

OCMULGEE RIVER CORRIDOR SPECIAL RESOURCE STUDY
ENVIRONMENTAL CONTEXT REPORT

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TABLE OF CONTENTS

Environmental Context	1
Introduction	1
Climate	1
Geology	1
Water Resources	3
Geographic Scope	3
Ocmulgee River Basin	3
Hydrologic Dynamics	4
Water Quality	4
Biological Resources	5
Historical Ecological Conditions	5
Ecological Overview	6
Vegetation and Habitat	8
Fire Regime	11
Wildlife	13
References	17

OCMULGEE RIVER CORRIDOR SPECIAL RESOURCE STUDY ENVIRONMENTAL CONTEXT REPORT

ENVIRONMENTAL CONTEXT

Introduction

The document provides an overview of the study area's environmental context and natural resources as context for the special resource study's significance analysis. The Bond Swamp National Wildlife Refuge (NWR) *Comprehensive Conservation Plan*, Natural Resource Condition Assessment for Ocmulgee Mounds National Historical Park, *Ocmulgee River Basin Management Plan*, and the *Integrated Natural Resources Management Plan* for Robins Air Force Base were the primary sources of information regarding the study area's climate, geology, and water and biological resources.

Climate

Located near the geographical center of Georgia, the study area has moderate climatic conditions throughout the year. The climate is a blend of maritime and continental types. Rarely does either system dominate for extended periods. Average rainfall at Ocmulgee Mounds National Historical Park, at the northern end of the study area, averages 51 inches per year (Burkholder 2017). Rainfall is reasonably well distributed throughout the year, although winter is the wettest season (USFWS 2009). Severe storms occur occasionally in the area. Tornadoes occur approximately twice each year in middle Georgia (USFWS 1989 as cited in USFWS 2009). Thunderstorms occur on an average of two days out of five during the period June through August. Snow occurs at some time during most winters, but amounts are usually small, as evidenced by monthly means of 0.1 to 0.9 inches. The heaviest snowfall over a 24-hour period occurred in February 1973 with 16.5 inches (USFWS 2009).

Mild winters and hot summers characterize the study area. January is usually the coldest month, with a mean temperature of 45.5°F and an average daily minimum of 35.5°F (USFWS 2009). July is normally the hottest, with mean temperatures of 81.1°F and an average daily maximum of 91.8°F. During winter, temperatures seldom remain below freezing for long. The prevailing northwesterly winds of winter and early spring are frequently superseded by southerly flows of warm, moist tropical air.

Geology

Topography

The study area is located just below the Fall Line, a 20-mile-wide (32 kilometers) geological boundary separating the hilly terrain and crystalline rock of the Piedmont region from the flat terrain and sedimentary rocks of the Coastal Plain. The Fall Line extends from Columbus, Georgia, to Augusta. Its name originated from the waterfalls and rapids that are the inland obstacles to navigation on Georgia's major rivers. The Fall Line can also be recognized by stream geomorphology. Streams and rivers above the Fall Line typically have small floodplains, and streams and rivers below it meander through floodplains or marshes (Burkholder 2017).

The floodplains along the Ocmulgee River and its tributaries are much wider in this area than floodplains in the southern Piedmont region.

General topographic features define the study area, including a series of hills and valleys. Ridges are broad and gently sloping, and steep side slopes extend from the hilltops. Many streams and drainages dissect the area. Almost all smaller tributaries flow southward to join the larger creeks at an acute angle (LeGrand 1962). The upland divides are smoother and broader than the Sandhills to the north, and the streams and their floodplains between the divides are broader and farther apart. Further south, the terrain is undulating and rolling and has a less-developed drainage system (Woods 1967). Except for the floodplains and drainageways, the landscape is well drained. However, in places where sediment washed away from the uplands has filled stream channels, excess water drains away slowly, and the floodplains are swampy or wet much of the time (Woods 1967).

Geology

Geologically, the Fall Line divides the resistant metamorphic and igneous Paleozoic rocks of the Piedmont physiographic province from the softer, gently dipping Mesozoic (251 to 65.5 million years ago) and Tertiary (65.5 to 2.6 million years ago) sedimentary rocks of the Coastal Plain (LeGrand 1962). Overall, the geology in the study area is relatively young — Upper Cretaceous to Holocene age (past 90 million years) (KellerLynn 2013). The Coastal Plain comprises thick, relatively unconsolidated strata to partially cemented sands, silts, and clays as well as Quaternary alluvium (sand, clay, lenses of gravel, and some organic material) along major streams (KellerLynn 2013; Miller 1990 as cited in Burkholder 2017).

In the Bond Swamp National Wildlife Refuge (refuge), the geology is dominated by the Tuscaloosa formation (USFWS 2009). The Tuscaloosa formation is the oldest outcropping formation of the Coastal Plain of Georgia (LeGrand 1962). It extends into Georgia from the vicinity of Tuscaloosa, Alabama, where it is typically exposed. The Tuscaloosa formation consists of light-colored sand, sandy clay, and lenticular masses of clay. The formation in Bibb County is characterized by fine to coarse sand, in places mingled with white kaolin and in others separated by lenticular and pure kaolin masses. In northern Twiggs County, the Tuscaloosa formation consists of clay, sand, and gravel. East of the Ocmulgee River, along the interstream area, outlying bodies of the late Eocene age occur. The deposits consist of Barnwell formation massive, deep-red clayey sand, beds of green or gray Fuller's earth type clay, and beds of limestone with spotty outcroppings. Alluvial deposits bordering the Ocmulgee River and some parts of the larger creeks are the youngest sediments in the area. They are of Pleistocene and Recent age. These deposits comprise unsorted clay, sand, and gravel (USFWS 2009). At Robins Air Force Base, the depth to consolidated deposits is estimated to be at least 1,700 feet (USAF 2017).

Soils

The northern section of the Coastal Plain is characterized by mostly red, well-drained soils that have a sandy surface layer and a loamy or clayey subsoil (GA DNR 2004). Water tables are not evident in most soils, except in depressions and along floodplains. The southern part of the Coastal Plain is more variable. Upland areas are dominated by yellow and brown, well-drained soils that have sandy surface and subsurface layers and a loamy subsoil. Many of these soils have

a perched water table at various depths during wet seasons. A significant area of sandier soils occurs near the Ocmulgee River, especially along the eastern side of the floodplain.

Soils in the area of Ocmulgee Mounds National Historical Park are classified as Bibb typic, fluvaquent, which is located on floodplains of streams in the Coastal Plain (Rasmussen 2009). The Bibb soils exhibit very deep, poorly drained, and moderately permeable characteristics and formed in stratified loamy and sandy alluvium. The soil is on the Georgia list of hydric soils, indicating that they are flood prone and are likely indicators of wetland conditions.

The majority of soils on the refuge are categorized as Chewacla–Congaree–Hydroquents (USFWS 2009). The US Fish and Wildlife Service (2009) notes that these soils are typical of the floodplain of the Ocmulgee River and its tributaries. Chewacla series soils generally contain a medium or small amount of organic matter and are medium acid or strongly acid (Woods 1963). Congaree soils are geographically associated with Chewacla soils but are better drained (Woods 1979). Both are found along streams that drain from the Piedmont uplands.

At Robins Air Force Base (base), soil scientists initially mapped the upland soils on the property as Lucy sand, Lakeland fine sand, and Orangeburg sandy loam, which range from very sandy and well-drained to well-drained and loamy (Hammack 2009). Bottomland soils were found to be Chastain-and-Leaf soils or swamp and are poorly drained and subject to intermittent flooding (Woods 1967). A more recent soil survey produced more detail but included some soil series not mapped in the original survey (USAF 2017). In Pulaski County, soils in the floodplain of the Ocmulgee River are categorized as Tawcaw–Meggett soils, which are somewhat poorly drained to poorly drained soils that have a clayey surface layer and subsoil (Pilkinton 2003). The Boswell–Susquehanna–Oktibbeha complex and the Greenville series are the most abundant upland soil types at Oaky Woods Wildlife Management Area, while Tawcaw soils are common in the bottomland areas (GA DNR 2014). Greenville soils comprise most of the uplands at Ocmulgee Wildlife Management Area, while Chastain and Leaf soils are found in the floodplain of the Ocmulgee River (GA DNR 2010).

Some of the inconsistencies in soil categorization between counties, particularly in the floodplain of the Ocmulgee River, may be due to the different county soil surveys being completed at different times, with mapping completed at different scales and/or at different levels of detail (Soil Survey Staff n.d.).

WATER RESOURCES

Geographic Scope

The Ocmulgee River and its tributaries have watersheds that extend beyond the study area. This section describes the broader watershed.

Ocmulgee River Basin

The Ocmulgee River basin is located in the central part of Georgia, occupying an area of approximately 6,085 square miles. The basin occupies parts of the Piedmont and Coastal Plain physiographic provinces, which extend through the southeastern United States. The Ocmulgee River joins the Oconee River to form the Altamaha River, which drains into the Atlantic Ocean.

The headwaters of the Ocmulgee River system consist of three streams — Tussahaw Creek, the Yellow River/South River, and the Alcovy River. These three streams drain the eastern and southeastern Atlanta metropolitan area, and southeast of Atlanta they flow into an artificial impoundment called Lake Jackson created by the Lloyd Shoals Dam (constructed 1911). The Ocmulgee River begins at the outflow of this impoundment. It flows southward, converges with the Little Ocmulgee River at Lumber City in Telfair County, and about 8 miles (13 kilometers) farther downstream it converges with the Oconee River to form the Altamaha River. In the study area, numerous tributaries flow into the Ocmulgee River, including Tobesofkee, Echeconnee, and Stone Creeks.

The Ocmulgee River basin contains a dynamic hydrological system that includes interactions between streams, reservoirs, floodplains, estuaries, and aquifers (GA DNR 2004). Many principal rivers receive a substantial contribution of water from groundwater baseflow during dry periods. Three major aquifer systems, including the Piedmont crystalline rock aquifer and two Coastal Plain aquifers, underlie the Ocmulgee River basin (GA DNR 2004).

Hydrologic Dynamics

The Bond Swamp National Wildlife Refuge *Comprehensive Conservation Plan* (2009) notes that reservoirs and accompanying utility interests along drainages upstream have led to altered hydrologic dynamics along the Ocmulgee River (USFWS 2007 as cited in USFWS 2009). Seasonal flooding (primarily October through March) of bottomland forests still occurs with regularity; typically, the refuge floods five to six times a year, with flood events lasting from a couple of days to two to three weeks (USFWS 2009). Although the river returns to normal levels quickly, the swamp often holds flood waters for several weeks afterward. The extent and frequency at which “natural” flooding occurs is in large part affected by hydropower operations at Lake Jackson, upstream along the Ocmulgee River. The Lloyd Shoals Dam at Lake Jackson was constructed in 1911. The hydrology of the Ocmulgee River has been further affected by the installation of the Macon levee in 1950 and the construction of Interstate 16 in the 1960s, both of which cut the river off from its floodplain and disrupt natural flow (Burkholder et al. 2017, DeVivo et al. 2008). An unfinished levee was constructed in the late 1930s to protect the Lamar unit of Ocmulgee Mounds National Historical Park from flooding and borders the northern, eastern, and part of the southeastern sides of that unit (Burkholder et al. 2017).

The Metropolitan North Georgia Water Planning District (MNGWPD) uses the Ocmulgee River for at least 8% of its water supply, and that percentage is projected to increase (Burkholder 2017). The water withdrawn by the Atlanta area is returned to the Ocmulgee River as sewage that, except for during malfunction periods, is treated to some extent (that is, with secondary treatment or more advanced treatment) (MNGWPD 2011 as cited in Burkholder et al. 2017).

Water Quality

The stretch of the Ocmulgee River that flows through the refuge has been classified as a fishing stream. Though quite turbid in the winter and spring months, the general water quality in the entire Ocmulgee River basin is “very good” (USFWS 1999 as cited in USFWS 2009). The Ocmulgee River, via Lucas Lake Reservoir, is the water source for the Macon Water Authority

(MWA), which serves the city of Macon, Bibb County, and portions of Monroe and Jones counties. In 2009 MWA pumped more than 28 million gallons of water per day from the river (MWA as cited in USFWS 2009). In Macon, the Ocmulgee River had an average daily flow of 1,740 million gallons. Drought conditions have at times severely reduced this flow rate and will do so again in the future. The Ocmulgee River, south of Macon, historically had water quality problems due to point discharges such as pulp/paper manufacturing and urban sewage effluent. The Clean Water Act and resulting regulation have corrected these problems. Nationally, the primary causes of water impairment are related to stormwater runoff/non-point pollution, and many of the water quality impairments in the Ocmulgee watershed are due to such runoff. The Ocmulgee River from Macon to downstream of Bond Swamp NWR is on the 2002 EPA 303(d) list of impaired waters for the presence of poly-chlorinated biphenyls. The draft 2006 303(d) list also includes the impairments of fecal coliform and low dissolved oxygen, likely caused by urban runoff. Tobesofkee Creek is also listed for fecal coliform and low dissolved oxygen. Another significant threat to water quality is mercury, particularly mercury emissions that result from coal burning (USFWS 2009).

The forested wetlands in the study area serve to enhance the quality of the area's water resources. These wetland areas catch the overflow of flood waters during the wet seasons and store water for longer periods during dry seasons. The water resources in these wetlands replenish both surface and ground water systems. Water passing through is filtered by a natural process that aids in removal of organic and inorganic wastes, as well as silt and other sediments (USFWS 2009).

BIOLOGICAL RESOURCES

Historical Ecological Conditions

The study area's current species composition has been influenced by thousands of years of human occupation of the area. A paleoenvironmental study completed in 2009 reconstructed the climatic and biotic history of the area through an analysis of a thick peat deposit in Robins Air Force Base (Hammack 2009). Around 8,000 to 5,000 years ago, species present included oak, gum, pine, alder, sweetgum, yellow poplar, basswood, magnolia, and grape. Increased charcoal also suggests that there was a moderate increase in fire during this period, possibly resulting from lightning strikes and/or the intentional burning of the understory by native peoples (Lamoreaux 1999 as cited in Hammack 2009). From 3,800 BP to present, pollen in the sediment record indicates that pine, oak, and gum were present, as well as understory trees, shrubs, and herbs — representing conditions that are very similar to modern day (Lamoreaux 1999 as cited in Hammack 2009).

According to the Muscogee (Creek) Indian tradition, it was in the area of Ocmulgee Mounds that their ancestors “first sat down” and began farming the productive alluvial bottomlands of the Ocmulgee River corridor (NPS 2014). Agricultural practices likely included clearing vegetation and other modifications of forest and forest understory, particularly through burning. In the late 1770s, William Bartram traveled through Georgia passing the Ocmulgee Old Fields (Wheeler 2007). Bartram (1791) noted that the trading road on the east bank of the Ocmulgee River ran nearly two miles through cultivated fields in the rich low lands of the river. However, the native plant communities that he noted in the vicinity of the Ocmulgee River were

similar to the communities that exist today. Traveling from the banks of the Ocmulgee River westward, Bartram (1791) described the terrain as “generally ridges of low swelling hills and plains supporting grand forests, vast Cane meadows, savannas and verdant lawns.”

These natural communities also occur in the area today, although they have all been reduced in extent since the time of European settlement through conversion for agriculture, logging, introduction of invasive plant and animal species, and development. While relatively few details are known about prior land-use history at the refuge, there are signs of clear-cutting or selective timber harvesting in most portions, including areas where high-grading practices may have been used (Wright 2002). In particular, there has been an extensive loss of canebrakes (Platt and Bradley 1997). Platt and Brantley (1997) hypothesized that the large canebrakes recorded by European settlers and explorers were probably anthropogenic in cause, resulting from desertion of agricultural fields and burning practices. As populations of native people declined due to the introduction of disease by European settlers and explorers, agriculture also declined, and giant cane invaded fallow fields (Platt and Brantley 1997). Additionally, native peoples in the area continued to regularly burn cane, which maintained and expanded canebrakes by removing competing vegetation (Campbell 1985, DeVivo 1991 as cited in Platt and Brantley 1997). However, after European-Americans settled the area, canebrakes rapidly declined due to a combination of overgrazing, altered burning regimes, and land-clearing (Platt and Brantley 1997).

The largest canebrake in modern times possibly occurred along the Ocmulgee River bottoms near Macon, Georgia, as noted by biologist Brooke Meanley (Cely n.d.). In the 1940s, Meanley estimated one of these canebrakes covered a square mile (640 acres) with cane stems averaging 15 to 20 feet high and with maximum diameters of 1.25 inches. More recently, Platt and Brantley (1997) note that existing southeastern canebrakes are only a “remnant” of the vast tracts of giant cane reported by earlier writers.

Ecological Overview

The study area contains over 80,000 acres of forested floodplains and uplands. Most of the study area is forested wetlands that are flooded periodically each year. Within the study area, the sixth-order Ocmulgee River and its tributaries meander through densely forested wetlands. These wetlands and other major water features such as creeks, oxbow lakes, and sloughs support numerous fish, birds, herpetofauna, mammals, and other aquatic life.

The study area is part of the Atlantic Coastal Plain, a biophysiological region of low relief along the East Coast of the United States. Biophysiological provinces are large geographic areas with similar biological communities, geologic history, structures, and landforms. The provinces are based on the recognition that the general character of natural diversity is regionally distinct and correlated with broad patterns of physiography. The Atlantic Coastal Plain extends 2,200 miles from the New York Bight southwards to a Georgia/Florida section of the Eastern Continental Divide. The province is bordered on the west by the Atlantic Seaboard Fall Line and the Piedmont Plateau, to the east by the Atlantic Ocean, and to the south by the Floridian province. Atlantic Coastal Plain forests have many key wetland areas, including those associated with the large river bottomlands as well as many types of isolated wetlands. These play a critical role in maintaining biodiversity in this region.

The Georgia Department of Natural Resources further divides the Atlantic Coastal Plain into two physiographic ecoregions: Southeastern Plains and the Southern Coastal Plain. These regions are comprised mostly of loblolly, slash, and longleaf pine and lowland hardwoods. The study area is part of the Southeastern Plains.

Within the Atlantic Coastal Plain, the Ocmulgee floodplain itself largely coincides with the Level IV ecoregion, “Southeastern Floodplains and Low Terraces,” as delineated by the Environmental Protection Agency. Ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. According to the Environmental Protection Agency:

Southeastern Floodplains and Low Terraces comprise a riverine ecoregion of large sluggish rivers and backwaters with ponds, swamps, and oxbow lakes. River swamp forests of bald cypress and water tupelo and oak-dominated bottomland hardwood forests provide important wildlife corridors and habitat. In Alabama, cropland is typical on the higher, better-drained terraces, while hardwood forests cover the floodplains. In Georgia, the terraces are not as broad and are primarily in bottomland hardwood forest (Griffith et al. 2001).

This region includes the major alluvial river corridors, such as the Chattahoochee, Flint, Ocmulgee, Oconee, Ogeechee, and Savannah Rivers. Large river bottomlands are a priority area for the state of Georgia. Many of these rivers have unique flora and fauna associated with them. The forest overstory is typically dominated by a combination of tall, broad-leaved deciduous trees and needle-leaved deciduous trees, while the understory can be quite variable. Variation from site to site is driven by site-specific variables such as hydroperiod, terrain, and elevation, resulting in diverse vegetation distribution patterns around rivers of the Coastal Plain (Hupp 2000).

Significant portions of the native plant cover in this region have been impacted by construction of dams, clearing for agriculture and timber, conversion to pine plantations, invasion by exotic pest plant species, and development. Habitat loss and modification attributed to increases in suburban areas, including loss of stream habitat due to construction of the water supply reservoirs to accommodate suburban growth, represent the primary long-term threats to wildlife diversity in Georgia. In particular, forested wetland habitat has been disappearing at an increasing rate over the last several decades. This is particularly common across the southeastern United States, where it is estimated that over 90% of the total forested wetland loss occurred between the mid-1950s and mid-1970s (Keeland et al. 1995 as cited in USFWS 2009). Because of this, almost all of the native plant communities that remain contain sensitive, rare, or endangered flora and fauna.

In recent decades, some biological surveys and inventories have been conducted within or near the study area, including vegetation inventories, surveys associated with environmental impact assessments, studies of individual species locations and movement, reports on habitat, flora, and fauna of various public lands, and more. However, these studies have all been limited to particular geographic areas and often to particular biota, meaning that biological data does not exist at an equal level of detail throughout the study area. In addition, this means that biological

resources, such as rare plants, animals, and habitats, may exist in unsurveyed areas beyond their current known locations.

Vegetation and Habitat

The following sections give a broad overview of the vegetation and wildlife resources found in the study area.¹ The vegetation descriptions for the sections titled “Coastal Plain Hardwood and Swamp Forests,” “Upland Forests,” and “Beaver Swamps/Oxbow Lakes” are taken from the Bond Swamp National Wildlife Refuge *Comprehensive Conservation Plan* (USFWS 2009). The vegetation description for the sections titled “Blackland Prairies” and “Coastal Plain Brownwater (Alluvial) Rivers and Streams” are taken from *Georgia’s Natural Communities and Associated Rare Plant and Animal Species: Thumbnail Accounts* (Chafin 2011). Within the broad habitat classifications described below are many more specific vegetation communities, several of which are sensitive or rare. Many of the plant species that are present in the corridor are culturally significant to descendant Creek peoples. Because comprehensive biological surveys have not been conducted for all portions of the study area, it is likely that rare or imperiled vegetation alliances exist or might be found in new locations within the study area.

Coastal Plain Hardwood and Swamp Forests

Bottomland hardwood forests and canebrakes in the southeastern plains are identified as a high-priority habitat in the *Georgia State Wildlife Action Plan* (GA DNR 2015). The Bond Swamp conservation plan indicates that in bottomland hardwood and swamp forest types, principle overstory species include: water tupelo (*Nyssa aquatica*); black gum (*Nyssa sylvatica*); red maple (*Acer rubrum*); sweetgum (*Liquidambar styraciflua*); elm (*Ulmus* spp.); ash (*Fraxinus* spp.); hickory (*Carya* spp.); and water, willow, overcup, and swamp chestnut oaks (*Quercus nigra*, *Q. phellos*, *Q. lyrata*, and *Q. michauxii*) (USFWS 2009). Wright (2002) also observed American elm (*Ulmus americana*) and sugarberry (*Celtis laevigata*) within the refuge. In some parts of the refuge, a mature forest structure with trees over 120 years old has been observed (Wright 2002). Swamp forests are essentially the lowest elevation areas of bottomland systems and are distinguished as being subject to extended or regular periods of inundation. As bottomland forests grade into swamps, tree species diversity decreases and forests tend towards dominance by water tupelo and, in the southern portion of the study area, bald cypress (*Taxodium distichum*). Beaver ponds and oxbow-type lakes can lead to significant portions of refuge floodplains remaining inundated throughout the year, allowing establishment of submerged and emergent aquatic plant communities. Common midstory and understory species in bottomlands, particularly in the refuge, include: poison ivy (*Toxicodendron radicans*), rattan vine (*Berchemia scandens*), flowering dogwood (*Cornus florida*), Eastern hophornbeam (*Ostrya virginiana*), boxelder (*Acer negundo*), non-native privets (*Ligustrum* spp.), and others. Giant cane (*Arundinaria gigantea*) is present sporadically in small patches in the refuge (USFWS 2009); in some places it is a dominant feature of the understory, especially on the natural levee next to the river (Wright 2002).

¹ The general habitat types described here give a broad perspective of the habitat types in the study area but do not represent the diversity of distinct plant communities. The National Vegetation Classification System is the system used by the National Park Service when conducting vegetation mapping. Vegetation mapping is completed at the association level, which generally requires field visits for accurate identification and mapping. Plant community data at this level of detail is not available for the study area.

Although other factors are at play, the development and complexity of understory layers is predominantly influenced by the combined impacts of light penetration and hydrologic forces that affect recruitment, survival, and growth of shrubs, vines, and small trees. Significant patches of bottomland forest habitat on the refuge are closed canopy and lack understory complexity, especially in interior stands away from roads, sites of old logging operations, and other disturbed areas. Nevertheless, areas do exist where midstory and understory strata are quite well developed, providing important structure and foraging/nesting substrates for many wildlife species (USFWS 2009).

At Robins Air Force Base, farther south in the study area, southern floodplain forest is present on bottomlands associated with streams and rivers (USAF 2017). The largest parcel of undeveloped land is the bottomland forest located on the Horse Creek/Ocmulgee River floodplain on the eastern side of the base. This section includes a seasonally flooded old growth bottomland hardwood forest with an overstory of oaks and other hardwoods. Interspersed among this bottomland forest are tupelo sloughs. The floodplain of Sandy Run Creek that flows along the southern boundary of the base also is relatively undisturbed bottomland forest. This natural swamp forest community has a canopy dominated by sweetbay (*Magnolia virginiana*), redbay (*Persea borbonia*), blackgum, sweetgum, red maple, and water oak. At Ocmulgee Wildlife Management Area, bottomland hardwoods are associated with the floodplain of the Ocmulgee River, Magnolia and Shellstone Creeks, Carden Branch, and smaller creeks and drainages (GA DNR 2010). Much of the floodplain has been heavily and recently impacted by selective hardwood cutting (GA DNR 2010). At Oaky Woods Wildlife Management Area, bottomland hardwoods are associated with the floodplain of the Ocmulgee River, Big Grocery Creek, Little Grocery Creek, Beaver Creek, and the associated drainages (GA DNR 2014).

Wright (2002) noted that in Georgia, private land management activities that impact bottomland forest ecosystems appeared to have increased after several decades of relative stability. These impacts include conversion of bottomland forests to pine plantations, as well as timber harvests involving the practice of “high-grading,” in which only the largest and most valuable trees are removed (Wright 2002). This may result in a population of individual trees with less desired genetic makeup, resulting in a degraded population (M. Ford, pers. comm., 2020). Some of the bottomland forest in the study area outside of the refuge and state wildlife management areas are managed as pine plantations.

Upland Forests

The Bond Swamp conservation plan indicates that upland forests within the study area and the refuge can be broadly classified as oak–hickory–pine (USFWS 2009). Chief overstory species include: hickories; sweetgum; white oak (*Q. alba*); persimmon (*Diospyros virginiana*); tulip poplar (*Liriodendron tulipifera*); and loblolly, shortleaf, and longleaf pines (*Pinus taeda*, *P. echinata*, and *P. palustris*). Mixed forest types on the refuge are typically hardwood dominated. The fire-tolerant/dependent pines now comprise only a minor component of upland stands, presumably due to the exclusion and suppression of fire, and resultant hardwood encroachment. Hardwoods can shade and suppress existing pine trees and preclude the establishment of future pine cohorts through shading and competition for space and nutrients. Advance regeneration of softwood species appears to be lacking in much of the uplands at Bond

Swamp National Wildlife Refuge. A mixture of understory species includes dogwood, red bud (*Cercis canadensis*), and greenbrier (USFWS 2009).

At Robins Air Force Base, upland forest occurs primarily in the southeastern portion of the base. The current upland pine forests are dominated by longleaf pine and loblolly pine, while upland hardwood forests are characterized by dominants including various species of oaks, southern magnolia (*Magnolia grandiflora*), American beech (*Fagus grandiflora*), sweetgum, and loblolly pine (USAF 2017). Other trees present include sweetgum, flowering dogwood (*Cornus florida*), elm, redcedar (*Juniperus virginia*), southern red oak (*Quercus falcate*), and hickories (USAF 2017). Ocmulgee and Oaky Woods Wildlife Management Areas contain several thousand acres of pines, almost all of which are less than 50 years old and the majority of which are loblolly pine (GA DNR 2010, GA DNR 2014). Ocmulgee Wildlife Management Area also contains some slash, sand, and longleaf pine stands, as well as upland hardwoods and mixed pine-hardwood forest (GA DNR 2010).

Beaver Swamps/Oxbow Lakes

The Bond Swamp conservation plan notes that many parts of the floodplain in the study area remains inundated throughout the year due to beaver swamps and oxbow-type lakes (USFWS 2009). Beavers build ponds on small- to medium-sized streams or on small channels in floodplains in order to raise water levels. Beaver ponds, and the marshes that develop around their edges, provide habitat diversity in a region of the state where ponds and lakes do not otherwise occur naturally. Many species of moist-soil and aquatic plants establish in these areas, including cattail, sedges, rushes, arrowhead, pond weed, duck weed, and water shield. Button bush is a common understory species along with river cane and alder. Wetland trees, such as red maple and willows may be present, depending on the successional state of the pond (USFWS 2009, Chafin 2011).

Blackland Prairies

Georgia's Natural Communities and Associated Rare Plant and Animal Species: Thumbnail Accounts notes that blackland prairies are among the rarest natural communities in Georgia, occurring in only a few locations in Houston, Peach, Twiggs, and Bleckley Counties (Chafin 2011). Examples of blackland prairies that are open to the public are found in Oaky Woods Wildlife Management Area. Blackland prairies are small, open grasslands surrounded by hardwood and pine forests. They are characterized by their chalky, clay-rich soils that are derived from marl, chalk, or limestone. These soils shrink and crack when dry and expand when wet, becoming very sticky. Shrink-swell soils inhibit the growth of trees and shrubs and instead promote the development of an interesting and rare plant community dominated by showy wildflowers such as gray-headed coneflower, starry rosinweed, butterfly-weed, whorled milkweed, blue sage, eastern coneflower, and eastern gray goldenrod, as well as prairie grasses such as Indian grass, big blue stem, broomsedge, three-awn, and muhly grass (Chafin 2011). Sixteen rare plants are found in grassland/woodland habitats of Oaky Woods (GA DNR 2014). Blackland prairies are identified as a high-priority habitat in the *State Wildlife Action Plan* (GA DNR 2015).

Coastal Plain Brownwater (Alluvial) Rivers and Streams

Georgia's Natural Communities and Associated Rare Plant and Animal Species: Thumbnail Accounts notes that brownwater (alluvial) rivers and streams originate in the Piedmont and carry large amounts of sediments, mostly eroded from Piedmont agricultural lands, that color the water brown and contribute to the creation of extensive floodplain swamps (Chafin 2011). These usually large, meandering rivers have sand and silt substrates and floodplains that are inundated for long periods. Extensive cypress-gum swamps can be found on most major alluvial rivers in Georgia's Coastal Plain. Brownwater rivers and their floodplain communities support a wide variety of fish and other aquatic organisms, including many species of rare and endangered fish and mussels (Chafin 2011).

The dynamic nature of the flooding regimes along the waterways and adjacent floodplains provides a constantly renewable fishery supporting a diversity of warmwater species (approximately 100), including largemouth bass (*Micropterus salmoides*), spotted bass (*M. punctuatus*), crappie (*Pomoxis* spp.), bluegill (*Lepomis macrochirus*), and white catfish (*Ictalurus catus*) (USFWS 2009). Due to the lack of significant downstream obstructions, several anadromous species also occur in the Ocmulgee system, including striped bass (*Morone saxatilis*), American eel (*Anguilla rostrata*), and Atlantic sturgeon (*Acipenser oxyrinchus*). Several species of freshwater mussels and many other species of fish are possible within the study area. The Ocmulgee River is a designated critical habitat for the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), which was federally listed as endangered under the Endangered Species Act in 2012.

Special Status Plants

Two federally listed plant species are known to occur in the study area: the fringed campion (*Silene polypetala*) (endangered) and the relict trillium (*Trillium reliquum*) (endangered). Both of these species are also on the protected plant list of Georgia (GA DNR 2020). The US Fish and Wildlife Service is currently evaluating the status of the Ocmulgee skullcap (*Scutellaria ocmulgee*) in an effort to determine whether the species is warranted for listing as threatened under the Endangered Species Act. The study area also contains two species listed as “at risk” by the US Fish and Wildlife Service — the Gulf sweet pitcher plant (*Sarracenia rubra* ssp. *Gulfensis*) and the Georgia bully (*Sideroxylon thornei*) — and one “candidate” species — Georgia aster (*Symphyotrichum georgianum*). The study area also contains habitat that may be suitable for other species on the protected plant list of Georgia, such as the yellow flytrap (*Sarracenia flava*) (state unusual), ovate catchfly (*Silene ovata*) (state rare), sweet pitcher-plant (*Sarracenia rubra*) (state threatened), and the Indian olive (*Nestronia umbellula*) (state threatened) (NPS 2014). The Robins Air Force Base *Integrated Natural Resource Management Plan* indicates that Ocmulgee skullcap is the only state-protected plant reported to occur on the base, and no federally listed plant species have been recorded.

Fire Regime

Today, fire does not appear to be a dominant natural factor in the bottomland hardwood forests and swamps (Pyne and Teague 2015). Fire is probably more important in small stream examples than in larger river ones, because distances to uplands are short and stream channels and

sloughs are smaller and less effective as firebreaks. Most of the vegetation is not very flammable and usually will not carry fire. However, historical references to canebrakes dominated by *Arundinaria gigantea* suggest that at least in some portions of stands, fire may have once been more of a factor (Gagnon 2009). Giant cane, when associated with bottomland hardwood forests, is successional and is thought to be maintained by periodic fires. Fires occurring about once every decade will maintain stands of giant cane; more frequent fires promote fire resistant trees and shrubs, and yearly burning will eliminate cane (Platt and Brantley 1997). Conversely, if fire is completely suppressed, stand health will decline, and the stand will gradually be replaced by woody vegetation (Hughes 1966 as cited in Platt and Brantley 2001).

Upland forests in the study area include fire-dependent oak–pine and oak–hardwood forests and woodlands. In successional examples of oak-dominated forests, *Pinus* spp. (e.g., *Pinus echinata*, *Pinus taeda*) may dominate in stands for a number of decades, with oak and hickory gradually entering the understory and then the canopy (Pyne 2015b). In some areas, fire-intolerant species such as sweetgum and tulip tree may invade the understories of older stands on dry-mesic, acidic sites (Pyne 2014). When natural fires were more frequent, fire would have kept canopies open by limiting or slowing tree regeneration and would have promoted a more diverse, grass-dominated herb layer (Pyne 2015b).

In stands of shortleaf pine–oak forests and woodlands, fire is an important influence and may be the sole factor determining the relative dominance of pines versus hardwoods under natural conditions (Pyne 2015a). A sizeable hardwood component may be partly due to a lack of fire. Historically, natural fires probably were either (1) frequent and of low intensity or (2) a mix of low and higher intensity (Pyne 2014). Loblolly pine, longleaf pine, and shortleaf pine are generally fire resistant. Longleaf pine and shortleaf pine are both shade-intolerant species and do not survive or grow well without fire (Carey 1992a, 1992b), while loblolly pine will tolerate some shade when young but becomes intolerant with age (Carey 1992c). Under current conditions, the understories of these stands are typically shrub- and small tree-dominated, with the typical species varying with aspect, soil, and moisture relations. More open and grass-dominated understories may have been more prevalent prior to the mid-20th century, when open grazing and surface fires were more common (Pyne 2014). However, changes in land use have prohibited the continuation of natural fire regimes on a broad scale. As a result, the landscape today differs from the historic open oak woodlands, parklike longleaf pine, and other fire-dependent habitats.

The Bond Swamp conservation plan notes that fire management at the refuge is conducted in the context of suppression (USFWS 2009). The response to any natural or artificially occurring fires on the refuge is to control and suppress them. As such, the fire-tolerant/dependent pines now comprise only a minor component of upland stands, likely due to the exclusion and suppression of fire and resulting hardwood encroachment. The refuge intends to complete a plan that allows prescribed fire use in order to restore, rehabilitate, and maintain fire-adapted ecosystems consistent with desired future habitat conditions (USFWS 2009).

At Robins Air Force Base, areas of longleaf pine forest had reverted to upland hardwood habitat due to past fire suppression. Prescribed burns were conducted in longleaf pine forests in 2004, 2009, and 2011 to facilitate the reestablishment of the original longleaf pine–wiregrass habitat (USAF 2017). Prescribed burning is also included in management plans for the state wildlife

management areas within the study area as a method to reduce hardwood encroachment and stimulate growth of herbaceous vegetation in open canopy pine stands (GA DNR 2010, GA DNR 2014).

Wildlife

The study area supports a diverse, abundant wildlife community, reflecting the vegetation and habitat types available. Bottomland forests and associated swamps are important habitats for a variety of wildlife groups, including neotropical migratory birds, waterfowl, mammals, reptiles, and amphibians. The wildlife subsection descriptions are taken from the Bond Swamp conservation plan (USFWS 2009).

Mammals

The Bond Swamp conservation plan notes that 50 species of mammals could occur within the study area (USFWS 2009). The USFWS (2009) notes that white-tailed deer (*Odocoileus virginianus*), gray squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), cottontail rabbit (*Sylvilagus floridanus*), and gray fox (*Urocyon cinereoargenteus*) occur commonly at the refuge. In addition, the study area and surrounding lands support low numbers of black bear (*Ursus americanus*) from one of three recognized populations in Georgia. Coyotes (*Canis latrans*) and beaver (*Castor canadensis*) also occur and can have important impacts on habitats and other wildlife on the refuge. Nonnative feral hogs (*Sus scrofa*) are also present in the study area. The USFWS (2009) notes that feral hogs reproduce quickly in the rich bottomland hardwood forests and cause a wide variety of environmental damage, including soil erosion, changing natural water flows by rooting and wallowing, feeding on rare and sensitive native plants, and competing with native wildlife. Other more diminutive species (e.g., shrews, rodents, and bats) are also likely to occur based on existing habitat conditions (USFWS 2009).

Further south, at Robins Air Force Base, the typical mammals seen on the base include, but are not limited to, white-tailed deer, black bear, bobcat (*Lynx rufus*), gray fox, raccoon, gray and fox squirrel (*S. niger*), eastern chipmunk (*Tamias striatus*), white-footed mouse (*Peromyscus leucopus*), pine vole (*Pitymys pinetorum*), short-tailed shrew (*Blarina brevicauda*), and cotton rat (*Sigmodon hispidus*) (USAF 2017). Mammals that have been reported at Ocmulgee or Oaky Woods Wildlife Management Areas include black bear, white-tailed deer, eastern cottontail (*Sylvilagus floridanus*), swamp rabbit (*Sylvilagus aquaticus*), gray squirrel, and fox squirrel (GA DNR 2010).

Amphibians and Reptiles

The Bond Swamp conservation plan notes that the combination of warm weather and wet areas in the area of the refuge provides ideal conditions for a variety of reptile and amphibian species (USFWS 2009). About 80 species of reptiles and amphibians could occur on the refuge, including 26 species of snakes, 10 species of lizards, 12 species of turtles, 13 species of salamanders, and 18 species of toads and frogs. Although Bond Swamp NWR is on the northern edge of the range for the American alligator (*Alligator mississippiensis*), it is occasionally seen on the refuge, especially on warm, sunny days. Alligators up to 10 feet in length have been documented on the refuge. There are several species of venomous snakes, including cottonmouths,

copperheads, and rattlesnakes. Other common reptiles and amphibians that might be encountered at Bond Swamp NWR include the box turtle (*Terrapene carolina*), eastern king snake (*Lampropeltis getula*), snapping turtle (*Chelydra serpentina*), green treefrog (*Hyla cinerea*) and southern fence lizard (*Sceloporus undulatus*). No reptile or amphibian species of special concern are known from Bond Swamp NWR, though several are possible, such as Southern dusky salamander (*Desmognathus auriculatus*) and spotted turtle (*Clemmys guttata*). Uplands could possibly support the poorly known coal skink (*Eumeces anthracinus*), and with reintroductions and appropriate habitat management, uplands could also support the state threatened gopher tortoise (*Gopherus polyphemus*) (USFWS 2009).

A baseline survey for reptiles and amphibians in 2003 recorded 32 reptile and amphibian species at Robins Air Force Base (USAF 2017). Turtles and frogs are the most diverse groups of reptiles and amphibians in both bottomland and upland habitats. Herpetofauna observed include eastern box turtle, common garter snake, and water moccasins (*Agkistrodon piscivorus*). Gopher tortoises have been detected in Ocmulgee Wildlife Management Area in low numbers in recent years (GA DNR 2010).

Birds

The Bond Swamp Comprehensive Conservation Plan notes that roughly 200 bird species are thought to occur on the refuge and, by extension, in the study area (USFWS 2009). Many species of waterfowl, waterbirds, shorebirds, and neotropical songbirds pass through, overwinter, or nest in the refuge as they follow their seasonal migration routes. Waterfowl make extensive use of the wetlands and naturally flooded bottomlands during non-breeding periods (Sept-March). Mallard (*Anas platyrhynchos*), American black duck (*A. rubripes*), blue-winged teal (*A. discors*), wood duck (*Aix sponsa*), and ring-necked duck (*Aythya collaris*) are the most common species during these months. The study area supports one of the most significant concentrations of wintering waterfowl in middle Georgia (USFWS 2009). Although the flooded swamps of the Ocmulgee River and vicinity are difficult to survey accurately, the comprehensive conservation plan for the refuge estimates peak midwinter waterfowl usage at 3,000–5,000 individual birds (USFWS 2009). The area contains outstanding wood duck habitat, and several thousand wood ducks remain or return to the refuge to breed (USFWS 2009). Isolated beaver ponds and adjacent forests provide exceptional foraging habitat and rookery sites for herons, egrets, ibis, and anhingas (*Anhinga anhinga*). The floodplain forests of the refuge are an important habitat supporting the conservation of dozens of species of resident and migratory landbirds, many of which are designated as priorities due to continued concern over declining populations, habitat threats, and other factors. Priority neotropical migratory birds found breeding on Bond Swamp NWR include Swainson's warbler (*Limnothlypis swainsonii*), prothonotary warbler (*Protonotaria citrea*), yellow-billed cuckoo (*Coccyzus americanus*), Acadian flycatcher (*Empidonax virescens*), and wood thrush (*Hylocichla mustelina*). A single pair of bald eagles (*Haliaeetus leucocephalus*) has been nesting on the refuge, and others may utilize the refuge in nonbreeding seasons. Other occurring bird species include woodpeckers, doves, kingfishers, hummingbirds, hawks, owls, and Caprimulgids (nocturnal birds). American woodcock (*Scolopax minor*) and wild turkey (*Melagris gallopavo*) are two important gamebird species found on the refuge. The refuge and surrounding lands form one of the largest remaining blocks of forested wetlands in Georgia, and their conservation is critical to the many species of

landbirds that require large, relatively unfragmented forest systems to successfully breed and sustain their populations. At the same time, heterogeneity in forest age, structure, and composition is important in providing the full complement of resources and structural characteristics necessary to support a diversity of bottomland forest birds (USFWS 2009).

Birds found at Robins Air Force Base include wild turkey, bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaidura macroura*), red-eyed vireo (*Vireo olivaceus*), cardinal (*Cardinalis cardinalis*), tufted titmouse (*Parus bicolor*), wood thrush (*Holocichia mustelina*), summer tanager (*Piranga rubra*), blue-gray gnatcatcher (*Polioptila caerulea*), hooded warbler (*Wilsonia citrina*), and Carolina wren (*Thryothorus ludovicianus*) (USAF 2017). Numerous bird species have been found on Ocmulgee Wildlife Management Area, including neotropical bird species such as Swainson's warbler, Kentucky warbler (*Geothlypis Formosa*), wood thrush, hooded warbler (*Setophaga citrina*), yellow-billed cuckoo (*Coccyzus americanus*), and eastern wood pewee (*Contopus virens*) (GA DNR 2010).

Fish

The Bond Swamp conservation plan notes that the Ocmulgee River and Stone and Tobesofkee Creeks are the three principal waterways on Bond Swamp National Wildlife Refuge, and all are classified as fishing streams (USFWS 2009). The dynamic nature of the flooding regimes along these waterways and adjacent floodplains provides a constantly renewable fishery supporting a diversity of warmwater species (approximately 100) including, largemouth bass (*Micropterus salmoides*), spotted bass (*M. punctuatus*), crappie (*Pomoxis* spp.), bluegill (*Lepomis macrochirus*), and white catfish (*Ictalurus catus*). Due to the lack of significant downstream obstructions, several anadromous species also occur in the Ocmulgee system, including striped bass (*Morone saxatilis*), American eel (*Anguilla rostrata*), and the federally endangered shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Several species of freshwater mussels and many other species of fish are possible in the study area (USFWS 2009).

Invertebrates

The Bond Swamp conservation plan notes that approximately half of the expected butterfly species for the region have been documented on the refuge (USFWS 2009). Many of the 63 species of butterflies that have been identified are species of concern in Georgia (Johnson 2006 as cited in USFWS 2009). It is likely that many of the others occur within the study area, but perhaps infrequently or in limited numbers. Many species require specific host plants to complete their life cycles, and a number of such host plants require forest openings, early successional patches, and other sunlit areas to thrive. Some of the more common species tied to mature bottomlands and found on the refuge include the American snout (*Libytheana carinenta*), hackberry emperor (*Asterocampa celtis*), and tawny emperor (*A. clyton*) (USFWS 2009).

Special Status Wildlife

One federally listed animal species has been documented in the study area: the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) (endangered), which occurs in the Ocmulgee River system (USFWS 2009; Ingram and Peterson 2016). Additionally, in the Bond Swamp conservation plan

the US Fish and Wildlife Service notes that there are occasional sightings of wood stork (*Mycteria americana*) (threatened) in the refuge using the open wetland habitats for post-breeding feeding. Wood stork have also been observed at Ocmulgee Mounds National Historical Park (GBIF.org 2020). As of 2009, one active bald eagle nest was located on the refuge and was one of 112 in the state of Georgia (USFWS 2009). In addition to the refuge's year-round resident pair of eagles, during the winter months eagles may temporarily use the refuge as they pass through the region (USFWS 2009).

The robust redhorse sucker (*Moxostoma robustum*), a Georgia state-listed endangered fish, occurs in the Ocmulgee River. This fish lives in Georgia rivers and was once thought to have disappeared from the Ocmulgee River entirely; however, it was rediscovered in the river near Bond Swamp National Wildlife Refuge in 1999 (USFWS 2009). The conservation needs of this species are being addressed through a Candidate Conservation Agreement with Assurances which covers an area on the Ocmulgee River between Lloyd Shoals Dam and the low-head dam at Juliette, GA. The state threatened Altamaha shiner (*Cyprinella xaenura*), the state rare goldstripe darter (*Etheostoma parvipinne*), and the spotted turtle (*Clemys guttata*) are listed as occurring in Bibb and Twiggs Counties, but it is unknown whether these are found in the study area (USFWS 2009). The Altamaha arc mussel (*Alasmidonta arcula*) is listed as threatened by the state of Georgia and is also likely to be found in the area, assuming appropriate habitat exists (USFWS 2009).

As of 2017, no threatened or endangered animal species are found on Robins Air Force Base, although the base does provide habitat that would be listed for at least transient occurrences of some listed animal species (USAF 2017).

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