McWilliams 1981, p 168-9). Despite this sacrilege, the Mobilians continued to venerate the ancient site, and excavations there revealed the residence of a native priest occupied well into the 1730s (Silvia 1998; Brown 2003a). But the French had symbolically challenged the old religion and, with their church at Mobile and chapels at several missions, introduced Roman Catholicism to the region.

Salt and Trade

Salt was another local resource exploited by humans for at least a thousand years, processed from saline springs in the lower Tombigbee River valley. Archeological investigations in southern Clarke County at the upper, middle, and lower salt works, centered on a large hill called Salt Mountain, reveal intensive exploitation by Late Woodland and Mississippian peoples (Spanos 2006; Dumas 2007; Brown 2009). Salt becomes a critical resource as subsistence shifts to fulltime farming, which probably inspired the agricultural Mississippian to colonize the northern Gulf Coast in the first place (Brown 2004b; Brown 2009, p 114-5). Tomés and Choctaws continued to exploit these salines in the colonial period, as did the region’s 19th-century inhabitants (Figure 18-2).

Until the French ceded this portion of Louisiane to the British in 1763, they maintained substantial trade
with native societies of the region for deerskins, pelts of furbearing mammals, and foodstuffs like maize, dried fish, venison, and bear oil (Usner 1992; Waselkov 2004; Miller Surrey 2006). In fact, Mobile (relocated by the French in 1711 to the area of the modern city’s downtown) became increasingly important as a market for the region’s Native Americans and remained so for at least 2 centuries (Waselkov and Gums 2000, p 35-44). In the early 18th century, French willingness to treat and trade with all indigenous societies led many petites nations to seek refuge in the Mobile area, including elements of the Apalachees, Chatos, Towasas, and Taensas. French households held enslaved members of the Chitimachas, Alabamas, and other distant nations, and French traders ranged widely among the Creeks, Choctaws, Natchez, Tunicas and a multitude of other peoples. In this remarkably diverse linguistic environment, with over 20 native languages, a pidgin known as Mobilian (distinct from the language of the Mobilian people) became the lingua franca for intercultural relations (Crawford 1978; Drechsel 1997).

**African Slaves**

Forced immigration of enslaved Africans, mainly from Senegambia, to Louisiane began on a large scale in 1719 (Hall 1992; Berlin 1998), coinciding with the establishment of large plantations by wealthy French colonists. West Africans were particularly sought for their knowledge of indigo and rice cultivation (Wood 1974; Carney 2001), which, along with maize and small acreages of cotton, sugar, and tobacco, formed the basis of crop husbandry throughout the 18th century. But plantation economies in the region were diverse and relied equally on forest products and cattle raising (another skill common among West Africans). Later British and Spanish plantations emulated the earlier French “long lot” plantation configuration, stretching inland from a waterway to provide each one with river access, floodplain arable soils, and either upland or bottomland forest (Figure 18-3; Fabel 1988; Rea 1990).

**The British Colonial Period**

We are fortunate to have two exceptional travelers’ accounts of the region’s natural and cultural landscape from the British colonial period. Bernard
Figure 18-3. Numbered long lot plantations in the Mobile-Tensaw Delta area, detail from “A Plan of part of the Rivers Tombecbe, Alabama, Tensa, Perdido & Scambia in the Province of West Florida,” by David Taitt, circa 1771. (Image credit: Library of Congress, Geography and Map Collection, Washington DC; G3971.P53, 1771.T3 Vault.)
Romans described a 1772 hurricane that devastated the LaPointe-Krebs plantation, and the great botanist William Bartram spent the summer of 1775 exploring the Mobile-Tensaw Delta from his base at the Farmar plantation (Harper 1958, p 250-66, 277-8; Waselkov and Braun 1995, p 93-8; Romans 1999, p 90-1). Colonial plantations here were restricted to the west side of Mobile Bay, the Mobile-Tensaw Delta, and up the Tombigbee River to McIntosh Bluff. Archeologically investigated sites include the Rochon-Demouy-Hollinger plantation (circa 1725 to 1848) at the mouth of Dog River; the Augustin Rochon plantation (circa 1750 to 1781) at the edge of the lower delta in modern day Spanish Fort; the LaPointe-Krebs plantation (circa 1717 to 1940) in Pascagoula, Mississippi; and the Badon plantation (1763 to 1780) in Blakeley State Park, on the site of an earlier Apalachee village and mission from 1733 to 1763 (Gums and Waselkov 1997, 2015; Gums 2000; Waselkov and Gums 2000). These sites confirm the varied basis of colonial economy, with an abundance of cattle remains, vats for tanning cowhides, and pitch and tar processed for naval stores from the region’s abundant pines. Live oaks were valued for ship’s knees, and pines for masts and spars, while pine, cypress, and oak were exploited for clapboards, shingles, and barrel staves. British and Spanish colonists constructed water-powered sawmills (which could double as gristmills and cotton gins), such as Lizar’s mill near Twenty-one Mile Bluff. Early Americans built others, including Hinson and Kennedy’s mill on Rain’s Creek near Stockton (Brooms and Smith 1996; Waselkov and Gums 2000). These sites confirm the varied basis of colonial economy, with an abundance of cattle remains, vats for tanning cowhides, and pitch and tar processed for naval stores from the region’s abundant pines. Live oaks were valued for ship’s knees, and pines for masts and spars, while pine, cypress, and oak were exploited for clapboards, shingles, and barrel staves. British and Spanish colonists constructed water-powered sawmills (which could double as gristmills and cotton gins), such as Lizar’s mill near Twenty-one Mile Bluff. Early Americans built others, including Hinson and Kennedy’s mill on Rain’s Creek near Stockton (Brooms and Smith 1996; Waselkov and Gums 2000, p 63-70; Smith 2008, p 102-8).

From British to Spanish to US Control

The greater Mobile-Tensaw River area changed hands from British to Spanish control in 1780-1781 with the conquest of British West Florida by Spanish General Bernardo de Gálvez (DuVal 2015). Each change in government increased the region’s ethnic diversity, as British, then Spanish colonial families joined and intermarried with long-established French residents. In 1799 the United States acquired lands north of 31° longitude, a line established by surveyor Andrew Ellicott that bisected the Mobile-Tensaw Delta. A stone demarcating the Ellicott Line between Spanish Florida and Mississippi Territory still stands in modern day Axis. Although ostensibly everything between that international border and Tennessee belonged to the US, American settlers were in fact hemmed in by the sovereign Choctaw and Creek nations, within boundaries confirmed by treaties in 1765.

The Americans established Fort Stoddert (in modern day Mount Vernon) on the Mobile River as their military and administrative seat once Spain transferred the Tensaw and Tombigbee districts to US control. Not until April 1813 did the US Army seize Mobile and the rest of the modern day Alabama coast from the Spanish. Several archeological excavations in downtown Mobile, particularly at the Gulf Coast Exploreum Science Center, have revealed important aspects of the city’s colonial and early American occupations (Harris and Nielsen 1972; Sheldon and Cottier 1983; Gums and Shorter 1998). Mobile at that time had a majority black population, including a substantial number of free blacks (Brown 2001). Completion in 1811 of the Federal Road, a military and postal road from Milledgeville, Georgia, to Fort Stoddert, opened the region to massive immigration across the Creek Nation from the southern states (Christopher and Waselkov 2012). This immigration quickly shifted the city’s demographics and strained relations between the Creek Indians and their American neighbors.

The Redstick War and Alabama Fever

In the summer of 1813, amid the War of 1812 between the US and Great Britain, a civil war in the Creek Nation spilled over the border into Mississippi Territory with the destruction of Fort Mims by the Redstick faction of the Creek Nation. This conflict, known as the Redstick War of 1813-1814 (also known as the Creek War), transformed the southern social landscape. Within 7 months, US armies invaded the Creek Nation from south, east, and north and crushed the Redstick movement. General Andrew Jackson imposed a 21-million-acre land cession on the Creeks, which opened large portions of Georgia and Alabama to American settlement. Jackson’s success against the Creeks led to his command of US forces defending New Orleans and a victory that propelled him to the Presidency. In 1830, at Jackson’s urging, Congress passed the Indian Removal Act, which forcibly evicted most Native Americans from lands east of the Mississippi River. So the Redstick War had immense repercussions for American history. The site of Fort Mims is now a 5-acre state park and has been intensively investigated archeologically (Waselkov 2006; Waselkov et al. 2006).
Alabama Fever, a land rush complete with boom towns, followed in the wake of the Redstick War. East of the lower Mobile-Tensaw Delta, the town of Blakeley briefly competed with Mobile and for a time boasted thousands of residents, but declined just as quickly in the wake of a yellow fever outbreak (Stowe 1977). On the lower Tombigbee River, the town of St. Stephens experienced similarly rapid growth. From 1817 to 1819 it served as capital of Alabama Territory, but declined precipitously with statehood and loss of capital status to Cahawba (Lewis 2014). Both of these remarkable archeological sites are now state parks, although perpetually underfunded, underdeveloped, and generally underappreciated.

In the 1820s, Mobile’s economy benefited enormously from the rise of cotton plantations on the Black Belt soils of central Alabama, reflected in the proliferation of cotton warehouses near the city’s waterfront (Gums and Shorter 1998; Gums 1999; Shorter and Mattics 2006). Steamboats on the Alabama and Tombigbee rivers transported vast quantities of cotton downstream to Mobile (Figure 18-4), for export to Europe, and were only challenged decades later by railroads (Cline 1997, p 30-64; Fickle 2014, p 33). The region’s maze of waterways and swamps occasionally hid runaway slave camps; militia destroyed one such maroon settlement on Hal’s Lake in 1827 (Anonymous 1827; Riley 1906; Diouf 2014, p 153-5).

Native Americans in the Greater Mobile-Tensaw River Area

Southern Monroe County soils supported cotton farming, but elsewhere in the greater Mobile-Tensaw River area forest products and cattle raising (in woods and canebrakes) continued to dominate the local economy. Some Choctaws along the Mobile-Washington county border managed to avoid forcible removal to the west in the 1830s, and their descendants today are organized as the MOWA (Mobile-Washington) Band of Choctaws (Matte 2002). To the east, from Tensaw to Atmore, a few Creeks received land grants for assisting the US military during the Redstick War; one of these tracts formed the nucleus of a reservation, today home to the Poarch Band of Creek Indians, a federally-recognized tribe (Paredes and Knight 2012).

Throughout the 19th century, Native Americans in the greater Mobile-Tensaw River area continued carrying forest resources to the Mobile market, while maintaining many traditional subsistence practices. In 1875, Dr. Gideon Lincecum published an account of mass capture fishing by Chickasaw Indians in August 1828, during low water level above the Paineyigaby shoal on the Tombigbee River. Although north of our study area, this sort of fishing was practiced throughout the region for millennia. According to Lincecum, the men went into the woods to dig buckeye (Aesculus rubra) roots, which they pounded and grated. An hour before sunset they carried baskets of root into the water, “plunging, or rather churning these violently as they moved along, [and] distributed the pulverized root everywhere the whole length of the deep hole.” Within an hour, fish “were visible everywhere on the surface of the water; not dead, but feebly moving about on their back.”

Over a 24-hour period, thousands of fish were taken from the river pool, split open, and

**Figure 18-4.** “Scene on the Alabama River, Loading Cotton.” From *Ballou’s Pictorial* 13(22), p 1, November 28, 1857. (Image credit: Center for Archaeological Studies, University of South Alabama.)
dried over fires kindled beneath low wooden racks. Lincecum (1875) related:

It was a little curious to observe the different degrees of power among the fish to resist the deleterious effects of the poison. The perch and small scale fish came first, then the trout family, suckers, all the scale fish. Then the blue cats, then the big, fat yellow cats, then the mud cats and eels, and, lastly, the soft shell turtle and loggerheads [alligator snapping turtles]. . . . I did not know before that a deep hole in the river could be so densely populated.

**Impact of the Civil War**

In 1830, the US Army established Mount Vernon Arsenal near the site of old Fort Stoddert. Just prior to Alabama’s secession from the Union in 1861, state militia seized the arsenal and Forts Morgan and Gaines at the mouth of Mobile Bay. The schooner *Clotilda*, last slaving ship to enter the US, had slipped into the bay 6 months earlier, offloaded her human cargo, and been scuttled near Twelve-Mile Island—one of numerous shipwrecks awaiting discovery in the region’s waterways. Many of those Africans, Yorubas from Dahomey, lived out their lives in a post-war community called Africa Town, on land they purchased in north Mobile (Roche 1914; Diouf 2007; Robertson 2008; Sledge 2015, p 114-5, 261-5).

During the Civil War, as the federal blockade of southern ports became increasingly effective, thousands of workers, enslaved and free, took up residence at the saline springs in southern Clarke County, processing salt for the state and for personal use (Figure 18-5; Lonn 1933). Likewise, as imported coffee, chocolate, and Asian tea became nearly unobtainable, caffeine-bearing leaves of native yaupon holly (*Ilex vomitoria*) were harvested throughout the southern coastal plain and brewed into “Black Drink” (Hudson 1979, p 7).

War took a long time to impact Mobile directly. The submarine *H.L. Hunley* was built in the city, far from battlefields, and taken by rail to Charleston, where it sank a blockade ship. Eventually though, in August 1864, Confederate-held forts at the mouth of Mobile Bay fell to a federal invasion force. Still, the city’s 3 robust lines of fortification discouraged a direct Union assault, so US forces marched north along the bay’s eastern shore to besiege entrenched Confederate troops at Spanish Fort and Blakeley, which fell in April 1865 in two of the final battles of the Civil War (Bergeron 1991; Stowe 1977; Shorter 2001, 2008; Sledge 2015, p 132-9).

**Following the Civil War**

Post-war Mobile witnessed a redistribution of population as freed urban and plantation slaves found new means of employment and modes of housing. Historical and archeological research has revealed little physical segregation of white and black residences in late-19th century Mobile (Gums 1998; Wilkie and Shorter 2001; Wilkie 2003; Shorter et al. 2007).

In 1873, the US Army converted Mount Vernon Arsenal to Mount Vernon Barracks, where Geronimo and 450 other Chiricahua Apaches were held as prisoners of war from 1887 to 1894. The property was transferred to the State of Alabama, which repurposed the buildings in 1905 as a mental hospital for African-American patients. In 1906, Dr. George Searcy reported an outbreak of pellagra among patients...
and correctly recognized their maize-based diet as a contributing factor to this nutritional disease, considered to that point a psychiatric disorder (Rajakumar 2000). Initially called Mount Vernon Hospital for the Colored Insane, and renamed Searcy Hospital in 1919, the facility was integrated in 1969, and closed by the state in 2012. This virtually intact early-19th century US arsenal and nationally significant historic site remains closed, as buildings deteriorate and collapse.

**The Logging Economy**

Forests of the uplands and bottomlands of the greater Mobile-Tensaw River area provided the basis of most residents’ livelihoods until the mid-20th century, and to a lesser extent they continue to do so today. Evidence of past logging is everywhere, in the region’s altered vegetation, land surfaces, and soils. In upland forests, teams of oxen hauled pine logs by high-wheel carts (Figure 18-6) to a proliferation of short-spur rail lines, both narrow gauge and standard gauge. From there the logs traveled by steam locomotive to sawmills from 1875 to 1930, when trucks began replacing carts and rails (Burnette 2006, p 269-75; Smith 2008, p 29-41, 116, 123-4, 265-7; Fickle 2014, p 73, 87-8, 92-106). At the northeast end of the Old Mobile archeological site, one can still discern the raised bed of a circa 1900 “dummy line” that serviced a logging camp overlooking the Mobile River; soils compacted by logging trucks are evident throughout the site.

Swamps called for different methods of tree harvest. Oxen proved useful there, too, until largely replaced by mechanized pullboats— barges with winches that hauled huge gum and cypress logs to waterways. Radial patterns visible in aerial and satellite views of the Delta are deep trenches left by pullboats, permanent scars that altered the topography and surface hydrology. Logs were also floated to waterways by damming or channeling small tributaries. Robert Leslie Smith’s account of high-water logging and rafting in the Mobile-Tensaw Delta is an invaluable firsthand description of a way of life that ended just after World War II (Smith 2008, p 42-53, 115-30). Tupelo gum and cypress logs, which float, were bound together in rafts, while non-floating logs of oak and red gum were suspended beneath pontoon “gunboats.” Watermen guided them, via river current, to downstream mills in and around Mobile.

Turpentine distillation from pine resin was a major industry in the upland longleaf and slash pine forests of the region from the 1850s to 1950s. At first, resin was collected in triangular troughs or “boxes” axed into tree trunks and cleaned out monthly by dip iron. Trees exploited in this manner were vulnerable to disease and fire. Adoption after 1900 of the French cup and gutter system, in which resin flowed from grooved bark into ceramic or metal cups, revolutionized southern turpentine production (Figure 18-7) (Sargent 1884, p 202, 516-8; Smith 2008, p 255-6; Fickle 2014, p 36-7, 81).

More recently, forestry has remained important, with local mills specializing in paper products, preservative-treated wood, plywood, and laminates. In addition, the region’s forest-dwelling animals continue to be intensively hunted, for subsistence and sport (Jordan 1999; Smith 2008, p 15-8, 96). Deer and bears were extirpated early in the 20th century, but...
deer returned during World War II, and bears were reintroduced recently. Hunting clubs and wildlife management areas established in the early- and mid-20th century are scattered throughout the middle and upper portions of the study area, and recreational fishing, canoeing, and kayaking draw substantial numbers of people into the Delta.

**On-going Connections**

A multitude of connections continue to tie the human population of the greater Mobile-Tensaw River area to the region’s natural resources. One need only recall the baptisms that once occurred in local springs and streams (Jordan 1999, p 45, 99) to realize the depth of the bonds linking one to the other.

![Figure 18-7. Turpentine gathering containers and dip iron, collected by Robert Leslie Smith from the Mobile-Tensaw Delta. The log is a longleaf pine stump with an axe-cut turpentine collecting box. (Photo credit: Center for Archaeological Studies, University of South Alabama.)](image-url)
Ride through the Mobile-Tensaw Delta any given day and you will encounter pleasure seekers of all manner, from birdwatchers and duck hunters, to fishermen, kayakers and water skiers. But in the mix out on the water, you’ll also find a lot of people making money off the Delta. Commercial boats ply the lower Delta rivers for live shrimp for the bait shops that line the US 98 Causeway. Restaurant owners run catfish box traps out of johnboats for the fresh Alabama River channel cats they will fry up and sell that night. Fishing guides number in the dozens. And most days, you are likely to see one of the big tour boats carrying 40 paying customers up river to see the sights.

If your eyes are keen, you might also spy a few modern day bandits, perhaps poaching turtles from Big Briar, or scraping through Native American sites for artifacts to sell on eBay. Game wardens routinely arrest scofflaws in the Delta, sometimes illegally netting mullet under cover of night in the Delta’s rivers, or even killing anhingas for their elaborate tail feathers.

The People of the Delta

The Delta, in many ways, is the same as it has always been: part playground, part natural bounty waiting to be reaped and brought to market. The players may have changed over the years—for instance, the logging crews are gone and no one grazes cattle on the islands anymore—but the landscape that has supported various human endeavors for millennia remains.

Most of the people you see in the Delta are locals, and most of them have grown up visiting the big swamp with their families. For those unfamiliar with navigating the Delta’s twisting and shoal-ridden waters, making that first trip into the giant swamp can be forbidding. Even more than the alligators and snakes, many fear getting hopelessly lost, or breaking down deep in the interior. There are countless boat owners in the area surrounding the Delta who say they prefer the open waters of Mobile Bay, where navigation is easy, and help is never far.

The type of folks you’re likely to meet in the Delta depends largely on what time of year it is. In the fall, speckled trout fishermen number in the thousands, a virtual armada of center console fishing boats drifting across the big bays, choking the Raft and Tensaw rivers, or surrounding the Battery at the junction of the Apalachee and the Blakeley. Come winter, the duck hunters appear in camouflage boats, hunting from blinds built from the tall Roseau cane (*Phragmites australis*) that lines the inner creeks. Spring means professional bass tournaments and birdwatchers numbering in the hundreds. And in the summertime pontoon boats and jet skis raft up around Gravine Island in the heart of the Delta. Hundreds of people crowd up on its sandy beach, boiling pots of crawfish, drinking beer, and getting sunburned while Sweet Home Alabama booms out of a ski boat stereo system. The beach makes a tall hill, about 15 ft (5 m) high. Revelers up on top shout warnings to swimmers if an alligator makes an appearance nearby.

When the US Army Corps of Engineers bought up much of the lower Delta in the 1980s, it changed the complexion of the place in some ways. Numerous people who were living full time in the Delta were forced out when it was discovered they did not have legal title to the marshy land beneath the ramshackle homes they had built. The federal purchase, coupled with the arrival of modern game and fish regulations, hastened the end of the Delta’s resident trapper/fisher population, people who had eked out a living entirely from what they could pull from the great swamp. Even so, there are likely more people out in the Delta on a day-to-day basis today than at any point in its modern history.

Stories from Delta Locals

Lucy “Pie” Hollings has been watching the world drift by her “little piece of paradise” on the Tensaw River on the Delta’s eastern edge her entire life. She inherited Cloverleaf Landing, where she charges $4 to launch a boat, from her father. Most days, she can be found sitting on her houseboat next to the ramp. The Delta has defined her life. As she says,

I don’t want for anything. Everything I’ve ever needed was right here in the Delta. I have fish
to eat, crabs. People bring me things when they come to the boat ramp. It’s just a wonderful life. My foreparents was Indians. My grandmama was Cherokee. So I enjoy living off the land. Very seldom go to the store and buy food. Don’t have to.

Her brother, Sylvester Crooks, hunts wild hogs in the Delta. The hogs, domesticated pigs turned feral, number in the hundreds of thousands in the Delta, by most estimates. With teeth to rival a German shepherd, and the ability to reproduce when they are just 6 months old, the invasive animals cast a long shadow over Delta life, consuming everything from baby deer and ducks to the tender roots and tubers of the wetland plants that hold the soft Delta mud in place. Hog hunting has emerged as a major sport in the Delta, with several butcher shops in the area now specializing in dressing the wild pigs.

Crooks doesn’t use a gun when he hunts. Just his dogs and a knife. The dogs run the pig down and corner it somewhere, and then Crooks jumps on its back and slits its throat. He won’t let anyone accompanying him bring a gun, he says, for fear they will shoot one of his prized dogs.

Larry Scott and his twin brother Barry own Scott’s Landing, a boat launch and bait shop on the edge of the Causeway. The shop was owned by their father when the Scott boys were young, but sold in their teens, when the name was changed to Mizell’s Landing. The Scott boys bought it back decades later. Fishing the Delta, particularly the Blakeley River, has been a way of life for their family for 4 generations. Larry, who lives on a houseboat behind the bait shop with various pets, including a raccoon, relates:

We were fishing from the time we were real small. Our grandfather had a seafood market in Mobile, and my father shrimped and fished for him. By the time we were 4 or 5 years old, Daddy had us in a boat.

In the 1970s, the Scotts’ father nearly froze to death while trying to run a commercial gill net on one of the coldest days on record in south Alabama. After his boat ran aground, the elder Scott tried to wade to shore, but collapsed due to hypothermia. When he was finally rescued, lying in the shallows, his body cocooned in a layer of ice, his eyeballs were frozen in place, staring straight ahead. Miraculously, he made a full recovery and went back to fishing.

Sitting in the bait shop where his son now works, Larry went on:

It’s about all we’ve ever known and it has been good to us. A lot of people would die to have our sunsets every afternoon, overlooking Mobile, same thing with sunrises when we’re out shrimping. It doesn’t get much better.

Jimbo Meador likes to say he grew up in the Delta and it taught him everything he ever needed to know. Meador earned pocket money as a teen trapping around the edges of the Delta and its adjoining swamps. In 1957, at age 15, he entered and won one of the first nutria rodeos in the nation, killing the largest nutria in the tournament. Even today, at 73, he still spends long nights gigging frogs in Little Bateau, his favorite of the Delta’s inner lakes. Meador now runs 17 Turtles Outfitters, which specializes in providing guided trips in the Delta, and renting kayaks and stand-up paddleboards to people who want to explore the area. For him, the Delta provides a place of solitude amid the technology that surrounds modern life. In Jimbo’s words:

I spent most of my life over there. Grew up in the Delta. I’ve seen what’s transpired. One of the reasons I’m doing what I’m doing [the kayak business] is because I want to make more people aware of the treasure we have. People pass it on the Interstate, but nobody really knows what’s out there. I’ve seen it change.

Over the years, I was obsessed with duck hunting over there. I ran a trap line and sold furs. I shrimped. I did crabbing. I’ve done a whole lot of fishing there. Frog gigging. I don’t want to say it, but I used to hunt alligators, and I used to eat them. The snipe hunting. Oh gosh, I love the Delta for snipe hunting. I had trot lines up there, caught catfish, bream fishing, bass fishing, speckled trout, redfish, sheepshead. The beauty of it is you got freshwater fishing and saltwater fishing. I have caught bass, speckled trout, flounder and redfish all in the same spot, on the same bait, on the same morning.

“Delta Rats”

There’s a sort of fraternity of Delta lovers, people who call themselves “Delta rats.” They might be commercial shrimpers, or water skiers, or recreational trout fishermen. It doesn’t matter. They are people who love
to be out in the Delta, and their diverse backgrounds offer proof that the Delta is big enough, and changeable enough, that just about anyone can find whatever they may be looking for.

I, personally, have fallen under the Delta’s spell. For the last 15 years I’ve worked my way deeper and deeper into its interior, and gotten to know more and more of these self-described Delta rats. I learned my way around by running aground and getting lost, the best way according to the old timers, who warn that the Delta is not easy. GPS [global positioning system] is unreliable because the shorelines change and reshape with every spring flood. Getting lost and finding your way out teaches you a certain respect for the place, they say. And it teaches you to pay attention.

Now I guide people into its inner reaches, to places seldom seen. I look forward to July, when the giant yellow flowers of the American lotus bloom, tens of thousands of golden heads nodding in the summer breeze. And to October, when the trout and redfish run up the rivers in great numbers, and it is possible to catch 40 or 50 before going to work in the morning. I love February, when the entire Delta disappears beneath 10 ft (3 m) of water in the spring flood and you can drift through the forest amongst the trees, floating over places where you’ll be walking on dry ground in a few months. I’ve learned where I can go in May and play a recording of a Prothonotary Warbler and call 2 or 3 of the tiny, canary yellow birds right to my boat.

I see the same faces at the boat ramp again and again. We trade notes on what’s happening where—birds diving over schools of menhaden at the mouth of Crab Creek; a new log down on the way into Jessamine Bayou; a colony of Yellow-crowned Night Herons nesting in One-Mile Creek—the way people talk about old friends. The boat ramp crowd includes doctors, lawyers, shrimpers, mechanics, teachers, artists, and commercial fishermen, because the Delta as the common thread makes for easy friendships. The big swamp has defined the communities that surround it, in both Mobile and Baldwin counties. And it is the central focus for recreation for thousands of people living in those counties, year round.

Looking to the Future
Perhaps the greatest testament to the importance of the Delta as a cultural touchstone for south Alabama was revealed in the last congressional election. The two leading candidates for US Representative for District 1 spent more time talking about the future of the Mobile-Tensaw Delta than any other topic. At issue was the question of whether the Delta might one day become a national park, a proposition backed by former Representative Jo Bonner before his resignation. Both men competing for Bonner’s seat were adamantly opposed, arguing that the Delta belongs to the people of south Alabama, and it would amount to a horrible crime to allow federal officials any dominion over the precious wetland.

There remains a local group campaigning for some sort of federal status for the Delta, perhaps as a national preserve, which would still allow unrestricted hunting and fishing, among other activities. In the eyes of those pushing for federal recognition, such protection could prove vital to the long-term viability of the Delta’s rich habitats. They cite two remarkable but opposing facts about Alabama and its wild environs.

First, the state leads the nation in aquatic diversity, with more species of fish, mussel, snail, and crayfish than any other state. Most of those creatures can be found in the rivers of the Mobile Basin, which drain into the Delta. The second often cited truth about Alabama is that the state ranks as the king of extinctions for aquatic creatures, responsible for roughly half of all extinctions that have occurred in the continental US since the 1800s.

Obviously, a state cannot forever wear both the crown for most aquatic diversity and the crown for most extinctions. Unfortunately, the current political climate in the state suggests the scale may be tipping toward more extinctions. The Alabama Legislature has provided zero funding to the state’s environmental agency, the Alabama Department of Environmental Management, for the last several years. And Alabama ranks dead last among the 50 states in terms of money spent on environmental protection. In many ways, the future of the Delta rests squarely on the backs of the people who use it most: the kayakers, the fishermen, the birders, the water skiers, the ecotour guides, and the charter captains.

For all the majesty of the Mobile-Tensaw Delta, you often hear the same lament from old timers: “You should have seen it then.” Often the losses are plain to see, from bays in the lower Delta taken over with invasive milfoil or filled with dredge spoil, to duck hunters returning to the dock with no ducks on cold winter
mornings. But to focus too much on those voices from the past ignores the fecundity of the present. It is possible to venture out most fall mornings in the Delta and catch 50 speckled trout before 9 AM, something possible in only a few places on Earth. Likewise, birders heading out during the spring migrations often add dozens of species to their life lists in a single morning. The Delta is like that, so rich you can’t help but be impressed.

I often think of the Delta the way a man at a boat ramp described the fishing one morning. “Just put something wiggly on a hook and you’ll catch something,” he said. “The Delta’s easy, no matter what you’re after.”

Suggested Readings


20. National Historic Landmarks

David B. Schneider, Schneider Historic Preservation; Bonnie L. Gums, University of South Alabama; Gregory A. Waselkov, University of South Alabama; George W. Shorter, Jr., retired archeologist, Mobile, Alabama; Richard S. Fuller, retired archeologist, Mobile, Alabama

National Historic Landmarks (NHLs) are places deemed nationally significant by the US Secretary of the Interior for their exceptional value in interpreting the historical heritage of our country. Slightly more than 2500 sites are so recognized nationwide, compared to about 85,000 historic properties listed on the National Register of Historic Places, a sister program also administered by the National Park Service. One might legitimately characterize National Historic Landmarks as the best of the best. National Historic Landmarks include both privately and publicly owned properties, and participation in the program is voluntary. Like National Natural Landmarks, another Department of the Interior program that recognizes our country’s outstanding biological and geological places, National Historic Landmarks are so designated to promote the preservation and protection of these gems, and more generally to raise public awareness of our nation’s historical heritage.

There are currently 6 National Historic Landmarks in the greater Mobile-Tensaw River area: Bottle Creek Site (Archeological Site 1BA2), Government Street Presbyterian Church, Fort Morgan, Mobile City Hall (Southern Market), the USS Alabama, and the USS Drum. A 7th place, the Old Mobile Site (Archeological Site 1MB94), has been determined eligible for National Historic Landmark status, but has not been so designated because of landowner objection, 1 of 5 such properties in the country. The National Park Service is tasked with reporting on the conditions of landmarks through periodic status updates provided by owners of National Historic Landmarks. This chapter summarizes status updates on the 6 National Historic Landmarks in the greater Mobile-Tensaw River area, as compiled by the authors in a lengthier report (Schneider et al. 2015).

Bottle Creek Site (Archeological Site 1BA2; 1994 NHL Designation)

Bottle Creek, located on Mound Island in the Mobile-Tensaw Delta, is the largest Mississippian archeological site on the north-central Gulf Coast, from the Florida Panhandle to the Mississippi River (Figures 20-1 and 20-2). One of Alabama’s most significant

Figure 20-1. Location of Bottle Creek Site National Historic Landmark, Baldwin County, Alabama (7.5-minute Stiggins Lake, Alabama, 1983 USGS quadrangle).
prehistoric sites, second in size only to Moundville, Bottle Creek served as a social, political, religious, and trade center for a society named by archeologists as the Pensacola culture, part of the Mississippian tradition, from around AD 1200 to 1550. The site is owned by the State of Alabama and administered by the Alabama Historical Commission.

There are 19 documented earthen mounds at Bottle Creek. Most are platform mounds that would have held wooden temples and dwellings. Five of the mounds, including the largest and tallest (at over 45 ft [14 m]), Mound A, encircle an open plaza or public space. Apart from a few outlying mounds, the others line the wetlands on the north and west edges of the site. The village site around the mound complex covers at least 46 acres (0.2 km²). Shell middens representing food remains of the residents occur throughout the site, and there are at least 3 borrow pits dug for soil to build the mounds.

The mounds at Bottle Creek were first mapped in 1853 (Bigelow 1853), followed by limited excavations in 1905 and in 1931 to 1932 (Sheldon 2001). In 1990, staff from the University of South Alabama’s Center for Archaeological Studies and volunteers from the University of Alabama, University of Southern Mississippi, and Auburn University-Montgomery created a modern topographic map of the mounds at Bottle Creek (Waselkov 1993). Between 1991 and 1994, the University of Alabama’s Gulf Coast Survey conducted the first intensive excavations at Bottle Creek, directed by Ian Brown (Fuller and Brown 1998; Brown 2003a, 2012). Those explorations uncovered prehistoric and historic Indian house floors, as well as evidence of mound construction methods. Excavation trenches into Mounds A and B documented the sophisticated engineering involved in their construction (Brown 2003a). On November 30, 2014 Richard Fuller discovered a previously undocumented mound, inspired by a search of LiDAR imagery by archeologist Jason Gardner (Fuller 2014). Based on these various investigations, Bottle Creek is considered one of the most significant archeological sites in the north-central Gulf Coast region.

The site is monitored by officers from the Alabama Department of Conservation and Natural Resources, who check for evidence of looting or other disturbances. There has been little recent evidence of looting for artifacts, but rooting by wild hogs is damaging the site surface, a fairly recent phenomenon. Damage to trees has occurred from hurricanes, most recently with Hurricane Ivan (2004) and Hurricane Katrina (2005). Heavy rains from hurricanes and tropical storms can erode the earthen mounds, as happened in the mid-20th century when Mound A suffered a major slump on its western face.

Historic Blakeley State Park, Five Rivers, and private ecotourism companies offer boat trips to Bottle Creek that bring several hundred people to the site annually. Maps of the local waterways distributed at fish camps, bait stores, and other outlets mark the site, which is also a highlight on the Delta’s Bartram Canoe Trail, so many people find their own way to the mounds.
As the site has become better known in recent years, evidence of illicit digging on the site has declined, which suggests that higher public visibility and more visitors may deter vandalism and looting.

Bottle Creek is one of the few major Mississippian sites in the southeastern United States that has not been developed for tourism, due to its isolated location. This heavily forested site in the Mobile-Tensaw Delta gives visitors a sense of the rich natural environment that supported Native American societies for thousands of years.

**Government Street Presbyterian Church (1992 NHL Designation)**

Located at 300 Government Street in Mobile, Government Street Presbyterian Church is significant as one of the oldest and least-altered Greek Revival-style houses of worship remaining in the United States today (Figures 20-3, 20-4, 20-5) (Hamlin 1944; Kennedy 2010). Along with a distinctive monumental *distyle-in-antis* façade, the building is noted for its intact Greek Revival-style interior. The sanctuary has seen only minor modifications since original construction in 1838. This privately owned church is an active religious facility and is open to the public.

Government Street Presbyterian Church is in excellent condition, little changed in appearance since construction. The building was last rehabilitated in 2002 with new paint, carpeting, rewiring, and installation of a new organ, in conformance with the Secretary of the Interior’s standards (Morton et al. 1997). Government Street Presbyterian Church is very well maintained, with an active program of cyclical maintenance and restoration overseen by a property manager and building committee. The city’s historic preservation ordinance requires prior approval of any proposed exterior work.

As Mobile is prone to hurricane and tornado activity, weather poses the primary threat to Government Street Presbyterian Church. Hurricanes have

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**Figure 20-3.** Locations of National Historic Landmarks in Mobile, Mobile County, Alabama: Government Street Presbyterian Church, Mobile City Hall (Southern Market), USS *Alabama*, USS *Drum* (7.5-minute Mobile, Alabama, 1953 USGS quadrangle).
Figure 20-4. South façade detail, Government Street Presbyterian Church, Mobile, Mobile County, Alabama. (Photo credit: David B. Schneider, March 2015.)

Figure 20-5. Interior sanctuary, Government Street Presbyterian Church, Mobile, Mobile County, Alabama. (Photo credit: David B. Schneider, March 2015.)
damaged the church in the past and are likely to be a threat in the future. The surrounding urban area has changed considerably since the building’s construction, with most of the adjacent historic streetscapes already lost prior to landmark designation. Government Street Presbyterian Church now exists within an essentially modern urban setting. At the present time, Government Street Presbyterian Church is in excellent condition, is well maintained by ownership that recognizes and appreciates it historical and architectural significance, and the overall threat level is minimal, except as already noted for the unpredictable nature of the region’s extreme weather events.

Fort Morgan (1960 NHL Designation)
Located at the entrance to Mobile Bay, in Baldwin County, Fort Morgan played a significant role in the 1864 Civil War battle of Mobile Bay, when Admiral Farragut’s Union Navy fleet ran past the fort to seize control of the bay, losing the ironclad USS Tecumseh to a mine in the process (Figures 20-6 through 20-9) (Bergeron 1991; Hearn 1993). Fort Morgan was constructed between 1819 and 1834 as a pentagonal, masonry, coastal defense fortification. Extensively damaged during the Civil War, when a central citadel was destroyed, the fort was remodeled in 1895 to 1898 with reinforced concrete gun emplacements. Frame barracks, officers’ quarters, hospital, and other structures were added when the fort was reactivated as a Spanish-American War training base. All but 4 frame structures have been lost to hurricanes after landmark designation in 1960.

Fort Morgan was recorded in 1937 as archeological site 1BA186. After World War II the state-owned military reservation became a park overseen by the Alabama Department of Conservation, then by the Alabama Historical Commission since 1977. Prior to state ownership, many individuals removed artifacts from Fort Morgan by careless digging and metal detecting. Most of the fort’s cannons were sold for scrap in the early-20th century (England et al. 2000, p 48).

![Figure 20-6. Location of Fort Morgan National Historic Landmark, Baldwin County, Alabama (7.5-minute Fort Morgan, Alabama, 1958 USGS quadrangle).](image-url)
Limited amateur and professional archeological investigations have occurred at Fort Morgan over the last 50 years. In 1970, 3 of the fort’s 4 cisterns were excavated (Keebler 1970). A 1979 survey of Mobile Point, where Fort Morgan sits, recorded fort-related surface features (Stowe et al. 1979), and a Troy State University team investigated the drainage system between casemates in 1991. In 1993 archeologists surveyed an area north of the park’s museum prior to relocation of the historic 1872 metal lighthouse.

Expeditions 21 and 22, educational programs organized by the Alabama Museum of Natural History, were held at Fort Morgan in 1999-2000, directed by University of South Alabama archeologist George Shorter (Shorter 2001). These extensive excavations focused on Battery Duportail and the Citadel that once stood in the center of the fort. Massive brick remains of the Citadel and a large privy pit yielded Civil War munitions, such as a wooden sabot and a Federal 3-inch (8-cm) Schenkl shell, as well as medicine bottles, uniform buttons, and smoking pipes. Archeological testing by Panamerican Consultants in 2008 of the fort’s terreplein and parapet revealed a clay surface of the original War of 1812 fort (Carruth 2008). These investigations amply demonstrate the existence of significant archeological deposits throughout Fort Morgan.

Fort Morgan is generally in good condition and is subject to a continual program of maintenance and restoration consistent with the Secretary of the Interior’s standards (Morton et al. 1997). In recent years, restoration has concentrated on reconstruction of the east rampart and addressing the fort’s continuing drainage problems. The surviving frame buildings at Fort Morgan and concrete artillery batteries are stable. An iron lighthouse installed in 1872 was sold to a scrap dealer in 1966, only to be returned to the fort in 1991, then again dismantled in 2003 for restoration. Funding has not been available to complete the project.

Figure 20-7. Entrance at north rampart, Fort Morgan, Baldwin County, Alabama. (Photo credit: David B. Schneider, March 2015.)

Figure 20-8. Interior vaulted casemates, Fort Morgan, Baldwin County, Alabama. (Photo credit: David B. Schneider, March 2015.)
Fort Morgan retains most of its essential historic design elements. Historic fabric and materials are respected during ongoing maintenance and restoration work and original workmanship of Fort Morgan remains visible. The setting has been compromised to some degree by gas wells in Mobile Bay and the Gulf of Mexico that are readily visible from the fort. Fort Morgan is well maintained by the Alabama Historical Commission, which recognizes and appreciates its historical and architectural significance. The overall threat level is minimal, except for the unpredictable nature of the region’s extreme weather events. Ongoing restoration efforts are attempting to address chronic water penetration that adversely affects the masonry structure, which remains an ongoing conservation concern.

**Mobile City Hall (1973 NHL Designation)**

Long known as the Southern Market and Municipal Building, Mobile City Hall, constructed in 1855 to 1857, exemplifies a mid-19th-century trend to combine multiple civic functions in public structures (Figures 20-3, 20-10, 20-11) (Holmes 1987; Ewert 1993). This complex of 4 Italianate, stuccoed brick buildings links smaller flanking structures to the main gabled buildings with crenellated, arched wing walls. The lower floors of the buildings on South Royal Street housed a market, with upper floors for municipal offices. By the mid-20th century the entire complex was occupied by City Hall and continued to serve as such until the buildings were severely damaged by Hurricane Frederic in 1979.

Mobile City Hall was built on a site that straddles the colonial era riverfront. Between 1997 and 2000, two major archeological investigations of the site, designated 1MB189, uncovered deposits up to 5 m (16 ft) deep that date to the 18th- and early-19th centuries. These deposits relate to the northeast bastion of Fort Condé, a Spanish colonial residence (circa 1800), Montuse’s tavern (circa 1815), and 1830s cotton warehouses and commercial buildings (Gums and Waselkov 1997; Gums and Shorter 1998, 2000).

The old Mobile City Hall buildings were rehabilitated in 2000 to 2001 to serve as the city’s history museum. This project resulted in some alterations, but was generally consistent with the Secretary of the Interior’s standards for rehabilitation (Morton et al. 1997). The essential character-defining elements of the buildings’ design, materials, and workmanship remain intact and were enhanced through appropriate repair and restoration work.

At the present time, the buildings are in excellent condition, are well maintained by ownership that recognizes and appreciates their historical and architectural significance, and the overall threat level is minimal except for the unpredictable nature of the region’s extreme weather events. The structures suffered substantial damage from flooding during Hurricane Katrina in 2005, which necessitated extensive repairs. The surrounding urban area has changed considerably since construction and most of the surrounding historic elements of the adjacent streetscapes had been lost prior to landmark designation. Mobile City Hall is now, and was at time of designation, a historic building complex that exists within an essentially modern urban setting.
Figure 20-10. Mobile City Hall, Mobile County, Alabama. (Photo credit: David B. Schneider, March 2015.)

Figure 20-11. Interior first-floor lobby of the History Museum of Mobile, in Mobile City Hall, with 1936 Works Progress Administration murals by John Augustus Walker. (Photo credit: David B. Schneider, March 2015.)
USS Alabama (1986 NHL Designation)

USS Alabama is a South Dakota-class battleship (designated BB-60 by the US Navy), commissioned in 1942, that spent 40 months in active service during World War II, participating in 26 engagements (Figures 20-3, 20-12, 20-13, 20-14) (Sumrall 2001; Arnhart 2007). The ship was decommissioned in 1947 and transferred to the State of Alabama in 1964 for use as a museum (although the federal government retains ownership). The battleship is administered by the USS Alabama Battleship Commission, which operates the USS Alabama Battleship Memorial Park. The curatorial staff maintains an active program of restoration and maintenance, and has developed interpretive exhibits throughout the vessel, with considerable sensitivity to the ship’s historic fabric. The ship is nearly unique among World War II vessels in never having undergone updating for use in subsequent wars.

USS Alabama is in good condition and is subject to a continual program of maintenance and restoration work that is consistent with the Secretary of the Interior’s standards (Morton et al. 1997). Other than enhancement through restoration of damage caused by Hurricane Katrina, as well as ongoing maintenance and repair work, the exterior has remained unaltered since decommissioning. The battleship is located in Mobile Bay at a waterside park in which it and the submarine USS Drum are interpreted. USS Alabama was damaged by Hurricane Katrina, which caused it to list 12° in its cofferdam. It has since been righted and restored and a new protective cofferdam has been created. At the present time, USS Alabama is in good condition, is well maintained by ownership that recognizes and appreciates it historical and architectural significance, and the overall threat level is minimal, except for the unpredictable nature of the region’s extreme weather events.
Figure 20-14. Galley of the USS Alabama. (Photo credit: David B. Schneider, March 2015.)

Figure 20-15. USS Drum at Battleship Alabama Memorial Park, Mobile, Alabama. (Photo credit: David B. Schneider, March 2015.)
USS Drum (1986 NHL Designation)

USS Drum is a Gato-class submarine (designated SS-228 by the US Navy), commissioned in 1941, that represents the standard design for American fleet submarines early in World War II (Figures 20-3, 20-15, 20-16, 20-17). This vessel served throughout the war, sinking 15 enemy ships and earning 12 battle stars. USS Drum was decommissioned in 1946, served as a training vessel for the Navy Reserve, and was donated to the USS Alabama Battleship Commission in 1969 for display at USS Alabama Battleship Memorial Park in Mobile, Alabama. Initially moored in Mobile Bay, USS Drum was damaged by storm surge during Hurricane Georges in 1998 and subsequently moved on shore. The ship has suffered considerable rust damage to its below decks prior to being relocated to a fixed aboveground platform. Ongoing restoration is underway to repair the damage.

USS Drum is in good condition and is subject to a continual program of maintenance and restoration that is consistent with the Secretary of the Interior’s standards (Morton et al. 1997). USS Drum is well maintained, but still requires restoration work. All of the essential character-defining elements of the USS Drum remain intact, and historic fabric and materials are carefully respected during ongoing repair and restoration. Integrity of setting has been compromised to a degree by its removal from the water and placement on land. However, this action was necessary for the long-term preservation and interpretation of the submarine. While the ownership’s maintenance program and emergency management plan minimize threats to the vessel, a major storm could pose a threat to the submarine given the unpredictable nature of the region’s extreme weather events.

Figure 20-16. View across the foredeck of USS Drum. (Photo credit: David B. Schneider, March 2015.)

Figure 20-17. After torpedo room of USS Drum. (Photo credit: David B. Schneider, March 2015.)
Summary
The 6 National Historic Landmark resources assessed in this study retain integrity, are well maintained, and are continuing established maintenance and restoration programs. None of the landmarks faces any immediate threat to their current status. The common threat to each of the landmarks is weather related, as all are located in a region prone to hurricanes and tornadoes and each has previously suffered significant damage from storms. While steps have been taken to minimize this risk at some of the individual landmarks, there is nothing that can prevent damage in the event of a major storm. Most of the owners of these landmarks have developed an emergency response plan to respond to natural and other disasters.
For the purposes of this socioeconomic overview, the greater Mobile-Tensaw River area is considered as the Alabama portion of the Mobile-Tensaw watershed that spans an area of approximately 7600 km² (2900 mi²; Figure 21-1A). This region includes stakeholders from the counties of Baldwin, Clarke, Escambia, Mobile, Monroe, and Washington. The total population of the area is 704,106, with 37.6% identifying as African American, 60.1% Caucasian, and the remaining 2.3% Hispanic and other races (US Department of Commerce 2013). A graphical analysis of the age distribution of the population of this area is illustrated in Figure 21-1B.

The population pyramid reveals a near-stationary pattern where the age groups are similar in percentage terms, except for the upper tail of the age distribution. This result contrasts with the constrictive pattern of the US national population pyramid that is similar to Western European countries (Cohen 2003; Pollack 2005). Median age of the population is 38 years, in line with the national trend and that of other developed countries (United Nations 2002). The dependency ratio for this region (calculated as the ratio of people who are not potentially in the labor force to those typically in the labor force) is approximately 71%, which is slightly above the national dependency ratio of 67% estimated by Vincent and Velkoff (2010). (To be consistent with the national estimates of Vincent and Velkoff [2010], the dependency ratio in the current study is calculated as (# of people 0 to 19 + # of people 65 and above)/(# of people 20 to 64). The assumption that the segments of the population age 15 to 19 and 65 and above are not in the labor force is quite strong. However, the dependency ratio in this case should be considered as a combined ratio of youth and old-age group to the population aged 20 to 64 years.)
**Socioeconomic Analysis**

According to the US Census Bureau, the population increased by 8.9% between 2000 and 2013. In 2013, 1.7% of the population was composed of new residents who relocated to the Mobile-Tensaw region from other counties in Alabama, 2.2% of the population were new residents who relocated from other states in the US, and 0.3% of the population consisted of new foreign residents. In the same year, income per capita was $21,503, 22.6% of the population lived below the poverty line, and the unemployment rate was approximately 7.95%. The proportion of the population with less than a high school education was 17.3%, while 29.3% of residents were reported to hold an associate's degree.

A disaggregated geospatial analysis of per capita income and unemployment rate of this region is reported in Figure 21-2. The analysis, based on data at the census tract level available from the US Census Bureau's American Fact Finder (US Census Bureau [date unknown]a), shows a spatial dependence of these two socioeconomic factors. In fact, it appears that residents who belong to the first quartile of the income distribution ($3,062 to $17,002) are located mainly in the northern part of the Mobile-Tensaw watershed and in the Mobile metropolitan area (Figure 21-2A). Residents belonging to the 4th quartile of the income distribution ($26,507 to $39,073) are located in the southern parts of the watershed in Mobile and Baldwin counties. The portions of the region with the largest unemployment rate are those areas in the northern part of the watershed (Figure 21-2B). These spatial trends may predict the geographic economy of the greater Mobile-Tensaw River area with major economies located in the southern part of the watershed and minor economies that occupy the northern part of the watershed.

**Overview of Economic Activities**

The County Business Pattern dataset of the US Census Bureau was used to identify major and minor economies of the study area, as well as the main economic activities sorted by number of industrial establishments and annual employee payroll. Note that the County Business Pattern was built by the US

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**Figure 21-2.** A disaggregated geospatial analysis of A) per capita income and B) unemployment rate for the region.
Census Bureau upon the Business Register, which is a comprehensive database of business establishments at county level. Business Register information is confidential, according to Title 13 and 26 of the US Code, so data that would disclose the operation of an individual employer are not reported in the public dataset. Further, the US Census Bureau adopts the noise infusion method, which adds a bias (2 to 5% noise) to protect sensitive data prior to publication (US Census Bureau [date unknown]b). In the case of the current study, information on annual payroll of some of the industrial sectors may be subject to noise infusion. However, even if there is a small bias in part of the information on the County Business Pattern reported by the public agency, these data still provide a valid snapshot of the current state of economic activity in the greater Mobile-Tensaw River area.

Data on number of establishments and annual employee payroll of the industrial sectors in the counties of Baldwin, Clarke, Escambia, Mobile, Monroe, and Washington were extracted from the national dataset and reported in Tables 21-1 and 21-2. According to the most recent available data, in 2013 there were 15,357 industrial establishments in the area of study. As expected, retail trade is the sector with the largest number of enterprises (2840) representing 18.5% of total establishments. Interestingly, there were 1379 establishments in the healthcare and social assistance sector (9.0% share of total establishments) mainly located in the counties of Baldwin and Mobile (88% of total establishments within the sector). These data may be consistent with the demographic structure of the population, with a 22.6% old age dependency ratio. Furthermore, Serow (2001) finds scientific evidence of a retirement migration towards coastal locations of the southeastern United States that may potentially shift the demand for healthcare services.

The number of establishments in the accommodation and food services sector was 1296 (8.4%), while in the agriculture, forestry, fishing, and hunting sector there were 179 enterprises representing less than 1% of the total number of firms in this area. By looking at the spatial distribution of the industrial sectors, it appears that 55.8% of the enterprises are located in Mobile County, followed by Baldwin County hosting 31.7% of total establishments, while Washington County has only 217 firms representing 1.4% of the total share.

Annual salaries received by employees can be considered a proxy of the value of the industrial output per each sector. Table 21-2 reports the annual payroll of each industry in the 6 counties of the study area. Compared to the previous considerations based on number of establishments, the payroll analysis provides more accurate information on the state of the economy in an attempt to identify the major industrial areas that characterize the region.

Descriptive statistics show that manufacturing is the leading industrial sector in the area with a payroll volume of approximately $2.6 billion, representing 26.0% of the annual volume of employee payroll across the entire industry. Among the top 5 industrial sectors, healthcare and social assistance is the second largest economic sector that paid its employees approximately $1.22 billion (12.2%), followed by the construction sector with $913 million (9.1%), retail and trade with $882 million (8.8%), and wholesale trade with $824 million (8.2%). When retail and wholesale are combined, the entire trade sector amounts to approximately 17% of the value of total wages received by workers in this region. The agricultural, forestry, fishing, and hunting sector paid its employees approximately $59 million, only 0.6% of total salaries across the reported industries.

The geographic distribution of annual payroll clearly shows two outliers: Mobile and Baldwin counties with approximately $7.37 billion and $1.65 billion total aggregate value of wages paid by the entire industry of the area. These two counties represent 73.7% and 16.5% of the total annual payroll volume of the industry, respectively. Consequently, these two counties can certainly be considered the major economies of the greater Mobile-Tensaw River area. Figure 21-3 illustrates a graphic summary of the geographic distribution of annual payroll across the various segments of the industry of this region.

Major Economies of the Greater Mobile-Tensaw River Area

1) Mobile Metropolitan Area

Metropolitan Mobile is located on the western shore of Mobile Bay over an area of 562 km² (217 mi²) with a population of 413,188 inhabitants (US Census Bureau [date unknown]a). As illustrated in Figure 21-4, this metropolitan area is the crossroads of two main highways: Interstate 10 (a transcontinental highway that connects Santa Monica CA to Jacksonville FL) and Interstate 65 (connecting Mobile AL to Gary IN). In addition, the presence of an international port and a
Table 21-1. Business pattern in the greater Mobile-Tensaw River area: number of establishments in 2013 (US Census Bureau [date unknown]).

<table>
<thead>
<tr>
<th>Industrial Sector</th>
<th>Baldwin</th>
<th>Clarke</th>
<th>Escambia</th>
<th>Mobile</th>
<th>Monroe</th>
<th>Washington</th>
<th>Total</th>
<th>Sector Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail trade</td>
<td>964</td>
<td>137</td>
<td>170</td>
<td>1,445</td>
<td>93</td>
<td>31</td>
<td>2,840</td>
<td>18.49%</td>
</tr>
<tr>
<td>Other services (except public administration)</td>
<td>451</td>
<td>76</td>
<td>94</td>
<td>975</td>
<td>47</td>
<td>35</td>
<td>1,678</td>
<td>10.93%</td>
</tr>
<tr>
<td>Professional, scientific, and technical services</td>
<td>454</td>
<td>30</td>
<td>37</td>
<td>843</td>
<td>16</td>
<td>14</td>
<td>1,394</td>
<td>9.08%</td>
</tr>
<tr>
<td>Health care and social assistance</td>
<td>456</td>
<td>53</td>
<td>61</td>
<td>758</td>
<td>32</td>
<td>19</td>
<td>1,379</td>
<td>8.98%</td>
</tr>
<tr>
<td>Accommodation and food services</td>
<td>475</td>
<td>48</td>
<td>52</td>
<td>681</td>
<td>30</td>
<td>10</td>
<td>1,296</td>
<td>8.44%</td>
</tr>
<tr>
<td>Construction</td>
<td>487</td>
<td>24</td>
<td>62</td>
<td>638</td>
<td>12</td>
<td>19</td>
<td>1,242</td>
<td>8.09%</td>
</tr>
<tr>
<td>Finance and insurance</td>
<td>335</td>
<td>64</td>
<td>65</td>
<td>646</td>
<td>34</td>
<td>12</td>
<td>1,156</td>
<td>7.53%</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>224</td>
<td>14</td>
<td>23</td>
<td>580</td>
<td>22</td>
<td>8</td>
<td>871</td>
<td>5.67%</td>
</tr>
<tr>
<td>Administrative and support and waste management and remediation services</td>
<td>239</td>
<td>14</td>
<td>18</td>
<td>452</td>
<td>6</td>
<td>2</td>
<td>731</td>
<td>4.76%</td>
</tr>
<tr>
<td>Real estate and rental and leasing</td>
<td>282</td>
<td>12</td>
<td>18</td>
<td>398</td>
<td>12</td>
<td>0</td>
<td>722</td>
<td>4.70%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>151</td>
<td>26</td>
<td>35</td>
<td>323</td>
<td>19</td>
<td>14</td>
<td>568</td>
<td>3.70%</td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>118</td>
<td>30</td>
<td>23</td>
<td>313</td>
<td>18</td>
<td>13</td>
<td>515</td>
<td>3.35%</td>
</tr>
<tr>
<td>Information</td>
<td>63</td>
<td>11</td>
<td>19</td>
<td>130</td>
<td>9</td>
<td>1</td>
<td>233</td>
<td>1.52%</td>
</tr>
<tr>
<td>Arts, entertainment, and recreation</td>
<td>80</td>
<td>6</td>
<td>7</td>
<td>95</td>
<td>2</td>
<td>2</td>
<td>192</td>
<td>1.25%</td>
</tr>
<tr>
<td>Educational services</td>
<td>39</td>
<td>4</td>
<td>1</td>
<td>107</td>
<td>3</td>
<td>0</td>
<td>154</td>
<td>1.00%</td>
</tr>
<tr>
<td>Agriculture, forestry, fishing and hunting</td>
<td>11</td>
<td>27</td>
<td>19</td>
<td>41</td>
<td>26</td>
<td>25</td>
<td>149</td>
<td>0.97%</td>
</tr>
<tr>
<td>Management of companies and enterprises</td>
<td>21</td>
<td>1</td>
<td>5</td>
<td>79</td>
<td>3</td>
<td>1</td>
<td>110</td>
<td>0.72%</td>
</tr>
<tr>
<td>Utilities</td>
<td>11</td>
<td>7</td>
<td>8</td>
<td>36</td>
<td>7</td>
<td>9</td>
<td>78</td>
<td>0.51%</td>
</tr>
<tr>
<td>Mining, quarrying, and oil and gas extraction</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>18</td>
<td>2</td>
<td>1</td>
<td>37</td>
<td>0.24%</td>
</tr>
<tr>
<td>Industries not classified</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>0.08%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,871</td>
<td>586</td>
<td>723</td>
<td>8,567</td>
<td>393</td>
<td>217</td>
<td>15,357</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>County Share</strong></td>
<td>31.72%</td>
<td>3.82%</td>
<td>4.71%</td>
<td>55.79%</td>
<td>2.56%</td>
<td>1.41%</td>
<td>100.00%</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 21-2. 2013 Annual payroll (expressed in thousands of dollars) of industrial sectors in the greater Mobile-Tensaw River area, shown by county (US Census Bureau [date unknown]).

<table>
<thead>
<tr>
<th>Industrial Sector</th>
<th>Baldwin</th>
<th>Clarke</th>
<th>Escambia</th>
<th>Mobile</th>
<th>Monroe</th>
<th>Washington</th>
<th>Total</th>
<th>Sector Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>169,242</td>
<td>95,018</td>
<td>99,878</td>
<td>1,921,898</td>
<td>0</td>
<td>313,764</td>
<td>2,599,800</td>
<td>25.97%</td>
</tr>
<tr>
<td>Health care and social assistance</td>
<td>275,388</td>
<td>29,085</td>
<td>40,787</td>
<td>846,330</td>
<td>23,008</td>
<td>8,410</td>
<td>1,223,008</td>
<td>12.22%</td>
</tr>
<tr>
<td>Construction</td>
<td>116,834</td>
<td>3,196</td>
<td>12,547</td>
<td>774,138</td>
<td>4,801</td>
<td>1,998</td>
<td>913,514</td>
<td>9.13%</td>
</tr>
<tr>
<td>Retail trade</td>
<td>310,116</td>
<td>32,189</td>
<td>34,543</td>
<td>482,402</td>
<td>17,098</td>
<td>5,896</td>
<td>882,244</td>
<td>8.81%</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>100,451</td>
<td>6,483</td>
<td>13,614</td>
<td>691,666</td>
<td>10,233</td>
<td>1,853</td>
<td>824,300</td>
<td>8.24%</td>
</tr>
<tr>
<td>Professional, scientific, and technical services</td>
<td>87,782</td>
<td>2,101</td>
<td>6,304</td>
<td>509,302</td>
<td>1,170</td>
<td>2,442</td>
<td>609,101</td>
<td>6.09%</td>
</tr>
<tr>
<td>Administrative and support and waste management and remediation services</td>
<td>71,599</td>
<td>4,286</td>
<td>3,743</td>
<td>431,993</td>
<td>1,644</td>
<td>0</td>
<td>513,265</td>
<td>5.13%</td>
</tr>
<tr>
<td>Finance and insurance</td>
<td>86,800</td>
<td>15,170</td>
<td>16,245</td>
<td>373,971</td>
<td>7,363</td>
<td>2,088</td>
<td>501,637</td>
<td>5.01%</td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>32,701</td>
<td>6,386</td>
<td>17,765</td>
<td>306,549</td>
<td>26,312</td>
<td>5,561</td>
<td>395,274</td>
<td>3.95%</td>
</tr>
<tr>
<td>Accommodation and food services</td>
<td>185,017</td>
<td>6,942</td>
<td>10,800</td>
<td>175,429</td>
<td>4,315</td>
<td>609</td>
<td>383,112</td>
<td>3.83%</td>
</tr>
<tr>
<td>Other services (except public administration)</td>
<td>64,993</td>
<td>5,926</td>
<td>7,303</td>
<td>181,835</td>
<td>4,774</td>
<td>1,467</td>
<td>266,298</td>
<td>2.66%</td>
</tr>
<tr>
<td>Management of companies and enterprises</td>
<td>16,759</td>
<td>0</td>
<td>2,240</td>
<td>177,751</td>
<td>0</td>
<td>0</td>
<td>196,750</td>
<td>1.97%</td>
</tr>
<tr>
<td>Utilities</td>
<td>0</td>
<td>0</td>
<td>5,362</td>
<td>179,626</td>
<td>3,857</td>
<td>0</td>
<td>188,845</td>
<td>1.89%</td>
</tr>
<tr>
<td>Information</td>
<td>24,174</td>
<td>1,923</td>
<td>6,946</td>
<td>147,492</td>
<td>2,969</td>
<td>0</td>
<td>183,524</td>
<td>1.83%</td>
</tr>
<tr>
<td>Real estate and rental and leasing</td>
<td>56,172</td>
<td>1,107</td>
<td>1,380</td>
<td>78,882</td>
<td>984</td>
<td>0</td>
<td>138,525</td>
<td>1.38%</td>
</tr>
<tr>
<td>Agriculture, forestry, fishing and hunting</td>
<td>656</td>
<td>10,063</td>
<td>8,065</td>
<td>23,660</td>
<td>10,401</td>
<td>5,772</td>
<td>58,617</td>
<td>0.59%</td>
</tr>
<tr>
<td>Mining, quarrying, and oil and gas extraction</td>
<td>0</td>
<td>0</td>
<td>9,050</td>
<td>45,324</td>
<td>0</td>
<td>0</td>
<td>54,374</td>
<td>0.54%</td>
</tr>
<tr>
<td>Arts, entertainment, and recreation</td>
<td>16,560</td>
<td>163</td>
<td>0</td>
<td>24,800</td>
<td>0</td>
<td>0</td>
<td>41,523</td>
<td>0.41%</td>
</tr>
<tr>
<td>Educational services</td>
<td>35,656</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>35,656</td>
<td>0.36%</td>
</tr>
<tr>
<td>Industries not classified</td>
<td>0</td>
<td>0</td>
<td>93</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>93</td>
<td>0.00%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,650,900</td>
<td>220,038</td>
<td>296,572</td>
<td>7,373,141</td>
<td>118,929</td>
<td>349,860</td>
<td>10,009,440</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>County Share</strong></td>
<td>16.49%</td>
<td>2.20%</td>
<td>2.96%</td>
<td>73.66%</td>
<td>1.19%</td>
<td>3.50%</td>
<td>100.00%</td>
<td>NA</td>
</tr>
</tbody>
</table>
Regional airport makes Mobile a hub for distribution and transportation logistics. In fact, the Alabama State Port Authority reported an overall annual tonnage of 29 million tons (26 billion kg) for the fiscal year 2014. Primary cargos (outbound/inbound) include coal, metals, forest products, containers, frozen poultry, cement, chemicals, and project cargo. With over $500 million of direct and indirect tax impact, the total economic value of the port of Mobile is approximately $18.7 billion (Alabama State Port Authority 2015).

Data on Gross Domestic Product (GDP) for the Mobile metropolitan area from 2001 to 2013, available from the US Bureau of Economic Analysis, were used to calculate the GDP deflator for the study area as 100% times the ratio of the nominal GDP to the real GDP (2009 = 100). The GDP deflator was then used to calculate the inflation rate in the Mobile metropolitan area. Figure 21-5A shows nominal and real GDP expressed in 2009 constant dollars. A qualitative assessment, based on the diagram of the real GDP, shows a positive trend of economic growth from 2001 to 2013, most readily evident Figure 21-5B. Note that the economic growth rate peaked in 2006, the year after Hurricane Katrina, with approximately a 5.9% increase in real growth compared to the previous year.
These data are consistent with Mobile having been moderately damaged by Hurricane Katrina in 2005. The area may have attracted residents from neighboring counties who suffered major injuries from the storm. Garber et al. (2006) found that employment in the Mobile area had grown by 3.1% in August 2005, when the hurricane struck, but Katrina did not stop the employment growth. In fact, in the 4th quarter of 2005, Mobile experienced storm-related job growth. Economic growth slowed down in 2007 and increased again in 2013, when the economic growth rate of the metropolitan area was 2.9%. The inflation rate has been in a range between 1.3 and 3.9 %, with a deflationary 1.1% in 2009.

2) Comparison of the Mobile Metropolitan Area with Daphne-Fairhope-Foley
The micropolitan area (defined as an urban area with a population greater than 10,000 but less than 50,000) of Daphne-Fairhope-Foley is the second largest economy of the greater Mobile-Tensaw River area. This area occupies 125 km² (48 mi²) of the Eastern Shore of Mobile Bay, with a total population of 187,114 residents in 2013 (US Census Bureau [date unknown]a).
A comparison of the industrial sectors of the Daphne-Fairhope-Foley micropolitan area and the Mobile metropolitan area is based on business pattern survey data of the US Census Bureau for 2013. As in the previous analysis, total annual payroll per industrial sector is used as a proxy for the value of industrial production. Total value of wages received by the workers across all industries in the Mobile metropolitan area was approximately $5.53 billion versus $1.50 billion received by the employees in the Daphne-Fairhope-Foley area. Volume of the payroll in the Mobile metropolitan area is 368% of Daphne-Fairhope-Foley, more than their corresponding population ratio (which is 413,188/187,114 ≈ 221%). Pie charts illustrate a disaggregated comparison by the top 8 industrial sectors (Figure 21-6).

Industrial sectors such as wholesale trade, administrative and support, waste management, transportation and warehousing, management of companies and enterprises, real estate, and others have been aggregated in one class called “other services” that represents 30% of the total annual industry payroll in the Mobile metropolitan area versus 26% of the

![Figure 21-6. Comparison of the industry of A) Mobile metropolitan area, and B) Daphne-Fairhope-Foley micropolitan area.](image)
Daphne-Fairhope-Foley area. Healthcare and social assistance appears to be the largest industrial sector in the Mobile metropolitan area and the second largest sector in Daphne-Fairhope-Foley, representing 17% of total annual payroll in both areas. Manufacturing is the second largest sector in Mobile with $923 million in total payroll (17% sector share) versus $145 million in the Daphne-Fairhope-Foley (10%, third largest sector). The manufacturing sector of Mobile includes aviation and aerospace, chemical, maritime, steel, and others (Mobile Area Chamber of Commerce 2015).

The largest industrial sector, ranked by total annual payroll, in the Daphne-Fairhope-Foley area is retail and trade, with $290 million annual payroll (19% sector share). The same sector is ranked 4th in the Mobile metropolitan area, with a total annual payroll of $474 million (8% sector share), after the financial sector. The two areas have different industrial patterns. While the economy of Mobile is primarily dominated by manufacturing industry, Daphne-Fairhope-Foley is mostly a residential area, which may increase demand for retail and trade services. In addition, given the proximity of the two areas connected by several routes, including Interstate 10, a consistent number of workers reside in Daphne-Fairhope-Foley and commute daily to Mobile for work.

The geographic spillover of demand for housing in these two areas, which may include potential differences in neighborhood quality, could be a topic of academic research by urban economists. However, comparison of the accommodation and food services sector in these two areas is noteworthy. In the Mobile metropolitan area this sector accounts only for 3% of total annual payroll across all industries ($174 million), while in the Daphne-Fairhope-Foley area this is the third largest sector with 11% share among all industries and $165 million in annual payroll. This data may reflect the geographic proximity of this area to the coast, which potentially attracts more tourists compared to the metropolitan area of Mobile.

**Minor Economies of the Greater Mobile-Tensaw River Area**

Marginal economies are spread over the rural territory of the greater Mobile-Tensaw River area, outside the main urban areas already analyzed. According to the USDA, in 2014 Baldwin, Escambia, Monroe, and Mobile counties topped the state production of peanuts with 95.3, 72.6, 33.1, and 26.7 million lb (43, 33, 15, and 12 million kg), respectively. The same year, Escambia and Monroe counties were the largest producers of cotton in Alabama with 40,300 and 31,200 bales, respectively (USDA-NASS [date unknown]).

Total value of agricultural products of the greater Mobile-Tensaw River area is available from the Census of Agriculture, a survey conducted every 5 years by the National Agricultural Statistical Service (NASS) of US Department of Agriculture. These data have been deflated using the Consumer Price

![Figure 21-7. Total value of agricultural production in constant 2012 dollars.](image-url)
Index (2012 = 100), South Region, released by the US Census Bureau (Figure 21-7). According to the survey, total value of agricultural output of the area increased by 9.7% from 2002 to 2007 and by 27.9% from 2007 to 2012. The commercial value of agricultural output was approximately $267 million in 2012. At a qualitative level, the chart shows that agricultural production in Mobile County declined slightly in the last decade of the survey, while agricultural activities of Baldwin, Escambia, Monroe, and Washington counties increased. For example, Monroe County experienced a sharp decline in the value of its agricultural output of approximately 80% from 1997 to 2002. However, after 2002 the total value of the agricultural product in the county increased from $5.2 million in 2002 to $10.4 million in 2007 (99.6% real growth) to reach $32 million of 2012 (209% real growth). Monroe County had the best relative performance in terms of increased value of agricultural product in the entire area.

Summary
The major conclusion derived from this short descriptive analysis of socioeconomic indicators of the greater Mobile-Tensaw River area is that a spatial trend exists in the economic development of the area. In this region it is possible to distinguish a predominantly rural economy in the northern part of the Mobile-Tensaw watershed and a major emerging economy in the southern part, towards the coast. This spatial trend is not new. It has persisted since the boom of the cotton trade in the 19th century, when the economies of riverside commercial cities such as New Orleans, Natchez, and Mobile flourished downstream of agricultural areas (O'Sullivan 2007, p 22).
22. Conservation and Tourism Development in the Greater Mobile-Tensaw River Area

Michele L. Archie, The Harbinger Consulting Group

In 2013 and 2014, my firm consulted with an informal coalition of organizations on potential economic impacts of conservation designations in the greater Mobile-Tensaw River area, and on compatible tourism development. A public dialogue was taking shape—perhaps re-emerging—in the greater Mobile-Tensaw River area about the essential character and significance of the place and the feasibility of coordinated, landscape-level conservation to protect it. This emerging public dialogue is reminiscent of conversations that have occurred in other places coming to grips with efforts to align natural resource management and socioeconomic development with maintaining ecological integrity and health. Paralleling Rick Reese’s (1985) popular encapsulation of the policy debate around the Greater Yellowstone Ecosystem in the mid-1980s (Clark and Zaunbrecher 1987), several key themes are emerging in the greater Mobile-Tensaw River area:

1. The Delta is a very special, and in some ways unique, place.
2. The Delta is not an isolated feature; rather, it exists in a larger ecological context that includes the surrounding uplands and an extensive river drainage.
3. This ecosystem is an extraordinary national treasure, encompassing the nation’s richest aquatic system and some of the world’s richest temperate forests.
4. Most resource management decisions in the greater Mobile-Tensaw River ecosystem are made in a fragmented manner that does not recognize the area as an ecological unit.
5. The environmental integrity of the greater Mobile-Tensaw River ecosystem is imperiled by activities and developments, and the task of conserving and maintaining its integrity is incomplete.

In this chapter I draw on my research in the greater Mobile-Tensaw River area, particularly on interviews (Archie and Mullins 2013) with more than 3 dozen business leaders, local government officials, land managers, scientists, conservation leaders, and tourism promoters from 7 southwest Alabama counties (Baldwin, Clarke, Escambia, Mobile, Monroe, Washington, and Wilcox). These interviews, and observation of emerging forums for regional collaboration such as the Delta Roundtable, suggest that area residents and communities may be on a path toward developing—or at least considering—a regional identity that also makes ecological sense.

This research confirms that a tremendous personal affection for the Delta is shared by many across the region. The interviews also revealed a common view that the Delta and surrounding uplands and communities are a largely untapped resource for economic growth that complements the existing economy and is compatible with maintaining both the area’s ecological health and its rural character.

The evolution of a regional identity that corresponds with a functional natural system may be motivated in part by these common perceptions, as well as by shared desires, such as increasing public recreational access to the scenic environments of the Mobile-Tensaw Delta and surrounding uplands, providing better protection for culturally significant features and diverse habitats, and ensuring the ecological health of already conserved areas.

Local organizations are exploring a variety of ways to expand conservation and recreational access in the greater Mobile-Tensaw River area. Communities across the region are developing and promoting nature, heritage, and cultural tourism in and near the Delta. The natural areas at the core of this ecosystem are seen by many as assets that could be leveraged to attract more tourists, greater investment, and new residents and businesses.
Tourism is Underdeveloped in the Greater Mobile-Tensaw River Area

According to census data, between 2001 and 2010, tourism made a steady contribution to the region’s economy. In each of the 4 counties for which figures were reported, two sectors closely related to tourism maintained a relatively consistent share of the overall economy, as measured through the proxy of private employment (US Department of Commerce 2001). In 2013, as in years past, Baldwin County had the strongest concentration of tourism jobs, with a total of 30% of private employment in accommodation and food services and in arts, entertainment, and recreation (Table 22-1; US Department of Commerce 2013).

These data suggest that the north-south spatial trend in the area’s economic development identified by Affuso (this volume) is also reflected in economic activity related to tourism. The concentration of tourism-related jobs in Mobile and Baldwin counties reflects a bias in visitation toward the more developed coastal and urban areas to the south. The northern, more rural portions of this region that encompass the Delta and bluffs see significantly less economic activity from tourism.

The relative underdevelopment of tourism in these more rural and inland parts of the greater Mobile-Tensaw River area is further illustrated by business activity related to wildlife tourism. A recent study of wildlife tourism in coastal areas along the Gulf of Mexico (Stokes and Lowe 2013) identified 89 companies that provide wildlife watching, fishing, and hunting guide services in Baldwin and Mobile counties. Only 4 of these offered services in the Delta. An Internet search covering the entire 7-county region yielded just 6 additional service providers.

Factors Contributing to Underdevelopment of Tourism in the Greater Mobile-Tensaw River Area

My research suggests 4 important factors, described below, that contribute to underdevelopment of tourism in the greater Mobile-Tensaw River area. These factors focus on nature, heritage, and cultural tourism, consistent with sustaining the character and ecological integrity of the area’s landscapes and waterways.

1) Key Elements of Visitor and Transportation Infrastructure Are Missing or Not Well Developed

High-quality, year-round lodging is in short supply, especially in the upper reaches of the Delta and adjacent uplands. Facilities are not large enough to accommodate group tours, and there are few lodging options that appeal to nature and heritage travelers looking for authentic, local experiences.

Public and shared private transportation networks are lacking. Without a private vehicle, it is difficult to reach destinations in and around the Delta from Mobile and the coastal areas that attract the bulk of the region’s visitation. A recent tourism strategic plan for Mobile (Dow 2012) identified high-speed ferry connections as a key to tying together attractions, small towns, beaches, ecotours, and the downtown Mobile Maritime Center. The plan also suggests developing other land- and water-based transportation services, including water taxis, expanded bus tours, and easy-access rental cars to connect tourists to places they want to visit or to key hubs for visitor activity.

Expanding regional transportation links beyond Mobile and Baldwin counties—or even to northern Baldwin County, a crucial point for accessing the Delta—may not be viable without significant added attractions to draw more local and out-of-area visitors into the northern part of this region. The northernmost terminal considered in a decade-old feasibility study for a Mobile Bay ferry was in

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**Table 22-1. Concentration of jobs in tourism-related industries, 2013 (US Department of Commerce 2013).**

<table>
<thead>
<tr>
<th>County</th>
<th>Accommodation and food services share of private employment (%)</th>
<th>Arts, entertainment, and recreation, share of private employment (%)</th>
<th>Total private-sector jobs in two tourism-related industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baldwin</td>
<td>20.8</td>
<td>2.0</td>
<td>12,426</td>
</tr>
<tr>
<td>Clarke</td>
<td>9.1</td>
<td>0.1</td>
<td>615</td>
</tr>
<tr>
<td>Escambia</td>
<td>9.9</td>
<td>7.4</td>
<td>1,730</td>
</tr>
<tr>
<td>Mobile</td>
<td>8.9</td>
<td>1.3</td>
<td>15,076</td>
</tr>
<tr>
<td>Monroe</td>
<td>7.4</td>
<td>0.4</td>
<td>391</td>
</tr>
<tr>
<td>Washington</td>
<td>1.1</td>
<td>0.1</td>
<td>67</td>
</tr>
<tr>
<td>Wilcox</td>
<td>8.7</td>
<td>0.2</td>
<td>154</td>
</tr>
<tr>
<td><strong>Total reported jobs in two industries, 2013</strong></td>
<td><strong>30,459</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Daphne, in Baldwin County south of the Delta (Day Wilburn Associates 2004). To connect visitors with destinations further north, ferry service would need to connect public and private transportation providers serving these areas. Such services currently do not exist, except for small-scale operations focused on commuters and persons with special needs (Archie 2014a).

2) Public Recreational Access is Limited
Despite a roster of more than 40 public and private fishing access sites and launches, the Delta is accessible mostly by private boat. Few companies rent canoes and kayaks or offer guided tours (Archie 2014b). Fuel availability limits the range of powerboats traveling through or deep into the Delta. The number, location, and quality of public land and water access are seen as impediments to expanding guided and outfitted experiences for visitors (Archie 2014c).

Interviews identified other limitations on public recreational access: few developed camping opportunities in the upper reaches of the Delta and surrounding bluffs; a lack of long-distance or connected networks of hiking, biking, and horseback trails; and underutilized or closed recreational sites managed by agencies without a primary focus on natural area conservation and recreation, such as the US Army Corps of Engineers.

3) The Area and Its Existing Nature, Heritage, and Cultural Tourism Opportunities Are Fragmented, Not Well Promoted, and the Area is Not Easily Identifiable as a Distinct Destination
The Delta itself is not well known outside the region, nor is there a flagship attraction within the Delta and surrounding area to draw significant numbers of nature, heritage, and cultural visitors.

Tourism promoters in the area have recognized this kind of tourism as an important avenue for increasing economic activity in the area. This focus is seen as a way to complement an already strong, beach-focused tourist trade, and to help draw visitors to less known and less traveled parts of the region. Lack of funding for marketing and promotion of facilities, sites, and services offered in the Delta is a major hurdle in increasing visibility and visitation, especially for more rural and remote communities and sites.

4) Regional Collaboration on Tourism is Just Beginning and is Not Well Developed Outside Baldwin and Mobile Counties
Most efforts to promote nature, heritage, and cultural tourism have focused on specific communities or counties, and most attempts to collaborate across community or county lines have been limited in scope, aimed at establishing small-scale partnerships and specific efforts. A more ambitious collaborative effort began in 2014, when representatives of several tourism promotion organizations in Mobile and Baldwin counties formed the Regional Tourism Council to advise the Coastal Alabama Partnership on policies needed to develop and promote tourism regionally. In May 2015, the council launched a collaborative “Visit Coastal Alabama” website.

Mobile and Baldwin counties anchor the region’s population and developed visitor services and attractions. But focusing on those two counties alone leaves out a) a significant portion of the geography of the area, and b) a good share of the opportunity to include the upstream portions of the Delta and surrounding uplands and communities as part of a common visitor destination. The ground seems fertile for developing active partnerships to develop and promote nature and cultural tourism in the Delta region. Many key players are acknowledging the potential benefits, and even the necessity, of regional collaboration to leverage and protect the area’s natural and historical resources, and to attract more visitors to rural areas (Archie 2013).

Opportunities to Align Conservation and Tourism/Economic Development
Local organizations—including a nascent regional leadership forum known as the Delta Roundtable—have been exploring a variety of ways to expand and coordinate conservation and recreational access in the greater Mobile-Tensaw River area, including large-scale conservation agreements with private landowners and enhancing and expanding state conservation lands. National support, including broadening the role of the National Park Service in the region, is also being explored to complement and extend these efforts.

As these explorations mature, connections between conservation and leveraging the region’s rich natural and heritage resources for shared economic benefit are emerging.
The majority of conserved land in the Delta and surrounding uplands is in the floodplain. Among the highest conservation priorities in the region are natural areas adjacent to the floodplain, contiguous blocks of longleaf pine and related habitats, and unique ecotypes away from the floodplain. Depending upon the management regime adopted, adding these priority landscapes to the region’s conserved-lands portfolio could help boost the region’s appeal to visitors by increasing land-based recreation opportunities, which are popular among visitors, even in areas that are seen as largely water-oriented (Figure 22-1).

Another way in which conservation and tourism development could reinforce each other in the greater Mobile-Tensaw River area is through expanding guide and outfitting services. Visitor research at other destinations may provide a window into types of experiences for which travelers prefer to use guides or outfitters. For example, visitor surveys in the Florida Everglades—a landscape that, like the Delta, is dominated by water and wetlands—suggest that some types of visitor activities lend themselves to guided experiences better than others (Table 22-2).

A study of Montana’s outfitting and guiding industry (Nickerson et al. 2007) identified several advantages of promoting guided recreation. Outfitters both help attract visitors to Montana and benefit from existing visitation, and visitors who participate in an outfitted trip tend to spend more money than those who do not. Visitors learn about the area’s natural and cultural history from their guides. Guides can help their clients minimize the impact and risks associated with recreation. In the Montana study, visitors rated their connection to nature as the most valued part of their outfitted trip.

Further, guides and outfitters have a business interest in—and most often a personal commitment to—conserving the areas and resources on which their

![Most Popular Activities at Water-Focused National Parks](image)

Table 22-2. Everglades National Park, visitor group participation in selected guided and self-guided activities for winter and spring 2008 (Papadogiannaki et al. 2008; NPS [date unknown]).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Guided # of visitor groups participating on day of survey</th>
<th>Self-guided # of visitor groups participating on day of survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boat tour</td>
<td>428</td>
<td>47</td>
</tr>
<tr>
<td>Tram tour</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>Walking/hiking</td>
<td>65</td>
<td>683</td>
</tr>
<tr>
<td>Photography/painting</td>
<td>30</td>
<td>531</td>
</tr>
<tr>
<td>Boating</td>
<td>30</td>
<td>57</td>
</tr>
<tr>
<td>Canoeing/kayaking</td>
<td>30</td>
<td>85</td>
</tr>
<tr>
<td>Birdwatching</td>
<td>12</td>
<td>114</td>
</tr>
<tr>
<td>Bicycling</td>
<td>12</td>
<td>114</td>
</tr>
<tr>
<td>Camping</td>
<td>6</td>
<td>85</td>
</tr>
</tbody>
</table>
profits depend (Nickerson et al. 2007). Mark Grisham (personal communication, unreferenced, 2013), a longtime member of the Grand Canyon River Outfitters Association, points out that guides and outfitters can play an important leadership role with other local businesses, influencing the path of tourism development and conservation. Grisham suggests that developing a business alliance can help strengthen guides, outfitters, and other businesses, enable collaboration, and expand the influence of member businesses in working with government partners, whether land management agencies, permitting agencies, or tourism promotion boards.

Interviews in the greater Mobile-Tensaw River area confirm that this kind of leadership and collaboration is seen as necessary for sustaining public support for conservation. Alabama’s Forever Wild conservation land trust program was created in 1992 by a constitutional amendment that passed with 83% of the popular vote (League of Women Voters 2012). The program was reauthorized in 2012 with 75% voter support (Ballotpedia.org [date unknown]). Recently, Forever Wild has withheld support for acquisition of high quality lands surrounding the delta that could have addressed issues of large landscape scale connectivity and ecological processes; and it is expected that such acquisitions would likely require state-federal partnerships, e.g. Land and Water Conservation Fund.

Raising local awareness of, and appreciation and support for, protecting the area’s natural, historical, and cultural resources is also important because word of mouth is one of the primary drivers of visitation to regional tourism trails, byways, and other natural and historical attractions. A study of visitors to Minnesota’s Paul Bunyan Scenic Byway, for example, found that over 25% of byway users discovered it through word of mouth, about 20% through signage, and 15% on maps (Liechty et al. 2010). Along the Crooked Road, a music heritage trail spanning 10 counties in southern Virginia, almost half of study participants discovered the Crooked Road venue they were visiting on the recommendation of friends or coworkers (Jones 2008).

**Potential Economic Benefits of the Bartram Canoe Trail**

The state-run Bartram Canoe Trail in the Mobile-Tensaw River Delta includes roughly 200 mi (320 km) of day-use and 1-to-2-night routes, several access points, 3 land-based camping areas, and 4 floating campsites for paddlers only. A southward expansion is underway to extend the trail to the 5 Rivers Delta Resource Center.

The Bartram Canoe Trail was started in the mid-2000s by the Alabama State Lands Division and the Alabama Department of Conservation and Natural Resources, mostly on land secured by Alabama Forever Wild. Between 2004 and 2012, ADCNR recorded 762 reservations for the 4 floating campsites designated for use by paddlers only. Beyond that, trail use is not tracked. Because it is a young and relatively unknown water trail, Bartram may have a long way to go before reaching the “full use” levels of more mature trails.

Comparing the Bartram Canoe Trail with other trails provides a sense of its potential as a draw for paddlers. Averages derived from studies of 6 paddling destinations that include 75 or more waterway miles (120 km) provide data—including average expenditure per trip—needed to estimate both likely potential use and economic impact for the Bartram Canoe Trail in its current configuration. At 200 miles (322 km) of waterway and an average of 199 paddlers/mi/yr (124 paddler/km/yr), the Bartram trail would host 39,800 annual visitors. At an average visitor expenditure of $67 per trip, the total visitor spending would be $2.67 million. Using a multiplier to estimate the secondary and indirect impacts of this spending, the annual impact of these paddlers would be $4.4 million in sales at local businesses, and 58 jobs (a rough calculation that does not attempt to differentiate between local and non-local visitation).

**Managing for Shared Benefits**

As the local exploration of ways to expand and coordinate conservation, recreational access, and economic development in the greater Mobile-Tensaw River area continues, it will be important to continue to identify and refine the region’s shared goals for these activities. These goals can help guide strategic decisions and collaborative action, for example deciding which public and private conservation and land management agencies and approaches are the best fit.

Conservation acquisitions and designations are not guaranteed, by themselves, to improve recreational access, to boost visitation, nor even to maintain or improve ecological integrity. How these areas are managed matters, as does what happens outside their boundaries. A review of World Heritage Sites
A State of Knowledge of the Natural, Cultural, and Economic Resources of the Greater Mobile-Tensaw River Area

(Rebanks Consulting and Trends Business Research 2009) recently concluded that even with this internationally prestigious status, increased visitation and economic gain are not givens. Without additional efforts, sites and their host communities may see a 0 to 3% increase in visitation. But for a small and growing number of World Heritage Sites, most designated relatively recently, the status has been a powerful catalyst for socioeconomic change. The study attributes these differences to specific interventions based on shared intentions to use the designation to catalyze change. Among the study’s conclusions: “World Heritage Site status is what you make of it.”

A preliminary evaluation by Harbinger Consulting Group (2015a, 2015b) examined how a National Park Service unit, such as a National Park and Preserve, might help develop the economic potential of the patchwork of natural, cultural, and historical sites in the Mobile-Tensaw Delta and surrounding region. This preliminary study found that economic impacts could vary widely depending upon many factors, such as how the park and preserve is configured; the types of visitor facilities and services developed; the extent to which surrounding communities support, promote, and enhance visitors’ park experience; and how well discreet sites and events are coordinated and promoted to create more cohesive offerings for visitors.

The study found that by its 10th year a National Park and Preserve, complemented by additional natural and cultural tourism development in the Delta region, could support up to 1074 new jobs in the 7-county region. Those jobs would be primarily in areas away from the beaches, where most current tourism activity is focused. Further benefits are anticipated. For example, a park-centered alternative transportation system could help connect the Delta region with established population and tourism centers around Mobile Bay and the Gulf Coast. Park visitors could also represent significant business for a proposed Mobile Bay ferry system and other regional transportation services.

In an interview one local business owner stated that he believes an expanded National Park Service role in the area could provide recreational access and visitor interaction that would help more people see, enjoy, and come to know the Delta. He sees NPS as being able to work in complementary ways with state and local agencies that focus more on enforcement. That juxtaposition raises an important point for local consideration. Different public agencies and private organizations involved in conservation and land management have different priorities, mandates, expertise, assets, and rules for budgeting and allocating their resources. These differing priorities can result in marked differences in natural area management and visitor services that significantly affect conservation and economic activity from tourism. Examples of some of these points of comparison and their likely impacts on conservation and tourism goals can be found in 2 studies comparing the US Forest Service and the National Park Service as potential managing agencies for specific public lands (Kathy and Steve Berman Environmental Law Clinic 2008; Harbinger Consulting Group 2011).

**Inhabiting the Ecosystem**

In the 1990s, land managers in Alberta, British Columbia, and Montana drew the first maps of what would become known as the Crown of the Continent, an ecological region 3 times the size of Connecticut that encompasses Waterton-Glacier International Peace Park, forested mountain ranges, river valleys, and windswept prairies. At a public meeting in those early days, a man stood up and expressed a sentiment not uncommon in rural western communities beset by dramatic changes in natural resource management and the global economy: “We don’t want to be part of your stinkin’ ecosystem” (personal communication with S. Thompson, unreferenced, 2014).

For a time, land managers carefully drew “their” ecosystem boundaries to exclude human communities. But in areas like the Crown of the Continent, Greater Yellowstone, and the greater Mobile-Tensaw River area, it is difficult to avoid the conclusion that human communities do not really have the choice to opt in or opt out of the ecological systems they inhabit. Yet interestingly, the re-emerging conversation about protecting the essential character and ecological integrity of the greater Mobile-Tensaw River area suggests that evolving a regional identity that makes ecological sense might also make economic sense.
Sea encroachment, Mobile Bay, Alabama. Photograph courtesy of Hunter Nichols.
Alabama citizens have consistently recognized and praised the qualities of their own Mobile-Tensaw Delta as an area of local, regional, and national significance. Ben Raines has characterized the Delta as it has been and is still now for many, part playground and part natural bounty, a landscape of wondrous complexity and diversity that has been home to humans and supported human endeavors for millennia (Raines, this volume)—a landscape of such dynamic complexity that, if one does not deliberately seek to understand, can be quite forbidding, if not downright dangerous. The people who live in and near the Delta know and respect this place.

Yet there is so much more to learn about the Delta. How do the physical properties of the area’s geology and hydrology underpin diverse and dynamic biotic systems, and how do they together shape the ecological setting for human relations with the Delta’s lands, waters, flora, and fauna?

A combination of personal experience, natural and cultural history, and science helps us understand that dynamic ecological and cultural connections bind together the Mobile-Tensaw Delta. This report’s contributors have explored how this landscape’s connectivity is organized and pointed out some consequences if our collective stewardship fails to preserve the Delta we have inherited.

Lay of the Land

This landscape has been described as resembling a giant dowsing rod pointing south to the ocean, where the Tombigbee and Alabama river valleys merge into the extensive Mobile River valley, which forms a “bayhead” delta at the head of Mobile Bay (Rodriguez, this volume). Deltas form at places where rivers meet oceans. The dynamic waters of ocean coasts and rivers never cease to sculpt the land they contact. The way river currents shape the land is evident to any visitor to the Mobile-Tensaw Delta today, and is especially clear to those viewing the region from the air. As described by Ward et al. (this volume), the Delta’s water level can change from minute to minute, driven variously by tides, precipitation, wind, and drought. Bars and channels reposition over days or weeks in response to shifting currents. Changes occurring at the scale of decades or centuries can be seen in floodplain oxbow lakes, created from cut-off sections of river, and in winding swaths of deep green vegetation growing in rich soils of infilled former channels.

Finch and Plumb (this volume) describe how the Mobile-Tensaw Delta and particularly the lower Alabama River and its tributaries slice through unusually complex and highly exposed Cenozoic and Pliocene-Pleistocene strata, resulting in steep riparian bluffs, coves, and the Red Hills erosional cuestas that in places drop several hundred feet to the river bed. Such features, highly unusual in the Southern Coastal Plain, are believed to have been shaped by the interaction of uplift of ancient seabeds and large- and small-scale fluvial processes. The cause of the uplift remains a matter of speculation, but active tectonics appears responsible for the highest rate of elevational change (approximately 4 mm/yr [0.2 inches/yr]) of any place in the Southeastern coastal plain. This vertical relief and the complex mineralogy associated with it have had profound effects on the ecosystems surrounding the Delta and also on the development of the rivers that wind through these steep headlands. As with other rare areas of high relief or unusual soil characteristics within the coastal plain, such as the Apalachicola bluffs region, this combination of factors has resulted in high total species diversity and unusual floral and faunal endemism (Duncan, this volume).

Looking beneath the modern land surface reveals a deeper history to those who understand the language of sedimentology and geology. Rodriguez (this volume) helps us appreciate how the location and morphology of the valley is controlled, in part,
by ancient tectonic events related to the creation of the Gulf of Mexico. More recently, over the past few hundred thousand years, the valley experienced multiple episodes of erosion and deposition related to climate cycles and associated fluctuations in sea level that repeatedly exposed and inundated the continental shelf of the northern Gulf of Mexico.

Rodriguez (this volume) interprets this record of deep time to show how changes in sea level over the past million years or so shaped the Delta in the past, and may influence its future. The Delta has occupied its current location for only the past few thousand years. Prior to that, it repeatedly migrated seaward, then landward, with falling and rising sea levels responding to the advance and retreat of continental ice sheets. Glacial ice never reached the Delta, buts its effects did.

The last time the Delta sat at its current location was about 120,000 years ago. Evidence from the last 9000 years shows that the Mobile Bayhead Delta has responded to small increases in the rate of sea level rise. This knowledge raises questions about the sustainability of the bayhead delta’s present extent in the face of projected sea level rise from global warming. In this broader context, taking a long view, the Delta seems like a living organism, adapting and changing to internal and external conditions. In some sense the Delta is simultaneously ephemeral and eternal. As long as river water reaches the ocean, it will exist in some manner.

As climate changed the Delta over the ages, so did it also influence the area’s ecosystems. Stults and Axsmith (this volume) describe how even during times of extensive glaciers and sea level change, some of the trees that define today’s Delta forests were present, though pines were far less abundant. The Delta forests were not so profoundly impacted by distant ice sheets as environments just to the north. Deeper in time, before the era of ice sheets, plants familiar to us today were preceded by evolutionary ancestor species and increasingly exotic taxa occupying very different environments. Nevertheless, the comparative stability of plant species is remarkable and may reflect the stabilizing climatic influence of nearby Gulf waters.

**As Goes the Water**

The Delta is considered a drowned alluvial plain and valley, where rivers flow through a relatively flat landscape in broadly meandering channels and often overtop their banks. Ward et al. (this volume) describe how the waters of the Mobile-Tensaw River system move through 7 major channels. South of the confluence of the Alabama and Tombigbee rivers, the Mobile River splits to form the Tensaw River, which runs along the eastern side of the Delta, and the Mobile River, which runs along the western side. The Mobile River Basin, the 6th largest in the US and the largest (44,000 mi² [114,000 km²]) east of the Mississippi River that drains into the Gulf of Mexico, covers most of Alabama, parts of Mississippi and Georgia, and a small portion of Tennessee (Ward et al. 2005). It has, by far, the largest discharge (79,300 ft³/s [2246 m³/s]) of any Gulf of Mexico river system east of the Mississippi River embayment, representing 35 times the discharge of all the other eastern Gulf Coast river systems combined. Therefore, the Delta receives water and materials that emerge from an expansive river system and serves as a critical buffer for coastal areas to the south. Abundant rainfall and runoff in the basin supply the Delta with ample water each year. Indeed, it is this abundance within the basin that ultimately creates the vast wetland landscape we now observe as the Delta.

Ward et al. (this volume) helps us understand the Delta’s complex geomorphology of landforms and aquatic habitats, created by thousands of years of geological, fluvial, and geomorphic interactions. In addition to active distributary channels, other major landscape components include islands, flood basins, levees, bays, abandoned channels, lakes, sloughs, and bayous. The levees observed frequently along distributary channels develop from deposition of sand and silt suspended in flood waters that overtop river banks, and they build in height over time from repeated flooding. Flood basins are major landscape features that receive flood water when levees are overtopped, or receive inflow through breaches (crevasse channels) when water levels are below levee height. The dynamic ebb and flow of the Delta is seen as inflowing floodwaters later drain back through these breaches into distributary channels, or over low points in levees.

The greater Delta area is one of the most important and valuable hydrologic resources in the US. It has existed for tens of thousands of years, and currently receives water, sediments, and solutes from a substantial area of Alabama and adjoining states via the river system of the Mobile River Basin. The Delta, which receives nutrients from this vast upgradient river system via the Mobile River, also likely functions as a nutrient retention and transformation zone between the Mobile...
River and Mobile Bay, thus lessening nitrate-nitrogen export to Mobile Bay and fragile coastal areas. Sea level changes and water flow from the basin have over time carved an extensive and complex riverscape of channels, lakes, bays, bayous, and bottomland forests, which both harbor extensive wildlife resources and act to sequester sediments, nutrients, metals, and pesticides draining from the basin upstream. It is important to recognize that human activities in the Mobile River Basin have profound impacts on the Delta downstream. We do not currently have a thorough understanding of the fates of water and material flow in the Delta, nor of the myriad roles of biota in mitigating nutrient and other chemical inputs that otherwise would be transported into Mobile Bay, and thence to the Gulf. Without this knowledge, effective management of the Delta will remain elusive.

Connectivity, the Whys and Wherefores
An area’s ecosystems are defined by plant and animal communities that represent a dynamic temporal and spatial mosaic of interconnected patterns and processes. Taking into account evidence of interacting geomorphologic, hydrologic, and ecological considerations, a greater Mobile-Tensaw River area can be seen to include the Mobile-Tensaw Bottomlands and Delta, and adjacent contributing watersheds, bluff lands, and pinelands. All told, the area extends north from the head of Mobile Bay across the deltaic floodplain, including locally rising watersheds and streams and the forests that shelter them, through the Red Hills region that overlooks the northern extent of the Delta. We can appreciate a greater Mobile-Tensaw River area as a large landscape of intimately connected ecosystems without any formal jurisdiction across northeastern Mobile County, southeastern Washington County, southern Clarke County, southwestern Monroe County, western Escambia County, and northern Baldwin County (Figure 23-1).

Within this area, there is ample evidence of tightly coupled ecological drivers and stressors that interact across temporal and spatial gradients, resulting in a high degree of ecological connectivity that underpins and essentially defines the area. Finch and Plumb (this volume) describe how hydrological alteration affects both blackwater streams and upland pitcher plant bogs surrounding the Delta. Unlike water conditions of the interior Delta, which are primarily controlled by inflow from hundreds of miles upstream or by tidal inflow, water quality on most of the Delta’s blackwater streams is determined by local conditions and hydrological connectivity to the surrounding uplands. Relatively small changes to freshwater inflow as a result of house construction, road building, or groundwater pumping can result in rapid loss of stream head and rapid replacement by siltier waters from the Delta’s brownwater systems, or by more saline tidal waters. Such changes can dramatically alter floral and faunal communities. In the longleaf forests above these blackwater streams, mesic flatwoods and pitcher plant bogs exhibit extraordinarily high diversity (up to 60 species/m² [6 species/ft²]) in part because the plants have carefully partitioned habitat as a result of minute (1 cm [0.4 inch]) changes in depth to the water table. Road building and house construction can severely impair the sheet-flow hydrology that feeds these highly diverse wetland systems, resulting in the loss of hundreds of species of plants and insects from relatively small areas.

The greater Mobile-Tensaw River area hosts a diverse assemblage of freshwater crustaceans notable for their ecological and economic importance. Stoeckel and Helms (this volume) describe the importance of the salinity gradient where, in freshwater non-tidal portions of the system, the crustacean fauna is dominated by crayfish, but, as tidal influences and salinity increase in the Mobile-Tensaw Delta, fiddler crabs gradually replace crayfish in semi-terrestrial environments and Blue Crabs replace crayfish as the dominant aquatic crustacean. Finally, as the Mobile-Tensaw Delta empties into Mobile Bay, a wide range of crabs, prawns, and shrimps depend on estuaries as critical habitat for various life-history stages. Stoeckel and Helms then demonstrate how protection and maintenance of dynamic natural flows, seasonally flooded areas, groundwater fluctuations, and general hydrologic connectivity are of considerable importance to the conservation of crustaceans in the greater Mobile-Tensaw River area. This approach includes careful consideration of future construction of dams and impoundments, road crossings, and bridges where maintenance of salinity gradients is paramount. Alterations in freshwater inflow/saltwater intrusion patterns, as a result of water withdrawal for agricultural and industrial uses, and drought, can potentially have devastating effects. Large groundwater withdrawals have been reported in the coastal zones of Baldwin and Mobile counties. Such changes in supply, coupled with changes in rainfall patterns (e.g.,
Figure 23-1. The greater Mobile-Tensaw River area. (Image credit: Mark Bailey, Glenn Plumb, Bill Finch, Greg Waselkov, and Fred Andrus.)
drought), are viewed as a major threat to the sustainability of the Blue Crab fishery of Alabama.

Heterogeneity within and between upland and wetland landscape communities is promoted and mediated by fire, which makes continuity between vegetation communities and across broad landscapes particularly important. Finch and Plumb (this volume) describe how human-induced habitat fragmentation has changed the fire ecology of the greater Mobile-Tensaw River area so that sources of ignition must be artificially introduced into ecosystems and the fires must be managed on a regular basis. Loss of connectivity between longleaf uplands and surrounding broadleaf and wetland communities has resulted in greatly reduced fire frequencies in those areas. These “ecotonal” marginal areas are integral to the existence of many if not most of the listed engendered, threatened, and special concern species (e.g., Red Hills Salamander, Reticulated Flatwoods Salamander, American chaffseed, pot of gold lily, Wherry’s pitcher plant). In the greater Mobile-Tensaw River area, along the lower Alabama River at the top of the Delta, tree species diversity ranks among the highest of any place in North America, with some 25 species of oaks, 7 species of magnolias, and many other species occupying a very small area. There is indication that the Red Hills of southwest Alabama support the highest oak diversity (28+ oak species) for North America. Occasional fire trickling in from the adjacent longleaf forests is necessary to maintain diversity, and loss of connectivity between these areas and the surrounding longleaf ecosystem has resulted in decline in oak regeneration and the decline or loss of many other species.

Borden and Major (this volume) describe how habitat diversity, environmental patchiness, and natural and human-induced disturbances affect the area’s ability to serve as a breeding ground for seasonally resident birds and as a stopover refuge for refueling migratory birds. The greater Mobile-Tensaw River area supports high bird diversity (over 200 species) and provides critical habitat for avian populations across the Eastern Gulf Coastal Plain and much of the Eastern Deciduous Forest ecoregions. Best (this volume) and Plumb and Finch (this volume) also describe how movement of wildlife between floodplain and uplands and wetlands (e.g., indigo snakes, black bear, freshwater turtles, numerous bird species). Williams et al. (this volume) describe how the three counties surrounding the Delta support what is likely the greatest turtle diversity in the world. Protection of the Delta alone, without giving attention to the surrounding upland habitat, is not likely to benefit turtles, since some of these turtle species are primarily upland species and use the Delta rarely or not at all. Most of those that do are threatened primarily by loss of suitable upland (non-flooded) habitat for egg laying and hatchlings. A great number are lost while trying to lay eggs on the grassy highway medians that run through the lower Delta.

Historical Connections

According to the Alabamas, descendants of the original inhabitants of the place that would become the state of Alabama, their ancestors “sprang out of the ground, between the Cahawba and Alabama Rivers” (Lankford 2011, p 111). Prior to that distant time, there had been only the Above World of flying creatures and the Under World of swimming creatures, until an earth-diver created the Middle World where humans reside. While visiting some of his Alabama-Coushatta Indian friends in 1930s Texas, Martin (1977, p 2-3) transcribed a traditional Alabama legend about an earth-diver, a crayfish who accomplished this feat.

“Once, long ago, before the time of the oldest people, water covered everything.” A log raft drifted on the great ocean, occupied only by some small animals. “Land is somewhere beneath the water,” said their leader, Horned Owl. “Who will make it appear?”

Beaver, a strong swimmer, tried first, but he tired and returned to the raft. Frog tried next, but Garfish chased him, and he too returned to the raft. Horned Owl, in some desperation, asked Crawfish to look for land, and Crawfish eagerly answered, “I am ready.” Garfish did not think him good to eat, and he did not tire like Beaver. Finally he reached the floor of the great ocean.

Crawfish used his wide tail “to scoop mud into a great chimney. He worked rapidly, building it higher and higher, where it began to spread and form a mass of soft earth. The birds and animals on the raft looked at the new earth and agreed that Crawfish had done a good job.”
This origin myth of the Alabamas, and its parallels by other southeastern Indians, accounts for creation of the land, the “earth island,” which Mississippian societies replicated in microcosm with their earthen platform mounds (Knight 2006). Mound A at the Bottle Creek archaeological site, in the heart of the Mobile-Tensaw Delta, stands today as an impressive example of this Mississippian cosmological symbol.

Likewise, the discovery in 1922 of a massive stone pipe carved in the shape of a crayfish, near the large Mississippian shell mound on Dauphin Island, a site subsidiary to the Bottle Creek chiefdom, is most enlightening (Figure 23-2). Sculpted in the 11th century at the greatest of the Mississippian centers, Cahokia, in the central Mississippi River valley, this remarkable portrait of the land’s creator was buried in the 13th century at the southern edge of the North American “earth island” (Emerson et al. 2003). A more recent archeological discovery in Orange Beach, a 10th-century crayfish effigy modeled in clay as if crawling over the lip of a pottery vessel, perhaps represents the legendary earth-diver’s “great chimney,” and testifies to the time depth of this ancient belief in this part of the world (Price 2009, Figures 6-10b) (Figure 23-3).

Morgan (this volume) describes how this region’s time depth of human history can be read literally in archeological layers buried by the near bottomless alluvium of the Mobile-Tensaw Delta. In fact, only the most recent 3000 years of the delta’s archeology sits close enough to the present-day land surface to be accessible for study. One must look to the adjacent bluffs and hilly uplands on either side of the delta to find archeological exposures documenting an additional 8000 or more years of human occupation.
in the greater Mobile-Tensaw River area. In “The Forks” between the Tombigbee and Alabama rivers, in Clarke County, stone tools dating from 11,000 to 3400 years ago (the Paleoindian and Archaic periods) are frequent finds, especially around outcrops of Tallahatta Formation sandstone and agate, both quarried by ancient flintknappers. But equally impressive are the Delta middens at Douglas Lake and Bryant’s Landing, where fired clay balls from Late Archaic earth ovens and Gulf Formational pottery, the region’s oldest, are visible in eroding banks at low water.

A magnificent Middle Woodland shell midden faces the lower Delta at Blakeley State Park, a prime candidate for National Historic Landmark status as well as a refuge for rare, endemic, shell-midden adapted plants. David Morgan’s analysis of a midden at Little Lizard Creek is, so far, the only modern study of a Late Woodland site in the Delta proper, although a flurry of Woodland research on the Alabama coast suggests what potential these data-rich sites offer for understanding long-term human adaptation to the region’s fisheries (Morgan 2003a; Price 2008, 2009; Reitz et al. 2013; Hadden 2015). Biologists in search of historic baseline data on fish and shellfish species ranges and population structures, as well as paleoclimatic data, should consider collaborating with archeologists, who have been retrieving faunal samples from sites threatened by unceasing waterfront development, a catastrophic oil spill, and shoreline and riverbank erosion. Vastly improved methods of stable isotope and elemental analysis of animal growth structures, such as teeth and mollusk shells, are beginning to reveal the selective and seasonal nature of hunting and fishing in the greater Mobile-Tensaw River area with a level of precision previously thought unachievable. There is some irony in the timing of these analytical breakthroughs, which are occurring as sites are disappearing at an alarming rate. Preservation of some of these increasingly scarce middens has become a matter of urgency.

The arrival of Europeans and Africans—the latter most often in bondage—eventually transformed the region’s cultural landscape, but Native American occupants proved adaptive and the transition was long and contested (Waselkov, this volume). Although the long-sought battle site of Mabila, where Hernando de Soto’s Spanish army narrowly escaped destruction at the hands of the Chief Tascalusa’s warriors, remains undiscovered, many other sites of national historical significance are located in the area. The first location of colonial Mobile, earliest French town successfully established on the Gulf Coast, has been extensively investigated by archeologists and determined eligible for designation as a National Historic Landmark, an honor already bestowed on 6 treasured sites and structures in the greater Mobile-Tensaw River area (Schneider et al., this volume). Other likely candidates for NHL status include Fort Stoddert, Old St. Stephens Park, Fort Mims Park, Historic Blakeley State Park, Africatown (Figure 23-4), and the site of Mount Vernon Arsenal/Barracks and Searcy Hospital. Most of these important historic sites are owned by the State of Alabama and administered by a variety of agencies that struggle to maintain them for public interpretation. Searcy Hospital complex, where several 1830s arsenal buildings have collapsed in recent years, remains in the greatest jeopardy.

In recent years the region’s historical connections to forest products industries, especially tree harvest and

![Figure 23-4. Photograph of Cudjo Lewis, enslaved in Africa and transported to Mobile in 1861 aboard the Clotilda, at home in Africatown, circa late 1920s. (Overbey Collection, Doy Leale McCall Rare Book and Manuscript Library, University of South Alabama.)](image-url)
Despite their importance to humans as disease vectors, we have barely begun to count the unfathomably diverse insect taxa of the Delta (Burkett-Cadena, this volume; McCreadie and Adler, this volume). We have a better handle on fishes, with the knowledge that Alabama supports more fish species than any other state. The Mobile Basin alone accounts for most of that. Its endemic fauna once included 40 fish, 33 mussels, and 110 aquatic snails. Though extinctions in this basin exceed any other river system in North America, it still contains 60% of North America’s mussel species, 52% of its turtle species, 43% of its snail species, and 38% of its fish species (DeVries and Wright, this volume; Gangloff, this volume; Williams et al., this volume). The Cahaba, a single small river tributary to the lower Alabama, supports more than twice as many fish species as the entire state of California. The turtle diversity concentrated in the hydrological unit surrounding the lower Alabama and lower Tombigbee rivers and Mobile-Tensaw Delta is rivaled globally only by a much larger area in northwest India.

Terrestrially, the area is equally significant. Duncan (this volume) describes some of the reasons for the high biodiversity and endemism of the greater Mobile-Tensaw River area. The Red Hills region at the head of the Delta is now recognized as the national center of oak diversity. Surveys in pinelands on the bluffs near the Delta have revealed some of the highest counts of vascular plant species anywhere in North America, up to 60 species/m² [6 species/ft²]. Terrestrial endemism in the region ranges from the tree-like Red Hills azalea to one of the world’s most distinctive salamanders. But, importantly, we are acquiring a better understanding of the natural extent of the greater Delta, what it encompasses, and its critical context.

We have begun to better appreciate that the Delta region is much broader than the deltaic portion of the floodplain. And the floodplain’s significance—ecologically, biologically, historically, culturally—is almost entirely dependent on the lands surrounding it. Locals have long recognized this fact. When they refer to the Delta region, they draw from their experience. The floodplain is simply the cornerstone of a much larger area of contiguous wilderness, history, and unusual biodiversity. Recent scientific evidence and popular accounts of the Delta region, including the PBS movie America’s Amazon, extend the concept of the Delta up the lower Alabama River deep into the Red Hills, and west and east into the longleaf pine region that surrounds it.
There is merit in denoting a Greater Mobile-Tensaw River Area. The deltaic floodplain is one of the best preserved in North America and is extraordinarily rich in comparison to any other delta. But the Delta itself is not the richest or even the most biologically and historically significant portion of the Delta region. So many of the globally significant attributes we associate with the Delta region—much of its turtle diversity, its fish diversity, its flowering plant diversity, even the Delta black bears, the last breeding population of bears in Alabama—are rarely or never found in the floodplain itself, but rather spend most of their lives in the bluffs, pinelands, broad-leaf forests, and feeder streams that surround the Delta.

Similar reassessments have given us a much better understanding of the Delta’s human history. The rivers of the Mobile Basin were great corridors of North America’s pre-Columbian and modern history. Shellmounds, complex architectural features of some of the region’s earliest human communities, abound. The north-central Gulf Coast’s largest and most significant Mississippian-era city, a sprawling complex of mounds, plazas, and canals, sits in the midst of the Delta. The Redstick War, instigated in the Mobile River Basin, ushered in the Jacksonian populist movement that forcibly removed most American Indians to lands in the west, and thereby changed the social fabric of the eastern United States.

The Alabama and Tombigbee rivers and their surrounding landscape was also a central corridor for 19th-century American politics. These rivers were major highways for the antebellum South’s cotton and slaves, wealth and oppression (Figure 23-5). Slave-holding counties along these rivers influenced national politics in the mid-19th century, and the community of Africatown, overlooking the Delta, traces its origins to the Clotilda, last slave ship to dock in North America.

It’s no accident that the city of Montgomery, near the head of the Alabama River, was the Cradle of the Confederacy, and that Mobile and its surrounding Delta and Bay was a strategic location from the start of the Civil War until its very last battle. And it’s no accident that the Alabama River and its surrounding landscape became the cradle of the Civil Rights movement where the march from Selma to Montgomery became a turning point in the nation’s history.

The evidence is clear that for millennia, the Greater Mobile-Tensaw River Area has been a place where people have gathered to share in nature’s beauty and bounty to improve their quality of life. More people are exploring and using the Greater Mobile-Tensaw River Area at the present than perhaps at any time in its long history. Thus, there are now more opportunities than ever for continuing our education and study of the Greater Mobile-Tensaw River Area, and sharing in stewardship that will ensure its continued well-being as central to the American experience.


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Ermanno Affuso, Assistant Professor of Economics at the University of South Alabama, earned his PhD in Applied Economics from Auburn University and an MS degree in Civil Environmental Engineering from the Bari Polytechnical University, Italy. He is a member of the American Economic Association and the Urban Economics Association and has published in several scholarly journals, including *Energy Economics* and *Urban Studies*, and has given a number of invited lectures in the US and abroad. His primary research interest is environmental and natural resource economics. In addition, he is interested in computational economics and spatial econometrics applied to regional science.

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J. J. Apodaca is a professor of conservation biology at Warren Wilson College and Senior Co-Chair for Partners in Amphibian and Reptile Conservation (PARC). His research interests include combining genetics techniques with spatial ecology to inform the management of imperiled species and using geographic information systems to identify priority areas for the conservation of amphibians and reptiles. He has been conducting herpetological conservation research for nearly 15 years and has led efforts to identify Priority Amphibian and Reptile Conservation Areas in the southeastern United States.

Michele Archie is a principal at The Harbinger Consulting Group, specializing in economic analysis and community engagement around nature, heritage, cultural tourism, and protected areas. This work, spanning more than a dozen years, includes analysis and projections of economic benefits, evaluation of management alternatives, and strategy development for leveraging natural and historical resources and special designations for community and economic benefit. Her contribution to this report draws on research conducted in 2013-14 on potential economic impacts of conservation designations in the Mobile-Tensaw Delta and bluffs region, and on compatible tourism development.

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Troy L. Best completed BS degrees in Biology, Anthropology, and Secondary Education at Eastern New Mexico University and MS and PhD degrees in Zoology at the University of Oklahoma. He is Professor of Biological Sciences at Auburn University and Curator of the Auburn University Collection of Mammals. In addition to Alabama, he has studied mammals in Argentina, Canada, Kenya, Mexico, South Africa, Swaziland, and much of Europe. He has received honors from the American Society of Mammalogists, Southeastern Bat Diversity Network, and Southwestern Association of Naturalists. He has served as Editor of the Journal of Mammalogy, Mammalian Species, and The Southwestern Naturalist, and he recently co-authored Mammals of Alabama with Julian Dusi (University of Alabama Press, 2014).

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Larry Davenport holds a PhD in biology from the University of Alabama and is currently Professor of Biological and Environmental Sciences at Samford University, Birmingham. In 2007, Dr. Davenport was named Alabama Professor of the Year by the Carnegie Foundation for the Advancement of Teaching. He is an expert on Alabama's plant life, aquatic plants, wetlands, and rare species, including the Cahaba Lily and Confederate Daisy. His most recent research focuses on the potential effects of climate change on Alabama’s plant life and the history of botany. He also writes the Nature Journal column for Alabama Heritage magazine, and a collection of those essays appeared in Nature Journal (University of Alabama Press, 2010).
Dennis DeVries is a Professor and an Assistant Director for Research Programs in Auburn University’s School of Fisheries, Aquaculture and Aquatic Sciences, where he is involved in research, teaching, and part-time administration. He teaches a course in Fish Ecology and 2 courses in the Auburn University Sustainability minor. His research program addresses questions related to aquatic food web interactions, fish early life history, and conservation and ecology of threatened or endangered species. DeVries has published more than 80 peer-reviewed papers and book chapters, and has edited 1 book.

R. Scot Duncan is a Professor of Biology at Birmingham-Southern College. His upbringing in a family of ardent birdwatchers shaped his conservationist outlook and career as a scientist. Scot received a BS in Biology from Eckerd College (1993), and an MS (1997) and PhD in Zoology (2001) from University of Florida. He and his students study the ecology of endangered species and threatened ecosystems in Alabama. Scot wrote the award-winning Southern Wonder: Alabama’s Surprising Biodiversity (University of Alabama Press, 2013, foreword by Dr. Edward O. Wilson). The book interweaves several scientific disciplines to explain why Alabama hosts more species than any other state in the eastern US.

William Finch, senior fellow with the Ocean Foundation, is a well-known writer and natural historian. He has served as Director of Conservation with the Alabama chapter of The Nature Conservancy, as executive director of Mobile Botanical Gardens, and as assistant managing editor at the Mobile Press Register, where his environmental writing received numerous regional and national awards. Finch is the author of Longleaf: Far as the Eye Can See, published in 2012 by the University of North Carolina Press.

Richard S. Fuller, now retired, has practiced archeology on the US Gulf Coast for 40 years, at various times affiliated with Harvard University’s Lower Mississippi Survey, the University of South Alabama’s Archaeology Laboratory, the University of Alabama’s Gulf Coast Survey, and with Coastal Environments, Inc. His specialty is Native American ceramics, with a particular interest in potteries created by the Mississippian, protohistoric, and early historic period Indians of the north-central Gulf Coast.

Michael Gangloff is an Assistant Professor of Biology at Appalachian State University in Boone, NC. He received his PhD from Auburn University in 2003 and has been working with freshwater mollusks in Alabama and the southeastern US for 17 years. Gangloff has authored more than 30 peer-reviewed publications, many of which focus on the ecology and systematics of the Southeast’s unique freshwater mollusk assemblages.

Bonnie Gums is a Research Associate at the Center for Archaeological Studies at the University of South Alabama in Mobile. She received her BA and MA from Southern Illinois University focusing on French colonial archeology in southwestern Illinois. She joined the Center for Archaeological Studies in 1995 and directs cultural resource studies focusing on historic archeological sites along the northern Gulf Coast. Her most recent publication is entitled Archaeology at LaPointe-Krebs Plantation on the Mississippi Gulf Coast (co-edited with Gregory A. Waselkov, Mississippi Department of Archives and History, 2015).

Craig Guyer is a Professor in the Department of Biological Sciences and Curator of Herpetology at Auburn University. He received a BS in Zoology at Humboldt State University, an MS in Biology at Idaho State University, and a PhD in Biology from the University of Miami. His work centers on population and community ecology of southeastern amphibians and reptiles, especially of the Lower Coastal Plain. He has produced 27 graduate students, authored more than 100 scientific articles, and authored or edited 4 books, including Turtles of Alabama (with Mark A. Bailey and Robert H. Mount, University of Alabama Press, 2015).

Brian Helms is Assistant Research Professor in the Department of Biological Sciences at Auburn University and manages the Invertebrate Collection at the Auburn University Museum of Natural History in Auburn, Alabama. His research primarily focuses on freshwater environments spanning organismal biology, system ecology, and resource management. This includes investigating the natural history, population connectivity, ecology, and conservation of crayfishes; quantifying physical and biological effects of human disturbance on stream systems; and development of tools for stream assessment and restoration. He is also enjoys student mentoring, teaching, and biodiversity conservation outreach, but really he just digs crayfish.
Alex Maestre is a civil engineer from the Universidad de Los Andes (Colombia), where he developed environmental programs and models for large marsh ecosystems. He developed strategies for the implementation of surface water management plans in compliance with federal and local regulations. At the University of Alabama, his dissertation involved the development of the National Stormwater Quality Database. As a post-doctoral fellow, he studied the estimation of nutrient fluxes for the Mobile Alabama River System and use of cyberinfrastructure for studying coastal hazards and ecological protection. Maestre is currently working at the NOAA National Water Center in Tuscaloosa.

C. Smoot Major is a Senior Instructor/Research Faculty member of the Department of Biology at the University of South Alabama. Previously he served as State Ecologist and Natural Heritage Coordinator for the State of Tennessee, as well as coordinator for the central basin’s Partners in Flight program, a cooperative partnership of agencies and organizations dedicated to conserving land birds, both resident and migratory. His research now focuses primarily on the Mobile-Tensaw river basin. He has mentored 11 graduate students and 2 honors students in research ranging from ecotoxicology and plant community ecology to avifauna and herpetofauna.

John W. McCready is an insect ecologist, with a special interest in aquatic insects. Professor McCreadie received his PhD from Memorial University, St. John’s, Newfoundland in 1991 on the ecology and cytogenetics of larval black flies (Diptera: Simuliidae). He has been at the University of South Alabama since 1999 and has undertaken research in Canada, the US, the Galapagos Islands, and mainland South America. Currently, his primary interests are in the structuring processes responsible for aquatic communities and insect-fungal symbiosis.

David W. Morgan, PhD, works for the National Park Service, where he serves as the Regional Archeologist for the Southeast and Director of the Southeast Archeological Center (SEAC). His research focuses on the prehistoric and historic southeastern United States, particularly on underwater archeological methods and resource management; the archeology of the African Diaspora and creolization; settlement and subsistence patterns of the indigenous Gulf Coast; and changing concepts about how heritage is perceived and valued. Prior to SEAC, Morgan worked in federal, university, and private sector archeological enterprises.

Hunter Nichols is a photographer and filmmaker based in Birmingham, Alabama. He has been producing conservation-related productions since 2006 and graduated from Auburn University with a BA in Radio, Television, and Film. His most recent feature film, River Dreams, chronicles a 44-day solo canoe trip from Birmingham, Alabama to Horn Island off Mississippi’s Coast. You can find his photography and other film projects at www.hnproductions.com.

Glenn Plumb is the National Park Service Chief Wildlife Biologist, having worked as a biologist at Grand Teton National Park 1990-1993, Badlands National Park 1993-1998, and Yellowstone National Park 1998-2010. He served in Mobile, Alabama on the Department of Interior Strategic Science Group and Incident Command Team for Deepwater Horizon and developed a lasting interest and fondness for the Mobile-Tensaw River area.

Ben Raines has explored and reported on Alabama’s wild places for 15 years. His print work has garnered numerous national environmental journalism awards, and America’s Amazon, a film he wrote and produced, is airing across the country on public television. His underwater film work has appeared in documentaries on the Discovery Channel and National Geographic Television. He reports on nature for the Alabama Media Group and guides sightseeing and fishing trips in the Delta and Mobile Bay, and scuba diving trips in the Gulf of Mexico.

Antonio B. Rodriguez is a Professor at the University of North Carolina at Chapel Hill, Institute of Marine Sciences and has been working there since 2005. He graduated from Hamilton College in 1994 with a BA in Geology and Rice University in May 1999 with a PhD in Geology and Geophysics. After graduation, he stayed at Rice as a Postdoctoral Research Associate (May 1999 to January 2000) and Lecturer (January to July 2000). In August 2000, he moved to the University of Alabama, Department of Geological Sciences as an Assistant Professor and left in 2005 as a College of Arts and Sciences Leadership Board Faculty Fellow and the George Lindahl Fellow. His research is on estuarine evolution and he examines anthropogenic and climate impacts on bayhead-delta, bay, marsh, oyster-reef, and beach environments along the northern Gulf of Mexico and southern Atlantic Coast.
**David B. Schneider**’s firm, Schneider Historic Preservation, LLC, established in 1999, provides a full range of historic preservation consulting services. Mr. Schneider’s historic preservation career spans 34 years, during which time he has successfully completed a diverse range of projects for both private and public sector clients in 15 states and one other country. He specializes in community preservation planning, design review in historic districts, historic resource documentation, and certification of projects for historic rehabilitation tax credits.

**George W. Shorter, Jr.**, now retired, had a successful career as a landscape architect before discovering the joys of archeology and obtaining an MA degree in that field from Louisiana State University. During his 20-year career at the University of South Alabama’s Center for Archaeological Studies, Shorter investigated Late Woodland sites in the Forks region of the Mobile-Tensaw Delta, a French colonial settlement on Dauphin Island, and Fort Morgan, scene of the battle of Mobile Bay in 1864. More recently he has devoted years to the study of Old St. Stephens, Alabama’s territorial capital from 1817 to 1819.

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**Debra Z. Stults** earned an MS in Biology and PhD in Marine Sciences, with studies focusing on paleobotany, palynology, paleoclimatology, and paleo-CO2 atmospheric concentrations during the Late Neogene. She is currently involved in research on Upper Cretaceous through Pleistocene floras from various sites along the Mid-Atlantic to Gulf of Mexico Coastal Plains. The route to paleobotany was not a direct one, as a BS degree in Medical Technology attests. In addition to her clinical duties at the University of South Alabama Children’s and Women’s Hospital, she teaches biology students and continues her paleobotanical research at the University of South Alabama.

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Jennifer M. (Jen) Williams serves as the Federal Coordinator for Partners in Amphibian and Reptile Conservation (PARC), a position hosted by the Wildlife Conservation Branch in National Park Service. Jen is the only full-time, paid national employee for PARC and is afforded the opportunity to work with 11 agencies that serve on PARC’s Federal Agency Steering Committee, as well as many other partners across the US and internationally. She obtained her PhD in Forest Resource Science from West Virginia University, her MS in Wildlife and Fisheries Science from Pennsylvania State University, and her BS in Biology from Gannon University.

Edward O. Wilson is generally recognized as one of the leading scientists in the world. He is also recognized as one of the foremost naturalists in both science and literature, as well as synthesizer in works stretching from pure biology across to the social sciences and humanities. Wilson is acknowledged as the creator of two scientific disciplines (island biogeography and sociobiology), three unifying concepts for science and the humanities jointly (biophilia, biodiversity studies, and consilience), and one major technological advance in the study of global biodiversity (the Encyclopedia of Life). Among more than 100 awards he has received worldwide are the US National Medal of Science, the Crafoord Prize (equivalent of the Nobel, for ecology) of the Royal Swedish Academy of Sciences, and the International Prize of Biology of Japan; and in letters, two Pulitzer Prizes in non-fiction, the Nonino and Serono Prizes of Italy and COSMOS Prize of Japan. For his work in conservation he has received the Gold Medal of the Worldwide Fund for Nature and the Audubon Medal of the Audubon Society. He is currently Honorary Curator in Entomology and University Research Professor Emeritus, Harvard University.

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Photograph of Mobile-Tensaw Delta, Alabama.
Photograph courtesy of Hunter Nichols (http://www.hnproductions.com).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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