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Southeast Coast Network
Atlanta, Georgia

Vital Signs Monitoring in the Southeast Coast Inventory & Monitoring Network

Phase I (DRAFT) Report

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1. Introduction and Background

Program Purpose and Scope

The Southeast Coast Network (SECN) monitoring plan is being developed over a multi-year period following specific guidance from the National Park Service, Washington Office (WASO). Networks are required to document monitoring planning progress in three distinct phases and to follow a standardized reporting outline. Each phase report requires completion of specific portions of the outline.

This Phase I Report emphasizes work on Chapter 1 (Introduction and Background), Chapter 2 (Conceptual Models) and Chapter 11 (Literature Cited), but includes partial work on several other chapters (3, 6, and 8). Some chapters will remain unwritten until future Phase Reports are completed. This document presents the SECN framework and approach to vital signs monitoring planning and a summary of work accomplished to date. Specifically the Phase I Report summarizes existing information on National Park Service and related natural resource monitoring programs within the network, presents an overview of biological and physical resources of network parks, describes monitoring goals and needs, and presents a theoretical framework with conceptual models for guiding future efforts.

Phase II and Phase III Reports will be developed during FY 2005 and FY2006, respectively. The Phase II Report will describe the initial set of vital signs with supporting rationale and prioritization, as well as provide updated information presented in the Phase I Report. The Phase III Report will constitute the first full working version of the SECN Monitoring Plan and will present results of the monitoring design work and implementation planning.

The Importance of Long- Term Monitoring

In 1992, the National Academy of Sciences (1992) reviewed the natural resource management program of the National Park Service (NPS) and concluded, “If this agency is to meet the scientific and resource management challenges of the twenty-first century, a fundamental metamorphosis must occur.” Indeed, that metamorphosis materialized when the National Park Service implemented a strategy to standardize inventories and monitoring of natural resources on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possessed the resource information needed for effective, science-based, managerial decision-making and resource protection. The national strategy consists of a framework having three major components:

1. Completion of basic natural resource inventories in support of future monitoring efforts;
2. Creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and
3. Implementation of operational Vital Signs monitoring in all natural resource parks.

A fundamental goal of the National Park Service is to protect or maintain natural ecosystem structure and function in national parklands. Knowing the condition of natural resources in national parks is crucial to the Service's ability to protect and manage parks. National park managers across the country confront increasingly complex and challenging issues and are asked to provide scientifically credible data to defend management actions. Many of the threats to park resources, such as invasive species and air and water pollution, come from outside the park boundaries, requiring a landscape approach and integrated long-term monitoring to understand and protect the park's natural resources.

In this plan, we define integrated monitoring as “systematic, consistent, and simultaneous measurements of physical, chemical, biological, and human-effects variables through time and at specified locations in a manner that is designed to effectively inform adaptive management decisions.” In theory, by monitoring a wide range of variables at long-term sites, it is possible to gain an understanding of how ecosystems function and respond to

change (Bricker and Ruggiero 1998). Coupling monitoring with research and modeling might make it possible to predict what will happen in the future and, if necessary, devise appropriate response strategies. Ecological monitoring is vital to park management for a variety of reasons:

- Ecological monitoring provides understanding and insight into long-term ecological phenomena and the function of complex ecosystems across park and network boundaries.
- Ecological monitoring provides the basis for evaluating whether NPS is achieving mandates and policies of protecting park natural resources. One of the major shortcomings of most of natural resource management and conservation plans has been the absence of a comprehensive ecological monitoring program (Kremen et al. 1993).
- Ecological monitoring allows for detection of long-term adverse effects of human activities on park ecosystems. Because of the delay between a human disturbance and a subsequent response, long-term ecological monitoring provides significant data.
- Ecological monitoring provides information to inform stakeholders, park visitors, and the public about the status and threats to park ecosystems, organisms, and ecological processes.

Legislative Mandates Linking Monitoring to Natural Resources Management

The enabling legislation establishing the National Park Service and its individual park units clearly mandates as the primary objective, the "*protection, preservation, and conservation of park resources, in perpetuity for the use and enjoyment of future generations*" (16 USC 1). National Park Service policy and recent legislation (National Parks Omnibus Management Act of 1998) require that park managers know the condition of natural resources under their stewardship and monitor long-term trends in those resources in order to fulfill the NPS mission of conserving parks unimpaired. The laws and management policies that follow provide the mandate for inventorying and monitoring in national parks.

National park managers are directed by federal law and National Park Service policies and guidance to know the status and trends in the condition of natural resources under their stewardship in order to fulfill the NPS mission to conserve parks unimpaired (see Appendix 2: Legislation Relevant to SECN Vital Signs Monitoring). The mission of the National Park Service (National Park Service Organic Act, 1916) is:

> *"...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."*

Congress strengthened the National Park Service's protective function, and provided language important to recent decisions about resource impairment, when it amended the Organic Act in 1978 to state that *"the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…."*

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the national park system. The act charges the secretary of the interior to "*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System*," and to "*assure the full and proper utilization of the results of scientific studies for park management decisions*." Section 5934 of the act requires the secretary of the interior to develop a program of "*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriations bill:

> *"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."*

The 2001 NPS Management Policies updated previous policy and specifically directed the service to inventory and monitor natural systems:

> *"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions."*
>
> *Further, "The Service will:*
>
> - *Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents.*
> - *Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources.*
> - *Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals.*
> - *Analyze the resulting information to detect or predict changes, including interrelationships with visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames.*
> - *Use the resulting information to maintain-and, where necessary, restore-the integrity of natural systems" (2001 NPS Management Policies).*

Additional statutes that provide legal direction for expending funds to determine the condition of natural resources in parks and specifically guide the natural resource management of network parks are summarized in Appendix 2.

Goals of the Vital Signs Monitoring Program

Table 1-1. Goals of the Southeast Coast Network Vital Signs Monitoring Program

Vital Signs Monitoring Goals
1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress toward performance goals.

The overarching purpose of natural resource monitoring in parks is to develop scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems (http://www.nature.nps.gov/im/monitor/#GoalsObj). The monitoring program of the Southeast Coast Network will be designed around the five broad, servicewide goals common to all networks within the Vital Signs Monitoring Program (Table 1-1).

Environmental Setting of the Southeast Coast Network

Network Parks

The Southeast Coast Network contains twenty parks, seventeen of which contain significant and diverse natural resources (Table 1-2). In total, SECN parks encompass more than 178,000 acres of federally-managed land across North Carolina, South Carolina, Georgia, Alabama, and Florida. The parks span a wide diversity of cultural missions also, including four National Seashores, two National Historic Sites, two National Memorials, seven National Monuments, two national Military Parks, as well as a National Recreation Area, National Battlefield, and Ecological and Historic Preserve. The parks range in size from slightly more than 20 to nearly 60,000 acres, and when considered with non-federal lands jointly managed with SECN parks the Network encompasses more than 253,000 acres.

Table 1-2
Parks of the Southeast Coast Network with significant Natural Resources.
[Park codes in italics are administered by the nearest non-italicized entry above]

Park Code	Park	Significant Natural Resources?	Federal Acres	Non-Federal Acres	Total Acres
CANA	Canaveral National Seashore	Yes	**57,647.69**	**14**.00	**57,661.69**
CAHA	Cape Hatteras National Seashore	Yes	34,500.00	--	34,500.00
FORA	Fort Raleigh National Historic Site	Yes	355.00	--	355.00
WRBR	Wright Brothers National Memorial	No	421.00	--	421.00
CALO	Cape Lookout National Seashore	Yes	25,173.62	3,069.74	28,243.36
CASA	Castillo de San Marcos National Monument	No	20.18	0.33	20.51
FOMA	Fort Matanzas National Monument	Yes	298.00	--	298.00
CHAT	Chattahoochee River National Recreation Area	Yes	5,462.16	5,437.84	10,900.00
CONG	Congaree National Park	Yes	21,768.79	4,663.45	26,432.24
CUIS	Cumberland Island National Seashore	Yes	18,849.14	17,566.69	36,415.83
FOFR	Fort Frederica National Monument	Yes	239.19	2.23	241.42
FOPU	Fort Pulaski National Monument	Yes	5,365.13	257.97	5,623.10
FOSU	Fort Sumter National Monument	Yes	194.37	0.23	194.60
CHPI	Charles Pinckney National Historic Site	No	28.00	--	28.00
MOCR	Moores Creek National Battlefield	Yes	87.75	--	87.75
HOBE	Horseshoe Bend National Military Park	Yes	2,040.00	--	2,040.00
KEMO	Kennesaw Mountain National Battlefield Park	Yes	2,879.60	4.54	2,884.14
OCMU	Ocmulgee National Monument	Yes	701.54	--	701.54
TIMU	Timucuan Ecological and Historic Preserve	Yes	8,416.95	37,583.05	46,000.00
FOCA	Fort Caroline National Memorial	Yes	133.15	5.24	138.39
	Total		**184,581.26**	**68,605.31**	**253,186.57**

Canaveral National Seashore

The natural resources of Canaveral National Seashore include a diverse assemblage of wildlife, vegetative communities, geophysical features and natural processes reflecting the complexity of the land/lagoon/sea interface of east central Florida. Throughout the park, the relationship of land and water is paramount. From ephemeral wetlands to Atlantic beaches, the natural processes shaping the coastal environment are present in full diversity where change is the only constant.

Unlike many barrier islands, Canaveral has only a single dune ridge, averaging 12 feet in height. For the vast majority of its length the dune is quite stable, backed by a dense growth of saw palmetto (*Serenoa repens*) and several other species of hardy shrubs and grasses.

Mosquito Lagoon, extending along the backside of Canaveral's barrier island, is the northernmost part of the Indian River Lagoon. Containing the most diverse assemblage of aquatic species on the entire Eastern Seaboard, this 155-mile long lagoon has been designated as an Estuary of National Significance by the Environmental Protection Agency and an Outstanding Florida Water by the State of Florida. It contains one of the last significant populations of oysters on the entire Atlantic Coast that has not been depleted by over harvesting or pollution. Commercial shell fishing is extremely important to the local economy; recreational fishing and shrimping in the lagoon support a multimillion-dollar tourist industry. The estuary also acts as an important nursery area for a number of commercially important ocean-going species such as flounder, mullet, black drum and shrimp.

The park is located along the "frost line", resulting in a unique combination of temperate and subtropical plants found nowhere else in the Western Hemisphere. Several temperate species extend no farther south than Canaveral, while a number of subtropical species occur no farther north. Signs of this unusual mixture include Canaveral's hammocks, which contain an overstory dominated by temperate species and an understory comprised of subtropical plants. Another sign is the significant shift in vegetation along the edge of the lagoon from salt marsh cordgrass (*Spartina alterniflora*), which predominates in areas north of Canaveral, to mangrove species that predominate to the south.

Wildlife resources are considerable, ranging from a myriad of terrestrial and aquatic species inhabiting estuarine systems to small endemic populations of mammals living in the dunes. Canaveral is second only to Everglades National Park in number of federally protected species with 14. These include such species as the highly endangered West Indian manatee (*Trichechus manatus*), right whale (*Balaena glacialis*) and little known Atlantic salt marsh snake (*Nerodia fasciata taeniata*), who's entire known range consists of a single county in Florida. Canaveral's 24 miles of beach provides a critical nesting area for sea turtles, harboring 3,000 to 4,000 nests each year. The majority are loggerhead (*Caretta caretta*), with a smaller number of green (*Chelonia mydas*) and an occasional leatherback (*Dermochelys coriacea*). Mosquito Lagoon provides an important nursery area for juvenile sea turtles.

Boaters are coming into Canaveral National Seashore in increasing numbers due to the growing popularity of fly-fishing for redfish. This increases the destruction of seagrass beds, impacts to fisheries are unknown and manatees are highly affected. One of the very controversial and volatile issues among boaters in Florida is the establishment of slow speed zones to protect the West Indian manatee. Canaveral has supplied sighting data and engaged in several discussions with DEP on the proper placement of slow speed zones in the vicinity of the park. The park also assisted DEP with a boating survey to determine boating use patterns and areas that warrant speed restrictions.

Additionally, the park has long been concerned about the impact of commercial harvesting on hard clams (*Mercenaria* spp.) and eastern oysters (*Crassostrea virginica*). As shellfish have been depleted along other portions of the Atlantic coast, harvesting pressure has increased significantly in Mosquito Lagoon. Currently, the park requires all fishermen commercially harvesting shellfish to submit monthly catch logs. The accuracy of these logs is questionable and compliance has been poor.

Canaveral faces a number of complex issues regarding water quality in Mosquito Lagoon. These include septic tank, agricultural and industrial effluents, mosquito control activities, dredging of the Intracoastal Waterway, impacts of aquaculture, and increased boating activity. While water quality in Mosquito Lagoon is quite good overall, septic tank effluent and stormwater runoff from adjacent communities are threatening to degrade the

lagoon. Currently park waters are closed to shellfishing when rainfall exceeds 1.5 inches in a 72-hour period, due to high fecal coliform levels. Another of the delicate issues with which Canaveral NS must grapple is mosquito control. In the designation of lands for NPS management, both NASA and the State of Florida stipulated that Canaveral NS must cooperate with the local mosquito control districts to control salt marsh mosquitoes. Canaveral and East Volusia Mosquito Control District have tested several measures, including Open Marsh Water Management (OMWM) techniques, to reduce the use of chemicals and to restore lost salt marsh.

Canaveral's most extensive resource management program involves sea turtle nest protection. The park documents 3,000 to 4,000 sea turtle nests each year. In the early 1980's, over 95 percent were destroyed by raccoons (N01). In 1984, the park began a nest screening program and has reduced depredation to 20-30 percent. However, this program is costly, averaging about $45,000 a year, and raises questions about the diverted predation pressure on other ground nesting species. Some parties recommend removing raccoons as a solution; in fact, MINWR does so with considerable success.

Canaveral NS is located in one of the most active lightning strike areas in the country. This, combined with the volatile fuels (particularly saw palmetto) and the extremely high fuel loads that have been allowed to accumulate, makes wildfire or human-ignited fire a serious threat. In addition, a number of vegetative communities and the animals that they support are dependent on periodic light to moderate fires. A Fire Management Plan has been completed which will allow the park to utilize prescribed fire to maintain and restore habitat for protected species such as the scrub jay, gopher tortoise and indigo snake

Like a number of other parks in the southeast, Canaveral faces a serious threat from the invasion of exotic plants, including Brazilian pepper (*Schinus terebinthifolius*), Australian pine (*Casuarina equisetifolia*) and century plant (*Agave sp.*). Brazilian pepper has spread throughout virtually all of the disturbed areas of Canaveral. A small number of *Melaleuca quinquenervia*, a species, which has severely impacted the Everglades, have been found in MINWR, less than 5 miles from the park boundary.

Exotic animals are also a threat to park resources. The feral hog (*Sus scrofa*) has become established in the southern half of Canaveral NS, particularly in the joint management area, and is seriously disrupting native vegetation. A voracious snake eater, it may also be affecting native snakes, including the protected eastern indigo snake (*Drymarchon corais couperi*). Another exotic animal impacting the park is the feral cat (*Felis catus*). During a two-year survey to determine the distribution of the southeastern beach mouse within Canaveral NS, no mice were captured in the northernmost section of the park (Stiner 1991; Stiner 1992). In addition, a number of potentially harmful amphibian and reptile species are expanding their ranges into Florida from tropical areas throughout the world. The park is attempting to detect these invaders through the long-term herpetofaunal monitoring program established by Southeastern Louisiana University in 1992.

Outer Banks Group - Cape Hatteras National Seashore

The Outer Banks Group includes Cape Hatteras National Seashore, Fort Raleigh National Historic Site, and Wright Brothers National Memorial. Cape Hatteras National Seashore is part of the east coast barrier island system. The Seashore contains 35,400 acres of land and 74 miles of virtually unspoiled beach. The U.S. Fish and Wildlife Service administers Pea Island National Wildlife Refuge within the boundary of the seashore. The intensely developed town of Nags Head borders the northern end of the Seashore and nine other villages border the seashore. Seashore marshes contribute heavily to primary estuarine productivity and provide habitat for numerous wildlife and aquatic species. Buxton Woods is located on the widest portion of the Seashore and is one of the largest maritime forests on the east coast. Approximately one-third of the forest, about 1,000 acres, lies within Park Service boundaries. Of the rest, about 800 acres are under state protection. The unique and varied habitats, mature broad-leafed evergreen forest and shrub, freshwater marsh, and bog support an unusual assemblage of aquatic, terrestrial, and avian species. Buxton Woods also overlies, protects, and provides for recharge of an important freshwater aquifer. The seashore has recently been designated a Globally Important Bird Area by the American Bird Conservancy because of the importance of the seashore habitats to avian breeding, migration, and wintering.

The ecological zonation of Cape Hatteras National Seashore is resultant in part on artificial alterations dating from the turn of the twentieth century. The most important perturbations were: (1) early efforts at mosquito control and

waterfowl management which involved excavation of drainage ditches and construction of water control structures; and, (2) construction and vegetative stabilization of primary dunes along the length of the Seashore. Later changes were wrought when road construction included excavation of borrow ponds for road bed material. For the most part, these actions ended by the 1970's, save for localized projects designed to protect specific and discrete portions of infrastructure.

Fort Raleigh NHS is located on the north end of a forested island between the barrier islands and the mainland of coastal North Carolina. The site's 355 acres vary in elevation from sea level to 20 feet. Over half of Fort Raleigh is heavily forested with the remainder of the area supporting a visitor center, administrative and maintenance buildings, residences, the Waterside Theatre complex, and maintained open grassed areas. The maturing mixed deciduous and pine forest occurs on land that was previously disturbed, having been used for farming, grazing, transportation routes, and early settlement activities. Habitats include upland forests dominated by pines or a mixture of pine and hardwoods, brackish marsh, and swamp forests dominated by hardwoods. Species within the forest canopy include live oak, laurel oak, blackjack oak, American holly, dogwood, persimmon, and loblolly pine.

Wright Brothers NM covers over 421 acres in Kill Devil Hills, NC. The area's wind-blown sand flats and hills were the Wright brother's chosen practice field, and in 1903, the site of the first human flight. WRBR is situated on a barrier island within a rapidly developing residential and commercial community. The site has been transformed from its original relatively barren, dynamic state to a stabilized, dune and grass flat region. Grassed areas are vegetated with native and introduced grasses. Loblolly pine dominates the forested areas with laurel and live oak being the more predominant broad-leafed trees. Evergreen broad-leafed shrubs are interspersed within the forested area and between the forested and grassed areas. Much of the site is occupied by a visitor center, reconstructed buildings of the period, the monument itself, maintenance and residential structures, a paved airstrip, roads, walkways, and parking lots. Only limited vegetation and faunal inventories have been conducted at the site.

Developmental pressures outside the Park and visitor and recreational uses represent the major categories of threat to the integrity of natural resources on the CAHA Group parks. Adjacent property development has resulted in direct loss and fragmentation of habitat upon which numerous park wildlife species were partially dependent. Replacement of natural areas with impervious surfaces increases storm water runoff with its associated contaminants. Two potentially profound adverse impacts associated with adjacent development are contamination of ground and surface water by septic leachate and drawdown of the aquifer associated with excessive groundwater withdrawals. Other threats to natural resources include the introduction of exotic plants and animals, off-road vehicle use, and dredging of channels adjacent to the park.

Cape Lookout National Seashore

Largely undeveloped and accessible only by boat, Cape Lookout National Seashore is made up of three barrier islands covering 56 miles of the central coast of North Carolina. Most of the Seashore consists of North and South Core Banks, a 44-mile (71-km)-long barrier system oriented in a southwest to northeast direction and separated by the infrequently maintained New Drum Inlet. Cape Lookout extends into the Atlantic Ocean from its southern end, and abandoned Portsmouth Village is located at its northern end. The other barrier system within the Seashore, Shackelford Banks, extends westward from Cape Lookout and, while smaller (13 km long), is considered ecologically more diverse than Core Banks.

Core Banks is a long, narrow expanse of low dunes, maritime grasslands, and extensive salt marshes. Shrub thickets border the grassland in many places, and a low maritime forest occupies small areas of higher ground, such as Guthries Hammock. The islands are generally about 1 to 2 meters in elevation and 1 to 2 kilometers in width. For the most part, they are open and treeless. Windblown salt spray is carried across the entire barrier.

The wide berm and low, scattered dunes of Core Banks are characteristic of overwash-influenced barrier systems that have not been altered by man-made structures. When storms occur, the dunes here offer little resistance to flooding. Another process that has shaped these islands is the opening and closing of inlets. Dramatic changes in the position of inlets may take place in the period of a few years or even months. Many of the creeks in the marshes along Core Banks have probably been inlets in the past.

Although the physiography of Core Banks is more or less uniform along its length, the areas of Portsmouth Village and Cape Lookout are unique. Instead of exhibiting the typical zonation of a wide berm, low dunes, grasslands and shrub thickets, and salt marsh, the northern end of Portsmouth Island is characterized by vast tidal sand flats (averaging 1 km in width) located between the berm and the dunes of a series of marsh-fringed islands. At triangular Cape Lookout, continuous dunes similar to those on Shackleford Banks can be found on the southwest side, with several small freshwater marshes present in depressions between the dunes. With high dunes significantly reducing overwash, thickets have further stabilized the flats of the Cape's interior. A long spit extends from the western tip of Cape Lookout, where a jetty built in the early 1900s has encouraged accretion in this direction.

The dunes at the western end of Shackleford Banks are 10 to 13 meters (34 to 44 ft) above sea level and contain the highest elevations on Shackleford. The presence of high dunes on the western section may be due to the island's east-west orientation. Because the island faces the prevailing southwest winds rather than being parallel to them, sand is continually blown from the accreting beach into the dunes, where it is trapped and stabilized by the dune grass, *Uniola*. In the lee of this wall of rolling dune ridges, there is an impressive maritime forest, as well as several fresh and brackish marshes. On the side of the island that faces Back Sound, the beach is narrow and, in some places, the scarped bank is eroding away. Unlike most of the Outer Banks, the inner shore here is not fringed with salt marsh.

The western end of Shackleford is an accreting sand spit. Young dunes with *Spartina patens* and *Fimbristylis castanea* are forming along the edge of the curving berm, while areas of salt marsh are developing on the sound side of the spit. The eastern two-thirds of Shackleford Banks consists of low dunes, grassland, and salt marsh. In contrast to the western third, it is influenced by overwash. This part of the Island is characterized by dunes of less than 3 meters (10 ft) in height, open grassland (on overwash terraces), mesic meadows, and salt marsh. Shrub thickets occur in a few areas.

Specific issues of concern to Cape Lookout National Seashore include off-road vehicle use and associated impacts to dunes, threatened and endangered species, commercial fishing, military overflights, and non-native species.

Castillo de San Marcos and Fort Matanzas National Monuments

Fort Matanzas National Monument (FOMA) is located 14 miles south of St. Augustine on the northeast Atlantic coast of Florida. It encompasses of a total of 298 acres divided between the southern tip of Anastasia Island (108 acres) and the northern end of Rattlesnake Island (190 acres). Both are barrier islands separated from the Florida mainland by the Matanzas River and the Intracoastal Waterway.

The Anastasia Island portion of FOMA consists of stabilized beach dunes rising as much as 7.6 meters above sea level. Predominant habitats in this portion of the park include beaches along both the Matanzas River and the Atlantic shore, stabilized sand dunes supporting maritime forest, secondary dunes further inland, and salt marsh.

Most of Rattlesnake Island is less than 5 feet above sea level, though it rises to 15 ft at one point on it s northern end. Much of northern portion of Rattlesnake Island consists of sandy fill pumped in from dredging operations that maintain the boat channels in the Intracoastal Waterway. In addition to the habitats found on Anastasia Island, Rattlesnake Island supports slash pine and red bay woodlands, oyster shell beaches, and developing hardwood forests typified by wax myrtle, cedar, and cabbage palm.

FOMA has actually increased in size by an estimated 13 acres over the past three decades. This continuing growth is evident in the expanding shoal banks inside and outside the Matanzas River inlet. Shoals inside currently allow fishermen on Rattlesnake Island to wade into the middle of the Matanzas River west of the inlet bridge, while shallow bars outside break Atlantic waves before they can roll into the mouth of the Matanzas River.

Moderate threats to sea turtle nests are due to the high level of vehicular traffic on the beach (it is legally a state highway), and the threat of human poaching of new nests. Beach mouse habitat, a small area (less than 5 acres) is located just behind the first barrier dunes on the beach and is also threatened by overwash from extreme weather conditions accelerated by the vehicular traffic. The park, in cooperation with the State DOT, will be installing two new parking lots and a dune crossover trail all just north of the bridge and improvement of the parking area at the beach access. This project will help reduce the number of vehicles on the beach and provide a hardened interpretive

trail that will help keep visitors out of the delicate dune ecosystem. Unfortunately, a separate threat also exists from occasional illegal "dune busting" by 4-wheel drive vehicles.

Minor threats include disturbance of a least tern rookery area by vehicles. In addition, natural plant succession is decreasing the attractiveness of the area as a rookery for the least tern. Foot traffic into the dunes is a constant occurrence, creating blow-outs in the dunes, which reduce their ability to maintain plant life. The dunes directly protect the fort by reducing erosion of the barrier island that shields Fort Matanzas from damaging storms.

Introduced plants pose another minor threat, competing with native species in several disturbed areas of the park. They are beginning to threaten the survival of some species and habitat. Exotic animals such as house cats, both feral and free roaming pets, are a direct threat to the Anastasia Island Beach Mouse. House mice and European rats are considered a potential threat to the Beach mouse and other indigenous mammals.

Chattahoochee River National Recreation Area

On August 15, 1978, Congress passed Public Law 95-344 establishing Chattahoochee River National Recreation Area as a unit of the National Park Service. Congress authorized boundary expansions in 1984 and 1999. The park extends for 48 miles along the Chattahoochee River within the Piedmont Plateau, between the city of Atlanta and the Appalachian Mountains further to the north. The park contains mesic hardwood and pine uplands, scattered cliffs, floodplains, and riparian, aquatic and shoal habitats. The park also contains significant cultural resources, for the river corridor has attracted humans for thousands of years and the remaining features have recorded their passage and story. These natural habitats and cultural resources adjacent to, and partly surrounded by, the growing greater Atlanta metropolitan area, provide a unique opportunity for environmental education and resource-based outreach programs.

The park's entire 48-mile length runs along the Brevard Fault Zone, which forms the Chattahoochee River channel, one of the oldest river channels in the United States. The Brevard Fault is a major 320+ mile long geological feature that, in part, forms the dividing line between two physiographic provinces, the Appalachian Mountains, and the Piedmont Plateau. The steep and rocky Palisades section of the park is generally considered to be the best location along the entire Brevard Fault Zone to view and study this major geologic feature.

The combination of park's mixed habitat types, coupled the old and stable Chattahoochee River channel forming a biological link/corridor with the Appalachian Mountains, has resulted in a high biodiversity within Chattahoochee River National Recreation Area. These diverse habitats support numerous rare and protected aquatic and terrestrial species.

The park constitutes an important outdoor recreation resource to over 3.7 million people located in a major southeastern metropolitan area. The park's green space and the river significantly improve the quality of life by serving as a sanctuary as well as providing a variety of outdoor recreation opportunities such as hiking, nature viewing, paddling, boating and fishing. The Chattahoochee River is inhabited by 22 species of game fish, including the largest stocked trout fishery in Georgia.

At the upstream terminus of the park is Buford Dam, which is operated by the Corps of Engineers. Buford Dam generates electricity and the impoundment, Lake Lanier, provides water to the greater Atlanta metropolitan region. The operation of the dam dramatically alters river flows and water temperatures within the park.

Chattahoochee River NRA (CHAT) consists of 15 separate units, however the park is currently acquiring additional land which will eventually link many of these units. The lands surrounding many of these units, especially closer to Atlanta, are experiencing rapid development and urban sprawl. This urbanization of adjacent lands has resulted in significant river and visual impacts and has taxed the region's sewer utility capacity. As a consequence, heavy rains and storm water runoff routinely cause sewer spills which flow directly into the Chattahoochee River. Additionally, siltation is a consistent problem. Currently there are five permitted commercial sand and gravel mining operations within the park. All utilize suction dredging barges along with an upland dewatering plant.

Although there is a high diversity of native plant species, impacts from exotic species are extensive and pervasive.

Existing baseline data on park resources and impacts are minimal at best. Historically, management has focused primarily upon the park's recreational opportunities. It is only lately that the park has begun to address its long overdue natural and cultural resource stewardship responsibilities. The park has recently begun the development of a long-term water quality monitoring program and is increasing resource staff to address many of the challenges facing Chattahoochee River NRA. Since the park contains a rich assemblage of natural and cultural resources, and is located so close to a large metropolitan region and institutions of higher education, Chattahoochee River NRA provides a great opportunity for resource-based environmental educational outdoor lab "facility".

The park is currently going through the General Management Plan (GMP) planning process. In this document, the stated purpose of Chattahoochee River National Recreation Area is to "lead the preservation and protection of the 48 mile Chattahoochee River corridor from Buford Dam to Peachtree Creek, and its associated natural and cultural resources, for the benefit and enjoyment of the people".

Congaree National Park

Congaree National Park is situated immediately adjacent to the Congaree and Wateree Rivers in southeast Richland County, South Carolina, approximately 20 miles southeast of the capital city of Columbia. The park protects towering old-growth trees and diverse plant and animal life within the largest contiguous bottomland hardwood forest remaining in the United States. Periodic flood waters from the adjacent rivers sweep through the bottomland forest in winter and spring, carrying the nutrients and sediments that nourish and rejuvenate this unique floodplain ecosystem. Nearly 90 species of trees grow within the park, with many that are recognized as national and state champions for their size. Forested wetlands, oxbow lakes, and slow moving creeks and sloughs provide superb habitat for fish, birds, reptiles, mammals and other aquatic life. The diversity of flora and fauna, tall tree canopy and giant trees, and intact floodplain ecosystem earned the park the designation of an International Biosphere Reserve, National Natural Landmark, Globally Important Bird Area, and congressionally designated Wilderness Area.

Congaree National Park encompasses a 26,800-acre bottomland hardwood forest in central South Carolina. Located 20 miles southeast of Columbia, it borders the northeast side of the Congaree River and the west side of the Wateree River. Densely forested, most of the Park is located within the river floodplain. A wide variety of forest communities are represented, with dominant tree species ranging from upland pines to wetland cypress (*Taxodium* spp.) and tupelo (*Nyssa* spp.). The Congaree River forest environment is characterized by silty clay soils, oxbow lakes, swales and sloughs, and meandering creeks. The Congaree and Wateree Rivers are the major source of floodwaters, sediment, and nutrients delivered to the Park, although several tributary creeks also flow through it. The significance of CONG lies in its (1) unique old-growth bottomland hardwood forest community associated with the swamp-like floodplain; (2) remarkably large trees, including loblolly pine, bald cypress (*Taxodium distichum*), tupelo, sweet gum (*Liquidambar styraciflua*), American sycamore, cottonwood (*Populus* spp.), oak (*Quercus* spp.), and holly (*Ilex* spp.) trees; (3) the intact floodplain ecosystem, and (4) high biodiversity. On June 30, 1983 Congaree National Park was designated an International Biosphere Reserve.

Congaree National Park's mission calls for accomplishing the long-term goal of "preserving, protecting, and perpetuating the bottomland hardwood ecosystem in a manner that promotes the natural function of the Congaree River floodplain by (a) managing and restoring designated wilderness areas and all-inclusive wetlands, so as to minimize disturbances to natural landforms, vegetation, and wildlife habitat, and (b) conserving the rich and abundant biodiversity within the Congaree and Wateree River alluvial floodplains by controlling, where necessary, the adverse effects caused by human activities.

Threats to the health and viability of the surface and ground water in the park include: (1) chemical runoff from agricultural fields; (2) an Environmental Protection Agency Superfund Site located five miles from the park northwest boundary; (3) aquaculture operations on the north boundary perimeter; (4) highway treatment residues; and (5) discharges and corporate expansion of two neighboring companies: a nuclear fuel production plant and a pulp and paper manufacturer. Also upstream from the park is the Teepak Company, a manufacturer of synthetic skins for meat products, and the Carolina Eastman Company, a manufacturer of synthetic filament products. The Congaree River receives effluent from many smaller manufacturing plants and from sewage-treatment facilities in

Columbia and adjacent counties. All of these plants are monitored by the State Department of Health and Environmental Control and the State Water Resources Commission. Little, however, is known about their operation or impacts, if any, on park resources.

Exotic species and past land use practices also pose threats to park resources. Although efforts are underway to control populations within the park, feral hog rooting and herbivory causes potentially severe impacts to forest community structure. The past suppression of fire has altered successional processes in parts of the park, while forestry practices have led to the creation of species-poor pine plantations in some areas.

Cumberland Island National Seashore

Cumberland Island National Seashore (CUIS), a 17 ½ mile long sandy barrier island, is one of the larger and more diverse islands on the Atlantic Coast. It totals 36,415 acres of which 16,850 are estuarine. A *Spartina* grass dominated salt-marsh, oyster mud flats and six tidal creeks provide the habitat for a diverse marine-based fauna. The remaining acreage is terrestrial. A live oak -palmetto dominated forest backs an extensive dune system. As the elevation of the island rises on the northwest, a mixed pine-deciduous forest can be encountered. The island is known for nesting loggerhead sea turtles, abundant shore birds, undeveloped dune fields, maritime forest ecosystems, and the historic structures in five historic districts on the National Register of Historic Places. Cumberland Island and its surrounding waters provide habitat for at least thirteen federally listed threatened or endangered species

The National Seashore was established in 1972, to preserve the scenic, scientific, and historical values of the largest and most southerly island off the coast of Georgia. Cumberland Island is also part of the South Atlantic-Carolinian Biosphere Reserve and will be permanently protected in a primitive state. The northern half of the island has also been designated a wilderness area. This unspoiled environment, once prevalent on all the barrier islands, provides a unique opportunity to experience the flora and fauna of a natural coastal ecosystem.

Many of the resource issues at CUIS stem from either external development or past human uses of the island. The southeast Georgia coast is going through profound growth in new, residential communities, many of which incorporate marinas. Recreational pressure will in turn increase on the island, much of it uncontrolled, and the threat to resources and critical habitat will intensify. The dredging and maintenance of the adjacent Intracoastal Waterway and St. Marys Inlet complicate the natural processes of sand budgets and tidal flow, which are key components in the island's stability and ecology. Boat wakes may be contributing to erosion on the back-barrier (west) side of the island. The nearby urban centers of St. Marys, Fernandina Beach, Brunswick, and Jacksonville may contribute to a range of island issues, from air and water quality to light pollution. Regional industries, such as commercial fishing and paper mills, also have an impact on Cumberland Island's resources. Kings Bay Naval Submarine Base is located immediately across the Cumberland Sound from the park.

Past development and human use of the island has significantly changed landscapes and introduced destructive non-native species. Streams and wetlands were altered historically to accommodate agriculture uses. More recently, roads and causeways were constructed which now effect the island's hydrology where they cut across tidal streams, high salt marsh, freshwater sloughs, and wetlands. Non-native species were introduced for ornamental and agricultural purposes but, introductions have been both intentional and accidental. Their presence is significantly degrading the native flora and fauna on the island. Feral hogs present problems in virtually every type of Cumberland Island habitat and, although a management program is in place and the population decreasing, monitoring and actions must be long term. Feral horses also have a serious impact across the island however, their management has been and will continue to be highly complex due to their public popularity. Multiple species of non-native plants have established themselves on the island, with several of the most invasive in dense and/or expanding populations.

Forces driving ecosystem change and diversity are being compromised by current NPS management practices. Without a Fire Management Plan, it is mandatory to suppress all wildfires. Lightning-caused fires are no longer regenerating patchiness and pine forest ecosystems.

Global issues such as sea level rise from increased greenhouse gases in the atmosphere are also important resource issues. Changes in the shoreline and biota from flooding of lower elevations and changes in coastal dynamics may threaten nesting of threatened species and create ecosystem level perturbations.

Fort Frederica National Monument

Established on St. Simon's Island in 1736 to protect South Carolina and Georgia from the Spanish, the town of Frederica was the southernmost post of the British colonies in North America. Today, stately oaks, exceptionally large grapevines, and Spanish moss lend an air of antiquity unequaled on the coast.

The monument is divided by the Frederica River, one of the primary salt marsh rivers in the Brunswick area, with 99 acres of marsh lands at the Frederica site on the west side of the river and approximately 137 acres of uplands adjoining the east side of the river. The Bloody Marsh site consists of 8 acres of which approximately 5 acres are tidal marsh. Approximately 50% of park-owned lands are classified as wetlands.

Outside of the park, the vegetation is composed primarily of pine-hardwood and gum-bay assemblages. Dominant plants include loblolly pines, live oaks, water oaks, saw palmetto, cabbage palms, gums, bays, magnolias and myrtles. A large variety of under brush including several species of ferns and vines is also present. Inside Frederica, clearing and possibly selective cultivation has led to a different variety of plants, especially trees. These include large live oaks, loblolly pines, pecan, magnolia, cedars, sweet gum, and cabbage palm. Large muscadine vines, saw palmetto, and small bamboo are also common. Although the largest part of the marsh is dominated by smooth cord grass, a number of other species are common along the upland boundary. These include black rush, giant cord grass, sea ox-eye, marsh elder, salt myrtle, and *Distichlis*.

Sedimentary deposits composed primarily of sandstone, limestone and clay underlie Frederica. Surface deposits of sand are common to the upland area, while the marsh substrata are composed of unconsolidated clays containing high organic matter content and sand. In most areas the soils are well drained; however, poorly drained soils occur in the northeastern portion of the park.

The climate of the island area and coastal mainland is hot and humid in the summer and cool and wet in the winter with occasional very cold spells. Sub-freezing temperatures are relatively common at night from late November into early February. Spring and fall are marked by heavy concentration of pest insects. The summer months are characterized by frequent, locally severe, thunderstorms with high winds often interrupting commercial electricity.

Specific threats to the resource include:

Water quality deterioration is a concern from industrial pollutants as well as the impact of the intensive recreational use of the Frederica River by boaters and fishermen. The wave action from watercraft presents possible damage to park wetlands and the cultural landscape through erosion by wave action. Several of the nearby industrial plants have buried or discharged, legally and otherwise, toxic wastes in the Brunswick, Georgia, community. This dumping has, in turn, contaminated ground water.

Pest Management: Insect and animal pests at the park present human safety hazards and some natural resource concerns in the form of pine beetle and gypsy moth infestations.

Coastal Dynamics: Any long-term change in coastal dynamics caused by sea level increases would present a clear threat to the Monument's natural and cultural resources. Frederica's elevation is three feet above high tide.

Fort Pulaski National Monument

Fort Pulaski National Monument (FOPU) is located in Chatham County, Georgia along the Savannah River only a few miles from its junction with the Atlantic Ocean. The site consists of two islands that were, before human intervention, primarily salt marsh. Judging from the composition of existing vegetation, Cockspur Island probably supported some coastal hammock forest or woodland. It was selected for fortification as early as the seventeen hundreds. In the eighteen hundreds, as part of the development of the site for defense, the island was modified by the installation of drainage canals and a dike system. In latter years, the site was also impacted by the deposition of spoil material. The addition of dredge material from the Savannah River to Cockspur Island continued until recent

times. During the civil war period, the vegetation was removed to enhance visibility and kept in early successional stages. Since the abandonment of the fort in the late eighteen hundreds, a large portion of central Cockspur Island has reverted to maritime forest. Currently the upland portions of Cockspur (approximately 260 acres) support a mosaic of maritime forest, maritime shrub communities, maintained grasslands and successional spoil deposit areas. It also includes over 340 acres of tidal shrubland and tidal herbaceous marsh.

McQueens Island makes up the largest portion of land holdings for the National Monument (about 4,900 acres) and the majority of this consists of salt marsh. A railroad was constructed along the northern edge of the island in 1887 to connect the city of Savannah with Tybee Island and operated until 1933. In 1923, US Highway 80 was constructed, occupying a location across the central portion of the island and adjacent the old railroad grade along the eastern section. In 1994 Chatham County converted the abandoned railroad right-of-way to a multipurpose hiking trail. Both the highway and the converted rails-to-trails areas support ruderal habitat for a number of coastal plain herbaceous species. Other upland habitat on McQueens Island occurs in association with a public fishing and boat ramp on the eastern end of the island and an abandoned section of US 80 leading to the Bull River.

The natural resources at FOPU face a number of threats, primarily related to its proximity to the city of Savannah. Heavy industrial development on the Savannah River, as far upstream as the Savannah River Site near Aiken, SC, have been known to impact the water quality and ecological health in and around the park. Pollutant levels in water, sediment, and invertebrate tissue will be analyzed as part of an upcoming study. Shipping traffic and associated dredging are contributing to increased shoreline erosion along the north shore of Cockspur Island. Finally, Highway 80 between Savannah and Tybee Island is slated for widening in the near future, impacting park wetlands adjacent to the existing roadway. The Monument is currently working with the U.S. Fish and Wildlife Service, the Federal Highways Administration, and the Georgia Department of Transportation to develop a mitigation plan that complies with NPS Wetlands Policies.

Fort Sumter National Monument

Fort Sumter National Monument (FOSU) consists of 200 acres of land located at the mouth of Charleston harbor and on nearby Sullivan's Island, South Carolina. The park's two major features are Fort Sumter, site of the Civil War's first engagement, and the somewhat older Fort Moultrie.

Historic Fort Sumter is influenced dramatically by the surrounding natural elements. Of the 198 acres that comprise the park, 122 acres surrounding the Fort are submerged under the waters of Charleston Harbor. The remaining acreage is located on Sullivan's Island and in Charleston. Adjacent to the park, but outside its boundaries, are shoals, islands, and marshes important to the Fort Sumter scene. Two endangered species, the manatee and the loggerhead turtle, migrate through the waters adjacent to the park, but do not live or nest within the park itself.

The 28-acre Charles Pinckney National Historic Site (CHPI) was established under Public Law 100-421 and is a relatively new addition to the National Park Service. It is a rural vernacular landscape in use from 1695 until the 1980's, and was actually a working farm until the 1960's when nearly 700 acres were sold for development. The grounds include three acres of wetlands, eight acres in mixed hardwoods and pines, and ten acres of open pasture. The site, which fronts Long Point Road, a scenic highway, is surrounded by suburban housing developments.

A Servicewide issue potentially threatening Fort Sumter is sea level rise. At present, sea level rise is approximately 1.3 millimeters per year, but many experts believe this rate may accelerate in coming decades. An annual increase in sea level, no matter how small, over a long period of time would upset coastal dynamics in the Charleston area and could eventually pose a direct threat to Fort Sumter and Fort Moultrie.

Harbor dredging is another major concern. Dredging is necessary in order to maintain Charleston as a viable seaport; however, it negatively impacts Fort Sumter's marine ecosystems as well as disturbing the historic viewshed by creating spoil banks on nearby barrier islands. The park staff continues to monitor dredging activities within the harbor, working with the Army Corps of Engineers and local authorities to mitigate the impact of dredging on the historic scene whenever possible.

Insect infestations present a natural resource management concern. Fire ants, termites, and other insects are unsightly to the visitor and can be harmful. As in the case of fire ants, they may bite visitors creating painful welts. The park's approved Integrated Pest Management Plan requires revision to incorporate the new facilities of Charles Pinckney NHS, Moores Creek NB and the Curatorial Storage Facility.

Horseshoe Bend National Military Park

Horseshoe Bend National Military Park (HOBE) is comprised of 2,040 acres. The park is situated near the southern end of the Piedmont Plateau. It contains low rolling hills, which reach elevations from 600 feet to 711 feet above sea level. The park not only contains many species of plants endemic to the Piedmont region, but also species associated with the Southeastern and Southern Coastal Plains. River bottomland borders each side of the Tallapoosa River. This land, which was extensively cultivated from 1832 until the establishment of the park in 1959, is in various stages of ecological succession.

The land has undergone some minor changes in the intervening 175 years since the battle. In many places pines have displaced the climax hardwoods that existed in 1814. The vegetation has been altered by human settlement, logging, and by the introduction of exotic species. The timbered lands that once gave way to agricultural crops have now given way to natural reforestation or open fields. "Forest type is mesic beech-oak-hickory with some loblolly pine. Drier areas and ridge tops are dominated by loblolly pine. The understory is relatively open and dominated by sapling elms, blueberries, silver bells, muscadines and ferns." The condition of wildlife species was basically unknown upon acquisition of the park. It was found that all wildlife species had been indiscriminately hunted and preyed upon by feral dogs and cats until many species barely continued to exist. Enforcement of resource laws concerning flora and fauna has allowed a diversity of wildlife species to be re-established upon the varied habitats of the park.

The hydrologic regime of the Tallapoosa River, three and one-half (3 ½) miles of which are within the park boundary, is dam-controlled upstream of the Park by Alabama Power Company. The release schedule is determined by hydroelectric needs and bears no relationship to natural flows, more resembling a "trickle or torrent" that impacts both natural resources and the cultural landscape. The U.S. Fish and Wildlife Service is currently seeking to accelerate reauthorization of the dam in order to negotiate a flow regime less detrimental to river ecology.

Pine forests at HOBE have been impacted heavily in recent years. Southern Pine Beetle infestations are growing and rapidly spreading in many areas of the park. In some cases infestations are moving toward park boundaries and endangering private lands. A heavy accumulation of slash and downed trees due to beetle kills and the aftermath of Hurricane Opal have resulted in potentially dangerous fire situations. Ladder fuels, heavy pine needle litter, and duff accumulation could substantially increase the difficulty of controlling wildfires. Ladder fuels, such as honeysuckle and other vines would assist a hot ground fire into a crowning fire.

Exotic species have impacted some areas within the park. Invading exotic plants such as Ailanthus (*Altissima*), Mimosa (*Albizia julibrissin*), Chinaberry (*Melia azedarach*), Japanese Honeysuckle (*Lonicera japonica*), Kudzu (*Pueraria lobata*), and Sandburs (*Cenchrus longispinas*) continue to expand and invade new areas.

Kennesaw Mountain National Battlefield Park

Kennesaw Mountain National Battlefield Park (KEMO) was created to commemorate the 1864 Atlanta Campaign of the Civil War. In particular it preserves the battle lines where from mid-June to early July the Confederate forces under Joseph E. Johnson delayed the advance of William T. Sherman's Union forces in their advance from Chattanooga to Atlanta. The Park's Enabling Legislation is included in Appendix 2.

The natural resources of the 2,884-acre park include the 1,808-foot peak of Kennesaw Mountain, Little Kennesaw Mountain and hundreds of acres of mixed hardwood/pine forests intermixed with a number of grassy fields. Included are over 16 miles of designated hiking trails that attract hundreds of recreational visitors daily. The Park's location in the Atlanta metropolitan area makes it the second most visited battlefield in the National Park System and has earned it a position on the Secretary of Interior's list of twenty-five most threatened parks.

Largely because of its proximity to Atlanta, major natural resource threats exist at KEMO. The development of Cobb County and greater metro Atlanta makes the lands within Kennesaw Mountain relatively valuable for natural habitats of localized plant and animal communities. Cobb County has plans to expand roads and highways that traverse the park and pose a potential threat to both cultural and natural resources. In addition, there are minor threats from encroachment of adjacent landowners, exotic plant species, and industrial air and water pollution. Since 1993 a pine beetle infestation has killed off thousands of pine trees throughout the park and the resulting increase in fuels laying on the forest floor pose an increased fire risk. Natural succession to hardwood forest is expected. There appears to be an increase in the beaver population. As the beavers create their dams, distribution and water quality is altered. The mitigation of encroachments and the removal of exotic plants are ongoing programs. A formal water-monitoring program is on-going and collected data indicates an extremely high fecal coliform level.

Moores Creek National Battlefield

Moores Creek NB is located in an area of second growth forest interspersed with small farms. Local woodlands are harvested for the pulp industry. Presently, no significant industrial, commercial, or residential developments exist near the park. The topography of the region is relatively flat. A short distance within the park, the higher land characteristic of the inland Carolina coastal plain descends abruptly to the lowlands that comprise the greater portion of the park land, reaching to Moores Creek. This freshwater stream, averaging 30 feet in width, forms the western boundary of the park. Bordering the park are screens of dense second-growth vegetation, while the landscape at the center of the development consists of grass-covered meadows and slopes with scattered trees and brush. Habitats: alluvial woods, old fields, ditches, sandy xeric woods, lawns, a pond, pinewoods, mixed wooded slopes, creek banks, roadside ditches and meadows.

Several potential threats to MOCR resources have been noted. Although the park is fairly isolated, residential development on adjacent lands has been increasing in recent years. Past landscape practices at the Battlefield have likely impacted several locally rare and/or state-listed plant species. Efforts to restore habitat for these species is currently underway, although long-term monitoring is necessary to fine-tune efforts and ensure their eventual success. Finally, the predominant tree species, loblolly pine, is greatly affected by pine bark beetle. Long-term efforts are underway to restore the beetle-resistant, native Longleaf pine across much of the Battlefield.

Ocmulgee National Monument

Ocmulgee National Monument (OCMU) sits on the “Fall line,” the transition between the rolling Piedmont and the flat Atlantic Coastal Plain. A portion of the monument is within the city limits of Macon, GA. The Ocmulgee River comprises the boundary on one side of the monument. Ocmulgee National Monument preserves the history of the people of the Southeast; artifacts have been found dating back 10,000 years. The visible features are mounds, built by the Mississippians who lived here from approximately 900-1100 AD.

The natural resources of the park have been heavily impacted by human activities, including I-16 and its associated berm, which has essentially cut off the river from its floodplain and disrupted the natural flow of the area. Despite this, and its proximity to Macon, Ocmulgee has a surprising amount of wildlife present. This is probably a result of a corridor, or what is known locally as the “Greenway,” connecting the monument to other natural areas south of the monument. Numerous bird species are present in the monument, either feeding or nesting or both. Migratory birds utilize the area as a stopover during spring and fall migrations. The endangered wood stork (*Mycteria americana*) feeds here during summer months. Numerous other wildlife live here, including deer, beaver, bobcat, alligators, and various reptiles and amphibians. Recreational fishing is allowed, with largemouth bass and bream being two common catches. Within the last eight years, coyotes have entered the monument. What effect this will have is unknown. Exotic species include nutria, fire ants, feral pigs, as well as domestic dogs and cats. Vegetative exotics include privet, Japanese honeysuckle, and kudzu.

The overall lack of knowledge of the natural resources in the monument has become both a problem and a frustration. Major changes have occurred, such as a 500-year flood associated with Tropical Storm Alberto in 1994, pressure from exotic species, particularly feral pig damage, as well as more subtle changes over time. Since there is no baseline data for the monument, there has been no way to track these changes or impacts over time.

Threats affecting the native plants and animals in the monument result mainly from human activities, and include exotic species, water quality, air quality, development, and the general proximity to the city of Macon. Exotic species are a disruptive influence in the monument. Disruptive and invasive species include privet, Japanese honeysuckle, and feral hogs. Within the last year, feral pigs are responsible for a tremendous amount of resource damage in both the main unit and the detached Lamar unit. Fire ants are spreading through the park.

Human occupation has severely impacted the park. A railroad and I-16 bisect the park; a sewage lift station and its associated underground pipes are in the park. A once small stream now drains a large part of east Macon, bringing large amounts of trash, pollution, and occasionally raw sewage into the park. This has raised questions regarding water quality, groundwater quality, and where the pollution goes. The city of Macon is also close to failing air quality standards; what will result from this remains to be seen. Development around the monument is a threat as well; development within the corridor could cut off the monument, leaving the existing populations isolated fragments.

Timucuan Ecological and Historic Preserve

Situated entirely within Duval County and the city limits of Jacksonville, FL, Timucuan Ecological and Historic Preserve encompasses approximately 46,000 acres between the St. Johns and Nassau rivers. The southern third of the Preserve lies at the mouth of the extensive St. Johns River watershed, which includes parts of Duval and several other counties for approximately 300 miles to the south. The St. Johns River is heavily impacted by agricultural, industrial and urban pollution; however, marine tidal waters near its mouth serve to ameliorate pollution through dilution and flushing. Water quality is considered relatively good in the Preserve due to this flushing action. The northern two thirds of the Preserve lies within the Nassau River drainage basin, a small watershed that covers parts of Duval and Nassau counties. The Nassau River watershed has not yet experienced the concentrated urban and industrial growth found along the St. Johns River; still, portions of the watershed exhibit poor water quality. The area surrounding the Preserve to the west and north is predominantly marsh and low uplands utilized for timbering, residential and agricultural uses.

Several rare, threatened or endangered species are known to use the Preserve, including the West Indian Manatee (*Trichechus manatus*), Colonial Wood Stork (*Mycteria americana*), Least Tern (*Sterna antillarum*), Gopher Tortoise (*Gopherus polyphemus*), Arctic Peregrine Falcon (*Falco peregrinus*), and Loggerhead Sea Turtle (*Caretta caretta*). Other rare, threatened or endangered species are suspected to occur within the Preserve, such as the Eastern Indigo Snake (*Drymarchon corais couperi*) and Atlantic Sturgeon (*Acipenser oxyrhynchus*).

Timucuan and Fort Caroline National Memorial are administered as one park. Fort Caroline NM includes approximately 138 acres located along the St. Johns River within the city of Jacksonville and Duval County, Florida. Located primarily on a bluff overlooking the river that rises to a height of nearly 90 feet, the park consists of mixed species forest with fresh water wetlands, preserving an enclave of representative species native to the North Florida-South Georgia community.

Duval is one of the fastest growing counties in Florida. The Preserve is located in an area that has historically experienced limited development and growth due to lack of easy and quick access. Development and recreational use pressures have increased, however, with the opening of a six-lane bridge in 1989 and ongoing construction of a major highway linking the bridge to the interstate highway system.

Throughout both watersheds, many residential homes operate private well and septic systems, the failure of which is a presently unquantified source of water pollution. An unknown amount of pesticide, herbicide, and fertilizers is transported by stormwater runoff to the marshes of the Preserve. Contaminated sediments are known to occur in some areas of the Preserve, but the extent of contamination and the effects of sediments resuspension are not known. This is of particular concern as several major dredging projects are proposed in the near future.

Exotic plants and animals are known to occur within the Preserve, but information on species, locations and potential threats is lacking. The Preserve presently has little information on vegetative and aquatic habitats, ecological processes, and current ecological conditions. Related to the issue of exotic species is the recent

development of a prescriptive fire program, which is expected to be instrumental in returning native species to the numerous pine plantations within the Preserve.

Water Resources of the Southeast Coast Network

Water Bodies

Eight percent (23/274) of water resources within or adjacent to SECN Parks are 303(d)-listed waters, with 39% (9/23) of those occurring at CHAT (See Appendix 8 for more details). 303(d)-designated waters are considered to be relevant to park managers if (a) they pass through, enter or are contained within Park boundaries as EPA-designated 303(d) waters or (b) they are designated 303(d) waters within the same 12- or 14-digit HUC boundaries as each respective Park. Twelve-digit HUC coverages were available for AL (i.e., in draft form), FL and GA; 14-digit HUC coverages were available for NC and SC. All 303(d) designations are based on the most recent (2002) EPA and state listings of impaired waters and GIS coverages (http://www.epa.gov/waters/data/downloads.html).

Various GIS coverages [e.g., Digital Raster Graphics, National Hydrography Dataset, EPA 303(d) listed waters] and existing Park narratives were reviewed for all available information regarding documented SECN Park water bodies. Special designations of Park waters were also noted (Appendix 8, Tables A8-1- A8-9). CHPI, FOCA and WRBR have no documented water resources within Park boundaries.

Water Quality

Despite the Federal Water Pollution Control Act of 1956, subsequent amendments in 1972, the Federal Water Pollution Control Act of 1972, the Clean Water Act of 1977 and the Safe Drinking Water Act of 1977, the chemical, biological and physical integrity of the nation's waters remains threatened (Hermann et al. 1998). Compromised water quality is largely the result of management of chemical, biological and physical discharge/waste from urbanization/population growth and agricultural and industrial activities. Adverse effects of impeded water quality on biota include altered floral- and faunal- species composition, reduced fecundity, low fitness, and bioaccumulation. The Southeastern U.S. is one of the fastest growing areas in the nation; consequently, marine and freshwater water quality throughout Southeast Region Parks has been impacted (White et al. 1998). Despite the abundance of 303(d)-listed waters in the Southeast Region, only ten percent of SECN water resources are 303(d) listed. However, most of the SECN parks are downstream from multiple 303(d) listed waters outside NPS jurisdiction (Figure 1-1).

Water quality data in most SECN Parks, and adjacent lands, have been collected by a variety of governmental and private entities. Existing data were compiled and summarized by the Inventory and Monitoring Program and Water Resources Division of the USDI National Park Service (NPS) and Horizon Systems Corporation (HSC) into documents referred to as the Horizon Reports (National Park Service 1994a, National Park Service 1994b, National Park Service 1994c, National Park Service 1994d, National Park Service 1994e, National Park Service 1994f, National Park Service 1997, National Park Service 1998a, National Park Service 1998b, National Park Service 2001, National Park Service 2002a, National Park Service 2002b). Although the Horizon Reports provide a very thorough summary of baseline water quality data in SECN Parks, the data compiled and summarized for this endeavor included data only as recently as 1990 and 1992 for FOFR and CAHA, respectively, or 1998 for FOMA, FOPU, and FOSU (Appendix 8, Table A8-10). As a result, recent trends in water quality are unknown. The SECN Inventory and Monitoring team is currently acquiring these data to establish recent trends in water quality at SECN Parks.

Thoroughness of water quality data varies from park to park, however data are adequate to establish trends in waterbodies adjacent to parks, and infer status in parks if data within park boundaries are limited, if not the parks themselves. However, gaps in the datasets, in terms of evaluations of all significant water resources in each park, do exist (e.g., no water-quality sampling has occurred on two freshwater ponds at FOPU that account for 67% of freshwater resources at the park) and attempts to rectify these issues will be incorporated into future water-quality sampling designs. Because many agencies, organizations and individuals have contributed to existing long-term

water-quality data (in regard to data collection and laboratory analyses), estimates of data accuracy, precision, and subsequent reliability, are currently unknown.

Results from the Horizon reports were qualitatively summarized in order to determine potential “red flags”, or parameters that consistently exceed established water quality criteria, in SECN park water resources and assist in determining focal points (i.e., water-quality parameters) for future water-quality sampling design (Appendix 8, Table A8-11). Total Coliform measurements commonly exceeded EPA standards in SECN parks, although Fecal Coliform, several forms of which are naturally occurring, was not consistently differentiated from Total Coliform. Although no other “red flags” are evident in existing Network-wide data, Chloride and Copper levels exceeded EPA standards in several Parks, which can cause gastrointestinal irritation and kidney and liver damage, respectively, in humans. Current EPA guidelines for select water quality parameters are also presented (Appendix 8, Tables A8-12 through A8-14).

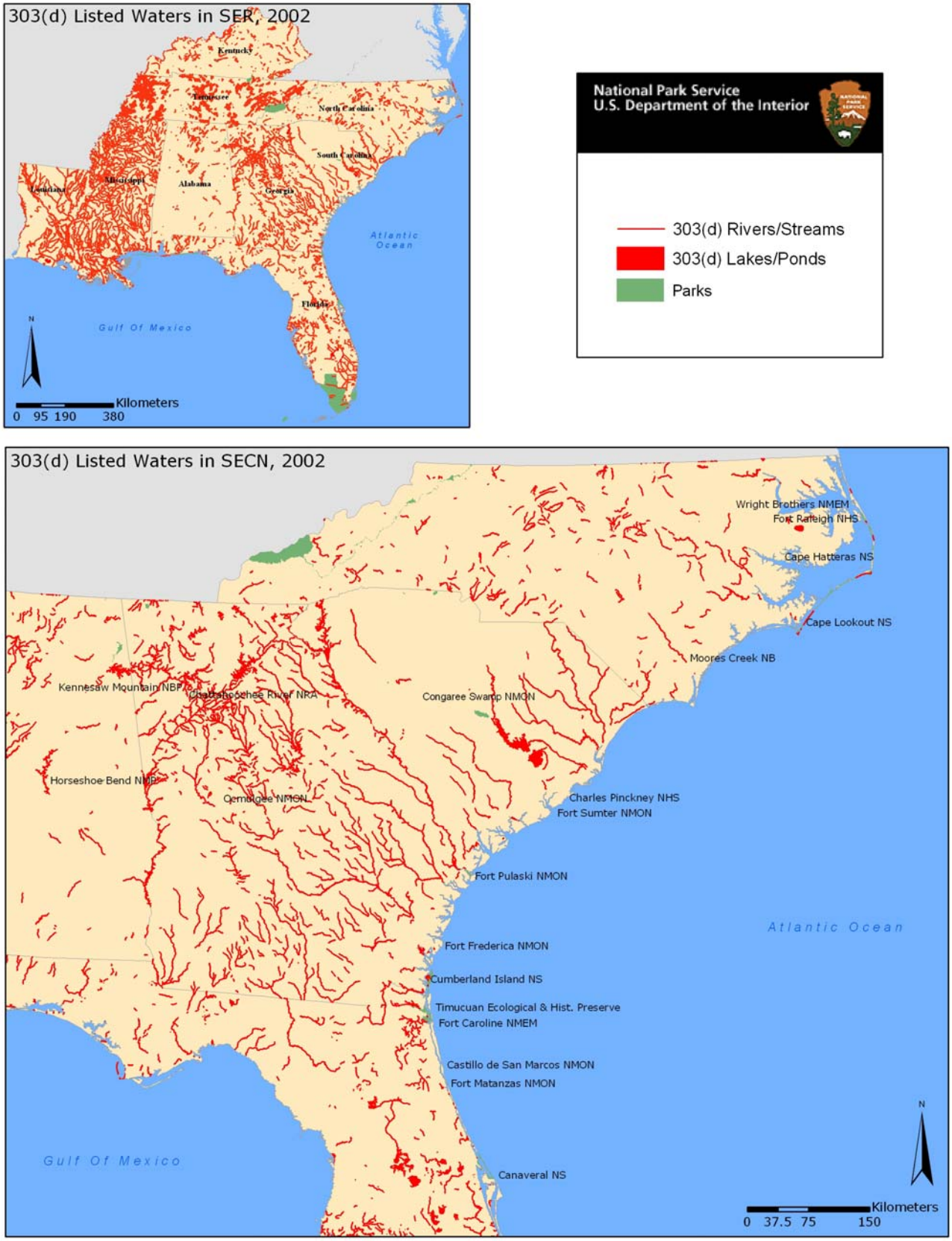


Figure 1-1. 303(d) waters in SER and SECN, 2002.

Air Resources of the Southeast Coast Network

None of the Southeast Coast Network parks are within Class I airsheds. However, air quality is of concern at several parks within the network due to ozone exposure and atmospheric deposition of metals and nutrients (Table 1-3). Four parks within the network (CHAT, KEMO, HOBE, and OCMU) are in areas where vegetation is at a high risk of damage due to ozone exposure. Park water quality data were reviewed for fifteen Southeast Coast Network parks; surface waters at CONG and MOCR are extremely sensitive to acidification from atmospheric deposition. Elevated concentrations of metals in surface waters indicate that atmospheric deposition of metals might be an issue for half of he Southeast Coast Network parks.

Table 1-3. Summary of air quality issues in Southeast Coast Network Parks. ["↑", Increasing; "↓", Decreasing; "NT", No Trend; "Y", Yes; "N", No; "○", Frequent or consistently surpasses air quality thresholds; "○", surpasses or infrequently surpasses air quality thresholds; "-", either does not surpass air quality thresholds or no data are available; "L", Low; "M", Medium; "H", High].

		CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU / CHPI	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Wet Deposition																
Ammonium	Deposition		↑		NT		↑					NT		↑	NT	NT
	Concentration		↑		NT		↑					↑		↑	NT	NT
Nitrate	Deposition		↑		NT							↑		NT	NT	NT
	Concentration		↑		NT							↑		NT	NT	NT
Sulfate	Deposition		NT		↓							↓		↓	↑	↓
	Concentration		NT		↓							↓		↓	↑	↓
Dry Deposition																
Nitrogen	Overall dry deposition			NT								NT		NT	↑	
	Percentage of total N that is dry			32								36		37	42	
Sulfur	Overall dry deposition			NT								↓		NT	↓	
	Percentage of total S that is dry			36								41		34	42	
Surface Water Chemistry																
Acidification	Concern for Park	N	N	N	N		Y	N	N	N		N	N	Y	N	N
Metals	Potential aerial deposition						Y			Y		Y	Y	Y	Y	Y
Nutrients	Potential aerial deposition	N	N	N	N		N	N	N	N		N	N	N	n	N
Ozone																
Sum06	Frequency standard surpassed	●	○	●	●	●	○	○	○	○	○	●	●	●	●	○
W126	Frequency standard surpassed	○	-	○	-	●	○	-	-	-	-	●	●	○	●	-
Foliar Injury	Risk based on conditions	M	L	M	M/L	H	L	L	L	L	L	H	H	M	H	L

Analysis of SECN Natural Resource Issues

Monitoring program-related issues of highest importance to parks in the Southeast Coast Network fall into seven broad categories: exotic plant management & control, water quality, geology & geomorphology, water quantity, fire management, habitat management, and species management. Detailed descriptions of park natural resource issues and relative monitoring priorities for each park can be found in Appendix 5 and Appendix 9.

Exotic Plant Management and Control. Monitoring questions related to exotic plant management were the only questions consistently of high priority across all parks within the Southeast Coast Network. Currently only parks within Florida are included in an operation exotic plant management program: Canaveral National Seashore (CANA), Timucuan Ecological & Historic Preserve (TIMU), Fort Caroline National Monument (FOCA), Castillo de San Marcos National Monument (CASA), and Fort Matanzas National Monument (FOMA). Beginning in FY 2005, the remaining parks within the network will be included in a three-year pilot program to identify and remove exotic plant species. Monitoring needs related to identification of sites of existing exotic plants and tracking the success of management actions will be critical for the long-term success of this program.

Water Quality. In general, questions relating to water quality were high across all parks also, but the water bodies among the park vary substantially across the Network.

- Estuarine / Lagoonal. Nine parks within the network contain significant estuarine or marine waters: Cape Hatteras National Seashore (CAHA), Cape Lookout National Seashore (CALO), Fort Sumter National Monument (FOSU), Fort Pulaski National Monument (FOPU), Fort Frederica National Monument (FOFR), Cumberland Island National Seashore (CUIS), TIMU, FOMA, and CANA. Mosquito Lagoon at CANA is another significant brackish water body. Water quality in these systems is almost entirely driven by upstream or up-shore factors outside National Park Service boundaries or jurisdiction, and water quality monitoring is in general conduced by the various coastal states. Currently University of North Carolina at Wilmington, The University of Georgia, and The University of Florida are investigating watershed / landscape level influences of estuarine water quality at CAHA, CALO, FOPU, CUIS, TIMU, and CANA.
- Coastal. Six parks (CAHA, CALO, CUIS, TIMU, FOMA, and CANA) contain significant areas with access to marine / ocean waters. In all cases except CANA, NPS jurisdiction extends only to mean high tide; CANA's jurisdiction extends ½ mile east of the shore line. Threats to coastal water quality include non-point source chemical contaminants from up-shore as well as marine debris.
- Riverine. Six parks within the network contain or are bordered by significant river systems ranging from upland to coastal plain drainages: Chattahoochee River National Recreation Area (CHAT), Kennesaw Mountain National Battlefield Park (KEMO), Horseshoe Bend National Military Park (HOBE), Ocmulgee National Monument (OCMU), Congaree National Park (CONG), and Moores Creek National Battlefield (MOCR). With the exception of the rivers contained within CONG, all other parks contain limited portions of the watersheds that the rivers drain. Adjacent land use and upstream development pressures are consistent threats to water quality among the river parks, but the types of land use and development pressures range widely from agriculture / animal husbandry operations, to extremely dense urban and suburban landscapes.

Geology and Geomorphology. Parks within the network are all in highly dynamic coastal or riverine ecosystems. Although changes in the landscape are a natural part of the evolution of the landscape, the degree to which observed processes can be considered "normal" are largely unknown. Coastal barrier islands and river systems are the two predominant systems with high rates of geomorphic change.

- Coastal Geomorphology. All coastal parks are experiencing geomorphic changes either through accretion or erosion. Though these processes are natural in barrier island ecosystems, the current rates and locations of accretional and erosional zones are likely outside natural norms. Non-natural factors that are suspected to influence erosion and deposition rates include dredging operations, jetty and pier construction / placement, and hardening of shorelines.
- Stream Bank Erosion. Stream bank erosion and stability is a major concern at CHAT, HOBE, KEMO, and OCMU where hydrologic modification resulting from upstream watershed development and hydropower facility management has resulted in altered riverine flow regimes.

Water Quantity. Water quantity issues in general are currently of concern, but will likely become larger during the next 10-20 years as water demands in the Southeast increase.

- Surficial. River systems provide the majority of drinking water for the southeast. Major water supply reservoirs are located upstream of HOBE, CHAT, OCMU, and CONG, that serve the areas of Montgomery, AL, Atlanta, GA, Macon, GA, and Columbia, SC respectively. The amount of fresh water that reaches estuarine systems is likely one of the major drivers that influences estuarine and salt marsh ecosystem health.
- Groundwater. The Floridan aquifer is the main water supply source for agricultural and industrial needs along the southeast coast. The degree to which withdrawals affect park resources is not known, but as demand increases, the potential for impacts on park ecosystems could increase.
- Effects of hydrologic modification. In addition to the average amount of water available within parks, the timing and distribution of flooding events is also changing due to upstream or watershed land use activities. In general flooding frequency of major floods has decreased during the last twenty years, and hydropower "peaking" operations have introduced a flow regime in riverine ecosystems that is outside expectations in natural systems. Multiple other water diversion structures occur in or near parks for agricultural, pest control, or transportation purposes.

Fire Management (effects, risks, and planning). Twelve of the network parks currently have or are in the process of developing fire management programs. The activities that will be conducted at each park will vary widely from suppression to routine prescribed burning. In all cases, climatic data relating to fire risk will be useful for fire management planning and risk assessment. Programs implementing prescribed burning would benefit from fire effects monitoring.

High Priority Ecosystems & Habitats. The Southeast Coast Network contains multiple habitat types. The following four systems / habitats had the most commonality among Network parks.

- Rivers. In addition to the six parks that contain large rivers, CAHA and CUIS contain smaller freshwater systems.
- Coastal Dunes. Coastal dunes are major habitat features at CAHA, CALO, CUIS, and CANA. Future land acquisitions at TIMU might result in the addition of dune habitats there as well. Coastal dunes are particularly important due to the fact that (a) they support a wide variety of sensitive or protected species, (b) they are fragile, (c) they are particularly threatened by visitor uses, and (d) they play a significant role in the overall stability of the island..
- Wetlands. Wetlands within SECN parks vary widely from intermittent interdunal pools to riparian floodplains to vast salt marshes. These systems are particularly sensitive to changes in water quantity.
- Intertidal zones. Intertidal zones, provide critical foraging and nesting habitats for many sensitive and protected species such as shorebirds and sea turtles. These areas are threatened by visitor uses, and predation from both native and non-native species.

Threatened, Endangered, and other Species of Management Concern. More than twenty species were identified for potential monitoring across the Network, though with very few exceptions, those needs were only relevant at 1-2 parks due to limited species' ranges. In general, species-specific monitoring questions had the largest difference between overall average scores and adjusted average scores. In nearly all cases, floral and faunal differences among parks were large enough that few species' ranges span more than three parks. Exceptions include shorebirds, marine turtles, and multiple exotic plant and animal species. The following include species whose distribution occurs across six or more parks *or* whose impacts are large.

- Feral Hogs. Eight parks in the network have current, historic, or potential infestations of feral hogs: CAHA, CANA, CASA, CONG, CUIS, FOFR, OCMU, TIMU. Active eradication programs are occurring at OCMU, and CUIS.
- Shorebirds. Plovers, oyster catchers, least terns, and wood storks are of large concern at all coastal beach parks. Active monitoring occurs at CANA, CUIS, CAHA, CASA, and CALO, those these

efforts are not currently coordinated.

- Marine turtles. Marine turtles are monitored and protected at seven Network parks (CAHA, CALO, CANA, CASA, CUIS, FOPU, and FOSU). These monitoring programs are currently coordinated with other state and federal agencies though not with one another. In addition to turtle monitoring, other related monitoring needs include predator, beach habitat, and light pollution monitoring.
- Feral Horses. Feral horses are present at CUIS, CALO, and CAHA. In addition to the need to monitor aspects of horse populations (i.e., demography, disease incidence rates), the effects of the horses on other park resources.

Summary of Existing Monitoring Programs

At least 140 historical or ongoing monitoring programs are being conducted by various agencies within the Network (Table 1-4; Appendix 3). Only 34 of those are being conducted by the NPS. However, more than 100 historical and on-going monitoring programs are being conducted in or adjacent to Network parks by other State, Federal, or County agencies or one of many NGOs. The majority of NPS programs have centered on threatened and endangered species monitoring, primarily with reptiles and birds. Non-NPS monitoring programs span a wide variety of categories, but nearly a quarter of those programs deal with water resources monitoring.

Table 1-4. Existing and historical monitoring programs relevant to Southeast Coast Network parks. For a detailed description of programs, objectives, and the types of monitoring data being collected, see Appendix 3.

Category	NPS programs	Non-NPS programs	Total
Water Resources	1	24	25
Air Resources	3	5	8
Climate & Weather	0	5	5
Ecosystem Processes	1	2	3
Pest Species	0	3	3
Exotics – Invertebrates	1	3	4
Exotics – Vertebrates	1	1	2
Exotics – Plants	1	4	5
Forestry	0	4	4
Geology	1	5	6
Marine / Estuarine Systems	1	12	13
Recreational Use	0	2	2
Threatened & Endangered Species	0[1]	10	10
Vegetation	5	7	12
Vertebrate Disease	0	3	3
Waste Management	0	1	1
Wetlands	0	1	1
Wildlife – Birds	8	8	16
Wildlife - Fish	0	3	3
Wildlife – Mammals	4	1	5
Wildlife – Reptiles & Amphibians	7	2	9
Total	**34**	**106**	**140**

[1]*Several NPS T&E species monitoring programs are included in the "wildlife" categories below*

2. Conceptual Ecological Models

Modeling Framework

Development of conceptual models is a required step in design of the Vital Signs Monitoring Program for each network. This requirement is based on lessons learned about monitoring program design from the NPS experience with its prototype parks program, and from many other monitoring programs. What these lessons demonstrate is that every monitoring effort is based on some underlying understanding of how the ecosystem in question works. This underlying understanding forms a mental model, often not written for others to read and discuss. To ensure a successful monitoring effort, these underlying models need to be explicit and available for discussion, evaluation, and refinement (Maddox et al. 1999).

Models are purposeful representations of reality (Starfield et al. 1994). Conceptual models provide a mental picture of how something works, with the purpose of communicating that explanation to others. Models (of all types) work best when they include only the minimum amount of information needed to meet the model's purpose (Starfield 1997).

Conceptual models play several useful roles in monitoring program design, including:

- Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;
- Expanding our consideration across traditional discipline boundaries, fostering integration of biotic and abiotic information;
- Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public.

The primary natural ecosystems within the network are terrestrial, riverine, and nearshore marine / estuarine, each of which can be defined by a combination of expected and observed characteristics of disturbance regimes, surrounding landscapes, hydrology, succession, habitats, and biota. In all systems, the goal of the modeling is to look at the ecosystems at multiple hierarchical levels: the overall generalized ecosystem, the processes that occur and define the status of resources within sub-ecosystems, and the key components and linkages that make up those ecosystems. Only the generalized and process models are considered here. Detailed descriptions of model components can be found in Appendix 7.

Generalized Ecosystem

An ecosystem conceptual model can be considered as a list of state variables and forcing functions of importance to the ecosystem and the problem in focus. General ecosystem models also show how these components are connected through ecosystem processes (Jorgensen 1986). Allen and Hoekstra (1992) emphasize that "we do not wish to show that everything is connected, but rather to show the minimal number of connections that we can measure may be used as a surrogate for the whole system in a predictive model." An important step in model construction is to identify an appropriate level of resolution given the model objectives (Starfield and Bleloch 1986). Processes that occur much more slowly than the system of interest may be aggregated and considered as constraints of the system; processes that occur more rapidly than the system of interest may be aggregated and considered as 'noise' (Turner and O'Neill 1994).

Purposes of the general ecosystem characterization models include:

- To indicate the driving abiotic factors that constrain the system, depict their relationships to key structural components and processes, and describe resultant ecosystem characteristics.

- To describe the predominant natural disturbances that historically influenced the system, indicate their relative importance in structuring the system, and summarize ecosystem-specific disturbance patterns (return intervals, extent, magnitude, seasonality).
- To characterize the prevalent anthropogenic stressors that are currently affecting the system, describe their relationships to key structural components and processes, and describe resultant ecosystem effects.
- To provide a foundation for evaluating the range of current conditions of key structural components within the context of historic natural variability.

Ecosystems in the Southeast Coast Network can be characterized by "natural" ecosystems that are faced with a combination of biotic and abiotic (both natural and anthropogenic) external agents of change (Figure 2-2).

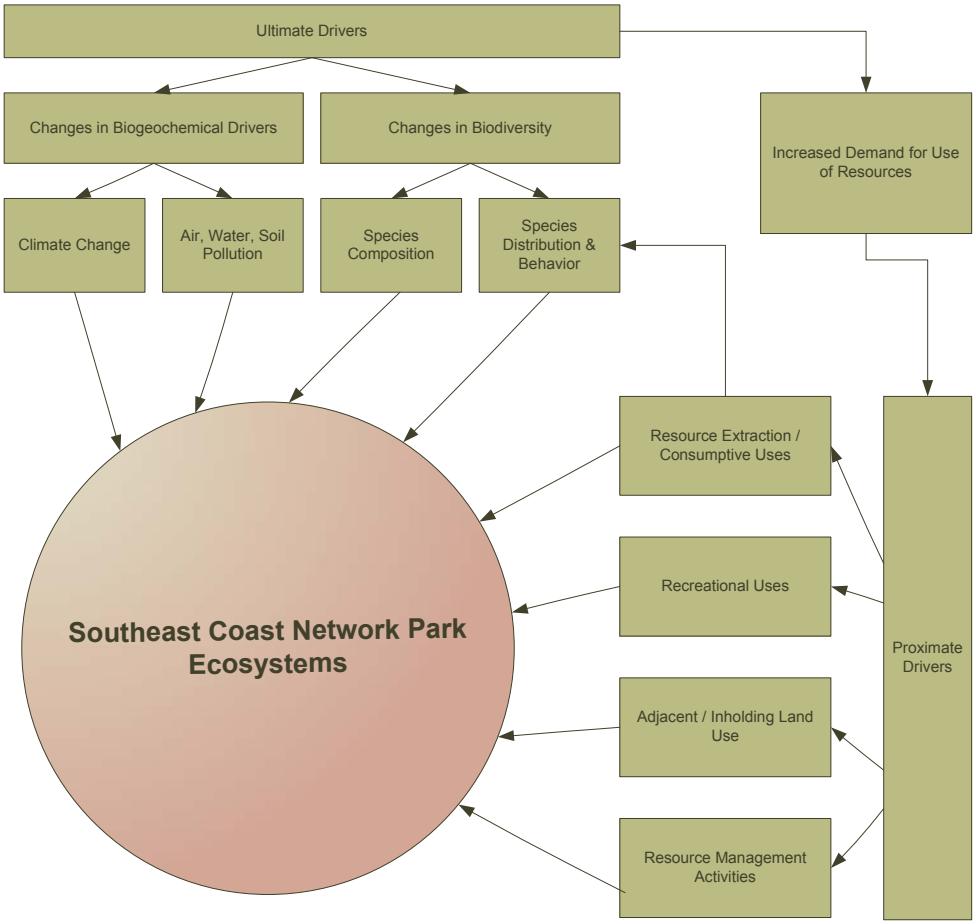


Figure 2-2. Generalized model of primary drivers that affect Southeast Coast Network ecosystems.

Dynamics of Ecosystems

Three of the five servicewide goals for vital-signs monitoring are oriented towards the *dynamics* of ecosystems or selected ecosystem components:

- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.

- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.

Ecosystem "Pinwheel" Models

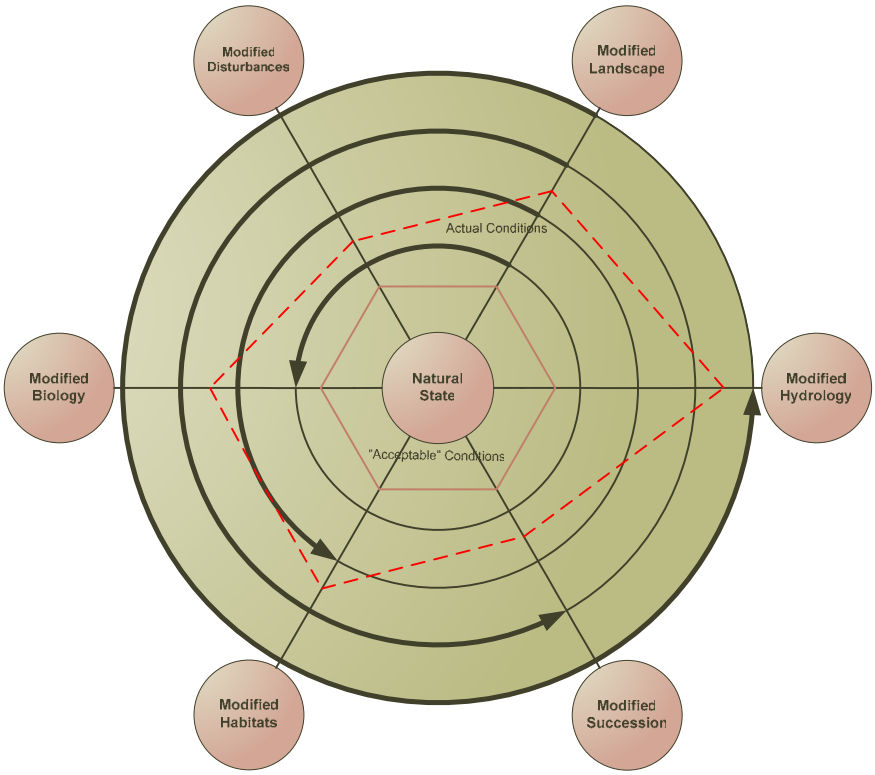
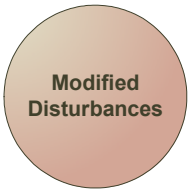


Figure 2-3. General "pinwheel" model template used by the Southeast Coast Network for description of the networks major ecosystems. Peach-colored spheres represent potential "states" of ecosystems. Arrows represent processes that move ecosystems from one state to another. The solid red line indicates conditions within the ecosystem considered to be "acceptable" given existing statutes and management plans; the dashed red line is a hypothetical depiction of "actual" ecosystem conditions.

The Southeast Coast Network has developed conceptual "pinwheel" models to describe the major ecosystems present in the network (Figure 2-3). The model assumes that each ecosystem exists in a "natural" state and that processes (natural or anthropogenic) act to push those systems to one or more modified states. The modified states fall into six broad categories: modified disturbances, landscapes, hydrology, succession, habitats, and biology as follows:

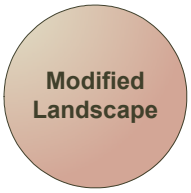
Modified Disturbances

All ecosystems are shaped to some extent by regularly occurring disturbances, which vary in frequency and intensity over time. Within the Southeast Coast Network, natural disturbances include fire, flooding, insect outbreaks, hurricanes and other high-energy storm events, and even earthquakes. Within the network, most disturbance regimes have been altered to some degree through fire suppression / reintroduction, flood control & river regulation, pest management, and potentially even global warming.



Changes in disturbance regimes can secondarily cause changes in hydrology, succession, habitats, and also the plant and animal communities on and surrounding network parks.

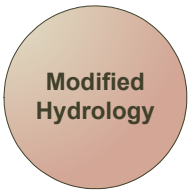
Modified Landscapes



Each park within the Southeast Coast Network is affected to some extent by both the surrounding landscape and a long history of landscape modification. However, the degree of influence from the surrounding landscape varies among the parks, and necessarily changes depending on the ecosystem being considered. The parks within the Network that have major river systems (CONG, CHAT, KEMO, HOBE, OCMU, and MOCR) are influenced by factors upstream within the watershed regardless of park jurisdictional boundaries. The coastal barrier island parks are affected by a combination of factors both upstream within their watersheds and up-shore along the Atlantic coast. For all parks, air resources are potentially affected by activities within the landscape independent of location within the watershed.

The primary driver of changes in landscapes in the southeast is the rapid population growth rate region-wide. As a result, typical landscape-level factors that affect park resources include both the type of adjacent land use, and conversion of those lands (typically residential, agricultural / forested, or urban). These changes, though landscape-scale in scope can dramatically affect local ecosystems. Local modifications to habitats, hydrology, and biology can result from landscape-scale changes in sediment budgets (in both riverine and coastal systems), water availability and use, and metapopulation dynamics.

Modified Hydrology



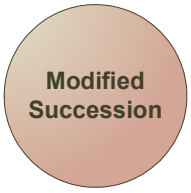
Alteration to the hydrological regime is a common disturbance in a variety of southeastern ecosystems: bottomland and floodplain forests, longleaf pine savanna, Carolina bays, Atlantic white-cedar swamps, barrier-island communities, mangrove forests, rivers, and streams (White et al. 1998). Hydrological change has altered flood depth, duration, frequency, and seasonal timing in many of these systems, leading to a raising and lowering of the water table in specific cases.

Southeast Coast Network riverine systems have been altered by human activities, including impoundment, channelization, lowering of water tables, increased runoff, acid mine drainage, air and water pollution, sedimentation, recreation, and introduced species (including mussels, fishes, and aquatic plants) (White et al. 1998). Many examples of effects on stream biota can be cited (Hackney and Adams 1992)—nearly all major stream systems have been channelized or dammed (Adams and Hackney 1992). In the Southeast, 144 major reservoirs have been built (Soballe et al. 1992), and one-third of all Florida rivers have impoundments.

Groundwater resources in the Southeast Coast Network include two major regional aquifers (the Floridan and the Northern Atlantic Coastal Plain) and multiple shallow groundwater aquifers. These groundwater resources provide both drinking and irrigation water to coastal areas and are likely to see increasing demand as the human population grows in the region.

Changes in hydrology can also secondarily cause changes in habitats succession, biology, and even disturbance regime.

Modified Succession



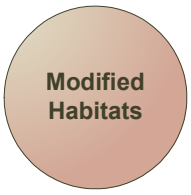
For the purposes of the pinwheel models, modified succession refers to any state where the natural evolution of the landscape has been either slowed down or accelerated. Plant communities in the Southeast Coast Network are to a large extent defined by a long history of land use practices that have altered natural succession, primarily in terrestrial habitats. Practices such as fire suppression, land conversion, agriculture, and silviculture have often focused on keeping lands in specific successional states. Conversely, altered flooding regimes (either by increasing or decreasing flooding frequency) have allowed succession within network habitats to either be curtailed or extended.

In addition to terrestrial plant communities, efforts to halt the evolution of landscapes also occur in coastal and riverine systems. Erosion control measures on coastal barrier islands through hardening and renourishment are examples of efforts to modify the rates of natural barrier island evolution. Similarly riparian zone management in river systems can lead to altered rates of stream bank erosion.

Changes in succession can directly alter habitats for dependent plant and animal species, and consequently can have dramatic effects on communities in general. Modified landscapes, disturbances, and hydrology can also lead to changes in succession.

Modified Habitats

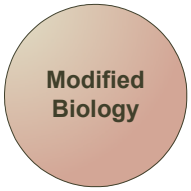
Habitats and the quality thereof are of critical importance for all organisms within network parks. For the purposes of the models described here, habitat includes all factors directly related to the *local* environments for park plant and animal resources. Factors such as fragmentation, heterogeneity, connectivity, and structural diversity are included, but also included are components such as, water quality, air quality, and soil quality.



Habitats within network parks can be influenced by either local or landscape-level processes, and can be either natural or anthropogenic in origin. Because of its direct impact on biodiversity, habitat modification is often a strategy used for managing park resources, particularly in threatened and endangered species management.

Modified Biology

Modified biology refers to changes in the biodiversity, distribution, behavioral ecology, and feeding ecology of the plant and animal species present within the ecosystem. Processes such as migration, competition, disease transmission, and predation all typify natural processes that can modify biological communities. However, other non-natural processes such as species invasions, hunting, and species reintroductions can also have dramatic impacts on communities.



Typically though, biological modifications are the "end result" of one or more processes or state-changes within the ecosystem, but in some cases can result in state changes themselves (i.e., changes in fire frequency due to altered fuel loading).

Use of pinwheel diagrams in a management & monitoring context

It is clear from these goals that a fundamental purpose of vital-signs monitoring is to detect meaningful changes in the condition (structure and functioning) of park ecosystems. It is therefore essential that conceptual models developed to support vital-signs monitoring reflect the current state of knowledge regarding ecosystem dynamics – how and why ecosystems change as a consequence of interacting natural and human factors. Monitoring can occur at one of two fundamental levels: either the processes described can be measured, or the mechanistic components describing either the process or the results (modified disturbance, landscape, hydrology, succession, habitats, or biology).

Finally, more detailed mechanistic models can be developed to further describe the processes included in the pinwheel diagrams. In such models, the environmental setting, resources of concern, and agents of change can be linked to expected ecosystem responses. From a management standpoint, both the status of the ecosystem and the trends either toward or away from an acceptable state might be important (Figure 2-3). Detailed descriptions of the key mechanistic components of Southeast Coast Network ecosystems can be found in Appendix 7.

Network Ecosystem Models

The Southeast Coast Network has developed pinwheel models for three major ecosystems found within the network: inland aquatic systems (rivers & streams), terrestrial systems, and coastal aquatic systems (nearshore marine and estuarine). For each modeled ecosystem, we have developed both the pinwheel models and textual descriptions of key model components (found in Appendix 7). Pinwheel models present hypotheses concerning relationships of selected components of the ecosystems and how or why they might change over time. Mechanistic models provide details concerning the actual ecological components and processes that are involved in the dynamic models.

Rivers & Streams

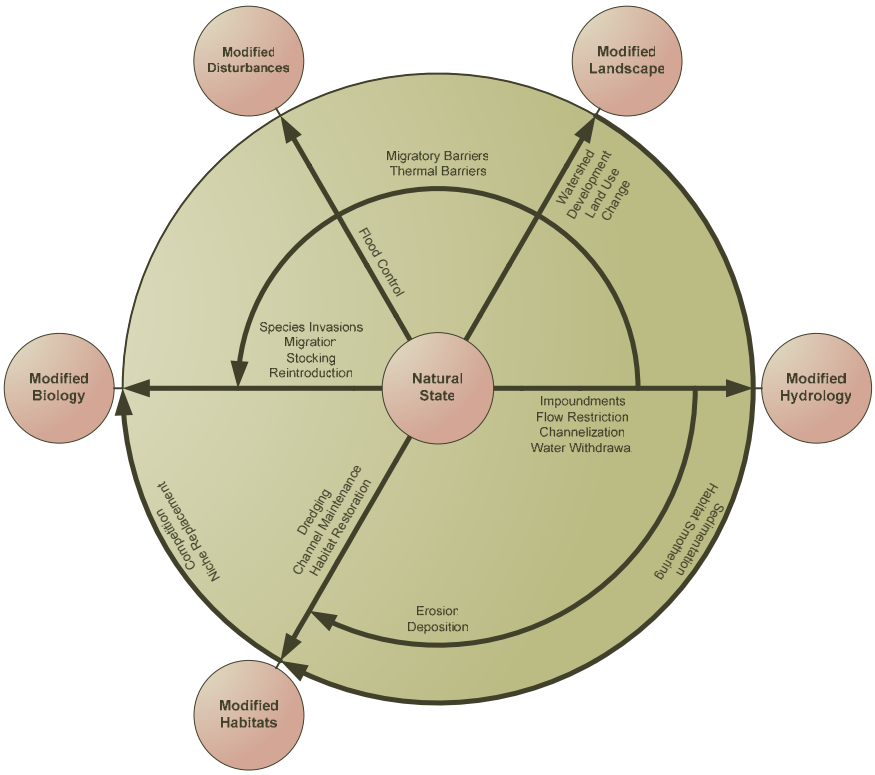


Figure 2-4. Model of ecosystem dynamics in rivers and streams within the Southeast Coast Network.

River systems in the Southeast generally follow trends as described in Vannote et al.'s (1980) River Continuum Concept, which describes linkages between streams, floodplains, and the watersheds that they drain along a longitudinal gradient from the headwaters to the sea. The River Continuum Concept maintains that biological, physical, and chemical properties and functions of river systems and their associated floodplains follow a general pattern from their headwaters to their mouths due to changes in elevation, geomorphology, amount of water, and the amount of light.

Southeast Coast Network parks contain significant riverine resources within three distinct zones along the river continuum—CHAT and KEMO are located in the Piedmont province, HOBE and OCMU are on the fall line, and MOCR and CONG are located within the coastal plain. Coastal parks within the network also contain smaller isolated systems.

Recognizing that rivers are highly dynamic in both space and time, several processes have been identified that cause rivers and streams to evolve from natural to modified conditions (Figure 2-4). Four distinct modification types exist for riverine ecosystems: habitat modification, hydrologic modification, watershed modification, biological modification. Although natural disturbances cause local or system-wide modifications to one or more of these components, these variations are considered to be a part of the natural state. Key processes that drive the natural system to one or more of the modified states include flow restriction and redirection, water withdrawal, species introductions, erosion, competition, migration, and restoration (Figure 2-4). In some cases, changes from the natural state to a modified state can cause further modifications (i.e., modifying hydrology can cause changes in habitats and therefore changes in community structure).

Southeast Coast Network streams and rivers are in a modified to highly modified state due to a combination of river regulation and rapid changes in land use that have resulted in extreme changes in water quality, habitat quality (through sedimentation) and aquatic community structure. Southeastern streams that were once dominated by

coarse woody debris and gravel-bottom substrates have seen those substrates either cleared or buried, and many sensitive species (such as mussels) have been extirpated as a result.

Estuaries & Nearshore Marine Systems

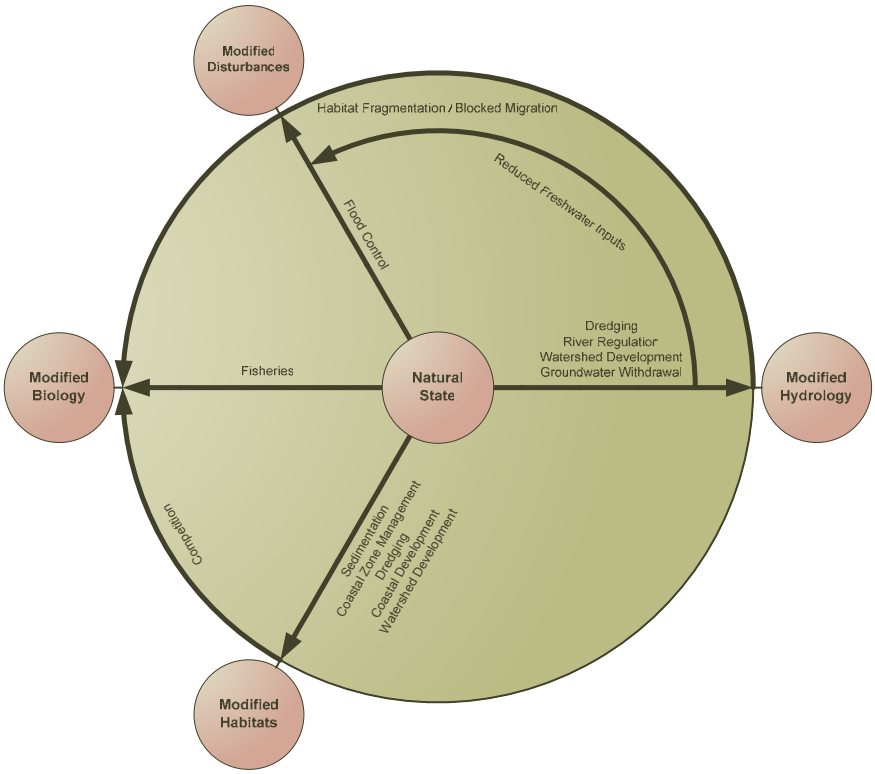


Figure 2-5. Model of ecosystem dynamics in estuaries and nearshore marine areas within the Southeast Coast Network.

The Southeast Coast Network contains seven parks with significant portions of estuarine and nearshore marine systems (CAHA, CALO, FOSU, FOPU, CUIS, TIMU, and CANA). Estuarine systems are particularly sensitive to changes in hydrology; particularly those that can affect salinity levels.

The major drivers of ecosystem change in estuarine and nearshore marine systems include coastal zone management (dredging, beach renourishment, and shoreline stabilization projects), fisheries, adjacent land use development, and hydrological modifications resulting from both upstream river regulation and groundwater extraction (Figure 2-5). Potential changes to the ecosystem include modified hydrology (flushing), modified disturbance regimes (flooding frequency), modified habitats (a combination of changes in sand / sediment budgets and water quality), and resultant shifts in community structures or distributions.

Most parks within the network (even within the coastal parks) do not have jurisdiction within estuarine or marine systems. However, many resources within park boundaries rely on estuarine or nearshore marine systems for part of their life cycle.

Terrestrial Systems

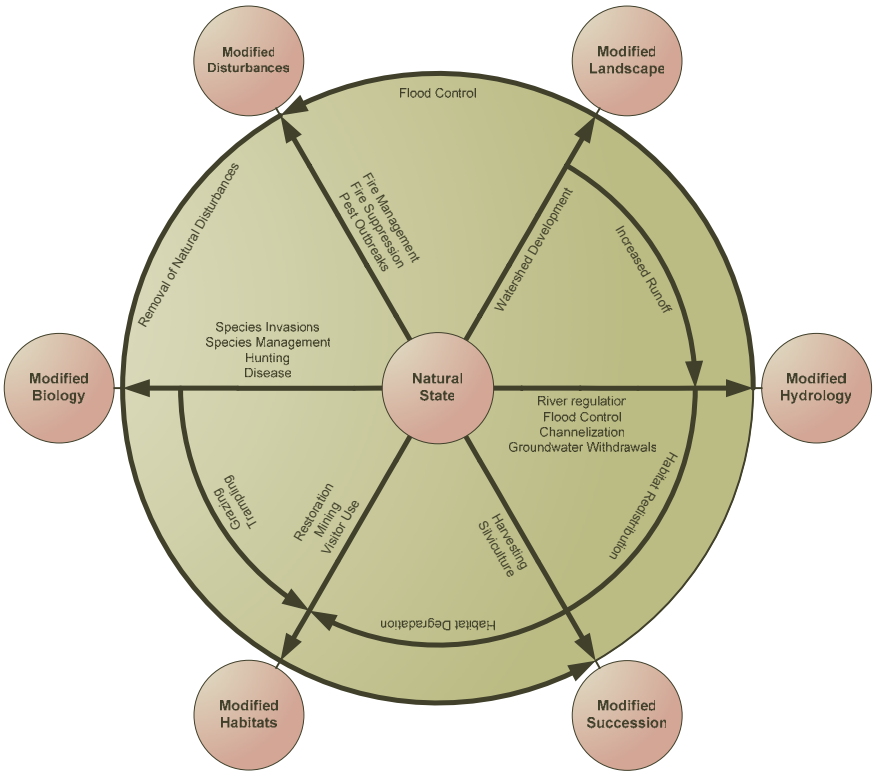


Figure 2-6. Model of ecosystem dynamics in terrestrial systems within the Southeast Coast Network.

Terrestrial systems within the Southeast Coast Network are very diverse, ranging from upland and bottomland forest communities to coastal dune ecosystems. Included in these systems are many plant and animal species of management concern (native, exotic, common, and rare).

Natural systems within the network are marked by high levels of plant diversity, and more often than not historical dependence on fire or flooding as significant landscape-level drivers of ecosystem function (Figure 2-6). However, agents of change exist at all spatial and temporal scales in terrestrial ecosystems. Wildlife disease, species invasions, visitor use impacts, and changes in adjacent land use are all significant drivers of ecosystem structure, function, and composition.

3. Vital Signs

During the last twenty years, indicator-based monitoring programs have been developed to assess almost every ecosystem type around the world. Recent syntheses have focused on topics such as qualities of "good" vs. "bad" indicators, statistical sampling design, and methods to integrate monitoring programs with adaptive management programs—all in an effort to ensure that new programs meet desired objectives (Busch and Trexler eds. 2003). However, to date no adequate discussion has occurred about methods for selecting *what* indicators to monitor in the context of an integrated monitoring program when multiple options exist. The need to select indicators based on sound, defensible methods is critical to program success, particularly as new monitoring programs are intended to support an increasing number of management goals for an increasing number of partners.

Two critical facts – that the networks are operating under significant budget constraints, and that the scarce resources necessary for the parks and networks to achieve their goals are being allocated from a common pool – necessarily mean that the procedures by which decisions over resource allocation are made will be as important as the actual ecological priorities themselves. That is, the same set of ecological priorities will lead to more or less efficient resource allocation decisions depending on the decision-making procedure. Thus, without careful consideration of the decision-making procedures, in all likelihood resources will be substantially under-utilized (Morrow 1994). Recognizing this, the Southeast Coast Network developed methods for vital sign *selection* prior to beginning the vital sign scoping process in earnest (Table 3-5; also see Appendix 4).

Resource Allocation Approach

Given the conditions of limited resources, and the need to divide those resources among multiple partners, resource allocation is as much dependent on the *process* as it is on the criteria for dividing those resources (Kreps 1990). Specifically, the Southeast Coast Network desired a selection method that explicitly accounts for:

- Assessing indicator utility based on synergism or redundancy with other indicators, in addition to technical merit. This implies focusing on *suites* of indicators rather than individual indicators.
- Incorporating individual Parks' needs and priorities into the decision-making process.
- Incorporating sociopolitical or other non-technical factors into the decision-making process in a formal and documentable manner.
- Developing legitimate alternative choices, all of which (a) meet minimum standards and needs of all parks within a network, and therefore (b) represent viable choices for implementation.
- Providing a framework for selecting alternatives, and modifying those choices at a later time.

The decision-making process that follows addresses the needs identified above, and is based on Bator's (1957) economic model designed to determine the best and most efficient distribution of multiple products to multiple constituents given limited resources. The underlying principle is to identify how an altruistic agent, who perfectly incorporates the interests of all of the relevant actors, would choose to allocate the existing resources. By doing so, the model identifies one or more solutions that cannot make any one actor better off without making the group as a whole worse off. The model has been modified for multiple applications such as to advise crop rotation planning, company expenditures, and distribution of air pollution credits (Bator 1957, Mclure 1968, Laudadio 1971, Grabowski and Mueller 1972). In each case the authors created a model to guide production levels that is inherently linked to both individual customers' preferences, and production costs.

Welfare Maximization is a three-step process:

1. <u>Maximizing Production Efficiency</u>. All possible combinations of resource allocation such that an increase in production of one product necessitates a decrease in production of another. Allocations that meet this criterion maximize production efficiency within budgetary or other resource constraints.

2. Maximizing Product Utility. Based on customers' preference, identify those resource allocations such that an increase in satisfaction for one customer necessarily decreases the satisfaction of one or more other customers.

3. Defining Constrained Bliss. From the combinations of production that both maximize production efficiency and utility, select the one production function that best meets the welfare of all customers. In this case, welfare is defined by the ethic of the group to whom the products are intended (*not* necessarily scientific).

For the purposes of monitoring program design, the model needs to be modified slightly such that the program is designed to produce answers to specific monitoring questions (the "products"), for fifteen Park units (the "customers") with differing preferences for those products. In such a program the Network will implement monitoring protocols (collection of indicators) designed to answer to one or more of the identified monitoring questions. A successful Vital Signs Monitoring Program under this model will be a balance of indicators (the "costs" of production) that maximizes the number of high priority and total questions answered at all parks.

Pivotal to the process are two explicit qualifications. First, all protocols must be related to one or more specific monitoring questions identified by at least one park within the network. Second, protocols may consist of single indicators, collections of indicators, or indicators and other associated information.

Given this framework, monitoring program design proceeds as follows:

1. Maximize Monitoring Efficiency: Identify all possible suites of indicators that can be implemented within varying budget constraints. At this point, each suite is a potential monitoring program. If one or more of the indicators can be removed from a suite without reducing the *number of questions* answered, the combination of indicators is inefficient and not considered further. The resultant set represents potential programs that maximize production efficiency.

2. Maximize Information Utility: Based on parks' priorities for receiving answers to specific monitoring questions, select from the set of efficient program possibilities those combinations of protocols that maximize (a) the total number of questions answered, (b) number of high-priority questions answered, and (c) average priority level of questions answered *for each individual Park*. At any given budgetary level, the resultant suites of indicators represent monitoring programs that can be implemented. In each case implementation of any of the alternative options would satisfy the needs and expectations of all Parks in the most efficient means possible.

3. Choose the Most Relevant Alternative: Select one option from the alternative potential programs for implementation based on qualities deemed important to the Parks and other stakeholders. This step assumes that although all potential alternatives represent desirable outcomes, some might be more relevant than others. Selection criteria can include scientific, social, or political considerations, and can be explicitly documented. This step is particularly suited toward a consensus-building process because regardless of the outcome, all parties are guaranteed a program that maximizes both utility and efficiency.

Process of Vital Signs Selection

The Southeast Coast Network is roughly two-thirds through the vital signs selection process (Table 3-5).

Table 3-5. Summary of the process used in the Southeast Coast Network to choose and prioritize Vital Signs.

Dates	Event	Purpose	Product
07/02 – 07/03	Scoping meetings at each park	Identify key natural resource issues at each park within the Network, and develop specific monitoring questions of interest.	Appendix 5 – Summary of Natural Resource Issues at SECN parks.
09/03 – 12/03	Developed new methods for vital sign selection	Develop both satisfactory and scientifically defensible methods for vital sign selection (not prioritization) to guide the process.	Appendix 4 – Methods for vital sign selection in the SECN. Developed in partnership with Emory University.
12/03– 12/04	Develop Vital Signs Selection Database Software and analysis tools.	Facilitate scoping meetings, reporting / synthesis of findings, and selection process as developed above.	
12/03 – 02/04	Review of Phase I and Phase II reports from first two cycles of Networks	Identify specific monitoring questions that have been relevant in other networks nationwide.	Appendix 9 – Monitoring program priorities for SECN parks
02/04 – 06/04	Scoping meetings at each park	Prioritize natural resource information needs around which a monitoring program can be designed.	Appendix 9 – Monitoring program priorities for SECN parks
08/04 – 12/04	Identify protocols / methods that can be used to answer monitoring questions of concern to the Network	Link potential vital signs to park priorities for getting answers to specific monitoring questions.	Prioritized list of Vital Signs
12/04 – 02/05?	Develop program alternatives	Use resource allocation models developed above to identify multiple sets of vital signs that can be implemented to answer priority monitoring questions.	
TBD	Review and Comment	Submit report of methods and potential monitoring programs to subject matter experts for comment and review.	
TBD	Full Network Meeting	Select vital signs to be implemented from among the alternative programs presented.	Final list of vital signs to be implemented by the monitoring program

6. Data Management and Archives

As part of developing a long-term monitoring program, the Southeast Coast Network is conducting an information needs assessment within the context of previously developed monitoring priorities identified in Appendices 5 and 9. This process mirrors that of selection of Network vital signs by conducting a series of targeted scoping meetings to clearly define park information needs and to develop conceptual data models. Utilizing information from these scoping meetings, a data management plan will be developed to support the needs of the parks and other stakeholders. The Network is currently in the process of undertaking the first steps of the process:

1. Individual park scoping meetings to identify available (and needed) data sets, training needs, and park information management capacity and capabilities – to serve as background information for the information needs assessment process and network data mining activities (Completed 07/04).
2. Identification of critical information product needs of the parks, the SECN Inventory and Monitoring Program, and for key partners,
3. Identification of a suite of data products necessary to support park, programmatic and partner needs and identify their cost, and
4. Development of a conceptual data object model that illustrates information flow within the program and describes programmatic responsibilities of involved personnel,

The process will inform the development of the data management plan as well as provide critical insight into the sampling and reporting needs to be considered during protocol development.

Information Needs Assessments

The Network will hold at least three meetings in FY2005 to conduct information needs assessments (INAs). Prior to conducting the INAs, the Network has identified key business needs (Table 6-6). Meetings in FY2005 will focus on defining the monitoring information needs of Park, Network, and Regional staff, and will focus defining those needs from an "end-user" perspective. The INA process will be conducted following the methods of (Tomlinson 2003).

Table 6-6. Key business areas of Southeast Coast Network parks that will govern the types of information products that will be produced and requisite information management strategies.

Category	Key Business Area	Description
Trends Monitoring	Water Quality	
	Water Quantity	
	Geology & Geomorphology	
	High-Priority Ecosystems & Habitats	
	Species of Management Concern	
Program Monitoring	Exotic Plant Management & Control	
	Fire & Fire Effects	
Project Management	Museum Management	
	Document Management & Archives	

Information Product Descriptions

Based on findings from the INA process, the Network will develop detailed information product descriptions (IPDs). Each IPD will include a description of the information product (i.e., map, image, table, documents, etc.), intended audience, frequency and purpose of use, and the data required to develop those products. IPDs will be cataloged in a central database for use during protocol development.

Conceptual Data Object Model

Based on the information needs assessment and the ecological relationships among resources within the SECN, a conceptual data object model will be created to serve as the framework for designing an information management system.

8. Administration / Implementation of the Monitoring Program

Coordination among Network Parks

Network member parks are committed to cooperate and foster an atmosphere of fairness, trust, and respect throughout the Network. They are pursuing an inclusive approach in defining Network management issues and resources of concern, and in identifying the best locations to monitor these resources, as well as implementing the I&M program using scientifically credible standards.

Board of Directors

The SECN Board of Directors (Board) is comprised of five Network park Superintendents and the Southeast Region I&M Coordinator, with one superintendent elected to serve as the chairperson (Figure 8-7). Board member Superintendents serve for three years, while the Chair serves for two years. The Chair leaves the Board after serving as Chair. Terms are renewable other than the Chair, which rotates off at least one year after serving as chair. At a minimum, one new board member is added from the remaining parks every two years at the time a new chairperson is selected. Vacancies will be filled by the Chairperson with the concurrence of the remaining Board. The SER I&M Coordinator is a permanent member of the Board. The SECN Coordinator and Chairperson will facilitate meetings and communications of members and with all network parks. The SECN Coordinator will serve as advisor to the Board of Directors.

The Board promotes accountability and effectiveness by reviewing progress toward goals, quality controls, and Network expenditures. The Board collaborates with the Network Coordinator, Technical Steering Committee, and Network parks' natural resource staffs in the overall design and implementation of vital signs monitoring and in other management activities related to the Natural Resource Challenge.

Technical Steering Committee

The Technical Steering Committee is comprised of resource managers (elected by the Network Park Resource representatives with the concurrence of their Park Superintendent), and non-voting, volunteer scientists as needed. The Committee includes the Network Coordinator, Data Manager, CESU coordinator, park natural resource managers, and other scientists with knowledge of sampling procedures, monitoring techniques, and statistical methods that serve as reviewers to evaluate conceptual designs, monitoring strategies, and ecological relevance of monitoring proposals.

The Technical Steering Committee advises the Board and Network parks on the development of the Network Monitoring Plan and identification of monitoring objectives by:

- Compiling and summarizing existing information about park resources and the findings and recommendations of scoping workshops,
- Assisting in the development of a network monitoring strategy,
- Assisting in the selection of Vital Signs
- Evaluating initial sampling designs, methods, and protocols to ensure that they are scientifically credible,
- Participating in the development of the Annual Work Plan and Annual Reports
- Reviewing annual data reports, I&M deliverables, and otherwise acting as a peer science review group, and
- Developing materials for and facilitating the Five Year Program Review

Products and recommendations of the Technical Steering Committee are presented to the Board of Directors for discussion, modification, and approval. When necessary, the Network Coordinator may recommend to the Board of

Directors the formation of groups of scientists or specialists from within or outside the Technical Steering Committee to accomplish specific studies/tasks.

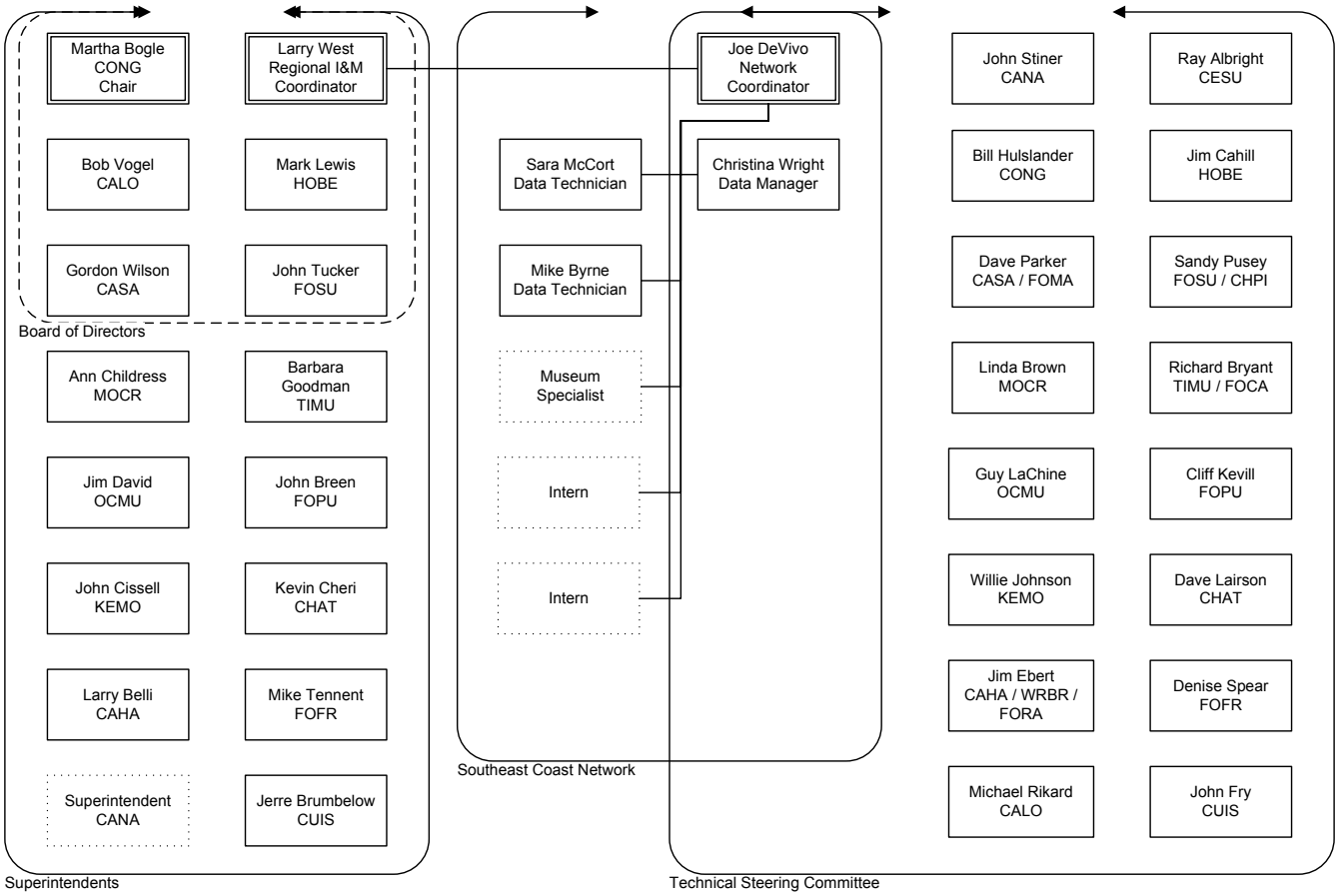


Figure 8-7. Current organizational and staffing plan for the Southeast Coast Network (08/09/2004).

Network Staffing Plan

To be completed during Phase III

Partnerships

To be completed during Phase III

Programmatic Review

The SECN I&M Coordinator, in consultation with the Technical Steering Committee and other designated subgroups, prepares and presents a draft Annual Report to the Board of Directors for consideration and approval on or before October 30th each year. Annual Reports detail specific accomplishments, products, lessons learned, coordination with others, and a budget summary. A detailed accounting of all SECN I&M program funds allocated to each park and office will be appended to and made part of the Annual Report.

At the end of the fifth Fiscal Year of Vitals Signs Monitoring, and every five years thereafter, the Network will undertake a comprehensive program review. The review shall be conducted by National Park Service specialists at the national and regional levels, and may involve qualified independent specialists from other agencies and

organizations. The purpose of these reviews is to evaluate accomplishments, products, and protocols used for gathering data, data management, fiscal management, and staffing. Program Reviews provide the basis for any significant changes in program direction or reassignment of resources to any park or office with the approval of the Network Board of Directors.

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National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 1 – Charter of the Southeast Coast Network

United States Department of the Interior

NATIONAL PARK SERVICE
Canaveral National Seashore
308 Julia Street
Titusville, Florida 32796

IN REPLY REFER TO:

July 2, 2001

Memorandum

To: Regional Director, Southeast Region

From: Chairperson Southeast Coastal Network

Subject: Charter for the Southeast Coastal Network

We are very pleased to present to you the Charter for the Southeast Coastal Network. All of the Superintendents in the Network have signed the document and we are eager to begin playing a leadership role in the inventory and monitoring aspects of the Network.

We are requesting that the Charter be signed by the appropriate Regional Officials and forwarded to the Washington Office.

Barbara Goodman
Chairperson, Barbara Goodman

John Tucker
Board Member, John Tucker

Robert Newkirk
Board Member, Robert Newkirk

Gordie Wilson
Board Member, Gordie Wilson

Martha C. Bogle
Board Member, Martha Bogle

Charter of the Southeast Coast Network

Introduction

The purpose of this document is to describe the basic practices that will be used to plan, organize, manage, and evaluate the Southeast Coastal Network's "Vital Signs" Monitoring Program. This charter is pursuant to the intent and purposes of the National Park Service Natural Resource Challenge with respect to the inventory and monitoring of natural resource ecosystem health within the Network.

The Southeast Coastal Network (SCN) is comprised of 17 units of the National Park System's 270 units that qualify for inventory and monitoring because of their significant natural resources. They include:

Canaveral National Seashore (CANA)

Cape Hatteras National Seashore (CAHA)

Cape Lookout National Seashore (CALO)

Castillo de San Marcos National Monument (CASA)

Charles Pinckney National Historic site (CHPI)

Chattahoochee River National Recreation Area (CHAT)

Congaree Swamp National Monument (COSW)

Cumberland Island National Seashore (CUIS)

Fort Caroline National Memorial (FOCA)

Fort Frederica National Monument (FOFR)

Fort Matanzas National Monument (FOMA)

Fort Pulaski National Monument (FOPU)

Fort Sumter National Monument (FOSU)

Horseshoe Bend National Military Park (HOBE)

Kennesaw Mountain National Battlefield Park (KEMO)

Moores Creek National Battlefield (MOCR)

Ocmulgee National Monument (OCMU)

Timucuan Ecological and Historic Preserve (TIMU)

Network member parks are committed to cooperate and foster an atmosphere of fairness, trust, and respect throughout the Network. They will pursue a inclusive approach in defining Network management issues and resources of concern, and in identifying the best locations to monitor these resources, as well as implementing the I&M Program using scientifically credible standards.

Board of Directors

The Board of Directors is comprised of five Network park Superintendents and the Southeast Region (SER) I&M Coordinator, with one superintendent elected to serve as Chairperson. The Board is elected by the Network Superintendents. Board member Superintendents serve for three years, while the Chair serves for two years. The Chair leaves the Board after serving as Chair. Terms are renewable other than the Chair, which rotates off at least one year after serving as chair. At a minimum, one new board member is added from the remaining parks every two years at the time a new chairperson is selected. Vacancies will be filled by the Chairperson with the concurrence of the remaining Board. The SER I&M Coordinator is a permanent member of the Board. The SCN Coordinator and Chairperson will facilitate meetings and communications of members and with all network parks. The SCN Coordinator will serve as advisor to the Board of Directors.

Responsibilities of the Board of Directors

The Board of Directors (Board) will promote accountability and effectiveness by reviewing progress toward goals, quality controls, and Network expenditures.

The Board will collaborate with the Network Coordinator, Science and Technical Committee, and Network parks' natural resource staffs in the overall design and implementation of vital signs monitoring and in other management activities related to the Natural Resource Challenge.

The Board shall contribute to and decide on strategies and procedures for leveraging Network funds and personnel to best accomplish vital signs monitoring and other natural resource needs of Network parks.

The Board is consulted on hiring of new personnel using funds provided to the Network and from other funds sources. They will seek additional funding from other sources to leverage Network funds provided through the Servicewide program.

The Board will solicit Professional guidance from and partnerships with other individuals and organizations.

Annually, the Board will review and approve the Network Annual Work Plan and associated budget.

Southeast Region I&M Coordinator

The SER I&M Coordinator is a voting member of the Board of Directors. He/she provides the SCN I&M Coordinator with professional and scientific direction and has program oversight and coordination responsibilities.

Responsibilities of the Southeast Region I&M Coordinator

The role and responsibilities of the SER I&M Coordinator have been fully articulated by the Regional Director's memorandum of December 8, 2000, including the following:

The SER I&M Coordinator is the selecting official and the supervisor of record of the SCN I&M Coordinator. He/she will be responsible for developing Critical Performance Elements; conducting periodic and annual performance appraisals; administering salary, benefits, leave, and attendance; and all other associated supervisory functions.

The SER I&M Coordinator consults with the Board of Directors regarding the hiring of specific staff identified in Annual Work Plans and other budget and planning documents.

The SER I&M Coordinator is responsible for timely distribution of funds attributed to the Network through

Regional Office accounts. The SER I&M Coordinator will be responsible for the accountability and tracking of all funds allocated to the Network. In this regard, expenditure documents such as DI-1's and other planning documents that require the expenditure of funds must be signed off by the SER I&M Coordinator before the funds can be obligated. The I&M Coordinator provides the Board of Directors with monthly status of funds accounting and tracking of projects. He/she will consult with the Board of Directors regarding the planned expenditures in any given funding cycle.

Southeast Coast Network I&M Coordinator

The SCN I&M Coordinator provides overall leadership, management, and coordination of the Network, and consults regularly with the SER I&M Coordinator, Science and Technical Committee, and Board of Directors to ensure efficient program management.

The SCN I&M Coordinator is responsible for maintaining the administrative record of the Network, including project direction and funding.

The SCN I&M Coordinator is the Chief Scientist for the Network and provides leadership in the development and implementation of inventory and monitoring protocols and special studies, and ensures scientifically credible products as programs outcomes.

It is expected that the SCN I&M Coordinator and subordinate staff will conduct a major portion of project business at Network parks relative to the approved study plans by the Board for "Vital Signs" monitoring.

Responsibilities of the Southeast Coast Network I&M Coordinator

The SCN I&M Coordinator is responsible for the development, management, and operation of the Network, with oversight and supervision by the SER I&M Coordinator and approval of the Board of Directors.

Subordinate Network program staff will be hired, supervised, and administratively supported by the SCN I&M Coordinator with concurrence from the SE Regional I&M Coordinator. The SCN I&M Coordinator is directly supervised by the SER I&M Coordinator and consults with the Science and Technical Committee to prepare a Network Annual Work Plan and associated budget for approval by the Board of Directors. He/she is responsible for managing funds allocated to the Network Program from a variety of sources, and is accountable for the appropriate expenditure of same following appropriate policies, laws, and regulations.

The Network I&M Coordinator serves as Chair of the Science and Technical Committee meetings and coordinates Committee business.

Science and Technical Committee

The Science and Technical Committee is comprised of natural resource managers, (elected by the Network Park Resource representatives with the concurrence of their Park Superintendent) and non-voting, volunteer scientists as needed. The Committee will include the SCN I&M Coordinator; park natural resource managers; and scientists with knowledge of sampling procedures, monitoring techniques, and statistical methods that will serve as reviewers to evaluate conceptual designs, monitoring strategies, and ecological relevance of monitoring proposals. Committee membership will be submitted to the Board of Directors for approval.

This Charter makes provision for and recognizes the opportunity to create a joint Network Science and Technical Committee or like body to serve more than one network. The Board of Directors will actively consider and vote on any such proposals.

Responsibilities of the Science and Technical Committee

The Committee will advise the Board of Directors and Network parks on the development of the Network Monitoring Plan and identification of monitoring objectives by:

compiling and summarizing existing information about park resources and the findings and recommendations of scoping workshops;

assisting in the development of a network monitoring strategy;

assisting in the selection of indicator species, communities, and processes for "Vital Signs;"

evaluating initial sampling designs, methods, and protocols to assure they are scientifically credible;

participating in the development of the Annual Work Plan and Annual Reports;

reviewing annual data reports, I&M deliverables, and otherwise acting as a peer science review group; and

developing materials for and facilitating the Five Year Program Review.

Products and recommendations of the Science and Technical Committee will be presented to the Board of Directors for discussion, modification, and approval. When necessary, the SCN I&M Coordinator may recommend to the Board of Directors the formation of groups of scientists or specialists from within or outside the Science and Technical Committee to accomplish specific studies/tasks. No such group is formed without inclusion of a specific "sunset" provision.

Each year the Science and Technical Committee and the Board of Directors will prepare a budget for the Network including travel, per diem, and other costs associated with the conduct of Committee meetings. Science and Technical Committee costs are summarized in the Network Annual Work Plan.

Procedures

Board of Directors Meetings

The Board conducts at least one meeting annually. The SCN Coordinator publishes an agenda at least three weeks prior to the meeting, provides the Board with background information and is responsible for publishing the minutes of the meeting. At the conclusion of the Annual Meeting, the Board will decide the date and location of the next annual meeting.

Any of the 16 Network Superintendents may raise issues to the Board and may participate in conference calls, meetings or discussions.

The Board may conduct special meetings and use telephone conferences to deal with discussion or decision topics as necessary. The Network Coordinator is responsible for arranging annual meetings, special meetings, and telephone conferences of the Board of Directors and for publishing the minutes. The Network may use monitoring funds to pay for costs associated with conducting the annual meeting including Board travel and may pay for other appropriate network meetings if needed.

Conference calls will be arranged with no less than 48 hours notice, providing the issues and intent of the calls have been provided to the Board. Any designated alternate will also be sent notice of a special meeting or conference call.

Simple business matters and other easily resolved issues and decisions are delegated to the Network Coordinator in consultation with an available board member for decision.

Alternates and Quorums

Any Network Superintendent who cannot attend or otherwise participate in a meeting of the Board of Directors may assign an alternate from their park. Network Superintendents may not serve as alternates nor carry the proxies of other Superintendents. A simple majority of the members present at a special meeting or conference call constitutes a quorum.

Decision-Making

Decisions of the Board of Directors are made by majority vote. If the Board of Directors cannot reach a decision on the matter, it will be referred to the Regional Chief, Science and Resource Management, for arbitration. If the matter cannot be resolved through arbitration, it will be referred to the Regional Director for resolution.

Network Funding

Inventory and Monitoring program funds are made available to the Network as directed through the Annual Work Plan. Multi-park funded activities are distributed from Regional Office accounts under control of the SER I&M Coordinator. All I&M funds must be strictly accounted for by the SER I&M Coordinator using a discrete Program Work Element (PWE) code and disclosed in the Annual Report Appendix. The Network Board of Directors will be responsible for overall program direction and allocating, and approving, of Network funds and all other funds contributed by parks, other NPS programs, and/or other sources. The Network I&M Coordinator under the direction of the SER I&M Coordinator will track and account for all expenditures and present his/her findings to the Board.

Monitoring Plan

A Monitoring Plan identifying what, how, and where a resource will be monitored is prepared by the Network I&M Coordinator in consultation with the Science and Technical Committee and the SER I&M Coordinator for approval by the Board of Directors. The Vital Signs Monitoring Plan for the Southeast Coast Network will be submitted for approval within two years after Vital Signs Monitoring funds for the Network are provided.

Annual Work Planning and Reporting

The SCN Coordinator, in consultation with the Science and Technical Committee and other designated subgroups, prepares and presents a proposed Annual Work Plan to the

Board of Directors for consideration and approval no later than October 30th each year. Annual Work Plans will identify proposed and actual accomplishments and products, responsible individuals, cooperators, partners, funding from all sources, and a budget.

Annual Report

The SCN I&M Coordinator, in consultation with the Science and Technical Committee and other designated subgroups, prepares and presents a draft Annual Report to the Board of Directors for consideration and approval on or before October 30th each year. Annual Reports detail specific accomplishments, products, lessons learned, coordination with others, and a budget summary. A detailed accounting of all SCN I&M program funds allocated to each park and office will be appended to and made part of the Annual Report. Thirty copies of the Annual Report will be published by the SCN I&M Coordinator for distribution no later than December 31 of each year to Network parks and the Region.

Five Year Program Review

At the end of the fifth Fiscal Year of Vitals Signs Monitoring, and every five years thereafter, the Network will undertake a comprehensive program review. The review shall be conducted by National Park Service specialists at the national and regional levels, and may involve qualified independent specialists from other agencies and organizations. The purpose of these reviews is to evaluate accomplishments, products, and protocols used for gathering data, data management, fiscal management, and staffing. Program Reviews provide the basis for any significant changes in program direction or reassignment of resources to any park or office with the approval of the Network Board of Directors.

Coordination

The Board of Directors will need to maintain close working relationships with the natural resources staffs of Network parks, the Science and Technical Committee, the SER I&M Coordinator, and the SCN I&M Coordinator. All Board of Directors meetings are open to all of these parties.

Members of the Board of Directors are encouraged to participate in and/or keep informed with respect to the work of the Science and Technical Committee. The SCN I&M Coordinator provides regular briefings to the Board of Directors by memoranda, electronic mail, or telephone.

The SER I&M Coordinator keeps in regular contact with the Science and Technical Committee and the Network I&M Coordinator.

Partnerships

The Network I&M Program works with others to achieve its "Vital Signs" inventory and monitoring goals. The Southeast Coastal Network cooperates with other agencies, academic institutions, and non-governmental organizations. Efforts will be made to partner with the Biological Resources Division (BRD) of the U.S. Geological Survey, and with the Cooperative Ecosystems Studies Units (CESU'S). It is understood that the Southeast Coastal Network I&M Program may evolve to include other land and resource managers (Federal, State, Tribal) in the Southeast Coastal biogeographic area. The Network Charter may be amended to identify the conditions under which membership in the Board of Directors may be expanded to include non-National Park Service participants. In no case will this be done without approval of the Network Superintendents.

Amendments

The Network Superintendents may make amendments to the Charter at any time.

Approval Signatures

Cape Hatteras National Seashore (CAHA) — Date: 07/09/01

Cape Lookout National Seashore (CALO) — Date: 07/11/01

Castillo de San Marcos National Monument (CASA) — Date: 07/16/01

Chattahoochee River National Recreation Area (CHAT) — Date: 8-16-01

Congaree Swamp National Monument (COSW) — Date: 07/31/01

Cumberland Island National Seashore (CUIS) — Date: 8/6/01

Fort Caroline National Memorial (FOCA) — Date: 7/24/01

Fort Frederica National Monument (FOFR) — Date: 8/9/01

Fort Matanzas National Monument (FOMA) — Date: 07-16-01

Fort Pulaski National Monument (FOPU)	8/10/2001 Date
Fort Sumter National Monument (FOSU) Charles Pinckney NHS (CHPI)	7/27/01 Date
Horseshoe Bend National Military Park (HOBE)	9-13-01 Date
Kennesaw Mountain National Battlefield Park (KEMO)	8-17-01 Date
Moores Creek National Battlefield (MOCR)	9-7-01 Date
Ocmulgee National Monument (OCMU)	8/22/01 Date
Timucuan Ecological and Historic Preserve (TIMU)	7/24/01 Date
Regional Director, Jerry Belson	1/7/02 Date
Regional I&M coordinator, Larry West	12/18/01 Date
Program Manager, WASO, Gary Williams	10/04/02 Date

Assoc. Dir., Nat. Resources, Mike Soukup

Date 10/11/02

National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 2 – Legislation and Policies Relevant to Vital Signs Monitoring in the Southeast Coast Inventory & Monitoring Network

The legislative mandates guiding the I&M Program, and the SECN in particular, can be divided into four sections: 1) general, overriding legislative Acts and 2) Executive Orders that influence a particular resource area or species or Acts that guide the development and implementation of monitoring, 3) Enabling Legislation, and 4) specific goals related to the Government Performance and Results (GPRA) Act.

General, Overriding Legislative Acts

The general, overriding legislative Acts guiding the I&M Program include such Acts as the National Park Service Organic Act of 1916 and the National Parks Omnibus Management Act of 1998, which led to the creation of the Natural Resource Challenge in 2000. Along with these Acts, the enabling legislation of each park unit contains general guidelines for the management of resources. The content of these pieces of legislation follow.

Legislation	Summary Content
National Park Service Organic Act of 1916 *16 USC 1*	This Act created the National Park Service within the U.S. Department of the Interior and gave it jurisdiction over parks, monuments, and reservations acquired by the U.S. government for the purpose of wilderness conservation and public enjoyment. "The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."
Fish and Wildlife Coordination Act of 1958 and 1980	The Fish and Wildlife Coordination Act requires federal agencies to consult with the US Fish and Wildlife Service (USF&W), or National Marine Fisheries Service, and with parallel state agencies, whenever water resource development plans result in alteration of a body of water. The Secretary of the Interior is authorized to assist and cooperate with federal agencies to "provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs."
Wilderness Act of 1964 *16 U.S.C. 1131 et seq. (1988), 78 Stat. 890, Pub. L. 88-577*	The Wilderness Act of 1964 established the National Wilderness Preservation System, composed of federal lands designated as Wilderness Areas. Wilderness Areas are to be administered "…for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, so as to provide for the …preservation of their wilderness character…" NPS policy mandates that any proposed wilderness areas be managed as *de facto* wilderness until a final determination regarding wilderness designation has been made by Congress. (NPS Management Policies 2001).
National Environmental Policy Act of 1969	The National Environmental Policy Act (NEPA) is the fundamental national charter for environmental protection. "NEPA is intended to help public officials to: (1) make decisions that are based on an understanding of environmental consequences; and (2) take actions that protect, restore, and enhance the environment." (National Park Service, 1990c). The National Environmental Policy Act states that the federal government will "preserve important historic, cultural, and natural aspects of our national heritage." It directs that all practicable means be used to improve federal functions so that the nation may "...attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences..." Specifically, NEPA requires that an environmental impact statement (EIS) be prepared for major actions by federal government agencies. The primary purpose of an EIS is to evaluate the environmental impacts of proposed projects and facilitate public review. An environmental assessment may be prepared to determine if an EIS is required.

Legislation	Summary Content
General Authorities Act of 1970	The General Authorities Act reinforces the National Park Service Organic Act by uniting all areas administered by the National Park Service into one National Park System. This was done in recognition of the growing variety of National Park Service units (e.g. national recreation areas, national seashores). The act assures a common preservation purpose for all units, regardless of title or designation. Hence, the fundamental duty of Recreation Area managers is to protect park resources, unless specifically exempted by Congress. Managers of all National Park Service units are accountable to the National Park Service Organic Act, related legislation and to National Park Service policies and guidelines.
Federal Water Pollution Control Act of 1972 (Clean Water Act)	This Act protects the biological, chemical, and physical nature of the Nation's waters through the elimination of pollutants and the creation of wastewater treatment plants. *"It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources…"*
Endangered Species Act of 1973	The Endangered Species Act was enacted in 1973 and amended in 1978, 1982 and 1988. It provides for the conservation, protection, restoration, propagation and recovery of species of native fish and wildlife (including plants) that are listed as being threatened with extinction. All entities using federal funding must consult with the Secretary of the Interior (through authority delegated to the US Fish and Wildlife Service) on activities that potentially affect endangered or threatened flora and fauna.
Migratory Bird Treaty Act of 1974 *16 U.S.C. §703-711*	On January 10, 2001, the President signed Executive Order 13186, directing Federal agencies to minimize their negative impacts on migratory birds, to enter into an MOU with the U.S. Fish and Wildlife Service, and to carry out certain actions to further the implementation of the Migratory Bird Treaty Act. In addition, the Executive Order calls on Federal agencies to take reasonable steps that include restoring and enhancing habitat, incorporating migratory bird conservation into planning processes, promoting research and information exchange, providing training and visitor education, and developing partnerships beyond agency boundaries. The Migratory Bird Treaty Act (MBTA), signed in 1918 and amended in 1936, 1974 and 1989, is the domestic law that implements the United States' commitment to four international conventions (with Canada, Mexico, Japan and Russia) for the protection of migratory birds. The species protected by the MBTA are listed at 50 CFR § 10.13. In 2000, a Federal Court ruled that Federal agencies, like private citizens, are subject to MBTA regulations regarding take of migratory birds. An MOU between the National Park Service and the U.S. Fish and Wildlife Service is currently being drafted to address this issue, as required by the Executive Order.
Safe Drinking Water Act of 1974	The Safe Drinking Water Act was enacted in 1974 and amended in 1986. This act, implemented by the states, sets national minimum drinking water quality standards and requires regular testing of public drinking water supplies. The National Park Service must comply with state regulations regarding the construction, operation, and monitoring of its public water supplies.
Surface Mining Control and Reclamation Act of 1977	The Surface Mining Control and Reclamation Act establishes a nationwide program to protect the environment from adverse effects of surface coal mining operations, establishes minimum national standards for regulating surface coal mining, assists states in developing and implementing regulatory programs, and promotes reclamation of previously mined areas with inadequate reclamation. Under the Act, the Secretary of the Interior is directed to regulate the conduct of surface coal mining throughout the United States for both federally and non-federally owned rights. The Act establishes the Abandoned Mine Reclamation Fund, which is for the reclamation of land and water affected by coal mining. Eligibility for reclamation under this program requires that the land or water had been mined for coal, or affected by coal mining, and had been inadequately reclaimed prior to the enactment of this act in 1977. Both public and private lands are eligible for funding. Sections 522(e)(1) and 533(e)(3) of the act specifically prohibit surface mining within the National Park Service, National Wildlife Refuge System, National System of Trails, National Wilderness Preservation System, or Wild and Scenic Rivers System. The act also prohibits surface mining that adversely impacts any publicly-owned park or place included in the National Register of Historic Sites. These prohibitions are subject to valid existing rights at the time of the Act, the exact definition of which remains the subject of administrative and legal action. How valid existing rights are ultimately defined will affect the ability of mineral owners to mine in the Recreation Area.

Legislation	Summary Content
Redwood National Park Act of 1978	The Redwood National Park Act amends the General Authorities Act of 1970, and reasserts the system-wide standard of protection prescribed in the original Organic Act. This Act strengthens the Secretary of the Interior's ability to protect park resources, yet qualifies that park protection will "not be exercised in derogation of the values and purposes for which these various areas have been established." Thus, specific provisions in a park's enabling legislation allow park managers to permit certain activities, such as hunting or grazing.
Clean Air Act of 1990 *42 U.S.C. Sec. 7401(c).*	The Clean Air Act provides a legal framework for the National Park Service to preserve and protect parks' air quality related values (AQRV's) from pollution sources emanating from within and outside park boundaries. Because of a perceived need for national and regional air quality research to support state programs, Congress passed its first federal air quality initiative in 1955. In response to increasing harm to public health and welfare and to inadequate controls and enforcement, Congress has slowly but steadily expanded and refined the law, now known as the Clean Air Act, to cover more types of pollutants and emitters; i.e., stationary and mobile sources of pollution. These efforts have culminated in the 1990 amendments to the Clean Air Act, which represent the most comprehensive and detailed set of measures to date to both prevent and curtail air pollution. The declaration of purpose as revised in 1990 states, "A primary goal of this Act is to encourage or otherwise promote reasonable Federal, State, and local government actions, consistent with the provisions of the Act, for pollution prevention."
Government Performance and Results Act of 1993	Passed in 1993, GPRA establishes a performance management system to set goals and track accomplishments within Federal Agencies. In accordance, Park Service-wide strategic plans, annual performance plans, and annual performance reports are prepared and analyzed for management accountability. The strategic plans, developed and updated at all organizational levels, drive budgeting and resource allocation decisions. The superintendent of each park, as well as other program managers, is required to prepare a 5-year strategic plan, an annual performance plan and an annual performance report. The strategic plan and annual performance plan reflect NPS policies and goals stated in the Service-wide Strategic Plan. Annual performance reports for parks and programs show accomplishments or results toward stated goals to evaluate organizational and individual performance. NPS GPRA goals must be consistent with National Park Service Management Policies (2001).
National Parks Omnibus Management Act of 1998	The Omnibus Act is the precursor to the Natural Resource Challenge, the prime directive guiding the NPS I&M Program. The goal of the act is to use state-of-the-art methods of scientific research to improve management decisions within the NPS. This act also made the superintendents of each park unit responsible for the care and condition of the resources within the parks. "The Secretary shall undertake a program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of the National Park System." In addition, the act created the Natural Resources Challenge, which provides the funding for the I&M Program and doubles the natural resources staff within the NPS. "The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."

Executive Orders

Directive	Summary Content
Exotic Organisms *E.O. 11987*	This Order states that government agencies will restrict the introduction of exotic species into natural areas. *"Executive agencies shall, to the extent permitted by law, restrict the introduction of exotic species into the natural ecosystems on lands and waters which they own, lease, or hold for purposes of administration; and, shall encourage the States, local governments, and private citizens to prevent the introduction of exotic species into natural ecosystems of the United States."*

Directive	Summary Content
Floodplain Management *E.O. 11988*	Requires all federal agencies to *"reduce the risk of flood loss, ... minimize the impacts of floods on human safety, health and welfare, and ... restore and preserve the natural and beneficial values served by flood plains."* To the extent possible, park facilities, such as campgrounds and rest areas, should be located outside floodplain areas. Executive Order 11988 is implemented in the National Park Service through the *Floodplain Management Guidelines* (National Park Service, 1993b). It is the policy of the National Park Service to 1) restore and preserve natural floodplain values; 2) to the extent possible, avoid environmental impacts to the floodplain by discouraging floodplain development; 3) minimize the risks to life and property when structures and facilities must be located on a floodplain; and, 4) encourage nonstructural over structural methods of flood hazard mitigation.
Off-Road Vehicle Use *E.O. 11989*	If the enabling legislation allows the use of off-road vehicles, NPS is required to designate specific areas for off-road vehicle use. These areas must be *"located to minimize damage to soil, watershed, vegetation, or other resources"* (Section (3)(a)(1)). If it is determined that such use is adverse to resources, the NPS is to immediately close such areas or trails until the impacts have been corrected.
Protection of Wetlands *E.O. 11990*	Requires all federal agencies to *"minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands".* Unless no practical alternative exists, federal agencies must avoid any activities that have the potential to adversely affect wetland ecosystem integrity. NPS guidance pertaining to this Executive Order is stated in *Floodplain and Wetland Protection Guidelines* (National Park Service, 1980).
Federal Compliance with Pollution Control Standards *E.O. 12088*	Requires all federal agencies to prevent, control, and abate environmental pollution from federal facilities and activities and to comply with all applicable pollution control standards, including the Federal Water Pollution Control Act.
Invasive Species Management *E.O. 13112*	Goal is to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause. Among other things, this Executive Order It established the National Invasive Species Council and required the preparation of a National Invasive Species Management Plan to recommend specific, performance-oriented goals and objectives and specific measures of success for Federal agency efforts concerning invasive species.
Protection of Migratory Birds *E.O. 13186*	This Order provides additional protection for migratory birds, such that Federal agencies should *"design migratory bird habitat and population conservation principles, measures, and practices, into agency plans and planning processes (natural resource, land management, and environmental quality planning, including, but not limited to, forest and rangeland planning, coastal management planning, watershed planning, etc.) as practicable, and coordinate with other agencies and nonfederal partners in planning efforts."*

Enabling Legislation

Park	Summary Content
Canaveral National Seashore	Established in 1975 to preserve and protect the outstanding natural, scenic, scientific, ecologic, and historic values of certain lands, shoreline, and waters of the State of Florida, and to provide for public outdoor recreation use and enjoyment of the same (16 USC 459j). Such seashore shall comprise approximately sixty-seven thousand five hundred acres within the area more particularly described by a line beginning at the intersection of State Highway 3 and State Road 402, thence generally easterly following State Road 402 to a point one-half mile offshore in the Atlantic Ocean, thence northwesterly along a line which is at each point one-half mile distant from the high water mark to Bethune Beach, thence inland in a generally westerly direction through Turner Flats and Shipyard Canal, thence northwesterly to the Intracoastal Waterway, thence southerly along the Intracoastal Waterway to the boundary of the Kennedy Space Center, thence southwesterly to United States Highway 1, thence southerly along State Highway 3 to the point of beginning.

Park	Summary Content
Cape Hatteras National Seashore	Established, dedicated, and set apart in 1937 as a "national seashore recreational area for the benefit and enjoyment of the people" (16 USC 459).
Cape Lookout National Seashore	Established in 1966 to *"preserve for public use and enjoyment an area in the State of North Carolina possessing outstanding natural and recreational values."* Original boundaries comprised the lands and adjoining marshlands and waters on the outer banks of Carteret County, North Carolina, between Ocracoke Inlet and Beaufort Inlet, as generally depicted on the map entitled ''Boundary Map, Cape Lookout National Seashore'', dated March 1974, and numbered 623-20,009, which is on file in the Office of the National Park Service, Department of the Interior (16 USC 459g).
Castillo de San Marcos National Monument	Fort Marion National Monument, Florida Monument redesignated Castillo de San Marcos National Monument by act June 5, 1942, ch. 337, 56 Stat. 312). - Proc. No. 1713, Oct. 15, 1924, 43 Stat. 1968.
Charles Pinckney National Historic Site	Established in 1988 to include the lands and improvements of Snee Farm (Pub. L. 100-421).
Chattahoochee National Recreation Area	Established in 1978, Congress found that *"the natural, scenic, recreation, historic, and other values of a forty-eight-mile segment of the Chattahoochee River and certain adjoining lands in the State of Georgia from Buford Dam downstream to Peachtree Creek are of special national significance, and that such values should be preserved and protected from developments and uses which would substantially impair or destroy them… The recreation area shall consist of the river and its bed together with the lands, waters, and interests therein within the boundary …"* *In addition to the lands managed exclusively by the National Park Service, Chattahoochee National Recreation Area has authority to facilitate "Federal technical and other support to State and local governments to assist State and local efforts to protect the scenic, recreational, and natural values of a 2,000 foot wide corridor adjacent to each bank of the Chattahoochee River and its impoundments in the 48-mile segment referred to above, such corridor is hereby declared to be an area of national concern"* (16 USC 460ii).
Congaree National Park	Congaree Swamp National Monument was established in 1976 and limited to 15,200 acres (Pub. L. 94-545). Boundary expanded in 1988 to 21,773.34 acres, and portions therein were designated as wilderness. (Pub. L. 100-524). Renamed to Congaree National Park in 2004 with authorization to acquire new lands totaling ~4,842 acres.
Cumberland Island National Seashore	Established in 1972 *"to provide for public outdoor recreation use and enjoyment of certain significant shoreline lands and waters of the United States, and to preserve related scenic, scientific, and historical values"* (16 USC 459i). Total acreage capped at 40,500 acres.
Fort Caroline National Memorial	Fort Caroline National Memorial, Florida. - Act Sept. 21, 1950, ch. 973, 64 Stat. 897. Established Jan. 16, 1953.
Fort Frederica National Monument	Established the site of Fort Frederica on Saint Simon Island, Georgia and related areas not to exceed 250 acres in 1936 (16 USC 433g). Amended in 1958 to allow for the acquisition of the Bloody Marsh Battle Site and marshland across the river to the west of lands originally designated as Fort Frederica National Monument (16 USC 433h-1)
Fort Matanzas National Monument	Fort Matanzas National Monument, Florida. - Proc. No. 1713, Oct. 15, 1924, 43 Stat. 1968; Proc. No. 2114, Jan. 9, 1935, 49 Stat. 3433; Proc. No. 2773, Mar. 24, 1948, 62 Stat. 1491; Pub. L. 106-524, Nov. 22, 2000, 114 Stat. 2493.
Fort Pulaski National Monument	Fort Pulaski National Monument, Georgia. - Proc. No. 1713, Oct. 15, 1924, 43 Stat. 1968; June 26, 1936, ch. 844, 49 Stat. 1979; Nov. 12, 1996, Pub. L. 104-333, div. I, title VIII, Sec. 807, 110 Stat. 4188.
Fort Raleigh National Monument	Established in 1990 to preserve and interpret (1) the first English colony in the New World, and (2) the history of the Native Americans, European Americans, and African Americans who lived on Roanoke Island, North Carolina (Pub. L. 101-603).

Park	Summary Content
Fort Sumter National Monument	Established in 1948 after transfer of property from the U.S. Army (16 USC 450ee).
Horseshoe Bend National Military Park	Established in 1956 on the site of the Horseshoe Bend Battle Ground on the Tallapoosa River (16 USC 430ff).
Kennesaw Mountain National Battlefield Park	Established in 1935 (16 USC 430t). Designated as the terminus of the Blue Ridge Parkway in 1968 (16 USC160a-6).
Moores Creek National Battlefield	Acquired from North Carolina in 1926 to preserve for historical and professional military study (16 USC 422).
Ocmulgee National Monument	Established in 1934 pursuant to the donation of the "Old Ocmulgee Fields" in the vicinity of Macon, Georgia (16 USC 447a). Boundaries and monument designation finalized in December 1936 by presidential proclamation.
Timucuan Ecological and Historic Preserve	Established in 1988 to include the lands, waters, and interests within designated boundaries, and will administer all lands included within the Preserve *"in such a manner as to protect the natural ecology of land and water areas"* (16 USC 698n).
Wright Brothers National Memorial	Kill Devil National Monument, North Carolina. - Act Mar. 2, 1927, ch. 251, 44 Stat. 1264. Name change to Wright Brothers National Memorial, Dec. 1, 1953.

GPRA Goals

GPRA Goal	Park Code	Park Goal Details
1a0 – Other	Natural and cultural resources and associated values are protected, restored and maintained in good condition and managed within their broader ecosystem and cultural context.	
	CONG	By September 30, 2005, 15/50 of FY 1996 identified threats to the Monument's wilderness character, associated values, and aesthetic qualities are reduced.
	FOPU	Historic Vistas in existence during baseline year and those created since are maintained in good condition and managed within their broader ecosystem and cultural context.
1a01B – Containing Exotic Animal Species	This goal provides parks an opportunity to plan/report all efforts spent in restoring park lands disturbed by exotic animal species and other species not covered by Ia1B.	
	CONG	By September 30, 2005, park lands disturbed by feral hogs as of September 30, 1999 are reduced by 3%
	CUIS	By September 30, 2005, reduce by 5% or 1,820 acres out of 36,450 the acreage damaged by feral hogs and develop a horse management program for reduced impacts for the same acreage. (RESOURCE MANAGEMENT)
	HOBE	By September 30, 2005, exotic insects on 20% of targeted acres (108 of 540 acres) of park land are contained.
1a1A – Restoring Formerly Developed Lands	By September 30, 2005, 10.1% of targeted parklands, disturbed by development or agriculture, as of 1999 (22,500 of 222,300 acres), are restored.	
	CALO	By September 30, 2005, 20 acres (10%) of 200 acres of land at Cape Lookout National Seashore disturbed by development or agricultural use, and targeted by September 1999 for restoration, are restored.

GPRA Goal	Park Code	Park Goal Details
	CANA	By September 30, 2005, 15 (75%) of 20 acres of disturbed land in Canaveral National Seashore, identified as of 1999, are restored.
	CHAT	By September 20, 2005, 25 (13%) of 192 acres of Chattahoochee River National Recreation Area's targeted lands disturbed by prior development or agricultural uses, as of FY99, are restored.
	CONG	By September 30, 2005, 20% (418 acres) of the Monument's lands identified as disturbed as of 2001, are restored.
1a1B – Containing Exotic Plant Species	By September 30, 2005: Exotic vegetation on 6.3% of targeted acres of parkland (167,500 of 2,656,700 acres) is contained.	
	CALO	By September 30, 2005, Exotic vegetation on 1 acre (10%) of 10 acres targeted at Cape Lookout National Seashore is contained.
	CANA	By September 30, 2005, Exotic vegetation on 325 (19%) of 1700 acres at Canaveral National Seashore's is contained.
	CASA / FOMA	By Sept 30, 2005, 6 acres of Fort Matanzas lands will be treated for Brazilian Pepper and other exotic infestation. The treatment will be performed under contract via a joint initiative between the Exotic Plant Management Team and the Florida Department of Environmental Protection.
	CHAT	By September 30, 2005, exotic vegetation on 60 (8%) of 767 targeted acres of Chattahoochee River National Recreation Area lands is contained.
	CONG	By September 30, 2005, exotic vegetation on 6.3% of targeted acres of park land (2 of 29 acres) is contained.
	CUIS	By September 30, 2005, exotic vegetation on 1.0% of targeted acres (220 upland acres) of parkland acres is contained for two (2) non-native plants (tung tree and tamarisk). (RESOURCE MANAGEMENT)
	HOBE	By September 30, 2005, exotic vegetation on 20% of targeted acres (108 of 540) of park land is contained.
	KEMO	By FY2005 identify and remove 30% (30 acres) of 100 acres affected by exotic species.
	OCMU	By September 30, 2005, exotic vegetation on 20% of 100 targeted acres of Ocmulgee NM (20 of 100) acres is contained.
1a2 – Managing T&E Species	Managing T&E Species: By September 30, 2005, 14.4% of the 1999 identified park populations (64 of 442) of federally listed threatened and endangered species with critical habitat on park lands or requiring NPS recovery actions have improved status; and an additional 28.7% (127 of 442) have stable populations.	
	CAHA	By September 30, 2005, 1 of 5 (20%) of the FY 1999 Federally listed threatened and endangered species have stable populations.
	CALO	By September 30, 2005, 2 (33%) of Cape Lookout National Seashore's 6 identified populations of federally listed threatened and endangered species with critical habitat on parkland and/or requiring NPS recovery actions, as of 1999, have a stable status.
	CANA	By September 30, 2005, 2 (14%) of CANA's 14 identified populations of federally listed threatened and endangered species with critical habitat on park lands and/or requiring NPS recovery actions, as of 1999, have an improved status.
	CHAT	[NOT IN PMDS]
	CONG	By September 30, 2005, one (25%) of the four FY 1997 federally listed threatened and endangered species with critical habitat on Monument lands has a stable population.

GPRA Goal	Park Code	Park Goal Details
	CUIS	T & E Species Stable – By September 30, 2005, 2 (100%) of CUIS's 2 of both federally listed threatened and endangered species (loggerhead sea turtle and wood stork) with critical habitat on the island requiring NPS recovery actions, as of 1999, have stable nesting populations. (RESOURCE MANAGEMENT)
	OCMU	By September 30, 2005, 50 % of park T&E species population levels will be identified.
1a4 – Water Quality	75% of Park units will have unimpaired water quality.	
	CAHA	By September 30, 2005, the park will have 1 water quality with no days of water quality failed standards.
	CHAT	By September 30, 2005, Chattahoochee River National Recreation Area has impaired water quality. However, we are making strong efforts to reduce the threats to the resources.
	CUIS	By September 30, 2005, Cumberland Island National Seashore has unimpaired water quality. (RESOURCE MANAGEMENT)
	FOPU	By September 30, 2005, Fort Pulaski has unimpaired water quality.
	OCMU	By September 30, 2005, Ocmulgee National Monument has unimpaired water quality.
1a6 – Park Museum Collections	72.3% of preservation and protection standards for park museum collections are met.	
	CAHA	By September 30, 2005, 115 of 144 applicable preservation and protection standards for Cape Hatteras NS's museum collections are met.
	CALO	By September 30, 2005 , 45 (61%) of 74 applicable preservation and protection conditions for Cape Lookout National Seashore museum collections are met.
	CANA	By September 30, 2005, 90 (75%) of NPS preservation and protection standards for Canaveral National Seashore's museum collection are met.
	CASA / FOMA	By September 30, 2005, 87.6% of applicable preservation and protection standards for CASA/FOMA museum collections are met.
	CHAT	By September 30, 2005, 39 (55%) of 71 preservation and protection standards for Chattahoochee River National Recreation Area's museum collections are met.
	CUIS	By September 30, 2005, 83% (302) of preservation and protection standards for park museum collections are met. (RESOURCE MANAGEMENT)
	FOFR	By Sept 30, 2005, 142 of 158 (90%) of applicable park preservation and protection conditions standards of FOFR's Museum collection are met.
	FOPU	By September 30, 2005, 76% of 108 applicable preservation and protection standards for Fort Pulaski's museum collections are met.
	FOSU / CHPI	73% of preservation and protection standards for park museum collections are met.
	HOBE	By September 30, 2005, 115 (88%) of preservation and protection standards for park museum collections are met.
	KEMO	By September 30, 2005, 55 (75%) of 76 applicable preservation and protection standards for Kennesaw Mountain NBP's museum collections are met.

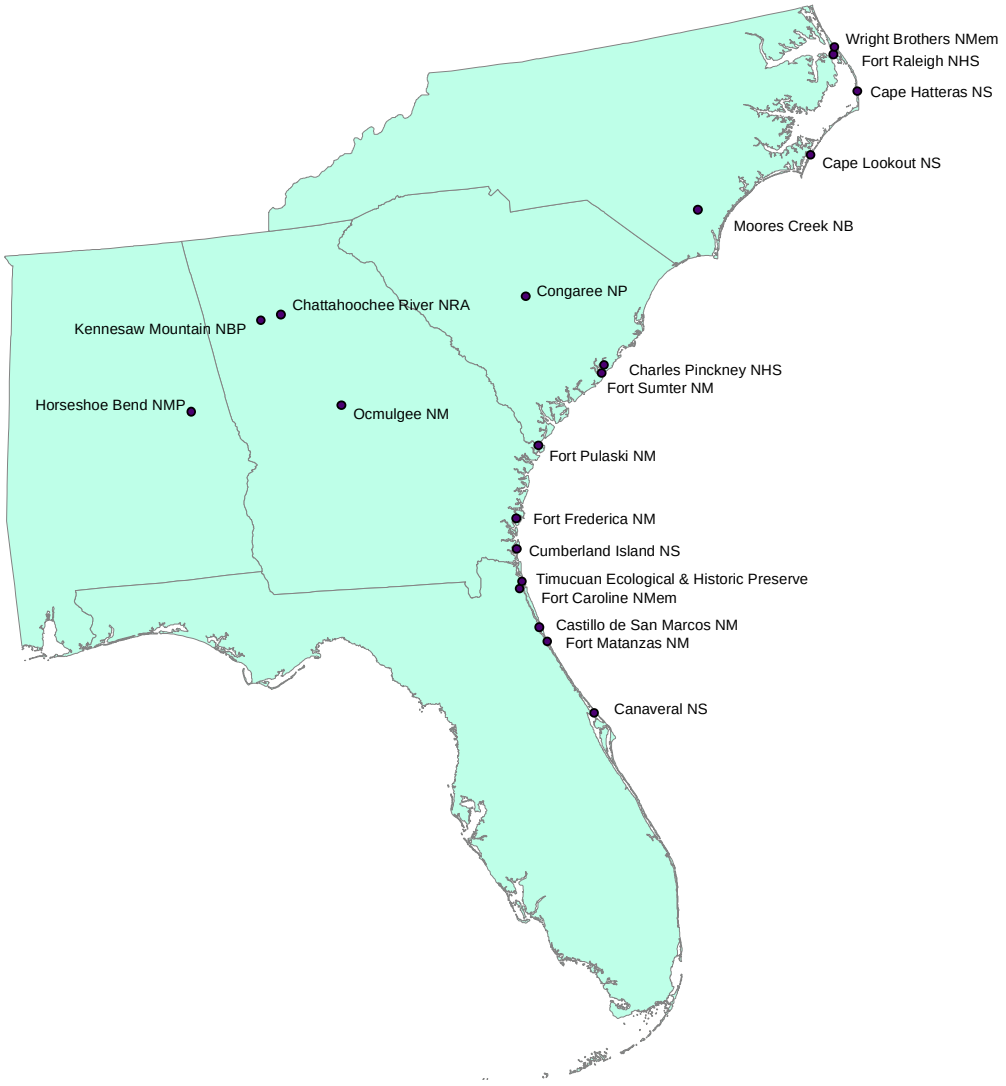
GPRA Goal	Park Code	Park Goal Details
	MOCR	By September 30, 2005, 82% of preservation and protection standards for park museum collections are met.
	OCMU	By September 30, 2005, 184 (60%) of Ocmulgee NM 307 preservation and protection standards for museum collections are met.
	TIMU / FOCA	By September 30, 2005, 138 (88%) of 157 applicable preservation and protection standards for Timucuan Preserve's museum collections are met.
1b0 / 1b1 / 1b01 – Data Sets	Acquire or develop 87% (2,203) of the 2,527 outstanding data sets identified in 1999 of basic natural resource inventories for all parks. [Only the Natural Resource Stewardship and Science Division reports to this goal – Parks report to Ib01]	
	CALO	By September 30, 2005, collect 100% of foal survival information on feral horses on Shackleford Banks in order to develop management decisions.
	CANA	By September 30, 2005, Canaveral National Seashore will have acquired 8 of 11 natural resource inventories, identified as needed in 1999.
	CHAT	[NOT IN PMDS]
	CUIS	By September 30, 2005, 4 (44%) of 9 primary Cumberland Island natural resource inventories identified in Resource Management Plan are complete. (RESOURCE MANAGEMENT)
	HOBE	By September 30, 2005, 34% (4) f the 12 natural resource inventories identified in the Resource Management Plan, etc. are complete.
	MOCR	By September 2005, Moores Creek NB will acquire or develop 87% of outstanding data sets identified in 1999 basic natural resource inventories for all parks.
	TIMU / FOCA	By September 30, 2005, 8 of 12 natural resource inventories identified in the Natural Resource Challenge will be completed and one park-specific data set outlined in the GMP.
1b2 – Museum Objects Cataloged	Museum objects cataloged are increased by 34.3% (from FY 1999 baseline of 37.3 million to 50.1 million).	
	CAHA	Museum Objects Cataloged: By September 30, 2005, Museum objects cataloged are increased from FY 1999 baseline of 33,512 to 38,000.
	CALO	Cultural Resource Baselines, Museum Collections: By September 30, 2005, the number of Cape Lookout National Seashore's museum objects catalogued into the NPS Automated National Catalog System (ANCS+) and submitted to the National Catalog is increased from 1017 in FY 1999 to 1,870 (84% Increase). [are NR collections included in this at all?]
	CANA	By September 30, 2005, the 1999 baseline inventory and evaluation of museum objects are increased by 7507 catalog records to 118205.
	CASA / FOMA	By September 30, 2005, the number of CASA museum objects cataloged submitted to the National Catalog is increased from 452473 in FY1999 to 461522 (2% increase).
	CHAT	By September 30, 2005, the number of Chattahoochee River National Recreation Area museum objects cataloged into the National Park Service Automated National Catalog System (ANCS+) and submitted to the National Catalog is increased by 37% from 4,404 in FY99 to 6,054.
	CUIS	By September 30, 2005, the number of Cumberland Island museum objects cataloged into the National Park Service Automated National Catalog System (ANCS+) and submitted to the National Catalog is increased from 37,000 in FY1999 to 89,844 objects. (RESOURCE MANAGEMENT)

GPRA Goal	Park Code	Park Goal Details
	MOCR	By September 30, 2005, Museum objects cataloged are increased by 1%. MOCR has 3977 objects of which 293 (7%) remain to be cataloged. An increase of 1% in cataloging would result in 50 of the 293 being cataloged by 2005.
	OCMU	By September 30, 2005, the number of Ocmulgee NM museum objects cataloged into the NPS Automated National Catalog System (ANCS+) and submitted to the National Catalog is increased from 169,453 in FY 1999 to 347,903 (105% increase).
	TIMU / FOCA	By September 30, 2005, the number of Timucuan Preserve museum objects cataloged submitted to the National Catalog is increased from 4,944 in FY 1999 to 6,328 (22% increase).
1b3 – Vital Signs	Vital Signs Identified: 80% (216) of 270 parks with significant natural resources have identified their vital signs for natural resource monitoring.	
	All Parks	By September 30, 2005 All Parks Have Identified Vital Signs for natural resource monitoring.

National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 3 – Summary of Existing & Historic Monitoring Data Relevant to the Southeast Coast Inventory & Monitoring Network



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Aquatic Resources

Alabama Rivers Alliance

Aquatic ecosystems
Freshwater ecology
Water quality
Water pollution
Watersheds

Responsible Agency / Park
Non-Profit – Alabama Rivers Alliance

Relevant Parks:
HOBE

Period of Record:
1993 – Present (Ongoing)

Description:
The Alabama Rivers Alliance was formed out of the efforts of its predecessor – the Alabama State Rivers Coalition. The Alabama State Rivers Coalition was formed in 1993 and led by the Cahaba River Society, Alabama Chapter of the Sierra Club, Lake Watch of Lake Martin, Alabama Citizen Action, Friends of the Locust Fork River, and Alabama Environmental Council.

In 1995 the Cahaba River Society hired Brad McLane to serve as the organizer for the Coalition and Policy Director for the Cahaba River Society's state policy programs. After a year of working for the Cahaba River Society, and with the full support and blessing of all Coalition partners, Brad convened the Board of Directors of a new organization for the first time in September 1996. The new Board chose the name of the Alabama Rivers Alliance. Soon thereafter the organization chose its mission, incorporated, developed a strategic plan, and applied for and soon received its 501(c)(3) tax exempt status. Still using the Cahaba River Society as its fiscal sponsor, the fledgling Alabama Rivers Alliance moved into a new office in December of 1996. On July 1, 1997, the Alliance started its first fiscal year operating without fiscal sponsor.

The mission of the Alabama Rivers Alliance is to unite the citizens of Alabama to protect clean, healthy waters. The Alliance works to achieve its mission through three programs: (1) Through its Healthy Rivers Campaign the Alliance supports the creation and advancement of effective watershed protection policies, and their implementation through wise water and land use management decisions, (2) Through its Alabama Watershed Leadership Program the Alliance works to build, support, and unite a strong network of local watershed guardian organizations in every Alabama watershed, each working to bring about the development and implementation of an effective watershed protection plan, and (3) Through its Watershed Awareness and Research Initiative the Alliance is working to develop an understanding of watershed values, conditions, problems and solutions, and to communicate this understanding to decision-makers and citizens through personal outreach, presentations, publications, a quarterly newsletter, web page, and other means.

Date Last Updated:
Catalog Number:
More Information:
http://www.alabamarivers.org/index.htm

Alabama Water Watch

Bacteria
Benthic Macroinvertebrates
Water Chemistry
Stream Habitat

Responsible Agency / Park:
Alabama Water Watch (AWW) is coordinated through Auburn University's Department of Fisheries and Allied Aquacultures, and the International Center for Aquaculture and Aquatic Environments.

Relevant Parks:
HOBE

Period of Record:
1992 – Present (Ongoing)

Description:
Since the AWW Program began in 1992, nearly 225 citizen groups have become involved with water monitoring on hundreds of waterbodies. Monitors have sampled 1,400 sites on 500 waterbodies and submitted over 25,000 chemistry and 4,000 bacteriological data forms. This water information has had positive impacts on education, restoration and local-to-state water policy.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.alabamawaterwatch.org/awwp/aww.htm

BacteriALERT
E. coli

Responsible Agency / Park:
BacteriALERT is a partnership between State and Federal agencies and non-government organizations. This partnership includes the Georgia Environmental Protection Division, the National Park Service, and the U.S. Geological Survey (USGS) and non-governmental organizations such as the Upper Chattahoochee RiverKeeper, Georgia Conservancy, and Trust for Public Lands.

Relevant Parks:
CHAT

Period of Record:
October 2000 – FY2004 (terminated)

Description:
Because of historically high levels of indicator bacteria in the Chattahoochee River, the concept of a bacteria alert network was proposed as a means to inform people when bacteria levels in the river exceed U.S. Environmental Protection Agency (USEPA) criteria. Thus, a program of bacteria monitoring called BacteriALERT was initiated on the Chattahoochee River within the Chattahoochee River National Recreation Area (CRNRA, National Park Service) in Fall 2000. The CRNRA contains about three-fourths of all public green space in a 10-county area of Metropolitan Atlanta, Georgia. In 1999, the recreation area attracted about 2.9 million visitors with nearly 30 percent of those participating in water-based recreation. Within the area of the bacteria alert network, drinking water and recreation are the designated uses for the Chattahoochee River.

The main objective of this network is to collect and analyze water samples for total coliform and Escherichia coli (*E. coli*) bacteria. Results are posted on a publicly-accessible web site within 24 hours of data collection. A second objective is the statistical analysis and interpretation of these data under a wide range of seasonal, weather, and river conditions.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://ga2.er.usgs.gov/bacteria/default.cfm

Charleston Harbor Project - FOSU
Water Quality

Effects of Dredging

Responsible Agency / Park:
Multi-agency Consortium – Federal, State and Industry

Relevant Parks:
FOSU, FOMO

Period of Record:
Post-1991

Description:
Charleston Harbor is located near and around Charleston, South Carolina. The project areas consist of Charleston estuary and the Ashley, Wando, and Cooper Rivers encompassing 808,000 hectares (2 million acres) of land area.

The Charleston Harbor Project is based on EPA's National Estuary Program guidance. EPA Region IV has provided both technical and management assistance along with monitoring support. The Charleston Harbor Project evolved from a grass-roots effort of the concerned citizens in the Charleston area. Their efforts resulted in 1991 funding approval for a special area management plan implemented through the South Carolina Coastal Council and initial funding from the National Oceanic and Atmospheric Administration.

Four major tasks are being undertaken to identify pollution causes and subsequent management strategies: (1) Water Quality Modeling and Nutrient Dynamics Project, (2) Water Quality Management and Best Management Practices Project, (3) Biological Habitat Project and, (4) Land Planning and Cultural Resource Projects.

Date Last Updated:

Catalog Number:

More Information:
http://www.epa.gov/ecoplaces/part2/region4/site10.html

Sediment Microbial Communities and Mercury Methylation - CONG

Mercury Contamination

Responsible Agency / Park:
US Geological Survey – Water Resources Division

Relevant Parks:
CONG

Period of Record:

Description:
To develop an understanding of the microbial controls that link atmospheric mercury to the formation of toxic methyl mercury.

Date Last Updated:

Catalog Number:

More Information:
Celeste Journey: cjourney@gsvaresh01.er.usgs.gov

Florida Department of Agricultural and Consumer Services

Fertilizer Use

Responsible Agency / Park
FDACS

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
1997-2003

Description:
The mission of the Department of Agriculture and Consumer Services (FDACS) is to safeguard the public and support Florida's agricultural economy by: (1) Ensuring the safety and wholesomeness of food and other consumer products through inspection and testing programs; (2) Protecting consumers from unfair and deceptive business practices and providing consumer information; (3) Assisting Florida's farmers and agricultural industries with the production and promotion of agricultural products; and (4) Conserving and protecting the state's agricultural and natural resources by reducing wildfires, promoting environmentally safe agricultural practices, and managing public lands.

Date Last Updated:
2003

Catalog Number:

More Information:
http://www.flaes.org/

Florida Department of Environmental Protection (FDEP) STORET

Water Quality

Responsible Agency / Park
FDEP

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The DEP STORET warehouse contains all of the water quality, biological, and physical data collected in Florida that is loaded to the U.S. Environmental Protection Agency's (EPA's) Modernized STORET database. This website allows you to retrieve data from the warehouse and download as a text file or display it on a map. This website allows you to dynamically query the STORET data warehouse by station, stations by map, or by aspects of water quality.

Date Last Updated:

Catalog Number:

More Information:
http://www.dep.state.fl.us/water/monitoring/data.htm

Florida Stream Condition Index

Benthic Macroinvertebrates

Responsible Agency:
Florida Department of Environmental Protection

Relevant Parks:
TIMU, FOCA, FOMA, CANA

Period of Record:
1998 – Present (ongoing)

Description:
The Stream Condition Index (SCI) is a composite macroinvertebrate metric for use in flowing streams. Sampling consists of 20 sweeps of the most productive habitats found in a 100-meter stretch of stream using a dip net. Organisms collected are brought back to the laboratory for identification. The

SCI assigns points to seven biological metrics to rate a site as excellent, good, poor, or severely degraded. The scoring system is the calibrated to be regionally specific for three bioregions in Florida, the panhandle, peninsula, and northeast.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.dep.state.fl.us/water/bioassess/flupdate.htm

Florida BioRecon
Benthic Macroinvertebrates

Responsible Agency / Park:
Florida Department of Environmental Protection

Relevant Parks:
TIMU, FOCA, FOMA, CANA

Period of Record:
1998 – Present (ongoing)

Description:
BioRecon is the screening tool version of the SCI. Only four dip-net sweeps of the most productive habitats are sampled, and the organisms are sorted in the field and identified in the laboratory. Thresholds specific to this method have been established. If a site exceeds the threshold in two out of the three metrics calculated (a subset of the seven metrics used in the SCI), the site is considered healthy.

Date Last Updated:
Unknown

Catalog Number:
More Information:
http://www.dep.state.fl.us/water/bioassess/flupdate.htm

Georgia Adopt-A-Stream
Benthic Macroinvertebrates

Responsible Agency / Park:
Georgia Department of Natural Resources

Relevant Parks:
KEMO, CHAT, OCMU, FOFR, CUIS, FOPU

Period of Record:
Unknown

Description:
Georgia Adopt-A-Stream (AAS) is housed in the Non-point Source Program in the Water Protection Branch of the Georgia Environmental Protection Division. The program is funded by a Section 319(h) Grant. The goals of Georgia Adopt-A-Stream are to (1) increase public awareness of the State's non-point source pollution and water quality issues, (2) provide citizens with the tools and training to evaluate and protect their local waterways, (3) encourage partnerships between citizens and their local government, and (4) collect quality baseline water quality data.

To accomplish these goals, Georgia Adopt-A-Stream encourages individuals and communities to monitor and/or improve sections of streams, wetlands, lakes or estuaries. Manuals, training, and technical support are provided through Georgia EPD, five Adopt-A-Stream Regional Training Centers and more than 40 established Community/Watershed Adopt-A-Stream organizers. The Adopt-A-Stream and Wetland Regional Training Centers are located at State Universities in Columbus, Milledgeville, Americus, Valdosta and Savannah. These centers play a key role in providing training, technical support and organizational support to citizens throughout Georgia.

There are more than 40 Community/Watershed Programs that organize Adopt-A-Stream groups in their watershed, county or city. These local Adopt-A-Stream programs are funded by counties, cities and nonprofit organizations and use the Georgia Adopt-A-Stream model, manuals and workshops to promote nonpoint source pollution education and data collection in their area. The State office works closely with these programs to ensure that volunteers are receiving appropriate support and training.

The Adopt-A-Stream program offers different levels of involvement. At the most basic level, a new group informs their local government about their activities and creates partnerships with local schools, businesses and government agencies. A watershed survey and 4 visual surveys are conducted within a year's time. Volunteers create a "Who To Call List" so that if something unusual is sighted, the appropriate agencies can be notified. *Getting To Know Your Watershed* and *Visual Stream Survey* manuals provide guidance in these activities.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.riversalive.org/aas.htm

Georgia Department of Natural Resources (GADNR), Environmental Protection Division
Water Quality
Watershed Management Plans
305(d)/303(b) GIS Data

Responsible Agency / Park
GADNR

Relevant Parks:
CHAT, CUIS, FOFR, FOPU, KEMO

Period of Record:
1997-2004

Description:
The Georgia Environmental Protection Division helps provide Georgia's citizens with clean air, clean water, healthy lives and productive land by assuring compliance with environmental laws and by assisting others to do their part for a better environment.

Date Last Updated:
2004

Catalog Number:

More Information:
http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/gaenviro.htm#waterqual

USDI National Park Service
Baseline Water Quality

Responsible Agency / Park
National Park Service

Relevant Parks:
CAHA, CALO, CANA, CASA, CONG, CUIS, FOFR, FOMA, FOPU, FOSU, HOBE, KEMO, MOCR, OCMU, TIMU

Period of Record:
Varies by Park

Description:
A cooperative endeavor initiated in 1993 by the NPS Water Resources Division (WRD) and the Servicewide Inventory and Monitoring Program, the NPS Baseline Water Quality Data Inventory and Analysis Project is an effort designed to characterize baseline water quality at all units of the National Park System containing significant natural resources. The goal of this effort is to provide descriptive water quality information to every national park unit in a format usable for park planning and management.

Specific objectives of the project are to: (1) retrieve water quality and related data from the Environmental Protection Agency's (EPA) STORET and other database systems; (2) develop a complete inventory of all retrieved data; (3) produce descriptive statistics and appropriate box and whiskers and time series plots of the water quality data to characterize annual, seasonal, and period of record central tendencies and trends; (4) compare park water quality data with relevant EPA national water quality criteria on a station by station basis; and (5) reformat the water quality and other related data for use with the park-based Water Quality Data Management System (currently under development in the WRD) and other appropriate analytical tools. Every park unit participating in this project will receive a detailed analog report and several hydrographic digital databases, including: (1) all water quality parameter data; (2) 1:100,000 scale hydrography; (3) surface-water quality monitoring station locations; (4) stream gage locations; (5) National Pollutant Discharge Elimination System permit locations; and (6) drinking water intake locations.

Date Last Updated:
1993

Catalog Number:

More Information:
http://www1.nrintra.nps.gov/wrd/quality/horizon.htm

http://www1.nrintra.nps.gov/wrd/miscfiles/horizon.htm

National Water Quality Assessment Program
Water Chemistry / Quality
Benthic Macroinvertebrates
Stream Habitat
Fish
Algae

Responsible Agency / Park:
U.S. Geological Survey

Relevant Parks:
All SECN Parks except FOPU and MOCR.

Period of Record:
1991 – Present (Ongoing)

Description:
The overall goals of the National Water Quality Assessment (NAWQA) Program are to (1) describe current water-quality conditions for a large part of the Nation's freshwater streams and aquifers, (2) describe how water quality is changing over time, and (3) improve our understanding of the primary natural and human factors affecting the water quality.

Network parks fall into five NAWQA study units:

Mobile River Basin: Among the issues addressed by the Program are nutrient enrichment from human and animal wastes and runoff from residential and commercial development and agricultural lands, which ultimately affects the health of the estuarine environments and fisheries in Mobile Bay and Gulf of Mexico. In addition, the Alabama studies address increased sedimentation and pesticide concentrations from the agricultural, industrial, and urban activities, as well as degradation of the riparian habitats and their subsequent impacts on aquatic life and water quality.

Apalachicola-Chattahoochee-Flint River Basin: Among the issues addressed by the Program are bacteria, nutrients, pesticides, and emerging contaminants in urban streams from wastewater discharges, combined and sanitary sewer overflows, and nonpoint source runoff. In addition, the Georgia studies address effects of agriculture on the quality of ground water and surface water, including effects associated with the high production rates of broilers (chickens), such as elevated phosphorus.

Georgia-Florida Coastal Plain Drainages: Water quality and aquatic life have been degraded by drainage, development, alteration of water flows, contamination from agricultural and urban runoff, and continuing invasions of exotic species. Among the issues addressed by the Program are the accumulation of mercury and other toxic compounds in sediment and fish, elevated nitrate and phosphorus from agricultural and urban lands, and the frequent occurrence of pesticides and volatile organic compounds in the ground water and streams.

Santee River Basin & Coastal Drainages: Among the issues addressed by the Program are bacteria, nutrients, pesticides, volatile organic compounds, and emerging contaminants in ground water and streams throughout the Basin and in and around major urban centers. In addition, the South Carolina studies address effects of agriculture on the quality of ground water and surface water; the presence of radon in major drinking water supply aquifers; accumulation of mercury, PCBs, DDT, and other organochlorine compounds in sediment and fish; and documentation of habitat characteristics and biological community structures.

Albemarle-Pamlico Drainages: Among the issues addressed by the NAWQA Program are increased nutrients and bacteria resulting from increasing confined-animal populations; elevated nutrients and mixtures of pesticides from intensive row-crop production; effects of elevated phosphorus and nitrogen on stream eutrophication; effects of rapid urbanization in Raleigh on concentrations of nutrients, pesticides, volatile organic compounds, trace elements, and aquatic life; and mercury and its resulting accumulation in stream ecosystems.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://water.usgs.gov/nawqa/

http://wwwga.usgs.gov/nawqa/

http://al.water.usgs.gov/pubs/mobl/mobl.html

http://fl.water.usgs.gov/Gafl/gafl.html

http://sc.water.usgs.gov/nawqa/

http://nc.water.usgs.gov/albe/

http://infotrek.er.usgs.gov/servlet/page?_pageid=543&_dad=portal30&_schema=PORTAL30

North Carolina Department of Environment and Natural Resources (NCDENR), Division of Water Quality
305 (b) and 303 (d) Waters
Fish Kills

Responsible Agency / Park
NCDENR

Relevant Parks:
CAHA, CALO, FORA, MOCR, WRBR

Period of Record:
2000-2004

Description:
The North Carolina Division of Water Quality (DWQ) in the NCDENR is the agency responsible for statewide regulatory programs in groundwater and surface water protection. DWQ's mission is to preserve, protect and enhance North Carolina's water and groundwater resources through quality monitoring programs, efficient permitting, responsible management, fair and effective enforcement and excellence in public service. The agency, with central offices in Raleigh and seven regional offices located across the state, issues pollution control permits, monitors permit compliance, evaluates environmental quality and carries out enforcement actions for violations of environmental regulations.

The division, composed of five sections (Water Quality, Groundwater, Construction Grants & Loans, Laboratory, and the Wetlands Restoration Program) administers the policies and rules established by the state's Environmental Management Commission (EMC). These policies and rules are designed to support the division in its resource protection, management and regulatory efforts.

Date Last Updated:
2004

Catalog Number:

More Information:
http://h2o.enr.state.nc.us/tmdl/General_303d.htm#Downloads

http://www.esb.enr.state.nc.us/Fishkill/fishkillmain.htm

North Carolina Stream Bioassessment
Fish Communities
Fish Tissue
Benthic Macroinvertebrates

Responsible Agency / Park:
North Carolina Department of Environment and Natural Resources – Division of Water Quality

Relevant Parks:
MOCR (maybe CALO & OBXG)

Period of Record:
Early 1990s – Present (Ongoing)

Description:
The North Carolina Index of Biological Integrity is used in wadeable streams and incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of all classes of factors influencing aquatic faunal communities such as water quality, energy source, habitat quality, flow regime, and biotic interactions. While any change in a fish community can be caused by many factors, certain aspects of the community are generally more responsive to specific influences. Species composition measurements reflect habitat quality effects. Information on trophic composition reflects the effect of biotic interactions and energy supply. Fish abundance and condition information indicates additional water quality effects. It should be noted, however, that these responses may overlap. For example, a change in fish abundance may be due to decreased energy supply or a decline in habitat quality, not necessarily a change in water quality.

Benthic macroinvertebrates, especially aquatic insects, are associated with the substrates of streams, rivers and lakes. The Biological Assessment Unit uses aquatic macroinvertebrates as one type of indicator of biological integrity in streams and rivers. A large number of sites are sampled each year during basin-wide sampling and special studies, and resulting information is used to document both spatial and temporal changes in water quality, and to complement water chemistry analyses. Although bioassessments are useful for identifying biological impairments, they do not identify the causes of impairment.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.esb.enr.state.nc.us/BAU.html

South Carolina Department of Health and Environmental Control (SCDHEC), Bureau of Water
Water Quality

Responsible Agency / Park
SCDHEC

Relevant Parks:
CONG, FOSU, FOMO, CHPI

Period of Record:
Varies

Description:
The SCDEHC In 1991 the Bureau of Water of the SCDHEC implemented the Watershed Water Quality Management Strategy in order to more efficiently protect and improve the quality of South Carolina's surface water resources. This management strategy recognizes the interdependence of water quality and all the activities that occur in the associated drainage basin. Under the watershed management approach monitoring, assessment, problem identification and prioritization, water quality modeling, planning, permitting and other SCDHEC initiatives are coordinated by basin. A watershed water quality assessment document is produced for each basin.

All water quality data generated by SCDEHC monitoring programs have been uploaded into the EPA STORET database.

Date Last Updated:
2004

Catalog Number:

More Information:
Although no data are available, several publications are available for download:

http://www.scdhec.net/water/shed/home.html

http://www.scdhec.gov/eqc/admin/html/eqcpubs.html#Water

http://www.scdhec.net/water/html/monitoring.html

http://www.scdhec.net/water/html/wpcpage.html

St. John's Water Management District (SJWMD)

Water Quality

Responsible Agency / Park
SJWMD

Relevant Parks:
CANA, CASA, FOCA, FOMA, TIMU

Period of Record:
Varies

Description:
The surface water quality monitoring program of the SJWMD, established in 1983, maintains an ambient surface water quality monitoring network of 72 stations located throughout the District. Fourteen of these stations are a part of the Florida Department of Environmental Protection's (FDEP) Temporal Variability (TV) Network and are sampled twelve times per year. The remaining 58 stations are sampled six times per year. Monitoring of sediments for priority pollutants was added to the program in 1990, followed by benthic (underwater bottom) community sampling in 1999 to enhance understanding of the biological consequences of sediment pollution.

Data generated under the program are uploaded to the U.S. Environmental Protection Agency's (EPA) National Water Quality Data Base (STORET) and used by FDEP for Florida's biennial 305(b) report. The program provides support for modeling efforts involving surface water quality and produces a biennial district-wide assessment of surface water quality status and trends, and sediment, benthic, and other assessments. This program also participates in FDEP's Integrated Water Resources Monitoring (IWRM) Tier 1 Network.

Date Last Updated:
2004

Catalog Number:

More Information:
Although no data are available, several publications are available for download:

http://sjr.state.fl.us/programs/outreach/pubs/techpubs/tpubs1.html#sj20043

http://sjr.state.fl.us/programs/outreach/local_gov/map_atlas/map_atlas.html

http://sjr.state.fl.us/programs/plan_monitor/sw_monitor/overview.html

http://sjr.state.fl.us/programs/data.html

Groundwater Monitoring

Groundwater Level
Water Chemistry
Salinity

Responsible Agency / Park:
U.S. Geological Survey

Relevant Parks:
CONG (13 active wells on site)
FOPU (two active wells on site)

Period of Record:
Unknown

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

US Geological Survey, Ground Water – Climate Response Network
Groundwater Quality

Responsible Agency / Park:
USGS, Ground Water – Climate Response Network

Relevant Parks:
Parks Listed with monitoring wells in the vicinity:

HOBE – Site K107 MTG-3
KEMO, CHAT – Site 11FF04 Doraville
OCMU: 21T001
CAHA/WRBR/FORA: Site NC-195 (Elizabeth City)

Period of Record:
Varied depending on monitoring well.

Description:
The USGS maintains a network of wells to monitor the effects of droughts and other climate variability on ground-water levels. The network consists of a national network of about 150 wells monitored as part of the Ground Water Resources Program, supplemented by wells in some States monitored as part of the Cooperative Water Program.

There are three types of data available from wells measured by the USGS:

Periodic data: which are ground-water levels measured manually at selected intervals, usually with a steel or electric tape. These measurements typically are made from once per week to once per year.

Continuous data: which are ground-water levels measured by an automatic sensing device, recorded by data loggers, and retrieved periodically from the field. The availability of these data may lag current conditions by one to several months because they must be retrieved from the field, processed, and loaded into the database.

Real-time data: which are continuous data that are transmitted from the field to the USGS at least once per day. Barring occasional equipment malfunctions, these data reflect current ground-water conditions at the well.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://groundwaterwatch.usgs.gov/

US Geological Survey – Water Resources Division
Stream Flow
Surface Water Discharge
Surface – Groundwater interactions

Responsible Agency / Park:
U.S. Geological Survey – Water Resources Division

Relevant Parks:
CONG

Period of Record:
Station 02169625: 1987; 1994 – present
Station 02169672: 1981-83; 1986; 1993 - present

Description:
USGS gauging stations 02169660 and 02169672 are within the boundary of Congaree National Park. In addition, USGS – WRD is working to quantify the influence of the Saluda Dam on the frequency and magnitude of flooding at Congaree National Park, relative to surface and groundwater interactions.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Larry Harrelson – lgharrel@usgs.gov

Toby Feaster – tfeaster@usgs.gov

North Carolina Department of Environment and Natural Resources, Division of Water Quality
Water Quality (Surface and Groundwater)

Responsible Agency / Park:
NC Department of Environment and Natural Resources, Division of Water Quality

Relevant Parks:
CAHA, FORA, WRBR, CALO, MOCR

Period of Record:
Variable, depending on dataset

Description:
The North Carolina Division of Water Quality (DWQ) in the Department of Environment and

Natural Resources is the agency responsible for statewide regulatory programs in groundwater and surface water protection. DWQ's mission is to preserve, protect and enhance North Carolina's water and groundwater resources through quality monitoring programs, efficient permitting, responsible management, fair and effective enforcement and excellence in public service. The agency, with central offices in Raleigh and seven regional offices located across the state, issues pollution control permits, monitors permit compliance, evaluates environmental quality and carries out enforcement actions for violations of environmental regulations.

The DWQ offers many surface and ground water quality related publications and datasets. This information includes, but is not limited to: basin-wide assessments of water quality, state 303d and 305b reports, Basin-wide Information Management System (BIMS) that tracks point-source discharge, non-point source pollution, state geology maps, groundwater recharge maps, rainfall data etc.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Home: http://h2o.enr.state.nc.us/#DOCSRULES

Download:
http://h2o.enr.state.nc.us/wqs/index.html#DOCUMENTS

Groundwater:
http://www.ncwater.org/Data_and_Modeling/Ground_Water_Databases/

Benthic Macroinvertebrates:
http://www.esb.enr.state.nc.us/BAUwww/benthicbasins.htm

SC Department of Health and Environmental Control (SCDHEC)

Water Quality

Responsible Agency / Park:
South Carolina Department of Health & Environmental Control

Relevant Parks:
CONG

Period of Record:
Description:
One (maybe two) permanent monitoring sites on the Park.

Date Last Updated:
Unknown

Catalog Number:

More Information:

University of North Carolina Aquatic Ecology Research Projects

Water Quality
Non-point Source Pollutants
Phytoplankton
Benthic Macroinvertebrates
Marine Water Quality
Tides
Storm Water Management
Pfiesteria

Responsible Agency / Park:
University of North Carolina

Relevant Parks:
CAHA, WRBR, FORA, CALO, MOCR

Period of Record:
Variable depending on the data set.

Description:
This website has links to ten UNC research projects. To follow is a brief description of each project.

The Lower Cape Fear River Program: Since 1995 data have been collected regularly on numerous physical, chemical and biological parameters at 35 locations. The data are sent to the North Carolina Division of Water Quality and entered into the EPA STORET national water quality database. Comprehensive reports are issued to interested parties annually. Current and recent research projects in this watershed include analysis of animal waste lagoon spills, effects of hurricanes and storms on water quality, factors controlling phytoplankton production in the estuary and tributary rivers, factors contributing to BOD loads in the Cape Fear watershed, and the effect of nutrient loading on the biota and metabolism of blackwater streams. In conjunction with the water quality sampling, benthos is analyzed by the UNCW Benthic Ecology Lab and

finfish research is carried out by UNCW researcher Dr. Tom Lankford.

The Coastal Ocean Research and Monitoring Project: In January 2000, several researchers from UNCW began a broad scale analysis of the coastal ocean adjacent to southeastern North Carolina, the South Atlantic Bight. The South Atlantic Bight supports a variety of important resources and uses including hydrocarbons, hard minerals, fisheries, protected species, recreation, navigation and cultural resources. Two major areas in the South Atlantic Bight will be studied including Onslow Bay and the Cape Fear River Plume.

The New Hanover County Tidal Creeks Project: Since 1993 research has been conducted on bacterial pollution, algal blooms, effect of tides on water quality parameters, nutrient limitation of phytoplankton productivity, and nutrient loading in five tidal creeks in New Hanover County, with annual reports regularly published. A major accomplishment of this project has been publication of a set of management recommendations for environmentally-sound coastal development practices.

City of Wilmington Watersheds Project: In autumn 1997 a project assessing water quality in each of the City of Wilmington's watersheds was initiated. This includes collecting baseline data on pollutants such as nutrients, fecal coliform bacteria, turbidity, and other parameters, analyzing effectiveness of large stormwater detention ponds, runoff from golf courses, and effect of loadings on adjacent waterways. Current efforts also include detection of illicit sewer discharges to the stormwater system, and a comprehensive study of nutrients, BOD and algal blooms in Greenfield Lake.

Carolina Beach Stormwater Project: In May 2003 the UNCW Aquatic Ecology Laboratory began assessing the water quality of the lake and the network of major surface runoff ditches in the town. Pollutants being examined are biochemical oxygen demand (BOD), fecal coliform bacteria, nutrients, chlorophyll a, turbidity, conductivity/salinity, and dissolved oxygen. The UNCW Benthic Ecology Laboratory is also collaborating by assessing the fish community in Carolina Beach Lake.

Bald Head Creek Environmental Analysis: The Village of Bald Head has applied for a permit to dredge the mouth of Bald Head Creek in order to improve shellfishing water quality. The Aquatic Ecology Laboratory has initiated a program to collect pre-dredging and post-dredging water quality data to analyze the success of this estuarine manipulation project. Data being collected include fecal coliform bacteria, nitrate, phosphate, ammonium, chlorophyll a, total suspended solids, turbidity, dissolved oxygen, temperature, and salinity. Physical parameters are collected both on site during water sample collection and on a high-frequency basis through diel studies with in-situ instruments. Because Bald Head Creek has a low level of human development surrounding it, the project location makes an excellent contrast to the highly developed tidal creeks being studied under the New Hanover Tidal Creeks Project.

Ecology of the New River Estuary: This is an ongoing research project studying water quality, algal bloom formation, and nutrient limitation in the New River Estuary, North Carolina. Published are results of the damage caused by a major swine waste spill to the New River and its estuary, also results of nutrient limitation experiments in the estuary.

Field Conditions for *Pfiesteria* growth: This is a coordinated effort with the North Carolina State University Center for Applied Aquatic Ecology to characterize field conditions supporting the growth of the toxic dinoflagellate *Pfiesteria piscicida* in the New River Estuary, the New Hanover County Tidal Creeks system, and the Cape Fear River Estuary.

Assessing the Relationship Between Phosphorus and Fecal Microbes in Blackwater Stream Sediments: In collaboration with Dr. Larry Cahoon of the UNCW Biological Sciences Department, a study of the sediments of blackwater streams in the Cape Fear River basin is being conducted. In this project, the primary goal is to assess the ability of these stream sediments to serve as a reserve and potential incubator for fecal pathogen indicator organisms, particularly in terms of sediment nutrient content. These streams receive nutrient loading and potentially fecal pathogens from concentrated animal feeding operations (CAFOs), yet are utilized for recreation by the public.

Assessment of Coastal Water Resources and Watershed Conditions in Southeast Atlantic Coast National Parks: In a collaborative effort with Dr. Merryl Alber of the University of Georgia, assessment of the coastal and freshwater resources of Cape Hatteras, Cape Lookout, and Cumberland

Island National Seashores has been initiated. Present and future water quality, as well as the potential impacts of human infrastructure both within and outside of the Parks will be analyzed, with recommendations made for management.

Date Last Updated:
Variable depending on the program / data set.

Catalog Number:

More Information:
http://www.uncw.edu/cmsr/aquaticecology/Laboratory/research.htm

University of North Carolina at Wilmington (UNCW), Center for Marine Science
Water Quality
Benthic Macroinvertebrates

Responsible Agency / Park
UNCW

Relevant Parks:
MOCR

Period of Record:

Description:
The UNCW Center for Marine Science is dedicated to providing an environment that fosters a multidisciplinary approach to questions in basic marine research. The mission of the center is to promote basic and applied research in the fields of oceanography, coastal and wetland studies, marine biomedical and environmental physiology, and marine biotechnology and aquaculture. Faculty members conduct marine science research in the departments of biological sciences, chemistry and earth sciences participate in this program. The center fosters research programs of the highest quality and thereby enhances the educational experience provided by The University of North Carolina at Wilmington for both undergraduate and graduate students in marine science

Since 1995 the UNCW Marine Science Center's laboratory has regularly collected data on numerous physical, chemical and biological parameters at 35 locations throughout the Cape Fear River watershed (Lower Cape Fear River Program). Data are sent to the North Carolina Division of Water Quality where they are entered into the EPA STORET national water quality database. Comprehensive reports are issued to interested parties annually. Current and recent research projects in this watershed include analysis of animal waste lagoon spills, effects of hurricanes and storms on water quality, factors controlling phytoplankton production in the estuary and tributary rivers, factors contributing to BOD loads in the Cape Fear watershed, and the effect of nutrient loading on the biota and metabolism of blackwater streams. In conjunction with the water quality sampling, benthos is analyzed by the UNCW Benthic Ecology Lab and finfish research is carried out by UNCW researcher Dr. Tom Lankford.

As part of the Cape Fear River Program, the UNCW Benthic Ecology Lab examines trophic dynamics and anthropogenic impacts in the Cape Fear River. Specifically, we examine seasonal benthic infaunal composition and abundance at several subtidal stations along the lower Cape Fear River and in the lower Northeast Cape Fear.

Additionally, samples of epibenthic organisms, such as juvenile fish, mysid shrimp, and crabs are collected using epibenthic sled tows. This data allows for examination of timing and magnitude of recruitment events, and establishment of baselines to understand causality of changes in the river. Recently this data has been useful in determining the impact of large scale events such as hurricanes and chronic problems such as pollution inputs. Results to date indicate the benthic communities in the Cape Fear River estuary have high resistance and resilience to disturbance. However, there are some sites that indicate lose of species richness over the last four years. While this trend may be due in part to repeated natural disturbance events it is an area we will watch closely to see if the trend continues. The data collected for this project has been made available to concerned industries, as well as state agencies, to assist in improving resource management practices. This project expands our understanding of trophic linkages and controls within the estuary.

Water quality data are available for STORET. Benthic macroinvertebrate data are not available, however, contacts and a publication list are.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.uncwil.edu/cmsr/aquaticecology/Laboratory/research.htm

http://www.uncwil.edu/cmsr/benthic/

US Environmental Protection Agency – Environmental Monitoring and Assessment Program (EMAP)
Benthic Invertebrates
Demersal Trawl
Sediment
Water Quality

Responsible Agency / Park
EPA – EMAP

Relevant Parks:
All SECN Parks

Period of Record:
1984-Present

Description:
EMAP is a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources.

EMAP aims to advance the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate multi-agency monitoring through large regional projects. EMAP develops indicators to monitor the condition of ecological resources. EMAP also investigates designs that address the acquisition, aggregation, and analysis of multiscale and multitier data.

Date Last Updated:
2001

Catalog Number:

More Information:
http://www.epa.gov/emap/index.html

http://www.epa.gov/emap/html/status.html

US Environmental Protection Agency, STORET
Water Quality

Responsible Agency / Park
EPA

Relevant Parks:
All SECN Parks

Period of Record:
Varies-Present

Description:
The U.S. Environmental Protection Agency (EPA) maintains two data management systems containing water quality information for the nation's waters: the Legacy Data Center (LDC), and STORET. The LDC is a static, archived database and STORET is an operational system actively being populated with water quality data.

STORET (short for STOrage and RETrieval) is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others.

The LDC contains historical water quality data dating back to the early part of the 20th century and collected up to the end of 1998. STORET contains data collected beginning in 1999, along with older data that has been properly documented and migrated from the LDC. Both systems contain raw biological, chemical, and physical data on surface and ground water collected by federal, state and local agencies, Indian Tribes, volunteer groups, academics, and others. All 50 States, territories, and jurisdictions of the U.S. are represented in these systems.

Each sampling result in the LDC and in STORET is accompanied by information on where the sample was taken (latitude, longitude, state, county, Hydrologic Unit Code and a brief site identification), when the sample was gathered, the medium sampled (e.g., water, sediment, fish tissue), and the name of the organization that sponsored the monitoring. In addition, STORET contains information on why the data were gathered; sampling and analytical methods used; the laboratory used to analyze the samples; the quality control checks used when sampling, handling the samples, and analyzing the data; and the personnel responsible for the data. The main database concepts of STORET follow the business of water quality monitoring.

Date Last Updated:
2004

Catalog Number:

More Information:
http://www.epa.gov/STORET/dbtop.html

US Geological Survey – Water Resources Division
Water Quality

Responsible Agency / Park
USGS

Relevant Parks:
All SECN Parks

Period of Record:
Varies-Present

Description:
The USGS collects and analyzes chemical, physical, and biological properties of water, sediment and tissue samples from across the Nation. The NWISWeb discrete sample data base is a compilation of over 4.2 million historical water quality analyses in the USGS district data bases through September 2003. The discrete sample data is a large and complex set of data that has been collected by a variety of projects ranging from national programs to studies in small watersheds. Users should review the help notes and particularly the Data retrieval precautions before beginning any retrieval or analysis of data from this data set. Additions of more current data, modifications to ancillary information, and enhanced retrieval options to help users find and appropriately use the data they need are planned for a future release of NWISWeb.

At selected surface-water and ground-water sites, the USGS maintains instruments that continuously record physical and chemical characteristics of the water including pH, specific conductance, temperature, dissolved oxygen, and percent dissolved-oxygen saturation. Supporting data such as air temperature and barometric pressure are also available at some sites. At sites where this information is transmitted automatically, data are available from the real-time data system.

Date Last Updated:
2004

Catalog Number:

More Information:
http://waterdata.usgs.gov/nwis/qw

Drinking Water Monitoring - CUIS
Drinking Water Quality

Responsible Agency / Park

Relevant Parks:
CUIS

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

National Coastal Assessment Program
Water Quality

Responsible Agency / Park
US Environmental Protection Agency

Relevant Parks:
SECN Coastal Parks

Period of Record:

Description:
Formerly known as the National Environmental Monitoring and Assessment Program (EMAP), the National Coastal Assessment Program was created in 1988 by the U.S. EPA in cooperation with other federal agencies to provide basic answers relating to environmental problems impacting the Nations ecological resources. Similar to the freshwater EMAP sampling protocol, Coastal EMAP applies a similar probability-based study design on regional scales to address many coastal resource related issues.

The objectives of this project are to estimate geographic extent of the nations ecological resources, to estimate current status, trends, and changes in the environmental condition of those resources, to seek association between natural and anthropogenic stresses and the condition of ecological resources and to provide annual statistical summaries and periodic assessments of the Nations ecological resources

The National Coastal Assessment (NCA) Program is designed to be a five-year effort of data collection and compilation to be done in July and August. The NCA Program sampling design focuses on characterizing broad spatial differences in selected indicators. Environmental indicators are selected based on 1) their responsiveness to environmental problems (such as pollution or nutrient enrichment, 2) the ease of measurability, and 3) how representative they are of the area being sampled.

Date Last Updated:

Catalog Number:

More Information:

Beach Water Quality Monitoring - CUIS

Beach Water Quality

Responsible Agency / Park

US Environmental Protection Agency
GA Department of Natural Resources

Relevant Parks:

CUIS

Period of Record:

Description:

Each year tens of millions of people are drawn to the beaches to enjoy the beauty and the recreational activities they provide. Unfortunately, water pollution continues to degrade the quality and health of many of our nation's ocean, bay and Great Lakes beaches. The public's concern regarding the safety of swimming at their local beaches has led many to limit or even stop their use of certain beaches. Until sources of beach water pollution can be eliminated, monitoring is the best way to protect swimmers and surfers from polluted water.

The Beach Water Quality pages of Earth 911 deliver up-to-date, community-specific water quality information that enables the public to make informed decisions about the relative safety of swimming at their local beaches. The initial pilot project was intended to partially fulfill the EPA's mission of protecting human health, reducing risks associated with pollutants, and maintaining beneficial uses of water bodies by providing public access to shoreline bacteriology information collected at beaches by a variety of public agencies.

Date Last Updated:

Catalog Number:

More Information:

http://georgia.earth911.org/usa/WaterQuality/default.asp?cluster=2

Duval County, Environmental Resource Management, Environmental Quality Division

Water Quality
Stormwater Management
Wastewater Permitting and Management

Responsible Agency / Park:

Duval County, FL - Duval County, Environmental Resource Management, Environmental Quality Division

Relevant Parks:

TIMU, FOCA, FOMA, CASA

Period of Record:

Variable, depending on topic

Description:

The Ambient Water Quality Section (AWQS) is the lead environmental agency collecting surface water quality data in Duval County. As such AWQS closely coordinates all of its monitoring activities with other agencies working in the area. All of the data collected by AWQS are regularly provided to state, regional and local agencies charged with permitting activities that may impact surface water quality. This information is available to the public upon request. The AWQS is also the lead agency responding to citizen complaints or fish kills for surface waters of the state in Duval County.

Date Last Updated:

Unknown

Catalog Number:

More Information:

http://www.coj.net/Departments/Environmental+Resource+Management/Environmental+Quality/Water+Quality.htm

Air Quality

Ozone Monitoring

PM_{10} Monitoring (Particles less 10 microns)

Responsible Agency / Park:
South Carolina Department of Health & Environmental Control (SCDHEC) / CONG

[Others Unknown]

Relevant Parks:
Congaree NP and Fort Sumter NM have ozone monitors on-site, the rest of the Southeast Coast Network parks have one or more ozone monitors within 35 miles.

Period of Record:
CONG: 23 years of air quality data

FOSU:

[Unknown]

Description:
Chattahoochee River NRA, Congaree NP, Kennesaw Mountain NBP, and Ocmulgee NM are in areas that will likely be designated non-attainment under EPA's new human-health based 8-hour NAAQS.

Date Last Updated:
Unknown

Catalog Number:

More Information:

North Carolina Department of Environment and Natural Resources, Division of Air Quality

Air Quality
Emissions
Air Pollution

Responsible Agency / Park:
North Carolina Department of Environment and Natural Resources, Division of Air Quality

Relevant Parks:
CAHA, FORA, WRBR, CALO, MOCR

Period of Record:
Variable, depending on dataset

Description:
The Division of Air Quality (DAQ) is responsible for protecting and improving outdoor, or ambient, air quality in North Carolina. To carry out this mission, the DAQ has programs for monitoring air quality, permitting and inspecting air emissions sources, and educating and informing the public about air quality issues. The DAQ, which is part of the N.C. Department of Environment and Natural Resources (DENR), also enforces state and federal air pollution regulations. The DAQ does not make these rules. In North Carolina, the General Assembly enacts state air pollution laws, and the Environmental Management Commission adopts most regulations dealing with air quality. In addition, the U.S. Environmental Protection Agency (EPA) has designated the DAQ as the lead agency for enforcing federal laws and regulations dealing with air pollution in North Carolina.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://daq.state.nc.us/monitor/data/

Particulates Monitoring

PM_{10} Monitoring (Particles less 10 microns)

Responsible Agency / Park:
[Unknown]

Relevant Parks:
FOSU – Monitoring station on site.
Other SECN parks – Station within 35 miles.

Period of Record:
[Unknown]

Description:
Small or "fine" particles in the air, typically those less than 2.5 micrometers in diameter, $PM_{2.5}$, are a leading cause of human respiratory illness. Particles are present everywhere, but high concentrations and/or specific types have been found to present a serious danger to human health. Fine particles in the air are the main contributor to human-caused visibility impairment. The particles not only decrease the distance one can see; they also reduce the colors and clarity of scenic vistas. Moisture in the air enhances the impact, so areas in the Eastern U.S., with higher relative humidity, have worse visibility than areas in the arid West (see attached Air Inventory map). In 1997, EPA finalized new stricter, human-health based, National Ambient Air Quality Standards (NAAQS) for particulate matter. Original NAAQS for particulate matter were for those

particles 10 microns or less (PM10). The new national standards now regulate PM2.5.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Georgia Air Pollution Monitoring

Ambient Monitoring Program

Responsible Agency / Park:
Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch

Relevant Parks:
CHAT, KEMO, OCMU, FOPU, FOFR, CUIS

Period of Record:
Ongoing since at least 1998

Description:
The Ambient Monitoring Program (AMP) measures levels of air pollutants throughout Georgia. The data are used to determine compliance with air standards established for five compounds and to evaluate the need for any special controls for various other pollutants. Pollutants monitored are ozone (O3), sulfur dioxide (SO2), carbon monoxide, (CO), nitrogen dioxide (NO2), and particulate matter (PM10 and PM2.5). Further, all these data are used to calculate the Air Quality Index (AQI) - a simple measure of a region's air quality.

Date Last Updated:
Daily monitoring

Catalog Number:

More Information:
http://www.air.dnr.state.ga.us/amp/index.html

Air Quality, Particulates, and Ozone Monitoring

Air Quality
Particulates
Ozone
Greenhouse Gases

Responsible Agency / Park:
National Oceanic and Atmospheric Administration (NOAA) Air Quality

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing; date of initiation unknown

Description:
NOAA has numerous air quality monitoring links for various large-scale air quality parameters including ozone forecasts, wildfire smoke forecasts, aerosols, greenhouse gases, halocarbons, and atmospheric trace species. Also on the site is a source/receptor concentration matrix, which computes the transport and dispersion from all pollutant sources to compute the contribution of each source to a specific receptor (sampling location).

Date Last Updated:
June 10th, 2004

Catalog Number:

More Information:
http://www.noaa.gov/airquality.html

Georgia Air Quality

Air Quality

Ozone

Emissions

Responsible Agency / Park:
Georgia DNR, Environmental Protection Division

Relevant Parks:
CHAT, KEMO, OCMU, FOPU, FOFR, CUIS

Period of Record:
Ongoing

Description:
Georgia DNR, Environmental Protection Division has links to several air quality programs and data for the state of Georgia. The following programs can be found on the website:

Georgia's Clean Air Force: In Georgia, mobile sources, like cars and light trucks, are one of the top contributors to our ozone problem. Metro Atlanta's emission testing program is the result of the Federal Clean Air Act, which was enacted by the U.S. Congress and supported by the Georgia General Assembly. The goal of the program is simple: identify the vehicles that are the heavy polluters, and have them fixed.

Clean Air Campaign: The Clean Air Campaign is a not-for-profit organization that works to reduce traffic congestion and improve air quality through a variety of voluntary programs and services, including free employer assistance, public information and children's education. Formed in 1996 by government, business, civic, health, environmental and educational organizations, The Clean Air Campaign serves as a clearinghouse for a multitude of organizations that have programs in place to address traffic congestion and air pollution.

Georgia and Atlanta Air Quality Data: The Ambient Monitoring Program measures levels of air pollutants throughout the State. The data are used to determine compliance with air standards established for five compounds and to evaluate the need for any special controls for various other pollutants. Recent measurements are available.

Greenhouse Gas Emissions Program and the Final Report on Georgia's Greenhouse Gas Emissions Inventory: The Air Protection Branch completed a project to inventory the 1990 and 1996 greenhouse gas emissions to determine the total quantity and sources of greenhouse gas emissions. These sources include: fossil and biomass fuels, industrial emissions, landfills, forest management and land use changes, natural gas and oil systems, coal mining, domestic livestock, manure management, and fertilizer use. [Revised Jan 1999]

Date Last Updated:
June 14th, 2004

Catalog Number:

More Information:
http://www.dnr.state.ga.us/dnr/environ/

South Carolina Air Quality
Ozone
Emissions
Air Quality
Dispersion modeling

Responsible Agency / Park:
South Carolina Department of Health and Environmental Control / Bureau of Air Quality

Relevant Parks:
CONG, FOSU, CHPI

Period of Record:
Ongoing

Description:
This agency website provides links to and information about a variety of South Carolina air quality monitoring programs. Ozone forecasts, air quality data and dispersion modeling, and South Carolina emissions inventory data are available here, as well as various other types of information, such as educational programs, public notices, publications, and technical management documents.

Date Last Updated:
July 23rd, 2004

Catalog Number:
More Information:
http://www.scdhec.net/baq/

Air Quality Photopoint Monitoring - FOPU
Air Quality
Viewshed

Responsible Agency / Park:
National Park Service - FOPU

Relevant Parks:
FOPU

Period of Record:
Ongoing

Description:
FOPU takes photographs at seven photopoint locations, twice per year, to capture changes in air quality conditions, over time.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Duval County, Environmental Resource Management, Environmental Quality Division
Air Quality
Emissions Monitoring

Responsible Agency / Park:
Duval County, FL - Duval County, Environmental Resource Management, Environmental Quality Division

Relevant Parks:
TIMU, FOCA, FOMA, CASA

Period of Record:
Variable, depending on topic

Description:
Concentrations of carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, lead and particulate matter in the outdoor atmosphere are measured and recorded in accordance with Federal and State regulations. Data are available to the citizens of Jacksonville and to consultants for use in air pollution dispersion modeling.

The amount of each pollutant emitted by various air pollution sources in Duval County is maintained by the AQB. Most of this data is compiled from Annual Operating Reports which major industrial sources are required to submit to AQB annually. Other inventory data from small and mobile air pollution sources is compiled collectively. This data is available for use by the general public, news media and industrial sources.

AQB compiles air toxic emissions information from facilities in Duval County and can assess relative risk at surrounding locations. Toxic Release Inventory (TRI) data is available to the public, private industry and the media. Also, ambient concentrations of air toxics are measured for 38 pollutants at two stationary air toxics monitoring sites and by using a mobile air toxics monitoring laboratory at various locations within the county. Summaries of air toxics monitoring data for the stationary sites and the mobile laboratory are available for review.

Date Last Updated:
Unknown

Catalog Number:
More Information:
http://www.coj.net/Departments/Environmental+Resource+Management/Environmental+Quality/Air+Quality.htm

Climate & Weather

The Drought Monitor

Soil Moisture
Streamflow
Drought Conditions

Responsible Agency / Park:
A partnership between US Department of Agriculture, National Oceanic and Atmospheric Administration, National Weather Service, and University of Nebraska – Lincoln.

Relevant Parks:
All SECN parks

Period of Record:
1999 – present (ongoing)

Description:
Tracking drought blends science and art. No single definition of drought works for all circumstances, so people rely on drought indices to detect and measure droughts. But no single index works under all circumstances, either. That's why we need the Drought Monitor, a synthesis of multiple indices, outlooks and news accounts that represents a consensus of federal and academic scientists. The product will be refined over time as we find ways to make it better reflect the needs of decision-makers and others who use the information. Products include national maps indicating: current drought conditions, historic drought conditions, drought forecasts, streamflow forecasts, soil moisture forecasts, and seasonal drought outlook.

Date Last Updated:
July 29, 2004

Catalog Number:

More Information:
http://drought.unl.edu/dm/monitor.html

NOAA - Large-Scale Climate Monitoring

Temperature
Precipitation

Responsible Agency / Park:
National Oceanic and Atmospheric Administration (NOAA) Climate Data Center

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
NOAA's Climate Data Center provides information on national scale archived and current weather and climate data.

Date Last Updated:
Variable depending on the data set.

Catalog Number:

More Information:
http://www.noaa.gov/climate.html

http://www.ncdc.noaa.gov/oa/climate/uscrn/

NOAA – US Climate Reference Network

Air Temperature
Precipitation
Solar Radiation
Wind Speed
Surface Temperatures
Relative Humidity

Responsible Agency / Park:
National Oceanic and Atmospheric Administration (NOAA)

Relevant Parks:
CUIS will have a station

Period of Record:

Description:
The U.S. Climate Reference Network (USCRN) is a network of climate stations now being developed as part of a National Oceanic and Atmospheric Administration (NOAA) initiative. Its primary goal is to provide future long-term homogeneous observations of temperature and precipitation that can be coupled to long-term historical observations for the detection and attribution of present and future climate change. Data from the USCRN will be used in operational climate monitoring activities and for placing current climate anomalies into an historical perspective. The USCRN will also provide the United States with a reference network that meets the requirements of the Global Climate Observing System (GCOS). If fully implemented, the network will consist of about 110 stations nationwide. Implementation of the USCRN is contingent on the availability of funding.

Date Last Updated:
Variable depending on the data set.

Catalog Number:

More Information:
http://www.ncdc.noaa.gov/oa/climate/uscrn/

Regional Drought Watch
Drought Conditions
Soil Moisture
Precipitation

Responsible Agency / Park:
National Oceanic and Atmospheric Administration (NOAA) Climate Data Center - U.S. Regional Drought Watch

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
NOAA's U.S. Regional Drought Watch has information on precipitation and drought summaries for regional and state areas. Links to the Climate Prediction Center's weekly soil moisture and weekly drought monitoring are provided on the website.

Date Last Updated:
May 2004

Catalog Number:

More Information:
http://www.ncdc.noaa.gov/oa/climate/research/2004/may/drought-regional-overview.html

National Weather Service
National Weather Monitoring

Responsible Agency / Park:
National Oceanic and Atmospheric Administration (NOAA)

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
The National Weather Service is the primary source of weather data, forecasts and warnings for the United States. Television weathercasters and private meteorology companies prepare their forecasts using this information. The NWS is the sole United States official voice for issuing warnings during life-threatening weather situations. Past weather information is also available.

Date Last Updated:
Data are collected in real-time and updated on the operational server throughout the day.

Catalog Number:

More Information:
http://www.noaa.gov/wx.html

National Atmospheric Deposition Program
Precipitation Monitoring
Acid Rain

Responsible Agency / Park:
U.S. Geological Survey (USGS)

Relevant Parks:
All SECN Parks

Period of Record:
1978- Present (ongoing)

Description:
The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups, including the State Agricultural Experiment Stations, U.S. Geological Survey, U.S. Department of Agriculture, and numerous other governmental and private entities. The NADP/NTN has grown from 22 stations at the end of 1978 (the first year), to more than 200 sites spanning the continental United States, Alaska, and Puerto Rico, and the Virgin Islands. The purpose of the network is to collect data on the chemistry of precipitation for monitoring of geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium).

NADP data products include:

- Weekly and daily precipitation chemistry data
- Monthly, seasonal, and annual precipitation-weighted mean concentrations
- Annual and seasonal wet deposition totals

- Mercury deposition data
- Daily precipitation totals
- Color isopleth maps of precipitation concentrations and wet deposition
- Site photos, maps, and information
- Quality Assurance data and information

Date Last Updated:
Unknown; There is a five to six month lag time between data collection and data posting on the website.

Catalog Number:

More Information:
http://bqs.usgs.gov/acidrain/

Ecological Systems and Processes

NatureServe – Ecological Systems of the United States

Ecological Classification Systems

Responsible Agency / Park:
NatureServe

Relevant Parks:
All SECN parks

Period of Record:

Description:
Conservationists and land managers seeking to take a multi-faceted approach to ecosystem management benefit from consistent ways to characterize the landscape. These data represent the first version of a new mid-scale ecological classification developed by NatureServe for use in conservation and environmental planning. Ecological Systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. These data sets describe nearly 600 upland and wetland ecological system types found in the lower 48 United States, southern Alaska, and adjacent portions of Mexico and Canada.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.natureserve.org/getData/ecologyData.jsp#US

USDA Forest Service Center for Forested Wetlands Research

Forested Wetlands
Forest Management
Riparian Zones
Soil Science

Responsible Agency / Park
Forest Service

Relevant Parks:
CHAT, CONG, HOBE

Period of Record:
Ongoing

Description:
The Center for Forested Wetlands Research is an interdisciplinary unit whose program is designed to: "To develop, quantify, and synthesize ecological information needed to sustainably manage and restore the structure, function, and productivity of wetland-dominated forested landscapes."

The Center's mission is conducted under the basic tenets of forest sustainability, and is intended to provide the data and tools necessary for managing forested wetland landscapes to sustain ecosystem functions, goods, and services for future generations. The relevance of the research is regional, national, and international, although it is derived primarily from work in the Atlantic Coastal Plain of the southeastern United States

Date Last Updated:
2004

Catalog Number:

More Information:
No data are available, but website has links to various publications.

http://www.srs.fs.usda.gov/charleston/

Fire Effects Monitoring

Responsible Agency / Park:

Relevant Parks:

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Fire Effects Information System

Fire Effects on Species Data

Responsible Agency / Park:
USDA, Forest Service

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
FEIS provides up-to-date information about fire effects on plants and animals. It was developed at the United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory in Missoula, Montana.

The FEIS database contains literature reviews, taken from current English-language literature of almost 900 plant species, about 100 animal species, and 16 Kuchler plant communities found on the North American continent. The emphasis of each review is fire and how it affects each species. Background information on taxonomy, distribution, basic biology, and ecology of each species is also included. Reviews are thoroughly documented, and each contains a complete bibliography. Managers from several land management agencies (United States Department of Agriculture, Forest Service and United States Department of Interior, Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, and National Park Service) identified the species to be included in the database. Those agencies funded the original work and continue to support maintenance and updating of the database.

Date Last Updated:

Catalog Number:

More Information:
http://www.fs.fed.us/database/feis/index.html

Land Use and Landcover Change - CONG
Land Use

Landcover

Responsible Agency / Park:
University of South Carolina

Relevant Parks:
CONG

Period of Record:

Description:
To examine changes in land use through existing imagery and GIS products and provide a historical progression of landscape change over time.

Date Last Updated:

Catalog Number:

More Information:
Dr. William Graf: grafw@gwm.sc.edu

Pest Species

Bibb County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Bibb County, GA

Relevant Parks:
OCMU

Period of Record:
Not Listed

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.co.bibb.ga.us/

Brevard County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Environmental Monitoring

Responsible Agency / Park:
Brevard County, FL

Relevant Parks:
CANA

Period of Record:
Not Listed

Description:
Brevard County provides an integrated mosquito control program that provides: adulticiding, larviciding, source reduction, disease monitoring, environmental monitoring, and biological control of mosquitoes.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.brevardcounty.us/mosquito/index.cfm

Camden County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Camden County, GA

Relevant Parks:
CUIS, FOFR

Period of Record:
Not Listed

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

Carteret County Animal and Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Carteret County, NC – Carteret County Animal and Mosquito Control

Relevant Parks:
CALO

Period of Record:
Not Listed

Description:
Mosquito control activities include surveillance, application of larvacide in known breeding grounds, and regularly scheduled spraying targeted at adult mosquitoes.

Date Last Updated:
Unknown

Catalog Number:
More Information:
http://www.co.carteret.nc.us/departments/animal.htm

Charleston County Public Works:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Charleston County, SC

Relevant Parks:
FOSU, FOMO, CHPI

Period of Record:
Not Listed

Description:
Charleston County manages the mosquito population through inspection, treatment, site cleanup and public awareness

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.charlestoncounty.org/index2.asp?p=/departments/PublicWorks/D-PublicWorks.htm#This%20Department%20Does

Chatham County Mosquito Control:
Mosquito Trapping
West Nile Virus
Eastern Equine Encephalitis

Responsible Agency / Park:
Chatham County, GA – Chatham County Mosquito Control

Relevant Parks:
FOPU

Period of Record:
Post 1957

Description:
The Chatham County Mosquito Control staff locates and monitors mosquito-breeding sites for immature mosquitoes. Light traps, reports from residents, and human landing rates are used to monitor adult mosquito populations. A sentinel chicken flock is used to detect the presence of the mosquito-borne diseases, Eastern Equine Encephalitis and West Nile Fever. This agency is also responsible for mosquito control in the form of physical, biological, and chemical control.

Species lists and light trap data are available.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.chathamcounty.org/department_about_us_T8_R19.html

Dr. Henry B. Lewandowski, Director
65 Short Street Savannah, GA 31408
Phone: (912) 790-2540
Fax: (912) 790-2550
hblewand@chathamcounty.org

Cobb County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Cobb County, GA

Relevant Parks:
KEMO

Period of Record:
Not Listed

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

Dare County Public Works, Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Dare County, NC – Dare County Public Works, Mosquito Control

Relevant Parks:
CAHA, FORA, WRBR

Period of Record:
Not Listed

Description:
Dare County Public Works operates a mosquito control program aimed at identifying breeding areas; monitoring mosquito population and conducting larvaciding and adulticiding by the application of low volume concentrate insecticides. The insecticides are generally administered by the use of ULV Machines, or commonly known as mosquito sprayers, through safe and proven methods.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.co.dare.nc.us/Public_Works/index.htm#Mosquito

Duval County Mosquito Control:
Mosquito Trapping
West Nile Virus
Eastern Equine Encephalitis

Responsible Agency / Park:
Duval County, FL – Duval County Mosquito Control

Relevant Parks:
TIMU, FOCA, FOMA, CASA

Period of Record:
Post 1957

Description:
The Mosquito Control Division is part of the Environmental Resource Management Department of the City of Jacksonville. The Division provides county-wide mosquito surveillance and control.

Duval County has a modern mosquito control program that has been active since 1957, the Jacksonville Mosquito Control Division. Today, this unit joins with over 50 other mosquito control districts in Florida to lead the nation in community based mosquito control.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.coj.net/Departments/Environmental+Resource+Management/Mosquito+Control/default.htm

Forsyth County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Forsyth County, GA

Relevant Parks:
CHAT

Period of Record:
Not Listed

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

Fulton County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Fulton County, GA

Relevant Parks:
CHAT

Period of Record:
Not Listed

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

Gwinnett County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Gwinnett County, GA

Relevant Parks:
CHAT

Period of Record:
Not Listed

Description:
Date Last Updated:
Unknown

Catalog Number:

More Information:

Pender County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Pender County, NC

Relevant Parks:
MOCR

Period of Record:
Not Listed

Description:
Pender County attempts to reduce adult mosquito population through preventative larvicide's application and nightly spraying in season.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.pender-county.com/mosquitocntrl.html

Richland County Health Department, Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Richland County, SC

Relevant Parks:
CONG

Period of Record:
Not Listed

Description:
The Richland County Health Department has begun its seasonal mosquito control program. The program conducts surveillance on mosquito populations, treats larval breeding sites and sprays for adult mosquitoes in densely populated areas of the county.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.richlandonline.com/news/2002n/pr040502.htm

Tallapoosa County Mosquito Control:
Mosquito Trapping
Mosquito Spraying

Responsible Agency / Park:
Tallapoosa County, AL

Relevant Parks:
HOBE

Period of Record:
Not Listed

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

Mosquito Monitoring – CONG
Bird-associated virus diversity

Responsible Agency / Park:
CONG
University of South Carolina (Dr. Ivo Foppa)

Relevant Parks:
CONG

Period of Record:
2002-2003

Description:
Focus of the project is to contribute to the understanding of the ecology and epidemiology of mosquito-transmitted bird-associated viruses by surveying mosquitoes and wild birds for evidence of previous or current infection with agents maintained in a bird-mosquito-bird cycle at the park. Preliminary results documented no viruses, including West Nile Virus, Eastern Equine encephalitis, and Saint Louis encephalitis.

Date Last Updated:
May 2003

Catalog Number:

More Information:

Georgia Agricultural Pest Survey
Agricultural Crop Pests
Biological Control Agents

Responsible Agency / Park:
Cooperative effort among the following State and Federal agencies: USDA APHIS PPQ, Georgia Department of Agriculture, The University of Georgia, USDA Forest Service, Georgia Forestry Commission

Relevant Parks:
CHAT, KEMO, OCMU, FOPU, FOFR, CUIS

Period of Record:
Ongoing; date of initiation unknown

Description:
The Cooperative Agricultural Pest Survey (CAPS) is a combined effort by Federal and State agricultural organizations to conduct surveillance, detection, and monitoring of agricultural crop pests and biological control agents. Survey targets include weeds, plant diseases, insects, nematodes, and other invertebrate organisms.

Date Last Updated:
June 1st, 2003

Catalog Number:

More Information:
http://www.gacaps.org/

Pesticide Use Log – National Park Service

Responsible Agency / Park:
National Park Service

Relevant Parks:
All SECN Parks

Period of Record:
Variable by Park

Description:
In 1980 the National Park Service, one of the first agencies to examine and implement an improved IPM control and education program, designated IPM Coordinators in the Washington Office and at each of the Regional Offices. All Coordinators are trained certified pesticide applicators whose basic duties changed dramatically since 1980.

IPM Coordinators:

- Provide technical advice and support such as pest identification, location of information on a pest, treatment options, and on-site assistance to resolve a pest problem.
- Provide new information to park units on pertinent pest issues, new management policies, and new developments in pest management.
- Review and approve proposed pest management actions, including the use of cultural, biological, physical, and chemical control methods.
- Maintain the Pesticide Use Log which tracks the annual use of all pesticides in NPS units.
- Assist park units with meeting the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and state laws. FIFRA regulates the labeling, sale and distribution, storage, transportation, use and application, and the disposal of pesticides.

Date Last Updated:

Catalog Number:

More Information:
http://www.sero.nps.gov/natural/epmt.htm

Exotics – Invertebrate

Florida Department of Agricultural and Consumer Services

Exotic Invertebrates (Pest-Alert)

Responsible Agency / Park
FDACS

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The mission of the Department of Agriculture and Consumer Services (FDACS) is to safeguard the public and support Florida's agricultural economy by: (1) Ensuring the safety and wholesomeness of food and other consumer products through inspection and testing programs; (2) Protecting consumers from unfair and deceptive business practices and providing consumer information; (3) Assisting Florida's farmers and agricultural industries with the production and promotion of agricultural products; and (4) Conserving and protecting the state's agricultural and natural resources by reducing wildfires, promoting environmentally safe agricultural practices, and managing public lands.

Date Last Updated:

Catalog Number:

More Information:
http://www.doacs.state.fl.us/pi/enpp/pi-pest-alert.html

FWC Fish and Wildlife Research Institute

Invasive-Aquatic Invertebrate Species

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1952

Florida Department of Forestry (FDOF)

Southern Pine Beetle

Responsible Agency / Park
FDOF

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
1995-2004

Description:
Since 1995, the FDOF has participated in an annual southwide Southern Pine Beetle (SPB) spring trapping survey. The objective of the survey is to monitor numbers of adult SPBs and their clerid predators (*Thanasimus dubius*) captured in pheromone-baited flight traps during the SPB's primary spring dispersal phase. The results are then used as an early-season prediction of SPB population trends and activity levels, allowing forest managers to identify areas of potential SPB activity in advance of aerial detection flights. The survey also provides data for monitoring SPB population levels from year to year. The survey technique and accompanying prediction model were developed by Dr. Ron Billings at the Texas Forest Service, have been employed throughout the Southeast since 1986, and have

proven to be 75-85% accurate in predicting SPB activity for a given year. Recently, the Florida survey successfully predicted outbreak levels for several counties in 2001 as well as statewide low levels of activity in 2003.

As in previous years, the 2004 Florida survey was conducted using three pheromone traps in each of 27 counties, with each trap located in a different area of susceptible forest type. Traps were deployed and checked weekly through the month of March. The 27 counties surveyed included those that are most likely to experience SPB problems based on historical outbreaks and/or their relative abundance of loblolly pines.

Date Last Updated:
2004

Catalog Number:

More Information:
http://www.fl-dof.com/Conservation/forest_health/SPBindex.html

Gypsy Moth Monitoring – USDA, Forest Service
Gypsy Moth Trapping

Responsible Agency / Park:
US Department of Agriculture, Forest Service, Forest Health Protection

Relevant Parks:
All SECN Parks except CHAT, CAHA, CALO, and CANA

Period of Record:
Variable by park

CONG: 1983-1984; 1987-1995; 1997-1999; 2002-2004

Description:
USDA, Forest Service monitors the spread of gypsy moths throughout the United States. Each year, summary reports are distributed to each unit participating in the gypsy moth monitoring program – including where positive identifications were made. Parks participate in this program by deploying pheromone traps throughout park property.

Date Last Updated:

Catalog Number:

More Information:
http://na.fs.fed.us/wv/gmdigest/online_info/index.html

Exotics – Vertebrate

FWC Fish and Wildlife Research Institute
Invasive-Aquatic Vertebrate Species

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

The FWRI maintains information on exotic fish occurrences, abundance estimates, and observed location.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1952

Exotics/Invasives – Plants

Exotic Pest Plant Council (EPPC)
Exotic/Invasive Plant Species

Responsible Agency / Park
EPPC

Relevant Parks:
All SECN Parks

Period of Record:
1984-Present

Description:
The Exotic Pest Plant Council (EPPC) was founded for the purpose of focusing attention on:(1) The impacts exotic pest plants have on biodiversity, (2) The impact of exotic pest plants on the integrity of native plant community composition and function, (3) Habitat loss due to exotic plant infestations, (4) The impacts of exotic pest plants on endangered species primarily due to habitat loss and alteration, (5) The need to prevent habitat loss and alteration by comprehensive management for exotic pest plants, (6) The socioeconomic impacts of exotic pest plants (e.g. increased wildfire intensity and frequency in *Melaleuca quinquenervia*), (7) Changes in the seriousness of exotic pest plants and to indicate which are the worst problems, and (8) Informing and educating resource managers about which species deserve to be monitored, and to help managers set priorities for management.

Date Last Updated:
2004

Catalog Number:

More Information:
Florida:
http://www.fleppc.org/

Georgia:
http://www.gaeppc.org/

http://www.exoticpestplantcouncil.org/

Florida Department of Environmental Protection
Exotic/Invasive Plant Species

Responsible Agency / Park
FDEP

Relevant Parks:
TIMU, FOCA, CASA, CANA, CUIS, FOFR, FOPU

Period of Record:
Ongoing

Description:
The FDEP is the lead agency in Florida responsible for coordinating and funding two statewide programs controlling invasive aquatic and upland plants on public conservation lands and waterways throughout the state. Florida's aquatic plant management program is one of the oldest invasive-species removal programs, dating back to the late 1800s. With the addition of the upland program, the FDEP oversees the largest invasive plant management program of its kind in the United States. The FDEP also insures that beneficial native aquatic plants are protected through its permitting programs.

The FDEP maintains information regarding exotic/invasive species, effective treatments, and management recommendations.

Date Last Updated:

Catalog Number:

More Information:
http://www.dep.state.fl.us/lands/invaspec/index.htm

NatureServe – Invasive Species, Impact Assessments
Invasive/Exotic Species
Biodiversity

Responsible Agency / Park:
NatureServe

Relevant Parks:
All SECN parks

Period of Record:

Description:
Which non-native species pose the most serious threats to native species and ecosystems? To answer this question, NatureServe, in collaboration with The Nature Conservancy, has developed a protocol for assessing, categorizing, and listing non-native plants according to their impacts on native biodiversity. The protocol is designed to focus specifically on the effects non-native species have on native plants, animals, and natural communities and to make the process of assessing non-native species objective, transparent, and systematic. The protocol is intended to be applied to species as they occur over large areas, such as nations, ecoregions, provinces, or states.

NatureServe has recently begun to use the protocol to assess the approximately 3,500 non-native vascular plants recorded as occurring outside of cultivation in the United States. The downloadable dataset provides the results of using the Invasive Species Protocol Assessment to evaluate non-native plants for their impact on biodiversity in the U.S. This dataset will be periodically updated as additional non-native species are assessed.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.natureserve.org/getData/plantData.jsp

USDA Invasivespecies.gov
Exotic/Invasive Plant Species

Responsible Agency / Park
USDA

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
Invasivespecies.gov is the gateway to Federal efforts concerning invasive species. On this site you can learn about the impacts of invasive species and the Federal government's response, as well as read select species profiles and find links to agencies and organizations dealing with invasive species issues. Invasivespecies.gov is also the Web site for the National Invasive Species Council, which coordinates Federal responses to the problem.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.invasivespecies.gov/

http://www.invasivespecies.gov/council/main.shtml

Exotic Invasive Vegetation Monitoring
Exotic/Invasive Plant Species

Responsible Agency / Park:
National Park Service

Relevant Parks:
FOPU, HOBE, CANA, CASA FOMA, CUIS

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

US Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine
Exotic/Invasive Plant Species

Responsible Agency / Park:
USDA, APHIS, PPQ

Relevant Parks:
All SECN Parks

Period of Record:
Variable

Description:
Over the past 200 years, several thousand foreign plant and animal species have become established in the United States. About one in seven has become invasive, leading to problems that, according to figures provided by Cornell University, cost the United States more than $138 billion each year. An invasive species is an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Invasive plants, animals, and aquatic organisms often reduce the economic productivity and ecological integrity of U.S. agriculture and natural resources. In protecting the United States from harmful invasive species, APHIS is responsible for excluding and managing invasive species that can potentially affect plant and animal health, either directly or indirectly. Through its activities, APHIS protects not only agriculture but also forest, rangeland, and wetland ecosystems. APHIS works closely with USDA's Forest Service and the U.S. Department of the Interior's Bureau of Land Management, National Park Service, and Fish and Wildlife Service. APHIS controls certain types of invasive species and

vertebrate pests that affect native ecosystems, rather than agricultural resources. Certain specific activities focus on protecting and managing endangered species as well as migratory bird populations.

Date Last Updated:

Catalog Number:

More Information:
http://www.aphis.usda.gov/oa/invasive/invasive.html

Forestry

Florida Department of Forestry (FDOF)

Fuel-moisture Monitoring Program
Fire Weather

Responsible Agency / Park
FDOF

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The FDOF, in cooperation with the Nature Conservancy and the National Park Service, Everglades, is collecting Live Fuel Moisture data at eight locations statewide. Fuel moisture is determined from common fuels at each site, totaling 26 species statewide. Photopoint monitoring is also conducted at collection sites to provide a record of visual changes in sampling site over time.

The FDOF also monitors fire weather and provides fire weather forecasts.

Date Last Updated:
2004

Catalog Number:

More Information:
http://flame.fl-dof.com/Env/lfm/

http://flame.fl-dof.com/fire_weather/

Georgia Forestry Commission

Fire Weather

Responsible Agency / Park:
Georgia Forestry Commission

Relevant Parks:
CHAT, KEMO, OCMU, FOPU, FOFR, CUIS

Period of Record:
Ongoing; date of initiation unknown

Description:
This site provides extensive information about fire weather and prescribed burning. Links are available for obtaining burning permits in Georgia, and for 3-, 5-, and 7-day district weather forecasts, as well as 7-day National Fire Danger Ratings by GFC districts.

Date Last Updated:
Fire weather updated twice daily

Catalog Number:

More Information:
http://www.gfc.state.ga.us/

South Carolina Forest Management

Forest Management
Fire Weather
Southern Pine Beetle

Responsible Agency / Park:
South Carolina Forestry Commission

Relevant Parks:
CONG, FOSU, CHPI

Period of Record:
Ongoing

Description:
South Carolina Forestry Commission provides information about a variety of forestry related topics including Environmental Management (Best Management Practices) for conducting forest management activities and monitoring, reporting, and coordinating suppression of endemic pests affecting forest trees in South Carolina. The Insect and Disease section of this agency's website has information and surveys of the state's Southern Pine Beetle infested areas. Information on fire weather and other fire related information can be found here as well.

Date Last Updated:
Fire weather updated twice daily.

Catalog Number:

More Information:
http://www.state.sc.us/forest/fmgt.htm

Forest Inventory and Analysis

National Forest Inventory and Monitoring Databases

Responsible Agency / Park:
U.S. Forest Service

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing; the program has been in operation since the 1930's.

Description:
Forest Inventory and Analysis (FIA) is the Nation's forest census. FIA reports on status and trends in

forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. The enhanced FIA program will include information relating to tree crown condition, lichen community composition, soils, ozone indicator plants, complete vegetative diversity, and coarse woody debris. The program is managed by the Research and Development organization within the USDA Forest Service in cooperation with State and Private Forestry and National Forest Systems. FIA has been in operation under various names (Forest Survey, Forest Inventory and Analysis) for some 70 years. The program covers forests on all forest lands within the US. The program is implemented in cooperation with a variety of partners including State forestry agencies and private landowners who grant access to their lands for data collection purposes.

FIA Databases:

National FIA Database Retrieval System: This program produces tables and maps from the USDA Forest Service's Forest Inventory and Analysis Data Base (FIADB).

Phase 3 Forest Health Data Set Archive: This page includes links to archived data sets associated with the Phase 3 sample plots including attributes such as tree crown and damage data, lichen species diversity, ozone damage, and soil data. Prior to 2000, these attributes were collected as part of the Forest Health Monitoring program; since 2001, they have been collected as part of FIA. Data from both programs are available by year, and include metadata. Data are available in ZIPped archives, in both ASCII and SAS dataset formats.

Timber Output Product (TPO) Database Retrieval System: Developed in Support of the 1997 Resources Planning Act (RPA) Assessment, this system acts as an interface to a standard set of consistently coded TPO data for each State and county in the Country. This national set of TPO data consists of 11 data variables that describe for each county the roundwood products harvested, the logging residues left behind, the timber otherwise removed, and the wood and bark residues generated by its primary wood-using mills.

Date Last Updated:
Variable depending on the data set.

Catalog Number:

More Information:
http://fia.fs.fed.us/

Geologic Resources

Shoreline Erosion Monitoring – CUIS

Responsible Agency / Park:

Relevant Parks:
CUIS

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Shoreline Erosion Monitoring – FOPU

Shoreline Erosion

Responsible Agency / Park:
Skidaway Institute of Oceanography

Relevant Parks:
FOPU

Period of Record:
2004 – Present (ongoing)

Description:
This project is monitoring shoreline erosion of the north shore and Cockspur Lighthouse areas – looking at the effects of the Savannah River shipping channel traffic. This project will collect baseline information and develop a monitoring protocol for the park to continue monitoring after project completion.

Date Last Updated:

Catalog Number:

More Information:

North Carolina Coastal Monitoring

Shoreline Erosion
Storm Dynamics
Climate Change
Sea Level Rise
Beach Renourishment

Responsible Agency / Park:
A cooperative program between: East Carolina University Geology Department, North Carolina Geologic Survey, and US Geological Survey.

Relevant Parks:
CAHA, FOR A, WRBR, CALO

Period of Record:
Post-2001

Description:
North Carolina has experienced the economic devastation and human suffering resulting from six hurricanes and numerous tropical depressions since 1996. These storms have resulted in severe coastal and inland flooding, erosion of hundreds of miles of shoreline, and major damage and destruction of thousands of homes, businesses, and infrastructure systems. This emphatically underscores the great relevance to North Carolina that research scientists throughout the world are presenting compelling evidence that our global climate is warming, sea level is rising, and increased hurricane activity is predicted. Combined with the explosive development of our coastal zone, hundreds of thousands of people and billions of dollars of property continue to be at an ever-increasing risk in coastal North Carolina. It is imperative that we develop a better understanding of our coastal geology and associated resources, coastal storm dynamics, and high-risk coastal environments.

To respond to this critical issue, East Carolina University (ECU), the N.C. Geologic Survey (NCGS), and U.S. Geologic Survey (USGS) commenced in FY 2001 a cooperative geophysical and geological research program of the NC coastal region. These geologic investigations will develop a data base that is essential for resolving critical questions associated with utilizing and managing our extremely dynamic, but poorly understood coastal system and provide a sound scientific basis for policy and regulatory decisions. Among the issues being addressed are: shoreline erosion, storm dynamics and coastal system response, sand resources for beach renourishment, quality of crucial water resources, record of climate and sea level change, and habitat evolution within the barrier islands and estuaries.

Date Last Updated:

Catalog Number: More Information:
http://core.ecu.edu/geology/RIGGS/ECU_USGS/REVISEDPAGES/Home_Page1.html

Geologic Mapping of Congaree National Park
Geologic Map
Geomorphic Map

Responsible Agency / Park:
SC Department of Natural Resources – Geologic Survey

Relevant Parks:
CONG

Period of Record:
2002 – Present (and ongoing)

Description:
This project will create and updated, digital geology map of 10 USGS quadrangles that encompass and surround Congaree National Park. In addition, a larger scale, detailed geomorphic map will be produced.

Date Last Updated:

Catalog Number:

More Information:
http://www.dnr.state.sc.us/geology/geohome.htm

Dr. C. Scott Howard: howard@dnr.state.sc.us

North Carolina Department of Environment and Natural Resources, Division of Coastal Management – Shoreline Erosion
Shoreline Erosion

Responsible Agency / Park:
North Carolina Department of Environment and Natural Resources, Division of Coastal Management

Relevant Parks:
CAHA, FORA, WRBR, CALO

Period of Record:
1992, updated 1998

Description:
The Division of Coastal Management works to protect, conserve and manage North Carolina's coastal resources through an integrated program of planning, permitting, education and research. DCM carries out the state's Coastal Area Management Act, the Dredge and Fill Law and the federal Coastal Zone Management Act of 1972 in the twenty coastal counties, using rules and policies of the N.C. Coastal Resources Commission, known as the CRC. Coastal Management is part of the Department of Environment and Natural Resources, which is responsible for keeping the state's environment healthy. The division also receives oversight (and part of its funding) from the Office of Ocean and Coastal Resource Management, part of the National Oceanic and Atmospheric Administration.

Using current and historical aerial photography and sophisticated computer software, the Division of Coastal Management evaluates erosion rates about every five years. The small-scale maps below can provide information about oceanfront erosion rates for every section of the North Carolina coast, from the South Carolina border to the Virginia border. They are based on aerial photographs taken in 1992. Maps containing updated erosion rates based on 1998 aerial photography are also available.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://dcm2.enr.state.nc.us/Maps/erosion.htm

Seismic Monitoring
Seismic Activity

Responsible Agency / Park:
Charleston Southern University
South Carolina Seismic Network

Relevant Parks:
FOSU, CHPI

Period of Record:
[Unknown]

Description:
Charleston, being the site of the largest earthquake on the eastern seaboard in modern times, is closesly monitored and continues to be active. Data are recorded at the geology lab of Charleston Southern University. The Middleton Place/Summerville Seismic Zone is the most active area of tectonic seismicity in South Carolina. Annual totals average 12 to 15 events of magnitude 1.0Ml or greater with twice that number of quakes less than 1.0, many of which are too small to be located accurately. Research continues on the mechanisms at work in the Charleston area. One active fault has already been established along the Ashley River (Ashley River Fault) and recent work supports the concept of another fault running near parallel to the coastline

from SW of Charleston to the NE towards Lake Moultrie (Woodstock Fault).

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://scsn.seis.sc.edu/html/scsn.html

National Oceanic and Atmospheric Administration

Land Use Change
Urbanization
Estuarine Systems

Responsible Agency / Park:
National Oceanic and Atmospheric Administration, Center for Sponsored Coastal Ocean Research, Coastal Ocean Program

Relevant Parks:
FOSU, CHPI, FOPU, FOFR, CUIS, TIMU, CASA, FOMA, CANA

Period of Record:
Not Listed

Description:
The goal of the Coastal Ocean Program (COP) sponsored research in the Southern Atlantic Bight is to understand how changes in land-use and management patterns, population growth, habitat quality, and other environmental factors impact coastal ocean resources. These factors are being examined to quantify linkages and provide information to facilitate decision-making in order to minimize or avoid potential impacts to the resources and their habitats.

The primary objectives of the ongoing Urbanization and Southeastern Estuarine Systems (USES) study are: 1) to characterize and delineate the impact of multiple stresses resulting from urbanization on high-salinity estuaries; and 2) to develop models which will provide a scientifically valid basis for making land-use management decisions in the coastal zone. Emphasis has been placed on watershed dynamics, including an examination of land-use patterns and the impacts associated with watershed loading.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Program Webpage:
http://www.cop.noaa.gov/Fact_Sheets/USES_LUCES.html

USES Project:
http://www.urbanestuary.org/

Land Use Project:
http://www.lu-ces.org/

Program Contact:
John Wickham
CSCOR/Coastal Ocean Program
phone: 301-713-3338
coastalocean@noaa.gov

NOAA National Ocean Service – National Geodetic Survey

Shoreline Monitoring

Geophysical Processes Monitoring

Responsible Agency / Park
NOAA, NOS, NGS

Relevant Parks:
All Coastal SECN Parks

Period of Record:
Variable

Description:
The National Geodetic Survey implements a coastal mapping program, which measures precise positions of the shoreline and other features needed for creating accurate nautical charts. It conducts aerial photography surveys near airports in the United States and its territories to locate obstructions and aids to air travel. NGS also develops industry specifications and standards for conducting geodetic surveys, coordinates the development and application of new surveying instrumentation and procedures, and assists state, county, and municipal agencies through a variety of cooperative programs and training workshops.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.nos.noaa.gov/programs/ngs/welcome.html

USDA, Natural Resources Conservation Service:
Soil Mapping

Responsible Agency / Park:
USDA, Natural Resources Conservation Service

Relevant Parks:
All SECN parks

Period of Record:
Not Listed.

Description:
The Natural Resources Conservation Service provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment. While not monitoring, the NRCS provides baseline soils data (GIS and database) from both the STATSGO and SSURGO programs.

STATSGO: Soil maps for the State Soil Geographic (STATSGO) database are produced by generalizing the detailed soil survey data. The mapping scale for STATSGO is 1:250,000. STATSGO data are available for the entire United States.

SSURGO: Field mapping methods using national standards are used to construct the soil maps in the Soil Survey Geographic (SSURGO) database. Mapping scales generally range from 1:12,000 to 1:63,360; SSURGO is the most detailed level of soil mapping done by the Natural Resources Conservation Service (NRCS). Parks with available SSURGO data = CAHA, FORA, WRBR, CUIS, FOFR, TIMU, FOCA, CHAT (except Fulton county), KEMO.

Other baseline cartographic products available from the NRCS include: DEM, DRG, DLG, DOQQ, NED, LIDAR, and climate data.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.ncgc.nrcs.usda.gov/products/

US Geological Survey, Coastal and Marine Geology Program
Sea Level Rise
Shoreline Erosion
Storm Events

Responsible Agency / Park:
US Geological Survey, Coastal and Marine Geology Program, National Assessment of Coastal Change Hazards

Relevant Parks:
CAHA, CALO, FOPU, FOSU, FOMO, FOFR, CUIS, TIMU, CANA

Period of Record:
Not Listed

Description:
The National Assessment of Coastal Change Hazards is a multi-year undertaking to identify and quantify the vulnerability of U.S. shorelines to coastal change hazards such as the effects of severe storms, sea-level rise, and shoreline erosion and retreat. It will continue to improve our understanding of processes that control these hazards, and will allow researchers to determine the probability of coastal change locally, regionally, and nationally. The National Assessment will deliver these data and assessment findings about coastal vulnerability to coastal managers, other researchers, and the general public.

Projects currently online include: 1) National Assessment of Shoreline Change, 2) Coastal Classification Mapping Project, 3) Hurricane and Extreme Storm Impact Studies, and 4) National Assessment of Vulnerability to Sea-level Rise.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://coastal.er.usgs.gov/national-assessment/index.html

asallenger@usgs.gov

Marine & Estuarine Resources

FWC Fish and Wildlife Research Institute

Coastal Monitoring
Fish Kills
Manatees

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
1998-2002

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

The FWRI, in conjunction with the US Environmental Protection Agency, monitors several variables (e.g., water quality, sediment contaminants, SAV, etc.) as indicators of status and trends of ecosystem processes. The FWRI also monitors red tide occurrences and sport-fish stock assessments to evaluate ecosystem function.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1714

Georgia Adopt-A-Stream

Coastal Monitoring

Responsible Agency / Park:
Georgia Department of Natural Resources

Relevant Parks:
FOPU, FOFR, CUIS

Period of Record:
Ongoing

Description:
Georgia Adopt-A-Stream (AAS) is housed in the NonPoint Source Program in the Water Protection Branch of the Georgia Environmental Protection Division. The program is funded by a Section 319(h) Grant. The goals of Georgia Adopt-A-Stream are to (1) increase public awareness of the State's nonpoint source pollution and water quality issues, (2) provide citizens with the tools and training to evaluate and protect their local waterways, (3) encourage partnerships between citizens and their local government, and (4) collect quality baseline water quality data.

To accomplish these goals, Georgia Adopt-A-Stream encourages individuals and communities to monitor and/or improve sections of streams, wetlands, lakes or estuaries. Manuals, training, and technical support are provided through Georgia EPD, five Adopt-A-Stream Regional Training Centers and more than 40 established Community/Watershed Adopt-A-Stream organizers. The Adopt-A-Stream and Wetland Regional Training Centers are located at State Universities in Columbus, Milledgeville, Americus, Valdosta and Savannah. These centers play a key role in providing training, technical support and organizational support to citizens throughout Georgia.

There are more than 40 Community/Watershed Programs that organize Adopt-A-Stream groups in their watershed, county or city. These local Adopt-A-Stream programs are funded by counties, cities and nonprofit organizations and use the Georgia Adopt-A-Stream model, manuals and workshops to promote nonpoint source pollution education and data collection in their area. The State office works closely with these programs to ensure that volunteers are receiving appropriate support and training.

The Adopt-A-Stream program offers different levels of involvement. At the most basic level, a new group informs their local government about their activities

and creates partnerships with local schools, businesses and government agencies. A watershed survey and 4 visual surveys are conducted within a year's time. Volunteers create a "Who To Call List" so that if something unusual is sighted, the appropriate agencies can be notified. Getting To Know Your Watershed and Visual Stream Survey manuals provide guidance in these activities.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.riversalive.org/coastal_monitoring.htm

North Carolina Wildlife Resources Commission, Division of Marine Fisheries, Fish Harvest Statistics
Fisheries
Fish Harvest

Responsible Agency / Park:
North Carolina Wildlife Resources Commission, Division of Marine Fisheries

Relevant Parks:
CAHA, CALO

Period of Record:
Commercial Fishing: 1972 – Present (ongoing)
Recreational Fishing: 1989 – Present (ongoing)

Description:
The North Carolina Division of Marine Fisheries (DMF) is responsible for the stewardship of the state's marine and estuarine resources. The DMF's jurisdiction encompasses all coastal waters and extends to three miles offshore.

To accurately determine the status of a fish stock, managers must determine: age structure of the stock, age at spawning, average number of eggs each age fish can produce, ratio of males to females in a stock, number of new fish entering the catchable population, rate at which fish die from natural causes, rate at which fish are harvested, growth rate of the fish, time and the place fish spawn, migratory habits and food habits for all ages of fish in the stock, types and numbers of fishermen in a fishery, pounds of fish caught by each type of gear, fishing effort expended with each type of gear, age structure of the fish caught by each group of fishermen, ratio of males to females in the catch, value of the fish to different groups of fishermen, preferred size of the catch for market, and time and place where the best catches occur.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.ncfisheries.net/statistics/index.html

National Oceanic and Atmospheric Administration (NOAA), National Estuarine Research Reserve System
Estuarine Water Quality

Responsible Agency / Park
NOAA

Relevant Parks:
CAHA, CALO, CANA, CASA, CUIS, FOCA, FOFR, FOMA, FOPU, FORA, FOSU, TIMU, WRBR

Period of Record:
Ongoing

Description:
The National Estuarine Research Reserve System is a network of protected areas established for long-term research, education and stewardship. This partnership program between NOAA and the coastal states protects more than one million acres of estuarine land and water, which provides essential habitat for wildlife; offers educational opportunities for students, teachers and the public; and serves as living laboratories for scientists.

Data from this program may be used as reference values for intact estuarine systems.

Date Last Updated:
2004

Catalog Number:

More Information:
http://nerrs.noaa.gov/

http://cdmo.baruch.sc.edu/

NOAA Marine Protected Areas
Marine Inventory

Responsible Agency / Park
NOAA

Relevant Parks:
CAHA, CALO, CANA, CUIS, TIMU

Period of Record:
2000

Description:
The National Marine Protected Areas (MPA) Center's mission is to facilitate the effective use of science, technology, training, and information in the planning, management, and evaluation of the nation's system of marine protected areas. Their goals are to: (1) Develop the framework for a national system of marine protected areas, (2) Improve MPA stewardship and effectiveness, and (3) Facilitate national and regional coordination of MPA activities.

Marine protected areas serve many different purposes and are established for a variety of reasons. The term MPA has been used in many ways as well. Those impacted by or interested in MPAs have varying perceptions on the value and use of MPAs. This website's purpose is to provide information and resources that assist in national dialog and decision-making about MPAs.

No data currently exist for SECN parks, however, this site may prove valuable in the future.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://mpa.gov

NOAA National Ocean Service (NOS)
Coastal Ecosystem Science
Coastal Management
Oil and Chemical Spills
Shoreline Mapping
Tides/Currents/Water Levels
Algal Blooms

Responsible Agency / Park
NOAA

Relevant Parks:
CAHA, CALO, CANA, CUIS, TIMU

Period of Record:
Variable

Description:
The NOS is one of five offices of the NOAA in the U.S. Department of Commerce (DOC). It is a scientific and technical organization of more than 1,700 individuals whose mission is to preserve and enhance the nation's coastal resources and ecosystems along 95,000 miles of shoreline and 3.5 million square miles of coastal ocean. At the same time, it works to support economic growth for the long-term benefit of the nation. This theme is central to the sustainable development agenda of both NOAA and DOC.

The NOS website provides a substantial amount of data available for download. Record length of datasets varies.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://oceanservice.noaa.gov/dataexplorer/datasites/welcome.html

Estuarine Living Marine Data Base
Fish (relative abundance)
Invertebrates (relative abundance)

Responsible Agency / Park:
NOAA

Relevant Parks:
CANA

Period of Record:

Description:
In 1985, NOAA launched the Estuarine Living Marine Resources (ELMR) Program to develop a consistent data base on the distribution, relative abundance, and life history characteristics of ecologically and economically important fishes and invertebrates in the Nation's estuaries. The Nationwide ELMR data base includes information for 153 species found in 122 estuaries and coastal embayments. The data base is divided into five study regions - West Coast, Gulf of Mexico, Southeast, Mid-Atlantic, and North Atlantic. For each species, five life stages are considered - adults, juveniles, larvae, spawning, and eggs - with some exceptions. Each estuary is subdivided into one to five salinity zones. Relative abundance is ranked by month for

each life stage of each species, in each salinity zone of each estuary (Nelson et al. 1991, Nelson and Monaco 2000).

ELMR relative abundance data can be downloaded from this website, by using the search keys for Region, Estuary, Species, Life Stage, and Salinity Zone.

Last Updated:

Catalog Number:

More Information:
http://biogeo.nos.noaa.gov/products/elmr/

Indian River Lagoon National Estuarine Program
Water Quality
Sea Grass Communities
Tidal Salinity

Responsible Agency / Park:
NOAA
Saint Johns Water Management District

Relevant Parks:
CANA

Period of Record:

Description:
This project will continue the ambient water quality and seagrass monitoring networks and the hydrologic and tidal/salinity monitoring networks. The project also will support special diagnostic and feasibility investigations such as identifying the major components of suspended matter that limit light to sea grass, identifying other seagrass limiting factors besides light, developing new rapid monitoring technologies with the help of the National Aeronautic and Space Administration (NASA),and supporting the NASA Space Act Agreement database. Through this project, existing models will be refined for the purpose of enhancing accuracy and predictive capabilities such as the quantification of groundwater and atmospheric nutrient loadings to the lagoon.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Salt Marsh Health Assessment
Water Quality
Oyster Tissue Chemistry / Toxicity
Sediment Chemistry / Toxicity

Responsible Agency / Park:
Savannah State University

Relevant Parks:
FOPU

Period of Record:

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

Southeast Monitoring Assessment Program (SEAMAP)
Fish & Invertebrates

Responsible Agency / Park:
U.S. National Marine Fisheries Service

Relevant Parks:
All Coastal SECN Parks

Period of Record:
1981 – Present (and ongoing)

Description:
The Southeast Area Monitoring and Assessment Program (SEAMAP) is a State/Federal/university program for collection, management and dissemination of fishery-independent data and information in the southeastern United States. In the South Atlantic region, surveys include Shallow Water Trawl Survey, Pamlico Sound Survey, Benthic Characterization, and Bottom Mapping Project. The SEAMAP provides guidance, personnel, and other contributions to these studies for enhancement and protection of the marine resources.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.gsmfc.org/seamap.html

National Oceanic and Atmospheric Administration – CoastWatch
Sea Surface Temperature

Responsible Agency / Park:
National Oceanic and Atmospheric Administration, Center for Coastal Fisheries and Habitat, CoastWatch Program

Relevant Parks:
CAHA, CALO, FOSU, FOPU, FOFR, CUIS, TIMU, FOMA, CASA, CANA

Period of Record:
Not Listed

Description:
The National Oceanic and Atmospheric Administration established the CoastWatch Southeast Regional Node at the Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina. The purpose of the Southeast Regional Node is to develop and distribute NOAA satellite and oceanographic data products for the U.S. Southeast coast to academic and governmental researchers, managers and policy makers – at no charge.

The data products currently available to users through the CoastWatch Southeast Regional Node (CWSERN) are sea surface temperature map (SST) maps derived from digital images acquired by the Advanced High Resolution Radiometer (AVHRR) carried onboard the NOAA polar orbiting satellites. The images are projected to a Mercator map projection. The images provide partial to full coverage of the southeast from northern North Carolina to Florida several times daily depending on the orbital paths of the satellites.

Near real time data for the Southeastern United States are available to users at this site. User that do not require near real-time data may access retrospective imagery through NOAA CoastWatch Archive and Access System (NCAAS). Data derived from the NOAA satellites may be accessed by researchers, state and Federal government employees, and the general public who use the data for non-commercial purposes.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Real Time: http://www.ccfhrb.noaa.gov/cw/se-info.html

Legacy: http://www.saa.noaa.gov/nsaa/products/welcome

Georgia Coastal Resources Monitoring
Georgia Coastal Resources Information
Marine Water Quality Monitoring
Tide and Weather Information
Fishing License Information

Responsible Agency / Park:
Georgia Department of Natural Resources: Coastal Resources Division – Coastal Management Program

Relevant Parks:
CUIS, FOFR, FOPU

Period of Record:
Ongoing

Description:
Recognizing that the coast of Georgia comprises a vital natural resource system, the State of Georgia implemented the Georgia Coastal Management Program in order to balance economic development with preservation of coastal resources. Developed through an extensive public process, the Georgia Coastal Management Program addresses the economic development concerns and natural resource issues identified by the citizens of Georgia. For effective coastal management, the Georgia Coastal Management Program encompasses all tidally influenced water bodies and all areas economically tied to coastal resources. Georgia's Coastal Management Program service area includes the following eleven counties: Brantley, Bryan, Camden, Charlton, Chatham, Effingham, Glynn, Liberty, Long, McIntosh, and Wayne.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://crd.dnr.state.ga.us/

South Carolina Coastal Resources Monitoring
Beach Erosion Monitoring

Responsible Agency / Park:
South Carolina Department of Health and Environmental Control / Ocean and Coastal Resource Management

Relevant Parks:
CHPI, FOSU

Period of Record:
Ongoing since 1988

Description:
Following passage of the 1988 Beachfront Management Act, the Coastal Council established a beach-monitoring program at approximately 400 survey benchmarks along the coast. Each benchmark, a metal disk set in concrete, has a known vertical elevation which is used as the starting point for the beach survey. In addition, the horizontal coordinates of each benchmark have been established, so the benchmark can be replaced in the same location if it is ever destroyed. The information from this beach-monitoring program was used to delineate the position of the baseline, set at either the actual dune crest for natural beaches or the theoretical dune crest for armored beaches. With grant support from the US Geological Survey, this monitoring program collects beach profiles at all stations twice a year to a depth of -5 feet, as a surveyor wades into chest-deep water at low tide. In addition, offshore profiles to a depth of -20 feet are collected annually at selected stations, using a submersible survey rig towed by a boat.

Date Last Updated:
June 15th, 2004

Catalog Number:

More Information:
http://www.scdhec.net/eqc/ocrm/HTML/beach.html

RADAR Ocean Sensing Laboratory
Sea Surface Currents

Coastal Circulation

Responsible Agency / Park:
University of Miami – Division of Applied Marine Physics of the Rosenstiel School

Relevant Parks:
All Coastal SECN Parks

Period of Record:
Not Listed

Description:
The RSMAS Radar Ocean Sensing Laboratory (ROSL) is an interdisciplinary research group primarily based in the Division of Applied Marine Physics of the Rosenstiel School, but with additional members in Meteorology and Physical Oceanography. Its research efforts involve the use of a land-based Doppler radar to measure surface vector currents in the coastal ocean and airborne and satellite observations of different radar sensors such as wind speed and direction from scatterometers [SEASAT, ERS-1 and NSCAT], wave height and wind speed from altimeters [SEASAT, GEOSAT, ERS-1 and TOPEX/POSEIDON], and directional wave spectra and backscatter images from synthetic aperture radars [JPL/INSAR, SEASAT, and ERS-1]. The research and graduate education of ROSL complements the satellite oceanography activities of the Remote Sensing Group.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.rsmas.miami.edu/groups/rosl/

Recreational Use

South Carolina Fishing and Hunting
Fisheries
Fish Harvest
Stream Flow
Wildlife Management

Responsible Agency / Park:
South Carolina Department of Natural Resources

Relevant Parks:
CONG, FOSU

Period of Record:
Ongoing

Description:
This agency provides a variety of fresh and saltwater fishing information and hunting information for the state of South Carolina. For fishing, data and information are available on fishing regulations, fishing trends, records, tournaments, Fish Watch, and streamflow and lake elevation graphs. For hunting, there are links to South Carolina hunting rules and regulations, hunting license and application forms, and a variety of wildlife management information pertinent to hunting.

Date Last Updated:
Variable

Catalog Number:

More Information:
Fishing: http://www.dnr.state.sc.us/etc/fishing.html

Hunting: http://www.dnr.state.sc.us/etc/hunting.html

Boating, Fishing, and Hunting in Georgia
Fisheries
Fish Harvest
Fish Kills
Exotic/Invasive Species

Responsible Agency / Park:
Georgia Department of Natural Resources / Wildlife Resources Division

Relevant Parks:
CHAT, KEMO, OCMU, FOPU, FOFR, CUIS

Period of Record:
Unknown

Description:
Links to rules, regulations, permit and license information, records, surveys and other information related to hunting, fishing, and boating in Georgia.

To follow are descriptions of each section found on the website.

Boating: Information provided includes boating rules and regulations, boat ramp locations, boater safety, and boat registration.

Fishing: This section links to fisheries management, fishing regulations, fish kill reporting, aquatic nuisance species, fish consumption information, weekly fishing reports, fishing license information, and fisheries publications, research and surveys.

Hunting: Look here for hunter education and licenses, hunting seasons and regulations, publications, research and surveys, and other hunting related information.

Date Last Updated:
Variable depending on the data set.

Catalog Number:

More Information:
http://georgiawildlife.dnr.state.ga.us/

Visitor Use Impacts – National Park Service
Visitor Use Impacts

Responsible Agency / Park:
National Park Service

Relevant Parks:
All SECN Parks

Period of Record:
Varied

Description:

Date Last Updated:
Unknown

Catalog Number:

More Information:

T&E Species

Alabama Natural Heritage Program:
Federal and State T&E Species

Responsible Agency / Park:
Alabama Department of Conservation and Natural Resources, the Natural Heritage Section is a program of the State Lands Division.

Relevant Parks:
HOBE

Period of Record:
Not listed.

Description:
The Alabama Natural Heritage Program maintains a current inventory of plant and animal biological records for the state of Alabama. The database is GIS compatible and records are obtained from state and federal reports, professional publications, and field survey's conducted by in house staff. Currently the database has over 250,000 records and this information is available upon request and is free of charge.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.dcnr.state.al.us/research-mgmt/heritage.cfm

Florida Department of Agricultural and Consumer Services
State-listed T&E plants

Responsible Agency / Park
FDACS

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
2003

Description:
The mission of the Department of Agriculture and Consumer Services (FDACS) is to safeguard the public and support Florida's agricultural economy by: (1) Ensuring the safety and wholesomeness of food and other consumer products through inspection and testing programs; (2) Protecting consumers from unfair and deceptive business practices and providing consumer information; (3) Assisting Florida's farmers and agricultural industries with the production and promotion of agricultural products; and (4) Conserving and protecting the state's agricultural and natural resources by reducing wildfires, promoting environmentally safe agricultural practices, and managing public lands.

The FDACS maintains a current list of federal and state-listed T&E and commercially exploited plant species.

Date Last Updated:
2003

Catalog Number:

More Information:
http://www.doacs.state.fl.us/pi/enpp/botany/images/Notes2003.pdf

Florida Department of Forestry (FDOF)
Federal-listed T & E Plant Species
FDOF T & E Plant Species Management Plans

Responsible Agency / Park
FDOF

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Florida Plant Conservation Program originated in 1992 to work toward the recovery of federally-listed endangered and threatened plant species in Florida.

The goal of the Florida Plant Conservation Program is to restore and maintain existing populations of listed plants on public land and on private lands managed for conservation purposes. Previous or ongoing projects address demography, monitoring, reintroduction, germination, pollination, and other aspects of population ecology.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.fl-dof.com/Conservation/plant_program.html

Florida Natural Areas Inventory:
Federal and State T&E Species

Responsible Agency / Park:
Florida Natural Areas Inventory, Florida State Univeristy

Relevant Parks:
FOCA, TIMU, CASA, FOMA, CANA

Period of Record:
Not Listed.

Description:
FNAI is a non-profit organization administered by Florida State University. They are dedicated to gathering, interpreting, and disseminating information critical to the conservation of Florida's biological diversity. The Inventory was founded in 1981 as a member of The Nature Conservancy's international network of natural heritage programs. Funding is provided through contracts and grants, which currently include work for the Florida Department of Environmental Protection, the Florida Fish and Wildlife Conservation Commission, and other state and federal agencies.

Inventory staff continually build and maintain a comprehensive database of the biological resources of Florida, which now includes more than 28,000 element occurrences of rare plants, rare animals, and high-quality natural communities. These occurrences are maintained in a GIS database for mapping and analysis.

The Inventory also serves as the primary source for information on Florida's conservation lands. The Inventory database includes GIS boundaries and statistics for more than 1,400 federal, state, local, and private managed areas. The database also includes information on Florida Forever environmental land acquisition projects.

Inventory staff have expertise in a range of fields, including botany, zoology, ecology, land management, environmental planning, GIS, and database management.

FNAI is the best source for information regarding Florida's T & E species.

For information about data requests, contact Edwin Abbey, Environmental Reviewer.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.fnai.org/

http://www.fnai.org/data.cfm

Florida Natural Areas Inventory
1018 Thomasville Road, Suite 200-C
Tallahassee, Florida 32303
Phone: (850) 224-8207
Fax: (850) 681-9364

Florida Fish and Wildlife Conservation Commission (FWC)
Federal- and State-listed T&E animal species

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The FWC was created in 1998 as a combination of the Marine Fisheries Commission and specific components of the Divisions of Marine Resources and Law Enforcement of the Florida Department of Environmental Protection. As the state agency responsible for managing Florida's fish and wildlife resources, the FWC is responsible for managing approximately 4.3 million acres of public lands and 220,000 acres of private lands for recreation and conservation purposes. Further, the FWC develops hunting and fishing regulations, manages a fresh-fish culture and stock program, provides law enforcement and fishing access, and conducts lake restoration.

The FWC maintains a list of federal-and state-listed T&E animal species, management plans, and research/monitoring programs for various listed species.

Date Last Updated:

Catalog Number:

More Information:
http://wildflorida.org/imperiled/species.htm

FWC Fish and Wildlife Research Institute
Sea Turtles

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

The FWRI staff conducts research on the distribution, productivity, migration patterns, life history, and threats to sea turtles. Productivity data are available online by coastal region.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1289

http://www.floridamarine.org/features/category_sub.asp?id=3618

Georgia Natural Heritage Program:
Federal and State Listed T&E Species

Responsible Agency / Park:
Georgia Department of Natural Resources, Nongame Animals and Plants, Division of Natural Heritage.

Relevant Parks:
FOPU, FOFR, CUIS, OCMU, CHAT, KEMO

Period of Record:
Not Listed.

Description:
The Georgia Natural Heritage Program (GNHP) was established in 1986 through a cooperative agreement between the Georgia Department of Natural Resources (DNR) and The Nature Conservancy. Information from scientific literature, museum and herbarium collections, knowledgeable individuals, and scientific research organizations is utilized extensively to document occurrences of particular elements within the state. Field surveys are then conducted to verify these occurrences. The biological inventory thus represents a continuous, ongoing process whose product, a detailed atlas of Georgia's natural diversity, is constantly updated and revised.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=87

Greg Krakow
Georgia Natural Heritage Program
2117 US Hwy 278 SE
Social Circle, GA 30025-4714

(770) 918-6411 or (706) 557-3032

North Carolina Natural Heritage Program:
Federal and State Listed T&E Species

Responsible Agency / Park:
The North Carolina Natural Heritage Program is a part of the Office of Conservation and Community Affairs within the NC Department of Environment and Natural Resources.

Relevant Parks:
CAHA, WRBR, FORA, CALO, MOCR

Period of Record:
Not Listed.

Description:
The North Carolina Natural Heritage Program provides natural area and rare species information to landowners, consulting firms, local, state, and federal agencies, as well as conservation organizations and

private citizens. To request information about a specific site, please submit: (1) A cover letter describing the proposed activity, including existing vegetation cover, structures at the site, and the type of data requested, and (2) A photocopy of a portion of a USGS topographic map with the project area clearly outlined and the name of the quadrangle used.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.ils.unc.edu/parkproject/nhp/index.html

North Carolina Natural Heritage Program
Office of Conservation and Community Affairs
601 MSC, Raleigh, NC 27699
512 North Salisbury St., Raleigh, NC 27604
phone: (919) 715-4195
fax: (919) 715-3085

South Carolina Natural Heritage Trust
Federal and State Listed T&E Species

Responsible Agency / Park:
The South Carolina Department of Natural Resources Heritage Trust Program

Relevant Parks:
CONG, CHPI, FOMO, FOSU

Period of Record:
Not Listed.

Description:
The South Carolina Heritage Trust Program was created to preserve those natural features and cultural remains which are fast disappearing as the state grows. The South Carolina Heritage Trust's purpose is to inventory, evaluate, and protect the elements considered the most outstanding representatives of our state heritage. The Heritage Trust Database contains rare, endangered and threatened species occurrences, a literature file that is organized by county on places with rare or significant habitats, ecosystem features such as rock outcrops, limestone sinks, Carolina bays, and old-growth forests are described. This information is continuously updated as new occurrences are being found and old populations are disappearing. This database was formed from field reports, herbarium collection records, publications, and knowledgeable experts.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.natureserve.org/nhp/us/sc/

http://www.dnr.state.sc.us/etc/conservation.html

Status of Carolina Bogmint at CONG
State Listed T&E Species

Responsible Agency / Park:
US Geological Survey – Biological Resources Division and Clemson University

Relevant Parks:
CONG

Period of Record:

Description:
This project seeks to determine the health, extent and reproductive characteristics of the Carolina Bogmint population at Congaree National Park.

Date Last Updated:
Unknown

Catalog Number:
More Information:
Dr. Patrick Jodice -
http://people.clemson.edu/~pjodice/

Ms. Kate Manry - http://people.clemson.edu/~kmanry

US Fish and Wildlife Service, Endangered Species
Federally Listed T&E Species

Responsible Agency / Park:
US Fish and Wildlife Service, Endangered Species Program

Relevant Parks:
All SECN parks

Period of Record:
Not Listed

Description:
Restoring endangered and threatened species to a secure status in the wild is a key objective of the U.S. Fish and Wildlife Service. The Endangered Species web site has information on threatened and endangered wildlife and plants and lists of threatened and endangered species by state. There is no actual monitoring data available through this website; we

will have to contact US FWS directly to pursue any data that may be available.

The U.S. Fish and Wildlife Service and the NOAA Fisheries Service (National Oceanic and Atmospheric Administration National Marine Fisheries Service) Office of Protected Resources work together to protect species listed as endangered or threatened under the Endangered Species Act of 1973. We implement programs and regulations for terrestrial and freshwater species, while NOAA Fisheries is charged with marine and anadromous species.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Main website: http://endangered.fws.gov/

Southeast Region: http://southeast.fws.gov/

GIS: http://southeast.fws.gov/gis/datalinks.htm

Biological: http://www.fws.gov/data/gisbio.html

Historical Assessment of Carolina Bogmint and other Rare and/or Invasive Plants - CONG

Federal and State Listed T&E Plant Species
Exotic/Invasive Species

Responsible Agency / Park:
University of South Carolina

Relevant Parks:
CONG

Period of Record:
Variable by Species

Description:
This project seeks to create a palynological reference collection to be used to assess the historical distribution of selected rare and/or exotic invasive plant species.

A related project by the same investigators will assess the distribution and composition of rim swamp sediments through analysis of core samples.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Dr. Art Cohen: cohen@geol.sc.edu

David Shelley: shelleyd@mailbox.sc.edu

Vegetation

Florida Department of Agricultural and Consumer Services

Plant Diseases/Pathogens (Pest-Alert)

Responsible Agency / Park
FDACS

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The mission of the Department of Agriculture and Consumer Services (FDACS) is to safeguard the public and support Florida's agricultural economy by: (1) Ensuring the safety and wholesomeness of food and other consumer products through inspection and testing programs; (2) Protecting consumers from unfair and deceptive business practices and providing consumer information; (3) Assisting Florida's farmers and agricultural industries with the production and promotion of agricultural products; and (4) Conserving and protecting the state's agricultural and natural resources by reducing wildfires, promoting environmentally safe agricultural practices, and managing public lands.

Date Last Updated:

Catalog Number:

More Information:
http://www.doacs.state.fl.us/pi/enpp/pi-pest-alert.html

FWC Fish and Wildlife Research Institute

Seagrasses

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

As seagrass communities play a key ecological role, their preservation and restoration is a key issue for the FMRI. The FWRI is currently investigating several functions (e.g., seed bank mortality, nutrient flow, etc.) of seagrass systems in order to acquire necessary knowledge to improve management and preservation and facilitate restoration.

Date Last Updated:

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1323

The Institute for Systematic Botany Atlas of Florida Vascular Plants

Range Maps for Vascular Flora of Florida

Responsible Agency / Park
University of South Florida

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Atlas of Florida Vascular Plants is a joint effort by the Institute of Systemic Botany, the University of South Florida and the Florida Center for Community Design and Research to provide users with the most comprehensive searchable database of vascular plants in the State of Florida.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.plantatlas.usf.edu/

Effects of Altered Flow Regimes on Floodplain Forests - CONG
Floodplain Forest Communities

Responsible Agency / Park:
Southern Illinois University – Dr. Peter Minchin
University of Georgia – Dr. Rebecca Sharitz

Relevant Parks:
CONG

Period of Record:

Description:
This project seeks to detect changes in the composition and distribution of bottomland hardwood forest tree species resulting from the hydrological changes of the Saluda Dam.

Date Last Updated:

Catalog Number:

More Information:
http://www.uga.edu/srel/ESSite/Sharitz.htm

http://www.science.siu.edu/plant-biology/Adjunct/Minchin.html

University of Georgia – Savannah River Ecology Lab
Disturbance
Plant Recovery Rates

Responsible Agency / Park:
UGA, SREL, PI is Rebecca Sharitz

Relevant Parks:
CONG

Period of Record:
Post 1989

Description:
River floodplain forests have been increasingly affected by human activities, including industrial and agricultural development and forest management practices. One component of our research addresses structural and functional changes in wetland communities as a result of disturbances. For example, we have studied the effects of thermal discharges from industrial activities on the Savannah River Site (SRS) into streams, and the potential to restore these damaged riparian systems.

We are also examining the effects of natural disturbances such as floods and winds. The destruction by Hurricane Hugo in 1989 to one of our study sites, the Congaree National Park, has provided a rare opportunity to examine immediate and long-term forest recovery in one of the few old-growth floodplain forests in the Southeast. Specific studies are examining tree mortality patterns, regrowth, and the effects of environmental heterogeneity on woody seedling recruitment. This research is partly funded by the US National Park Service.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.uga.edu/srel/ESSite/Sharitz.htm

Modeling Forest Succession and Surface Hydrology at CONG
Forest Succession
Surface Hydrology

Responsible Agency / Park:
US Geological Survey – National Wetlands Research Center

Relevant Parks:
CONG

Period of Record:

Description:
This project will develop a flood prediction and ecological succession model for Congaree National Park.

Date Last Updated:

Catalog Number:

More Information:
Dr. Thomas Doyle -
http://www.nwrc.usgs.gov/about/feb/doyle.htm

Vegetation Photopoint Monitoring – FOPU

Photopoints

Responsible Agency / Park:
FOPU

Relevant Parks:
FOPU

Period of Record:
1998 to Present

Description:
Photos are taken at 12 established photopoints, twice per year, to track changes in vegetation over time.

Date Last Updated:

Catalog Number:

More Information:

Sea Beach Amaranth Monitoring – CALO

Responsible Agency / Park:
CALO

Relevant Parks:
CALO

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Sea Beach Amaranth Monitoring – CAHA

Responsible Agency / Park:
CAHA

Relevant Parks:
CAHA

Period of Record:
1996 – Present (Ongoing)

Description:
Surveys for seabeach amaranth (*Amaranthus pumilus*) were conducted at Cape Hatteras National Seashore. Seabeach amaranth plants were found growing on Hatteras Island within designated bird closures in upper dry sand flats at the Cape Hatteras Point (Cape Point and South beach), in small dunes adjacent to the flats at Hatteras Island spit and on Ocracoke Island at the base of the dunes on the beach.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.nps.gov/caha/nathistory.htm

Botanical Guardians Project

Rare or locating lost plant populations
Endangered habitats

Responsible Agency / Park:
Georgia Plant Conservation Alliance

Relevant Parks:
CHAT, KEMO, OCMU, FOPU, FOFR, CUIS

Period of Record:
Ongoing since 2003

Description:
The Georgia Plant Conservation Alliance (GPCA) is creating a network of volunteers from throughout the state of Georgia to help locate lost rare plant populations, monitor known locations of endangered habitats, and serve as stewards for the 21 rare habitats under powerline right-of-ways. The State Botanical Garden's Plant Conservation Program is charged with the task of coordinating this network. The program, called the Botanical Guardians project, is modeled after a successful volunteer program developed by the New England Wildflower Society (NEWFS). New England's program, launched in 1999, has trained nearly 400 volunteers to monitor rare plant populations, assist in management of these sites, and identify and control invasive plant species.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.uga.edu/gpca/project6.html

South Carolina Plant Atlas
Plant Distributions in South Carolina

Responsible Agency / Park:
University of South Carolina, Department of Biological Sciences, John Nelson, Curator

Relevant Parks:
FOSU, CHPI, CONG

Period of Record:
1970's – Ongoing (went online in 1994)

Description:
The purpose of the South Carolina Plant Atlas is to show, on a county by county basis, the distribution of all native and naturalized ferns, fern allies, gymnosperms, and angiosperms of South Carolina. All distributional information is based on the presence of at least one verified herbarium specimen; non-vouchered records have not been used. The presence of a species in a county is indicated by a dot, and the dot is positioned at the centroid of that county; the maps in this Atlas suggest no other geographical distribution.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://cricket.biol.sc.edu/herb/

Savannah Restoration - MOCR
Vegetation Monitoring

Responsible Agency / Park:
National Park Service - MOCR

Relevant Parks:
MOCR

Period of Record:

Description:
Following a prescribed burn at MOCR, native grasses were planted towards the restoration of savannah habitat. Vegetation monitoring plots were established to assess the success of revegetation efforts.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Horse Exclosure Monitoring – CUIS

Responsible Agency / Park:
CUIS

Relevant Parks:
CUIS

Period of Record:

Description:
Management of the horses at Cumberland Island National Seashore (CUIS) continues to be a highly controversial and political issue within the community, district, and region. The park needs to collect data on the horses to insure that management of the horses may be based as much as possible on proper scientific data. The use of horse exclosures will help the park determine the effects of horses upon vegetation at Cumberland Island.

Date Last Updated:

Catalog Number:

More Information:

Vertebrate Disease

National Biological Information Infrastructure (NBII) – Wildlife Diseases

Wildlife Disease

Responsible Agency / Park:
NBII – Wildlife Diseases

Relevant Parks:
All SECN parks

Period of Record:
Not Listed – real time access to disease information

Description:
The Wildlife Disease Information Node is a Web-based monitoring and information system, providing state and federal resource managers, animal disease specialists, veterinary diagnostic laboratories, physicians, public health workers, educators, and the general public with access to near real-time data in wildlife mortality events and other critical related information.

The major objectives of the Wildlife Disease Information Node include:

Documenting the prevalence and spread of wildlife diseases at the most discrete spatial and temporal levels possible via a nationwide Web-based reporting system

Maintaining current databases on wildlife mortality events and other critical information

Providing Web access to wildlife and zoonotic disease information for management, research, epidemiological, and educational purposes

Providing Web access to the general public for educational purposes and to disseminate information on the importance of wildlife and zoonotic diseases and related ecosystem and community effects

Developing partnerships to share wildlife mortality and other critical information in a distributed fashion and in a secure, partner-based data system.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://wildlifedisease.nbii.gov/

Florida Department of Agricultural and Consumer Services

Vertebrate Diseases
Zoonotic Diseases

Responsible Agency / Park
FDACS

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The mission of the Department of Agriculture and Consumer Services (FDACS) is to safeguard the public and support Florida's agricultural economy by: (1) Ensuring the safety and wholesomeness of food and other consumer products through inspection and testing programs; (2) Protecting consumers from unfair and deceptive business practices and providing consumer information; (3) Assisting Florida's farmers and agricultural industries with the production and promotion of agricultural products; and (4) Conserving and protecting the state's agricultural and natural resources by reducing wildfires, promoting environmentally safe agricultural practices, and managing public lands.

Date Last Updated:

Catalog Number:

More Information:
http://www.doacs.state.fl.us/ai/

US Geological Survey (USGS), Biological Resource Division, National Wildlife Health Center

Wildlife Disease

Responsible Agency / Park
USGS

Relevant Parks:
All SECN parks

Period of Record:
Ongoing

Description:
The (NWHC) is a science center of the Biological Resources Discipline of the United States Geological Survey. The NWHC was established in 1975 as a biomedical laboratory dedicated to assessing the

impact of disease on wildlife and to identifying the role of various pathogens in contributing to wildlife losses.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.nwhc.usgs.gov/about_nwhc/index.html

US Department of Agriculture, Animal and Plant Health Inspection Service – Wildlife Services
Wildlife Disease
Human, Wildlife Interaction
Wildlife Damage
Human Health

Responsible Agency / Park
USDA, APHIS, Wildlife Services

Relevant Parks:
All SECN parks

Period of Record:
Ongoing

Description:
Wildlife Services (WS) is the program within APHIS that is dedicated to preventing or reducing conflicts between people and wildlife. Every day State agencies, county and municipal governments, private homeowners, farmers, ranchers, and other property owners rely on WS' expertise to help prevent, minimize, or manage wildlife damage. This damage can impact agriculture, property, natural resources, and even threaten public health and safety. Research conducted at WS' National Wildlife Research Center (NWRC) provides WS field personnel with innovative and effective tools to manage wildlife damage in a professional and responsible way.

With this support, WS biologists handle a broad spectrum of issues for their customers and stakeholders. These activities include: protecting livestock and threatened and endangered species from predation by other wildlife, reducing the risk of wildlife collisions with airplanes, removing beaver dams that are flooding nearby roads and bridges, and monitoring for and reducing the threat of various wildlife-borne diseases that can spread to domestic livestock or even people.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.aphis.usda.gov/ws/index.html

Waste Management

Waste Management in South Carolina

Solid waste management
Environmental Indicators

Responsible Agency / Park:
South Carolina Department of Health and Environmental Control / Bureau of Land and Waste Management

Relevant Parks:
CONG, FOSU, CHPI

Period of Record:
Unknown

Description:
SCDHEC Bureau of Land and Waste Management's site provides information on solid waste management including the EPA's Environmental Indicator Summaries for South Carolina. Tables summarizing the EI evaluations for the 34 high-priority facilities in South Carolina are available. The table lists the name of the facility, the county in which it is located, and the status of the two environmental indicators. There is also a link from the facility name to a copy of the Environmental Indicator Evaluations for the particular facility.

Date Last Updated:
2004

Catalog Number:

More Information:
http://www.scdhec.net/lwm/

Wetlands

National Wetlands Inventory
National Scale Wetlands Information

Responsible Agency / Park:
U.S. Fish and Wildlife Service

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
Wetlands are mapped to show their current status, and updated or sampled to show their trends of losses or gains. Once wetlands are mapped, many types of wetland assessment can be performed. Wetland assessment is used for many activities: monitoring wetland health, making permit decisions, targeting voluntary wetland restoration activities, maintaining biodiversity, restoring species, measuring mitigation success, undertaking watershed management, developing wetland classifications, protecting public water supplies, implementing local land use plans and so on.

The U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) provides information on the status, extent, and characteristics of the nation's wetlands. Digital maps, GIS data, and information about obtaining hard copy maps are available through this website. GIS data are downloadable in zipped shapefile format, geodatabase format, or Arc Data format in both single quad and 1:250,000 scales. Some geographic areas are not yet available in all file format types.

Date Last Updated:
2004

Catalog Number:

More Information:
http://wetlands.fws.gov/

Wildlife – Bird

American Oystercatcher Breeding – CAHA

Responsible Agency / Park:
CAHA

Relevant Parks:
CAHA

Period of Record:
1999 – Present (and ongoing)

Description:
The breeding activities of American Oystercatchers (*Haematapus palliatus*) were monitored at Cape Hatteras National Seashore (CAHA). By the first week in April, traditional nesting territories were protected with symbolic fencing. Additional sites were posted as these solitary-nesting birds established territories.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.nps.gov/caha/nathistory.htm

Acoustic Monitoring for Endangered Birds and Amphibians – CONG

Responsible Agency / Park:
Cornell University Lab of Ornithology

Relevant Parks:
CONG

Period of Record:
2004 - ongoing

Description:
This project seeks to document the presence of Bachman's warbler and other wildlife species of special management concern. Additional goals include quantifying aircraft over-flight noise at the park.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.birds.cornell.edu/brp

Dr. Kurt Fristrup: kmf6@cornell.edu
Tel: (607)254-2438

Jay Watch

Florida Scrub Jay

Responsible Agency / Park
The Nature Conservancy and Archbold Biological Research Station

Relevant Parks:
CANA

Period of Record:
Ongoing

Description:
The Nature Conservancy and Archbold Biological Research Station organize a volunteer-based monitoring program of Florida Scrub Jay (*Aphelocoma coerulescens*) to estimate productivity and habitat use.

Date Last Updated:

Catalog Number:

More Information:
Contact Tabitha Biehl: tbiehl@tnc.org

http://nature.org/wherewework/northamerica/states/florida/press/press1459.html

http://www.ridgerangers.org/jwatch/

Audubon – Christmas Bird Counts

Bird Population Monitoring

Responsible Agency / Park:
State or local chapters of the Audubon Society

Relevant Parks:
All SECN parks.

Period of Record:
Variable.

Description:
Audubon's mission is to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity. Our national network of community-based nature centers and chapters, scientific and educational programs, and advocacy on behalf of areas sustaining important bird populations, engage millions of people of all ages and backgrounds in positive conservation experiences.

Bird monitoring occurs in the form of Christmas Bird Counts, Backyard Bird Counts, and local birding efforts.

Date Last Updated:
Unknown

Catalog Number:

More Information:
HOBE: No local Audubon chapter listed
TIMU/FOCA: http://www.duvalaudubon.org/
FOMA/CASA: http://members.aol.com/sjaudubon/
CANA: http://www.indianriveraudubon.org/
CHAT/KEMO: http://www.atlantaaudubon.org/
OCMU: bob.sargent@robins.af.mil
FOPU: http://www.geocities.com/coastalgas/
CUIS, FOFR: No local Audubon chapter listed
CAHA, FORA, WRBR, CALO, MOCR: http://www.ncaudubon.org/
CONG: http://www.columbiaaudubon.org/

Mid-winter Bird Survey – CUIS

Responsible Agency / Park

Relevant Parks:
CUIS

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Colonial Waterbird Breeding – CAHA

Responsible Agency / Park:
CAHA and North Carolina Wildlife Resource Commission

Relevant Parks:
CAHA

Period of Record:
1977 – Present (Ongoing)

Description:
Colonial waterbird nesting sites are monitored along Cape Hatteras National Seashore (CAHA). Species breeding on the Seashore beaches this year include Least Tern (*Sterna albifrons*), Common Tern (*Sterna hirundo*) and Gull-billed Tern (*Gelochelidon nilotica*), as well as Black Skimmers (*Rinchops niger*). All are listed as Species of Concern in North Carolina except for Gull-billed Tern having Threatened status (North Carolina Heritage Program, 2003). Breeding activity occurred between May and August. In many cases, birds utilized areas already closed to the public for breeding, including American Oystercatchers (*Haematapus palliatus*) and Piping Plover (*Charadrius melodus*). In other areas, symbolic fencing was erected once birds were observed exhibiting courtship behavior or nests were found.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.nps.gov/caha/nathistory.htm

Monitoring Avian Productivity & Survivorship (MAPS)

Bird Monitoring
Bird Habitat

Responsible Agency / Park:
Institute for Bird Populations
U.S. Geological Survey / Biological Res. Div.
SC Department of Natural Resources (John E. Cely)

Relevant Parks:
CONG

Period of Record:
1980 – Present

Description:
The Institute for Bird Populations (IBP) has become a partner with the United States Geological Survey (USGS) / Biological Resources Division (BRD) in the National Biological Information Infrastructure (NBII) web-based electronic information network. This has allowed IBP to make available on-line the annual reports of the MAPS (Monitoring Avian Productivity and Survivorship) program. Previously these data have been published only in IBP's peer-reviewed publication *Bird Populations*. This avian

demographics query interface includes the following components:

1. Regional between-year changes in adult population size and productivity indices for target species from analyses of MAPS banding data (1992-1998).
2. Regional annual adult apparent survival rate estimates for target species from mark-recapture analyses of MAPS data (1992-1998).
3. MAPS Station information:
    a. Geographic locations and operating history of MAPS stations operated during the years 1989-2000.
    b. Brief habitat descriptions summarized from the MAPS Habitat Structure Assessment data collected at each station. This includes USGS National Vegetation Classification Standard classifications of major habitat types to formation level.
4. Breeding status of each species captured, seen, or heard at each station during the years 1989-2000.
5. IBP ensures that species names provided through the web-based query interface conform to the taxonomic nomenclature provided by the Integrated Taxonomic Information System (ITIS)
6. Metadata. IBP has developed metadata records for the MAPS database and geospatial data layers that are made available electronically. Metadata records follow the format of the Biological Data Profile of the FGDC Metadata Content Standard.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.birdpop.org/nbiimaps.htm
http://www.birdpop.org/nbii/NBIIHome.asp

Partners in Flight:
Bird Population Monitoring
Bird Habitat

Responsible Agency / Park:
Partners in Flight

Relevant Parks:
All SECN parks

Period of Record:
Post 1990

Description:
Partners in Flight was launched in 1990 in response to growing concerns about declines in the populations of many land bird species and in order to emphasize the conservation of birds not covered by existing conservation initiatives. Partners in Flight's goal is to focus resources on the improvement of inventory and monitoring, research, management and education programs involving birds and their habitat.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.partnersinflight.org/

PIF Southeast Region Coordinator:

Laurel Moore-Barnhill
(803) 725-1034
lamoore@fs.fed.us

Piping Plover Monitoring at CALO
Piping Plovers

Responsible Agency / Park:
National Park Service (CALO)

Relevant Parks:
CALO

Period of Record:
1989 – Present (ongoing)

Description:
Piping plover monitoring at Cape Lookout National Seashore (CALO) began with a baseline study in 1989. The park is a significant nesting area with about 2/3 of the nesting pairs in the state of North Carolina. Monitoring focuses on factors limiting nesting success and methods that could be used to increase the productivity of this threatened species. Counts of wintering and migrating piping plovers were made monthly (Cordes and Rikard 2003b).

Date Last Updated:
Unknown

Catalog Number:

More Information:

Piping Plover Breeding – CAHA

Responsible Agency / Park:
CAHA

Relevant Parks:
CAHA

Period of Record:
1989 – Present (Ongoing)

Description:
Cape Hatteras National Seashore (CAHA) oversees Piping Plover (*Charadrius melodus*) breeding management. Beginning in early April, beaches were surveyed for plover activity. These surveys included sites that had been previously used for nesting as well as those deemed suitable but had no nesting documented in recent years. When plovers exhibited territorial or courtship behavior, the sites were investigated for the presence of nests. If none were found, the territories were revisited every two to seven days in attempts to locate newly initiated nests.

Potential and known breeding sites were closed to the public in late March. Each area was surrounded by symbolic fencing, which consisted of posted signs and twine. All located nests were protected by predator exclosures. These have been used at CAHA since 1994. Nests were viewed from a distance every one or two days during incubation. Observers noted the behavior of adults, presence of predators and the condition of the predator exclosure. Nests were approached briefly once a week to closely inspect the exclosure, count eggs and search for any predator tracks. After hatching, each brood was monitored at one or two day intervals. Observers noted brood status, behavior, movements, human disturbance, predator contacts or other environmental interactions.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.nps.gov/caha/nathistory.htm

National Biological Information Infrastructure (NBII) – Bird Conservation Node

Bird Populations
Bird Habitat

Responsible Agency / Park:
NBII – Bird Conservation Node

Relevant Parks:
All SECN parks

Period of Record:
Varied, depending upon dataset

Description:
In an effort to increase the accessibility of bird data and information useful in planning and evaluation of bird conservation strategies as well as in natural resource management, the U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS) Patuxent Wildlife Research Center, and USGS Center for Biological Informatics are working together under the umbrella of the National Biological Information Infrastructure (NBII) to establish and implement the NBII Bird Conservation Node. This node is intended to facilitate rapid access to North American bird population and habitat data maintained by a broad coalition of Federal, state, and non-governmental partners in conservation.

The NBII Bird Conservation Node, which came online in the fall of 2001, focuses on providing electronic access to some of the major bird monitoring and habitat databases held in North America. The node will initially emphasize delivery of raw and derived bird population data held by the USGS and USFWS Migratory Bird Data Center. But as the node grows, it will link to North American bird data sets and information maintained and managed by other partners.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Main: http://birdcon.nbii.gov/

Data Links: http://birdcon.nbii.gov/monitoring_links.html

US Geological Survey – Waterbird Monitoring Partnership

Waterbird Populations

Responsible Agency / Park:
USGS – Patuxent Wildlife Research Center

Relevant Parks:
CAHA, WRBR, FORA, CALO, FOSU, FOFR, CUIS, TIMU, FOMA, CANA

Period of Record:
Mid-1990's – present (ongoing)

Description:
Individuals across the continent are often faced with decisions that influence waterbird populations. Although some waterbirds have been counted for decades, numerous survey methodologies have been implemented over different spatial scales, resulting in data sets that cannot be compared. Too often, monitoring programs have been initiated without any thought given to future data use. The Waterbird Conservation for the Americas initiative, of which the North American Waterbird Conservation Plan is one product, has identified the need to establish a Waterbird Monitoring Partnership. The goal of the Waterbird Monitoring Partnership is to develop a continental network of collaborators who agree to and implement comparable population monitoring techniques and contribute to a centrally managed waterbird database. This continent-wide waterbird monitoring partnership is being coordinated by the USGS Patuxent Wildlife Research Center's Monitoring Program.

The waterbird monitoring database is made possible by the participation of monitoring partners throughout the Americas, who conduct surveys of waterbirds and voluntarily contribute their data to this centralized location. As of May 2002, this database contains data from the coastal surveys conducted in the mid 1990s from Maine to Georgia, funded by the US Fish and Wildlife Service, in addition to information published in a number of colonial waterbird atlases in the United States and Canada. In the near future, data from the Cornell Waterbird Register and the US Fish and Wildlife Service-sponsored Great Lakes waterbird surveys will become available. Over time, the utility of the database will grow, as partners throughout the Americas contribute data.

Date Last Updated:
Not Listed

Catalog Number:

More Information:
Main: http://www.pwrc.usgs.gov/cwb/

Data Link: http://www.pwrc.usgs.gov/cwb/database/

US Fish and Wildlife Service – Division of Migratory Bird Management:
Migratory Bird Populations

Responsible Agency / Park:
US Fish and Wildlife Service – Division of Migratory Bird Management

Relevant Parks:
All SECN parks

Period of Record:
Varied, depending upon dataset

Description:
The Fish and Wildlife Service is the lead Federal agency for managing and conserving migratory birds in the United States. The Division of Migratory Bird Management is charged with carrying out the Service's responsibilities, which it does in concert with a host of participating partners, both domestic and foreign.

Monitoring programs are an important part of responsible management. Only through knowledge of the status and trends of a species, and the habitats in which it occurs, can managers take appropriate actions. Monitoring efforts are numerous and varied, and are undertaken by a wide variety of organizations. The Office of Migratory Bird Management undertakes a number of surveys in conjunction with the U.S. Fish and Wildlife Regional Offices, the Canadian Wildlife Service, and State and Provincial wildlife-management agencies.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Main website: http://migratorybirds.fws.gov/

List of Monitoring Programs:
http://migratorybirds.fws.gov/statsurv/mntrtbl.html

Contact email: migratorybirds@fws.gov

US Geological Survey – Patuxent Wildlife Research Center:
Breeding Bird Populations

Responsible Agency / Park:
US Geological Survey – Patuxent Wildlife Research Center, Breeding Bird Survey

Relevant Parks:
The following routes are close to the park or within the park.

HOBE – AL route 51
CANA – FL route 25, 915
CHAT – GA route 42
CAHA – NC route 229, 129
MOCR – NC route 4, 285

Period of Record:
Late 1980's (depending upon the dataset and route)

Description:
Each year during the height of the avian breeding season, June for most of the U.S. and Canada, participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Over 4100 survey routes are located across the continental U.S. and Canada.

Once analyzed, BBS data provide an index of population abundance that can be used to estimate population trends and relative abundances at various geographic scales. Trend estimates for more than 420 bird species and all raw data are currently available via the BBS web site.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Main webpage: http://www.pwrc.usgs.gov/bbs/

Operations Contact: Keith Pardieck, email: Keith_Pardieck@usgs.gov

Analyses Contact: John Sauer, email: John_Sauer@usgs.gov

Wood Stork Monitoring – CUIS
Wood Stork Monitoring

Responsible Agency / Park:
Georgia Department of Natural Resources

Relevant Parks:
CUIS

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Neotropical Migratory Bird Monitoring - CONG
Migratory Birds

Responsible Agency / Park:
South Carolina Department of Natural Resources

Relevant Parks:
CONG

Period of Record:

Description:
To monitor neotropical migratory birds in order to document survival and productivity of these species in park forests.

Date Last Updated:

Catalog Number:

More Information:
John Cely

Lower Cape Fear Birding Club
Bird Inventory

Responsible Agency / Park:
Lower Cape Fear Birding Club

Relevant Parks:
MOCR and perhaps CAHA, CALO

Period of Record:
1980 and ongoing

Description:
In the summer of 1979, Dr. James Parnell, Professor of Ornithology at the University of North Carolina at Wilmington, contacted the core of local birders and the Lower Cape Fear Bird Club was organized and

chartered in September of that year. Dr. Parnell conducted the first program on September 25, 1979, with the subject of "Fall Bird Migration".

The Lower Cape Fear Birding Club has worked with MOCR to generate and update their bird list. In addition, the birding club has birding events at MOCR and occasionally to the outer banks of North Carolina.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Steve Emslie - Phone: (910) 962-3357

email: emslies@uncw.edu

http://people.uncw.edu/emslies/CFbirdclub/index.htm

Royal Terns (*Sterna maxima*) on the mid-Atlantic Coast in the Eastern U.S.
Royal Tern Research and Monitoring

Responsible Agency / Park:
Steven D. Emslie
Department of Biological Sciences
University of North Carolina
Wilmington, NC

Relevant Parks:
CAHA, CALO

Period of Record:
2001- 2003

Description:
The Royal Tern (*Sterna maxima*) is a large seabird that occurs along coastal regions in the Atlantic and eastern Pacific oceans where it forms dense breeding colonies on isolated beaches or islands. It migrates to Central and South America in winter, traveling as far south as the coasts of Peru and Argentina, before returning to breeding grounds to the north in early spring. In the mid-Atlantic region of the eastern U.S., Royal Terns breed primarily on dredge islands on rivers and estuaries from Maryland to Florida. In North Carolina, Royal Terns breed near inlets at Cape Hatteras, Cape Lookout, and on the Cape Fear River where it feeds primarily on larval fish that spawn in estuaries. At least five colonies are formed each year in these regions and number from hundreds to thousands of breeding pairs per colony. All colonies are protected from human disturbances by the North Carolina Wildlife Resources Commission and the local chapter of the National Audubon Society.

In summer 1999, the author initiated investigations of Royal Terns with graduate and undergraduate students at UNCW. The primary focus of these investigations has been the foraging ecology of this species, especially in relation to fishery stock abundance and annual variation in the marine environment. Other studies have been on the impact of pollutants and toxic compounds ingested by adults and chicks near their breeding sites, annual variation in chick growth by colony, and sex ratios in adult and juvenile terns as determined by blood analyses.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://people.uncw.edu/emslies/terns/

Wildlife – Fish

NatureServe – Native Fish Distribution by 8 Digit HUC

Native Fish Populations
Watershed

Responsible Agency / Park:
NatureServe

Relevant Parks:
All SECN parks

Period of Record:
Variable

Description:
NatureServe has compiled detailed data on the current and historic distributions of the native freshwater fishes of the United States, excluding Alaska and Hawaii. We believe these data are a useful tool for aquatic research and analyses and for conservation planning. Presented here are lists of the native fish species of each small watershed (8-digit cataloging unit) as defined by the U.S. Geological Survey.

These data derive in part from precise location data (element occurrences) compiled by state natural heritage programs for 307 vulnerable or imperiled U.S. fish species. The natural heritage-derived locational data were supplemented with information from the scientific literature and from species experts to compile the most complete distributional information possible for these species at the level of USGS 8-digit cataloging unit.

Analyses of these data were first presented in the report Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity (1998) and were published in amended form in Precious Heritage: The Status of Biodiversity in the United States (2000). Subsequent funding from the Regina Bauer Frankenberg Foundation for Animal Welfare and from The Nature Conservancy allowed us to expand the database. The data were thus compiled over a period of several years (1997 to 2003).

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp

FWC Fish and Wildlife Research Institute

Fish Kills

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
1972 – Present

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

The FWRI has compiled a history of reported fish kills, dating back to early 1972. The database can be queried based on specific criteria (i.e., county, data, and probable cause). The FWRI uses these data to infer aquatic health and focus research activitites.

Date Last Updated:
Ongoing

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1357

http://www.floridamarine.org/features/category_sub.asp?id=1697

South Carolina Fish Consumption Guides
Mercury, PCBs, Radioisotopes, and Organotins

Responsible Agency / Park:
South Carolina Department of Health and Environmental Control (DHEC)
USGS-BRD (Thomas May)

Relevant Parks:
CONG, FOSU

Period of Record:
Ongoing

Description:
To make sure that the fish that are caught are safe to eat, DHEC tests fish from lakes, rivers, streams, and estuaries throughout South Carolina. All estuarine and Atlantic king and Spanish mackerel samples are collected jointly by DHEC and the S.C. Department of Natural Resources (DNR). Based on the data collected, DHEC issues fish consumption advisories, which have been issued in South Carolina since 1976. In South Carolina, mercury, polychlorinated biphenyls (PCBs), radioisotopes, and organotins have been found in some fish from some waterbodies. The contamination is only in the fish and does not make the water unsafe for skiing, swimming, or boating. This site links to seven separate advisory tables in PDF format as well as a complete listing, also in PDF format.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.scdhec.net/eqc/admin/html/fishadv.html#tables

Fish Diversity, Condition, and Effects of Flooding
Fish Health
Fish Diversity
Flooding

Responsible Agency / Park:
South Carolina Department of Natural Resources

Relevant Parks:
CONG

Period of Record:

Description:
This project seeks to document the composition and health of the fish community at CONG. In addition, this project will define the temporal and spatial changes in the fish community resulting from the record flood of 2003.

Date Last Updated:

Catalog Number:

More Information:
Dr. Jim Bulak:
http://www.dnr.state.sc.us/wild/freshfish/fwfi/jim_bulak.htm

Leo Rose:
http://www.dnr.state.sc.us/wild/freshfish/fwfi/leo_rose.htm

Mercury Input and Bioaccumulation - CONG
Mercury Contaminants
Bioaccumulation

Responsible Agency / Park:
US Geological Survey

Relevant Parks:
CONG

Period of Record:

Description:
This project will determine the extent of mercury within the aquatic communities of CONG, by sampling sediments, invertebrates, and fish.

Date Last Updated:

Catalog Number:

More Information:
Thomas May

Wildlife – Mammals

Florida Fish and Wildlife Conservation Commission (FWC)

Breeding Birds
Hunter Returns
Waterfowl Check-station Surveys
Turkey Status and Distribution

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Varies

Description:
The FWC was created in 1998 as a combination of the Marine Fisheries Commission and specific components of the Divisions of Marine Resources and Law Enforcement of the Florida Department of Environmental Protection. As the state agency responsible for managing Florida's fish and wildlife resources, the FWC is responsible for managing approximately 4.3 million acres of public lands and 220,000 acres of private lands for recreation and conservation purposes. Further, the FWC develops hunting and fishing regulations, manages a fresh-fish culture and stock program, provides law enforcement and fishing access, and conducts lake restoration.

Date Last Updated:
2003

Catalog Number:

More Information:
http://www.floridaconservation.org/

Breeding Bird Atlas:
http://wildflorida.org/bba/default.asp

Waterfowl Check-station:
http://wildflorida.org/duck/Waterfowl_Surveys/waterfowl_surveys.htm

Alligator Harvest Data:
http://wildflorida.org/gators/Default.htm

Turkey Status and Distribution: http://wildflorida.org/

Other Hunter-returns Data by Request Only:
http://wildflorida.org/hunting/default.html

Horse Population Monitoring – CALO

Responsible Agency / Park:
CALO

Relevant Parks:
CALO

Period of Record:

Description:
Management of the horses at Cape Lookout National Seashore (CALO) continues to be a highly controversial and political issue within the community, district, and region. The park needs to continue to collect data on the horses to insure that management of the horses is based as much as possible on proper scientific data. The population of this herd is maintained by the coordinated use of an immunocontraceptive and horse removal. Contraceptive use is fertile ground for studies because of the unique situation including: (a) various patterns of use (a booster is administered each season conception is to be blocked), (b) the presence of non-contracepted control horses, and (c) the roundups necessary for removal of horses which also allows contraceptive antibody testing. Analysis of contraceptive data will be valuable for other NPS and BLM herds that have begun or will begin birth control programs.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Horse Population Monitoring – CUIS

Responsible Agency / Park:
CUIS

Relevant Parks:
CUIS

Period of Record:

Description:
Management of the horses at Cumberland Island National Seashore (CUIS) continues to be a highly controversial and political issue within the community, district, and region. The park needs to collect data on the horses to insure that management

of the horses may be based as much as possible on proper scientific data.

Date Last Updated:

Catalog Number:

More Information:

Deer Monitoring

Population Count

Responsible Agency / Park:

Relevant Parks:
FOPU

Period of Record:
1998 – Present (ongoing)

Description:
Annual nighttime census of deer populations.

Date Last Updated:

Catalog Number:

More Information:

Feral Hog Population Monitoring – CONG

Responsible Agency / Park:
US Geological Survey – Biological Resources Division and Clemson University

Relevant Parks:
CONG

Period of Record:
September 2000 – September 2002

Description:
This project will quantified feral hog impacts and developed a management plan and environmental assessment for long-term hob control

Date Last Updated:

Catalog Number:

More Information:
Dr. Craig Allen: https://coopunits.org/People/craig.allen

Scott Zengel: https://coopunits.org/People/scott.zengel

Southeastern Beach Mouse Monitoring

Responsible Agency / Park:
CANA, FOMA

Relevant Parks:
CANA, FOMA

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Marine Mammal Stranding Network

Marine Mammal Health
Environmental Contaminants

Responsible Agency / Park:
National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources

Relevant Parks:
CANA, TIMU, CUIS, CAHA, CALO

Period of Record:

Description:
To respond to marine mammal strandings, volunteer stranding networks were established in all coastal states and are authorized through Letters of Authority from the NMFS regional offices. Through a National Coordinator and five regional coordinators, NMFS oversees, coordinates, and authorizes these activities and provides training to personnel. For a copy of the Level A data form.

In recent years, high concentrations of potentially toxic substances in marine mammals and an increase in new diseases have been documented, and scientists have begun to consider the possibility of a link between these toxic substances and marine mammal

mortality events. These studies contribute to a growing, worldwide effort of marine mammal biomonitoring not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains and marine ecosystem health. NMFS provides participants in the program with training and some financial support. Using strandings, and bycatch animals, the participants provide tissue/serum archiving, samples for analyses, disease monitoring and reporting and additional response during disease investigations.

Date Last Updated:

Catalog Number:

More Information:
http://www.nmfs.noaa.gov/prot_res/PR2/Health_and_Stranding_Response_Program/mmhsrp.html

Northern Right Whale Monitoring Program
Whale Monitoring

Responsible Agency / Park:
Marine Resources Council of Eastern Florida

Relevant Parks:
CANA, TIMU, FOCA, FOMA, CUIS

Period of Record:
1998 – Present (and Ongoing)

Description:
The endangered right whale utilizes the Atlantic Coast off Georgia and Florida as calving grounds. Volunteer spotters, living in high rise condos beachside report right whale sightings to track the whales' movement and behavior patterns along the Atlantic Coast in an effort to determine migration characteristics of these highly endangered marine mammals.

Date Last Updated:

Catalog Number:

More Information:

http://www.mrcirl.org/whale/whale.html

Wildlife – Reptiles & Amphibian

FWC Fish and Wildlife Research Institute

Sea Turtles

Responsible Agency / Park
FWC

Relevant Parks:
TIMU, FOCA, CASA, CANA

Period of Record:
Ongoing

Description:
The Fish and Wildlife Institute (FWRI) was created in July 2004 as an integration of the biological research and support staff of the FWC Division of Wildlife, Division of Freshwater Fisheries, and Florida Marine Research Institute. The FWRI focuses on spatial analyses, biostatistics and modeling, wildlife forensics, and socioeconomic work relative to Florida's natural resources. More specifically, the FWRI is charged with: (1) Monitoring marine and freshwater resources, wildlife, and habitats, (2) Developing and implementing techniques for restoring plant and animal species and their habitat, (3) Providing technical support when oil spills and human-related or natural disasters occur, (4) Monitoring red tides and providing technical support for state and local government public health concerns, and (5) Providing fish and wildlife research technical results to state and local governments. The FWRI is divided into five interrelated science sections: (1) Marine Fisheries Research, (2) Freshwater Fisheries Research, (3) Ecosystem Assessment and Restoration, (4) Wildlife Research, and (5) Information Science and Management.

Date Last Updated:

Catalog Number:

More Information:
http://www.floridamarine.org/features/category_main.asp?id=1289

Acoustic Monitoring for Endangered Birds and Amphibians – CONG

Responsible Agency / Park:
Cornell University Lab of Ornithology

Relevant Parks:
CONG

Period of Record:
2004 - ongoing

Description:
This project seeks to document the presence of Bachman's warbler and other wildlife species of special management concern. Additional goals include quantifying aircraft over-flight noise at the park.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.birds.cornell.edu/brp

Dr. Kurt Fristrup:
kmf6@cornell.edu
Tel: (607)254-2438

Georgia Adopt-A-Stream

Amphibians

Responsible Agency / Park:
Georgia Department of Natural Resources

Relevant Parks:
All SECN Parks

Period of Record:
Ongoing

Description:
Georgia Adopt-A-Stream (AAS) is housed in the NonPoint Source Program in the Water Protection Branch of the Georgia Environmental Protection Division. The program is funded by a Section 319(h) Grant. The goals of Georgia Adopt-A-Stream are to (1) increase public awareness of the State's nonpoint source pollution and water quality issues, (2) provide citizens with the tools and training to evaluate and protect their local waterways, (3) encourage partnerships between citizens and their local government, and (4) collect quality baseline water quality data.

To accomplish these goals, Georgia Adopt-A-Stream encourages individuals and communities to monitor and/or improve sections of streams, wetlands, lakes or estuaries. Manuals, training, and technical support are provided through Georgia EPD, five Adopt-A-Stream Regional Training Centers and more than 40 established Community/Watershed Adopt-A-Stream organizers. The Adopt-A-Stream and Wetland

Regional Training Centers are located at State Universities in Columbus, Milledgeville, Americus, Valdosta and Savannah. These centers play a key role in providing training, technical support and organizational support to citizens throughout Georgia.

There are more than 40 Community/Watershed Programs that organize Adopt-A-Stream groups in their watershed, county or city. These local Adopt-A-Stream programs are funded by counties, cities and nonprofit organizations and use the Georgia Adopt-A-Stream model, manuals and workshops to promote nonpoint source pollution education and data collection in their area. The State office works closely with these programs to ensure that volunteers are receiving appropriate support and training.

The Adopt-A-Stream program offers different levels of involvement. At the most basic level, a new group informs their local government about their activities and creates partnerships with local schools, businesses and government agencies. A watershed survey and four visual surveys are conducted within a year's time. Volunteers create a "Who To Call List" so that if something unusual is sighted, the appropriate agencies can be notified. Getting To Know Your Watershed and Visual Stream Survey manuals provide guidance in these activities.

Date Last Updated:

Catalog Number:

More Information:
http://www.riversalive.org/amphibians.htm

Gopher Tortoise – CANA

Responsible Agency / Park:
CANA

Relevant Parks:
CANA

Period of Record:

Description:
CANA harbors one of the primary gopher tortoise populations in Florida. The tortoise is a keystone species; many other animals, including the federally threatened Eastern indigo snake, depend on its burrows for shelter. Once widespread and abundant in the Southeast, it is now listed as federally Threatened in its western range (Alabama, Louisiana and Mississippi) and is declining rapidly in Florida, due to extensive habitat destruction, human predation and Upper Respiratory Tract Disease (URTD). URTD, first noted in Florida in 1990, caused serious mortality in the desert tortoise of the Southwest, and resulted in its listing as a federally-protected species. A survey, done at CANA in the summer of 1995, revealed an alarming 100 percent infection in gopher tortoises collected in the Playalinda Beach area.

We use radio-telemetry to study the survival and movement patterns of neonate tortoises for two years. This is accomplished by locating and placing wire mesh cages over 5-10 gopher tortoise nests. Following hatching, randomly select 2-3 hatchlings from each nest and fit with miniature transmitters. Track hatchlings 2-4 days per week for a two year period to determine survivability and cause of death, if applicable. Although two years is still well short of maturity in gopher tortoises (15 years), two years of information will be adequate to characterize survival rates and movement patterns during the criticial first 24 months of life. Record all locations with GPS unit. At each location, also record soil type, percent canopy cover, distance to nearest vegetation and distance from last sighting. All data will be entered on an Excel spreadsheet and in a GIS database.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Gopher Tortoise Monitoring – TIMU

Responsible Agency / Park:
TIMU

Relevant Parks:
TIMU

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Sea Turtle Breeding and Stranding – CAHA

Responsible Agency / Park:
CAHA

Relevant Parks:
CAHA

Period of Record:
Not Listed

Description:
Cape Hatteras National Seashore (CAHA) beaches were patrolled daily between June 1 and

September 1 in search of turtle crawls. Volunteers In the Park, Student Conservation

Association volunteers and Park staff monitor approximately 55 miles each day on Bodie,

Hatteras, and Ocracoke Islands.

Date Last Updated:
Unknown

Catalog Number:

More Information:
http://www.nps.gov/caha/nathistory.htm

Sea Turtle Monitoring – CALO

Marine Turtles

Responsible Agency / Park:
Cape Lookout National Seashore cooperates with numerous agencies, including the North Carolina Wildlife Resources Commission (NCWRC), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) on sea turtle protection. The North Carolina Sea Turtle Program Coordinator receives all original stranding reports and annual nesting activity reports. NCWRC also issues Cape Lookout National Seashore an Endangered Species permit for possession and disposition of stranded marine turtles and relocation of nests.

Relevant Parks:
CALO

Period of Record:
1976 – Present (ongoing)

Description:
Cape Lookout National Seashore began monitoring marine turtles in 1976. Baseline data was collected for a portion of South Core Banks during an extensive six-year study from 1978 – 1983 (Cordes and Rikard 2003a). Nesting turtles were tagged and nests marked during nightly patrols. Since 1984 Cape Lookout has conducted daytime monitoring to document strandings, protect nest sites, relocate nests in danger of being flooded and protect hatchlings. Cape Lookout is a significant northern nesting beach and supports among the highest number of loggerhead turtle nests in North Carolina. Each year data have been collected, analyzed, and presented to management in hopes of better protecting our marine turtle population. In addition to providing CALO with management data, the information gathered on CALO beaches continues to be an important link for many state, federal, and private Atlantic coast sea turtle managers.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Sea Turtle Nesting – CANA

Responsible Agency / Park:
CANA

Relevant Parks:
CANA

Period of Record:

Description:
Five species of sea turtles occur in Canaveral National Seashore (CANA) waters. All are federally classified as threatened or endangered. Three regularly nest on the park's 24 miles of beach averaging between 3500 and 4500 nests a year. The park offers turtle watch programs in June and July each year, escorting small groups of people to see a

loggerhead nest at night. Reservations are required and early requests are advised since the slots fill up quickly.

At CANA, the sea turtle nesting season for loggerhead and green sea turtles generally extends from late April to early September, with peak numbers occurring in late June and early July. During that time, up to 100 nests may be deposited a night. The leatherback nesting period is earlier and shorter, with nests recorded between April and June.

Date Last Updated:
Unknown

Catalog Number:

More Information:

Sea Turtle Nest Monitoring - CUIS:
Sea Turtles

Responsible Agency / Park:
CUIS

Relevant Parks:
CUIS

Period of Record:

Description:

Date Last Updated:

Catalog Number:

More Information:

Towson University – Reptiles and Amphibians
Reptile and Amphibian Populations
Disease Monitoring

Responsible Agency / Park:
Rich Seigel and Colleagues

Relevant Parks:
CANA

Period of Record:
1975 – Present (Ongoing)

Description:
Rich Seigel began collecting reptile and amphibian data at CANA as part of his graduate school work. He has continued to study reptiles and amphibians at CANA since that point in time. The SECN is working with Rich to capture all of his data collected at CANA and the surrounding Kennedy Space Center and Merritt Island National Wildlife Refuge.

Date Last Updated:
Unknown

Catalog Number:

More Information:
Rich Seigel
Dept. of Biology
Towson University
8000 York Road
Towson, Maryland 21252
rseigel@towson.edu
410-704-3123

Sea Turtle Stranding Network

Responsible Agency / Park:
National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center

Relevant Parks:
CAHA, CALO, CUIS, TIMU, CANA

Period of Record:
Post-1980

Description:
The Sea Turtle Stranding and Salvage Network (STSSN) was formally established in 1980 to collect information on and document strandings of marine turtles along the U.S. Gulf of Mexico and Atlantic coasts. The network encompasses the coastal areas of the eighteen state region from Maine through Texas, and includes portions of the U.S. Caribbean. Data are compiled through the efforts of network participants who document marine turtle strandings in their respective areas and contribute those data to the centralized STSSN data base.

Date Last Updated:

Catalog Number:

More Information:
http://www.sefsc.noaa.gov/seaturtleSTSSN.jsp

Literature Cited

Cordes, J. and M. Rikard. 2003a. Cape Lookout National Seashore 2003 Sea Turtle Monitoring Program. National Park Service, Cape Lookout National Seashore, Harkers Island, NC.

Cordes, J. and M. Rikard. 2003b. Cape Lookout National Seashore Piping Plover Monitoring 2003. National Park Service, Cape Lookout National Seashore, Harkers Island, NC.

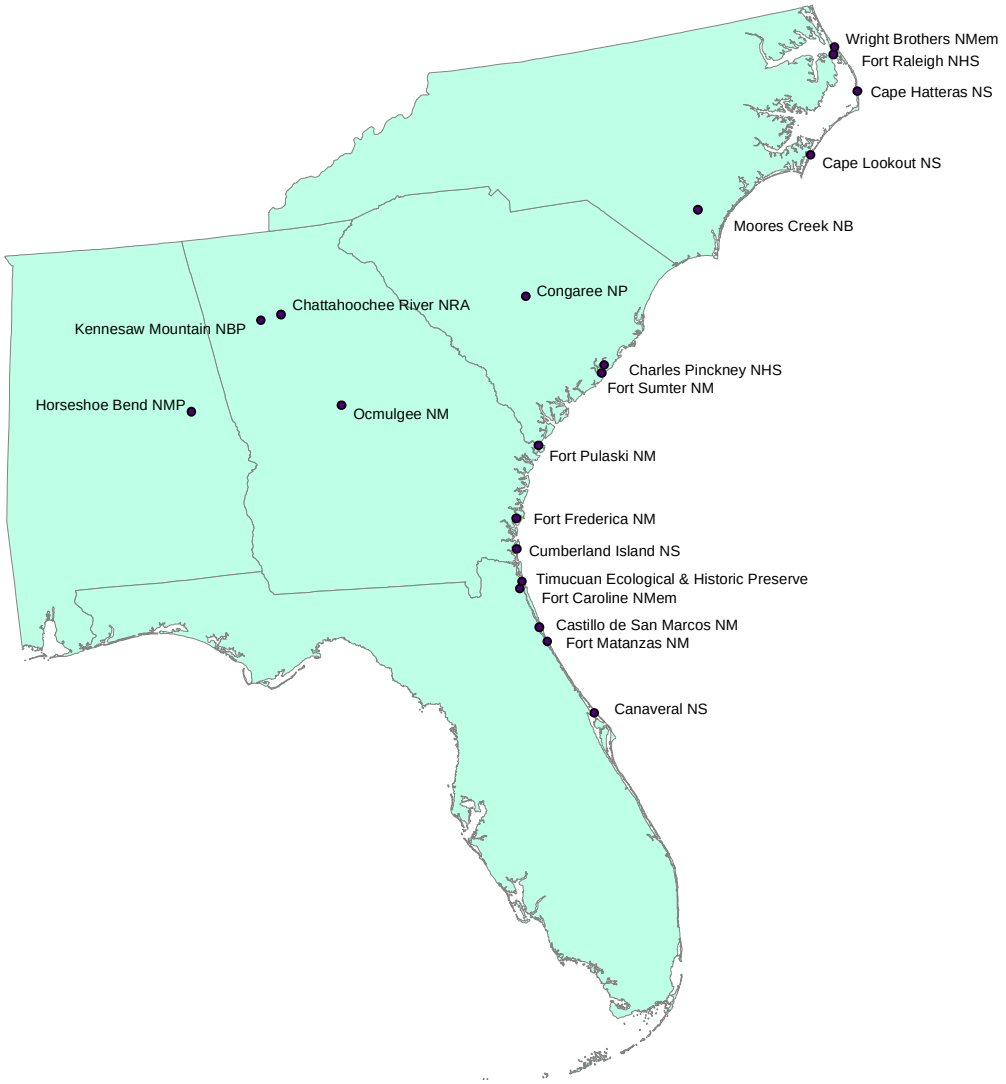
Nelson, D. M., E. A. Irlandi, L. R. Settle, M. E. Monaco, and L. C. Coston-Clements. 1991. Distribution and abundance of fishes and invertebrates in Southeast estuaries. National Oceanic and Atmospheric Administration, ELMR Report No. 9, Rockville, Maryland.

Nelson, D. M. and M. E. Monaco. 2000. National overview and evolution of NOAA's Estuarine Living Marine Resource (ELMR) Program. National Oceanic and Atmospheric Administration, Technical Memo NOS NCCOS CCMA-144.

National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 4 – Methods for Vital Signs Selection within the Southeast Coast Inventory & Monitoring Network



Joseph C DeVivo, National Park Service
Clifford J. Carrubba, Emory University

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Executive Summary

1. Ecological monitoring programs are often based on indicators because of their ability to provide relevant information in an efficient and cost effective manner. Although much study has been conducted to define characteristics of good indicators, little to no research has been conducted on appropriate methods for selecting indicators when multiple choices exist.
2. The National Park Service is currently developing an indicator-based long-term monitoring program designed around two principles: (a) Parks must coordinate efforts within "networks" of parks with similar ecosystems to efficiently share resources and (b) Resources are a fraction of what is likely to be necessary for adequate monitoring.
3. Given budgetary and staffing constraints, each Network of parks must select one or more indicators for implementation that provide the most relevant information to the greatest number of parks.
4. Because each network faces a situation of limited resources and resource sharing, the method of indicator selection needs to be evaluated to ensure the most efficient program design.
5. We propose using an economic-based (resource allocation) model for selecting indicators rather than one based solely on scientific merits of individual indicators. Welfare Maximization is an appropriate model in the case of monitoring program design when multiple partners with varying program needs are involved.
6. The underlying principle is to identify a suite of indicators, or multiple suites of indicators, that can only be modified to provide more useful information for one Park if the remaining parks receive less-useful information. This ensures that within programmatic constraints, an efficient program design will be selected that is of greatest benefit to all Parks.

Background & Objectives

During the last twenty years indicator-based monitoring programs have been developed to assess almost every ecosystem type around the world. Recent syntheses have focused on topics such as qualities of "good" vs. "bad" indicators, statistical sampling design, and methods to integrate monitoring programs with adaptive management programs—all in an effort to ensure that new programs meet desired objectives (Busch and Trexler 2003). However, to date no adequate discussion has occurred about methods for selecting *what* indicators to monitor in the context of an integrated monitoring program when multiple options exist. The need to select indicators based on sound, defensible methods is critical to program success, particularly as new monitoring programs are intended to support an increasing number of management goals for an increasing number of partners.

Congress charged the National Park Service (NPS) to manage natural resources on NPS lands based on sound science (Pub. L. 105-392). The NPS Inventory & Monitoring Program was developed to implement this directive by acquiring baseline information and developing and implementing long-term ecological monitoring programs at all NPS units with significant natural resources. To implement this plan, the NPS has grouped park units with significant natural resources into 32 networks nationwide and is phasing in funding and development of monitoring programs over the course of a five year span (National Park Service 2003). To date only twelve networks have completed the process of identifying natural resource issues on their respective parks and selecting indicators around which to design long-term monitoring programs (Milstead and Stevens 2003;Emmott et al. 2003;Hubbard et al. 2003;Leibfreid 2003;Welch 2003;Weber 2003). The Southeast Coast Network (SECN), located in the southeastern United States, is in the third "wave" of funding, and is just embarking on the design of its integrated monitoring program.

Although each network is responsible for developing an integrated monitoring program among all parks within the network, several issues must be considered in the design of the program. First, each network is funded at levels

significantly below that which is expected to be needed. Congress intentionally made this decision to encourage the National Park Service to design efficient programs and seek outside partners with which funds and efforts could be leveraged. Consequently, each Network must develop an indicator-based monitoring program whereby several information-rich indicators are chosen for monitoring because they are relevant to multiple natural resource issues, parks, or components within the ecosystem(s). The National Park Service refers to these indicators as "Vital Signs" because like the measurement of blood pressure for a sick patient, Vital Signs are intended to give an indication of the overall health of the natural resources.

Second, those resources are intended to be shared among several parks that share the common NPS mission, but are faced with very different management directives across a wide range of ecosystems. The SECN contains twenty parks, seventeen of which contain significant and diverse natural resources that in total encompass more than 178,000 acres of federally-managed land across North Carolina, South Carolina, Georgia, Alabama, and Florida. The parks range in size from slightly more than 20 to nearly 60,000 acres, and when considered with non-federal lands jointly managed with SECN parks the Network encompasses more than 242,000 acres. At the same time, SECN parks span a wide diversity of cultural missions as well, including four National Seashores, two National Historic Sites, two National Memorials, seven National Monuments, two national Military Parks, as well as a National Recreation Area, National Battlefield, and Ecological and Historic Preserve. Although the ultimate monitoring program is required to be explicitly tied to park management issues, each park within the Network necessarily has different priorities for both the management and monitoring of natural resources.

Two critical facts – that the networks are operating under significant budget constraints, and that the scarce resources necessary for the parks and networks to achieve their goals are being allocated from a common pool – necessarily mean that the procedures by which decisions over resource allocation are made will be as important as the actual ecological priorities themselves. That is, the same set of ecological priorities will lead to more or less efficient resource allocation decisions depending on the decision-making procedure. Thus, without careful consideration of the decision-making procedures, in all likelihood resources will be substantially under-utilized (Morrow 1994).

The purpose of this paper is to present a new method for selecting ecological indicators for a monitoring program that is shared among multiple park units within the National Park Service Inventory and Monitoring Program, each of which has different, but similar, management objectives. To do this, we will:

- Summarize methods, assumptions, and lessons learned by other networks in the NPS Inventory & Monitoring program,
- Present an alternative method for evaluating and selecting indicators in a monitoring program, and
- Discuss the method's utility in the context of adaptive management and long-term program development.

Lessons Learned: NPS Selection of Vital Signs

Each network is following a general four-step approach to developing its monitoring program including (a) identifying and stating the goals of the monitoring program, (b) developing conceptual models that describe ecosystems and link the components within them, (c) identifying potential indicators, and (d) selecting final vital signs from the list of candidate indicators. This is in line with recommendations set forth in Busch and Trexler (2003).

Assuming that each network adequately identifies issues facing natural resources, the end result is the compilation of two lists: one of specific monitoring questions, and a second list of potential indicators that can be monitored to answer those questions. In both cases the identification of questions and potential indicators lists are developed through a combination of literature review, expert opinion, conceptual modeling, and public scoping meetings. Invariably, the second list includes hundreds or thousands of potential indicators, only a small fraction of which will ultimately be chosen for Vital Signs monitoring.

Paring down the lists of indicators has been done following one or more of several methods including criteria matrices, consensus building, and BOGSAT (bunch of guys / gals sitting around a table). Other model-driven approaches include analytic group decision making / analytic hierarchy process (Schmoldt and Peterson 1997;Schmoldt and Peterson 2000). These methods have been implemented using a combination of computer software packages (such as Delphi) and facilitated meetings (Table A4-1). In all cases, the focus has been on describing qualities of candidate indicators and subsequently scoring and prioritizing those indicators based on those qualities (Table A4-2) (Jackson et al. 2000;Kurtz et al. 2001;Dale and Beyeler 2001). The strategy is based on selecting those monitoring variables that are most relevant to management concerns, logistically feasible, responsive to perceived threats and stressors, and easy to interpret and apply to environmental decision making.

Overall program design is then accomplished by selecting final vital signs from the top of the priority list (or near the top) to the extent that budgetary constraints allow. Often, this results in an inadequate suite of variables as they are biased toward one scale, technology, faunal group, etc., and a round of "horse trading" ensues until consensus is reached on a final set of Vital Signs. Although this procedure might result in a much more appropriate list of indicators, the methods by which changes are made can be haphazard at best, and arbitrary at worst. Usually, reasons for moving indicators up or down on a priority list are not documented. Further, although a consensual decision-making procedure may have intuitive appeal, it is important to recognize that this procedure by no means will yield the most efficient (or even *an* efficient) allocation of resources. The actual allocation will depend heavily upon the specifics of the "horse-trading", such as who is in a position to make proposals, what alternatives are considered, and in what order (Morrow 1994).

Review of the failure of these indicator selection methods is likely the result of making decisions based on two assumptions: (1) characteristics of individual indicators should drive monitoring program design, and (2) measurement of a single indicator provides sufficient information on which to base management decisions.

Assumption 1: Characteristics of Individual Indicators Should Drive Program Design

Although the attributes discussed in Table A4-2 are important when selecting indicators, at least two reasons exist for <u>not</u> using them as ranking criteria for potential indicators. First, ranking based on indicator characteristics (such as those in Table A4-2) is inherently flawed because individual indicators are evaluated based solely on the scientific / technical merits of the indicators themselves. However, a "best" indicator must also be based on a measure of how efficient it is at meeting goals of the entire monitoring program; a measure that necessarily changes depending on what *other* indicators are measured.

Second, any indicator must be considered in the context of what monitoring question is being asked, and at what scale. In other words, the question must be answered *"Is this indicator a <u>viable</u> indicator?"* For example, benthic macroinvertebrate community diversity is often used as an indicator of water quality (Barbour et al. 1996;Resh et al. 1996). Depending on whether managers are concerned with water quality at a local, watershed, or regional scale, macroinvertebrate community diversity might or might not be a *viable* indicator.

Viable indicators include those that can be used to answer specific monitoring questions at specific spatial and temporal scales given the current state of scientific knowledge. The criteria listed in Table A4-2 are more useful at determining whether a particular indicator should be considered in the first place – if potential indicators are too costly, logistically difficult, etc.; they do not meet the minimum requirements for inclusion in an indicator-base monitoring program.

When the process of vital sign selection is driven entirely by the qualities of individual indicators, there is a risk of losing sight of the monitoring questions and issues those indicators are trying to address – it ceases to be a goal-driven process. More important is the risk of losing site of which monitoring questions and issues are of highest importance, and to whom.

Assumption 2: Measurement of a Single Indicator Provides Sufficient

Information

The concept identifying one indicator to answer one or more monitoring questions is often thought to be the end goal of an indicator-based monitoring program. As a result, indicator selection necessarily focuses on the relative technical ability of any given indicator to answer its desired question(s). The traditional approach is therefore to identify indicators that are correlated with one or more components within an ecosystem, have known variances, and predictable responses to perturbations (natural and anthropogenic).

Although the statistical characteristics of any given indicator are important, it is equally important to note that indicators are seldom evaluated alone; those indicators are usually reported in the context of corollary data such as land use, season, etc. Many indicator-based monitoring protocols are themselves collections of indicators. For example, the methods discussed above of determining water quality based benthic macroinvertebrate communities in fact include a suite of indicators such as total taxa found, number of sensitive species found, number of taxa within sensitive groups, etc. Furthermore, the methods require a minimum level of habitat measurements, which are themselves indicators.

Consider the medical metaphor upon which the NPS Vital Signs monitoring program is based. Although a single vital sign might provide enough information to suspect that a problem exists, only in extreme cases does it properly diagnose what the specific medical problem might be (when the patient's heart rate reaches zero, everyone knows what the problem is!). However, a doctor would never rely solely on blood pressure data to diagnose a medical problem, and certainly wouldn't prescribe a treatment without more information such as a case history and / or lab tests.

Ideal indicators therefore, are those that not only provide an early warning for potential problems, but also allow managers to develop a "case history" of the ecosystem when considered in an integrative manner. In essence, individual indicators serve to both detect problems, and provide some level of context when trying to answer specific monitoring questions. Better indicators are those that provide context to multiple monitoring questions.

The Need for Another Method

Given the conditions of limited resources, and the need to divide those resources among multiple partners, resource allocation is as much dependent on the *process* as it is on the criteria for dividing those resources (Kreps 1990). The fact that all of the networks ended up with non-satisfactory lists of indicators (although individually scientifically sound) suggests that the processes used for Vital Sign selection were not well suited to the design challenge. More appropriate would be a selection method that explicitly accounts for:

- Assessing indicator utility based on synergism or redundancy with other indicators, in addition to technical merit. This implies focusing on *suites* of indicators rather than individual indicators.
- Incorporating individual Parks' needs and priorities into the decision-making process.
- Incorporating sociopolitical or other non-technical factors into the decision-making process in a formal and documentable manner.
- Developing legitimate alternative choices, all of which (a) meet minimum standards and needs of all Parks within a network, and therefore (b) represent viable choices for implementation.
- Providing a framework for selecting alternatives, and modifying those choices at a later time.

Welfare Maximization Model for Indicator Selection

The decision-making process that follows addresses the needs identified above, and is based on Bator's (1957) economic model designed to determine the best and most efficient distribution of multiple products to multiple constituents given limited resources. The underlying principle is to identify how an altruistic agent, who perfectly incorporates the interests of all of the relevant actors, would choose to allocate the existing resources. By doing so,

the model identifies one or more solutions that cannot make any one actor better off without making the group as a whole worse off. The model has been modified for multiple applications such as to advise crop rotation planning, company expenditures, and distribution air pollution credits (Bator 1957;Mclure 1968;Laudadio 1971;Grabowski and Mueller 1972). In each case the authors created a model to guide production levels that is inherently linked to both individual customers' preferences, and production costs.

Welfare Maximization is a three-step process:

1. Maximizing Production Efficiency. All possible combinations of resource allocation such that an increase in production of one product necessitates a decrease in production of another. Allocations that meet this criterion maximize production efficiency within budgetary or other resource constraints.

2. Maximizing Product Utility. Based on customers' preference, identify those resource allocations such that an increase in satisfaction for one customer necessarily decreases the satisfaction of one or more other customers.

3. Defining Constrained Bliss. From the combinations of production that both maximize production efficiency and utility, select the one production function that best meets the welfare of all customers. In this case, welfare is defined by the ethic of the group to whom the products are intended (*not* necessarily scientific).

For the purposes of monitoring program design, the model needs to be modified slightly such that the program is designed to produce answers to specific monitoring questions (the "products"), for fifteen Park units (the "customers") with differing preferences for those products. In such a program the Network will implement monitoring protocols (collection of indicators) designed to answer to one or more of the identified monitoring questions (Figure A4-1). A successful Vital Signs Monitoring Program under this model will be a balance of indicators (the "costs" of production) that maximizes the number of high priority and total questions answered at all parks.

Pivotal to the process are two explicit qualifications. First, all protocols must be related to one or more specific monitoring questions identified by at least one park within the network. Second, protocols may consist of single indicators, collections of indicators, or indicators and other associated information.

Given this framework, monitoring program design proceeds as follows:

1. Maximize Monitoring Efficiency: Identify all possible suites of indicators that can be implemented within varying budget constraints. At this point, each suite is a potential monitoring program. If one or more of the indicators can be removed from a suite without reducing the *number of questions* answered, the combination of indicators is inefficient and not considered further. The resultant set represents potential programs that maximize production efficiency.

2. Maximize Information Utility: Based on parks' priorities for receiving answers to specific monitoring questions, select from the set of efficient program possibilities those combinations of protocols that maximize (a) the total number of questions answered, (b) number of high-priority questions answered, and (c) average priority level of questions answered *for each individual Park* (Figure A4-2). At any given budgetary level, the resultant suites of indicators represent monitoring programs that can be implemented. In each case implementation of any of the alternative options would satisfy the needs and expectations of all Parks in the most efficient means possible.

3. Choose the Most Relevant Alternative: Select one option from the alternative potential programs for implementation based on qualities deemed important to the Parks and other stakeholders. This step assumes that although all potential alternatives represent desirable outcomes, some might be more relevant than others. Selection criteria can include scientific, social, or political considerations, and can be explicitly documented. This step is particularly suited toward a consensus-building process because regardless of the outcome, all parties are guaranteed a program that maximizes both utility and efficiency.

Maximizing Monitoring Efficiency

Identifying efficient potential monitoring programs is a two step process that includes conducting a (near) complete inventory of potential questions that might be answered by a monitoring program, and an estimate of indicator costs and overall budget constraints.

Step 1: Identify Monitoring Questions

Generating a comprehensive list of potential monitoring questions that the vital signs monitoring program might be able to answer is the first step in data gathering. To accomplish this, the SECN has compiled a list of all monitoring questions included in the first twelve network's Phase I and Phase II reports and associated appendices (Milstead and Stevens 2003;Emmott, Murdock, and Ranney 2003;Hubbard, Mau-Crimmins, Powell, Albrecht, Chambers, and Carder 2003;Leibfreid 2003;Welch 2003;Weber 2003). Where appropriate, monitoring questions were also included from the US Environmental Protection Agency's (2003) *Report on the Environment*, which included a list of monitoring questions applicable at the national scale. Evaluation and revision of the list of potential monitoring questions will be one of two major goals for public scoping meetings to be held at the end of FY 2004. Evaluation and revisions will be based on a combination of expert opinion, results from conceptual modeling, and summarization of natural resource issues and needs faced by the Parks in the Network.

Parks have identified specific resources or management issues of interest, and factors that either drive or alter those resources over space and time. In each case a specific question can be asked that might be answered through some level of ecological monitoring. Answers to those questions are the primary "products" of the Network. For example, one of the questions of interest to all parks within the Southeast Coast Network is the extent to which exotic plant management efforts are successful in meeting desired management objectives. The answer to that question, based on collection and analysis of data from one or more indicators, would then be a product of value to multiple parks within the Network.

It is important to note that the perceived value of any given product might differ among the parks. In the above example, a park that has only a few exotic plants would have a very different use for the answer to that question than a park with multiple large populations of exotic plants and an active exotic plant management program.

Step 2: Estimate implementation costs of potential indicators

The basic unit of production is the measurement, analysis, and reporting of data collected while implementing an indicator, or Vital Sign. Inherent in any given indicator, therefore is a measurement of field time, personnel requirements, data analysis and reporting time, and associated costs to the program to implement the indicator. Although the data, analysis, and reports can be considered as useful products to some individuals or organizations (including the Parks within the Network), for the purposes of the model they are not considered to be products of the Network. During the initial stages of planning, costs must be estimated, and can later be refined as more information is gathered.

As discussed above, the basic unit of cost is an indicator. An assessment of which indicators are relevant to answering the questions identified above needs to be conducted, which will allow for identification of those indicators that provide information relevant to multiple monitoring questions. Potential indicators are identified through review of existing protocols, research, and conceptual models upon which questions are based (if applicable). In most cases a particular monitoring question can be answered using a subset of all possible indicators that might apply.

If preferences and indicator relevance are determined as described, it is a relatively simple calculation to determine the degree of information richness of any given indicator at any given park through matrix multiplication (mathematical treatments are discussed below). Indicator cost can then be estimated based on the number of parks at which a particular indicator would be measured, if implemented.

Maximizing Information Utility (Generate Alternatives)

Generation of program alternatives is a five-step process, the goal of which is to identify suites of indicators that when considered as a group, answer the greatest number of questions (and high-preference questions) at all parks.

Step 1: Conduct Preference Analysis

The primary customers of the Monitoring Program are the parks that depend on the information to make management decisions. The decisions of *what to monitor* and *where to monitor* are therefore entirely driven by the needs of the parks, which are expected to vary.

Each monitoring question must then be evaluated by every park to assess its relevance for managing natural resources. This is critical not only from a modeling standpoint, but because national program priorities dictate that the monitoring program is to be designed to address issues of highest priority on each park. To accomplish the assessment of preferences, monitoring questions are categorized into six relatively broad categories ranging from "mandated" to "not the responsibility of the Park" (Table A4-3). Also included is a category for "Not Applicable" to account for those monitoring questions that relate to resources that a given Park does not have such as coast resources at an inland park.

The second goal of scoping meetings to be held at the end of FY 2004 is to obtain comments on park preferences from both internal and external experts. These meetings will not be designed to change preferences, but instead to give the opportunity to gather further information on particular issues and monitoring questions. Reassessment of preferences will be accomplished during scoping meetings to be held at each park during Phase II (FY 2005).

Other stakeholders obviously exist with interest in the program for a variety of purposes. These might include other state and federal agencies, academic institutions, regional and national offices within the Park Service, local partners, the general public, and others that might have use for the data and summary reports. Although information, reports, and data summaries might be tailored and delivered routinely to one or more of these stakeholders, these stakeholders are not considered to be the primary focus of the monitoring program.

Step 2: Calculate Options

All possible combinations of indicators are identified that have potential program costs with a projected program budget 1-1.5 times the actual estimated monitoring budget (estimated as the total budget minus overhead). This is done by summing the individual indicator costs as described above. Because of the large number of possible combinations of indicators (literally millions), this step needs to be automated using computers. The upper range of budget options is somewhat arbitrary, and can be further investigated during "what if" scenario exploration discussed below.

Step 3: Filter

After the first cut of potential programs has been generated, a course filter should be applied that removes any combinations that that do not include the measurement of required indicators. For example, all networks are required to incorporate pH, dissolved O_2, specific conductance, and temperature when implementing any water quality monitoring protocol.

Step 4: Programmatic Checks

Each suite of indicators then needs to be assessed to ensure that it meets minimum programmatic goals based on criteria such as those listed in Table A4-4. For example, it is a basic goal that at least one monitoring question needs to be answered at every park. Thresholds can be set for minimum number of questions answered per park, minimum number of high priority questions at each park. Also, "Program Relevance Scores" can be calculated for each park by summing the preference scores for all questions that would be answered at each park. These calculations can be completed during the generation of program options, and anything that does not meet minimum programmatic goals should be removed from consideration at this time.

Step 5: Indicator Utility Assessment

Maximization of overall indicator utility for all parks is the key principle of using a welfare maximization model (Bator 1957). If an indicator can be removed without changing the Program Relevance Scores for any of the parks,

the entire combination is therefore removed from consideration. The concept is that if a particular indicator fails to add enough information to answer a particular monitoring question, its inclusion in a final monitoring program is an inefficient use of resources. This is a fundamental difference in approach from other methods of vital sign selection. In every other case, decisions about whether or not to include indicators were based on the characteristics of the indicators themselves (see Table A4-2), as opposed to their relationship to one another or their utility to individual parks within their network.

Choosing Alternatives

The process described above should yield several alternatives for suites of indicators that could be implemented as Vital Signs in a monitoring program. Every one of the options that is considered from this point forward represents a potential program that will meet all of the goals set forth by the Network, with clearly defined expectations and benefits for each park. If multiple options exist (which is likely), a preferred alternative should be selected based on a consensus-building process among the parks within the network, and regional and national program leads with a stake in the final selection of vital signs. Cost estimates should be revised for each candidate program based on the protocols dictated by the indicators measured.

At this point it is appropriate to consider factors such as social and political ramifications for measuring (or not measuring) an indicator, staffing implications, logistics, equitability among parks, balance of time scales and spatial scales among the indicators, or any other mutually-agreed upon criteria upon which to arrive at an alternative to move forward with (Table A4-4).

Conclusion & Discussion

Other Economic Models

Welfare Maximization might not always be the most appropriate model upon which to base resource allocation natural resource management decisions. Other decision-making models include Pareto efficiency analysis, satisficing, and any type of voting-based process. Pareto efficient resource allocations are defined as those where reallocation of resources to make one individual (or Park) better off necessarily results in making one or more individuals (or Parks) worse off. Although Pareto efficient allocations are efficient, they are not necessarily desirable. For example, if all resources are allocated to a single park it is a Pareto efficient solution, though neither equitable nor desirable. However, the process of utility assessment in welfare maximization by design eliminates Pareto *inefficient* solutions and those solutions that are unreasonable. Decisions based on Pareto efficiency might be applicable in situations where the decision to include one or more partners in a potential program is also being evaluated (i.e., does it make sense to allocate monitoring resources to all of the parks within the network?).

Satisficing, also called MiniMax, is in essence the opposite of welfare maximization. It is based on minimizing harm of those among whom resources are to be shared. This model might be particularly well suited in situations where resources are to be shared among adversarial individuals or groups where common ground cannot be easily found.

Lastly, any voting mechanism can also be used, but it is important to recognize up front that such mechanisms are always politically rather than efficiency driven. As a result, the methods used to conduct the voting will drive the outcome rather than the overall goals. However, voting methods are particularly well suited for situations in which all (or none) of the alternatives being considered are reasonable solutions that if selected would satisfy all voting parties and meet the goals of the program. The methods we propose might in fact require Parks to rely on voting to select from alternative programs, but the process is designed to ensure that all of the choices represent “best” options that meet all of the programmatic goals.

Expanding the Public Health Metaphor

The NPS Vital Signs monitoring program is based on a public health metaphor whereby the goal is to measure the "health" of the ecosystem. Although ecosystem health is a loaded term that at best is undefined, and at worst cannot be defined, a reasonable assumption is that managers need to be able to identify when systems are in a poor health.

Like blood pressure, body temperature, or heart rate are for medicine, ecosystem vital signs are those indicators that help identify when portions of the ecosystem are in poor or even declining health. However, medical monitoring really has four types of measurements: vital signs / early indicator monitoring, case history investigations, diagnostic assessments, and recovery monitoring.

To take the public health metaphor to its logical conclusion, three types of data collection might be considered in an integrated monitoring program. This multi-tiered approach would include:

a. Vital Signs Monitoring that is specifically targeted toward identifying whether or not the ecosystem is in poor or declining health.

b. Case History Evaluations that assess the health of the ecosystem based on a variety of indicators and provide hypotheses as to potential root causes of environmental degradation.

c. Diagnostic Sampling that identifies and quantifies the magnitude, extent, and impacts of stressors on environmental systems, and the remedies for those stressors.

All three types of monitoring are required to provide a foundation of information to support adaptive management of natural resources. Using a welfare maximization model as described herein allows for the ability to monitor at both the "Vital Signs" and "Case History" levels, and by doing so provides a framework to implement additional diagnostic studies when necessary. Such a monitoring framework is a critical need in an adaptive monitoring framework.

Monitoring Within an Adaptive Management Framework

Because the NPS monitoring program is mandated to provide information relevant to management of natural resources at the Park level, programs need to be based around both identifying when ecological changes occur and determining likely causes of those changes. This necessarily means that programs must be designed at the least to provide early warning indicators (Vital Signs) as well as place indicator data in a larger context (landscape, land management, etc.), preferably within a framework for more intensive diagnostic sampling.

Program Expansion

The model provides a tool for basing requests for additional funds by allowing the Network to defensibly argue that if the program receives X dollars, it will be able to implement Y additional indicators that would answer Z questions of importance to parks. Ideally, the initially-selected suite of indicators should be based in part with any anticipated programmatic expansions during the implementation period.

Program Review

During five-year program reviews assumptions that went into the model should be checked. For example, this is an opportune time to recheck the park preferences for answering monitoring questions, updating indicator applicability matrices, estimated costs, and incorporate any new protocols that have been developed or identified.

Protocol Development

One potential use of funds is to invest in improving monitoring methodologies or developing new protocols entirely. In this model, the long-term ability to effectively *answer* a monitoring question is of higher importance than the long term implementation of a protocol. Therefore, it is to the program's advantage to change, update, or throw out protocols that do not sufficiently answer their intended questions or if better more efficient methods can be identified.

Partnership Identification

In much the same way that protocol development can be used as a strategy to improve program efficiency, the

model can be used to direct priorities for identifying partners to implement the program. Partners can potentially aid in the collection, analysis, or reporting of individual indicators, therefore reducing costs to the program.

Research

A second potential use of funds is to develop ways to answer more questions with any given indicator or group of indicators. Research dollars in this context would be focused on better understanding linkages among ecosystem components, agents of change, and expected responses, and identifying indicators that correspond to those linkages. The result of such research would be to increase the utility of any given indicator and would therefore make the indicator more likely to remain in future alternative selections.

Inventories – Synoptic Studies

Additional baseline inventories or synoptic studies that focus on a particular component of the ecosystems during any point in time potentially provide a wealth of information that can be useful for modifying existing priorities.

The use of a welfare maximization process has several advantages over other options, primarily because it provides a framework adaptation in the face of changing priorities. Because the model is explicitly tied to both budget constraints, and end-user priorities it allows for the exploration of scenarios where budgets increase, priorities change, partners are added or removed, or new methods or protocols are developed. A decision-making tool that is explicitly designed to make comparisons among potential management options is a critical and often lacking need for resource managers. Application of this model should prove to be a useful foundation not only for monitoring program design, but also for other aspects of natural resource management

Figures

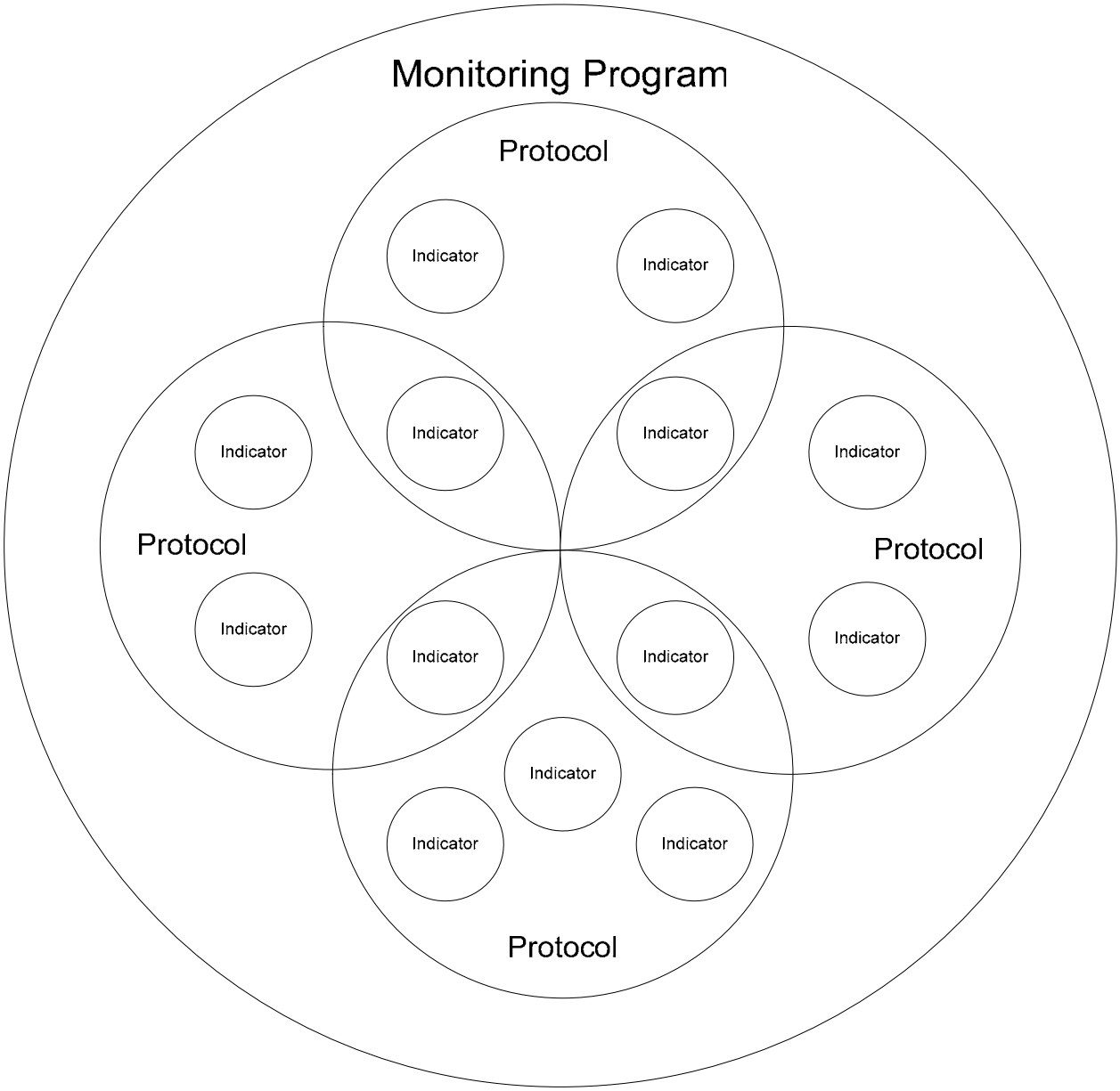

Figure A4-1. Hierarchy of indicators and protocols within an integrated monitoring program.

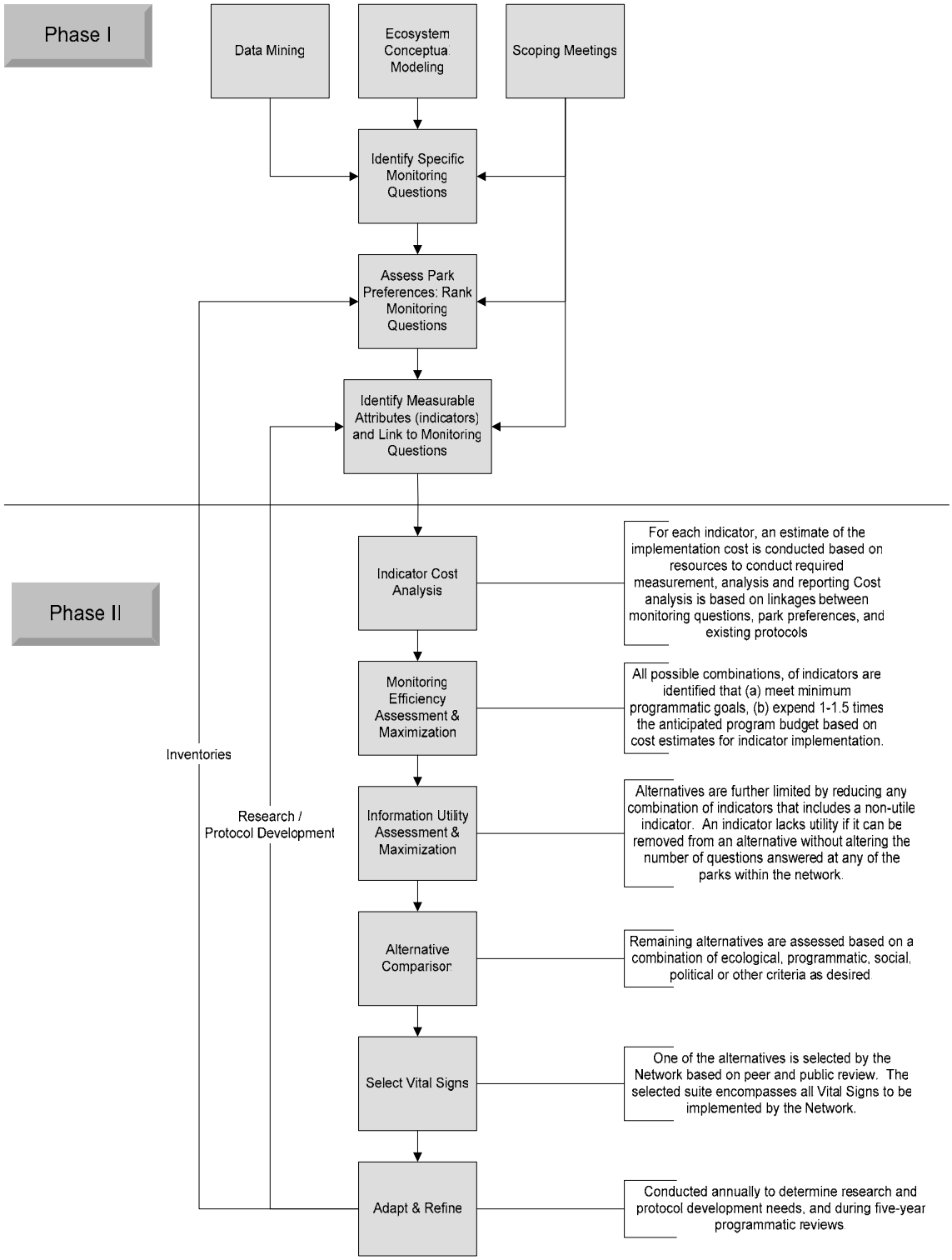

Figure A4-2. Implementation process for developing options for a Vital Signs Monitoring Program.

Tables

Table A4-1. Comparison of attributes of vital signs selection methods.

Vital Sign Selection Method	Prioritization of…	Choices Driven by…	Final Decisions based on…
BOGSAT	Indicators	Expertise / Knowledge of those at table	Consensus
Criteria Matrices	Indicators	Expertise / Bias of those applying Criteria	Highest Ranking Indicators, Consensus
Delphi	Indicators	Options included in software; expertise bias is controlled by facilitator	Highest Ranking Indicators, Consensus
Analytic Hierarchy Process (AHP)	Monitoring Questions or Indicators through multiple pairwise comparisons	Expertise / Bias of those evaluating pairwise comparison between questions or indicators	Highest Ranking Indicators, Consensus
Welfare Maximization	Monitoring Questions	End-User Needs, Economics	Alternative Comparison, Consensus

Table A4-2. Characteristics of effective monitoring variables (modified from National Park Service 2000;Jackson, Kurtz, and Fisher 2000;Kurtz, Jackson, and Fisher 2001;Dale and Beyeler 2001).

Relevant to Management Concerns and Ecological Resources

- Address monitoring questions of interest
- Have known linkages to ecological function or critical resource of interest
- Are at appropriate scales to answer specific monitoring questions
- Are integrative in space and time, so that the full suite of variables provides assessment of the entire system of interest

Applicable for Use in an Monitoring Program

- Are easy and practical to measure
- Are non-destructive or low impact to measure without disturbing the monitoring site
- Are measurable using standard well-documented methods
- Generate data that are compatible with other systems, partners, or programs
- Are cost-effective to measure

Responsive to Anthropogenic Stress

- Have known sampling and measurement error
- Have low natural variability
- Have predictable variability in time and space
- Are sensitive to anthropogenic stressors to target resources, while having predictable and limited sensitivity to other factors such as natural variations or disturbances

Interpretable and Useful for Environmental Decision-making

- Respond to stress predictably
- Are anticipatory: signal impending change in the ecosystem before substantial degradation occurs
- Are linked to management decisions; predict changes that can be averted or can result from future or past management actions
- Have known or expected thresholds of response that delineate acceptable from unacceptable ecological conditions
- Can be communicated to managers and the public

Table A4-3. Criteria for prioritizing potential monitoring questions.

Rank	Park Question	Example
5	Mandated (for the Park). The park is required to know the answer to the monitoring question as per legal or contractual obligations.	• Monitoring red cockaded woodpeckers. If breeding pairs are present on the park, required under the recovery plan to conduct 100% census of population on an annual basis.
4	Mission Critical. The Park should know the answer to this question to effectively manage its resources. Effectively answering this question through a monitoring program will shed light on multiple resource issues.	• Anything directly or explicitly mentioned in Park legislation or current / future management plans. Examples might include the size and impacts of horse populations at CUIS, water quality trends at CHAT, etc. • Success of NR Management, such as fire effects monitoring.
3	Mission Support. Answering this question would help the Park to better manage its resources, but is not necessary. Effectively answering this question through a monitoring program will shed light on multiple resource issues.	• Trends in external / adjacent land use • Trends and impacts of Air Quality (for some parks) • Habitat fragmentation
2	Answering this question is of interest to the Park, but is not necessary for natural resource management. Effectively answering this question through a monitoring program might or might not shed light on multiple resource issues.	• Research • Biological Inventories • Protocol Development
1	Not the responsibility of the Park.	• Marine Fisheries at CAHA (perhaps).
0	Not applicable to the Park.	• Estuarine processes at HOBE

Table A4-4. Suggested indicator characteristics for comparing alternative Vital Signs Monitoring programs.

Indicator Characteristic	Description	Potential Program Goal
Ecosystem Component	Structure: Habitats, and qualities of those habitats such as fragmentation. Function: Energy flow, nutrient dynamics, disturbance. Composition: Species diversity, trophic guilds, reproductive guilds.	Balance of indicators that measure structure, function, and composition
Conceptual Model Category	Agents of Change (leading indicators): Natural or anthropogenic factors that cause a change in the quality or quantity of target resources within the ecosystem. Target Resources: Structural, functional or compositional components of the ecosystem of interest. Expected Responses (lagging indicators):	Balance of indicators that includes agents of change, target resources, and expected responses.
Spatial Scale of variability		Indicators that span a wide variety of spatial scales.
Time Scale of variability		Indicators that span a wide variety of time scales.
Social-Political Desirability	Environmental Education Opportunities: Partnership Development:	Indicators that individually or in total provide information for a variety of non-target uses while at the same time do not inhibit the overall legitimacy of the program.

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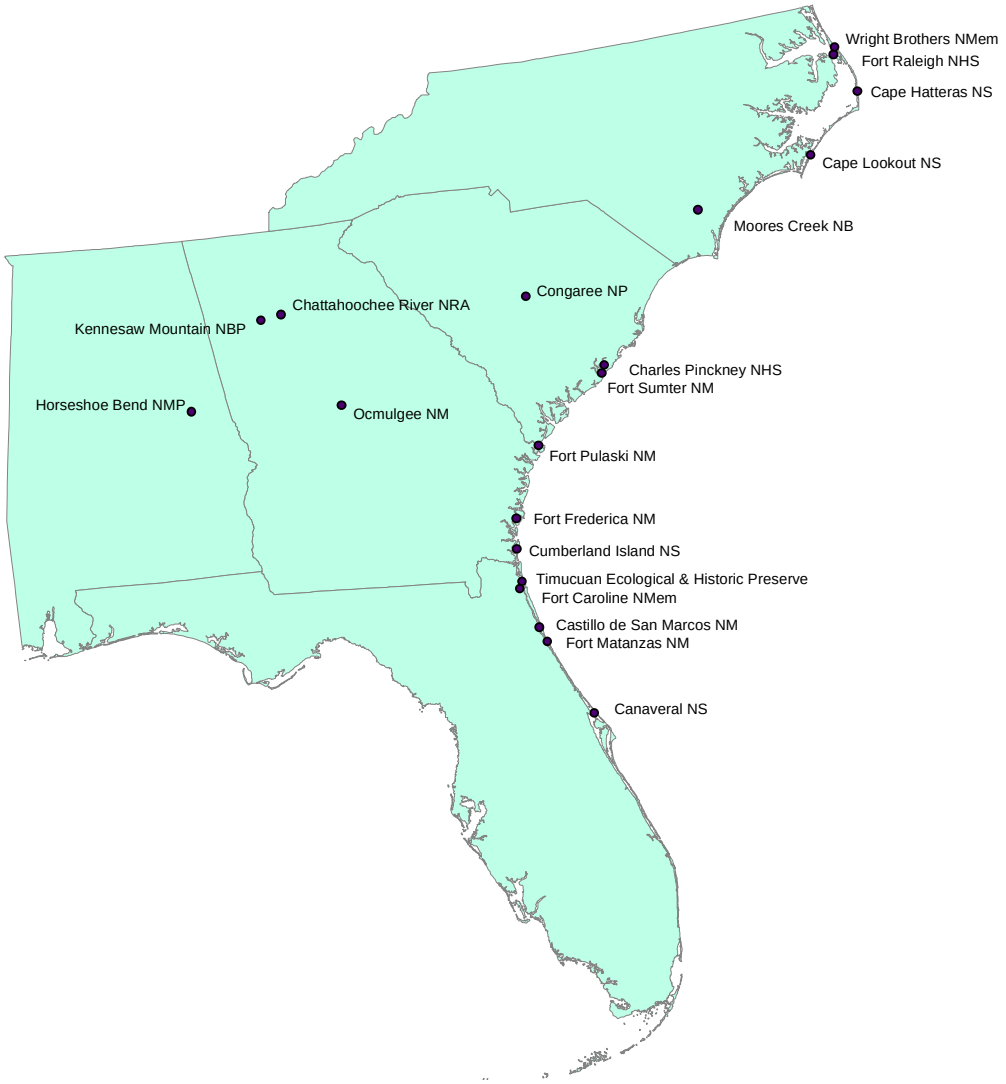
National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 5 – Summaries of Natural Resource Issues at Southeast Coast Network Parks



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Canaveral National Seashore (CANA)

Park Description

Canaveral National Seashore (CANA) consists of approximately 58,000 acres within the Mosquito Lagoon watershed. This National Park unit represents an excellent example of a relatively stable barrier beach backed by a productive lagoon system. Mosquito Lagoon is the northernmost part of the Indian River Lagoon (IRL) system, which contains the highest species diversity of any estuary in North America (Schmalzer 1995) and provides critical habitat for 14 federally listed threatened and endangered species, including the green sea turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), and West Indian manatee (*Trichechus manatus*). The far-reaching, ecological importance of this area has been demonstrated by the EPA in listing it as an Estuary of National Significance and by the state of Florida in classifying it as a Florida Outstanding Waterway and Aquatic Preserve, the highest level of state protection. Under these designations, ambient water quality must be maintained and protected, and any degradation must be short-term or temporary.

Park Mission relative to Natural Resource Management

CANA was established in 1975 to preserve and protect the outstanding natural, scenic, scientific, ecologic, and historic values of certain lands, shoreline, and waters of the State of Florida, and to provide for public outdoor recreation use and enjoyment of the same (16 USC 459j).

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Sea Turtles	• Exotic Animal Control
• Surface Waters	• RTE Species (general)	• Exotic Plant Management
		• Mosquito Control
		• Fire Management
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Fire Ants	• Atlantic Intracoastal Waterway
• Ozone	• Exotic Plants	• Aquaculture and Shellfish Harvesting
• Particulates	• Exotic Animals	• Septic Systems
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Erosion	• Salt Marshes	• Fire
• Overwash	• Coastal Dunes	
	• Estuaries	
Weather & Climate		Other Issues
• Hurricanes		• Visitor Use
• Lightning Strikes		• Disease Transmission

Water Resources

Water Quality: Surface waters within the study area are, with the exception of certain metals, generally of good quality and typical of the area (National Park Service 1994a). The source of elevated silver concentrations in Mosquito Lagoon that frequently exceed the acute marine criterion should be considered as a potential topic for research by the park. Potential anthropogenic sources of contaminants include municipal and residential development, septic tank systems, and wastewater discharges.

Surface Waters: Surface water resources in the CANA study area include the Indian River and Mosquito Lagoon.

Air Resources

Air Quality: Because surface waters associated with the park are either saline or tidally influenced, surface water acidification is not a concern for the park. Atmospheric deposition of nitrogen resulting in eutrophication is not an issue for the park.

Ozone: The low levels of ozone exposure and the relatively dry soil moisture conditions at Canaveral National Seashore make the risk of foliar ozone injury to plants low (National Park Service 2004a). While the Sum06 exposures exceed threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Soil moisture conditions of mild to severe drought reduce the effectiveness of the higher ozone exposures, and hourly concentrations of ozone only occasionally exceeded 80 ppb. If the level of risk increases in the future, a program to assess the incidence of foliar ozone injury on plants at the site could use one or both of the following bioindicator species: and American elder (*Sambucus nigra canadensis*).

Geologic Resources

Shoreline Erosion: A revetment has been installed immediately north of the northern park boundary. New current patterns can potentially cause erosion on park lands. Also, changes due to sea level change are unknown.

Overwash: In the event of hurricanes or big storm events, overwashes can weaken the overall dune system, particularly in places where the dune elevation is low. Following overwash disturbance, the dune system typically regenerates, but overwashes might also potentially threaten the road located behind a portion of the dune system.

Weather & Climate

Hurricanes:

Lightning: Canaveral NS is located in one of the most active lightning strike areas in the country.

Species of Concern (Threatened, Endangered, Rare, Special)

Sea Turtles: The Park documents 3,000 to 4,000 sea turtle nests each year. In the early 1980's, more than 95 percent were destroyed by raccoons (*Procyon lotor*). In 1984, the park began a nest screening program and has reduced depredation to less than 20 percent. However, this program is costly, averaging about $45,000 a year, and raises questions about the diverted predation pressure on other ground nesting species. Some parties recommend removing raccoons as a solution; in fact, MINWR does so with considerable success. Light pollution from directional sources is also a concern during nesting and hatching season.

Rare, Threatened, and Endangered Species (General): Canaveral is second only to Everglades National Park in number of federally protected species with 14. These include such species as the highly endangered West Indian manatee, right whale (*Balaena glacialis*) and little known Atlantic salt marsh snake (*Nerodia fasciata taeniata*), whose entire known range consists of a two counties in Florida. Canaveral's 24 miles of beach provides a critical nesting area for sea turtles, harboring 3,000 to 4,000 nests each year. The majority are loggerhead, with a smaller number of green (*Chelonia mydas*) and an occasional leatherback (*Dermochelys coriacea*). Mosquito Lagoon provides an important nursery area for juvenile sea turtles.

Exotic / Invasive Species

Fire Ants (*Solenopsis* spp.): Potentially a threat for nesting sea turtles.

Exotic Plants: Like a number of other parks in the southeast, Canaveral faces a serious threat from the invasion of exotic plants, including Brazilian pepper (*Schinus terebinthifolius*), Australian pine (*Casuarina equisetifolia*) and century plant / sisal hemp (*Agave sisalana*). Brazilian pepper has spread throughout virtually all of the disturbed areas of Canaveral. A small number of punktree (*Melaleuca quinquenervia*), a species that has severely impacted the Everglades, have been found in MINWR, less than 5 miles from the park boundary.

Exotic Animals: Exotic animals are also a threat to park resources. Feral hog (*Sus scrofa*) populations have become established in the southern half of Canaveral NS, particularly in the joint area, resulting in consistent disturbance of native vegetation and potentially improving habitat for exotic / invasive plant species. A voracious snake eater, it may also be affecting native snakes, including the protected eastern indigo snake (*Drymarchon corais couperi*). Another exotic animal impacting the park is the feral cat (*Felis catus*). During a two-year survey to determine the distribution of the southeastern beach mouse within Canaveral NS, no mice were captured in the northernmost section of the park (Stiner, 1991; Stiner, 1992). In addition, a number of potentially harmful amphibian and reptiles are expanding their ranges into Florida from tropical areas throughout the world. The park is attempting to detect these invaders through the long-term herpetofaunal monitoring program established by Southeastern Louisiana University in 1992.

Habitats & Communities

Salt Marshes / Mangrove Forests: A sign that CANA lies along a major transitional zone is the significant shift in vegetation along the edge of the lagoon from saltmarsh cordgrass (*Spartina alterniflora*), which predominates in areas north of Canaveral, to mangrove species that predominate to the south.

Coastal Dunes: Unlike many barrier islands, Canaveral has only a single dune ridge, averaging 12 feet in height. For the vast majority of its length the dune is quite stable, backed by a dense growth of saw palmetto (*Serenoa repens*) and several other species of hardy shrubs and grasses.

Estuaries: Mosquito Lagoon, extending along the backside of Canaveral's barrier island, is the northernmost part of the Indian River Lagoon. Containing the most diverse assemblage of aquatic species on the entire Eastern Seaboard, this 155-mile long lagoon has been designated as an Estuary of National Significance by the Environmental Protection Agency and an Outstanding Florida Water by the State of Florida. It contains one of the last significant populations of oysters on the entire Atlantic Coast that has not been depleted by over harvesting or pollution. Commercial shell fishing is extremely important to the local economy, while recreational fishing and shrimping in the lagoon support a multimillion-dollar tourist industry. The estuary also acts as an important nursery area for a number of commercially important ocean-going species such as flounder, mullet, black drum and shrimp.

Transitional Plant Communities: The Park is located along the "frost line", resulting in a unique combination of temperate and subtropical plants found nowhere else in the Western Hemisphere. Several temperate species extend no farther south than Canaveral, while a number of subtropical species occur no farther north. Signs of this unusual mixture include Canaveral's hammocks, which contain an overstory dominated by temperate species and an understory comprised of subtropical plants.

Oak Scrub: Major habitat for scrub jays, indigo snake and gopher tortoise

Pine Flatwoods: Harbors eagle nests on site.

Coastal Strands:

Oak / Cabbage Palm Hammocks:

Park NR Management

Mosquito Control: In the designation of lands for NPS management, both NASA and the State of Florida stipulated that CANA must cooperate with the local mosquito control districts to control salt marsh mosquitoes (*Aedes sollicitans*). The influence of various mosquito control techniques (e.g., impoundments, larvicides, etc.) and impoundment restoration measures on CANA's water resources are not fully understood (Walters et al. 2001).

Fire Management: High lightning strike frequency, combined with the volatile fuels (particularly saw palmetto) and the extremely high fuel loads, resulting from fire suppression and/or a lack of fire management, makes naturally- or human-ignited fire a serious threat. In addition, many vegetation communities are dependent on frequent light to moderate fires, as are the animals these communities support. A fire management plan has been completed which will allow the park to utilize prescribed fire to maintain and restore habitat for protected species such as the Florida scrub jay (*Aphelocoma coerulescens coerulescens*), gopher tortoise (*Gopherus polyphemus*) and indigo snake (*Drymarchon corais*) (National Park Service 1998c).

Long-term fire monitoring will measure the influence of fire on ecosystem structure and dynamics, identify areas for future research and validate the use of fire in perpetuating CANA ecosystems. The variables to be monitored will be those included in immediate postfire effects and variables which have been determined to be primary indicators of long-term change. CANA will determine primary indicators by examining park fire management goals and objectives and by consulting fire effects specialists (National Park Service 1998c).

Exotic Animal Management: CANA assists USFWS with hog trapping efforts (through field time, funding, traps bait, etc.), but the Refuge maintains primary responsibility for feral hog management. Overall, hog management is not currently as successful as desired / necessary to protect Park resources.

Exotic Plant Management: CANA is included in the Florida EPMT unit, managed out of Miami.

External Stressors

Atlantic Intracoastal Waterway: A survey by the Florida Inland Navigation District (FIND) in 1996 revealed significant shoaling of the Intracoastal Waterway (ICW), which is adjacent to or within CANA boundaries. FIND estimates that approximately 529,000 yd^3 of material will be dredged from the ICW in this area over the next 50 years. A 91.8-acre dredged-material management area 0.3 miles west of Mosquito Lagoon's western shoreline is where the dredged material will be piped in from the ICW and hauled away. A monitoring program is to be in place at all times because the release of contaminants (e.g., heavy metals) into local waters is potentially high during active dredging operations (Walters, Roman, Stiner, and Weeks 2001).

Aquaculture and Shellfish Harvesting: Aquaculture and commercial shellfish harvesting has increased in Mosquito Lagoon since the 1995 gill net ban went into effect in all Florida waters. The recreational harvest of clams, oysters, and crabs that occurs in CANA waters is not adequately monitored and the Park needs to ensure that these populations can sustain this harvest pressure. In addition, the Park is concerned with harvesting methods on associated fauna and flora, especially seagrasses (Walters, Roman, Stiner, and Weeks 2001).

Septic Systems: The nearby Oak Hill community is still on septic, as well as trailer parks on the northwest side of Mosquito Lagoon; both are potential sources of nutrient contamination. Within the Park, only a few buildings still have septic / drain fields.

Ecosystem Functions

Fire: CANA lies within an area that receives more thunderstorms than anywhere else in the entire United States. Until recently, FWS postulated that prehistoric fires burned all of the Canaveral area every 2-5 years.

However, recent research indicates that the natural burn cycle was somewhat longer, possibly 7-20 years, and fires burned in a mosaic, rather than uniform. Fire frequency fluctuated during the 20th Century, mainly in response to changing livestock policies (Davison and Bratton 1986). At the turn of the century, marsh, pine and scrub were deliberately burned every year between November and February to provide better livestock range. Burning in March was avoided because of high winds which could fan fires out of control.

Other Issues

Recreational / Visitor Use: Boaters are coming into Canaveral National Seashore in increasing numbers due to the growing popularity of fly-fishing for redfish. This increases the destruction of seagrass beds, impacts to fisheries are unknown and manatees are highly affected. One of the very controversial and volatile issues among boaters in Florida is the establishment of slow speed zones to protect the West Indian manatee. Canaveral has supplied sighting data and engaged in several discussions with DEP on the proper placement of slow speed zones in the vicinity of the park. The park also assisted DEP with a boating survey to determine boating use patterns and areas that warrant speed restrictions. A proposal was submitted in 2004 to conduct an aerial survey of boating use in the northern (NPS managed) portion of the Park.

Cape Hatteras National Seashore (CAHA)
Fort Raleigh National Historic Site (FORA)
Wright Brothers National Memorial (WRBR)

Park Description

The Outer Banks Group includes Cape Hatteras National Seashore, Fort Raleigh National Historic Site, and Wright Brothers National Memorial. Cape Hatteras National Seashore is part of the east coast barrier island system. The Seashore contains 35,400 acres of land and 74 miles of virtually unspoiled beach. The U.S. Fish and Wildlife Service administers Pea Island National Wildlife Refuge within the boundary of the seashore. The intensely developed town of Nags Head borders the northern end of the Seashore and eight other villages border the seashore. Seashore marshes contribute heavily to primary estuarine productivity and provide habitat for numerous wildlife and aquatic species. Buxton Woods is located on the widest portion of the Seashore and is one of the largest maritime forests on the east coast. Approximately one-third of the forest, about 1,000 acres, lies within Park Service boundaries. Of the rest, about 800 acres are under state protection. The unique and varied habitats, mature broad-leafed evergreen forest and shrub, freshwater marsh, and bog support an unusual assemblage of aquatic, terrestrial, and avian animals. Buxton Woods also overlies, protects, and provides for recharge of an important freshwater aquifer. The seashore has recently been designated a Globally Important Bird Area by the American Bird Conservancy because of the importance of the seashore habitats to avian breeding, migration, and wintering.

The ecological zonation of Cape Hatteras National Seashore is resultant in part on artificial alterations dating from the turn of the twentieth century. The most important perturbations were: (1) early efforts at mosquito control and waterfowl management which involved excavation of drainage ditches and construction of water control structures; and, (2) construction and vegetative stabilization of primary dunes along the length of the Seashore. Later changes were wrought when road construction included excavation of borrow ponds for road bed material. For the most part, these actions ended by the 1970's, save for localized projects designed to protect specific and discrete portions of infrastructure.

Fort Raleigh National Historic Site is located on the north end of the forested Roanoke Island between the barrier islands and the mainland of coastal North Carolina. The site's 355 acres vary in elevation from sea level to 20 feet. Approximately 80% of Fort Raleigh is heavily forested with the remainder of the area supporting a visitor center, administrative and maintenance buildings, residences, the Waterside Theatre complex, and maintained open grassed

areas. The maturing mixed deciduous and pine forest occurs on land that was previously disturbed, having been used for farming, grazing, transportation routes, and early settlement activities. Habitats include upland forests dominated by pines or a mixture of pine and hardwoods, brackish marsh, and swamp forests dominated by hardwoods. Species within the forest canopy include live oak (*Quercus virginiana*), laurel oak (*Q. laurifolia*), blackjack oak (*Q. marilandica*), American holly (*Ilex opaca*), dogwood (*Cornus* spp.), persimmon (*Diospyrus virginiana*), and loblolly pine (*Pinus taeda*).

Wright Brothers National Memorial covers over 421 acres in Kill Devil Hills, NC. The area's wind-blown sand flats and hills were the Wright brother's chosen practice field, and in 1903, the site of the first successful powered human flight. WRBR is situated on a barrier island within a rapidly developing residential and commercial community. The site has been transformed from its original relatively barren, dynamic state to a stabilized, dune and grass flat region. Grassed areas are vegetated with native and introduced grasses. Loblolly pine dominates the forested areas with laurel oak and live oak being the more predominant broad-leafed trees. Evergreen broad-leafed shrubs are interspersed within the forested area and between the forested and grassed areas. Much of the site is occupied by a visitor center, reconstructed buildings of the period, a monument, maintenance and residential structures, a paved airstrip, roads, walkways, and parking lots. Only limited vegetation and faunal inventories have been conducted at the site.

Developmental pressures outside the Park and visitor and recreational uses represent the major categories of threat to the integrity of natural resources on the Outer Banks Group parks. Adjacent property development has resulted in direct loss and fragmentation of habitat upon which numerous Park wildlife species were partially dependent. Replacement of natural areas with impervious surfaces increases storm water runoff with its associated contaminants. Two potentially profound adverse impacts associated with adjacent development are contamination of ground and surface water by septic leachate and drawdown of the aquifer associated with excessive groundwater withdrawals. Other threats to natural resources include the introduction of exotic plants and animals, off-road vehicle use, and dredging of channels adjacent to the park.

Park Mission relative to Natural Resource Management

None of the parks in the Outer Banks include language in their enabling legislation that specifically mentions natural resources management. However NPS is responsible for managing lands in accordance with the National Park Service Organic Act (16 USC 1) and National Parks Omnibus Management Act (Pub. L. 105-392) such that the Park makes sound resource decisions based on sound scientific data in an effort to leave resources unimpaired for the enjoyment of future generations.

Natural Resources Issues

The issues noted here are primarily for CAHA, though it is noted where applicable to FORA / WRBR.

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Septic Tanks	• Horses	• Exotic Plant / Animal Control
• Water Quality	• Sea Turtles	• Wildfire Management
• Hydrology	• Shore Birds	• Predator Management
• Park Facilities		• T&E Species Protection
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Fire Ants	• Adjacent Land Use
	• Exotic Plants	• Shellfishing Industry
	• Cactus	• Military Overflights
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Erosion	• Salt Marshes	• Barrier Island Rollover

- Overwash / Inlet Formation
- Soil Quality

Weather & Climate

- High Energy Weather Events
- Coastal Dunes
- Maritime Forests
- Natural Processes
- Biological Diversity

Other Issues

- ORV / Visitor Use
- Beach Nourishment

Water Resources

Septic Tanks: Septic systems from nearby communities present a source of nutrient contamination into estuarine and shallow groundwater bodies.

Water Quality: Surface waters at Cape Hatteras National Seashore include tidal creeks, freshwater creeks, and freshwater ponds, in addition to estuarine and nearshore marine waterbodies. The lands surrounding the rivers, streams and estuaries of the Albemarle-Pamlico estuarine system are undergoing changes (National Park Service 1994b). Increasing population, urbanization and industrialization are reflected in changing surface-water quality. Based on the data inventories and analyses contained in this report, surface waters within the CAHA study area generally appear to be of good quality, with some indications of impacts from development.

Hydrology: Wetlands at Cape Point have been ditched and flood-gated. The area is no longer a natural habitat and represents a high priority for Park management.

Air Resources

Air Quality: The 1994 *Baseline Water Quality Data Inventory and Analysis report* for Cape Hatteras NS suggests that all surface waters associated with the park are either saline or tidally influenced. If this is the case, then surface water acidification is not a concern for the park (National Park Service 1994b). The report did not indicate that nitrogen-associated eutrophication was an issue.

Ozone: The risk of foliar ozone injury at Cape Hatteras National Seashore is moderate (National Park Service 2004a). The threshold level for injury is consistently satisfied by the Sum06 index, while the W126 index satisfies the criteria on occasion. The N-values indicate that in some years there are consistent exposures to concentrations of ozone greater than 80 ppb, and significant hours of exposure at 100 ppb. The lack of a relationship between level of ozone and soil moisture suggests that conditions favorable for the uptake of ozone occur independently of the levels of exposure. This creates the possibility of reaching the threshold for injury when high levels of exposure happen to coincide with favorable soil moisture conditions. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: yellow-poplar (*Liriodendron tulipifera*), American sycamore (*Platanus occidentalis*), black cherry, American elder, crownbeard (*Verbesina* spp.), and northern fox grape (*Vitis labrusca*).

Geologic Resources

Shoreline Erosion: Active erosion is occurring downshore from revetments / riprap at Fort Raleigh National Historic Site, and is also of concern due to threats to the (old) coast guard station and the beach lot and facilities at Coquina Beach on Bodie Island. This, and its relationship to preserving Rte. NC12 may be the prime natural resource issue for CAHA.

Overwash / Inlet Formation: Large storms, as a part of natural barrier island geomorphology can cause a "flattening" of dunes resulting in the formation of new water channels. Hurricane Isabel created one such overwash inlet (Isabel inlet) in 2003, which has since been restored to pre-hurricane condition levels. Dune building by CCC in the 1930s (and maintenance of dunes until the 1970s) has altered the natural lense topography of Outer Banks barrier islands.

Boc and Langfelder (1977) used aerial photographic analysis to determine the distribution and extent of overwash sites along the North Carolina coast between the years 1938 and 1944. They described the types of overwash that occurred in each county during the study period, and assessed the susceptibility of selected areas within each county to overwash. Based on their findings, overwash frequency had declined over the course of the study period. This phenomenon was attributed to a decrease in the number of landfall hurricanes that have hit North Carolina in recent years and an increase in dune heights along the North Carolina coastline (Boc and Langfelder 1977). From 2001 to 2006, the North Carolina Coastal Geology Cooperative Research Program will be working on a model of the Outer Banks past, present, and future.

Soil Quality: Two superfund sites are located at or near Cape Hatteras National Seashore, in addition, the magnitude of contamination and / or impacts from off-road vehicles (i.e., tires and oil) is unclear.

Weather & Climate

Hurricanes: Hosier and Cleary (1978) analyzed storm washover impact and recovery patterns resulting from Hurricane Hazel (1954) and the March 1962 northeaster. The authors detected two basic geomorphic patterns of island recovery which they correlated with grain-size distributions of the washover sediments.

Species of Concern (Threatened, Endangered, Rare, Special)

Sea Turtles: Though nesting occurs at CAHA, numbers are typically lower than at other National Seashores within the network, because CAHA is at the extreme north limit of sea turtle nesting range. Loggerhead turtles are the bulk of nesters with a few green and leatherback sea turtles.

Shore Birds: Piping plovers (*Charadrius melodus*) and American oystercatchers (*Haematopus palliates*), and other colonial shorebirds are present and nest at CAHA. Primary threats to bird populations are predation and disruption from ORVs and pedestrians through direct mortality of individuals or eggs, or degradation of nesting or foraging habitats.

It is logical that some broad environmental factor, such as prey availability for chicks, is the reason for the poor productivity in North Carolina. Being at the southern extreme of the piping plover nesting range likely has limiting factors on nesting productivity that may not be overcome by the kind of management that is successful in the heart of the nesting range.

Exotic / Invasive Species

Fire Ants: Primarily a visitor use issue.

Exotic/Invasive Plants: At Fort Raleigh NHS, cultivars from the adjacent Elizabethan Gardens are expanding into park lands and present an ongoing control problem. Common reed (*Phragmites austrailis*) is present in many locations within and surrounding the Parks. Catus throughout much of the grass area at WRBR necessitates shoes and limits area for sitting on the gras.

Habitats & Communities

Salt Marshes: Because of the need to protect route NC12 along the barrier island sand moved west by high energy weather events such as northeasters and hurricanes is seldom allowed to migrate over to the sound side of the barrier island to build or sustain saltmarshes. The saltmarsh habitat in the park is being lost to rising sea level and the presence and maintenance of the only transportation route on the barrier island.

Coastal Dune System: The Enabling legislation allocates much of the park to a "primitive wilderness" (lower case "w") aspect. Coastal dunes are critical habitat for many species at CAHA, and are under severe pressure from visitor uses including ORV and foot traffic.

Park NR Management

Exotic Plant Management: CAHA is one of fourteen parks included in the Network's exotic plant management module being funded through CUIS.

Exotic Animal Control: Nutria (*Myocastor coypus*), red fox (*Vulpes vulpes*), and feral cats are the primary exotic animals at CAHA, both of which are growing in numbers. Currently feral cats are a larger problem due to impacts on shorebird and sea turtle nests, but nutria populations are growing in size and present a potential issue for cultural resources (i.e., the runway at Wright Brothers National Memorial). Red foxes, though not exotic, have currently undergone a range expansion into CAHA.

Predator Management: Red foxes, nutria, feral cats, and raccoons are the primary predators and are of extremely high concern for sea turtle and shorebird management. Current management strategies are limited to exclosure and trapping / removal. Ghost crabs (*Ocypode quadrata*) are another potential problem if population levels increase.

External Stressors

Adjacent Land Use: CAHA has seven small coastal villages interspersed within its authorized boundary. Each of which is dominated by residential land uses, primarily vacation rentals. The surrounding area of all of the Outer Banks parks continues to increase as a year-round recreation area.

Shellfishing Industry: Crab, scallops, shrimps, and oysters are all actively harvested by commercial shellfisheries located on the sound side of CAHA but all beyond the 150 foot sound-side boundary of the park.

Military Overflights: Aircraft overflights in CAHA and WRBR are increasing and potentially impacting the visitor experience and the native wildlife of the seashores. Transit ranges of three major military aircraft training facilities overlap the Seashores. In addition, two bombing ranges and the mid-Atlantic electronic warfare range are located only a few air miles from Seashore boundaries. An approximately 500-foot military tracking tower looms over the landscape of Bodie Island. No controlled evaluation of visitors' perceptions of this tower and other military operations has been conducted. Nor has the potential impact(s) of the overflights and structure on wildlife, including the federally threatened bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), and piping plover, been determined.

Proposed new U.S. Marine (Cherry Point) overflight areas will increase impacts to both the visitors and the wildlife of the seashores. If implemented, the seashores will experience increasingly active military airspace operations.

Overflights are obvious to the casual observer, but the frequency and type of occurrence are not well documented. Specific overflight studies need to be conducted to determine how best to preserve the natural sound, natural and cultural resources, and quality visitor experiences within the seashores.

Other Issues

ORV / Visitor Use: Area development and ORVs possibly represent the largest anthropogenic impact to natural resources at CAHA. Area growth and related recreation impacts are likely degrading the park resources. Area discussions of limiting development or ORV use are politically sensitive issues. Interpretation of the resource preservation aspect of the NPS and the idea of recreation in the enabling legislation for each of the

sites is difficult to combine. An environmental impact analysis is currently underway to assess the direct and indirect effects of allowing current levels of ORV access.

Beach Nourishment: Area communities are seeking assistance to attempt to prevent the effects of sea level rise and the impacts of frequent high energy weather events such as northeasters and hurricanes. This issue is linked to the methods of preservation of transportation along the Outer Banks.

Cape Lookout National Seashore (CALO)

Park Description

Largely undeveloped and accessible only by boat, Cape Lookout National Seashore is made up of three barrier islands covering 56 miles of the central coast of North Carolina. Most of the Seashore consists of North and South Core Banks, a 44-mile (71-km)-long barrier system oriented in a southwest to northeast direction and separated by the infrequently maintained New Drum Inlet. Cape Lookout extends into the Atlantic Ocean from its southern end, and abandoned Portsmouth Village is located at its northern end. The other barrier system within the Seashore, Shackelford Banks, extends westward from Cape Lookout and, while smaller (13 km long), is considered ecologically more diverse than Core Banks.

Core Banks is a long, narrow expanse of low dunes, maritime grasslands, and extensive salt marshes. Shrub thickets border the grassland in many places, and a low maritime forest occupies small areas of higher ground, such as Guthries Hammock. The islands are generally about 1 to 2 meters in elevation and 1 to 2 kilometers wide and are typically open and treeless. Windblown salt spray is carried across the entire barrier.

The wide berm and low, scattered dunes of Core Banks are characteristic of overwash-influenced barrier systems that have not been altered by man-made structures. When storms occur, the dunes here offer little resistance to flooding. Another process that has shaped these islands is the opening and closing of inlets. Dramatic changes in the positions of inlets may take place in the period of a few years or even months. Many of the creeks in the marshes along Core Banks have probably been Inlets in the past.

Although the physiography of Core Banks is more or less uniform along its length, the areas of Portsmouth Village and Cape Lookout are unique. Instead of exhibiting the typical zonation of a wide berm, low dunes, grasslands and shrub thickets, and salt marsh, the northern end of Portsmouth Island is characterized by vast tidal sand flats (averaging 1 km in width) located between the berm and the dunes of a series of marsh-fringed islands. At triangular Cape Lookout, continuous dunes similar to those on Shackleford Banks can be found on the southwest side, with several small freshwater marshes present in depressions between the dunes. With high dunes significantly reducing overwash, thickets have further stabilized the flats of the Cape's interior. A long spit extends from the western tip of Cape Lookout, where a jetty built in the early 1900s has encouraged accretion in this direction.

The dunes at the western end of Shackleford Banks are 10 to 13 meters (34 to 44 ft) above sea level and contain the highest elevations on Shackleford. The presence of high dunes on the western section may be due to the island's east-west orientation. Because the island faces the prevailing southwest winds rather than being parallel to them, sand is continually blown from the accreting beach into the dunes, where it is trapped and stabilized by seaoats (*Uniola paniculata*). In the lee of this wall of rolling dune ridges, there is an impressive maritime forest, as well as several fresh and brackish marshes. On the side of the island that faces Back Sound, the beach is narrow and, in some places, the scarped bank is eroding away. Unlike most of the Outer Banks, the inner shore here is not fringed with salt marsh.

The western end of Shackleford is an accreting sandspit. Young dunes with saltmeadow cordgrass (*Spartina patens*) and marsh fimbry (*Fimbristylis castanea*) are forming along the edge of the curving berm, while areas of salt marsh are developing on the sound side of the spit. The eastern two-thirds of Shackleford Banks consist of low dunes, grassland, and salt marsh. In contrast to the western third, it is influenced by overwash. This part of the

Island is characterized by dunes of less than 3 meters (10 ft) high, open grassland (on overwash terraces), mesic meadows, and salt marsh. Shrub thickets occur in a few areas.

Specific issues of concern to Cape Lookout National Seashore include off-road vehicle use and associated impacts to Dunes, threatened and endangered species, commercial fishing, military overflights, and non-native species.

Park Mission relative to Natural Resource Management

Cape Lookout National Seashore was established in 1966 to *"preserve for public use and enjoyment an area in the State of North Carolina possessing outstanding natural and recreational values."* Original boundaries comprised the lands and adjoining marshlands and waters on the outer banks of Carteret County, North Carolina, between Ocracoke Inlet and Beaufort Inlet, as generally depicted on the map entitled "Boundary Map, Cape Lookout National Seashore", dated March 1974, and numbered 623-20,009, which is on file in the Office of the National Park Service, Department of the Interior (16 USC 459g).

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Septic Tanks	• Horses	• Exotic Animal Control
• Water Quality	• Sea Turtles	• Exotic Plant Management
• Groundwater	• Shore Birds	
	• Sea Amaranth	
Air Resources	Exotic / Invasive Species	External Stressors
• Ozone	• Fire Ants	• Adjacent Land Use
	• Nutria	• Shellfishing Industry
	• Feral Cats	
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Erosion	• Salt Marshes	
Weather & Climate		Other Issues
• Hurricanes		• Visitor Use

Water Resources

Septic Tanks: Concession cabins, close to the park, are all on septic systems. Many of these were damaged by the Hurricane Isabel and washed out. As the historic structures near the Lighthouse are acquired, they will have to conform to county septic system standards.

Water Quality: Cape Lookout National Seashore comprises a series of undeveloped barrier islands along the Atlantic coast of North Carolina. Surface water resources in the study area include large expanses of salt marsh, bays, the North and Newport Rivers, and the Atlantic Ocean. Based on the data inventories and analyses contained in the baseline water quality report (National Park Service 1994c), surface waters within the study area are generally of good quality with some indications of impacts from human activities. Potential sources of contaminants include industrial and municipal discharges from Beaufort and Morehead City, and public recreational use.

Groundwater: Water samples from the lower confined aquifer, occurring at depths between 150 and 550 feet, generally met Environmental Protection Agency standards, though at some sites excessive concentrations of chloride, iron, and manganese were found. The potential yield for the lower aquifer was estimated at approximately 500 gallons per minute. The overlying unconfined aquifer was estimated to have a potential yield of up to 30 gallons per minute to a horizontal well in protected areas but episodic temporary contamination was expected in this aquifer from overwash during storms. The uppermost confined aquifer

at depths between 90 and 150 feet. yielded fresh water only in the vicinity of Drum Inlet and Harkers Island (Claxon and Renwick 1987).

Air Resources

Ozone: The risk of foliar ozone injury at Cape Lookout National Seashore is moderate (National Park Service 2004a). The threshold level for injury is consistently satisfied by the Sum06 index, while the W126 index satisfies the criteria on occasion. The N-values indicate that in some years there are consistent exposures to concentrations of ozone greater than 80 ppb, and significant hours of exposure at 100 ppb. The lack of a relationship between level of ozone and soil moisture suggests that conditions favorable for the uptake of ozone occur independently of the levels of exposure. This creates the possibility of reaching the threshold for injury when high levels of exposure happen to coincide with favorable soil moisture conditions such as 1996. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: yellow-poplar, black cherry, and northern fox grape.

Geologic Resources

Shoreline Erosion: CALO is undergoing a beach renourishment project to protect the land near the lighthouse and other sound-side structures. Already, one historic structure (a coal shed) has been lost due to erosion. The renourishment site will be roughly 100'x 1,700'.

Overwash: Boc and Langfelder (1977) used aerial photographic analysis to determine the distribution and extent of overwash sites along the North Carolina coast between the years 1938 and 1944. They described the types of overwash that occurred in each county during the study period, and assessed the susceptibility of selected areas within each county to overwash. Based on their findings, overwash frequency had declined over the course of the study period. This phenomenon was attributed to a decrease in the number of landfall hurricanes that have hit North Carolina in recent years and an increase in dune heights along the North Carolina coastline (Boc and Langfelder 1977).

Soils: Broome et al. (1973), in an investigation of saltmarsh cordgrass propagation, found fresh sediment to be the dominant factor in determining the height and yield of vegetation. More specifically, they found nitrogen availability to be the major limiting factor in productivity of marsh vegetation, with the lack of phosphorus and high salinity also negatively affecting growth. Troutman (Troutman 1980) examined soil-forming factors in Meade River, Alaska, and Portsmouth Island/Core Banks, with particular attention given to the effects of climate and soil on dune vegetation. The study concluded that vastly different climates can support dune soils with similar characteristics (low moisture content, high leaching) and plant communities which show similar adaptive responses. Perkins and Beck (1938) published a soil survey of Carteret County.

Weather & Climate

Hurricanes: Hosier and Cleary (1978) analyzed storm washover impact and recovery patterns resulting from Hurricane Hazel (1954) and the March 1962 northeaster. The authors detected two basic geomorphic patterns of island recovery which they correlated with grain-size distributions of the washover sediments.

Species of Concern (Threatened, Endangered, Rare, Special)

Horses: Horses at CALO are restricted to Shackleford Banks, except when displaced during storm events. The herd is currently ~125 individuals, with a management target between 110 and 130.

Sea Turtles: CALO has been monitoring marine turtles since 1976, and is a significant northern nesting beach that supports the highest number of loggerhead turtles in North Carolina (Cordes and Rikard 2003a). CALO is an index beach and implements a USFWS-standard protocol that allows for data comparison with other

nesting sites along the coast. Threats to turtle success include predation by raccoons, as well as nest disturbances by off-road vehicles.

Shore Birds: Piping plovers and oystercatchers are the two primary shorebirds of concern at CALO, with active management and monitoring to protect both species (through exclosures and restricted access). Like sea turtles, shore bird nests are particularly sensitive to off-road vehicles and predation.

In 2003 piping plovers nested on nine different islands in North Carolina (Cordes and Rikard 2003b). Each of the nine nesting islands had a different combination of predators, susceptibility to flooding and amount of disturbance from people. Productivity continued to be poor throughout the state (0.46 chicks fledged per nesting pair) despite the use of predator exclosures.

It is logical that some broad environmental factor, such as prey availability for chicks, is the reason for the poor productivity in North Carolina. Being at the southern extreme of the piping plover nesting range may have limiting factors on nesting productivity that may not be overcome by comparable management deemed successful in the heart of the nesting range. CALO and North Carolina contribute more to the survival of piping plovers as a migratory stop over and wintering area than as a nesting area.

Sea Beach Amaranth: CALO is home to the largest known populations of Sea Beach Amaranth, and monitoring is ongoing throughout the Park.

Exotic / Invasive Species

Fire Ants: Primarily a visitor use problem, but present.

Nutria: Present a problem due to rooting damage.

Feral Cats: Present at CALO, and of particular concern due to predation on both sea turtle and shore bird nests.

Habitats & Communities

Salt Marshes: Areas of frequent washover are dominated by annuals, plants that withstand frequent burial such as dune grasses, or salt-tolerant species (Hosier 1973). Fresh sediment input to the marsh was the dominant factor in determining the height and yield of saltmarsh cordgrass, and the marsh acts as a buffer for the entire estuarine system, providing a sink for excess nutrients which resulted from municipal wastes and land runoff (Broome et al. 1973).

Park NR Management

Exotic Animal Control: Currently management is limited to fencing out predators. A predator control plan is scheduled for future development.

Exotic Plant Management: Exotic plants are not a large issue at CALO as of yet, but limited populations of common reed exists on site, and when encountered are sprayed. CALO is one of fourteen parks within the network that is included in the EPMT module being coordinated through CUIS.

External Stressors

Adjacent Land Use: The local area is growing, with Beaufort adding commercial and industrial facilities. At the same time, residential land uses are rapidly growing with second-home dwellings being the primary building in the area.

Shellfishing Industry: Crab, oyster, scallops, shrimps, and oysters are all actively harvested by commercial shellfisheries located on the sound side of CALO. Overharvesting and netting issues are of concern to the Park.

Other Issues

Visitor Use: The primary concern with respect to visitor use is with regard to ORV use on beaches, primarily for fishing access. Threats from ORVs include nest disruption for both sea turtles and shorebirds. At the same time, personal watercraft use (boats, jetskis…) is increasing at Shackleford Banks, with landings approaching 300-400 crafts *per day* during the 4th of July weekend. With residential land use in the local area growing, both of these impacts might potentially rise in the future.

Castillo de San Marcos National Monument (CASA)
Fort Matanzas National Monument (FOMA)

Park Description

Castillo de San Marcos National Monument

Castillo de San Marcos National Monument comprises approximately 20.48 acres in St. Augustine, St. Johns County, Florida. The park lies north of St. Augustine's central plaza and fronts Matanzas Bay. Built as the northernmost Spanish stronghold in the southeastern United States and as a defense against pirate attacks on St. Augustine, the Castillo was originally located at the northern edge of the city, where it commanded the land and sea routes into the settlement. Today, colonial St. Augustine extends south of the monument, while the modern city has grown around this core in all directions (Brown 1997).

The city of St. Augustine lies on the eastern coastal plain of Florida. It is a low-lying, sandy area protected from the sea by a number of barrier islands. The San Sebastian River runs west of the city and formed a natural boundary for the colony early in its history. A seawall and water battery separate Castillo de San Marcos from the waters of Matanzas Bay on the fort's east side. The site of the Castillo is a rolling, grassy area sprinkled with a few trees. The outer portions of the grounds are flat up to the glacis, which slopes upward toward the fort and roughly follows the contour of the moat and covered way. The park area is irregular in shape, with much of its western boundary following the contour of State Road A-l-A.

Fort Matanzas

Fort Matanzas National Monument (FOMA) is located 14 miles south of St. Augustine on the northeast Atlantic coast of Florida. It encompasses of a total of 298 acres divided between the southern tip of Anastasia Island (108 acres) and the northern end of Rattlesnake Island (190 acres). Both are barrier islands separated from the Florida mainland by the Matanzas River and the Intracoastal Waterway.

The Anastasia Island portion of FOMA consists of stabilized beach dunes rising as much as 7.6 meters above sea level. Predominant habitats in this portion of the park include beaches along both the Matanzas River and the Atlantic shore, stabilized sand dunes supporting maritime forest, secondary dunes further inland, and salt marsh.

Most of Rattlesnake Island is less than 5 feet above sea level, though it rises to 15 ft at one point on it s northern end. Much of northern portion of Rattlesnake Island consists of sandy fill pumped in from dredging operations that maintain the boat channels in the Intracoastal Waterway. In addition to the habitats found on Anastasia Island, Rattlesnake Island supports slash pine and red bay woodlands, oyster shell beaches, and developing hardwood forests typified by wax myrtle (*Myrica cerifera*), red cedar (*Juniperus virginianus*), and cabbage palm (*Sabal palmetto*).

Park Mission relative to Natural Resource Management

In both cases, the Parks' enabling legislation does not specifically mention natural resources management, however, the CASA / FOMA is responsible for managing lands in accordance with the National Park Service Organic Act (16 USC 1) and National Parks Omnibus Management Act (Pub. L. 105-392) such that the Park makes sound

resource decisions based on sound scientific data in an effort to leave resources unimpaired for the enjoyment of future generations.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Sea Turtles	• Exotic Plant Management
• Surface Waters	• Beach Mice	
	• Least Tern	
Air Resources	Exotic / Invasive Species	External Stressors
• Ozone	• Exotic Plants	• Shellfish Harvesting
	• Feral Animals	• Adjacent Land Use
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Accretion	• Salt Marshes	
Weather & Climate		Other Issues
• Hurricanes		• Visitor Use Impacts
		• Off Road Vehicle Use

Water Resources

Water Quality: Based on the data inventories and analysis contained in this report, surface water quality within the study area appears to have been impacted by human activities. Potential anthropogenic sources of contaminants include municipal wastewater discharges; commercial and residential development; waterway navigation activities; stormwater runoff; recreational activities; and atmospheric deposition (National Park Service 1994d).

Surface Waters: Surface water resources in the FOMA study area include the Atlantic Ocean; portions of the Intracoastal Waterway; Matanzas River; Matanzas Inlet; Pellicer and other creeks; and numerous tidal swamps, marshes, and estuaries. Many of these water resources are influenced by tidal flow and contain fresh and saline waters in transition. Based on the data inventories and analysis contained in this report, surface water quality within the study area appears to have been impacted by human activities. Potential anthropogenic sources of contaminants include municipal wastewater discharges; commercial and residential development; waterway navigation activities; stormwater runoff; recreational activities; and atmospheric deposition.

Air Resources

Ozone: The Sum06 index exceeds the threshold for injury to vegetation (National Park Service 2004a). While the W126 accumulative value exceeded the threshold each year, the N100 count shows that the required number of hours was met in three of the years, although concentrations exceeded 100 ppb every year. The criteria for injury under the W126 exposure index are generally satisfied. It is anticipated that the risk of injury may be greatest in years when ambient levels of ozone are moderately high and soil moisture conditions favor uptake by plants. At present, no ozone-sensitive species have been identified at the site, and the risk remains unrealized.

Air Quality: Acid deposition is of concern to the park to because of the high susceptibility of coquina to dissolution. The fort at Castillo de San Marcos is constructed of coquina.

Geologic Resources

Shoreline Accretion: FOMA has actually increased in size by an estimated 13 acres over the past three decades. This continuing growth is evident in the expanding shoal banks inside and outside the Matanzas River inlet. Shoals inside currently allow fishermen on Rattlesnake Island to wade into the middle of the Matanzas River west of the inlet bridge, while shallow bars outside break Atlantic waves before they can roll into the mouth of the Matanzas River.

Weather & Climate

Hurricanes:

Species of Concern (Threatened, Endangered, Rare, Special)

Sea Turtles: Moderate threats to sea turtle nests are due to the high level of vehicular traffic on the beach (it is legally a state highway), and the threat of human poaching of new nests.

Beach Mice: Anastasia Island beach mouse (*Peromyscus polionotus phasma*) habitat, a small area (less than 5 acres) of habitat is located just behind the first barrier dunes on the beach, and is also threatened by overwash from extreme weather conditions accelerated by the vehicular traffic.

Least Tern: Minor threats include disturbance of a least tern (*Sterna antillarum*) rookery area by vehicles. In addition, natural plant succession is decreasing the attractiveness of the area as a rookery for the least tern.

Exotic / Invasive Species

Exotic Plants: Introduced plants pose another minor threat, competing with native species in several disturbed areas of the park. They are beginning to threaten the survival of some species and habitat.

Exotic Animals: Exotic Animals such as house cats, both feral and free roaming pets, are a direct threat to the Anastasia Island beach mouse. The common house mouse (*Mus musculus*) and the Norwegian rat (*Ratus norvegicus*) are considered potential threats to the Anastasia Island beach mouse and other indigenous mammals, as well as human health.

Habitats & Communities

Salt Marshes: The main structure of Fort Matanzas is located on a spoil island located in the middle of extensive salt marshes.

Park NR Management

Exotic Plant Management: FOMA / CASA is included in the Florida EPMT unit, managed out of Miami.

External Stressors

Shellfish Harvesting: Offshore shrimp harvesting has an effect of unknown magnitude on sea turtle mortality. However, mortality is documented at FOMA.

Adjacent Land Use: Paper mill and power generation facilities in the local area are contributors to potential air quality contaminants in the local area. The Parks are also potentially affected by airborne contaminants originating from nearby Jacksonville. Noise pollution is also of concern to the management of Fort Matanzas, whose interpretive mission includes the goal of providing an authentic atmosphere to visitors.

Other Issues

Off Road Vehicle Use: FOMA, in cooperation with the State DOT, will be installing two new parking lots and a Dune crossover trail all just north of the bridge and improvement of the parking area at the beach access. This project will help reduce the number of vehicles on the beach and provide a hardened interpretive trail that will help keep visitors out of the delicate dune ecosystem. Unfortunately, a separate threat also exists from occasional illegal "dune busting" by 4-wheel drive vehicles.

Visitor Use Impacts: Foot traffic into the dunes is a constant occurrence, creating blow-outs in the dunes, which reduce their ability to maintain plant life. The dunes directly protect the fort by reducing erosion of the barrier island that shields Fort Matanzas from damaging storms.

Chattahoochee River National Recreation Area (CHAT)

Park Description

On August 15, 1978, Congress passed Public Law 95-344 establishing Chattahoochee River National Recreation Area as a unit of the National Park Service. Congress authorized boundary expansions in 1984 and 1999. The park extends for 48 miles along the Chattahoochee River within the Piedmont Plateau, between the city of Atlanta and the Appalachian Mountains further to the north. The park contains mesic hardwood and pine uplands, scattered cliffs, floodplains, and riparian, aquatic and shoal habitats. The park also contains significant cultural resources, for the river corridor has attracted humans for thousands of years and the remaining features have recorded their passage and story. These natural habitats and cultural resources adjacent to, and partly surrounded by, the growing greater Atlanta metropolitan area, provide a unique opportunity for environmental education and resource-based outreach programs.

Chattahoochee River NRA (CHAT) consists of 15 separate units, however the park is currently acquiring additional land which will eventually link many of these units. The lands surrounding many of these units, especially at the northern end of the park, are experiencing rapid development and urban sprawl. This urbanization of adjacent lands has resulted in significant river and visual impacts. This rapid urbanization has taxed the region's sewer utility capacity. As a consequence, heavy rains and storm water runoff routinely causes sewer spills which flow directly into the Chattahoochee River. Additionally, siltation resulting from adjacent new development and land clearing is a consistent problem.

Park Mission relative to Natural Resource Management

Established in 1978, Congress found that "the natural, scenic, recreation, historic, and other values of a forty-eight-mile segment of the Chattahoochee River and certain adjoining lands in the State of Georgia from Buford Dam downstream to Peachtree Creek are of special national significance, and that such values should be preserved and protected from developments and uses which would substantially impair or destroy them… The recreation area shall consist of the river and its bed together with the lands, waters, and interests therein within the boundary…"

In addition to the lands managed exclusively by the National Park Service, Chattahoochee National Recreation Area has authority to facilitate "Federal technical and other support to State and local governments to assist State and local efforts to protect the scenic, recreational, and natural values of a 2,000 foot wide corridor adjacent to each bank of the Chattahoochee River and its impoundments in the 48-mile segment referred to above, such corridor is hereby declared to be an area of national concern" (16 USC 460ii).

Natural Resources Issues

Environmental Setting	Resources	Agents of Change

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Natural Hydrology	• Approximately 40 Federally and State Listed Species	• Fire Management
• Water Quality		• Fisheries Management
• Water Quantity		• Habitat Restoration
• River Regulation		• Exotic Plant Management
Air Resources	Exotic / Invasive Species	External Stressors
Air Quality	• Southern Pine Beetle	• Adjacent Land Use
• Ozone	• Exotic Aquatic Species	• Hydropower Generation
	• Exotic Plants	• Drinking Water Storage & Withdrawal
	• Exotic Animals	
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Sand and Gravel Mining	• Aquatic Communities	• Fire
• Shoreline Erosion		• Flooding
Weather & Climate		Other Issues
• Precipitation		• Dark Night Sky
		• Visitor Use Impacts

Water Resources

Water Quality: Point- and non point-source contaminants are of major concern to Park managers. Potential contaminants include nutrients, pesticides, heavy metals, sediment, bacteria, most of which originate from the urban landscape beyond the Park's boundaries.

Water Quantity: Stream water quantity is affected by regional climate (rainfall and drought), power demand, and available drinking water supply in Lake Sidney Lanier, located upstream of CHAT. Each of these three factors operates at different time scales ranging from hours ("peaking" from power generation) to years (water supply and climatic variation). One hundred fourteen direct water withdrawals are also present along the Chattahoochee mainstem and its tributaries within the 48 miles managed by CHAT. The cumulative volume of water withdrawn and its effect on Park resources is currently under study.

River Regulation: At the upstream terminus of the park is Buford Dam, which is operated by the Army Corps of Engineers. Buford Dam generates electricity and the impounded water, Lake Lanier, provides water to the greater Atlanta metropolitan region. The operation of the dam dramatically alters river flows and water temperatures within the park. River regulation has also lowered the temperature of the river to colder-than-natural levels, reducing success of native warm-water aquatic species.

Natural Hydrology: Wetland hydrology is disconnected, driven primarily by storm water management. Ditching and draining alters natural groundwater and surface water flows in both floodplain and riparian wetlands. The increased amount of impervious surface from heavy development has dramatically affected natural hydrologic conditions and has led to severe streambank erosion and siltation.

Air Resources

Air Quality: CHAT is currently designated a Class II air quality park, but the effects of metropolitan Atlanta on air resources is increasing. The effects of smog, ozone, particulates, and other atmospheric contaminants on natural resources are largely unknown. Because the population of Atlanta is expected to continue growing over the next several decades (Atlanta Regional Commission 1993), air quality is likely to be an ongoing and worsening issue.

Ozone: The risk of foliar ozone injury to plants at Chattahoochee River National Recreation Area is high (National Park Service 2004a). While the levels of ozone exposure consistently create the potential for injury, dry

soil conditions may reduce the likelihood of injury in a particular year. However, levels of exposure capable of producing foliar injury also occur under conditions of minor drought. The probability of foliar injury developing may be greatest during years in which ozone levels are somewhat reduced but still exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: spreading dogbane (*Apocynum androsaemifolium*), eastern redbud (*Cercis canadensis*), white ash (*Fraxinus americana*), yellow-poplar, American sycamore, black cherry, Allegheny blackberry (*Rubus allegheniensis*), cut-leaf coneflower (*Rudbeckia laciniata*), American elder, crownbeard, and northern fox grape.

Geologic Resources

Sand and Gravel Mining: Currently there are five permitted commercial sand and gravel mining operations within the park. All utilize suction dredging barges along with an upland dewatering plant.

Shoreline Erosion: Drainage / discharge sites, and sites of historic fishing docks along the mainstem Chattahoochee River are often sites of increased erosion. These locations present challenges for both natural resource maintenance programs, and potentially represent public safety hazards. Pulsing water releases from Buford Dam have scoured riverbanks and stream mouths in the northern sections of the park. Streams throughout the park are highly eroded due to adjacent development and increases in impervious surfaces.

Weather & Climate

Precipitation: The average annual precipitation for the Atlanta area is about 51 inches per year (Kunkle and Vana-Miller 2000). The precipitation depths are greater on going further north, and Lake Lanier receives approximately 3 to 4 inches more precipitation per year than Atlanta (according to U.S. Geological Survey isohyet maps for the area). Precipitation in the area occurs predominantly as rain; snowfall is only about 2 inches annually. Most of the thunderstorms in the area on an annual basis are small ones. Dry periods occur mainly during the late summer and early autumn; whereas, thunderstorms in July make that month the second wettest.

Exotic / Invasive Species

Southern Pine Beetle: Pine mortality by the southern pine beetle was exacerbated by drought conditions in the late 1990's. The extent of pine communities declined from roughly 1200 acres in 1999 to roughly 200 acres in 2002. This has increased fuel loading in former pine communities, and the number of hazard trees park-wide.

Aquatic Exotics: Exotic fish, plants, and invertebrates are all major components of the aquatic communities in the Chattahoochee River and it's tributaries within the metropolitan Atlanta area. Of particular interest to Park managers are Asiatic clam (*Corbicula corbicula*), Asian rice eel (*Monopterus albus*), parrot feather (*Myriophyllum aquaticum*), and common waterweed (*Egeria* sp.). The diversity and distribution of aquatic exotic plants is currently unknown but inventories are underway. An aquatic plant inventory found four exotic aquatic plant species in the Chattahoochee River National Recreation Area: Brazilian waterweed (*Egeria densa*), wartremoving herb (*Murdannia keisak*), parrot feather watermilfoil (*Myriophyllum aquaticum*), and alligatorweed (*Alternanthera philoxeroides*). These species inhabit the Chattahoochee River and various wetlands throughout the park.

Exotic Plants: Roughly 212 exotic plants are known to exist within CHAT. Of these, *Eleagnus* sp., English ivy (*Hedera helix*), Japanese honeysuckle (*Lonicera japonica*), kudzu, Japanese stilt grass (*Microstegium vimineum*), paulownia (*Paulownia tomentosa*), and privet (*Ligustrum* spp.) are of immediate management

significance. Most species have been introduced to adjacent lands as a result of landscaping or ornamental activities.

Exotic Animals: Fire ants

Habitats & Communities

Aquatic Communities: Fish, invertebrate, and algal communities within the Chattahoochee River and its tributaries are all of concern. Benthic macroinvertebrate communities might be good indicators of overall water quality.

Plant Communities: Plant community structure and composition was historically determined by a balance of flooding and fire cycles, both are now largely missing from the ecosystem. In addition, the influx of exotic plant species has further altered the system.

Park NR Management

Fisheries Management: The Chattahoochee River is inhabited by 22 species of game fish, including the largest stocked trout fishery in Georgia. Georgia Department of Natural Resources actively manages the fishery of the Chattahoochee River; CHAT, in cooperation with the Georgia Department of Natural Resources, is currently developing a fisheries management plan.

Fire Management: Fuel reduction is largely done mechanically due to wildland/urban interface concerns. The goal is to both reduce fuel loading for safety reasons while at the same time mimic ecosystem functions typical of a natural fire regime.

Habitat Restoration: The Park is partnering with the Corporate Wetlands Restoration Partnership, a group consisting of various federal agencies and local and national private corporations, on a multi-year project to restore and enhance habitats in an impacted urban wetland. Main objectives of the project are to control exotic species, restore native vegetation, stabilize hydrologic conditions, and stabilize stream channels. Other restoration projects in the Park include bio-engineered stream channel stabilizations, and re-vegetating Wildland/Urban Interface (WUI) sites. As part of the Park's damage assessment program, the Park is also pursuing several Park System Resource Protection Act (16 USC 19jj) cases in attempt to restore stream channels, river bank, and upland forested areas. The Park is also propagating and replanting Georgia aster (a Federal candidate species) at several locations to increase the populations of this relict species.

Exotic Plant Management: Chattahoochee National Recreation Area is one of fourteen park units included in the Southeast Coast Network's Exotic Plant Management module currently being managed by Cumberland Island National Seashore. The park has a long-standing volunteer program that targets mainly privet at locations throughout the park.

External Stressors

Adjacent Land Use: The highly modified and rapidly changing land uses associated with metropolitan Atlanta act as significant drivers of the environmental setting at CHAT. Soil loss, sedimentation, degradation of aquatic habitats, loss of topsoil, habitat fragmentation, edge effects, and other development pressures (roads, buildings, impervious surfaces) all potentially lead to changes in both the terrestrial and aquatic systems. Conversion of agricultural lands in the northern park units and upstream of the park causes soil loss, sedimentation, nutrients, and subsequent degradation of aquatic habitats. Loss of topsoil and associated organisms is also a potential issue. The high density of commercial / industrial land use with high degree of impervious surface results in both point- and non-point-sources of contaminants into water bodies. Residential land use in the metro Atlanta area has been cited as one of the major sources of contaminants in the Chattahoochee River System and its tributaries because of the application of lawn

fertilizers and pesticides (Hippe et al. 1995). In the watersheds encompassing the park, the residential land use is medium to high density and growing; the combination increases the amount of point source (wastewater treatment effluent) and non-point source contaminants to aquatic systems. Development in the area is a major cause of sediment inputs into river systems (Hippe et al. 1996). Encroachment by adjacent developers also has potential effects at the park boundaries.

Hydropower Generation: Large surges of water flow from upstream Buford Dam during electrical power generation on weekdays, while much less water is released on weekends when water supply demands are high (Kunkle and Vana-Miller 2000). Buford Dam was planned, designed, and constructed in the 1950s, emphasizing flood control, hydropower, navigation, and water supply/quality flows for the metropolitan Atlanta area. However, in 1989, the Corps recommended "reallocation" of water storage in the lake from hydropower use to water supply use (McMahon and Stevens 1995). In recent decades, recreation has assumed a much greater importance at the lake as well as downstream along the river in CHAT.

Morgan Falls Dam is approximately 35 river miles downstream of Buford Dam. Built in 1904 to generate electricity, the facility impounded the river and created Bull Sluice Lake. The lake has gradually filled with sediment, and is now relatively shallow. Below the dam, water temperatures are significantly warmer than above it, and peak releases from Buford Dam are moderated. Georgia Power is currently in the process of FERC re-licensing for Morgan Falls Dam. As part of the re-licensing process, Georgia Power is conducting a series of studies to investigate the effects of the dam operation on the following: geology and soils; water resources; fish and aquatic resources; wildlife and botanical resources; wetland, riparian, and littoral habitats; rare, threatened, and endangered species; recreation and land use; and cultural resources.

Drinking Water Storage and Withdrawal: Minimum flows in the river passing through CHAT are artificially controlled by upstream dam releases because Buford Dam must operate to maintain a minimum flow of 750 cfs for the intake of the City of Atlanta (Kunkle and Vana-Miller 2000).

Ecosystem Functions

Fire: In forested ecosystems such as those found in the Piedmont of North Georgia, and in particular CHAT, decades of fire suppression have led to detrimental effects on ecosystem integrity and loss of fire dependent species [e.g. Georgia aster (*Symphyotrichum georgianum*) and red cockaded woodpecker (*Picoides borealis*)] and an accumulation of woody fuels (National Park Service 2004b). Accumulations of combustible fuels near historic structures pose a high risk to the rich cultural resources on CRNRA. Kudzu, an invasive vine, accumulates flashy fuels quickly and poses a serious threat by providing ladder fuels that can facilitate the spread of wildfires into the forest canopy. Hazard trees pose an immediate risk to park facilities, staff, and visitors; neighboring buildings; and utility lines. Hazard trees, when felled, add to the accumulation of large woody fuels and can increase intensity of fire. Widespread mortality of loblolly pine due to bark beetle infestations in recent years has both added to the accumulation of fuel loads and reduced ecosystem integrity. In grasslands or wetlands, the accumulation of woody shrubs and nonnative vegetation can increase an already flashy fuel source. These fuel accumulations and altered vegetation structure increase the risk of high-intensity fires.

Flooding: Prior to completion of the Buford Dam in 1957, major winter and early-spring floods were a common occurrence and large floods of over 30,000 cfs occurred once or twice during most decades (Cherry et al. 1980;Collier et al. 1996). Extreme floods occurred at Atlanta in December, 1919 (peak of 63,000 cfs) and in January, 1916 (peak of 59,000 cfs). The latter would have been about 53,000 cfs at the upper end of the CRNRA. Since the dam's construction, flood peaks have been controlled (Kunkle and Vana-Miller 2000).

Other Issues

Visitor Use Impacts: CHAT constitutes an important outdoor recreation resource to over 3.7 million people located in the metropolitan Atlanta. The park's green space and the river significantly improve the quality of life by serving as a sanctuary as well as providing a variety of outdoor recreation opportunities such as hiking, nature viewing, paddling, boating, and fishing. The proliferation of unauthorized "social trails" located throughout the park have resulted in trampled vegetation, compacted soils, erosion, and streambank failures.

Dark Night Sky: Adjacent urban and suburban land uses alter the natural night sky. The effects on CHAT natural resources are unknown.

Congaree National Park (CONG)

Park Description

Congaree National Park is situated immediately adjacent to the Congaree and Wateree Rivers in southeast Richland County, South Carolina, approximately 20 miles southeast of the capital city of Columbia. The park protects towering old-growth trees and diverse plant and animal life within the largest contiguous bottomland hardwood forest remaining in the United States. Periodic flood waters from the adjacent rivers sweep through the bottomland forest in winter and spring, carrying the nutrients and sediments that nourish and rejuvenate this unique floodplain ecosystem. Nearly 90 species of trees grow within the park, with many that are recognized as national and state champions for their size. Forested wetlands, oxbow lakes, and slow moving creeks and sloughs provide superb habitat for fish, birds, reptiles, mammals and other aquatic life. The diversity of flora and fauna, tall tree canopy and giant trees, and intact floodplain ecosystem earned the park the designation of an International Biosphere Reserve, National Natural Landmark, Globally Important Bird Area, and congressionally designated Wilderness Area.

Congaree National Park encompasses a 26,800-acre bottomland hardwood forest in central South Carolina. The park borders the northeast side of the Congaree River and the west side of the Wateree River. Densely forested, most of the Park is located within the river floodplain. A wide variety of forest communities are represented, with dominant tree species ranging from upland pines to wetland cypress (*Taxodium* spp.) and tupelo (*Nyssa* spp.). The Congaree River forest environment is characterized by silty clay soils, oxbow lakes, swales and sloughs, and meandering creeks. The Congaree and Wateree Rivers are the major source of floodwaters, sediment, and nutrients delivered to the Park, although several tributary creeks also flow through it. The significance of CONG lies in its (1) unique old-growth bottomland hardwood forest community associated with the swamp-like floodplain; (2) remarkably large trees, including loblolly pine, bald cypress (*Taxodium distichum*), tupelo, sweet gum (*Liquidambar styraciflua*), American sycamore, cottonwood (*Populus* spp.), oak (*Quercus* spp.), and holly (*Ilex* spp.) trees; (3) the intact floodplain ecosystem, and (4) high biodiversity. On June 30, 1983 Congaree National Park was designated an International Biosphere Reserve, and on July 26, 2001, it was recognized as a Globally Important Bird Area.

Park Mission relative to Natural Resource Management

Congaree National Park's mission calls for accomplishing the long-term goal of "preserving, protecting, and perpetuating the bottomland hardwood ecosystem in a manner that promotes the natural function of the Congaree River floodplain by (a) managing and restoring designated wilderness areas and all-inclusive wetlands, so as to minimize disturbances to natural landforms, vegetation, and wildlife habitat, and (b) conserving the rich and abundant biodiversity within the Congaree and Wateree River alluvial floodplains by controlling, where necessary, the adverse effects caused by human activities.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Birds (general)	• Exotic Plant Management
• Surface Waters	• RCWs	• Fire Management
• Water Quantity	• Champion Trees	
• Flooding	• Listed plants	
• Groundwater		
Air Resources	Exotic / Invasive Species	External Stressors
• Air Toxics	• Exotic Aquatic Species	• Adjacent Land Use
• Surface Water Chemistry	• Exotic Plants	• Hydropower Generation
• Ozone	• Feral Animals	• Hunting
• Vegetation Effects	• Exotic Animals	
	• Forest Pest Species	
Geologic Resources	Habitats & Communities	Ecosystem Functions
	• Fish Communities	
Weather & Climate	Unique Areas	Other Issues
• Droughts		• Noise Pollution
		• Light Pollution

Water Resources

Water Quality: Baseline water quality inventories and analyses indicate that surface waters within the study area have been impacted by human activities (National Park Service 1998a). Potential anthropogenic sources of contaminants include municipal and industrial wastewater discharges; urban and residential development; storm water runoff; agricultural and silvicultural operations; quarrying operations; recreational use; landfill operations; atmospheric deposition; and military operations.

Surface Waters: Surface water resources in the CONG baseline water quality study area include the Congaree, Wateree, and Santee Rivers; Congaree, Wateree, and other swamps and wetland areas; Weston Lake Dam at Fort Jackson and numerous other reservoirs; Cedar, Toms, Gills, Congaree, and many other tributary creeks; and numerous oxbow and other natural lakes and ponds (National Park Service 1998a).

Flooding: The Congaree River overflows it banks approximately 10 times a year. Flooding, which typically occurs in late winter and early spring, may last from a few days to a few months. As much as 90% of the park is inundated at least once a year (National Park Service 2003b). Flood frequency and magnitude at CONG have been affected by upstream impoundments, most notably the Saluda Dam. Floods with a 2-year recurrence interval before the dam had only a 4.5-year recurrence interval after the dam. Even more noticeable was that a 5-year recurrence flood before the dam was only a 25-year recurrence flood after the dam. The effect of decreased flood frequency on the aquatic communities in CONG is unknown.

Groundwater: USGS is currently monitoring groundwater, and has recently installed a network of wells to study the effects of altered hydrology on ground and surface water resulting from the upstream Saluda Dam and associated hydropower facilities. Data from this study will be important for FERC relicensing proceedings if groundwater resources are affected by upstream hydropower facility management.

Natural Hydrology: Hydrology is the single most important factor integrating the natural, physical and biological components of the Park (National Park Service 2002b). Two comprehensive studies have previously described a framework for understanding the linkages between the hydrological network and the dependent vegetation communities (Patterson et al. 1985;Rikard 1988).

Air Resources

Air Toxics: Atmospheric deposition of metals (particularly mercury) from local commercial / industrial facilities is of concern to the Park. Congaree is classified as a Class II clean air area (42 USC 7401 et seq.). The Environmental Protection Agency (EPA) has established ambient air quality standards that may not be exceeded. Under Class II, modest increases in air pollution are allowed beyond baseline levels for sulfur dioxide and particulate matter, provided the National Ambient Air Quality Standards, established by the Environmental Protection Agency, are not exceeded (National Park Service 2002b).

Surface Water Chemistry: Samples collected in lower Tom's Creek, Cedar Creek, and the Congaree River had average pH values of 5.9 to 6.5, with a minimum pH of 5.1 (National Park Service 1998a). The average ANC value on Cedar Creek was 38 µeq/l, and the minimum value was 16 µeq/l. The average ANC on the Congaree River was 160 µeq/l and the minimum value was 64 µeq/l. Weston and Wise Lakes also had low pH values, with an average pH of 5.9 and a minimum of 4.0. These data indicate surface waters in CONG are extremely acid sensitive, and it's possible that they currently experience episodic acidification (i.e., precipitation events that cause the creeks and lakes to lose all buffering capacity for a short amount of time). There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics might be of concern for the park.

Ozone: The risk of foliar ozone injury at Congaree National Park is low (National Park Service 2004a). While the threshold level for injury is satisfied by the Sum06 index, the N-values indicate that there are only occasional exposures to concentrations of ozone greater than 80 ppb and exposures above 100 ppb are rare. Relationships between levels of ozone and soil moisture are inconsistent, but suggest that conditions limiting the uptake of ozone occur during most years and may be most prevalent during higher ozone years. It is anticipated that the risk of injury may be greatest in years when ambient levels of ozone are high and soil moisture conditions favor uptake by plants. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: eastern redbud, white ash, yellow-poplar, American sycamore, black cherry, American elder, and crownbeard.

Weather & Climate

Droughts: CONG climate is marked by extreme events—both flooding and droughts. During periods of prolonged drought, stressors to vegetation communities potentially have larger-than-normal affects. Wildfire and forest-pest (i.e., turpentine beetle) outbreaks have both been linked to periods of prolonged drought.

Species of Concern (Threatened, Endangered, Rare, Special)

Birds (general): More than 175 species of birds are known to inhabit Congaree National Park (Carter 1995). Water birds, songbirds, raptors [including the relatively common barred owl (*Styrix varia*)], and turkeys (*Meleagris gallopavo sylvestris*), are some of the birds found in the area. The wood duck is the most common species of waterfowl. Events such as Hurricane Hugo have created more diversity in habitat (more open areas and nesting opportunities). More bird species began frequenting the Park after Hurricane Hugo due to the increased amount of open areas caused by wind damage. The intact forest canopy blocks much of the light that would support an understory shrub layer; however Hurricane Hugo and routine storms have produced enough tree-fall to sustain shrub habitat throughout the Park (National Park Service 2002b).

RCWs: As late as 1996, the federally endangered red-cockaded woodpecker (RCW) was known to have active colonies on pine uplands within a small portion of the Park (National Park Service 2002b). In the summer of 1993, a population and habitat survey confirmed 4 birds and 9 active cavity trees. This species has received a considerable degree of management focus, as reflected in current management plans and actions. Prescribed fire was used to enhance a 300-acre plot of RCW habitat during the last three years. Currently

no RCWs are located within the park, but habitat is present and maintained for potential future adoptions of populations.

Champion Trees: CONG trees representing nineteen different species are either State or National champion specimens. Though not managed for individually, the trees are of high interest to visitors and naturalists alike.

Listed Plants: At least ten state listed plant species have been found within the Park.

Exotic / Invasive Species

Exotic Aquatic Species: The only known aquatic invasive animal at CONG is the Asiatic clam (*Corbicula corbicula*). Likely it was introduced into the system through disposal of aquarium water.

Exotic Plants: More than 25 species of non-native plants have been documented at CONG including Chinese privet (*Ligustrum sinense*), Japanese stilt grass, Jerusalem cherry (*Solanum pseudocapsicum*), and kudzu.

Feral Animals: Feral hogs and dogs are the primary concern; cats have not been known to be a problem at CONG. Feral dogs are both strays and loose hunting dogs from adjacent lands where hunting occurs. Affects on native flora and fauna are unknown. Feral hogs are present throughout the park and potentially cause much habitat degradation within the floodplains of the Congaree River and its tributaries.

Exotic Animals: Fire ants.

Forest Pest Species: Southern pine beetles and black turpentine beetles have both been recorded in the park and have caused damage to tree stands. Significant damage to pine stands was caused in 2002 by black turpentine beetles. Gypsy moths, though not yet recorded in the park, are also a management concern.

Habitats & Communities

Fish Communities: At least 59 fish species are present within or adjacent to park boundaries (Rose 2002). Of those, 56 have been documented in the park, and 3 have been documented in off-site, nearby locations.

Longleaf Pine Forests: Longleaf pine (*Pinus palustris*) stands within CONG are managed primarily for RCW habitat.

Pine Plantations: CONG has 2,000 acres of stagnant pine plantation.

Park NR Management

Exotic Plant Management: CONG is one of fourteen parks included in the Southeast Coast Network's exotic plant management module being administered by CUIS.

Fire Management: Director's Order 18 requires managers to conduct fire effects monitoring and long-term monitoring to assess the outcomes of wildland and prescribed fires relative to short-term and program goals (National Park Service 2003b). CONG will conduct its fire monitoring program in accordance with the NPS Fire Monitoring Handbook (National Park Service 2001b), which outlines standardized methods to be used for monitoring both wildland and prescribed fires. Monitoring protocols will be reviewed and approved at the Southeast Regional Office level before receiving funding.

External Stressors

Adjacent Land Use: Congaree National Park is surrounded by significant agricultural, commercial/industrial, residential, and silvicultural land uses. Nearby agricultural impacts include sedimentation and pesticide/herbicide impacts on regional groundwater supplies. Threats from nutrient inputs from high-density aquaculture are also a concern, as well as the possibility for introduction of non-native fish species

during routine flooding events. Several industrial entities are located in the area with permitted discharges. There is an EPA Superfund site within five miles of the Park. Residential land use (and conversion to residential land use) is a large source of impacts on surface waters through nutrient and sediment loading. Future impacts to drinking water supply needs have not been assessed. Adjacent silvicultural lands pose a potential source for outbreaks of forest pest species.

Hydropower Generation: The Saluda Dam is a water supply and hydropower generation facility located 38 river miles upstream of CONG that is scheduled for FERC relicensing in 2010 (extended by FERC from 2007) (National Park Service 1998a). After Saluda Dam became operational in 1930, the frequency and magnitude of floods on the Congaree River floodplain, including Congaree National Park (CONG), decreased (Patterson, Speiran, and Whetstone 1985).

Hunting: Several hunting clubs immediately adjacent to the park boundary, as well as in the surrounding area potentially add pressure to the game species found at CONG, such as white-tailed deer (*Odocoileus virginianus*) and turkey. These lands might also be a source for feral hog populations.

Superfund Sites: An Environmental Protection Agency Superfund Site is located five miles from the Park's northwest boundary and might potentially be a source for current and/or future soil, groundwater, or surface water contamination.

Other Issues

Noise Pollution: Military pilots occasionally use the river corridor for maneuvers. Park staff has observed military jets and helicopters violating the minimum 2000 feet (36CFR) airspace ceiling that is required when flying over the Park. In particular flights between 500 and 1,000 feet above the ground and along the river are the major concern because the noise disrupts the wilderness experience for visitors, and roosting and nesting of bird species might be negatively impacted (National Park Service 2002b). Key personnel at McEntire Air National Guard Base and Shaw Air Force Base have been contacted regarding this matter and have expressed an interest in cooperating.

Light Pollution: Light pollution from nearby Columbia interferes with Wilderness designation.

Disease Transmission: Monitoring for mosquito-borne diseases (such as West Nile Virus, Eastern Equine Encephalitis and St. Louis Encephalitis) has been conducted within CONG, but all cultures have been negative. Twenty-four species of mosquitoes have been identified at the park.

Visitor Use Impacts: Off-trail hiking and the creation of social trails and the subsequent effects on natural resources is a concern. The primary cause of the creation of social trails is to access the resident champion trees. Soil compaction around base of these champion trees is a long-term concern to park management.

Cumberland Island National Seashore (CUIS)

Park Description

Cumberland Island, a 26 km (17 ½ mile) long sandy barrier island, is one of the larger and more diverse islands on the Atlantic Coast. It totals 14,743 ha (36,415 acres) of which 6,821 ha (16,850 acres) are estuarine. A cordgrass (*Spartina* spp.) grass dominated salt-marsh, oyster mud flats and six tidal creeks provide the habitat for a diverse assemblage of marine-based fauna. The remaining acreage is terrestrial. A live oak/palmetto dominated forest backs an extensive dune system. As the elevation of the island rises in the northwest, a mixed pine-deciduous forest can be encountered. The island is known for nesting loggerhead sea turtles, abundant shore birds, undeveloped dune fields, maritime forest ecosystems, freshwater wetlands, and the historic structures in five historic districts on the National Register of Historic Places.

Park Mission relative to Natural Resource Management

Cumberland Island National Seashore was established in 1972, to preserve the scenic, scientific, and historical values of the largest and most southerly island off the coast of Georgia. Cumberland Island is also part of the South Atlantic-Carolinian Biosphere Reserve and will be permanently protected in a primitive state. The northern half of the island has also been designated a wilderness area. This unspoiled environment, once prevalent on all the barrier islands, provides a unique opportunity to experience the flora and fauna of a natural coastal ecosystem.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Channelization	• Sea Turtles	• Exotic Animal Control
• Water Quantity	• Shore Birds	• Exotic Plant Management
• Septic Tanks	• Wood Stork	
• Water Quality	• Red Cockaded Woodpeckers	
• Saltwater Intrusion	• Reptiles & Amphibians	
• Artesian Wells	• Manatees	
• Groundwater		
• Freshwater Sloughs, Lakes, & Streams		
Air Resources	Non-Native / Invasive Species	External Stressors
• Air Quality	• Fire Ants	• Adjacent Land Use & Development
• Ozone	• Exotic Plants	• Fishing Industry
	• Armadillo	• Naval Submarine Base
	• Feral Hogs	• Shipping & Boating
	• Feral Horses	• Coastal Zone Management
		• Dredging
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Erosion	• Salt Marshes	• Fire
• Dune Dynamics	• Coastal Dunes	
• Long Shore Sand Budget	• Plant Communities	
Weather & Climate	Unique Areas	Other Issues
• Hurricanes	• Designated Wilderness Area	• Visitor Use / Recreational Activity
• Drought		• Causeways
• Sea Level Change		

Water Resources

Channelization: Historically channelized streams and wetlands exist on CUIS, but the effects of that legacy on natural hydrology are unknown.

Water Quantity: On CUIS, freshwater is primarily available from the surficial and Upper Floridan aquifers, which on Cumberland Island are not hydrologically connected (Frick et al. 2002). The effects of regional water withdrawals on groundwater supplies is of concern as water use on the mainland increases over time, but the degree to which resources on Cumberland Island are affected by those withdrawals remains unclear. The 2002 shutdown of the Durango Paper Mill in St. Mary's and subsequent rebounding of the cone of depression coinciding with the cessation of water withdrawals has resulted in noticeable changes in flow of abandoned artesian wells.

Septic Tanks: All facilities and residences on Cumberland Island are on septic systems. Little Cumberland Island (private community), immediately north of the Island, has approximately 80 homes, all of which are on septic systems.

Water Quality: The 1997 Baseline Water Quality Data Inventory and Analysis report suggests that some surface waters associated with the park are either saline or tidally influenced (National Park Service 1997a). If this is the case, then surface water acidification is not a concern for the park. There is no indication that nitrogen-associated eutrophication is an issue. The University of Georgia is currently conducting a total watershed assessment to determine landscape-scale drivers of water quality.

Saltwater Intrusion: Changes in shallow groundwater / surface water chemistry can potentially alter plant communities and the system's ability to carry out key ecosystem functions such as nutrient cycling and carbon sequestration. However nothing has been observed to indicate that this is a problem at this point in time.

Artesian Wells / Groundwater: Most of the groundwater supply for Cumberland Island and vicinity is obtained from two series of water-bearing aquifers. The most important of these is a deep-lying limestone aquifer, known as the Floridan aquifer (Hillestad et al. 1975). This artesian aquifer is an important source of water throughout much of the Coastal Plain. In addition to the maintained artesian wells on the island, there are at least nine artesian wells or their associated works that were improperly abandoned or have failed, resulting in uncontrolled flow.

Freshwater Sloughs & Ponds: Lake Whitney, Lake Rhetta, Sweetwater Lakes Complex, Willow Pond complex, and South End Pond.

Air Resources

Air Quality: NADP/NTN sites have been installed at Okefenokee National Wildlife Refuge, Sapelo Island, and Skidaway, GA but data are not yet available from those sites. The state of Georgia prepares annual air toxics (mercury, dioxins, benzenes etc.) monitoring reports - the nearest monitoring station to Cumberland Island is in Brunswick, GA. Cumberland Island National Seashore will be acquiring a NOAA Climate Reference Network station in September, 2004. Primary threats to air quality include nearby paper mills and power plants.

Ozone: The low levels of ozone exposure and the relatively dry soil moisture conditions at Cumberland Island National Seashore make the risk of foliar ozone injury to plants low (National Park Service 2004a). While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to moderate drought reduce the effectiveness of the exposures, and hourly concentrations of ozone seldom exceeded 80 ppb, it is unlikely that foliar injury will be produced on plants. If the level of risk should increase in the future, a program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following indicator species: tree-of-heaven (*Ailanthus altissima*) (an invasive exotic), eastern redbud, white ash, American sycamore, black cherry, American elder, and crownbeard.

Geologic Resources

Shoreline Erosion: Primary effects are potentially on loss of maritime forest and potentially salt marsh on the sound side of CUIS. Although current erosion rates might be consistent with natural shoreline evolution, wake energy from boats (including Navy Trident submarines) might be an exacerbating factor.

Weather & Climate

Hurricanes:

Species of Concern (Threatened, Endangered, Rare, Special)

Horses: Horses, though exotic, are present on Cumberland Island. Horses have known or potential effects on marshlands, inland forest grasses, wetland, and coastal dune plant communities. The extent to which this occurs varies with population size, and the ecological effects overall are currently unknown. Trampling and grazing pressure on salt marshes is highly visible and is likely a problem. The target population for CUIS is 60 individuals; the population as of March 2003 was roughly 250 individuals.

Sea Turtles: All CUIS sea turtle monitoring is currently coordinated with other nesting success programs in the State by Georgia Department of Natural Resources. Depredation by hogs, raccoons, fire ants, and ghost crabs are all of concern.

Shore Birds: CUIS, similar to other national seashores is well known for its rich avifauna (Watson 2003b). Nesting American oystercatcher, Wilson's plover (*Charadrius wilsonia*), Least Tern, Black Skimmer (*Rhynchops niger*), gull-billed tern (*Sterna nilotica*), wood stork (*Mycteria americana*), bald eagle, brown-headed nuthatch (*Sitta pusilla*), dramatic shorebird and passerine migrations, and large numbers of over-wintering shorebirds establish CUIS as an important avian conservation area. CUIS was recognized as a Globally Important Bird Area (IBA) by the American Bird Conservancy for its wide variety of birds and the value this barrier island park has for protection of these birds. Shorebirds of interest include piping plovers, wood storks, least terns, willets, American oystercatchers, and black skimmers. Threats to shorebirds are largely the result of human activities on the island; habitat changes; depredation from raccoons, feral hogs, and bobcats; and nest trampling from horses.

Red Cockaded Woodpeckers: Currently on the species list for the park, though none are currently known to be present. Although extirpated from CUIS, potential suitable habitat remains for possible RCW reintroductions.

Reptiles and Amphibians: Gopher tortoises are found on the Island. Gopher tortoises are also regionally affected by an upper respiratory tract disease that increases mortality rates. Incidence and transmission rates on CUIS are currently unknown.

Manatees: Present in the park.

Bobcats: Predator concerns for shorebird management.

Exotic / Invasive Species

Horses: Horses, though exotic, are present on Cumberland Island. Horses have known or potential effects on marshlands, dune systems and plant communities, inland forest grasses, wetlands, and other critical habitats. The extent to which this occurs varies with population size, and the ecological effects overall have been well studied, but not holistically synthesized. Trampling and grazing pressure on salt marshes is highly visible and is likely a problem. The population as of March 2003 was estimated at 250 individuals. Management alternatives have been established to include maintaining a small, representative herd on the south end of the Island.

Fire Ants: Predation on egg masses and hatchlings during nesting seasons potentially increases the mortality of sensitive / T&E species.

Exotic Plants: Bamboo, tung tree, and tamarisk (*Tamarix* spp.) are of primary concern, but many others exist on the island such as tree of heaven, Bermuda grass (*Cynodon dactylon*), Chinese sumac (*Rhus chinensis*), Chinese tallow (*Sapium sebiferum*), common mullein, and a host of escaped cultivars from neighboring lands as well as the cultural landscapes managed by CUIS.

Armadillo: Armadillos (*Dasypus novemcinctus*) first appeared in the park in the early 1970's. There is currently no specific data documenting the impact of the armadillo on archeological resources, insects, vegetation or other natural resources. As a newly arrived animal, whether considered exotic or naturally expanding its range, the park needs baseline data on the population size, rate of spread, reproduction, and associated impacts on park resources.

Feral Hogs: Feral hog populations are present on the Island and are currently controlled through a combination of hunting and trapping. Hogs have a potential detrimental effect on the full range of island habitats including wetland and maritime forest habitats as well as nests of both shorebirds and sea turtles. Private lands within the park boundaries provide potential sanctuaries for feral hogs; effective eradication must be done with consideration of source / sink populations both within and outside of park jurisdiction.

Habitats & Communities

Salt Marshes: CUIS has roughly 16,000-18,000 acres of marshland within its boundaries. Marsh die-off is of concern throughout coastal Georgia (and beyond), the cause of which is unknown.

Coastal Dunes: Migration rates both with and without grazing pressure from horses is an issue, as well as dune stability over time with impacts from visitor use.

Plant Communities: Within the confines of Cumberland Island, 22 plant community or vegetation types were recognized and mapped (Hillestad, Bozeman, Johnson, Berisford, and Richardson 1975). These vegetation types are not associations in the strictest sense (i.e., the conceptual "association" as used by some schools). This scheme or classification system was devised t o show the diversity of habitats, the composition of the vegetation in these habitats and the spatial extent or coverage of each recognizable unit on the island. The system reflects natural units as nearly as possible, and it is extensive enough to include the principal variations in plant cover. Major communities of ecological importance include maritime forests, coastal dunes, salt marsh, wetlands, and mixed-pine forests.

Unique Areas

Designated Wilderness Area: The northern half of the island has also been designated a wilderness area. This unspoiled environment, once prevalent on all the barrier islands, provides a unique opportunity to experience the flora and fauna of a natural coastal ecosystem (National Park Service 2000a). At the same time, it has a limiting impact on park management and restoration.

Park NR Management

Exotic Animal Control: Feral hog populations are present on the Island and are currently controlled through a combination of hunting and trapping.

Exotic Plant Management: Current management activities are intended to prevent species that are allowed in the cultural landscapes from escaping and establishing populations in natural areas. Identifying and eliminating species in critical habitat is an ongoing challenge to the Park. CUIS is one of thirteen parks in the Southeast Coast Network's Exotic Plant Management Module to begin operation in FY 2005. CUIS is currently the lead park for the Module.

External Stressors

Adjacent Land Use & Development: Two river systems (St. Mary's and Satilla Rivers) drain into the sound side of Cumberland Island. These river systems drain areas primarily of urban and agricultural land use in the Jacksonville, Brunswick, and Waycross / Tifton areas of northeast Florida and Southeast Georgia. Suburban growth is increasing locally, with three major subdivisions in development or being proposed. Although these developments might not have direct impacts on the park, they are expected to result in higher (uncontrolled) visitor use through private boating access, and potential changes to regional water use and water quality.

Fishing Industry: The offshore commercial shellfishing (primarily shrimp) is the cause of sea turtle strandings / mortalities each year at CUIS. The overall impacts of commercial and recreational fishing are unknown.

Navy Submarine Base: Naval vessels pass through the Intracoastal Waterway regularly in association with the Atlantic Trident submarine fleet. Wave action from the wakes of these vessels has potentially high erosive energy on the sound side of CUIS. The Navy undertakes multiple activities with varying known and unknown effects including dredging.

Ecosystem Functions

Fire: Currently removed from the island ecology with an incomplete assessment of the full effects on island ecology.

Other Issues

Visitor Use Impacts: Visitor use is now concentrated on the south end of the island around Dungeness and Sea Camp, but this could increase over time, particularly at the Plum Orchard facility. Of specific concern are the effects of social trail creation on natural systems, particularly in coastal dune ecosystems. Visitor use is currently limited by legislation, which mandates a maximum of 300 people to be ferried to the island each day. With the new developments nearby, visitor use is expected to increase near landing access points on the southern tip of the island, as well as at Brick Hill and Cumberland Wharf / Burbank Point. Such uncontrolled visitation could have a significant impact, particularly on critical shorebird habitat.

Causeways: Causeways and associated culverts restrict and / or redirect flow.

Fort Frederica National Monument (FOFR)

Park Description

Established on St. Simon's Island in 1736 to protect South Carolina and Georgia from the Spanish, the town of Frederica was the southernmost post of the British colonies in North America. Today, old-growth oaks, exceptionally large grapevines (*Vitis* spp.), and Spanish moss (*Tillandsia usneoides*) lend an air of antiquity unequaled on the coast.

The monument is divided by the Frederica River, one of the primary salt marsh rivers in the Brunswick area, with 99 acres of marsh lands at the Frederica site on the west side of the river and approximately 137 acres of uplands adjoining the east side of the river. The Bloody Marsh site consists of 8 acres of which approximately 5 acres are tidal marsh. Approximately 50% of park-owned lands are classified as wetlands.

Park Mission relative to Natural Resource Management

The Park's enabling legislation does not specifically mention natural resources management, however, the FOFR is responsible for managing lands in accordance with the National Park Service Organic Act (16 USC 1) and National Parks Omnibus Management Act (Pub. L. 105-392) such that the Park makes sound resource decisions based on sound scientific data in an effort to leave resources unimpaired for the enjoyment of future generations.

FOFR has been divided into four fire management units (FMUs) to facilitate the achievement of fire management objectives. The natural-resource based passive recreation zone consists of vegetated communities exhibiting natural succession. The desired resource condition would be predominately natural, and management activities designed to encourage and support that condition governs management in this zone.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Deer	• Exotic Plant Management
• Water Quantity	• Wood Storks	• Fire Management
• Rivers		
• Groundwater Resources		
Air Resources	Exotic / Invasive Species	External Stressors

- Air Quality
- Ozone

- Exotic Plants
- Southern Pine Beetle
- Feral Hogs

- Adjacent Land Use

Geologic Resources

- Shoreline Erosion
- Soils

Habitats & Communities

- Salt Marsh
- Upland Pine Forest
- Oak Scrub / Shrub Community

Ecosystem Functions

Weather & Climate

- Precipitation
- Temperature

Unique Areas

Other Issues

Water Resources

Water Quality: Deterioration is a concern from industrial pollutants as well as the impact of the intensive recreational use of the Frederica River by boaters and fishermen. Several of the nearby industrial plants have buried or discharged, legally and otherwise, toxic wastes in the Brunswick, Georgia, community. This dumping has, in turn, contaminated ground water. In addition, Brunswick, Georgia has four superfund sites on the National Priorities List (http://www.epa.gov/superfund/sites/npl/ga.htm#Hercules_009_Landfill). Water Quality data inventories and analyses indicate a shortage of relatively recent observations for all parameters measured in the study area and a complete lack of any data collected within the FOFR park boundary (National Park Service 1998b). Of the 1,100 observations reported for the study area, approximately 98 percent were collected before 1973 from one station in Saint Simons Sound. Without adequate data it is difficult to make definitive statements regarding recent water quality within the study area. Potential anthropogenic sources of contaminants include industrial and municipal wastewater discharges; stormwater runoff; recreational use; and atmospheric deposition.

Water Quantity: Regional waters shortages have resulted in water rationing on St. Simons Island, primarily with respect to the water usage required by nearby golf courses within the community. The long-term effects of increasing water demand associated with increasing population growth are at this point unknown.

Surface Water: Surface water resources in the FOFR study area include the Atlantic Ocean; Saint Simons Sound; the Back Hampton, Frederica, Mackay, and other rivers; Gully Hole, Dunbar, and several other smaller creeks; and numerous marshes, wetlands, and estuaries. Many of these water resources are influenced by tidal flow and contain fresh and saline waters in transition.

Groundwater Resources: Several of the nearby industrial plants have buried or discharged, legally and otherwise, toxic wastes in the Brunswick, Georgia, community. This dumping has, in turn, contaminated ground water. In addition, Brunswick, Georgia has four superfund sites on the National Priorities List (http://www.epa.gov/superfund/sites/npl/ga.htm#Hercules_009_Landfill). Three artesian wells are also located on site.

Air Resources

Air Quality: Industrial effluent from nearby Brunswick includes chemical manufacturing and pulp / paper mill facilities.

Ozone: The low levels of ozone exposure and the relatively dry soil moisture conditions at Fort Frederica National Monument make the risk of foliar ozone injury to plants low (National Park Service 2004a). While the Sum06 exposures exceed threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to severe drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceed 80 ppb, it is unlikely that foliar injury will be produced on plants.

Geologic Resources

Shoreline Erosion: The cultural landscape of FOFR is located along the cutbank of the Frederica River. Active erosion is occurring to the south of the property near the boat dock. Erosion control measures near the Fort ruins have stabilized the shoreline for roughly thirty years.

Soils: Sedimentary deposits composed primarily of sandstone, limestone and clay underlie Frederica. Surface deposits of sand are common to the upland area, while the marsh substrata are composed of unconsolidated clays containing high organic matter content and sand. In most areas the soils are well drained; however, poorly drained soils occur in the northeastern portion of the park.

Weather & Climate

Precipitation: The average annual mean precipitation from 1960 to 2000, as indicated in Figure 7, was 52.8 inches. The linear red trend line indicates no discernible overall increase or decrease in precipitation since 1960 (National Park Service 2003a).

Temperature: Historic weather data from Jacksonville, Florida, approximately 60 miles to the south, serve as a reasonably accurate indication of historic weather patterns of the park area.

For the 41-year time period from 1960 to 2000, the average mean temperature, as indicated in Figure 6, was 68.6 °F. Although mild warming and cooling cycles have occurred, the temperature has remained quite constant, with no discernible overall warming or cooling trend since 1960.

Species of Concern (Threatened, Endangered, Rare, Special)

Deer: Historically, both white-tailed and fallow deer (*Dama dama*) were present at FOFR. Fallow deer have not been observed at the park for at least fifteen years. As the surrounding area of St. Simons Island continues to develop, though, the park might become a habitat island for those large animals that remain.

Wood Storks: Wood storks were once common on St. Simons Island, with one of the State's largest rookeries occurring on private lands adjacent to the Park. Development pressures have extirpated the wood storks from the area, and possibly from the Island entirely. However, a wood stork was seen in the Park parking lot last year (2003).

Exotic / Invasive Species

Exotic Plants: Privet is found in abundance, primarily in the former "yacht club" portion of the property. Other escaped cultivars are likely present. Chinese tallow (*Sapium sebiferum*) is present at FOFR in small numbers along the marsh edge and within the freshwater wetland areas of the moats and to the north.

Feral Hogs: Historically, feral hogs have presented a natural resource problem for Park managers at FOFR. However, eradication efforts by the park, and its partners have eliminated all evidence of the problem.

Habitats & Communities

Salt Marsh: To the west of the Frederica River is a tract (roughly 100 acres) of salt marsh that includes both low- and high-marsh communities dominated by saltmarsh cordgrass and needle rush (*Juncus roemerianus*) respectively. Also associated with the salt marsh communities are mud flats.

Live Oak / Magnolia Forests: Live oak and laurel oak are codominant, occurring with southern magnolia (*Magnolia grandiflora*) and pignut hickory (*Carya glabra*), in the understory are scattered saw palmetto, wax-myrtle, blueberry (*Vaccinium* spp.), dogwood, redbud, persimmon and yaupon holly. A variant on this community maintained at the marsh edges includes cabbage palm and red cedar along with groundsel tree (*Baccharis halimifolia*), saltwater falsewillow (*B. angustifolia*), grasses, vines such as peppervine

(*Ampelopsis* spp.), and a variety of other woody and herbaceous perennials. On the Bloody Marsh tract, Live Oak/Magnolia (or Maritime) forest is somewhat richer with more hickory, cabbage palm, slash pine (*Pinus elliottii*) and persimmon.

Pine Successional Forests: Forest dominated by loblolly pine with an advanced understory of live oak and water oak and an understory of blueberry, wax myrtle, and an occasional saw palmetto. This community covers a large area south of the fort and to the east of the park headquarters which was formerly cleared for agriculture. A wetter variant occurs on either side of the entrance drive dominated by loblolly pine, water oak, sweet gum, yellow poplar and some water tupelo in the wettest spots with an understory of saw palmetto, gallberry (*Ilex glabra*), cinnamon fern (*Osmunda cinnamomea*) and netted chain fern (*Woodwardia areolata*).

Park NR Management

Exotic Plant Management: FOFR is one of fourteen parks within the network that will be participating in a three-year exotic plant management module that is being coordinated by CUIS.

Fire Management: FOFR is in the final stages of developing a fire management plan (National Park Service 2003a). FOFR will use prescribed fire to reduce hazard fuels accumulations, to promote ecosystem sustainability, and to restore and maintain the historic landscape. Park planning documents will guide the use of prescribed fire. All wildfires at FOFR, regardless of origin, will be suppressed.

External Stressors

Adjacent Land Use: Land use in the immediate area is primarily residential, with a large vacation rental / winter resident population. Multiple golf courses are associated with the residential community.

Other Issues

Visitor Use: Individual boats are frequently spotted within the Frederica River fishing and crabbing. Extractive uses are assumed to have a minimal impact on native communities. However, wave action from watercraft presents possible damage to park wetlands and the cultural landscape through erosion. Also, the Bloody Marsh unit is used by the local community for acquiring bait (i.e., fiddler crabs); the detrimental effects of bait harvesting (if any) are unknown

Ticks: Forested areas within FOFR have many ticks, which present both a visitor experience and public health challenge.

Fort Pulaski National Monument (FOPU)

Park Description

Fort Pulaski National Monument is located in Chatham County, Georgia along the Savannah River only a few miles from its junction with the Atlantic Ocean. The site consists of two islands that were, before human intervention, primarily salt marsh. Judging from the composition of existing vegetation, Cockspur Island probably supported some coastal hammock forest or woodland. It was selected for fortification as early as the seventeen hundreds. In the eighteen hundreds, as part of the development of the site for defense, the island was modified by the installation of drainage canals and a dike system. In latter years, the site was also impacted by the deposition of spoil material. The addition of dredge material from the Savannah River to Cockspur Island has continued until recently. During the civil war period, the vegetation was removed to enhance visibility and kept in early successional stages. Since the abandonment of the fort in the late eighteen hundreds, a large portion of central Cockspur Island has reverted to maritime forest. Currently, the upland portions of Cockspur (approximately 260

acres) support a mosaic of maritime forest, maritime shrub communities, maintained grasslands and successional spoil deposit areas. It also includes over 340 acres of tidal shrubland and tidal herbaceous marsh.

McQueens Island makes up the largest portion of land holdings for the National Monument (about 4,900 acres) and the majority of this consists of salt marsh. A railroad was constructed along the northern edge of the island in 1887 to connect the city of Savannah with Tybee Island and operated until 1933. In 1923, US Highway 80 was constructed, occupying a location across the central portion of the island and adjacent the old railroad grade along the eastern section. In 1994 Chatham County converted the abandoned railroad right-of-way to a multipurpose hiking trail. Both the highway and the converted rails-to-trails areas support ruderal habitat for a number of coastal plain herbaceous species. Other upland habitat on McQueens Island occurs in association with a public fishing and boat ramp on the eastern end of the island and an abandoned section of US 80 leading to the Bull River.

Park Mission relative to Natural Resource Management

The natural resources at FOPU face a number of threats, primarily related to its proximity to the city of Savannah. Heavy industrial development on the Savannah River, as far upstream as the Savannah River Site near Aiken, SC, have been known to impact the water quality and ecological health in and around the park. Pollutant levels in water, sediment, and invertebrate tissue will be analyzed as part of an upcoming study. Shipping traffic and associated dredging are contributing to increased shoreline erosion along the north shore of Cockspur Island. Finally, Highway 80 between Savannah and Tybee Island is slated for widening in the near future, impacting park wetlands adjacent to the existing roadway.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Birds	• Exotic Plant Management
• Water Quantity	• Mammals	• Mosquito Control
• Natural Hydrology		
• Saltwater Intrusion		
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Exotic Plants	• Adjacent Land Use
• Ozone	• Armadillos	• Dredging
		• Shipping
		• Road Widening
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Erosion	• Salt Marshes	
	• Maritime Forest	
	• Wetlands	
Weather & Climate	Unique Areas	Other Issues
		• Pest Species

Water Resources

Water Quality: Water quality within the Savannah River, and the salt marsh of FOPU are largely driven by factors well outside the control of the park. Upstream agricultural land use and local uses by the shipping industry at the Savannah Port Authority both have large potential impacts on water quality. The degree to which Savannah affects water quality (through both point- and non-point-sources of pollution) has not yet been studied. Additionally, the effects of heavy metals contamination on higher level organisms through bioaccumulation and biomagnification are currently unknown. There have been occasional sewage spills

from the nearby Wilmington Island community and leaky pipes and other non-point source inputs of nutrients into the system. Golf courses also serve as a source of fertilizers, pesticides, and herbicides into the river system. Within the moat of the park, degraded water quality has been implicated in algal blooms and fish kills, both of which can severely impact visitor use and experience.

Water Quantity: Regional water withdrawals, from both inland agricultural use and coastal industrial and municipal uses affect the availability water resources to natural communities along the coast. Because FOPU largely consists of salt marsh communities, these resources are dependent on a natural balance between freshwater and saltwater flows.

Natural Hydrology: Concerns currently center on the potential effects of dredging on both Cockspur Island and the salt marsh tracts of the park. Specifically, the effects on the quantity of water and subsequent effects on wetland plant communities are unknown. The National Ocean Service (NOS) currently operates one continuously operating tide station in Georgia, located at Fort Pulaski, which records tide data, relative sea levels and storm surge levels.

Saltwater Intrusion: In the relatively near term, planned deepening of the dredged shipping channel within the Savannah River is hypothesized to potentially breach the confining layer of the Floridan Aquifer, potentially allowing a direct connection between ocean water and a recharge point within the aquifer. The effects of regional water withdrawals on availability and depth of freshwater resources in both the short- and long-term will continue to be of concern as population growth continues along the southeastern coast. Salinity within the moat surrounding the Fort at FOPU is also of concern as it can affect the longevity of the mortar.

Air Resources

Air Quality: The feeder canal and Savannah River had average pH values of 7.3, and the Wilmington River had a pH of 6.5 (National Park Service 2001a). The Savannah River had an average ANC of 504 μeq/l, and the Wilmington River had an ANC of 216 μeq/l. These data indicate surface waters in the park are not sensitive to acidification from atmospheric deposition. The report did not indicate that nitrogen-associated eutrophication was an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park. Local sources of pollution include paper plants, industrial facilities in the Savannah area, and the shipping industry.

Ozone: The low levels of ozone exposure and the relatively dry soil moisture conditions at Fort Pulaski National Monument make the risk of foliar ozone injury to plants low (National Park Service 2004a). While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to severe drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceeded 80 ppb, it is unlikely that foliar injury will be produced on plants. If the level of risk increases in the future, a program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: tree-of-heaven (an invasive exotic), redbud, yellow-poplar, American sycamore, black cherry, cut-leaf coneflower, American elder, and crownbeard.

Geologic Resources

Shoreline Erosion: Shipping and dredging operations both seem to be affecting the natural shorelines of the park. Although erosion in some areas is affected by wave energy caused by shipping vessels, in other areas the shoreline is aggrading with oyster shells. This new phenomenon might or might not be related to dredging operations.

Species of Concern (Threatened, Endangered, Rare, Special)

Birds: Partners in Flight has identified the painted bunting as an indicator for other neotropical migratory bird species at the park. Cattle egrets (*Bubulcus ibis*), are also present, but the degree to which they are of concern will depend on its nativity status. FOPU is one of eighteen sites along Georgia's Colonial Coast Birding Trail, established by the Georgia Department of Natural Resources.

Mammals: White-tailed deer populations are present at FOPU, but no studies have been done to determine what the carrying capacity of the park is or whether the current population is at, above, or below that capacity. Furthermore, the effects of deer populations on plant communities (browsing) are unknown, and the effects of competition with other animals are likewise unknown.

Exotic / Invasive Species

Exotic Plants: Chinaberry (*Melia azedarach*), Chinese tallow, and privet are all present within the park. Source populations are likely upstream within the watershed and ballast heaps from the adjacent shipping channel in the vicinity of Cockspur Island (Govus 1998).

Armadillos: There is currently no specific data documenting the impact of the armadillo on archeological resources, insects, vegetation or other natural resources. As a newly arrived animal, whether considered exotic or naturally expanding its range, the park needs baseline data on the population size, rate of spread, reproduction, and associated impacts on Park resources (natural and cultural).

Birds: The European starling (*Sturnus vulgaris*) and the rock dove (*Columba livia*) are exotic birds present at FOPU that potentially negatively impact native bird communities. Further, these birds adversely affect cultural resources by nesting in and loafing on historical cannons and other resources leaving debris and droppings that degrade the site and might potentially decrease visitor enjoyment.

Habitats & Communities

Salt Marshes: Roughly 5,200 acres at FOPU are in salt marsh habitat (National Park Service 2000a). The rate of gain / loss of salt marsh acreage has not been studied, but salt marsh loss is of local and regional concern.

Maritime Forest: FOPU has one tract of relatively old forest (~80 years) that, with the exception of missing oaks, is a maritime forest in what is assumed to be in good condition.

Wetlands: Wetlands near the growing shell berm could be affected by altered flooding frequencies. In addition, it is possible that sediment could fill in the wetland over time. This might or might not be a natural process.

Park NR Management

Exotic Plant Management: Fort Pulaski National Monument is one of thirteen parks included in the Southeast Coast Network's Exotic Plant Management Module being managed by Cumberland Island National Seashore.

Mosquito Control: FOPU cooperates with Chatham County Mosquito Control Commission (CCMCC) to control mosquito populations through pesticide applications. FOPU is a training site for such applications.

Fire Management: Though planned, a fire management plan has not yet been developed for the park.

External Stressors

Adjacent Land Use: In addition to the nearby shipping industry, other adjacent and upstream land uses include chemical, industrial, paper, and nuclear facilities, all of which can have significant impacts on water quality.

Dredging: Dredging offshore occurs regularly to support shipping through the Port of Savannah. US Army Corps of Engineers is currently considering a proposal to deepen the channel to increase the size of ships that can enter the Port.

Shipping: The port of Savannah is the fastest growing port on the East Coast.

Road Design and Management: Widening of US 80 from a two-lane to a four-lane highway is currently planned to allow for increased traffic flow to and from Tybee Island. The road bisects FOPU, and might potentially have detrimental effects on natural hydrology and animal migrations. Implementation of the project has been delayed by Georgia Department of Transportation (GDOT) until 2009 (Bell 2003). The Monument is currently working with the U.S. Fish and Wildlife Service, the Federal Highways Administration, and the GDOT to develop a mitigation plan that complies with NPS Wetlands Policies.

Other Issues

Pest Species: In the cultural portions of the park, mosquitoes, house mice and black rats are present and problematic.

Fort Sumter National Monument (FOSU)
Charles Pinckney National Historic Site (CHPI)

Park Description

Fort Sumter National Monument consists of 200 acres of land located at the mouth of Charleston harbor and on nearby Sullivan's Island, South Carolina. The park's three major features are Fort Sumter, site of the Civil War's first engagement, the somewhat older Fort Moultrie, which commemorates seacoast defense from 1776-1947, and Liberty Square, embarkation and visitor facility.

The 28-acre Charles Pinckney National Historic Site (CHPI) was established under Public Law 100-421 and is a relatively new addition to the National Park Service. It is a rural vernacular landscape in use from 1695 until the 1980's, and was actually a working farm until the 1960's when nearly 700 acres were sold for development. The site includes the Snee Farm House, approximately four acres of wetlands, ten acres in mixed hardwoods and pines, and fourteen acres of open grassland. The site, which fronts Long Point Road, a scenic highway, is surrounded by suburban housing developments.

Park Mission relative to Natural Resource Management

Historic Fort Sumter is influenced dramatically by the surrounding natural elements. Of the 200 acres that comprise the park, 122 acres surrounding the Fort are submerged under the waters of Charleston Harbor. The remaining acreage is located on Sullivan's Island and in Charleston. Adjacent to the park, but outside its boundaries, are shoals, islands, and marshes important to the Fort Sumter scene. Two endangered species, the manatee and the loggerhead turtle, migrate through the waters adjacent to the park, but do not live or nest within the park itself.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality (riverine)		• Exotic Plant Management
• Water Quality (marine)		
• Water Quantity		

Environmental Setting	Resources	Agents of Change
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Exotic Plants	• Dredging
• Ozone	• Exotic Animals	• Adjacent Land Use
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Earthquakes	• Coastal Dunes	• Harbor Drainage Area
• Barrier Island Geomorphology	• Riparian Wetlands	
	• Marine Fisheries	
	• Birds	
Weather & Climate	Unique Areas	Other Issues
• Sea Level Change		• Oil Spills and Chemical Hazards
• Hurricanes		

Water Resources

Water Quality (Riverine): A small unnamed tidal creek with associated wetlands borders the western boundary of Charles Pinckney National Historic Site. Located roughly 0.1 miles upstream is a golf course and several other sources of non-point contaminants that might influence water quality.

Water Quality (Marine): Fort Sumter National Monument includes a 122-acre plot of submerged lands within Charleston Harbor Estuary surrounding the historical Fort. The harbor receives water from the Cooper, Wando and Ashley River and is subject to both point-source and non-point-source contaminants including nutrients, and toxics mostly of human origin. Though water quality is generally considered good, some areas of the Charleston Harbor Estuary only partially support aquatic life and recreational uses (National Park Service 2003c).

Water Quantity: The degree to which surficial groundwater withdrawals affect flora and fauna is as yet unknown. The Mount Pleasant/East Cooper River Area is underlain by a series of aquifers and confining units of the Atlantic Coastal Plain sediments. The upper surficial aquifer is composed of surficial sands and clays and extends approximately 20 feet below the surface and is separated from the lower surficial aquifer by a clay and sand layer. Approximately 66 percent of drinking water distributed by the Mount Pleasant waterworks is derived from the Middendorf Aquifer which is located between 1800 and 2000 feet below the ground surface (Mount Pleasant Waterworks 2002). Groundwater generally moves from toward the east-southeast in the region. Charleston County Public Works Department has a large surface water area.

Air Resources

Air Quality: Fort Sumter NM has a PM_{10} monitor (particulate matter) on-site. Nearby paper mills, and exhaust from shipping vessels both potentially affect overall air quality.

Ozone: Fourteen plant species at (or potentially at) FOSU and CHPI are sensitive to ozone. The low levels of ozone exposure and dry soil moisture conditions at Fort Sumter National Monument make the risk of foliar ozone injury to plants low (National Park Service 2004a). While the Sum06 index meets the criteria for injury, the W126 does not since the N100 criterion is not satisfied. Because periodic soil moisture conditions of mild to moderate drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceed 80 ppb, it is unlikely that foliar injury will be produced on plants.

Geologic Resources

Earthquakes: The seismic history of the southeastern United States is dominated by the 1886 earthquake that occurred in the Coastal Plain near Charleston, South Carolina. It was one of the largest historic earthquakes in eastern North America, and by far the largest earthquake in the southeastern United States. The historic

record suggests the Charleston-Summerville area had a continuum of low level seismic activity prior to 1886, and low-level activity continues in the same area today (South Carolina Seismic Network 2003).

Shoreline Erosion: Rip-rap currently stabilizes the shoreline surrounding the Fort Moultrie portion of FOSU and protects the shoreline from erosion, and provides enough stability for a small coastal dune plant community to exist. Management of the rip-rap is conducted by the State of South Carolina, Office of Coastal and Resource Management.

Barrier Island Geomorphology: Adjacent natural lands are accreting on the eastern end of Sullivan's Island. Interest exists in the community for developing lands into housing lots East of Battery Logan. Sullivan's Island has a conservation easement along the oceanfront on the Federal property at the Charleston Light.

Weather & Climate

Sea Level Change: At present, sea level rise is approximately 1.3 millimeters per year, but many experts believe this rate may accelerate in coming decades. An annual increase in sea level, no matter how small, over a long period of time would upset coastal dynamics in the Charleston area and could eventually pose a direct threat to Fort Sumter and Fort Moultrie.

Hurricanes: Hurricane season is June 1 through November 30 each year. The potential for another category 4 storm like Hugo in 1989 is a potential threat to the park.

Exotic / Invasive Species

Exotic Plants: . Sources of exotic plants likely come from a combination of adjacent lands and escaped cultivars (particularly at CHPI), and ballast heaps associated with dredging activities.

Exotic Animals: Exotic insects include fire ants, which are of concern for both ecological and visitor experience reasons. Also found at the park are large populations of rock doves.

Habitats & Communities

Coastal Dunes: A small coastal dune plant community exists along the border of the Fort Moultrie portion of Fort Sumter National Monument. The degree to which plants in this community are representative of other regional examples is currently unknown.

Riparian Wetlands: Charles Pinckney National Historic Site includes a small tributary to the Wando River, which includes a plant community primarily made up of salt marsh grasses.

Marine Fisheries: Status is currently unknown.

Birds: Of local interest, but the diversity of birds at FOSU is currently undocumented.

Park NR Management

Exotic Plant Management: Fort Sumter National Monument (and CHPI) is one of fourteen park units included in the Southeast Coast Network's Exotic Plant Management module currently being managed by Cumberland Island National Seashore.

External Stressors

Dredging: The lower surficial aquifer is directly connected to the Cooper River. The river bottom and shipping channel is kept open by periodic dredging by the United States Army Corps of Engineers(National Park Service 1997b). Dredging is necessary in order to maintain Charleston as a viable seaport; however, it might negatively impact Fort Sumter's marine ecosystems as well as disturbing the historic viewshed by

creating spoil banks on nearby barrier islands. The park staff continues to monitor dredging activities within the harbor, working with the Army Corps of Engineers and local authorities to mitigate the impact of dredging on park resources whenever possible (National Park Service 2000a).

Adjacent Land Use: Both CHPI and FOSU are affected by a variety of land uses in the metropolitan Charleston area. The effects on NPS property, however, primarily manifest themselves in air quality and water quality. Industrial facilities and ships on the Cooper River are potential sources for contaminants or catastrophic damage. FOSU is affected by commercial ship traffic in the Charleston harbor.

Other Issues

Oil Spills and Chemical Hazards:

Horseshoe Bend National Military Park (HOBE)

Park Description

Horseshoe Bend National Military Park is comprised of 2,040 acres. The park is located along the southern boundary of the Northern Piedmont Upland physiographic region [1] and consists of metamorphic and igneous rocks of Paleozoic to Precambian age. The granite, gneiss, and schist bedrock weather to produce well-drained reddish loamy or clayey soils [2]. The elevations range from 535 feet along the river to 680 feet at the higher ridgelines. The topography is relatively flat along the river floodplain, with low rolling hills throughout much of the park. Slopes may reach 30 percent in some areas, but are more commonly 10 to 14 percent.

The park contains many plant species endemic to the Piedmont region, and also species associated with the Southeastern and Southern Coastal Plains. River bottomland borders each side of the Tallapoosa River. This land, which was extensively cultivated from 1832 until the establishment of the park in 1959, is in various stages of ecological succession.

The land has undergone significant changes in the 190 years since the battle. In many places shortleaf pine (*Pinus echinata*) and loblolly pine have displaced the mixed longleaf pine / hardwood forest that existed in 1814. Southern pine beetle infestations exist in numerous pockets of the park. In some cases, infestations are near park boundaries and endanger adjacent commercial forests. A heavy accumulation of slash and downed trees due to beetle kills and the aftermath of hurricanes and winter storms have resulted in potentially dangerous fire situations.

Park Mission relative to Natural Resource Management

The Creek Indian War consisted of 17 battles or skirmishes, with the final and most significant battle fought at Horseshoe Bend on March 27, 1814. In this battle, 3,300 frontier troops and Indian allies under the command of Andrew Jackson defeated 1,000 Creek warriors who had fortified themselves behind a seemingly impregnable log barricade. More than 800 Creek Indians were killed, ending for all time the power of the Creek Nation.

As a result of this battle, the Creek lands were subsequently added to the United States and opened for settlement. This cession of considerable magnitude, three-fifths of Alabama and one-fifth of Georgia, paved the way for Alabama's statehood five years later.

In August, 1959, President Dwight D. Eisenhower signed the Proclamation establishing Horseshoe Bend National Military Park, enacting the park's enabling legislation, passed in July, 1956. The 2,040 acre park was established to memorialize the final and most critical battle of the Creek Indian War. Although the Park’s enabling legislation does not explicitly mention natural resources, those resources are paramount to the history and the story of HOBE .

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Streams & Rivers	• Freshwater Mussels	• Fire Management
• Water Quality		• Fisheries Management
• Water Quantity		
• River Regulation		
Air Resources	Exotic / Invasive Species	External Stressors
• Ozone	• Southern Pine Beetle	• Adjacent Land Use
	• Exotic Aquatic Species	• Hydropower Generation
	• Exotic Plants	• Drinking Water Storage & Withdrawal
	• Exotic Animals	
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Shoreline Erosion	• Aquatic Communities	• Fire
		• Flooding
Weather & Climate	Unique Areas	Other Issues

Water Resources

Streams & Rivers: The Tallapoosa River bisects HOBE. The historical battlefield site is located within a single meander / bend of the River. At this point along the river drainage, the Tallapoosa River is a historically deep channel marked by several shoals.

Water Quality: The park is concerned about the impacts of livestock and chicken ranches upstream as well as agricultural runoff. The park is seeking funding to partner with USGS in a two-year water quality assessment of the Tallapoosa River.

Water Quantity: The impacts of artificial flow regimens determined by releases from hydropower facilities upstream are not completely understood. The river system has been targeted as a potential source of drinking water for the metropolitan Atlanta area through interbasin transfer of water resources.

River Regulation: Harris Dam, located roughly twenty miles upstream of HOBE near Lineville, AL, is one of two hydropower generation facilities along the Tallapoosa River. Another structure is located roughly 25 miles downstream of HOBE. Peak power generation activities at Harris Dam result in two high-water events per day; consequently river levels fluctuate 5-6 feet during these events. Impoundments and their associated lakes are likely restricting natural migration and breeding patterns of fish and mussel species within the drainage. The management of Harris Dam and the continuing tri-state negotiations over water allocation prompted American Rivers to list the Tallapoosa River as #9 on the 2003 list of America's Most Endangered Rivers (American Rivers 2003).

Air Resources

Ozone: The risk of foliar ozone injury to plants at Horseshoe Bend National Military Park is high (National Park Service 2004a). Although the levels of ozone exposure generally create the potential for injury, low soil moisture may reduce the likelihood of injury developing in the higher ozone years. Because the site is subject to potentially harmful levels of ozone in most years, the probability of foliar injury developing may be greatest during years in which ozone levels are somewhat reduced but still exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more

of the following bioindicator species: tree-of-heaven (an invasive exotic), redbud, white ash, yellow-poplar, American sycamore, black cherry, cut-leaf coneflower, American elder, and crownbeard.

Geologic Resources

Shoreline Erosion: Not currently a problem, but it could be long-term given the daily fluctuations and associated erosion potential resulting from hydropower generation upstream.

Species of Concern (Threatened, Endangered, Rare, Special)

Freshwater Mussels: Two endangered mussel species have been reported near the Park; both are assumed to be extirpated from the Park's boundaries. Both species are likely still in tributaries of the Tallapoosa River within Georgia. Impoundments along the mainstem river will likely be a major impediment for those species to re-colonize the Tallapoosa within HOBE boundaries.

Armadillo: The status of this species at HOBE is still unknown. Questions as to whether increasing populations represent an exotic species invasion or a natural range extension are unclear, and the impacts, if any, have not been studied.

Deer: Overpopulation on the north side of the river; possibly over-hunted on the south side of the river due to illegal poaching and dog hunting along the borders.

Turkeys: Overpopulation on the north side of the river; possibly over-hunted on the south side of the river due to illegal poaching and dog hunting along the borders.

Exotic / Invasive Species

Southern Pine Beetle: Occurs within the park and is a potential threat to other internal stands as well as those on neighboring lands. Standard BMPs call for cutting all pines within 100 ft (?) of infested trees when they are identified. Reintroduction of fire into the forest ecosystem should help to control or reduce outbreaks in the future. However, neighboring lands that are currently *un*managed (i.e., Alabama Power lands) might serve as source populations in the future.

Exotic Aquatic Species: Unknown at this time. Asiatic clam (*Corbicula corbicula*) assumed to be present in the system and potentially competing with native mussels.

Exotic Plants: During the last 190 years, the vegetation has been altered by human settlement, logging, and the introduction of invasive-exotic species. Exotic species have impacted many areas within the park an all occurrences were mapped in 2002. Invading exotic plants such as tree of heaven, mimosa (*Albizia julibrissin*), Chinaberry, Japanese honeysuckle, kudzu, and sandburs (*Cenchrus longispinas*) continue to expand and invade new areas. Some of these invasive plants, such as kudzu and honeysuckle, can serve as ladder fuels and increase fire danger (National Park Service 2003d).

Exotic Animals: Feral dogs are found within the border; some hunting dogs as well. Presence of hunting dogs should decrease or disappear during the next 4-5 years as dog hunting becomes limited by the State.

Habitats & Communities

Longleaf Pine / Mixed Hardwood Forest: HOBE is near the northern boundary of longleaf pine, but it is present within the boundary. Based on conversations with several botanists and ecologists, the best estimation is that the floodplains and drainages consisted of mixed hardwoods and the ridge tops were crested with patches of longleaf pine. The hillsides and some of the ridgelines likely consisted of hardwoods such as hickory (*Carya* spp.), oak, ash (*Fraxinus* spp.), walnut (*Juglans* spp.), and chestnut (*Castanea* spp.). Current management plans call for restoring the community to that found circa 1814 to better simulate the cultural landscape of the battlefield. To date, a desired future condition for this is undefined.

Park NR Management

Fire Management: Upon approval, the Fire Management Plan will permit fire management in the park to expand operations beyond immediate and total suppression to include prescribed fire. The restoration of fire as a natural force will have manifold ecological benefits, and at the same time will increase safety to the visitor, firefighter, and infrastructure alike. Both hardwood and longleaf pine ecosystems will benefit significantly from their current status, and the dangers of uncontrollable wildland fire associated with fuel build-up will be significantly reduced (National Park Service 2003d). Implementation of the plan is currently scheduled to begin in January 2004.

Fisheries Management: The Park does not currently have a fisheries management plan. As part of the annual creel census Alabama Department of Conservation and Natural Resources conducts annual creel surveys at the boat ramp in the park.

External Stressors

Adjacent Land Use: Primary land uses surrounding HOBE are silviculture and agriculture. Agricultural operations are typically cattle or chicken farming; primarily of medium-low density. Much of the surrounding land to the northwest (?) is owned by Georgia Power, which leases hunting. No active land management occurs on the Georgia Power lands. Hay farming occurs to the east of HOBE.

Hydropower Generation: Harris Dam, located roughly twenty miles upstream of HOBE near Lineville, AL, is one of two hydropower generation facilities along the Tallapoosa River. Peak power generation activities at Harris Dam result in two high-water events per day; consequently, river levels fluctuate 5-6 feet during these events. Another structure is located roughly 25 miles downstream of HOBE.

Drinking Water Storage & Withdrawal: Lake Martin, five miles downstream of HOBE serves as a drinking water supply for the cities of Alexander City, Dadeville, and Tallassee. However, because of the rapid growth of metropolitan Atlanta, the Tallapoosa River will likely be looked at as an additional water supply source for Atlanta in the future.

Ecosystem Functions

Fire: Before the large-scale impacts of white settlers in what is now eastern Alabama, fire played a significant role in shaping the vegetative conditions. Although direct evidence is difficult to find due to over 300 years of Euro-American occupation, numerous historians, ethnographers, and geographers believe the evidence of American Indian use of fire as a landscape tool is beyond doubt (Denevan 1992;National Park Service 2003d).

Flooding: According to local residents and park employees, prior to the construction of Harris Dam, natural flooding events occurred once every two years.

Kennesaw Mountain National Battlefield Park (KEMO)

Park Description

Kennesaw Mountain National Battlefield Park was created to commemorate the 1864 Atlanta Campaign of the Civil War. In particular it preserves the battle lines where from mid-June to early July the Confederate forces under Joseph E. Johnson delayed the progress of William T. Sherman's Union forces in their advance from Chattanooga to Atlanta. Enabling Legislation included in Appendix 1.

The natural resources of the 2,884-acre park include the 1,808-foot peak of Kennesaw Mountain, Little Kennesaw Mountain and hundreds of acres of mixed hardwood/pine forests intermixed with a number of grassy fields.

Included are over 16 miles of designated hiking trails that attract hundreds of recreational visitors daily. The Park's location in the Atlanta metropolitan area makes it the second most visited battlefield in the National Park System and has earned it a position on the Secretary of Interior's list of twenty-five most threatened parks.

Park Mission relative to Natural Resource Management

Largely because of its proximity to Atlanta, major natural resource threats exist at KEMO. The development of Cobb County and greater metro Atlanta makes the lands within Kennesaw Mountain relatively valuable for natural habitats of localized plant and animal communities. Cobb County has plans to expand roads and highways that traverse the park and pose a potential threat to both cultural and natural resources. In addition, there are minor threats from encroachment of adjacent landowners, exotic plant species, and industrial air and water pollution.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Streams	• Beavers	• Fire Management
• Water Quality	• Deer	
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Southern Pine Beetle	• Adjacent Land Use
• Ozone	• Exotic Plants	• In flight path for Dobbins AFB
	• Exotic Animals	
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Granite Outcroppings	• Birds	
Weather & Climate	Unique Areas	Other Issues
	• Granite Outcroppings	• Encroachment
		• Dumping
		• Visitor Use

Water Resources

Streams: Noses Creek and John Ward Creek both flow through the park boundaries. Both creeks have upstream portions outside the boundaries of the park, so KEMO has no direct control over factors that influence the quality of water resources. Both streams ultimately drain into the Chattahoochee River.

Water Quality: Development pressure in and around KEMO has a major impact on surface water quality of both Noses Creek and John Ward Creek. Sedimentation from construction-related land disturbances upstream has altered stream habitat quality and bed sediment grain size distribution; effects on turbidity during rain events are pronounced. The degree to which these systems are impacted by non-point sources of nutrients, metals, and pesticides is as yet unknown although they are presumed to be above target concentrations. Volunteer water quality monitoring is being conducted by North Cobb High School; data indicates an extremely high fecal coliform level.

Air Resources

Air Quality: KEMO is currently designated a Class II air quality park, but the effects of metropolitan Atlanta on air resources is increasing. The effects of smog, ozone, particulates, and other atmospheric contaminants on natural resources are largely unknown. Because the population of Atlanta is expected to continue growing over the next several decades (Atlanta Regional Commission 1993), air quality is likely to be an ongoing and worsening issue. Vehicular travel through the park exceeds 15 million cars per year.

Ozone: The risk of foliar ozone injury to plants at Kennesaw Mountain National Battlefield Park is high (National Park Service 2004a). While the levels of ozone exposure consistently create the potential for injury, low soil moisture may reduce the likelihood of injury developing in any particular year. Since the site is subject to potentially harmful levels of ozone annually, the probability of foliar injury developing may be greatest during years in which ozone exposures exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: tree-of-heaven (an invasive exotic), spreading dogbane, common milkweed (*Asclepias syriaca*), redbud, white ash, yellow-poplar, American sycamore, black cherry, cut-leaf coneflower, American elder, and northern fox grape.

Geologic Resources

Granite Outcroppings: Granite outcroppings exist on Kennesaw and Little Kennesaw Mountain. These areas provide habitat that supports a variety of Georgia state-protected plant species and species of special concern: openground draba (*Draba aprica*), green rockcress (*Arabis missouriensis*), and Stone Mountain Mint (*Pycnanthemum curvipes*) (Chris Hughes, personal communication, 2003).

Species of Concern (Threatened, Endangered, Rare, Special)

Beavers: There appears to be an increase in the beaver population. As the beavers create their dams, distribution and water quality is altered.

Deer: Excessively high deer populations reduce forest under story species due to grazing and ultimately lead to low or no forest regeneration.

Exotic / Invasive Species

Southern Pine Beetle: Occurs within the park and is a potential threat to other internal stands as well as those on neighboring lands. Standard BMPs call for cutting all pines within 150 m of infested trees when they are identified. Reintroduction of fire, which is a potential control for southern pine beetles, is not a management option at KEMO due to WUI and smoke concerns. Pine beetles were first identified within the park in 1993 and have since killed off thousands of pine trees throughout the park. The resulting increase in fuels lying on the forest floor pose an increased fire risk.

Exotic Plants: Common species include mimosa, garlic mustard, privet, tree of heaven, Japanese honeysuckle, and kudzu. Escaped cultivars from nearby private lands are also a concern. KEMO is one of fourteen parks covered in the exotic plant management module currently being managed by CUIS.

Exotic Animals: Fire ants.

Habitats & Communities

Birds: KEMO was the first designated Globally Important Bird Area in Georgia. The park's location at the southern terminus of the Appalachian Mountains provides a unique vantage point for viewing birds year-round, but particularly during spring and fall migrations. Bird watchers make up a significant portion of the visitors who come to KEMO.

Park NR Management

Fire Management: Much effort is being concentrated on fuels reduction on 105 acres within the park. Mechanical removal of fuels is the only viable means by which to reduce fire threat, but the degree to which these efforts mimic natural processes is unknown.

External Stressors

Adjacent Land Use: Surrounding land use was historically rural. However, because of KEMO's location in northwest Atlanta, the natural resources are under constant pressure from nearby suburban land use, and development of new lands into such uses. Inholdings within the park include significant developments (subdivisions). Other pressures originating from adjacent lands include sources of exotic plants and animals, automobile traffic, and traffic related to the nearby Cobb County landfill (located ~1 mile to the south of the park). Development pressure in and around the park is also a root cause of sedimentation into both John Ward Creek and Noses Creek, both of which flow through the park's boundaries. The Anderson Farm development to the ENE of the park is large new development currently underway.

Dobbins Air Force Base: KEMO is located on the flight path for Dobbins Air Force Base. Increased air traffic over the park causes increased noise and air pollution.

Other Issues

Encroachment: High degree of shared boundaries with private landowners has resulted in the creation of multiple social trails, particularly along the southwest boundary of the park.

Visitor Use: KEMO constitutes an important outdoor recreation resource to over 3.7 million people located in the metropolitan Atlanta. The primary use is recreation – jogging and walking. KEMO, along with CHAT, constitute 60-70% of the green space available to Atlanta residents. The park's green space significantly improves the quality of life by serving as a sanctuary as well as providing a variety of outdoor recreation opportunities such as hiking, birding, and nature viewing.

Dumping: The dumping of trash and other refuse by adjacent land owners and developers is an all too common occurrence at KEMO.

Moores Creek National Battlefield

Park Description

This 87-acre park preserves the site of the Revolutionary War battle of Moores Creek Bridge, fought February 27, 1776, between loyalists supporting the British Crown and patriots of North Carolina. The battlefield is located 20 miles northwest of Wilmington, NC, within the inland Carolina coastal plain.

Park Mission relative to Natural Resource Management

In recent years, natural resources management at MOCR has focused on restoring natural fire regimes, restoring longleaf pine and savannah communities, and removal of exotic invasive plants.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern	Park NR Management
• Moores Creek	• State Listed / T&E Plants	• Fire Management
• Water Quality	• Native Grasses	• Exotic Plant Removal
• Natural Hydrology		• Longleaf Pine Restoration
• Artesian Springs		• Longleaf Pine - Savannah Wetland Restoration
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Privet, Wisteria, and others.	• Adjacent Land Use

	• Fire Ants	
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Stream Channel Geomorphology	• Riparian Forests	
• Springs and Seeps	• Longleaf Pine (Sandhill) Communities	
Weather & Climate	Unique Areas	Other Issues
• Hurricanes	• Savanna / Wetland	• Rare plant poaching

Water Resources

Moores Creek: This black water stream, averaging 30 feet in width, forms the western boundary of the park, and represents a resource of both natural and cultural significance. Flow within Moores Creek is tidally influenced. Moores Creek is a freshwater system, but during high tide water "backs up" causing a reversal of flow within the boundaries of MOCR. During extremely wet years or during large rain events, the storage capacity of the watershed can cause floodwaters to cover portions of the causeway, boardwalk, and the lowest decking portions of the bridge.

Water Quality: Affects of adjacent land uses and other agents of change on water quality are unknown, but are assumed to have minimal effect on Moores Creek at this time.

Natural Hydrology: The savannah tract of MOCR was historically ditched to provide areas suitable for recreation, as well as to provide drainage from the visitor center parking lot. As a part of restoration efforts in the longleaf pine-savannah wetland beginning in 1996, hydrologic restoration began to better mimic natural hydrologic conditions. Fourteen shallow groundwater wells are located within the wetland to monitor groundwater levels in response to the restoration efforts.

Artesian Springs: Three artesian springs have pipes inserted and one was used as a drinking fountain in the 1940s – 1950s. None are currently used as public drinking water sources today, but all still have above ground pipes / valves in place.

Air Resources

Air Quality: MOCR is designated a class II air shed under the Clean Air Act. Under class II, modest increases in air pollution are allowed beyond baseline levels for particulate matter, sulfur dioxide, nitrogen and nitrogen dioxide, provided that the national ambient air quality standards, established by the Environmental Protection Agency (EPA), are not exceeded. Principal sources of air pollutants in the park vicinity are industry emissions from nearby Wilmington (National Park Service 2004a).

Ozone**:** The risk of foliar ozone injury at Moore's Creek National Battlefield is moderate (National Park Service 2004a). The Sum06 threshold is satisfied annually while the W126 threshold is satisfied only in the highest exposure years. The N-values indicate that exposures to 80 to 100 ppb vary considerably among years. Months of low soil moisture occur independent of the level of ozone and can significantly constrain the uptake of ozone. It is anticipated that the risk of injury would be greatest in years when high levels of ozone happened to occur when soil moisture conditions favor its uptake by plants. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: redbud, yellow-poplar, American sycamore, black cherry, and American elder.

Geologic Resources

Stream Channel Geomorphology: Natural cut banks within Moores Creek potentially threaten the stability of developed features on the cultural landscape – the causeway and reconstructed historical Moores Creek Bridge site (historic bridge abutments are buried on each side of the creek bank at the bridge crossing site). Geomorphic studies conducted by U.S. Geological survey indicated that the current vegetation communities within the swamp woodlands and pools within the river should serve to dissipate erosional

forces that might threaten the bridge site or the existing stream channel, but soil loss and cutbank migration might prove to be of long-term concern for the causeway, which is considered an historic structure.

Soils: Soil series represented within the region include Grifton (67%), Meggett (17%), Invershiel (8%), and other soils of minor extent (8%). Park soils are generally coarse-loamy, poorly drained and nutrient-poor (National Park Service 2003e).

Weather & Climate

Hurricanes: High winds and flood waters from hurricanes have caused repeated damage to natural (and cultural) resources at MOCR. The combined effects of Hurricanes Bertha and Fran (1996) resulted in the park closing for more than 40 days (Capps and Davis 1999).

Species of Concern (Threatened, Endangered, Rare, Special)

State Listed / Rare Plants: Two state listed plant species: the threatened Carolina bogmint (*Macbridea caroliniana* and the endangered Carolina grass-of-parnassus (*Parnassia caroliniana*). Both are known to exist within the park within the longleaf pine-savanna wetland within the park. Other rare species known to exist at the park include springflowering goldenrod (*Solidago verna*), which inhabits mesic to moist pinelands and pocosin ecotones, sarvis holly (*Ilex amelanchier*), which inhabits blackwater swamps and riverbanks and clay-based Carolina bays, and Venus flytrap (*Dionaea muscipula*) (Sieren 1982).

Native Grasses: Several native grass species are found within the park: wiregrass (*Aristida stricta*), cutover muhly grass (*Muhlenbergia expansa*), Carolina dropseed (*Sporobolus pinetorum*), and toothachegrass (*Ctenium aromaticum*). Park management efforts include reintroduction of these species from locally available seed sources from partnering lands managed by the State and The Nature Conservancy. Reintroduction efforts are currently focused within areas to be managed by prescribed burning as most of these species are fire dependent.

Exotic / Invasive Species

Exotic Plants: Historic home sites in the northeast corner of MOCR have served as sources for populations of privet, wisteria, mimosa, and Japanese honeysuckle. Populations of these species can potentially spread to other areas within the Park if left unchecked. Current eradication efforts have relied on manual removal by volunteer inmate crews.

Fire Ants: Fire ants are pervasive pests throughout the park, particularly within the cultural landscapes.

Habitats & Communities

Longleaf Pine (Sandhill) Communities: Ranges in elevation from 3 to 5 feet; contains longleaf and loblolly pine, oak, hickory, Georgia beargrass (*Nolina georgiana*), and prickly pear cactus, with thick hardwood brush.

Swamp Woodlands: Located adjacent to Moores Creek at an elevation of 3 to 4 feet above sea level; cypress, willow (*Salix* spp.), and water ash (*Fraxinus carolineana*) predominate.

Unique Areas

Longleaf Pine – Savannah Wetland: Largely created from drained swamp; contains grasses, vascular plants and scattered longleaf pine, with invasive hardwood brush and exotic vegetation.

Park NR Management

Fire Management: The current fire management plan calls for prescribed burning in several portions of the park to maintain ecosystem function and plant community diversity (National Park Service 2003e). Of primary concern is the use of fire to encourage recruitment and growth of many fire dependent grasses whose distribution is currently limited within the region such as wiregrass, cutover muhly grass, Carolina dropseed, and toothachegrass. Secondarily, fire will be used to suppress growth of fire intolerant species such as loblolly pine and boxelder (*Acer negundo*). Initial plans for burning call for fall burns once every 1-3 years evolving to a schedule of once every 5-7 years after the first few burn cycles.

Exotic Plant Removal: Moores Creek National Battlefield is one of thirteen parks included in the Southeast Coast Network's Exotic Plant Management Module being managed by Cumberland Island National Seashore.

Longleaf Pine Restoration: It is the Park's goal to convert stands of loblolly pine to longleaf pine upon completion of the Cultural Landscape Report and its associated management recommendations. In the early 90s, Moores Creek National Battlefield planted roughly 1000 longleaf pines, primarily in stands near the entrance and within the historical HWY 210 road bed, which cuts across the northern portion of the Park. MOCR hopes to plant 500 longleaf pines per year beginning in FY04 in combination with mechanical thinning and reintroduction of fire. The TarHeel trail area is targeted for reintroduction efforts in FY05.

Longleaf Pine-Savannah Wetland Restoration: Restoration of the longleaf pine-savannah wetland area consists of restoration of natural hydrology, reintroduction of fire, and reintroduction of native grass species following prescribed burns (Crighton and Sutter 2000).

External Stressors

Adjacent Land Use: International Paper owns significant holdings on the south side dominated by loblolly pine plantations. In the short term, this represents an ongoing source population for loblolly pines that could affect efforts to restore longleaf pine communities. In the long term, the parcel of land might be subject to development pressures that could affect park resources.

Other Issues

Rare Plant Collecting: Collection activities from the scientific community and those (illegal) activities from rare plant enthusiasts threaten the extant populations of rare plants still found within the unique habitats of MOCR.

Ocmulgee National Monument (OCMU)

Park Description

OCMU is located in central Georgia, in Bibb County. The main park unit, consisting of approximately 690 acres, is bordered on three sides by the city of Macon. It is accessed by heavily-traveled U.S. Highway 80. The Ocmulgee River runs along the southwestern boundary of the unit. Walnut Creek flows through the northeastern portion of the unit and then along its southeastern boundary, emptying into the Ocmulgee River at the southernmost point of the unit. The Ocmulgee River Bottoms, comprising the southern portion of the unit, constitute a low-lying floodplain with an average elevation of about 290 feet above sea level, which is inundated for several months each year.

The detached Lamar unit, consisting of approximately 45 acres, is located approximately two and one-half miles to the southeast of the main park unit. It is accessed by an unnumbered county road (Confederate Way). It is also classified as low-lying floodplain, with an average elevation of about 280 feet above sea level.

Park Mission relative to Natural Resource Management

Ocmulgee National Monument sits on the "Fall line," the transition between the rolling piedmont and the flat coastal plain. A portion of the monument is within the city limits of Macon, GA. The Ocmulgee River comprises the boundary on one side of the monument. Ocmulgee National Monument preserves the history of the people of the Southeast; artifacts have been found dating back 10,000 years. The visible features are mounds, built by the Mississippians who lived here from approximately 900-1100 AD.

The natural resources of the park have been heavily impacted by human activities, including I-16 and its associated berm, which has essentially cut off the river from its floodplain and disrupted the natural flow of the area. Despite this, and its proximity to Macon, Ocmulgee has a surprising amount of wildlife present. This is probably a result of a corridor, or what is known locally as the "Greenway," connecting the monument to other natural areas south of the monument. Numerous bird species are present in the monument, either feeding or nesting or both. Migratory birds utilize the area as a stopover during spring and fall migrations. The endangered wood stork feeds here during summer months. Numerous other wildlife live here, including white-tailed deer, American beaver (*Myocastor canadensis*), bobcat, alligators (*Alligator mississippiensis*), and various reptiles and amphibians. Recreational fishing is allowed, with largemouth bass and bream being two common catches. Within the last eight years, coyotes (*Canis latrans*) have entered the monument. What effect this will have is unknown. Exotic species include nutria, fire ants, feral pigs, as well as domestic dogs and cats. Vegetative exotics include privet, Japanese honeysuckle, and kudzu.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Reptiles & Amphibians	• Fire Management
• Streams		• Exotic Species Management
• Water Quantity		
• Natural Hydrology		
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Feral Hogs	• Adjacent Land Use
• Ozone	• Exotic Plants	• Road Construction
	• Other Feral Animals	• Sewer Lines
	• Exotic Animals	• Railroad Maintenance
	• Southern Pine Beetle	
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Stream Geomorphology	• Wetlands	• Fire
Weather & Climate	Unique Areas	Other Issues
• Flooding		• Visitor Use Impacts

Water Resources

Streams: Two major streams flow through OCMU – the Ocmulgee River and Walnut Creek. Ocmulgee National Monument has jurisdiction over half of the Ocmulgee River along its border.

Water Quality: Degradation of water quality is a major concern at OCMU. Walnut Creek is currently on EPA's 303d list for non-attainment of designated uses, and frequently appears to be carrying heavy silt loads. Fecal coliform counts have been recorded in excess of 50,000 ppm, and is likely the result of non-point-source inputs of nutrients. Historical sewage lines and disposal sites might also contribute to nutrient loading, however. Litter from upstream and from the highways that run through the Park is also a source of

degradation to riverine and riparian habitats. A sewage lift station and its associate pipes are located within the park. In the past these pipes have had major sewer leaks; pipe restoration is now near completion.

Water Quantity: The headwaters of the Ocmulgee River system originate in the Metropolitan Atlanta area. With the increasing growth in Atlanta, the demands for freshwater supplies are expected to continue. Pressure to impound headwater streams to create water supply reservoirs has the potential to reduce the amount of water that ultimately makes it to Ocmulgee National Monument.

Natural Hydrology: The berm surrounding I-16 potentially diverts stream flows to a point that influences natural wetland communities. Water that at one time flowed via sheet-flow through wetlands is now diverted through four culverts. The natural hydrology at OCMU is poorly understood at this point, including the natural flood frequency.

Air Resources

Air Quality: OCMU is designated a class II air shed under the Clean Air Act. Under class II, modest increases in air pollution are allowed beyond baseline levels for particulate matter, sulfur dioxide, nitrogen and nitrogen dioxide, provided that the national ambient air quality standards, established by the Environmental Protection Agency (EPA), are not exceeded. Vegetation at OCMU is at risk of ozone injury, where interpolated values are 21-39 ppm-hrs. Principal sources of air pollutants in the park vicinity include industrial emissions from Macon and Atlanta, and motor vehicle emissions. Also, surface water quality monitoring has revealed elevated levels of a number of heavy metals, so deposition of airborne toxics might be of concern for the Park (National Park Service 2002c).

Ozone: The risk of foliar ozone injury to plants at Ocmulgee National Monument is high (National Park Service 2004a). The levels of ozone exposure consistently create the potential for injury, however dry soil conditions may reduce the likelihood of injury in a high exposure year. Levels of exposure capable of producing foliar injury also occur under conditions of minor drought and normal soil moisture. The probability of foliar injury developing may be greatest during years in which ozone levels are somewhat reduced but still exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone. A program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: redbud, yellow-poplar, American sycamore, black cherry, American elder, crownbeard, and northern fox grape.

Geologic Resources

Stream Geomorphology: Tropical Storm Alberto, which deposited many inches of rain in 1994, caused significant flooding in the Macon area and as a result, portions of Walnut Creek “jumped channel” and the previous channel is now backwater. Although now in naturalized conditions, the degree to which the geomorphic changes were driven by road placement and design is unknown, as well as what might be expected during future flooding events.

Species of Concern (Threatened, Endangered, Rare, Special)

Reptiles and Amphibians: Recent inventories conducted by University of Georgia Savanna River Ecology Lab have indicated that the reptile and amphibian communities are much more diverse than previously known, likely due the park’s location on the fall line.

Birds: Ocmulgee National Monument is frequently visited by the Macon Audubon Society and other avid birders.

Exotic / Invasive Species

Feral Hogs: Feral hogs present a threat to both natural and cultural resources through their rooting activities. OCMU has an active trapping and eradication program that has removed more than 150 individuals to date. However, the Park is likely to continue receiving individuals from source populations outside its boundaries (the wetlands and Bond Swamp NWR to the Southeast).

Exotic Plants: Several exotic plant species are found at OCMU, with many seed sources present off-site. Specific species of known management importance include privet, which is located primarily within the wetlands, kudzu, which is not thought to be currently advancing, and Chinaberry, which has been controlled where it is affecting cultural resources. Tree of heaven populations have been expanding this past year possibly due to heavier precipitation than seen during the last several years. Most species have been introduced to adjacent lands as a result of landscaping or ornamental efforts.

Other Feral Animals: Feral dogs and cats are both present at OCMU. Feral dogs are assumed to most frequently be stray or abandoned pets. Feral cats are reproducing and pose a potential threat to migratory songbirds and reptile & amphibian populations.

Exotic Animals: Fire ants are present in the park and pose a threat to native ant species as well as potentially degrade cultural resources and visitor experience.

Southern Pine Beetle: A southern pine beetle occurs within the park and have historically caused heavy damage to the Park's loblolly pine stands. Standard BMPs call for cutting all pines within 150 m (?) of infested trees when they are identified. The effectiveness of mechanical fuel removal at reducing future outbreaks of pine beetle are unknown.

Habitats & Communities

Wetlands: Much of the existing acreage of OCMU is wetlands. To the southeast is a large tract of undeveloped wetlands considered to be one of the largest peat bogs in the Southeast. The parcel of lands that contain those wetlands is under consideration for future acquisition by the park and if acquired will be a significant natural resource.

Park NR Management

Fire Management: Currently the park is reducing fuel loads through mechanical removal and grinding efforts. The Park has recently completed its fire management plan (draft), which calls for the use of prescribed fire or non-fire applications to protect and maintain the prehistoric landscape, reduce hazard fuels accumulations, control exotic plant species, protect soil resources, and maintain safety relative to adjacent lands (National Park Service 2003f).

Exotic Plant Management: Ocmulgee National Monument is one of fourteen park units included in the Southeast Coast Network's Exotic Plant Management module currently being managed by Cumberland Island National Seashore.

External Stressors

Adjacent Land Use: The city of Macon, GA is located adjacent to the park to the Northwest, and is a major source of point- and non-point-source contaminants into both the Ocmulgee River and Walnut Creek. Development pressures associated with Macon are thought to be the largest threat to environmental quality at OCMU. Robbins AFB is also located nearby. Immediately to the southeast is a large tract of undeveloped wetlands that contains one of the largest remaining peat bogs in the region. A bit further to the southeast is Bond Swamp NWR. The lands to the southeast are likely a major refuge for feral hog populations.

Road Construction: Design options for the Fall Line Bypass are currently underway and most options call for major portions of the road to pass through or adjacent to the Park. Increased traffic in the area likely will increase non-point contaminant pressures as well as affect air quality.

Trail Management: The riverfront along the Ocmulgee River is currently scheduled to be developed into a greenway trail that will connect with other portions of the trail system in Macon.

Railroad Maintenance: A CSX railroad line passes through OCMU, and routinely sprays herbicides to control plant growth on and adjacent to the railroad bed. Effects on native flora and fauna are unknown.

Ecosystem Functions

Fire: Ecological and meteorological evidence indicates that lightning-caused fires were a major environmental force shaping the vegetation of North America for millions of years prior to human habitation (van Lear and Waldrop 1989). Fire-adapted ecosystems developed, as did individual plant species dependent upon or adapted to wildland fire. Frost (1998) maintains "…fire once played a role in shaping all but the wettest, the most arid, or the most fire-sheltered plant communities of the United States."

Although it is difficult to substantiate purposeful landscape burning by American Indians from the archeological record, diaries, letters, reports, and books by eyewitnesses of Indian fire use from the 1600s to the 1900s have yielded considerable evidence that American Indians did use fire to modify ecosystems, with profound cumulative effects on the landscape(Barrett 1980;Barrett 1981;Russell 1983;McClain and Elzinga 1994;Whitney 1994). At the time of European contact, many eastern deciduous forests were open and park-like, with little undergrowth, the result of regular burning by Native Americans (Day 1953;Olson 1996;Kay 2000;Bonnicksen 2000).

Other Issues

Visitor Use Impacts: With the creation of the greenway trail through the park, visitor use might to increase. The impacts (if any) of increased traffic are unknown.

Timucuan Ecological and Historic Preserve (TIMU)
Fort Caroline National Memorial (FOCA)

Park Description

Timucuan and Fort Caroline National Memorial are administered as one park. Fort Caroline NM includes approximately 138 acres located along the St. Johns River within the city of Jacksonville and Duval County, Florida. Located primarily on a bluff overlooking the river that rises to a height of nearly 90 feet, the park consists of mixed species forest with fresh water wetlands, preserving an enclave of representative species native to the North Florida-South Georgia community.

Timucuan Ecological and Historical Preserve covers approximately 46,000 acres between the St. Johns and Nassau rivers and is situated entirely within Duval County and the city limits of Jacksonville, FL. The southern third of the Preserve lies at the mouth of the extensive St. Johns River watershed, which encompasses parts of Duval and several other counties for approximately 300 miles to the south. The St. Johns River is heavily impacted by agricultural, industrial and urban pollution; however, marine tidal waters near its mouth serve to ameliorate pollution through dilution and flushing. Water quality is considered relatively good in the Preserve due to this flushing action. The northern two thirds of the Preserve lies within the Nassau River drainage basin, a small watershed that covers parts of Duval and Nassau counties. The Nassau River watershed has not yet experienced the

concentrated urban and industrial growth found along the St. Johns River; still, portions of the watershed exhibit poor water quality. The area surrounding the Preserve to the west and north is predominantly marsh and low uplands utilized for timbering, residential and agricultural uses.

Park Mission relative to Natural Resource Management

To preserve and interpret the wetlands and historic and prehistoric resources in the St. Johns Valley, Florida including the historic la Caroline settlement at Fort Caroline and to permit and manage cooperatively with other agencies the resource-based recreation that does not impair resource values (National Park Service 2000b).

The Preserve:

- Protects one of the largest, relatively healthy and undeveloped biologically diverse areas representing the coastal marshes of the Southeast U.S.
- Provides habitat for diverse species of animal life including rare or threatened and endangered species.
- Includes prehistoric archeological sites containing some of the oldest evidence of human habitation found to date in Florida.
- Initiates cultural interactions and exchanges influencing the beliefs, economies, and social communication between many cultures spanning 400 years.
- Protects natural areas that provide opportunities for solitude, recreation and expansive relatively unspoiled vistas.
- Contains one of the earliest, long term European settlements in what became the United States.

Natural Resources Issues

Environmental Setting	Resources	Agents of Change
Water Resources	Species of Concern (TERS)	Park NR Management
• Water Quality	• Wood Stork	• Exotic Plant Management
• Water Quantity	• Gopher Tortoise	
• Rivers	• Manatees	
Air Resources	Exotic / Invasive Species	External Stressors
• Air Quality	• Exotic Plants	• Jetties
• Ozone	• Feral Animals	• Dredging
	• Exotic Animals	• Adjacent land use
Geologic Resources	Habitats & Communities	Ecosystem Functions
• Sand Transport	• Salt Marshes	
• Shoreline Erosion	• Maritime Forests	
	• Oak/Scrubs	
Weather & Climate	Unique Areas	Other Issues
• Hurricanes	• Spanish Pond	• Visitor Use Impacts

Water Resources

Water Quality: Water quality impacts include increased nutrients, metals, and sediment from upstream sources (and in the case of metals, potentially from atmospheric sources). Most inputs are the result of non-point-sources from the Jacksonville, FL area. Salinity concentrations in the estuary are also important as they are dependent on a balance between freshwater inputs, which are affected by precipitation, groundwater withdrawals, and upstream water uses.

Surface water resources in the TIMU and FOCA study area include the Atlantic Ocean; portions of the Intracoastal Waterway; St. Johns, Fort George, Nassau, South Amelia, and other rivers; Dunn, Clapboard, Browns, Cedar Point, Edwards, and many other creeks; Sample, Clapboard, and numerous other swamps and marshes; many interconnected lakes and lagoons; and some small impoundments. Many of these water resources are influenced by tidal flow and contain fresh and saline waters in transition. Based on the data inventories and analyses contained in this report, surface water quality within the study area appears to have been impacted by human activities. Potential anthropogenic sources of contaminants include municipal and industrial wastewater discharges; commercial and residential development; agricultural operations; marine traffic; storm water runoff; recreational activities; and atmospheric deposition (National Park Service 2002a).

Water Quantity: Regional shallow groundwater withdrawals and deep-water withdrawals from the Floridan Aquifer are potentially major drivers of wetland and salt marsh ecosystems in both the short and long terms. As regional population growth continues, consumptive uses of fresh water from surficial and below-ground sources are likely to increase, and might potentially affect multiple Park resources.

Rivers: Most streams within the park are tidal creeks that flow through the salt marsh. However, both the St. Johns and Nassau River systems drain into the park providing the majority of freshwater inputs into the intertidal salt marsh ecosystem. Also through the park is the Intracoastal Waterway.

Air Resources

Air Quality: TIMU is a class II park, with minimal air-quality related issues due to prevailing air currents. Two very large coal and petroleum coke fire power plants are located on the park boundary. These two plants produce over 83,700 tons per year of emissions and an unknown amount of gaseous mercury. Besides ozone, these plants produce particulate, NO_X and SO_2 emissions. No monitoring is conducted in the vicinity of the Preserve and prevailing winds do move these plumes toward the preserve a substantial amount of time. The impacts to preserve resource are not evaluated due to the lack of monitoring devices in the preserve.

Ozone: The low levels of ozone exposure and the periodically dry soil moisture conditions at Timucuan Ecological and Historic Preserve make the risk of foliar ozone injury to plants low (National Park Service 2004a). Although the Sum06 exposures exceed the threshold level for injury, the W126 do not since the N100 criteria are not satisfied. High ozone exposures occur during periods of several continuous months of mild to severe drought significantly reduce their effectiveness. Hourly concentrations of ozone exceed 80 ppb for a few hours each year and are unlikely to produce foliar injury to plants. If the level of risk increases in the future, a program to assess the incidence of foliar ozone injury on plants at the site could use one or more of the following bioindicator species: redbud, white ash, yellow-poplar, black cherry, and American elder.

Geologic Resources

Sand Transport: Sand aggradation has restricted historic flows within the Fort George River system. Increased aggradation rates is likely a combination changes in upstream flows that historically flushed the system and jetties that have been constructed to maintain shipping channels along the Intracoastal Waterway.

Shoreline Erosion: Coastal shorelines at FOCA are at risk of erosion due to wave action associated with storm events, shipping and ongoing dredging of the St. Johns River. Along the Intracoastal Waterway (ICW), dredging and boating traffic (both commercial and pleasure), have an unknown impact to nearby marsh areas. A recent study comparing 1943 and 2000 aerial photographs indicate a significant loss (up to 19%?) of emergent vegetation along the ICW. Whether this loss is the result of rising ocean levels or sediment loss is unknown.

Weather & Climate

Hurricanes: [to be filled in later]

Species of Concern (Threatened, Endangered, Rare, Special)

Wood Storks: Currently no monitoring of wood stork rookeries is conducted by the preserve staff. Several colonies on neighboring lands are active and the preserve provides foraging areas. Population trends are unknown.

Gopher Tortoise: The gopher tortoise is a species of special concern present in the park. The impacts of urban development within and adjacent to the park reduces the availability of habitat for this species and isolates populations. Additional threats to the gopher tortoise result from declining habitat quality and fragmentation. Succession of sandhill habitat from past and current management practices reduces the availability of herbaceous food species needed by the tortoise.

Manatees: Present at the park, and are particularly at risk of harm due to interactions with watercraft.

Exotic / Invasive Species

Exotic Plants: Chinese tallow, kudzu, cogon grass (*Imperata cylindrica*), Bermuda grass, and air-potato (*Dioscorea bulbifera*) are all present on the park. Water hyacinth (*Eichhornia crassipes*) is also abundant in Spanish Pond at FOCA.

Feral Animals: Feral hogs, cats, and dogs are all present in the park. The impacts of feral cats on bird communities are unknown, but feral cats in natural areas typically result in *some* impact to birds (Watson 2003a). Unleashed dogs have been also observed to disturb feeding and resting shorebirds. Monitoring for gypsy moth and Asian moth is ongoing, though to date no observations have been recorded.

Exotic Animals: Hogs are problematic in some portions of the preserve and soil surface damage has been observed to increase exotic plant expansion. Impacts of hogs on other species are not monitored. Armadillos are also present, but their status as "exotic" is not known—there recent appearance in the Park might be the result of a natural range expansion eastward. Fire ants are also present in the park.

Habitats & Communities

Salt Marshes: Timucuan Ecological and Historic Preserve is one of eight network parks with significant salt marsh communities that have experienced varying levels of retraction in recent years due to potential stressors such as decreased water quality and saltwater intrusion. The salt marsh communities of TIMU represent one of the remaining "type" communities along the southeastern seaboard. Determining baseline conditions of salt marsh vegetation communities is both a high-priority for Park managers, and will serve as a potential comparison for future monitoring efforts within the Southeast Coast Network. Both cordgrass and rush species are present within the park, denoting community shifts along natural salinity gradients.

Maritime Forests: Also referred to as coastal hammocks; dominated by live oak, scrub oak, and cabbage palm. Found primarily on barrier islands, Big Talbot Island in particular. Fort Caroline also has a relatively undisturbed tract.

Oak/Scrubs: Similar to maritime forest community, but located further inland. Contains species that are less salt tolerant and more drought tolerant than the coastal hammocks.

Shell Midden Communities: Dominated by red cedar, located on historic shell middens and islands where soils are more calcareous than upland and barrier island soils.

Unique Areas

Spanish Pond: Spanish pond is a natural freshwater pond and associated wetland, primarily fed by sheet flow.

Park NR Management

Exotic Plant Management: TIMU is included in the Florida EPMT unit, managed out of Miami. The park has had a program of plant control that has varied in intensity based on funding of seasonal botanist and EPMT funding. Targeted species include mimosa (*Albizia julibrissin*), Chinese tallow (*Sapium sebiferum*), Chinese wisteria (*Wisteria sinensis*), air potato (*Dioscorea bulbifera*), chinaberry (*Melia azedarach*), winged yam (*Dioscorea atropurpurea*), kudzu (*Pueraria montana*), water hyacinth (*Eichhornia crassipes*), cogon grass (*Imperata cylindrical*), old world climbing fern (*Lygodium scandens*), and coral ardisia (*Ardisia crenata*).

External Stressors

Jetties: Jetties to the north and south of the St. Johns River Inlet modify flows of both sediment and water. As a result of modified flows, natural "flushing" of the salt marsh has decreased resulting in increased sedimentation, particularly in the Fort George River inlet. Also, reduced flows of saline water have the potential to shift the salinity gradient and subsequently affect distributions of salt marsh plant species (*Juncus* and *Spartina* spp.).

Dredging: The boundaries of TIMU include portions of the Intracoastal Waterway, which is routinely dredged as a part of channel maintenance. The effects of dredging on natural hydrology, fate of contaminants within dredge spoil, and impacts on native vegetation communities as a result of dredging activities are unknown. Contaminated sediments are known to occur in some areas of the Preserve, but the extent of contamination and the effects of sediments resuspension are not known. This is of particular concern as several major dredging projects are proposed in the near future.

Adjacent Land Use: Duval is one of the fastest growing counties in Florida. The Preserve is located in an area that has historically experienced limited development and growth due to lack of easy and quick access. Development and recreational use pressures have increased, however, with the opening of a six-lane bridge in 1989 and ongoing construction of a major highway linking the bridge to the interstate highway system.

Other Issues

Visitor Use Impacts: Personal watercraft use within the park poses a potential threat to natural resources.

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National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 6 – Maps of Southeast Coast Network Parks

Canaveral National Seashore
Florida

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Cape Hatteras National Seashore
Fort Raleigh National Historic Site
Wright Brothers National Memorial
North Carolina

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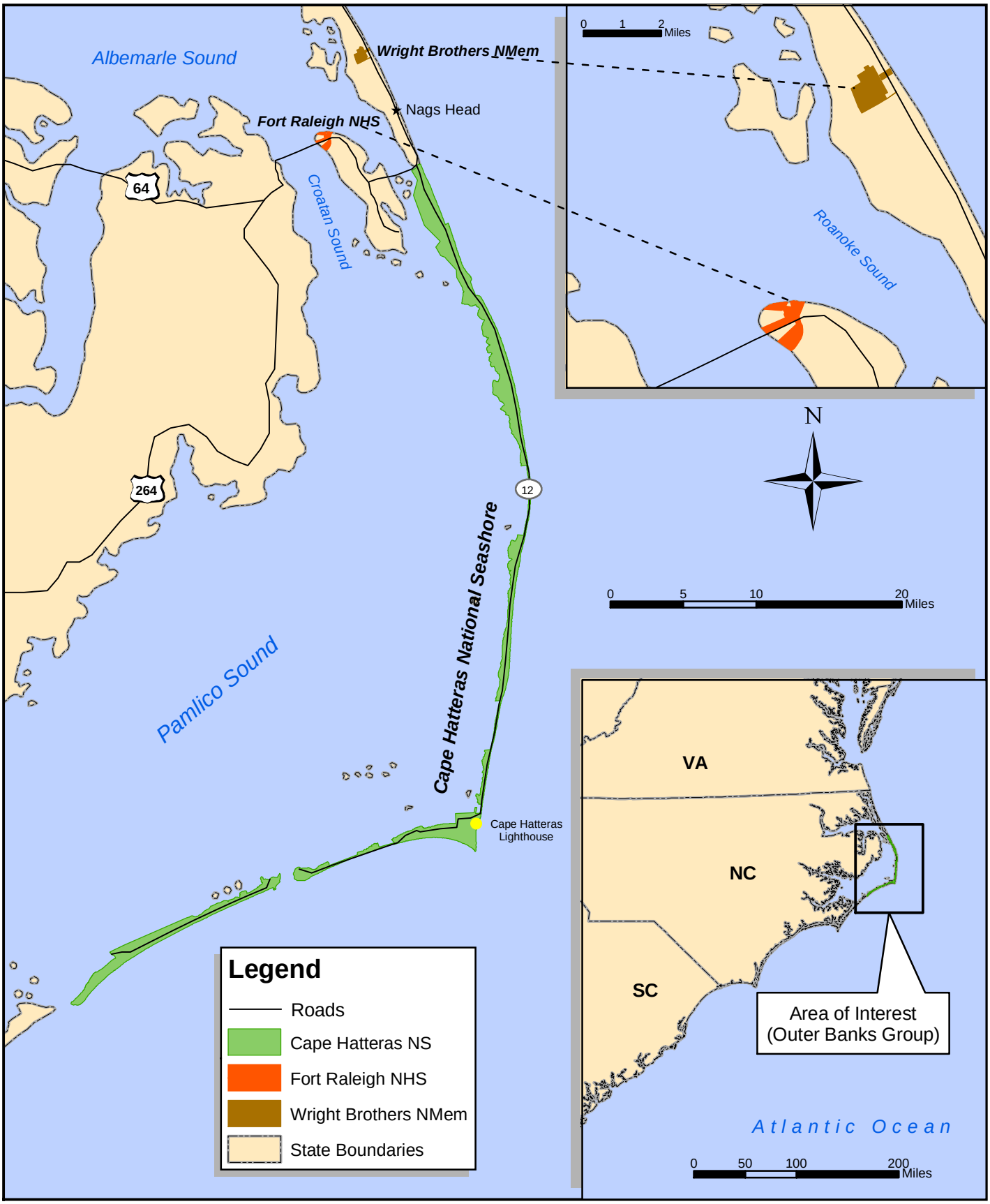
U.S. Department of the Interior



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Cape Lookout National Seashore
North Carolina

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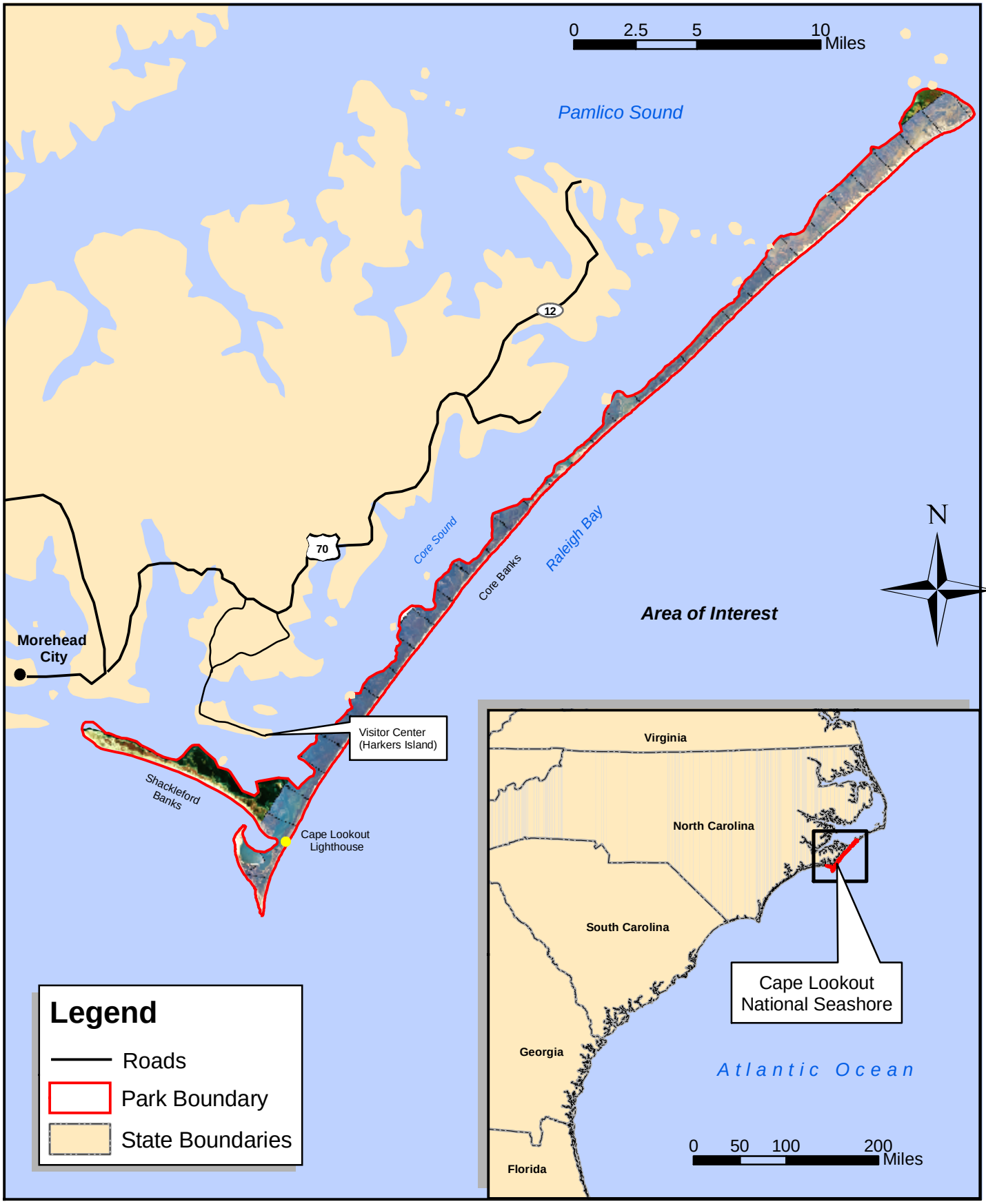
U.S. Department of the Interior



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Chattahoochee River National Recreation Area
Georgia

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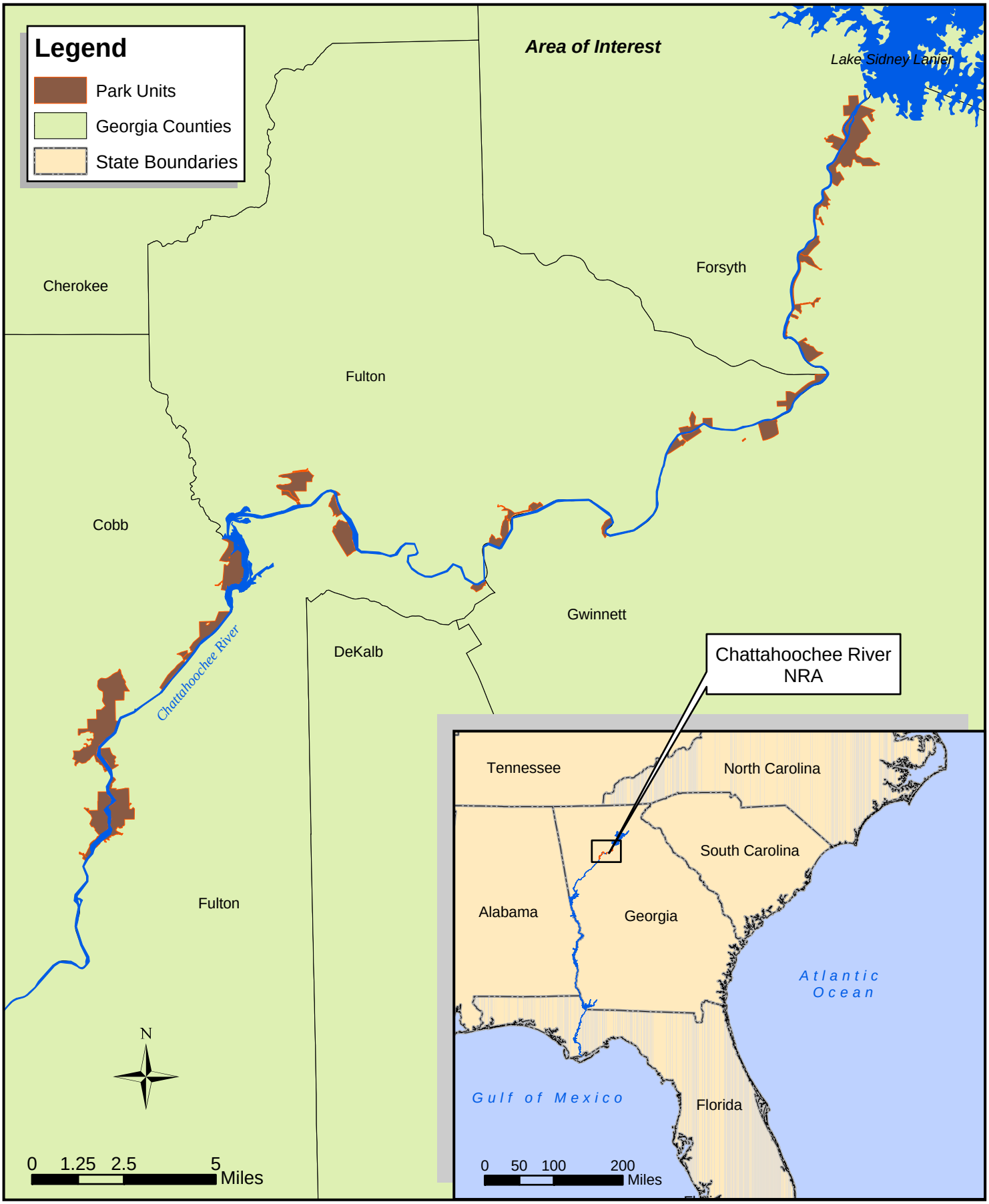
U.S. Department of the Interior



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Congaree National Park
South Carolina

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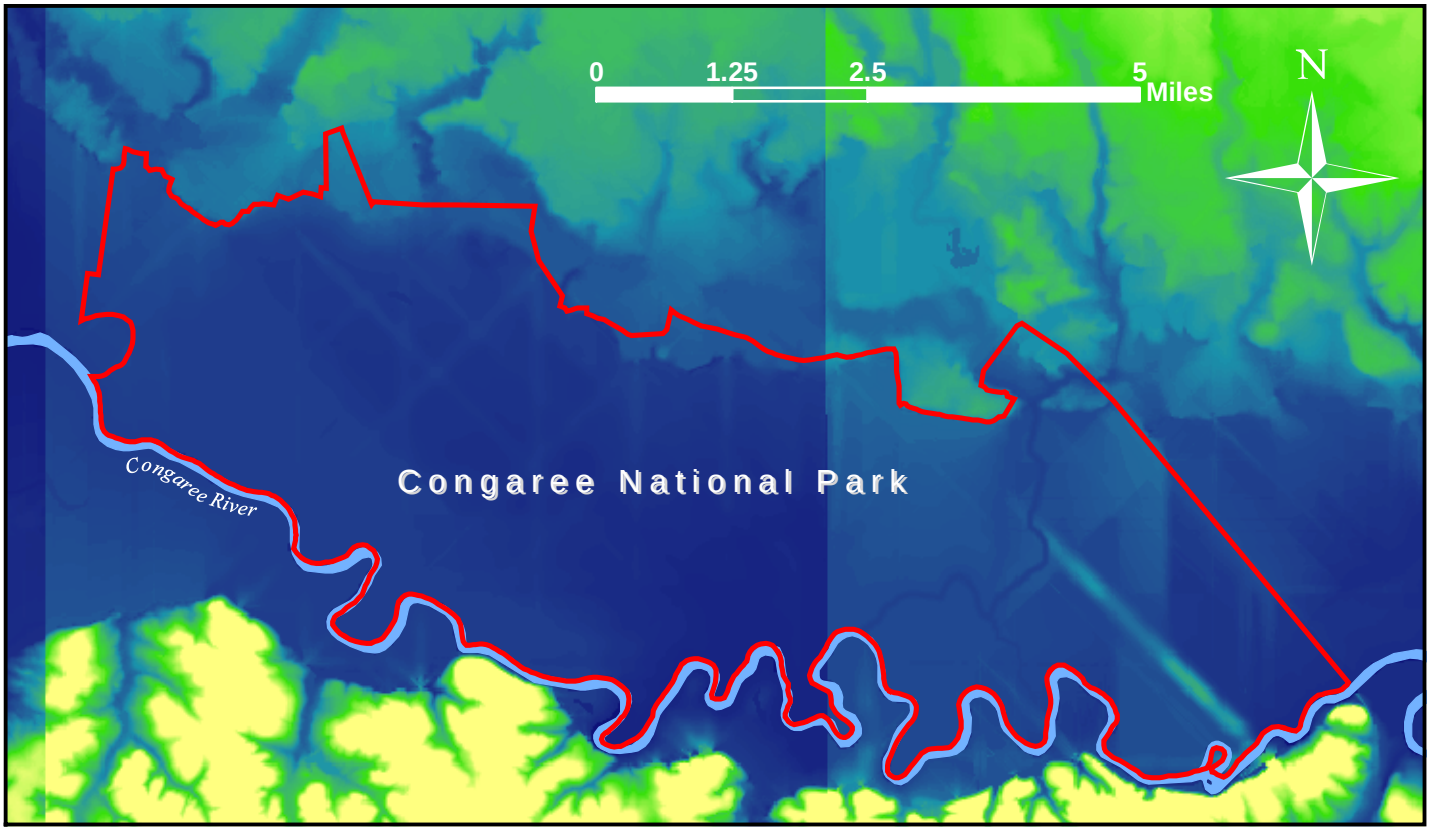
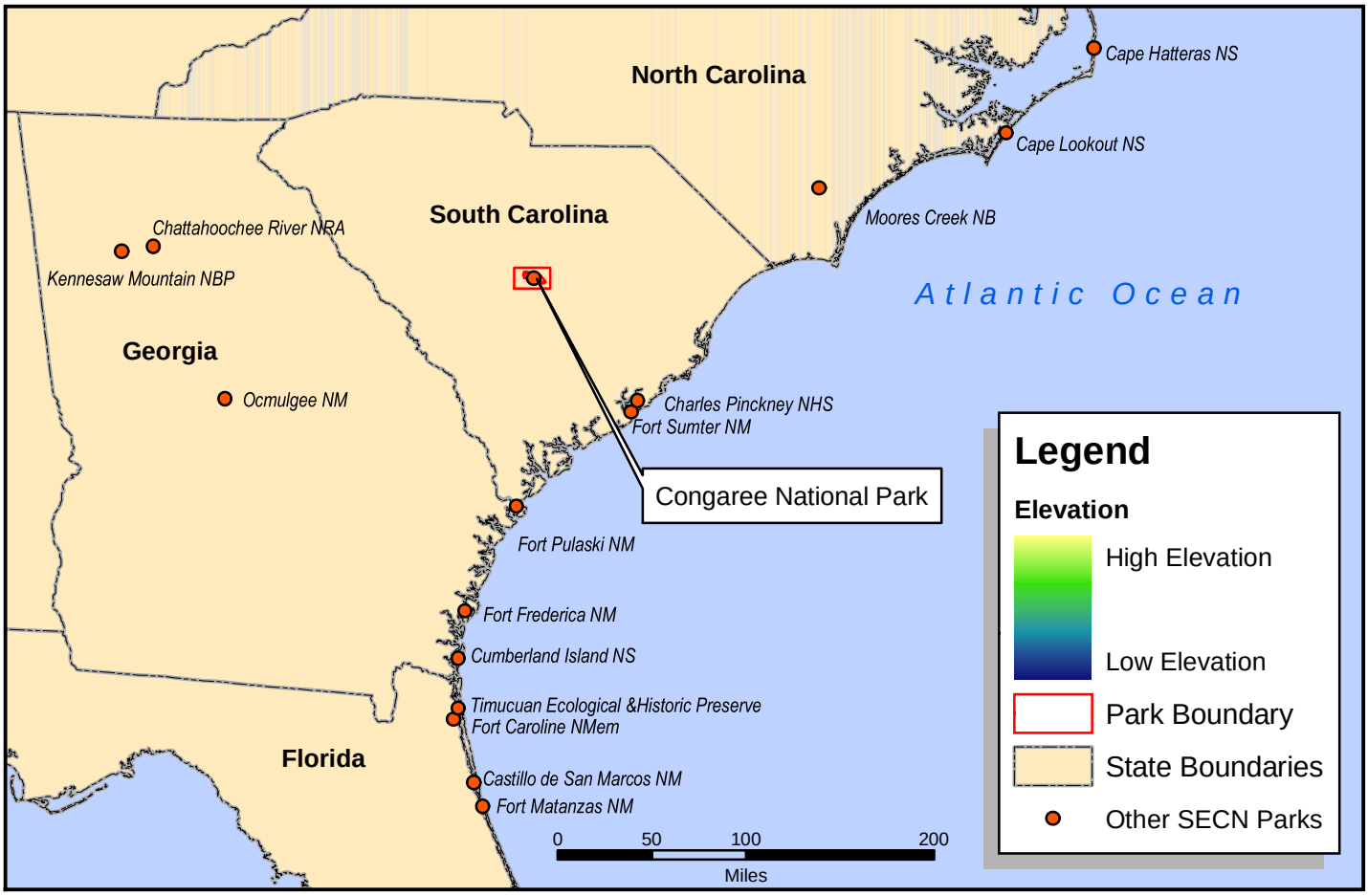
U.S. Department of the Interior





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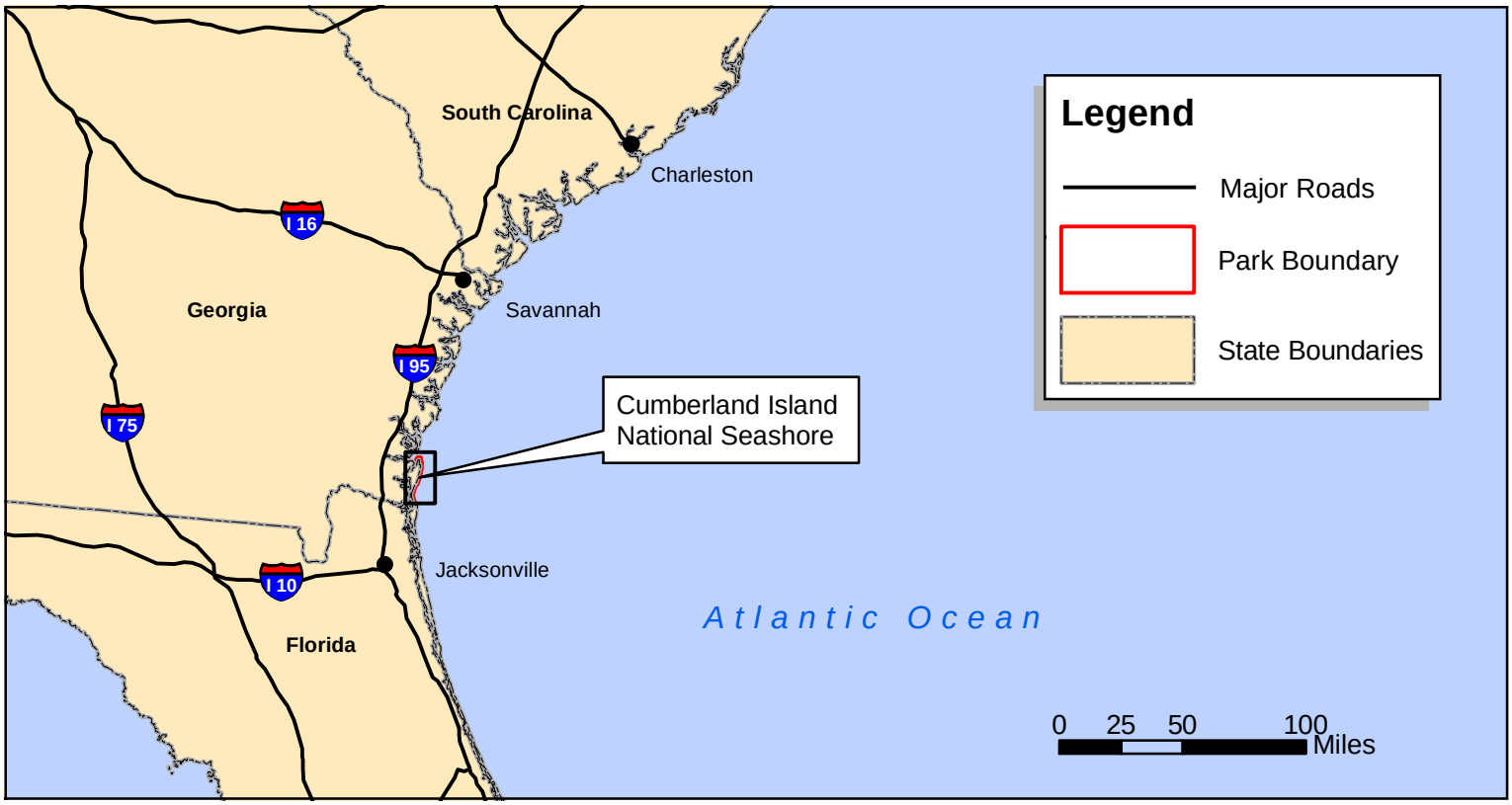
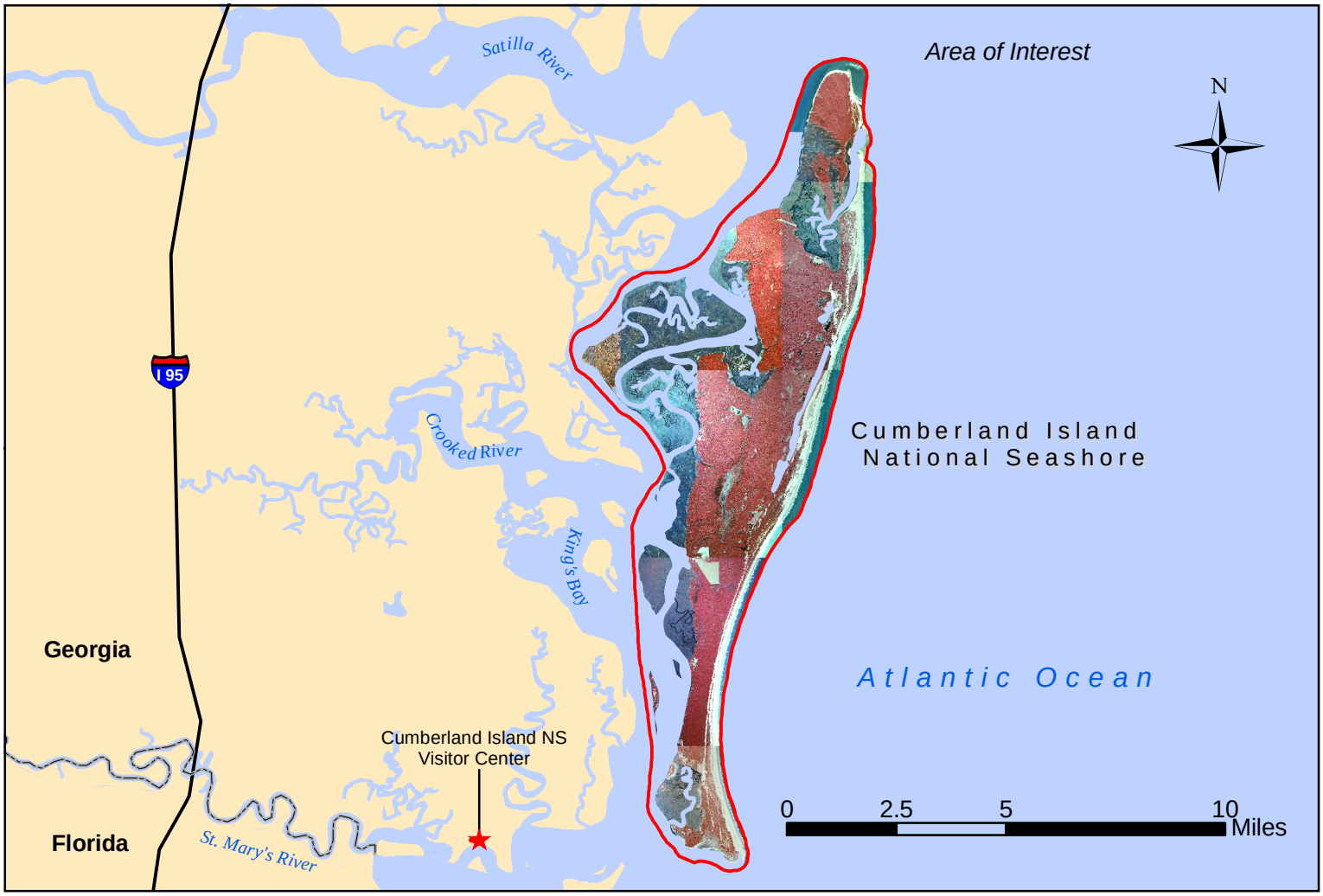
Cumberland Island National Seashore
Georgia

National Park Service
U.S. Department of the Interior





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Fort Frederica National Monument
Georgia

National Park Service
U.S. Department of the Interior

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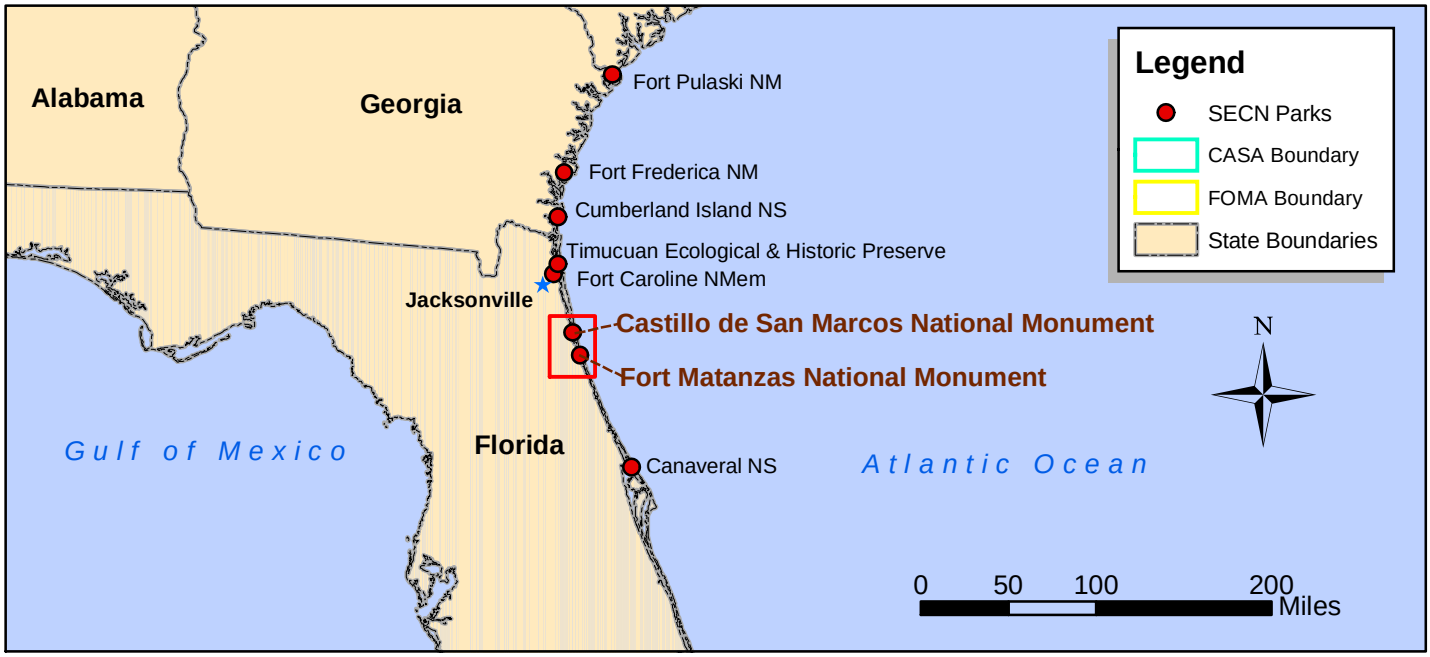
Fort Matanzas National Monument
Castillo de San Marcos National Monument
Florida

National Park Service
U.S. Department of the Interior



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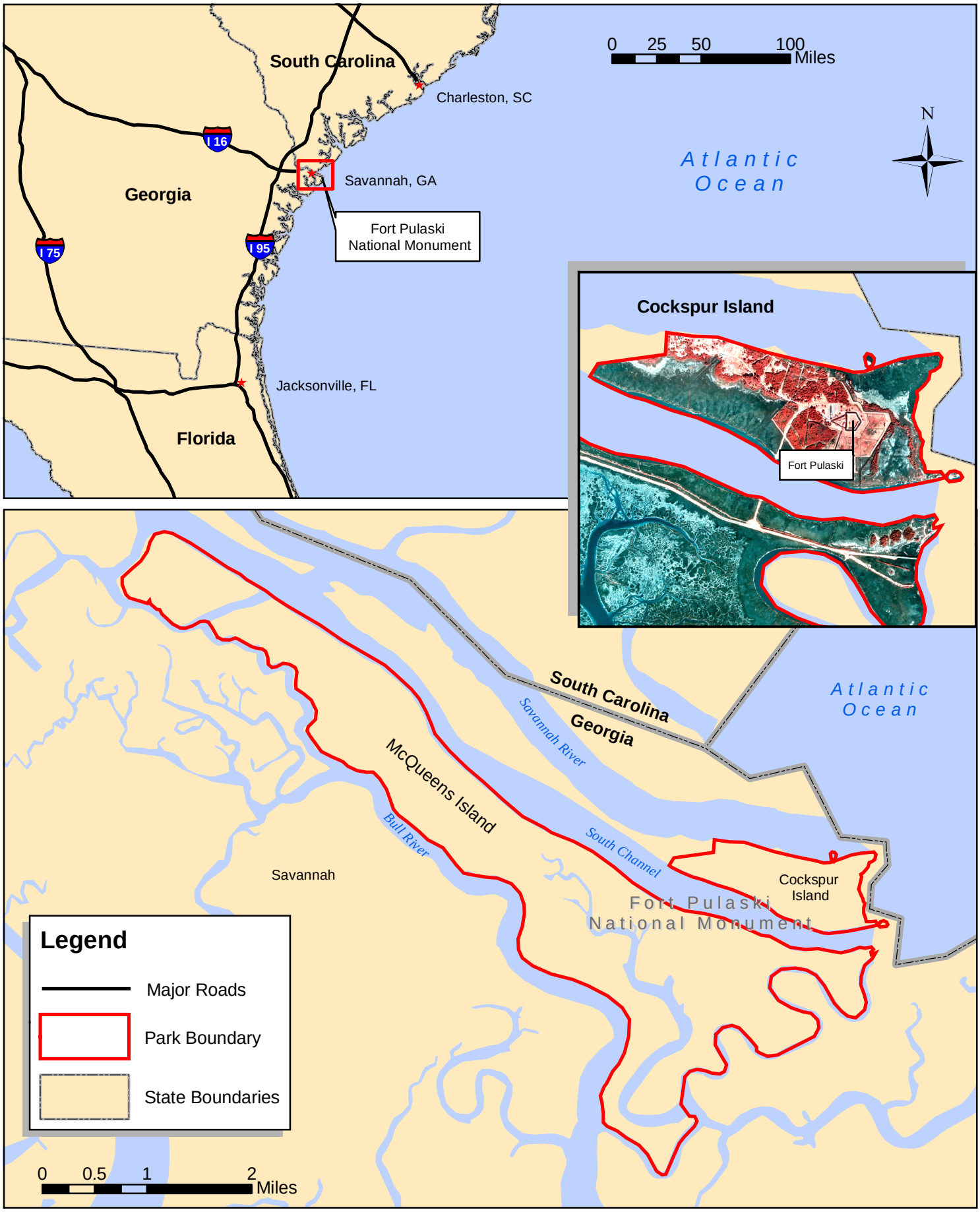
Fort Pulaski National Monument
Georgia

National Park Service
U.S. Department of the Interior



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Fort Sumter National Monument
Charles Pinckney National Historic Site
South Carolina

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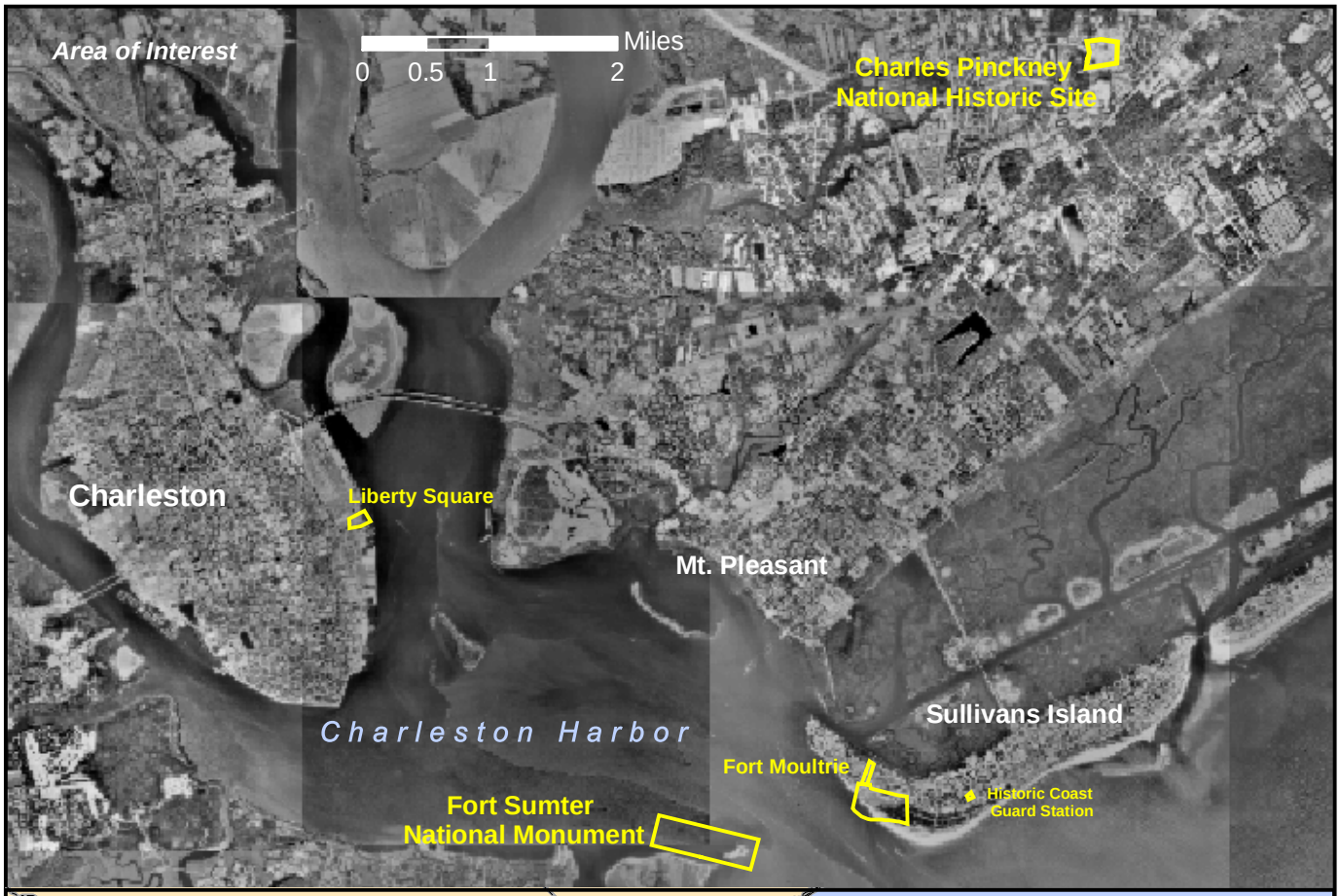

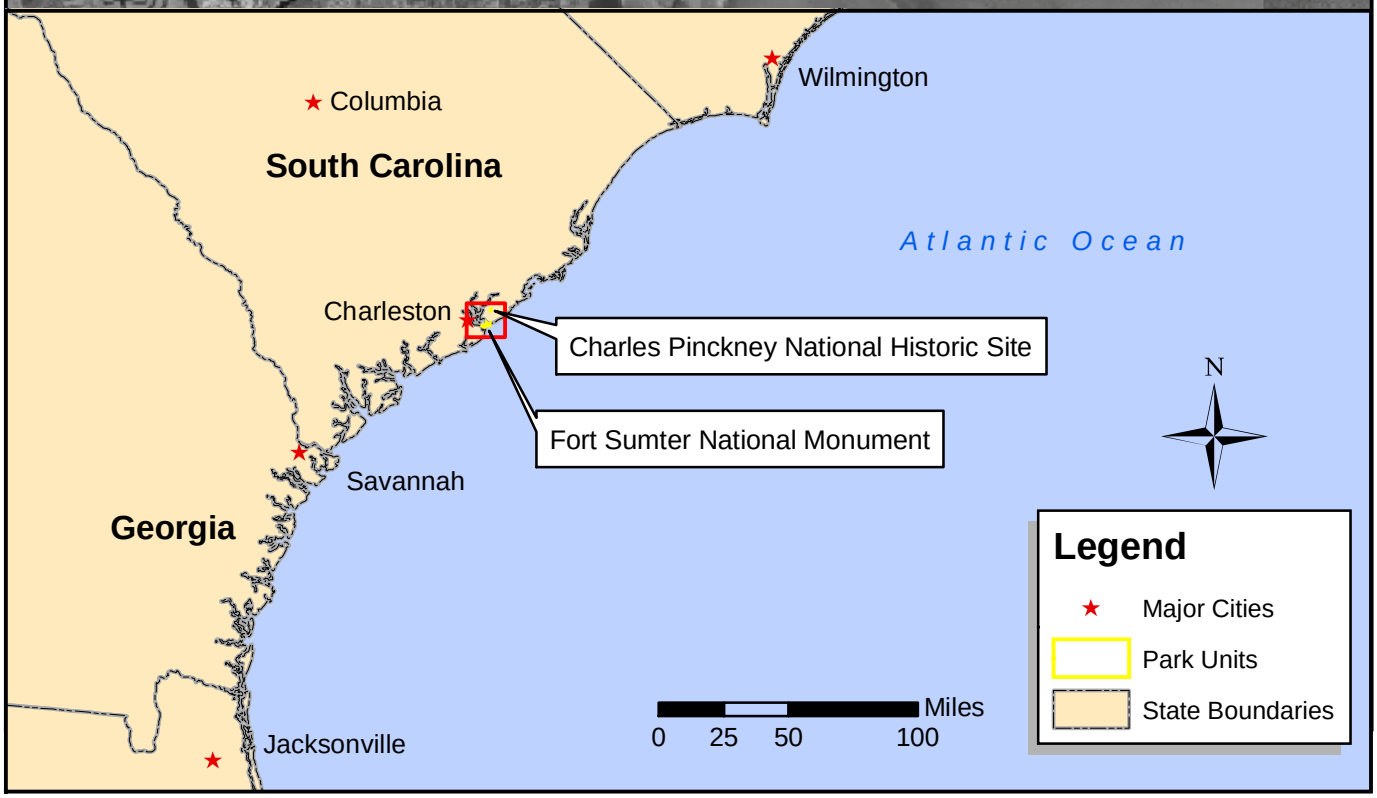

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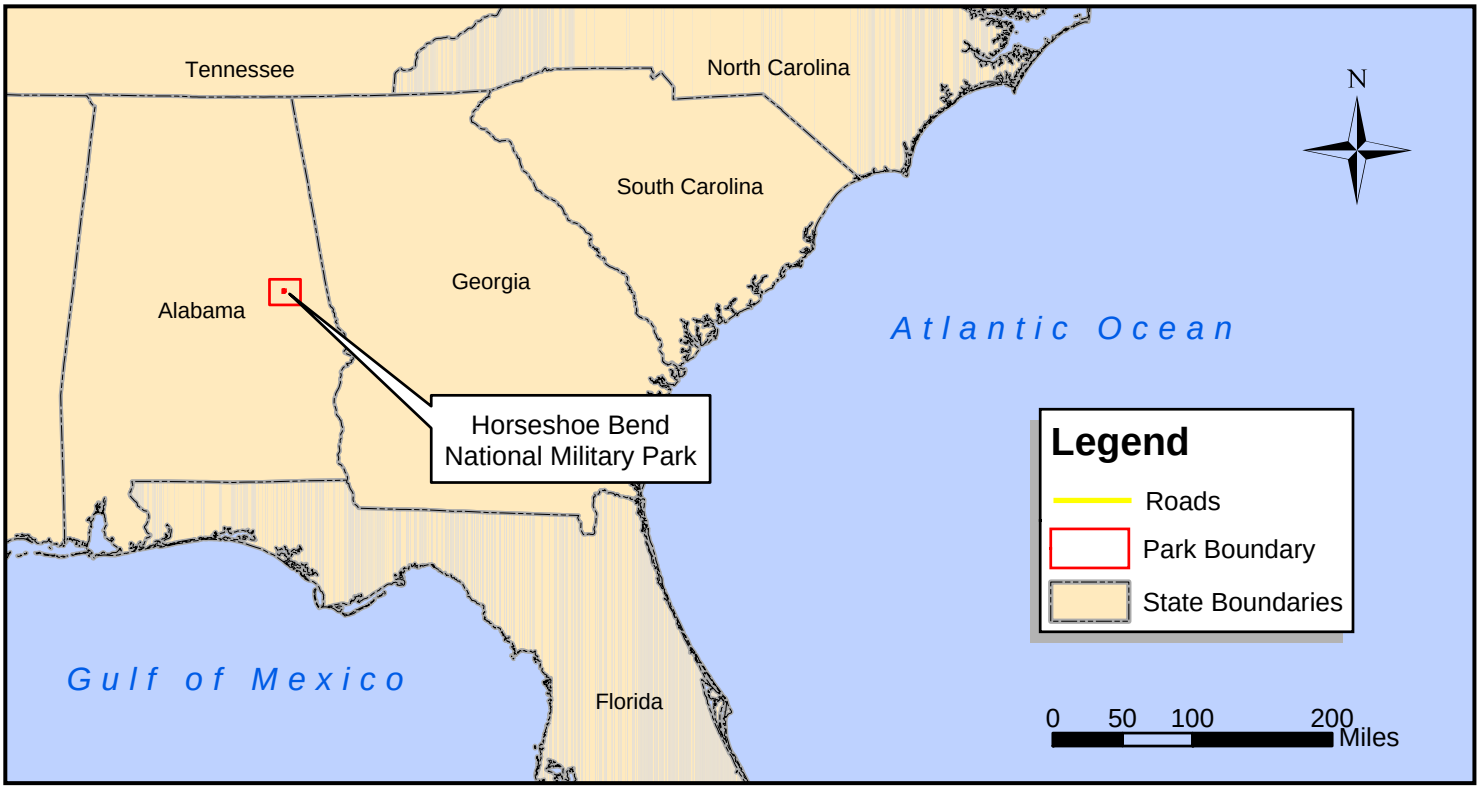
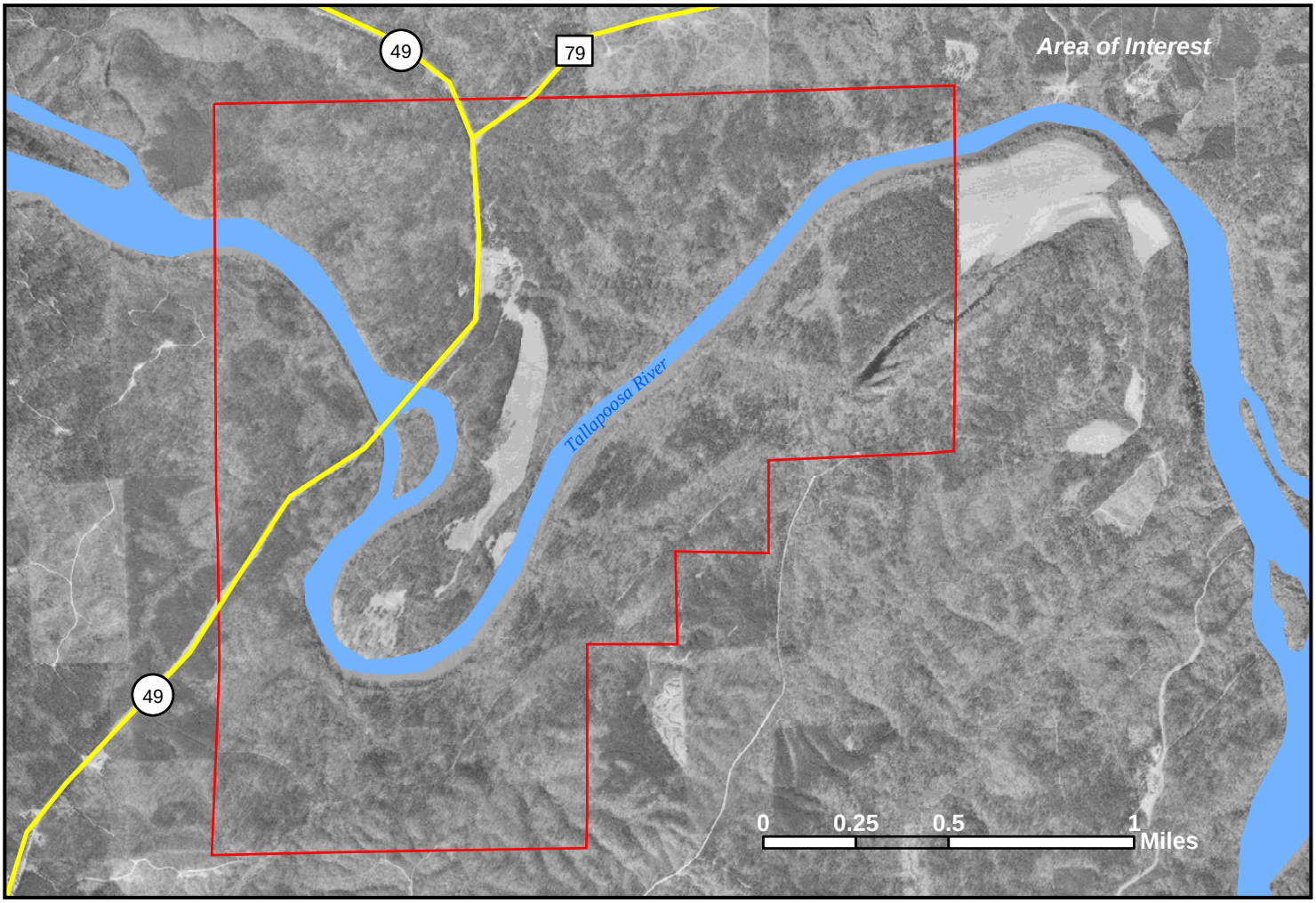
Horseshoe Bend National Military Park
Alabama

National Park Service
U.S. Department of the Interior





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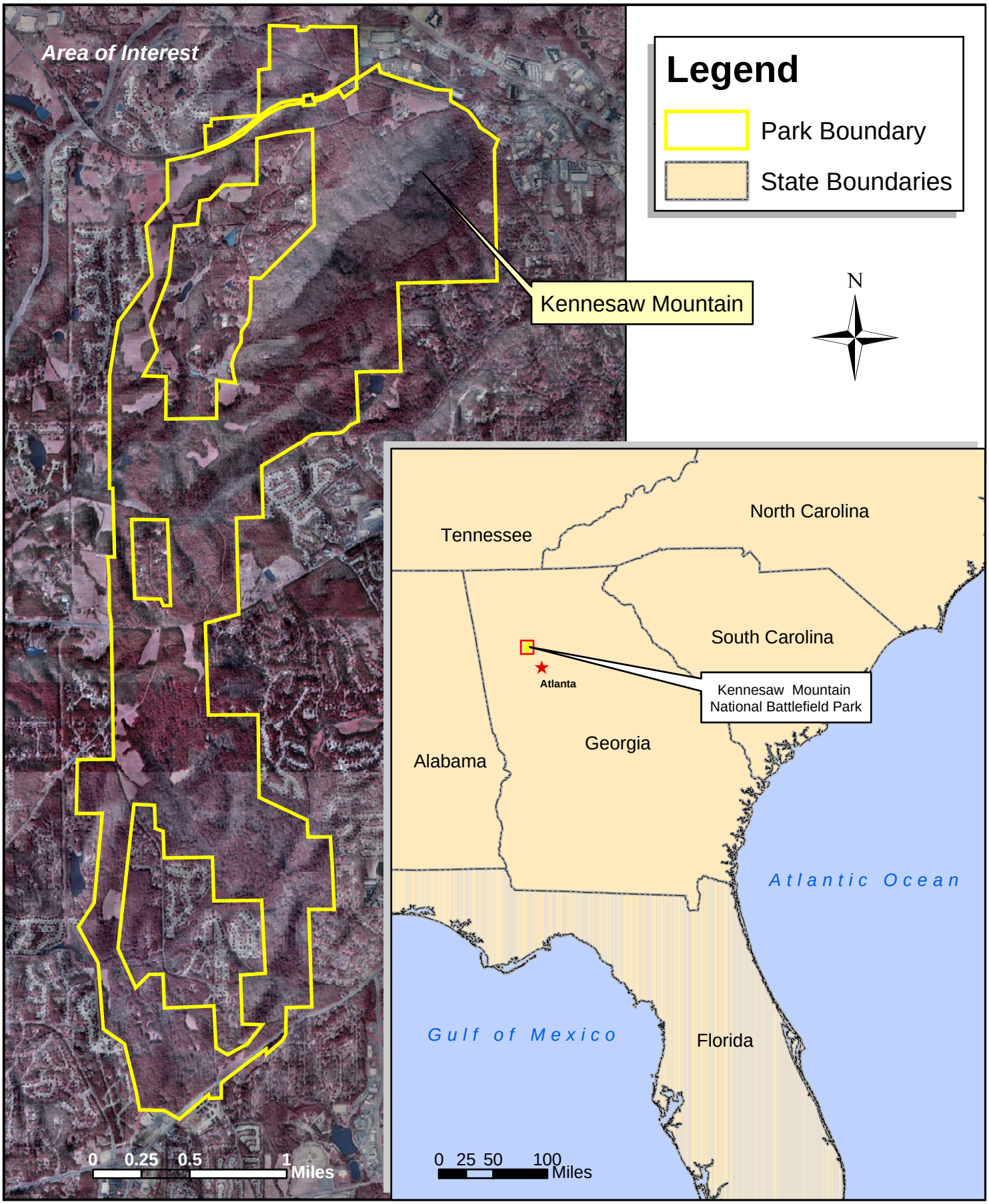
Kennesaw Mountain National Battlefield Park
Georgia

National Park Service
U.S. Department of the Interior



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Moores Creek National Battlefield
North Carolina

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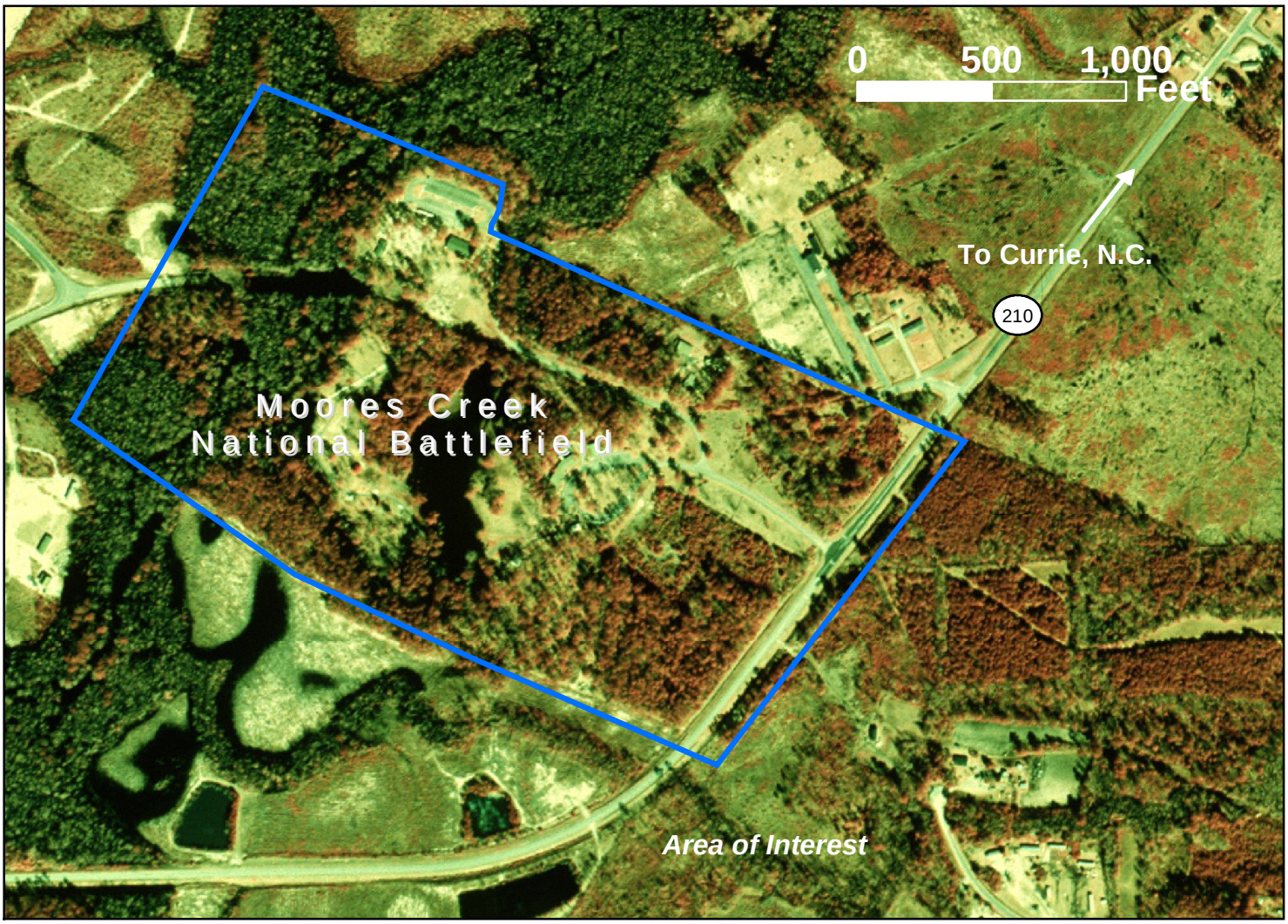
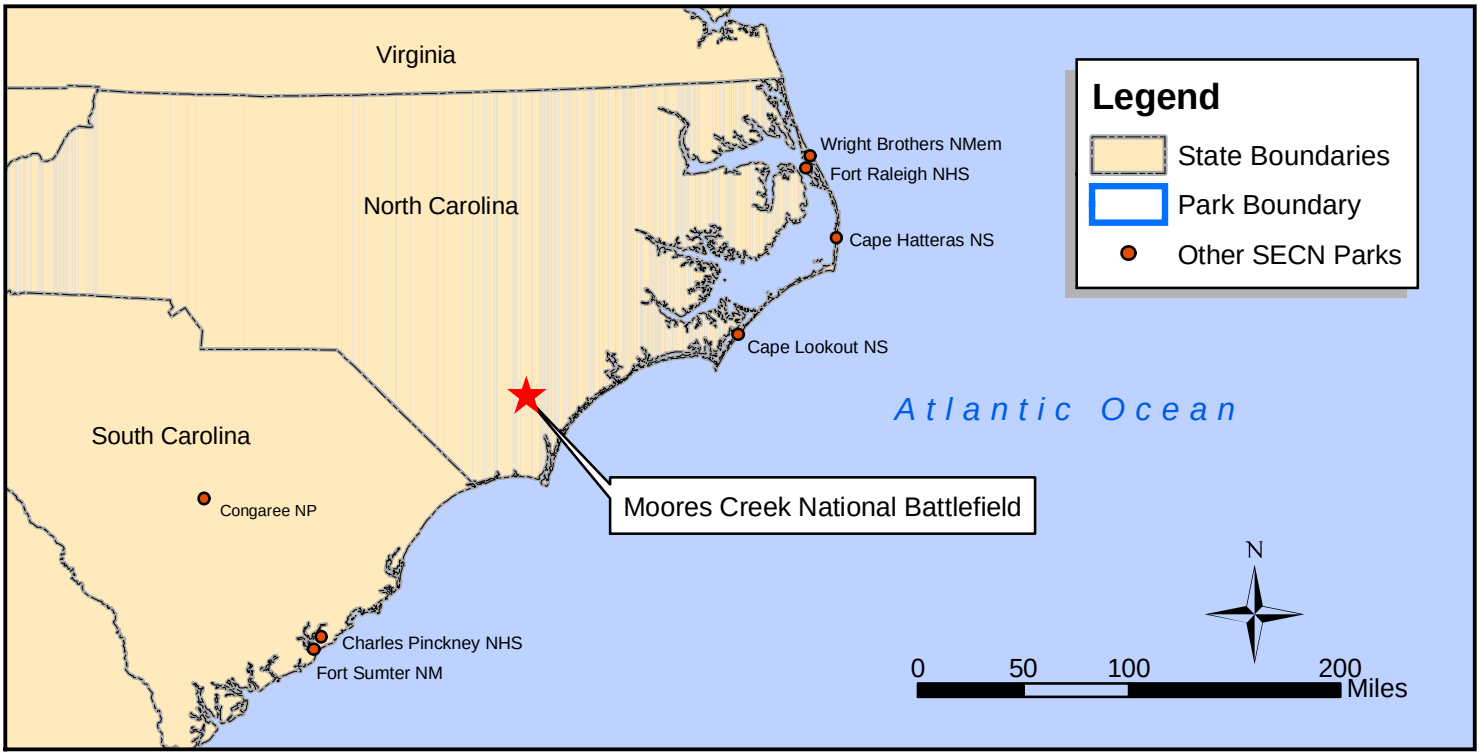
U.S. Department of the Interior





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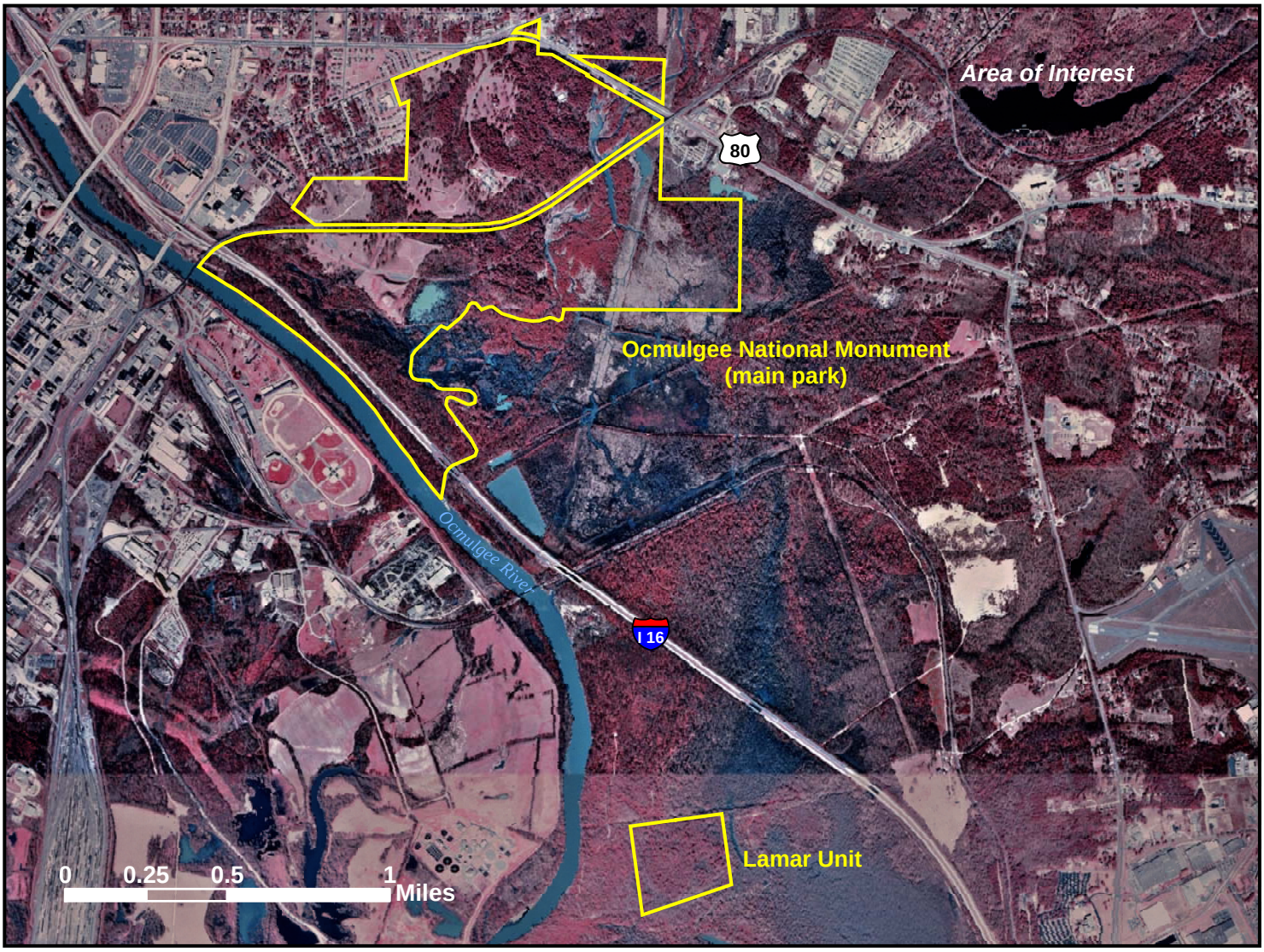
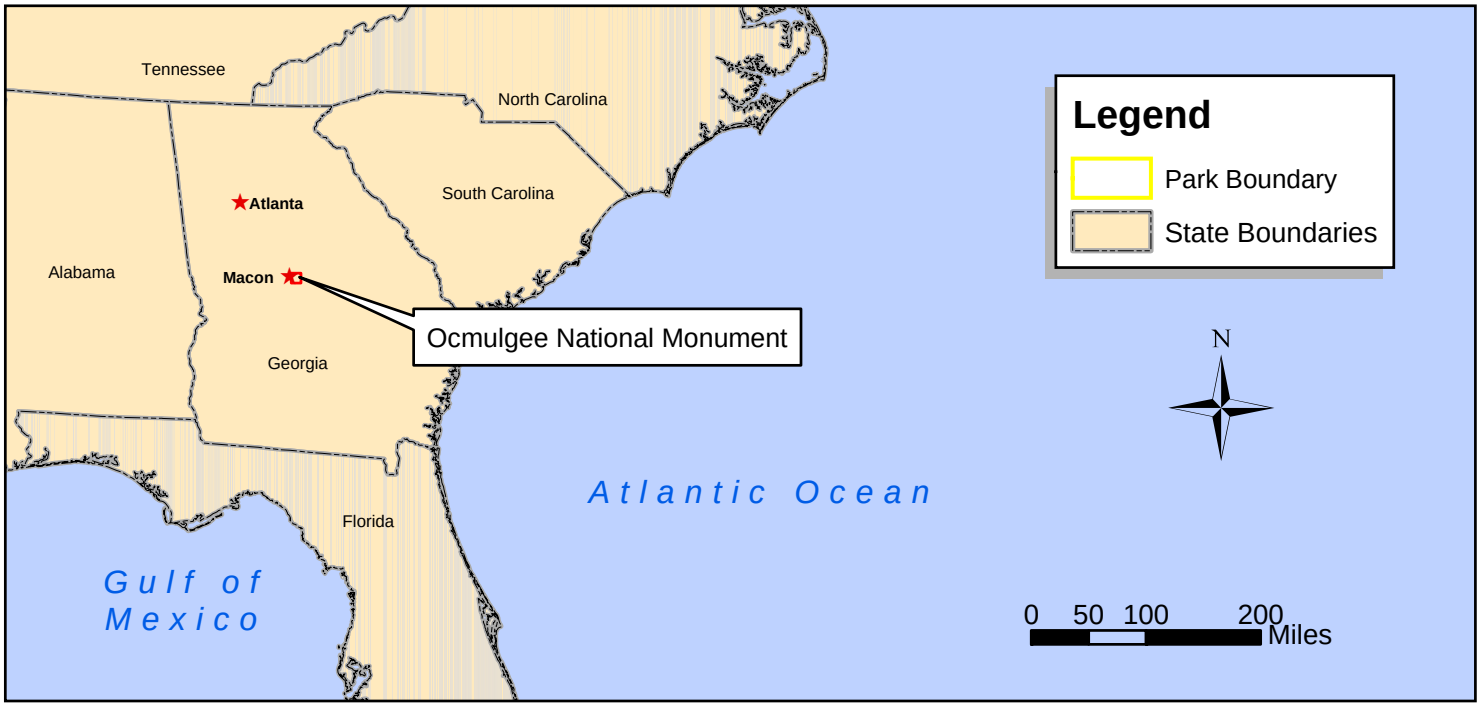
Ocmulgee National Monument
Georgia

National Park Service
U.S. Department of the Interior





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Timucuan Ecological and Historic Preserve
Fort Caroline National Memorial
Florida

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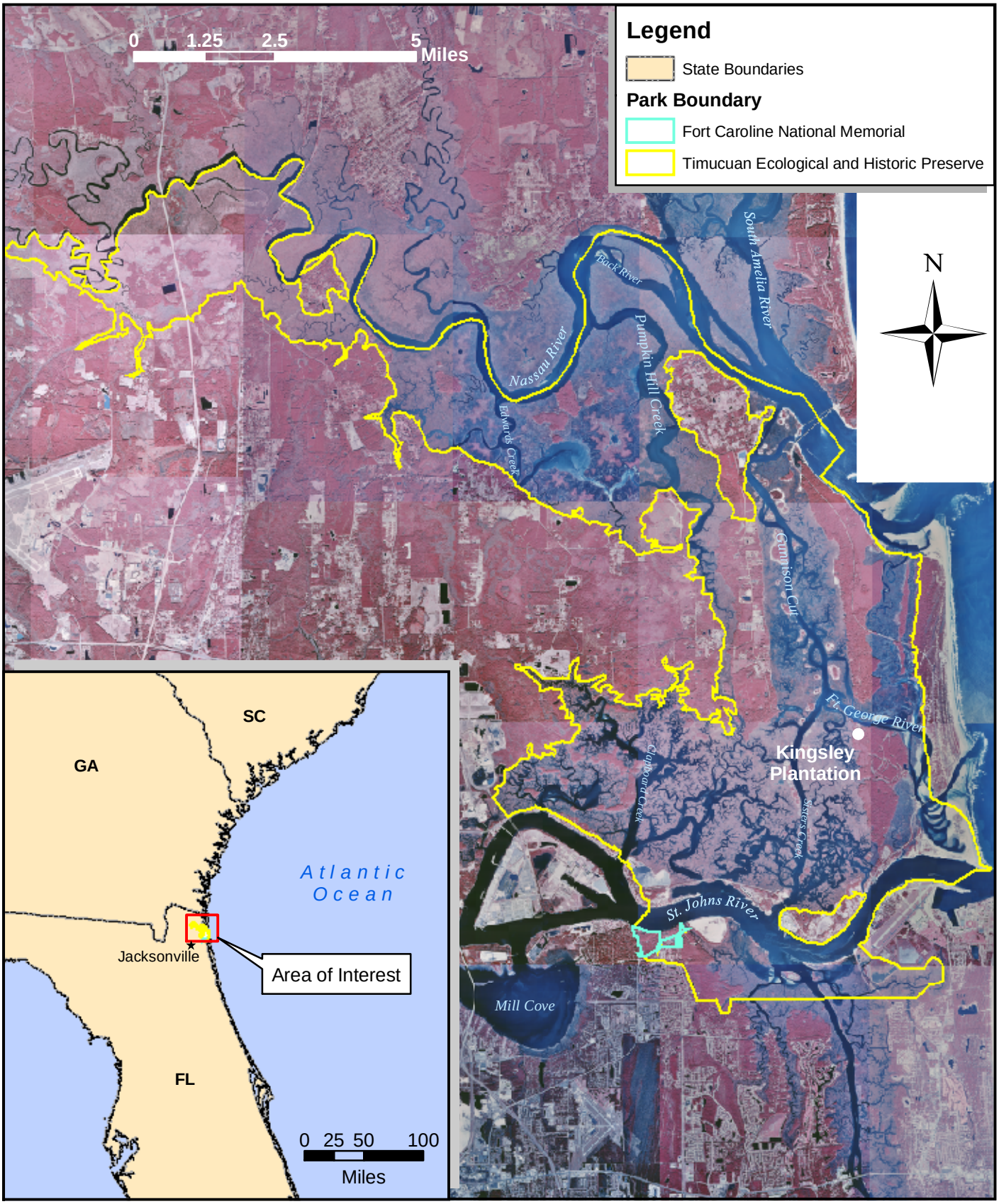

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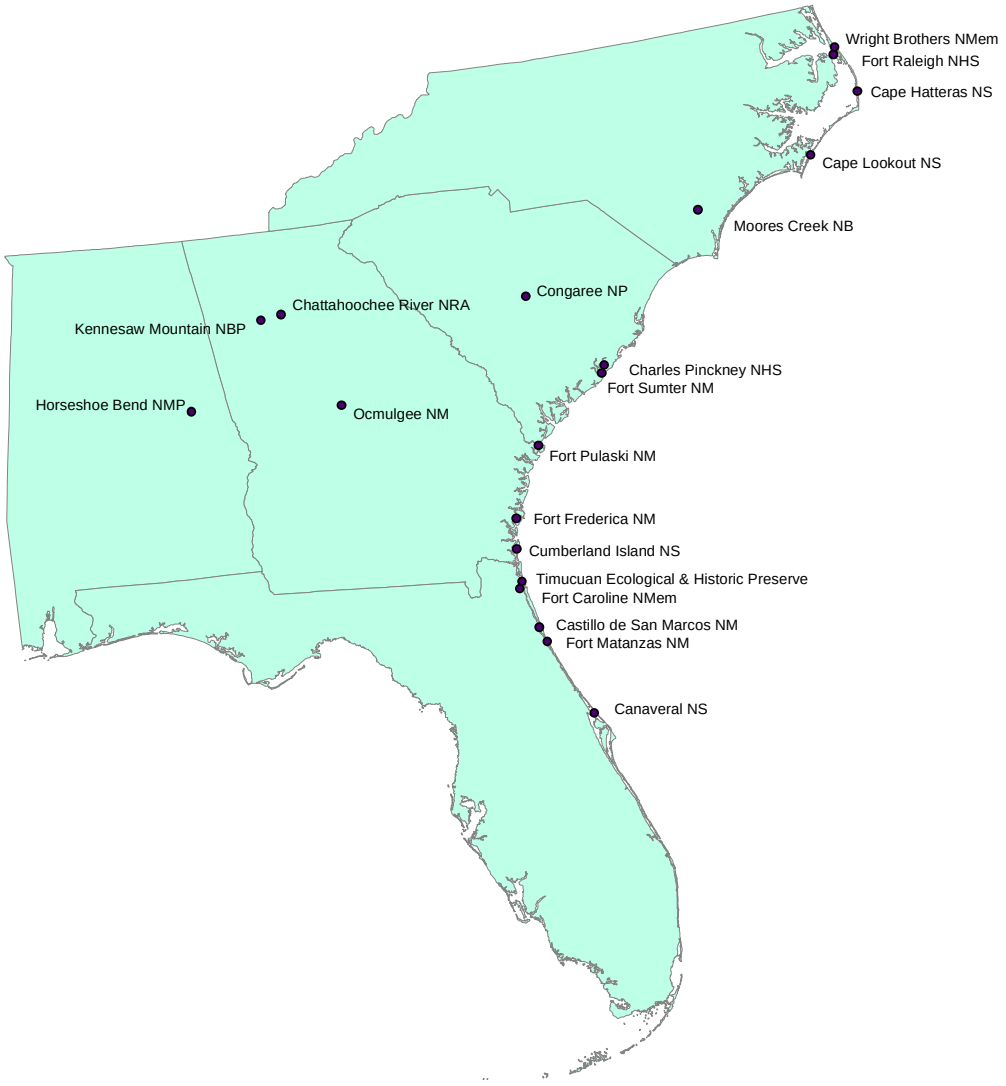
Atlanta, Georgia

Appendix 7 – Conceptual Models of Southeast Coast Network Ecosystems



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Introduction & Modeling Framework

Development of conceptual models is a required step in design of the Vital Signs Monitoring Program for each network. This requirement is based on lessons learned about monitoring program design from the NPS experience with its prototype parks program, and from many other monitoring programs. What these lessons demonstrate is that every monitoring effort is based on some underlying understanding of how the ecosystem in question works. This underlying understanding forms a mental model, often not written for others to read and discuss. To ensure a successful monitoring effort, these underlying models need to be explicit and available for discussion, evaluation, and refinement (Maddox et al. 1999).

Models are purposeful representations of reality (Starfield et al. 1994). Conceptual models provide a mental picture of how something works, with the purpose of communicating that explanation to others. Models (of all types) work best when they include only the minimum amount of information needed to meet the model's purpose (Starfield 1997).

Conceptual models play several useful roles in monitoring program design, including:

- Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;
- Expanding our consideration across traditional discipline boundaries, fostering integration of biotic and abiotic information;
- Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public.

The key point about conceptual models is their role in communication among people with different points of view (Abel et al. 1998). Conceptual models can take a variety of forms—from narrative descriptions to schematic diagrams or flowcharts with boxes and arrows. Regardless of form, the success of a model depends on its ability to share viewpoints and develop a common understanding based on multiple viewpoints.

Within the National Park Service Inventory & Monitoring program, the development of conceptual models has the specific purpose of guiding the process of selecting *Vital Signs*—information-rich attributes that will be selected for long-term monitoring. With this purpose, a critical role of the conceptual models discussed below is to identify (a) key resources and functions, (b) natural and anthropogenic agents of change, and (c) expected ecosystem responses within Southeast Coast Network ecosystems. With the drivers of change identified, the types of ecological changes most important for park managers to detect can be evaluated. Knowing what changes it is desired to detect is the foundation for the selection of vital signs.

Generalized Ecosystem

An ecosystem conceptual model can be considered as a list of state variables and forcing functions of importance to the ecosystem and the problem in focus. General ecosystem models also show how these components are connected by means of processes (Figure A7-1) (Jorgensen 1986). Allen and Hoekstra (1992) emphasize that "we do not wish to show that everything is connected, but rather to show which minimal number of connections that we can measure may be used as a surrogate for the whole system in a predictive model." An important step in model construction is to identify an appropriate level of resolution, given the model objectives (Starfield and Bleloch 1986). Processes that occur much more slowly than the system of interest may be aggregated and considered as constraints of the system; processes that occur more rapidly than the system of interest may be aggregated and considered as 'noise' (Turner and O'Neill 1994).

Purposes of the general ecosystem characterization models include:

- To indicate the driving abiotic factors that constrain the system, depict their relationships to key structural components and processes, and describe resultant ecosystem characteristics.

- To describe the predominant natural disturbances that historically influenced the system, indicate their relative importance in structuring the system, and summarize ecosystem-specific disturbance patterns (return intervals, extent, magnitude, seasonality).
- To characterize the prevalent anthropogenic stressors that are currently affecting the system, describe their relationships to key structural components and processes, and describe resultant ecosystem effects.
- To provide a foundation for evaluating the range of current conditions of key structural components within the context of historic natural variability.

Work by Chapin et al. (1996) on ecosystem sustainability and Harwell et al. (1999) on ecosystem integrity together outline a framework for the categories of ecosystem components / attributes to be considered in the general ecosystem characterization model. With respect to biotic ecosystem components responsible for contributing to ecosystem sustainability, Chapin and colleagues emphasize a functional-group perspective (Figure A7-2). The concept of ecosystem integrity emphasizes the full range of biotic components, irrespective of functionality.

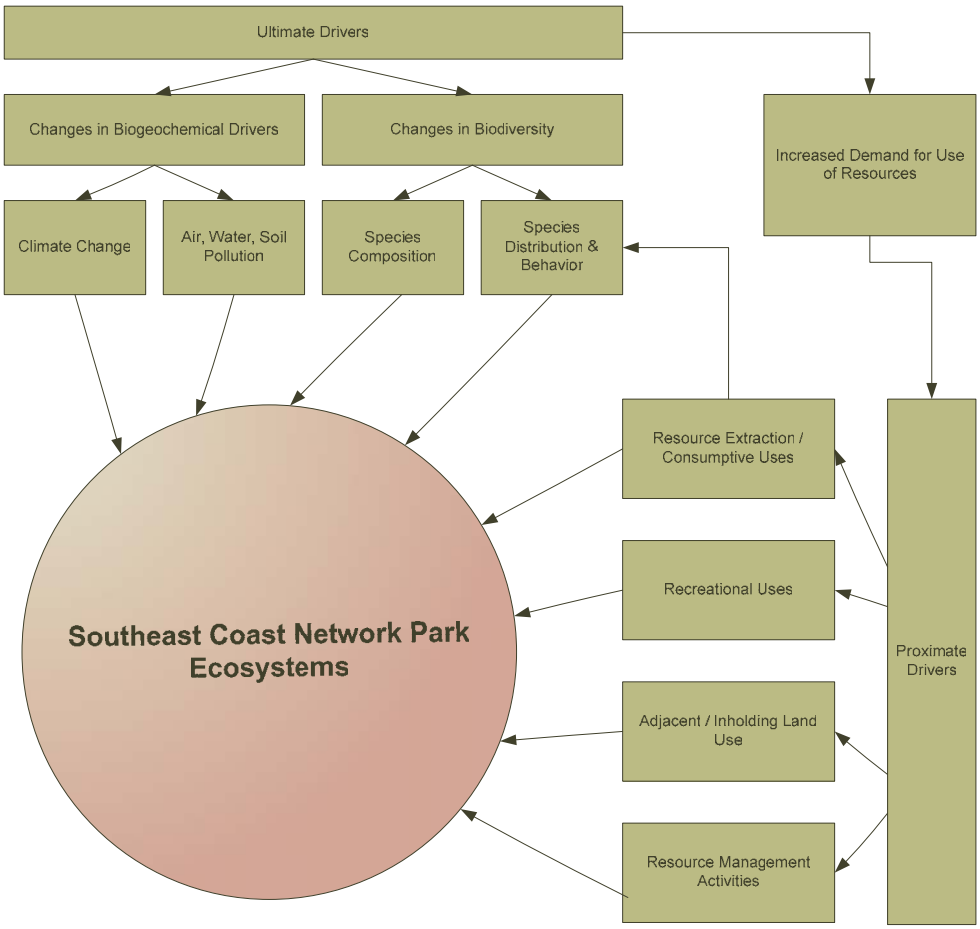


Figure A7-1. Generalized model of primary drivers that affect Southeast Coast Network ecosystems.

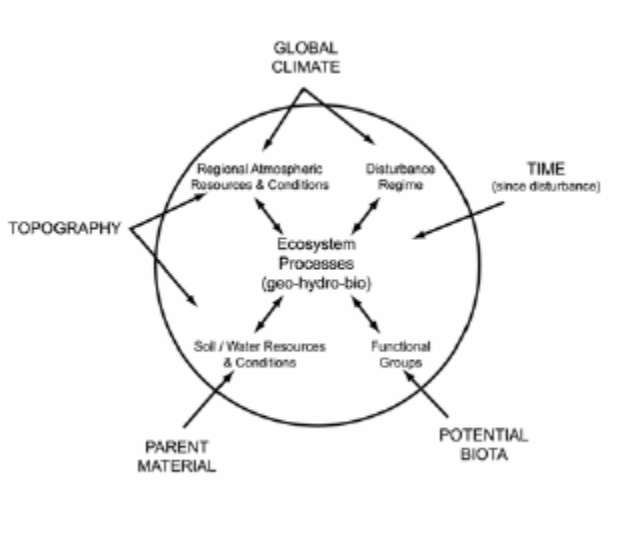


Figure A7-2. Modified version of Chapin et al.'s (Chapin et al. 1996) model of ecosystem sustainability. Factors outside the circle represent ultimate constraints on structural and functional characteristics of the ecosystem. Factors arranged around the inside perimeter of the circle (representing the ecosystem) are termed interactive controls of ecosystem sustainability.

Dynamics of Ecosystems

Three of the five servicewide goals for vital-signs monitoring are oriented towards the *dynamics* of ecosystems or selected ecosystem components:

- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.

It is clear from these goals that a fundamental purpose of vital-signs monitoring is to detect meaningful changes in the condition (structure and functioning) of park ecosystems. It is therefore essential that conceptual models developed to support vital-signs monitoring reflect the current state of knowledge regarding ecosystem dynamics – how and why ecosystems change as a consequence of interacting natural and human factors.

Ecosystem-dynamics models thus represent the next level of detail in conceptual modeling required by the Southeast Coast Network. Initially, dynamic models will be developed for broad functional groupings of ecosystems – but site-specific models might later be required for some systems. Several organizations (e.g., USGS, USDA-ARS, NRCS, BLM, The Nature Conservancy) currently are working on site-specific *state-and-transition models* for particular *ecological sites*. State-and-transition models generally have been used to describe the temporal dynamics of rangeland ecosystems, but they also have been applied to riparian ecosystems (Richter and Richter 2000, Stringham et al. 2001). State-and-transition models for upland ecological sites typically focus on soil quality (primarily dynamic soil properties) and vegetation composition/structure because of strong soil-vegetation feedbacks and the significance of soil and vegetation for structuring other biotic components of the ecosystem. Riparian and spring/seep state-and-transition models probably would focus on vegetation, geomorphology, and hydrology / geohydrology.

Ecosystem "Pinwheel" Models

The Southeast Coast Network has developed conceptual "pinwheel" models to describe the major ecosystems present in the network (Figure A7-3). The model assumes that each ecosystem exists in a "natural" state and that processes (natural or anthropogenic) act to push those systems to one or more modified states.

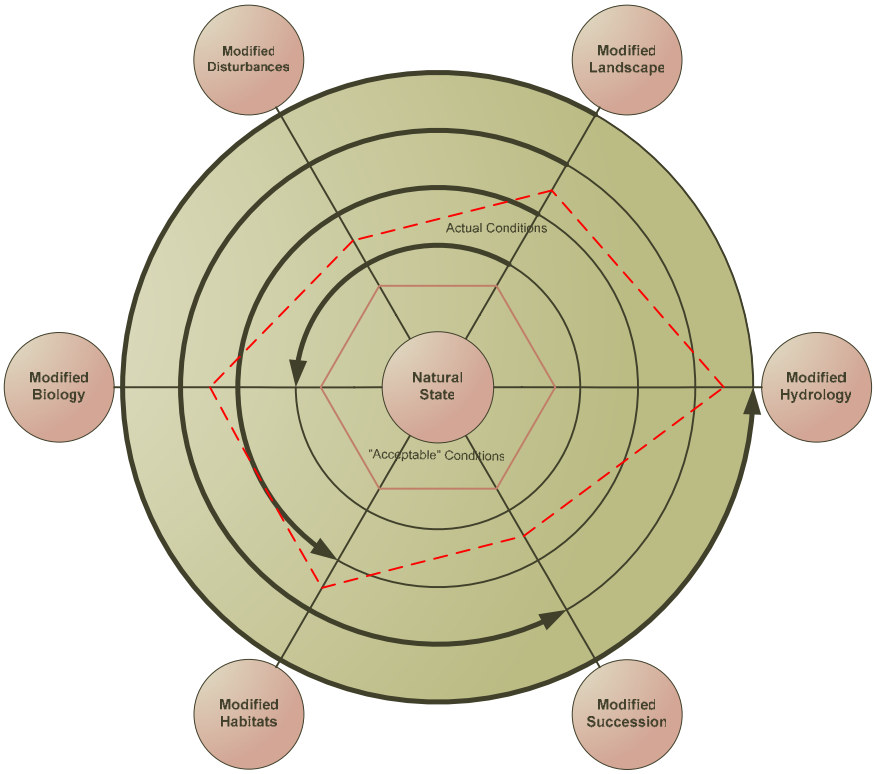
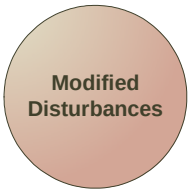


Figure A7-3. General "pinwheel" model template used by the Southeast Coast Network for description of the networks major ecosystems. Peach-colored spheres represent potential "states" of ecosystems. Arrows represent processes that move ecosystems from one state to another. The solid red line indicates conditions within the ecosystem considered to be "acceptable" given existing statutes and management plans; the dashed red line is a hypothetical depiction of "actual" ecosystem conditions.

The modified states fall into six broad categories: modified disturbances, landscapes, hydrology, succession, habitats, and biology as follows:

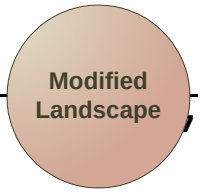
Modified Disturbances



All ecosystems are shaped to some extent by regularly occurring disturbances, which vary in frequency and intensity over time. Within the Southeast Coast Network, natural disturbances include fire, flooding, insect outbreaks, hurricanes and other high-energy storm events, and even earthquakes. Within the network, most disturbance regimes have been altered to some degree through fire suppression / reintroduction, flood control & river regulation, pest management, and potentially even global warming.

Changes in disturbance regimes can secondarily cause changes in hydrology, succession, habitats, and also the plant and animal communities on and surrounding network Parks.

Modified Landscapes

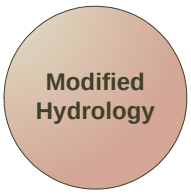


Each park within the Southeast Coast Network is affected to some extent by both the surrounding landscape and a long history of landscape modification. However, the degree of influence from the surrounding landscape varies among the parks, and necessarily changes depending on the

ecosystem being considered. The parks within the Network that have major river systems (CONG, CHAT, KEMO, HOBE, OCMU, and MOCR) are influenced by factors upstream within the watershed regardless of park jurisdictional boundaries. The coastal barrier island parks are affected by a combination of factors both upstream within their watersheds and up-shore along the Atlantic coast. For all parks, air resources are potentially affected by activities within the landscape independent of location within the watershed.

The primary driver of changes in landscapes in the southeast is the rapid population growth rate region-wide. As a result, typical landscape-level factors that affect park resources include both the type of adjacent land use, and conversion of those lands (typically residential, agricultural / forested, or urban). These changes, though landscape-scale in scope can dramatically affect local ecosystems. Local modifications to habitats, hydrology, and biology can result from landscape-scale changes in sediment budgets (in both riverine and coastal systems), water availability and use, and metapopulation dynamics.

Modified Hydrology



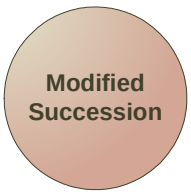
Alteration to the hydrological regime is a common disturbance in a variety of southeastern ecosystems: bottomland and floodplain forests, longleaf pine savanna, Carolina bays, Atlantic white-cedar swamps, barrier-island communities, mangrove forests, rivers, and streams (White et al. 1998). Hydrological change has altered flood depth, duration, frequency, and seasonal timing in many of these systems, leading to a raising and lowering of the water table in specific cases.

Southeast Coast Network riverine systems have been altered by human activities, including impoundment, channelization, lowering of water tables, increased runoff, acid mine drainage, air and water pollution, sedimentation, recreation, and introduced species (including mussels, fishes, and aquatic plants) (White et al. 1998). Many examples of effects on stream biota can be cited (Hackney and Adams 1992)—nearly all major stream systems have been channelized or dammed (Adams and Hackney 1992). In the Southeast, 144 major reservoirs have been built (Soballe et al. 1992), and one-third of all Florida rivers have impoundments.

Groundwater resources in the Southeast Coast Network include two major regional aquifers (the Floridan and the Northern Atlantic Coastal Plain) and multiple shallow groundwater aquifers. These groundwater resources provide both drinking and irrigation water to coastal areas and are likely to see increasing demand as the human population grows in the region.

Changes in hydrology can also secondarily cause changes in habitats succession, biology, and even disturbance regime.

Modified Succession



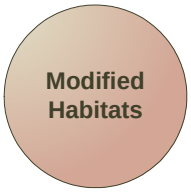
For the purposes of the pinwheel models, modified succession refers to any state where the natural evolution of the landscape has been either slowed down or accelerated. Plant communities in the Southeast Coast Network are to a large extent defined by a long history of land practices that have altered natural succession, primarily in terrestrial habitats. Practices such as fire suppression, land conversion, agriculture, and silviculture have often focused on keeping lands in specific successional states. Conversely, altered flooding regimes (either by increasing or decreasing flooding frequency) have allowed succession within network habitats to either be curtailed or extended.

In addition to terrestrial plant communities, efforts to halt the evolution of landscapes also occur in coastal and riverine systems. Erosion control measures on coastal barrier islands through hardening and renourishment are examples of efforts to modify the rates of natural barrier island evolution. Similarly riparian zone management in river systems can lead to altered rates of stream bank erosion.

Changes in succession can directly alter habitats for dependent plant and animal species, and consequently can have dramatic effects on communities in general. Modified landscapes, disturbances, and hydrology can also lead to changes in succession.

Modified Habitats

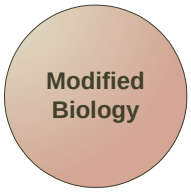
Habitats and the quality thereof are of critical importance for all organisms within network parks. For the purposes of the models described here, habitat includes all factors directly related to the *local* environments for park plant and animal resources. Factors such as fragmentation, heterogeneity, connectivity, and structural diversity are included, but also included are components such as, water quality, air quality, and soil quality.



Habitats within network parks can be influenced by either local or landscape-level processes, and can be either natural or anthropogenic in origin. Because of its direct impact on biodiversity, habitat modification is often a strategy used for managing park resources, particularly in threatened and endangered species management.

Modified Biology

Modified biology refers to changes in the biodiversity, distribution, behavioral ecology, and feeding ecology of the plant and animal species present within the ecosystem. Processes such as migration, competition, disease transmission, and predation all typify natural processes that can modify biological communities. However, other non-natural processes such as species invasions, hunting, and species reintroductions can also have dramatic impacts on communities.



Typically though, biological modifications are the "end result" of one or more processes or state-changes within the ecosystem, but in some cases can result in state changes themselves (i.e., changes in fire frequency due to altered fuel loading).

Use of pinwheel diagrams in a management & monitoring context

It is clear from these goals that a fundamental purpose of vital-signs monitoring is to detect meaningful changes in the condition (structure and functioning) of park ecosystems. It is therefore essential that conceptual models developed to support vital-signs monitoring reflect the current state of knowledge regarding ecosystem dynamics – how and why ecosystems change as a consequence of interacting natural and human factors. Monitoring can occur at one of two fundamental levels: either the processes described can be measured, or the mechanistic components describing either the process or the results (modified disturbance, landscape, hydrology, succession, habitats, or biology).

Finally, more detailed mechanistic models can be developed to further describe the processes included in the pinwheel diagrams. In such models, the environmental setting, resources of concern, and agents of change can be linked to expected ecosystem responses. From a management standpoint, both the status of the ecosystem and the trends either toward or away from an acceptable state might be important (Figure A7-3). Detailed descriptions of the key mechanistic components of Southeast Coast Network ecosystems can be found in Appendix 7.

Mechanistic Models

For the purposes of the Southeast Coast Network's planning efforts, the mechanistic models are for now limited to detailed descriptions of the key components of the ecosystems within and surrounding the Network parks (Figure A7- 8). It is not the intent to summarize all of the ecologically relevant information about all resources at all of the parks; rather to present the information needed to discuss resources in the context of the surrounding environment, processes that cause changes in natural variation, and factors that drive those processes.

Southeast Coast Network Ecosystems

The Southeast Coast Network has chosen to model three distinct ecosystem types within the network: terrestrial, riverine, and nearshore marine / estuarine, each of which can be defined by a combination of expected and observed characteristics of disturbance regimes, surrounding landscape, hydrology, succession, habitats, and biota. In all

systems, the goal of the modeling is to look at the ecosystems at multiple hierarchical levels: the overall generalized ecosystem, the processes that occur and define the status of resources within sub-ecosystems, and the key components and linkages that make up those ecosystems.

For each modeled ecosystem, we have developed two types of related conceptual models: generalized graphical ecosystem characterization models, and textual descriptions of key model components. Generalized ecosystem models present hypotheses concerning relationships of selected components of the ecosystems and how or why they might change over time. Mechanistic models provide details concerning the actual ecological components and processes that are involved in the dynamic models.

Ecosystems in the Southeast Coast Network can be characterized by "natural" ecosystems that are faced with a combination of biotic and abiotic (both natural and anthropogenic) external agents of change (Figure A7-1).

Rivers & Streams

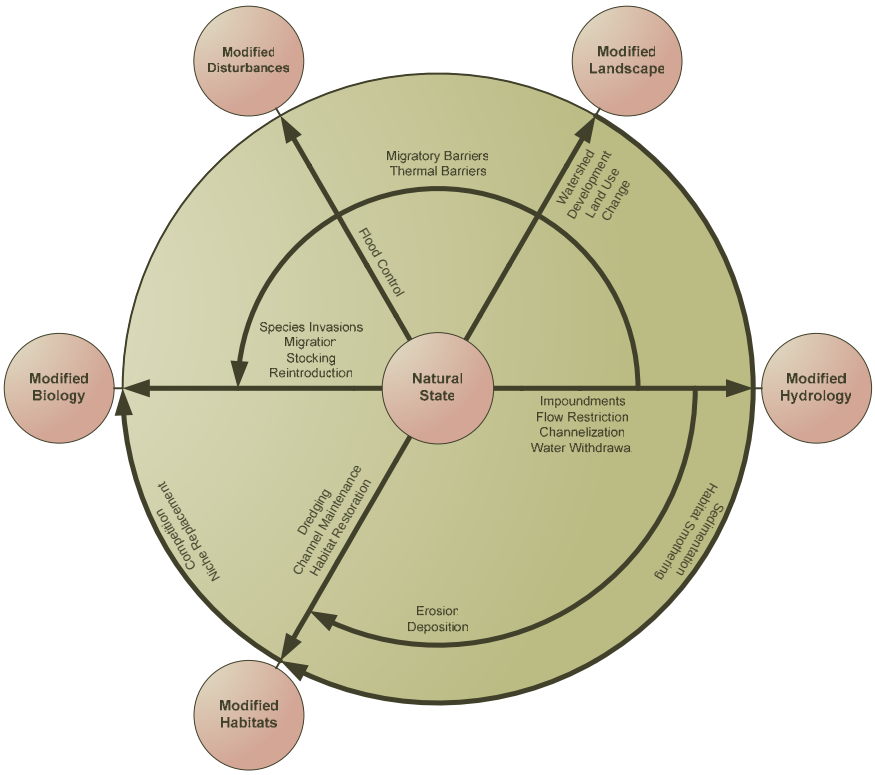


Figure A7-4. Model of ecosystem dynamics in rivers and streams within the Southeast Coast Network.

River systems in the Southeast generally follow trends as described in Vannote et al.'s (1980) River Continuum Concept. This model describes linkages between streams, floodplains, and the watersheds that they drain along a longitudinal gradient from the headwaters to the sea (Figure A7-5). The River Continuum Concept maintains that biological, physical, and chemical properties and functions of river systems and their associated floodplains follow a general pattern from their headwaters to their mouths due to changes in elevation, geomorphology, amount of water, and the amount of light.

Southeast Coast Network parks contain significant riverine resources within three distinct zones along the river continuum—CHAT and KEMO are located in the Piedmont province, HOBE and OCMU are on the fall line, and MOCR and COSW are located within the coastal plain. Coastal parks within the network also contain smaller isolated systems.

Recognizing that rivers are highly dynamic in both space and time, several processes have been identified that cause rivers and streams to evolve from natural to modified conditions (Figure A7-5). Four distinct modification types exist for riverine ecosystems: habitat modification, hydrologic modification, watershed modification, biological modification. Although natural disturbances cause local or system-wide modifications to one or more of these components, these variations are considered to be a part of the natural state. Key processes that drive the natural system to one or more of the modified states include flow restriction and redirection, water withdrawal, species introductions, erosion, competition, migration, and restoration (Figure A7- 8). In some cases, changes from the natural state to a modified state can cause further modifications (i.e., modifying hydrology can cause changes in habitats and therefore changes in community structure).

Southeast Coast Network streams and rivers are in a modified to highly modified state due to a combination of river regulation and rapid changes in land use that have resulted in extreme changes in water quality, habitat quality (through sedimentation) and aquatic community structure. Southeastern streams that were once dominated by coarse woody debris and gravel-bottom substrates have seen those substrates either cleared or buried, and many sensitive species (such as mussels) have been extirpated as a result.

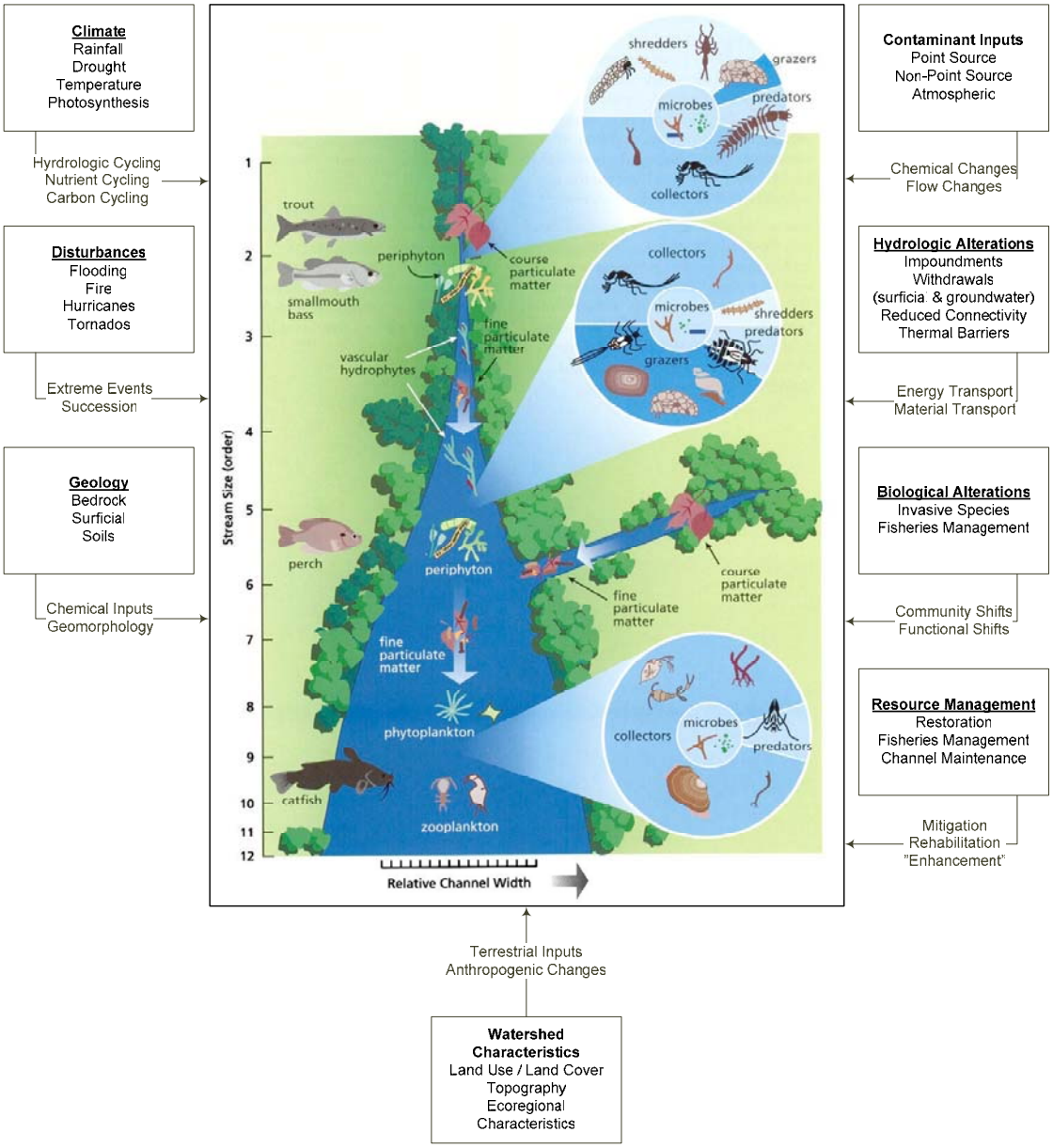


Figure A7-5. General ecosystem model for river and sytream systems within the Southeast Coast Network. Modified from Vannote et al. (1980).

Estuaries & Nearshore Marine Systems

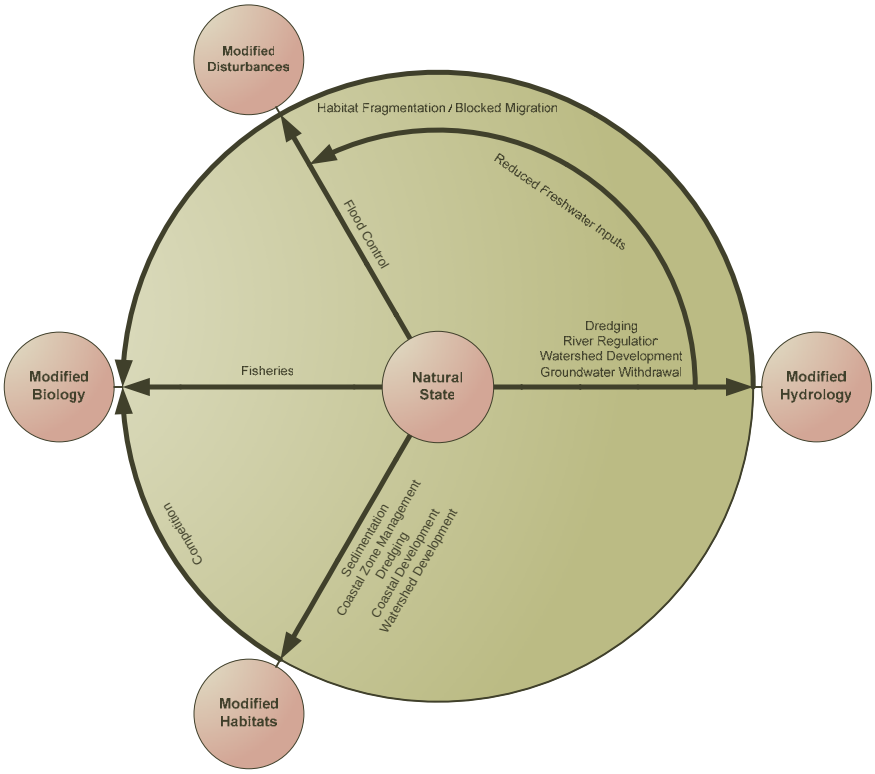


Figure A7-6. Model of ecosystem dynamics in estuaries and nearshore marine areas within the Southeast Coast Network.

The Southeast Coast Network contains seven parks with significant portions of estuarine and nearshore marine systems (CAHA, CALO, FOSU, FOPU, CUIS, TIMU, and CANA). Estuarine systems are particularly sensitive to changes in hydrology; particularly those that can affect salinity levels.

The major drivers of ecosystem change in estuarine and nearshore marine systems include coastal zone management (dredging, beach renourishment, and shoreline stabilization projects), fisheries, adjacent land use development, and hydrological modifications resulting from both upstream river regulation and groundwater extraction (Figure A7-6, Figure A7- 8). Potential changes to the ecosystem include modified hydrology (flushing), modified disturbance regimes (flooding frequency), modified habitats (a combination of changes in sand / sediment budgets and water quality), and resultant shifts in community structures or distributions.

Most parks within the network (even within the coastal parks) do not have jurisdiction within estuarine or marine systems. However, many resources within park boundaries rely on estuarine or nearshore marine systems for part of their life cycle.

Terrestrial Systems

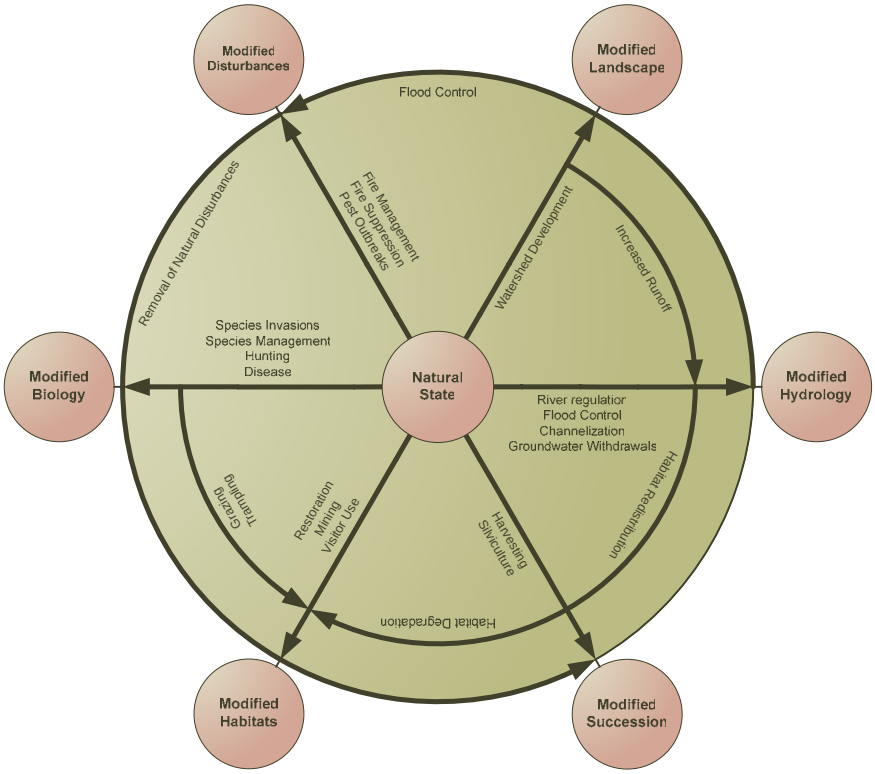


Figure A7-7. Model of ecosystem dynamics in terrestrial systems within the Southeast Coast Network.

Terrestrial systems within the Southeast Coast Network are very diverse, ranging from upland and bottomland forest communities to coastal dune ecosystems. Included in these systems are many plant and animal species of management concern (native, exotic, common, and rare).

Natural systems within the network are marked by high levels of plant diversity, and more often than not historical dependence on fire or flooding as significant landscape-level drivers of ecosystem function (Figure A7-7, Figure A7- 8). However, agents of change occur at all spatial and temporal scales in terrestrial ecosystems. Wildlife disease, species invasions, visitor use impacts, and changes in adjacent land use are all significant drivers of ecosystem structure, function, and composition.

Ecosystem Components and Relationships

Ecosystem components are divided into three broad categories: Environmental Setting, Park Resources, and Agents of Change (Figure A7- 8). Components in the "Environmental Setting" category include those that provide the primary drivers of ecosystem structure, function, and composition. In most cases they are not actively managed by the parks due to the spatial and time scales involved (i.e., water, air, geologic, and weather resources). Park resources refer to those that are managed at one or more spatial and temporal scales ranging from individuals to ecosystems. Agents of change include both natural and anthropogenic "drivers" of ecosystem change.

All Ecosystems
Southeast Coast Network

	Environmental Setting	Key Resources	Agents of Change
Individuals		Phenotypic Polymorphism / Diversity Genetic Diversity	Wildlife Disease
Species & Communities		Reptiles & Amphibians Mammals Birds Fishes Freshwater Mussels T&E Species	Species Invasions Plants Animals Forest Pest Species Aquaculture & Fisheries Mosquito Control
Ecosystems & Habitats	Freshwater Aquatic Systems Rivers & Streams Lakes Wetlands Estuaries Groundwater Soils	Bottomland / Floodplain Forests Longleaf Pine / Southern Pinelands Barrier Islands / Maritime Forests Coastal Wetlands & Salt Marshes	Visitor Use Impacts Shoreline Erosion Beach Renourishment Dredging
Landscapes	Earthquakes Precipitation / Drought High-Energy Storm Events Flooding Fire Adjacent Land Use Air Resources	Corridors	Natural Disturbances Changes in Hydrology Changes in water quality Fire Suppression Watershed Development / Land Conversion Atmospheric deposition Water Use

Figure A7- 8. Integrated mechanistic model for all ecosystems in the Southeast Coast Network.

Environmental Setting

Water Resources

Freshwater Aquatic Ecosystems – modified from White et al. (1998)
Isphording and Fitzpatrick (1992) described the Southeast's rivers and streams as an evolutionary laboratory. Thirty major river systems drain to the Gulf of Mexico or the Atlantic Ocean. Long isolation of these waters has produced high species richness and local endemism. Continental high points in diversity occur in fishes, salamanders, aquatic insects, crayfishes, mollusks, and freshwater snails (Isphording and Fitzpatrick, Jr. 1992, Wallace et al. 1992, Bogan et al. 1995). Taxonomic revision is ongoing in these groups, and new species are still being discovered. Systematic and genetic relatedness among the species has been used to describe biogeographic provinces and evolutionary histories (for example, Sheldon 1988). Six broad geographical provinces were based on several animal groups (fishes, mollusks, and crayfishes): the Atlantic Coastal Plain, the eastern Gulf Coastal Plain, the southern Appalachians, peninsular Florida, the Great River (Ohio-Mississippi) systems, and the trans-Mississippi region (Isphording and Fitzpatrick, Jr. 1992). The faunas of the Atlantic Coastal Plain and the eastern Gulf Coastal Plain had their origins in different parts of the southern highlands. The southern Appalachians have a high degree of endemism in isolated headwater streams. SECN parks contain systems in four of these provinces.

Southeastern stream systems have been altered by human activities, including impoundment, channelization, lowering of water tables, increased runoff, acid mine drainage, air and water pollution, sedimentation, recreation, and introduced species (including mussels, fishes, and aquatic plants). Many examples of effects on stream biota can be cited (Hackney and Adams 1992)—nearly all major stream systems have been channelized or dammed (Adams and Hackney 1992). In the Southeast, 144 major reservoirs have been built (Soballe et al. 1992), and one-third of all Florida rivers have impoundments. The closing of the Norris Dam on the Clinch River in Tennessee in 1936 caused a loss of 45 mussel species below the dam within 4 months (Soballe et al. 1992). The creation of the Tennessee-Tombigbee Canal is allowing mixing of formerly isolated native biota; Sheldon (1988) predicted this mixing will result in species loss through competition and interspecific hybridization. Between 1930 and 1971, 2,017 square kilometers were surface-mined in the Appalachian Highlands, leading to acidification of nearby streams and reductions in aquatic species diversity and biomass (Mulholland and Lenat 1992). Water hyacinth, a nonindigenous plant first introduced to New Orleans in 1884, had become a problem locally by 1890 and covered 80,000 hectares in Florida by 1975 (Crisman 1992).

Only 20% of the nation's freshwater communities are protected by federal laws, and of these, only 10% are east of the Mississippi (Benke 1990). Despite having the highest diversity of fish species in the United States (McAllister et al. 1986), the rivers and streams of the Southeast are little understood and only minimally protected. Lotic species (those that live in moving water), especially those of higher elevations, are most seriously affected, as their specialization to clear, fast-moving streams renders them unable to adapt to conditions caused by dredging or impoundment (Hackney and Adams 1992).

Estuaries – from U.S. Environmental Protection Agency (2001)
Existing data show that the overall condition of the U.S. coastal waters as fair to poor, varying from region to region and that 44% of estuarine areas in the U.S. are impaired for human use or aquatic life use. To determine the overall condition of the Nation's estuaries, EPA measured seven coastal condition indicators, including water clarity, dissolved oxygen, sediments, benthos, fish contamination, coastal wetlands loss, and eutrophication. These indicators were rated in estuaries in each region of the country (northeastern, southeastern, Gulf of Mexico, west coast, and Great Lakes regions). The condition of each resource was rated as good, fair, or poor. The indicators were combined to describe the overall coastal condition for each of the regions.

The northeastern estuaries, Gulf of Mexico and the Great Lakes are in fair to poor ecological condition, while southeastern and west coast estuaries are in fair ecological condition. Water clarity is good in west coast and northeastern estuaries, but fair in the Gulf of Mexico, southeastern estuaries, and the Great Lakes. Dissolved oxygen conditions are generally good and sediment contaminant conditions are generally poor throughout the

estuaries and Great Lakes of the United States. Eutrophication in coastal waters is increasing throughout much of the United States and results in poor eutrophic conditions in the Gulf of Mexico, west coast and northeastern estuaries and in fair to good conditions in the remaining estuaries of the continental United States.

Living resources are in fair condition in estuaries throughout the United States, although small changes in water quality could cause this condition to worsen and result in a poor rating. Living resources in the Great Lakes, northeastern estuaries, Gulf of Mexico and the west coast are currently in poor condition. Contaminant concentrations in fish tissues are low throughout the estuarine waters of the United States with exceptions in selected northeastern estuaries, Gulf of Mexico estuaries and the Great Lakes. Fish consumption advisories exist throughout the Gulf of Mexico and northeastern coastal areas, although these advisories largely pertain to offshore species (e.g., king mackerel).

State assessments of water quality presented in the EPA's *National Water Quality Inventory* Report largely agree with the water quality and ecological assessment of the Nation's estuaries in the *National Coastal Condition Report*. States determine water quality conditions by comparing available water quality data to their state water quality standards. If a body of water does not fully support its designated use, such as recreation and swimming, drinking water source, or aquatic life habitat, then it is considered impaired. In 1998, states reported that 44% of estuaries and 12% of coastal shoreline in the United States (excluding Alaska) were impaired by some form of pollution or habitat degradation.

Groundwater – modified from Barlow (2003)

Floridan Aquifer System

The Floridan aquifer system is one of the most productive aquifers in the world. It consists of a thick sequence of carbonate rocks (limestones and dolomites) that underlie all of Florida, southern Georgia, and small parts of adjoining South Carolina and Alabama; a total area of about 100,000 mi2. An estimated 4.0 billion gallons per day of water was withdrawn from the aquifer system in 2000, and, in many areas, it is the sole source of freshwater (Johnston and Bush 1988).

In addition to water supply, the Floridan is being used increasingly for aquifer storage and recovery systems, in which freshwater is injected into more saline zones of the aquifer and stored for later use. Moreover, in several places where the aquifer system contains saltwater, such as along the southeastern coast of Florida, treated sewage water and industrial wastes are injected into it.

The aquifer system generally thickens seaward from a thin edge near its northern limit to a maximum of about 3,500 ft in southwestern Florida. In most places, the system consists of the Upper and Lower Floridan aquifers separated by a less permeable confining unit (the “middle confining unit”) that restricts movement of water between the two aquifers. Much of the aquifer system is overlain by an upper confining unit that, where present, limits the amount of recharge to the system. Where the upper confining unit is thin or absent, recharge is plentiful and ground-water circulation is high.

In these areas of high recharge and vigorous circulation, ground water readily dissolves the carbonate rocks that make up the aquifer system, creating large and highly permeable conduits that store and transmit tremendous volumes of ground water. These large conduits are the cause for the many first-magnitude springs—those with a flow of 100 cubic feet per second or more—that issue from the aquifer system.

Ground-water withdrawals have resulted in long-term regional water-level declines of more than 10 ft in three broad areas of the flow system: (1) coastal Georgia and adjacent South Carolina and northeast Florida; (2) west-central Florida; and (3) the Florida panhandle. In these and a number of other coastal areas, ground-water withdrawals have reversed the generally seaward direction of ground-water flow, creating the potential for saltwater intrusion from the Gulf of Mexico or Atlantic Ocean or from deep parts of the aquifer that contain saltwater.

The transition between freshwater and saltwater in the Floridan aquifer system is illustrated by the distribution of chloride in water in the Upper and Lower Floridan aquifers. Although large areas of the Upper Floridan aquifer contain water with a chloride concentration less than 250 mg/L, much of the Lower Floridan aquifer contains water

with chloride concentrations that exceed the 250 mg/L drinking-water limit, which has limited the aquifer's use for water supply. In general, chloride concentrations in the Upper Floridan aquifer are related to ground-water-flow conditions and proximity to the coast. In areas where the upper confining unit is thin or absent, fresh ground-water circulation rates are high and chloride concentrations tend to be low (less than 250 mg/L). Where the flow system is tightly confined, flow is more sluggish and chloride concentrations in the aquifer are higher. This is the case in Florida south of Lake Okeechobee, where the Upper Floridan aquifer is extensively confined and ground-water flow is quite sluggish. Because of the slow movement of ground water in the area, it is thought that residual seawater that entered the aquifer during the Pleistocene when sea level was higher than its current level has not been completely flushed out by modern freshwater (Johnston and Bush 1988, Sprinkle 1989, Reese 1994, Reese 2000, Reese and Memberg 2000).

The anomalously high concentrations of chloride along the St. Johns River and the eastern coast of Florida are thought to be the result, in varying amounts, of two processes (Sprinkle 1989): (1) incomplete flushing by the modern-day freshwater flow system of residual seawater that invaded the aquifer during high sea-level stands of the Pleistocene; and (2) upward flow of brackish water from the underlying Lower Floridan aquifer along fracture zones in the aquifer system. The high chloride concentrations in the western panhandle of Florida also may have resulted from incomplete flushing of residual seawater from Pleistocene highstands. The generally low chloride concentrations in the Upper Floridan aquifer along the Georgia coast have been attributed to the thick confining unit that overlies the Upper Floridan aquifer in that area.

The confining unit has created relatively high groundwater heads that have kept the freshwater-saltwater interface offshore. In fact, freshwater flow has been observed to extend as far as 50 mi offshore of southeast Georgia (Johnston et al. 1982). However, along the coast in South Carolina and extending to Tybee Island, Georgia, high chloride concentrations in water from the aquifer system are attributed to intrusion of offshore saltwater caused by large ground-water withdrawals from the Upper Floridan aquifer in the Savannah, Georgia, and the Hilton Head Island, South Carolina, areas. Saltwater most likely enters the aquifer system by lateral intrusion from offshore areas combined with some downward vertical leakage of seawater to the Upper Floridan aquifer where the overlying confining unit is thin or absent (Krause and Clarke 2001).

Ground-water temperature and geochemical data from the Lower Floridan aquifer in the south Florida area suggest that a geothermally driven circulation of ground water occurs in the Lower Floridan aquifer in that area (Kohout 1965, Meyer 1989, Sanford et al. 1998). In this circulation, cold, dense ocean water enters the Lower Floridan aquifer where it is in direct contact with the ocean. As the seawater moves landward, it is warmed by geothermal heat generated naturally below the base of the thick Floridan aquifer system that underlies the Florida peninsula. The geothermal heating lowers the density of the seawater, causing it to rise where it is diluted and transported back to the ocean with seaward-flowing water of lower salinity.

Northern Atlantic Coastal Plain Aquifer System

The Northern Atlantic Coastal Plain encompasses a land area of about 50,000 mi^2 extending from Long Island, New York, southward to the North Carolina-South Carolina border. The Coastal Plain is underlain by a seaward-thickening wedge of predominantly unconsolidated sediments that increases in thickness from the Fall Line, which is the inland limit of the Coastal Plain, eastward toward the Atlantic Ocean. The Fall Line is so named because of the prevalence of falls and rapids in streams that cross the contact between the hard rocks of the Piedmont Plateau to the west and the less-resistive sediments of the Coastal Plain. The sediment wedge reaches a maximum onshore thickness of about 10,000 ft at Cape Hatteras, North Carolina, but exceeds 7.5 miles in thickness offshore from New Jersey and the Delmarva Peninsula (Trapp, Jr. and Meisler 1992). The sediments are mostly gravel, sand, silt, and clay, and have been subdivided into an aquifer system that consists of a vertical sequence of highly permeable aquifers separated by less permeable confining units. Ground-water withdrawals from the aquifer system total more than a billion gallons per day, making it one of the most productive aquifer systems in the United States.

Saltwater underlies freshwater in eastern parts of the regional aquifer system. The transition zone between freshwater and saltwater was delineated throughout the aquifer system in the early 1980s by using geochemical and geophysical data collected at more than 500 locations (Meisler 1989). The transition zone was defined as the zone

of water with chloride concentrations from 250 mg/L to 18,000 mg/L. Generally, chloride concentrations increase in the seaward direction of each aquifer and with depth from the shallowest to the deepest aquifers. Waters within the transition zone probably were produced by the mixing of fresh ground water with either seawater or highly concentrated brines. In the area from Virginia to New Jersey, some of the water samples showed the presence of chloride at concentrations greater than those in seawater, suggesting that the transition zone in that area is largely a mixture of freshwater with brine. For example, the chloride-concentration profile at well Virginia 57 shows a maximum chloride concentration of nearly 27,000 mg/L, which is about 8,000 mg/L greater than that of seawater. The most likely source of the brines appears to be the leaching of ancient evaporite deposits of probable early Jurassic age beneath the Continental Shelf and Slope (Meisler 1989, Knobel et al. 1998).

Two striking features of the transition zone within the regional aquifer system are its large vertical thickness and substantial horizontal width. The thickness of the transition zone ranged from 400 to 2,200 ft, whereas the width of the transition zone was as much as 40 miles in some areas. The development of the broad transition zone has been attributed to the cyclic movement of saltwater caused by global sealevel fluctuations that resulted in repeated advance and retreat of the freshwater-saltwater interface during at least the last 900,000 years (Meisler et al. 1985). As the sea level rose, saltwater invaded the aquifer sediments and mixed with freshwater. As the sea level declined, the fresher water advanced seaward, and the process of mixing continued. Repeated advance and retreat of the saltwater produced a broad zone of mixed waters in which saltwater predominates in the deeper and seaward parts, and freshwater predominates in the shallower and landward parts (Meisler et al. 1985).

The depth to the top of the transition zone is shallowest in North Carolina and deepens northward, reaching its greatest depths—as much as 2,800 ft below sea level—in Maryland and along the coast of New Jersey. Moreover, ground water containing chloride concentrations of less than 5,000 mg/L has been found as much as 55 mi from the New Jersey coast, but extends progressively shorter distances from the coast southward to Virginia and North Carolina (Meisler 1989). The occurrence of the transition zone at great depths in New Jersey and Maryland and the occurrence offshore of water considerably fresher than seawater have been attributed to long periods when sea levels generally were lower than at present (Meisler 1989). Overall, the average sea level during the past 900,000 years is estimated to have been about 150 ft lower than the present sea level. It has been hypothesized that, at least in some areas, the transition zone may not be in equilibrium with the present-day sea level, but may still be moving landward and upward to adjust to the present sea level (Meisler et al. 1985, Pope and Gordon 1999).

Air Resources – modified from United States Environmental Protection Agency (2003)

Ozone is not emitted directly into the air but formed by the reaction of volatile organic compounds (VOCs), nitrogen oxides (NO_x), and other chemical compounds in the presence of heat and sunlight, particularly in hot summer weather. Chemicals such as those that contribute to formation of ozone are collectively known as ozone "precursors." Particulate matter is emitted directly, and is also formed when emissions of NO_x, SO_2, and other gases react in the atmosphere.

With decreases in emissions of VOCs and other ozone precursors, 8-hour ozone concentrations fell by 11 percent nationally between 1982 and 2001 (U.S. Environmental Protection Agency 2002c). All regions experienced improvement in 8-hour ozone levels during the last 20 years except the North Central region, which showed little change. However, in 2001 more than 110 million people lived in counties with concentrations higher at times than the 8-hour standard for ozone (U.S. Environmental Protection Agency 2002c). Southern California, the eastern U.S., and many major metropolitan areas have continuing ozone problems.

In 2001, some 73 million people lived in counties where monitored air quality at times exceeded the standard for fine particulate matter ($PM_{2.5}$)—those particles less than or equal to 2.5 micrometers (µm) (U.S. Environmental Protection Agency 2002c). Concentrations of $PM_{2.5}$ vary regionally. California and much of the eastern U.S. have annual average $PM_{2.5}$ concentrations higher than the level of the annual $PM_{2.5}$ standard. The number of people living in counties with air quality levels that exceed the standards for ozone and PM signals continuing problems.

Pollution is impairing visibility in some of the nation's parks and other protected areas. In 1999, average visibility for the worst days in the East was approximately 15 miles. In the West, average visibility for the worst days was approximately 50 miles in 1999 (U.S. Environmental Protection Agency 2002c). Particulate matter is the major contributor to reduced visibility, which can obscure natural vistas. Without the effects of pollution, the natural visibility in the U.S. is approximately 47 to 93 miles in the East and 124 to 186 miles in the West. The higher relative humidity levels in the East result in lower natural visibility.

Two of the key pollutants that contribute to the formation of particulate matter—SO_2 and NO_x—react in the atmosphere with water, oxygen, and oxidants to form acid droplets. Rain, snow, fog, and other forms of precipitation containing the mixture of sulfuric and nitric acids fall to the earth as acid rain (wet deposition). The particles also may be deposited without precipitation, known as "dry deposition." Wet sulfate deposition has decreased substantially—20 to 30 percent—throughout the Midwest and Northeast, where acid rain has had its greatest impact, between the periods 1989-1991 and 1999-2001. During the same period, wet nitrogen deposition decreased slightly in some areas of the eastern U.S. but increased in other areas, including those with significant agricultural activity (U.S. Environmental Protection Agency 2002b).

In addition to the six criteria pollutants, the Clean Air Act identifies 188 toxic air pollutants to be regulated. Among those pollutants are benzene, found in gasoline; perchloroethylene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent by a number of industries. Often referred to as "air toxics," these are pollutants that may cause cancer or other serious health effects—reproductive effects or birth defects, for example—and may also cause adverse ecological effects.

Because there is currently no national monitoring network for toxics, concentrations of toxic air pollutants cannot be quantified on a comprehensive, national level. Data from several metropolitan areas do show downward trends in selected toxic air pollutants. For example, the levels of benzene measured at 95 urban monitoring sites decreased 47 percent from 1994 to 2000 (U.S. Environmental Protection Agency 2002c). Although data and tools for assessing the impacts of air toxics are limited, available evidence suggests that emissions of air toxics may still pose health and ecological risks in certain areas of the U.S. (U.S. Environmental Protection Agency 2002a).

Many health effects are associated with breathing polluted air, but air also transports pollutants and deposits them onto soils or surface waters, where they can potentially affect plants, crops, property, and animals. Toxic substances in plants and animals can move through the food chain and pose potential risks to human health. Airborne mercury from incineration, for example, can settle in water and contaminate fish. People and other animals higher on the food chain (e.g., bald eagles, bears, and cougars) that eat contaminated fish are then exposed to potentially harmful levels of mercury, which is known to affect the nervous system.

Direct exposure to ozone under certain conditions can be harmful to plants and forests; it reduces overall plant health and interferes with the ability of plants to produce and store food. Such weakened plants are in turn more susceptible to harsh weather, disease, and pests. Through its effects on plants, ozone can also pose risks to ecological functions such as water movement, cycling of mineral nutrients, and habitats for various animal and plant species. Airborne particles also can have an adverse impact on vegetation and ecosystems (U.S. Environmental Protection Agency 2002c).

Increased acid levels damage soils, lakes, and streams, rendering some waterbodies unfit for certain fish and wildlife species. Indirect effects of acid deposition are also responsible for damage to forest ecosystems. Excess deposition of acid ions in the soil causes calcium and other essential plant nutrients to be leached from the soil, and thus no longer available to sustain normal plant growth and maintenance. The calcium depletion also causes a scarcity of worms and other prey, affecting the ability of some birds to lay eggs and bring them to term.

Acid ions also can increase the movement of aluminum in soil, which competes with calcium and other nutrients in plant roots during absorption, further limiting plant growth. Acid deposition can also produce elevated levels of aluminum in waterbodies. This results either from direct deposits acidifying the waterbody itself or from water passing through soil that is high in aluminum and then entering the waterbody from adjacent terrestrial systems. Those elevated levels of aluminum in water can be toxic to fish and other aquatic life (U.S. Environmental Protection Agency 2002b).

The nitrogen in acid rain is one of the sources contributing to the total amount of nitrogen in terrestrial and aquatic systems. Although nitrogen is a necessary nutrient in productive ecosystems, too much nitrogen in terrestrial systems can cause changes in biodiversity. In aquatic systems, it fuels excessive growth of algae in coastal waters. When the dense algal blooms die, bacteria decay them. That process uses up the oxygen that is needed by fish to survive.

Geologic Resources

Soils

Island Soils – modified from (Hillestad et al. 1975)
The soils of the barrier islands were derived primarily from quartz sands, which are highly resistant to decomposition by chemical and physical weathering processes. They have resisted environmental degradation for 35-50,000 years and still closely resemble their parent materials. The coarse-to-fine sandy soils of the islands are commonly placed in the Regosol soil group (i.e., soils with a poorly differentiated profile).

Atmospheric fallout (Art 1974), high tidewaters and terrestrial birds and mammals that feed on marine organisms bring nutrients to the islands from the sea. These same agents also return nutrients to the sea, and the net gain, if any, is small. Nutrients are at a premium on the islands.

The dominant feature of island soils is their high permeability, which results in low water-holding capacity and rapid leaching. The lack of cation (Na, K, Ca, etc.) adsorption sites on the quartz crystals produces soils with a low cation exchange capacity (CEC) and, consequently, an inability to retain essential plant nutrients. Nutrients, therefore, are vigorously recycled, and at any given time most cations will be complexed in plants or organic humus. Microbial decomposition of organic matter releases the nutrients and they again are quickly tied up by vegetation.

Barrier Islands

Coastal barriers are geologically recent depositional sand bodies that are highly variable in shape, size, and their response to natural processes and human alterations (White et al. 1998). They may stretch many kilometers in length and contain high sand dunes--such as the Outer Banks of North Carolina – or they may be small and isolated islands, so low in relief that they are routinely overwashed by spring tides and minor storms. Their dynamic nature means coastal barriers are constantly shifting and being modified by winds and waves, but scientific field investigations over the past several decades are revealing some disturbing trends.

Earthquakes – from (South Carolina Seismic Network 2003)

The seismic history of the southeastern United States is dominated by the 1886 earthquake that occurred in the Coastal Plain near Charleston, South Carolina. It was one of the largest historic earthquakes in eastern North America, and by far the largest earthquake in the southeastern United States. A major shock, occurred August 31, 1886 at approximately 9:50 p.m. and lasted less than one minute, but resulted in about sixty deaths and extensive damage to the city of Charleston. Because the event took place before seismological instrumentation, estimates of its location and size must come from observations of the damage and effects caused by the earthquake. Most of what we know of the resulting damage comes from a comprehensive report by C.E. Dutton of the U.S. Geological Survey published in 1889. The meizoseismal area (area of maximum damage) of the 1886 earthquake is an elliptical area roughly 20 by 30 miles trending northeast between Charleston and Jedburg and including Summerville and roughly centered at Middleton Place.

The 1886 earthquake was followed by a series of aftershocks. Of 435 or more earthquakes reported to have taken place in South Carolina between 1754 and 1975, more than 300 were aftershocks that occurred in the first 35 years following 1886. The 1886 earthquake and its aftershocks dominate the seismic record of the southeast.

The historic record suggests the Charleston-Summerville area had a continuum of low level seismicity prior to 1886, and low-level activity continues in the same area today.

Weather & Climate – *modified from (White et al. 1998)*

Southeastern climates are humid and warm-temperate to subtropical. Major variation in climate occurs with change in latitude and elevation. Longitude has a more subtle influence on climate than latitude, as a result of maritime influence to the south and east and continental influences to the north and west.

Latitudinal gradients in temperature are steeper in winter than in summer, producing a strong geographic pattern in freeze-free periods and cold temperatures. The gradient in average minimum January temperature spans 22°C, whereas the gradient in average maximum July temperature spans only 4°C (Ruffner 1985, Martin and Boyce 1993). The freeze-free period decreases northward, from 365 days in the Florida Keys, which experienced freezing temperatures in fewer than half of the years on record, to 180 days in Arkansas and 150 days in northern Virginia. The freeze-free period also decreases with elevation, to 110 days at the highest elevations in the southern Appalachians. Canadian air masses bring the coldest winter temperatures, penetrating the Southeast from the continental interior and generally producing decreasing minimum temperatures westward at a given latitude. Annual snowfall shows the same steep gradients as cold winter temperatures, increasing from zero in south Florida to over 100 centimeters northward and to over 200 centimeters in the high mountains.

Annual precipitation averages 110-140 centimeters over much of the area, with a slight decrease northward to about 100 centimeters. Excluding the high mountains, the highest annual precipitation occurs along the Gulf of Mexico coast and in south Florida (140-160 centimeters). Annual precipitation increases to 200 centimeters where elevations surpass about 1,700 meters. The highest values are not, however, at the extreme elevations but are affected by the position of the mountain front relative to precipitation sources. The first high mountains encountered by moist air masses from the Gulf of Mexico coast and the Atlantic are those at the southern edge of the Blue Ridge near the joint boundaries of the region of North Carolina, South Carolina, and Georgia. This region has the Southeast's highest precipitation (as much as 250 centimeters) and the highest rainfall in the United States east of the Pacific Northwest.

Precipitation occurs throughout the year but is generally lowest in fall and highest in summer, when convective thunderstorms develop. Thunderstorms in Florida occur an average of 80-130 days annually, in the Gulf Coastal Plain 80-100 days annually; the number of thunderstorms decreases northward, occurring an average of 40-60 days a year in Kentucky, Virginia, and interior regions.

By combining climate and physiography, McNab and Avers (1994) classified the Southeast into 2 domains (humid temperate and tropical), 3 divisions (humid temperate, hot continental; humid temperate, subtropical; and humid tropical, savanna), 9 provinces, and 28 sections, the latter representing distinctive landscape types.

Park Resources

Individuals & Populations

Phenotypic Polymorphism / Diversity

Phenotypic polymorphism refers to the occurrence in a population (or among populations) of several phenotypic forms associated (but not entirely driven by) genes. Phenotypic polymorphism can be caused by environmental influences or biological interactions (Summers et al. 2003), and can result in within-population differences in morphology, feeding behavior, and reproductive behavior (Robinson et al. 1993, Kriegsfeld et al. 2000, Plague et al. 2001). Phenotypic polymorphism can itself be an adaptive trait to withstand environmental uncertainty (Yoshimura and Clark 1991). An example of phenotypic polymorphism within the SECN is temperature-driven gender determination in sea turtles.

Genetic Diversity

Species, Assemblages, & Communities

Reptiles & Amphibians – ***modified from White et al. (1998)***
Reptiles and amphibians are present in virtually all natural habitats in the Southeast. All the turtle species nest on land, some aquatic turtles and snakes hibernate on land, and dozens of species of southeastern frogs and salamanders are terrestrial as adults but require wetlands for breeding and development of young. Also, terrestrial corridors among aquatic habitats are essential for reptile and amphibian dispersal during unfavorable periods such as drought.

The Southeast has the highest regional total (130 species) of amphibians in the United States (Echternacht and Harris 1993), including 38 species of frogs and toads (12 of these are endemic to the Southeast) and 92 species of salamanders (45 of which are endemic to the Southeast). The southern Appalachians are a world center of diversity for salamanders and have 68 species of a unique group of lungless salamanders that evolved in this region of well-oxygenated streams and high rainfall. The Southeast has 6 species of large, fully aquatic salamanders and the Coastal Plain has 32 species of frogs and toads, of which 11 are endemic.

There are 52 species of snakes in the Southeast, of which 11 are endemic (Conant and Collins 1991, Echternacht and Harris 1993). Of the 91 species of lizards native to the United States, 21 occur in the Southeast, and 6 of these are endemic. The Southeast has 36 species of turtles, 13 of which are endemic; the Coastal Plain possesses North America's highest diversity in this group. One of the two greatest concentrations of freshwater turtle species in the world (the other is in Asia) is in the Mobile River basin (Iverson 1992, Lydeard and Mayden 1995).

The greatest threat to reptiles and amphibians comes from habitat loss and changes in water quality. Numerous examples can be given of population declines in individual wetlands as a consequence of human activities. Drainage and destruction of temporary ponds have resulted in the reduction of striped newts in Georgia (Dodd, Jr. 1995a), the extirpation of the flatwoods salamander from a portion of its range, and apparent declines of gopher frogs in Alabama and Mississippi (Dodd, Jr. 1995a).

Species that are adapted to terrestrial habitats have also suffered. Of the 242 native reptiles and amphibians in the Southeast, 170 (74 amphibians, 96 reptiles) are native to longleaf pine-wire-grass ecosystems (Dodd, Jr. 1995a). The near loss of this natural community, through timbering, development, and fire suppression, has had a significant, though largely unquantified, effect on reptiles and amphibians.

Highway deaths also deplete the numbers of many species of reptiles and amphibians that travel overland. A 2-meters-long indigo snake, for example, does not move fast enough to safely get across today's highways.

Some ecologists have reported declines in amphibian populations and related these to specific threats, such as acid rain, destruction of the ozone layer, global warming, or other forms of nonpoint pollution (Blaustein 1994). It is unclear if any of these factors are responsible for amphibian declines in some regions (Pechmann et al. 1991, Pechmann and Wilbur 1994), but habitat destruction is the primary threat to most species of reptiles and amphibians in this country and probably in most countries in the world today. Timber harvest, for example, dramatically reduces amphibian populations in the southern Appalachians (Petranka et al. 1993). Habitat destruction may take more subtle forms, though, and what may appear to be protected and pristine habitat may actually be experiencing degradation because of changes in hydrology, pollution, herbicide and pesticide runoff, the introduction of competitive nonindigenous species, the introduction of disease organisms, or the loss of important breeding sites such as temporary ponds (Blaustein 1994, Dodd, Jr. 1995b).

Insufficient knowledge of the distribution and ecology of native reptiles and amphibians is a major shortcoming in any national effort to detect change and avoid loss in this group. An example of the difficulty that ecologists face in confirming the presence of herpetofauna is apparent from studies by investigators at the Savannah River Ecology Laboratory and from studies by other investigators on the Savannah River Site in South Carolina. This site is the largest tract of land (750 square kilometers) in North America with high herpetofaunal species diversity and a long-term record of intensive ecological research and survey. Since the 1950's, herpetologists have collected data on

more than a million individual reptile and amphibian specimens representing more than 100 species (Gibbons and Semlitsch 1991). Nonetheless, despite intensive surveys, the presence of new species has been verified on the Savannah River Site at a rate of more than five species per decade.

Marine Turtles – modified from Dodd (1995a)

Five species of marine turtles frequent the beaches and offshore waters of the southeastern United States: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*). All five are reported to nest, but only the loggerhead and green turtle do so in substantial numbers. Most nesting occurs from southern North Carolina to the middle west coast of Florida, but scattered nesting occurs from Virginia through southern Texas. The beaches of Florida, particularly in Brevard and Indian River counties, host what may be the world's largest population of loggerheads.

Marine turtles, especially juveniles and subadults, use lagoons, estuaries, and bays as feeding grounds. Areas of particular importance include Chesapeake Bay, Virginia (for loggerheads and Kemp's ridleys); Pamlico Sound, North Carolina (for loggerheads); and Mosquito Lagoon, Florida, and Laguna Madre, Texas (for greens). Offshore waters also support important feeding grounds such as Florida Bay and the Cedar Keys, Florida (for green turtles), and the mouth of the Mississippi River and the northeast Gulf of Mexico (for Kemp's ridleys). Offshore reefs provide feeding and resting habitat (for loggerheads, greens, and hawksbills), and offshore currents, especially the Gulf Stream, are important migratory corridors (for all species, but especially leatherbacks).

Most marine turtles spend only part of their lives in U.S. waters. For example, hatchling loggerheads ride oceanic currents and gyres (giant circular oceanic surface currents) for many years before returning to feed as subadults in southeastern lagoons. They travel as far as Europe and the Azores, and even enter the Mediterranean Sea, where they are susceptible to longline fishing mortality. Adult loggerheads may leave U.S. waters after nesting and spend years in feeding grounds in the Bahamas and Cuba before returning. Nearly the entire world population of Kemp's ridleys uses a single Mexican beach for nesting, although juveniles and subadults, in particular, spend much time in U.S. offshore waters.

The biological characteristics that make sea turtles difficult to conserve and manage include a long life span, delayed sexual maturity, differential use of habitats both among species and life stages, adult migratory travel, high egg and juvenile mortality, concentrated nesting, and vast areal dispersal of young and subadults. Genetic analyses have confirmed that females of most species return to their natal beaches to nest (Bowen et al. 1992, Bowen et al. 1993). Nesting assemblages contain unique genetic markers showing a tendency toward isolation from other assemblages (Bowen et al. 1993); thus, Florida green turtles are genetically different from green turtles nesting in Costa Rica and Brazil (Bowen et al. 1992). Nesting on warm sandy beaches puts the turtles in direct conflict with human beach use, and their use of rich offshore waters subjects them to mortality from commercial fisheries (National Research Council 1990).

Marine turtles have suffered catastrophic declines since European discovery of the New World (National Research Council 1990). In a relatively short time, the huge nesting assemblages in the Cayman Islands, Jamaica, and Bermuda were decimated. In the United States, commercial turtle fisheries once operated in south Texas (Doughty 1984), Cedar Keys, Florida Keys, and Mosquito Lagoon; these fisheries collapsed from overexploitation of the mostly juvenile green turtle populations. Today, marine turtle populations are threatened worldwide and are under intense pressure in the Caribbean basin and Gulf of Mexico, including Cuba, Mexico, Hispaniola, the Bahamas, and Nicaragua. Subadult loggerheads are captured extensively in the eastern Atlantic Ocean and Mediterranean Sea. Thus, marine turtles that hatch or nest on U.S. beaches or migrate to U.S. waters are under threats far from U.S. jurisdiction. Marine turtles can be conserved only through international efforts and cooperation.

Information on the status and trends of southeastern marine turtle populations comes from a variety of sources, including old fishery records, anecdotal accounts of abundance, beach surveys for nests and females, and trawl and aerial surveys for turtles offshore. Surveys for marine turtles are particularly difficult because most of their lives are spent in habitats that are not easily surveyed. Hence, most status and trends information comes from counting females and nests. Few systematic long-term (more than 10-20 years) surveys have been conducted; the most

notable are the nesting surveys at Cumberland Island and adjacent barrier islands in Georgia (T.H. Richardson, University of Georgia, unpublished data), Canaveral National Seashore (1988 – present), and beaches south of Melbourne in Brevard County, Florida (Ehrhart et al. 1993). Beach monitoring is fairly widespread in many areas of the Southeast, but coverage varies considerably among beaches and field crews. The only long-term sampling of lagoonal or bay populations occurs at Mosquito Lagoon and Chesapeake Bay, although short-duration surveys have sampled Florida Bay, Pamlico Sound, and Laguna Madre. Trawl surveys of inlets and ship channels and aerial surveys of offshore waters have been undertaken periodically.

Sea turtles are threatened by beach development, light pollution, ocean dumping, incidental take in trawl and longline fisheries, disease (especially fibropapillomas), and many other variables. Because sea turtles are long-lived species, trends are difficult to monitor. Present methods of beach monitoring are extremely labor-intensive, expensive, and biased toward one segment of the population. Very little is known about marine turtle life-history and habitat requirements away from nesting beaches, and virtually nothing is known about male turtles. Because the effectiveness of measures aimed at protecting turtles may not be seen for decades, known conservation strategies should be favored over unproven mitigation schemes. Acquiring nesting habitat should be encouraged. One of the most important management measures to protect sea turtles, especially of the juvenile and subadult size class, in the southeastern United States, Caribbean, and western Atlantic Ocean is the use of TEDs to minimize drowning in commercial fisheries. Mature females should also be protected because of their importance to future reproduction. Researchers need to identify migratory routes, feeding and developmental habitat, and ways to minimize adverse impacts during all life-history stages.

Gopher Tortoise – modified from Neal (1990)

An understanding of the reasons behind the threatened status of gopher tortoises (*Gopherus polyphemus*) is perhaps the most essential step in developing this recovery plan. The gopher tortoise, historically and currently, is a component of xeric plant communities originally identified mostly by the occurrence of longleaf pine. The changes altering the original longleaf pine communities also changed the ecosystem of the gopher tortoise. This species was an animal of these forests, and to the extent maintenance of the listed population is possible, that goal is inextricably tied to forestland conditions.

Before the arrival of European colonists in the New World, the longleaf pine was the principal tree species on southeastern coastal plain upland soils. Croker (1987) cites 60 million acres in the original stands which he concludes are now reduced to about 4 million acres. After the red and white pine forests of New England and the Great Lake States were cut, lumbermen turned to the virgin longleaf stands, the mining of which peaked in 1909 (Croker 1987). Power skidders and railroad logging supported these final assaults.

Second growth longleaf pine stands came from the ruins of timber mining operations, but these second forests constituted a small fraction of the area of virgin stands. Because of planting difficulties with the longleaf pine, these droughty sites were often planted in slash (*Pinus elliottii*) and loblolly (*P. taeda*) pines. This practice, along with excessive burning intervals and intensive site preparation methods, continues on soils which originally supported longleaf pine.

Artificial planting of longleaf is now successful and many foresters are rediscovering the valuable traits of longleaf pine, including the fact that it can be successfully regenerated naturally through a shelterwood system of cutting combined with burning just in advance of an adequate seed fall. The U.S. Forest Service recently has adopted a practice of regenerating only longleaf pines on longleaf sites in the DeSoto National Forest. However, the agency's preferred method is by planting. Most private landowners continue to regenerate longleaf pine sites to off-site species.

The original longleaf pine community burned and reseeded naturally. It contained trees of many ages and a diverse ground cover with much edge, which would be of particular importance to the gopher tortoise. Landers and Speake (1980) found better gopher tortoise densities in longleaf pine-scrub oak stands that were thinned and burned every 2-4 years. Slash pine plantations, with a similar system of thinning and burning, had sparser population densities. While it is apparent that gopher tortoises can be maintained under a modified (heavily thinned, frequently burned)

plantation system of management, Landers and Buckner (1981) showed that gopher tortoise densities are significantly greater (32 percent) in more naturally managed stands of longleaf.

The natural longleaf pine community and its associated biological diversity represent optimal forest habitat for the gopher tortoise. This community occurred in pure stands, constantly trending toward small even-aged groups of a few hundred square feet (Chapman 1909). Larger even-aged patches and strips were found following blowdowns from severe weather. These were often interspersed with patches or single survivors, creating open glades and a patchiness which favored the gopher tortoise. Management practices which alter this system include: clearcuts of large blocks (including the crowded planting of off—site species), diversity—diminishing soil churning activities that often accompany even—aged timber manag9m~nt, and prolonged burning intervals. Timber practices that most nearly mirror the natural system, such as a shelterwood regeneration system with frequent burning and natural regeneration, improve the soil and herbaceous cover condition to optimally support the gopher tortoise.

Longleaf pine trees, as well as fire-dependent annuals and perennials, originally existed in a summer burning cycle which has long since been interrupted. The change in fire frequency and timing may be the single most important factor influencing other alterations which have changed the original xeric communities. For example, it has been a common practice to remove most of the longleaf pines from these dry ridges and then to exclude fire (or at least fail to burn). This allows eventual occupancy by poor site oaks (*Quercus laevis*, *Q. incana*, *Q. marilandica*, and *Q. margaretta*) and woody shrubs such as yaupon (*Ilex vomitoria*) and gallberry (*I. glabra*). When the leaf litter from oaks becomes a thick mat, it retards fires that would otherwise be carried by longleaf pine needles and the common grass associates under the open longleaf pine canopy. Fire exclusion allows the oaks to mature and shade out herbaceous ground cover needed by gopher tortoises. This situation is not uncommon throughout the range of the gopher tortoise. Landers and Speake (1980) provided substantial evidence that these altered sites originally were good gopher tortoise habitat but now support the fewest gopher tortoises.

Additional threats to gopher tortoise populations include mortality from predators (including humans), road mortality, and disease transmission.

Diamondback Terrapin – modified from Golder et al. (2004) and Diamondback Terrapins eGroup (2004)
During the late 1800s' into the late '20s of the previous century, diamondback terrapin (*Malaclemys terrapin*) populations were greatly depleted in the wild due to harvesting for the gourmet food market. Fortunately, several states acted in a timely fashion to protect them from complete annihilation, and diamondback numbers soon recovered in the wild. Their recovery was so dramatic and successful, that the states lifted their protective status and commercial trade in diamondbacks was once again allowed. Fortunately, terrapin meat was no longer in demand and diamondbacks were allowed to thrive in their natural habitats until recently. Now, diamondback populations are no longer threatened by just commercial harvesting but are faced with having to contend with urban progress as well as the effects of commercial crabbing. Habitat destruction, road kills, mass drowning in crab traps, and pollution are now threatening the status of diamondback populations throughout their range. A number of states have the species listed as either protected or of special concern. Among them is Florida (home to 4 different diamondback subspecies), which has again adopted protective measures to shut down commercial exploitation of terrapins.

Terrapins are found exclusively in brackish water habitats with the exception of the egg laying season, when gravid females venture out of the water and marshes to lay their eggs on dry land. Unfortunately, many nest sites have been destroyed by coastal development in the recent years. It is common knowledge that coastal property is prime real estate, and the continued encroachment of human development into diamondback habitat is not only depleting their habitat, but causing other lethal problems as well. Female terrapins that are no longer able to find nesting sites on developed barrier beach islands are forced to seek out alternative sites to lay their eggs. In the process, many gravid diamondback females are lost to traffic mortality annually, resulting in not only the deaths of the nesting females, but also the loss of viable diamondback eggs. A species cannot continue to survive without adequately replenishing its population.

Another factor that is having devastating effect on diamondback populations is the drowning of terrapins in commercial and recreational crab traps. Conservative numbers suggest that tens of thousands of diamondbacks

drown in these traps annually. Terrapins breath oxygen from the air, unlike the blue crabs that the majority of these traps were designed to catch. While road kills have been instrumental in reducing the number of females within a certain population, crab traps have the same effect on juveniles and males of the species. Female terrapins are twice the size of males and thus have a tendency not to be able to fit into the traps.

Although commercial harvesting is done at a considerably smaller level than earlier this century, it too is having a negative effect on wild terrapin populations. Although its effects are not as serious as those caused by the other factors mentioned earlier, coupled with these other factors, commercial harvesting can no longer be categorized as "sustainable use." Most collecting is now done for both the food industry and the pet trade. Once again, it is the adult females that are most valued to the food trade and this raises severe concerns as to whether the species can adequately replenish itself with continued indiscriminate harvesting.

The diamondback terrapin (*Malaclemys terrapin*) has been considered a status review species by the US Fish and Wildlife Service for over a decade. In part its conservation status has remained unchanged because the USFWS watches state designations and most states have little information concerning current population trends. Issues are further complicated by the fact that many states cover terrapin regulations under fisheries units, while state wildlife agencies typically oversee conservation status listings. Several key issues face diamondback terrapins. These include a commercial harvest, unregulated and illegal traffic of animals for food markets, loss of nesting beaches through shoreline erosion and bulkheads constructed to prevent erosion, road mortality of nesting females, increased egg predation by growing populations of raccoons which are supplemented by garbage associated with coastal development, and fatal collisions with boats and jet skis. One of the most serious problems is the drowning of terrapins accidentally captured in crab pots. New Jersey and Maryland require terrapin excluders on all recreational crab pots. In several states similar programs are now under consideration.

Mammals – *modified from White et al. (1998)*

Terrestrial and freshwater habitats in the Southeast are home to 101 mammal species (Echternacht and Harris 1993). Of these, 5 are extirpated, all of them ecologically important species of either large carnivores or grazers: jaguar, ocelot, gray wolf, elk, and bison (Echternacht and Harris 1993). Two other large carnivores are on the verge of extinction: the Florida panther, the only remaining subspecies of mountain lion in the eastern United States, and the red wolf.

Endemic species represent a relatively small percentage of the mammals. According to Echternacht and Harris (1993), eight small mammal species are endemic to the Coastal Plain province of the Southeast: southeastern pocket gopher, colonial pocket gopher, Sherman's pocket gopher, Cumberland Island pocket gopher, oldfield mouse, Florida mouse, Perdido Key beach mouse, and round-tailed muskrat. The region also has eight species of introduced mammals, four of which have many adverse effects on native communities: coyote, pig (feral domesticated pigs and wild boar) in the mountains and Coastal Plain, and nutria and horse in the Coastal Plain. Beavers were extirpated in the Southeast but have become reestablished in the last 20 years. Although beavers were historically important in the maintenance of habitat diversity, beavers of today inhabit landscapes with reduced predation and where the remnant habitats may themselves be vulnerable to loss from flooding.

There are 22 federally listed mammals in the Southeast: eastern mountain lion and the Florida panther, Key deer, gray wolf, red wolf, Louisiana black bear, 4 species of bats, 9 small mammal species restricted to the Coastal Plain in Florida or Alabama, a shrew restricted to Virginia and North Carolina, and 2 species of flying squirrels restricted to the mountains (Lee et al. 1982, Humphrey 1992). The eastern mountain lion and the gray wolf are already extirpated in the Southeast. In the following sections we discuss these and other species representative of trends in southeastern mammals.

Small Mammals – from White et al. (1998)

Small mammal species that are most at risk in the Southeast have narrow distributions. Most of the threats to these species come from development and subsequent loss of habitat. In isolated communities, such as beach habitats, feral cats represent a significant threat. Shrews and other insectivorous mammals suffer from the concentrated

effects of residual pesticides. Fleming and Holler (1989) described ongoing efforts to reintroduce the endangered Perdido Key beach mouse to a site in Gulf Islands National Seashore.

The future of the fox squirrel is linked to that of its habitat, the longleaf pine savannah. A long-lived species with low reproductive rates, the fox squirrel has not been well studied or understood, but timbering, fire suppression, and development are all limiting its range and reducing its population sizes.

Bats – from White et al. (1998)

Of the 39 bat species listed for the United States, 17 occur in the Southeast (Di Silvestro 1989). Widespread pesticide use, resulting in poisoning as well as loss of food sources, is responsible for significant declines in bat populations since the 1960's (Di Silvestro 1989, Humphrey 1992, Drobney and Clawson 1995). This threat has diminished with regulations on pesticide use. The greatest threat to bats now comes from habitat destruction and disturbance. Few caves meet the temperature and humidity requirements bats need for hibernation, and these caves are occupied by large numbers of bats, making these bats particularly vulnerable to disturbance. The slow rate of reproduction among bats (often only one offspring per year) means that a population can be quickly destroyed, with little opportunity for recovery (Di Silvestro 1989).

The Indiana bat ranges over a huge area of the eastern United States, but the winter habitat for 85% of the species is limited to just seven caves, with over half of the population using just two caves (Di Silvestro 1989). Human disturbance has caused numbers of this species to drop from 330,000 to 49,000 in Kentucky alone (Di Silvestro 1989). Nationally, the decline in the Indiana bat population has reached 22% in the past 10 years (Drobney and Clawson 1995). Missouri has experienced the greatest decline (34%), whereas bat numbers in Indiana have somewhat increased and Kentucky's population is now stable.

The gray bat has suffered a similar fate. Guano collection during the Civil War caused heavy losses initially because of disturbances to nursery caves and habitats, but the gray bat recovered, only to be decimated by the popularity of cave exploration in the 1960's and 1970's. Between 1970 and 1976 the population of some colonies dropped more than 50%. Though only a handful of caves are suitable for the gray bat, this species is showing signs of recovery, largely due to the protection of four critical caves (Di Silvestro 1989).

Manatees (Lefebvre and O'Shea 1995)

The endangered Florida manatee (*Trichechus manatus latirostris*) is a survivor. It is one of only three living species of manatees which, along with their closest living relative, the dugong (*Dugong dugon*), make up the Order Sirenia. This taxonomic distinctiveness reflects their evolutionary and genetic uniqueness. Sirenians are the only herbivorous marine mammals; manatees feed on seagrasses; freshwater plants, including nuisance species such as hydrilla and water hyacinth; and even some shoreline vegetation. Because manatees depend on marine, estuarine, and freshwater ecosystems, our efforts to protect them necessitate protection of aquatic resources.

Species recovery criteria for the Florida manatee are three-fold: the population trend must be stable or increasing; mortality must be stable or declining; and threats to manatee habitat must be under control (U.S. Fish and Wildlife Service 1989). Better population and life-history data suggest a greater potential for increase and higher numbers than previously recognized and strong steps taken by local, state, and federal governments are increasing the number and area of sanctuaries and slow boat-speed zones. These steps may reduce mortality if they are continued and expanded, allowing the population to recover more quickly.

Management has focused on ways to reduce human-related mortality. Of greatest concern has been an increase over the years in the number of human-caused deaths, particularly those caused by collisions with boats. Boat strikes account for 78% of human-related manatee mortality and 25% of all documented deaths (O'Shea et al. 1995). A moderate reduction in the number of boat-related deaths in the last 2 years caused optimism; however, watercraft collisions accounted for 49 manatee deaths in 1994, almost matching the record number of 51 in 1991.

Habitat threats are far from under control, however. Florida has one of the fastest-growing human populations in the nation, with an estimated net gain of close to 1,000 people per day (Fernald et al. 1992). Much growth has occurred along the coast, with inevitable consequences for coastal habitats. For example, about a third of the

600,000 ha (1.5 million acres) of seagrass meadows present in coastal Florida in the 1940's no longer exist (Lewis, III 1987). One of the most important regions for manatees on the Atlantic coast is the Indian River Lagoon. Over the past 20 years, losses of submerged aquatic vegetation in some areas of the lagoon have exceeded 95% (Busby and Virnstein 1993). Submerged freshwater plants have also been affected adversely by increases in turbidity and nutrients.

Debris, particularly monofilament line, plastics, and unattended fishing nets and ropes, directly threatens manatees, who may ingest or become entangled in these materials (Beck and Barros 1991). Manatees are also vulnerable to natural and human-caused catastrophes, such as disease and oil spills, particularly when the animals are concentrated at winter aggregation sites.

Deer – modified from White et al. (1998)

White-tailed deer populations have fluctuated dramatically with changing human influence and land use. We can identify four periods of contrasting trends and influence on native ecosystems. Before 1500, deer populations were moderate in size--Native Americans hunted deer extensively, and large native predators of deer were also present. Between 1500 and 1800, deer populations probably increased in some areas and decreased in others. Increases occurred because of reduced hunting by Native Americans and the increase in old-field habitats as Native American farms and villages were abandoned after Europeans displaced the native populations. Decreases were the result of exploitive hunting for trade by Native Americans and European colonists. Between 1800 and 1930 deer populations were reduced to near extirpation in many areas because of increased hunting, widespread agricultural clearing, and also other causes such as draining of wetlands. Since 1930 deer populations have rebounded vigorously because of farm abandonment, lower hunting pressure, and the near-absence of natural deer predators. Deer populations are still increasing in the Southeast and in some areas are drastically altering the composition and density of understory stems in forests. Deer are a major issue in forest and conservation management.

Birds – modified from White et al. (1998)

The Southeast originally had 237 native species of birds, none of which were strictly endemic to the region (Echternacht and Harris 1993). Three species are nearly restricted to the Southeast: Bachman's warbler (which may be the rarest vertebrate in the region), Swainson's warbler, and the brown-headed nuthatch. Twenty-six percent of the total (61 species) is associated with water. Of these, 19 are large wading bird species, a group for which the Southeast has the continent's highest total. The greatest species richness of birds occurs in the coastal wetlands. Thirty-one species (13.4%) are restricted to the high mountains. Echternacht and Harris (1993) estimated that there are 17 established nonindigenous bird species in the Southeast, but they warned that the number may be an underestimate, considering that other species have been released in the area.

Land clearing and hunting were responsible for the extinction of two bird species in the Southeast: the passenger pigeon (last reported in the wild in 1899) and the Carolina parakeet (last reported in the wild in 1913). Passenger pigeons were hunted for their market value whereas Carolina parakeets, birds of old wetland forests, were hunted to protect fruit crops.

Three species have been extirpated from the Southeast: ivory-billed woodpecker (last seen in the 1950's and thought to persist in Cuba), which was dependent on large-cavity trees in extensive and old riparian forests; and the Zenaida dove and the Key West quail-dove, which were rare Caribbean species restricted to Florida-- the reason for their extirpation is not known (Echternacht and Harris 1993). An additional subspecies, the dusky seaside sparrow, became extinct because of poor fire management of its marsh habitat in coastal northern Florida.

Fourteen species and subspecies of birds are federally listed, of which 12 are Coastal Plain species: crested caracara, Mississippi sandhill crane, Florida scrub-jay, brown pelican, piping plover, Cape Sable seaside sparrow, dusky seaside sparrow (now extinct), wood stork, least tern, Bachman's warbler, ivory-billed woodpecker, and red-cockaded woodpecker. The fate of these species is largely tied to habitat loss, including reductions in longleaf pine savannah, Florida scrub, wetlands, and beach communities. Two other federally listed species, the bald eagle and the peregrine falcon, were formerly wide-ranging species sensitive to pesticides; these species are now recovering.

The Southeast is important not only for summer breeding populations but also for birds that winter in the Southeast and for birds that migrate farther distances (for example, to the Caribbean and Central and South America) after passing through the South in spring and fall. Coastal habitats, maritime forests, and longleaf pine savannah are all important to migrating species. Threats to bird species include land-use changes, forest fragmentation (which often results in increased nest predation and cowbird parasitism), tropical deforestation (for Neotropical migrants), elimination of wetlands, and coastal development.

Critical information for the conservation of bird species includes understanding the relationship between reproductive success and habitat size and quality. Hunter (draft report) stated that to create populations that will endure and that will generate excess individuals to colonize new sites, some bird species (for example, the ivory-billed woodpecker) require 2,000 to 40,000 hectares of unbroken habitat. Further, we have to understand the relation between reproductive success and such microhabitat variables as forest-age structure. Hunter also reported that species that require large areas can act as umbrella species for species with smaller area requirements. If we understand the habitat area each bird species needs, it will help us determine optimum block sizes and rotations for harvested forests. The need for large habitat areas is another argument for reforestation of marginal farmlands and the retention of wetlands. Because the southeastern landscape is so heavily in private ownership, land used for agriculture and forestry must play a large role in the survival of bird species diversity. Erwin (1995) suggested that recent increases in great blue heron populations resulted from this bird's practice of feeding in aquaculture ponds. Finally, regional monitoring of bird populations is essential because of geographic movements of species. For example, white ibis and wood stork populations have declined in south Florida but are stable in the Southeast as a whole because of population shifts northward to northern Florida, Georgia, and the Carolinas (Erwin 1995).

Red Cockaded Woodpeckers – modified from Costa and Walker (1995)

The red-cockaded woodpecker (RCW; *Picoides borealis*) is a territorial, nonmigratory, cooperative breeding species (Lennartz et al. 1987). Ecological requirements include habitat for relatively large home ranges (34 to about 200 ha or 84 to about 500 acres; Connor and Rudolph 1991); old pine trees with red-heart disease for nesting and roosting (Jackson and Schardien 1986); and open, parklike forested landscapes for population expansion, dispersal (Connor and Rudolph 1991), and necessary social interactions.

Historically, the southern pine ecosystems, contiguous across large areas and kept open with recurring fire (Christensen 1981), provided ideal conditions for a nearly continuous distribution of RCWs throughout the South. Within this extensive ecosystem red-cockaded woodpeckers were the only species to excavate cavities in living pine trees, thereby providing essential cavities for other cavity-nesting birds and mammals, as well as some reptiles, amphibians, and invertebrates (Kappes 1993). The loss of open pine habitat since European settlement precipitated dramatic declines in the bird's population and led to its being listed as endangered in 1970.

The historical range of this species covered southeast Virginia to east Texas and north to portions of Tennessee, Kentucky, southeast Missouri, and eastern Oklahoma. The range included the entire longleaf pine ecosystem, but the birds also inhabited open shortleaf, loblolly, and Virginia pine forests, especially in the Ozark-Ouachita Highlands and the southern tip of the Appalachian Highlands.

The decline of the red-cockaded woodpecker coincided with the loss of the longleaf ecosystem. As forests were cleared, birds were isolated in forest tracts where unmerchantable trees were left. Aerial and ground photographs from the 1930's show that scattered medium to large trees (0.4-2 per ha or 1-5 per acre) were left in many stands. The culled trees (undoubtedly including red-cockaded woodpecker cavity trees) provided residual nesting and foraging habitat for the birds. In some places these trees remain and are used by red-cockaded woodpeckers today.

Since the 1950's, on lands managed for forest products, the forest structure and composition changed in conjunction with clear cutting, short timber rotations, conversion of longleaf stands to other pine species, and "clean" forestry practices (removal of cavity, diseased, or defective trees). These practices eliminated much of the remaining red-cockaded woodpecker habitat. Additionally, aggressive fire suppression promoted the development of a hardwood midstory in pine forests. The adverse impacts of a dense midstory on RCW populations are well-documented (Connor and Rudolph 1989, Costa and Escano 1989).

The Red-cockaded Woodpecker Recovery Plan (U.S. Fish and Wildlife Service 1985) specifies that range-wide recovery will be achieved when 15 viable populations are established and protected by adequate habitat management programs. The recovery populations are to be distributed across the major physiographic provinces and within the major forest types that can be managed to sustain viable populations. Each recovery population will likely require 400 breeding pairs (or 500 active clusters, as some clusters are occupied by single birds or contain non-breeding groups) to ensure long-term population viability (Reed et al. 1993). At a density of 1 group/80-120 ha (200-300 acres; USFWS 1985; USFS 1993), landscapes of at least 40,000 ha (100,000 acres) will be needed to support viable populations. Most forested pine areas large enough to supply this habitat are on public, mostly federal, lands.

With two exceptions (Hooper et al. 1991); USFS, Apalachicola National Forest, FL, unpublished data), there is no evidence that red-cockaded woodpecker populations can expand to viable levels without considerable human intervention. Conversely, numerous population extirpations have been documented (Baker 1983, Costa and Escano 1989). Ensuring the survival of the species, even in the short term (50 years), will require landscape-scale habitat and population management to provide the forest structure and composition needed for nesting and foraging habitat and population expansion; and to manage limiting factors (primarily a lack of suitable cavity trees, cavity competition, and demographic isolation) that can extirpate small populations. Both strategies are part of management guidelines drafted by several federal land stewards (U.S. Forest Service 1993, U.S. Army 1994, U.S. Fish and Wildlife Service 1994).

These ecosystem management plans promote practices that minimize landscape fragmentation, retain suitable numbers of potential cavity trees well distributed throughout the landscape, and restore the original forest cover by planting the appropriate pine species. They recommend the use of growing-season fires to control hardwoods, create open forest conditions, and begin to restore the understory plant communities of the pine ecosystems. Stabilization and growth of small high-risk populations will be aided by creating artificial red-cockaded woodpecker cavities (Copeyon 1990) and translocating juvenile birds from stable larger populations into small ones (Rudolph et al. 1992). Technologies that minimize or eliminate predation and competition problems are available (Carter, III et al. 1989).

Shorebirds – Modified from Harrington (1995)

The North American group of shorebirds includes 48 kinds of sandpipers, plovers, and their allies, many of which live for most of the year in coastal marine habitats; others live principally in non-marine habitats including grasslands, freshwater wetlands, and even second-growth woodlands. Most North American shorebirds are highly migratory, while others are weakly migratory, or even nonmigratory in some parts of their range. Here we discuss shorebirds east of the 105th meridian (roughly east of the Rocky Mountains). Historically, populations of many North American species were dramatically reduced by excessive gunning (Forbush 1912). Most populations recovered after the passage of the Migratory Bird Treaty Act of 1918, although some species never recovered and others have declined again.

High proportions of entire populations of shorebirds migrate by visiting one or a small number of "staging sites," areas where the birds accumulate fat to provide fuel before continuing with their long-distance, nonstop flights to the next site (Morrison and Harrington 1979, Senner and Howe 1984, Harrington et al. 1991). Growing evidence (Schneider and Harrington 1981) indicates that staging areas are unusually productive sites with highly predictable but seasonally ephemeral "blooms" of invertebrates, which shorebirds use for fattening. In some cases, especially for "obligate" coastal species, specific sites are traditionally used; even other species sites may shift between years. Because of this, conservationists believe some species are at risk through loss of strategic migration sites (Meyers et al. 1987). Other species are threatened by the loss of breeding and wintering habitats (Page et al. 1991, Haig and Plissner 1993).

The predicted consequences of global warming, such as sea-level change, will also strongly affect the intertidal marine habitats, which many species of shorebirds depend upon. Some of the strongest warming effects will be at high latitudes, including those where many shorebirds migrate to breed, as well as south temperate latitudes, where many of them winter.

Population trend evaluation has been conducted for 27 of 41 shorebird species common in the United States east of the 105th meridian. Of the 27 species for which trend data are available, 12 show no change, 1 increased, and 14 decreased. There were no clear correlations with habitat.

It is important that shorebird populations are monitored nationally, yet most species are hard to monitor because they inhabit regions that are difficult to access for much of the year. Migration seasons appear to be the most practical time for monitoring most species. Unfortunately, sampling for population monitoring during nonbreeding seasons presents a group of unresolved analytical challenges. Additional work on existing data can help identify how or whether broad, voluntary, or professional networks can collect data that will better meet requirements for monitoring population change.

Piping Plovers – Modified from Haig and Plissner (1995)
The piping plover (*Charadrius melodus*) is a wide-ranging, beach-nesting shorebird whose population viability continues to decline as a result of habitat loss from development and other human disturbance (Haig 1992). In 1985 the species was listed as endangered in the Great Lakes Basin and Canada and threatened in the northern Great Plains and along the U.S. Atlantic coast. The U.S. Fish and Wildlife Service is proposing that birds in the northern Great Plains also be listed as endangered.

Avian and mammalian predation is a problem throughout the species' breeding range, although population numbers appear to be stabilizing on the Atlantic coast and the Great Lakes as a result of using predator exclosures over nests (Rimmer and Deblinger 1990, Mayer and Ryan 1991, Melvin et al. 1992). Human disturbance continues to be a problem on the Atlantic coast (Strauss 1990).

The discovery of the high proportion of wintering piping plovers on algal and sand flats has significant implications for future habitat protection. Current development of these areas on Laguna Madre in Texas and Mexico, increased dredging operations, and the continuous threat of oil spills in the Gulf of Mexico will result in serious loss of piping plover wintering habitat.

In summary, piping plovers suffer from many factors that may cause their extinction in the next 50 years. Most devastated are the Great Lakes and northern Great Plains birds whose viability is severely threatened. Unfortunately, recovery is hindered by a lack of knowledge about the winter distribution, status of winter sites, adequate water-management policy in western breeding sites, and direct human disturbance on the Atlantic coast.

Aquatic Communities

Fishes – Modified from Walsh et al. (1995)
The Southeast has about 485 known species of native freshwater fishes, representing 27 families. Most of the diversity of the southeastern fish fauna is in five families: the darters and perches (family Percidae; 31.3%); the minnows (family Cyprinidae; 29.7%); the madtoms and bullhead catfishes (family Ictaluridae; 6.8%); the suckers (family Catostomidae; 6.6%); and the sunfishes and basses (family Centrarchidae; 5.8%). The greatest diversity is in the Appalachian Mountains and Interior Plateau, but other regions of the Southeast also harbor many more species than do similar-sized geographic areas elsewhere in the United States.

In the Southeast, fish declines are the result of the same factors that cause global deterioration of aquatic resources, primarily habitat loss and degraded environmental conditions. The principal causes of freshwater fish imperilment in the Southeast and other areas of the United States are dams and channelization of large rivers, urbanization, agriculture, deforestation, erosion, pollution, introduced species, and the cumulative effects of all these factors (Moyle and Leidy 1992, Warren, Jr. and Burr 1994). The most insidious threat to southeastern fishes is sedimentation and siltation resulting from poor land-use patterns that eliminate suitable habitat required by many bottom-dwelling species. Cumulative effects of physical habitat modifications have caused widespread fragmentation of many fish populations in the Southeast, presenting difficult challenges for those trying to reverse and restore diminished fish stocks.

Aquatic resources are often resilient and capable of recovery, given favorable conditions. Conservation of southeastern fishes will require significant changes in land management and socioeconomic factors (Moyle and

Leidy 1992, Warren, Jr. and Burr 1994), but such changes are necessary to stem future losses of biodiversity. The first step required is to improve public education on the value and status of native aquatic organisms. For resource managers and policy makers, increased efforts must be made to assume proactive management of entire watersheds and ecosystems; establish networks of aquatic preserves; restore degraded habitats; establish long-term research, inventory, and monitoring programs on fishes; and adopt improved environmental ethics concerning aquatic ecosystems (Warren, Jr. and Burr 1994). The southeastern fish fauna is a national treasure of biodiversity that is imminently threatened. If this precious heritage is to be passed on, its stewardship must be improved through cooperative actions of all public and private sectors within the region.

Freshwater Mussels – modified from White et al. (1998)

The Southeast's freshwater mussels include 270 species and subspecies in 49 genera, representing 90% of the freshwater mussel fauna of all of North America north of Mexico (Williams et al. 1993). Ten genera are endemic to the Southeast. Of 93 species and subspecies limited in the United States to one or two states, 91 occur only in the Southeast. The species richness of freshwater mussels in the Southeast is attributed to habitat diversity (including substrates of attachment), evolution within isolated river basins, stream capture over geologic time (which produces new patterns of dispersal and isolation), and high richness in fish species (larval forms use fish as hosts).

Forty-eight percent of the freshwater mussels of the Southeast are endangered, threatened, or possibly extinct (Williams et al. 1993, Williams and Neves 1995). An additional 25% are of special concern, resulting in 73% of this diverse fauna being at risk. Only 25% of the fauna is considered stable (Williams et al. 1993). Of 21 species that are now potentially extinct, 14 were endemic to the Southeast (Williams et al. 1993). Declines in freshwater snails and other mollusk groups are probably also occurring in the Southeast, but surveys of these groups are less complete.

Declines in mussel faunas have affected river basins region wide, including those with higher and lower amounts of endemism. Historically, diversity of mussels increased from headwaters to the mouths of rivers; pollution and other human influences also increase in this direction. Hence, declines in diversity have been most significant in the lower reaches of rivers. Habitat specialists (those requiring, for example, a particular kind of hard substrate) have declined more than habitat generalists.

Factors that are important in declines in mussel richness and abundance are sedimentation, pollution, changes in river flow due to dams and channelization, invasions of nonindigenous species (for example, the zebra mussel and Asian clam), and loss of fish hosts. In addition, commercial harvest of mussels is causing unknown effects on target and non-target species (Williams et al. 1993). As with other aspects of aquatic diversity, retention of natural vegetation in floodplains and along riverbanks is a key element in the protection of water quality and mussel populations. Many southeastern states still have areas with high mussel diversity and abundance, such as the Clinch River in Virginia, Swift Creek in North Carolina, Stephens Creek in South Carolina, and the Ogeechee River in Georgia. These waters tend to be tributary and headwater rivers within drainage basins of several hundred square kilometers in which silviculture is the dominant land use and agricultural and urban areas are limited.

No region wide monitoring or conservation plan exists for freshwater mussels. Conservation efforts will require cooperation of many public and private groups because mussel populations ultimately depend on water quality that is affected by human activities over large areas. The growing human population and its need for sources of clean drinking water will increase the pressure for the creation of additional reservoirs, which in turn will further imperil this distinctive element of the southeastern fauna.

Species with Conservation Status

Based on uncertified data, fifty nine vertebrate species with designated federal conservation status (i.e., Threatened, Endangered, or Candidate) are known to be present in Southeast Coast Network Parks (See Appendix 10). A total of 206 species with State listing status have also been identified within Network parks. In both cases the number is likely *under*estimated and will be revised as baseline inventories of vertebrates and vascular plants are completed during the next three years. Species of conservation status that are found on more than two parks include Red Cockaded Woodpecker, gopher tortoise, eastern indigo snake, piping plover and other shorebirds, wood stork, bald

eagle, and all sea turtle species. Seven cetacean species, all of which are listed as "Endangered," have also been documented at coastal parks within the network but management of those species is limited to beaching events rather than of overall species conservation. Declines of the majority of these species are related to changes in available habitat, primarily in longleaf pine forest and coastal dune ecosystems. Agents of change include fire suppression, visitor use, and adjacent or historical land uses (primarily residential and forestry).

Habitats, Ecosystems, & Ecosystem Functions

Key Habitats

Bottomland and Floodplain Forests – modified from White et al. (1998)
The Southeast contains 36% of all wetlands and 65% of the forested wetlands of the conterminous United States, even though it makes up only 16% of this area (Keeland et al. 1995). Noss et al. (1995) estimated that 78% of southeastern wetlands were lost between settlement and 1980.

The forested wetlands of the Coastal Plain and Piedmont and the continental interior include bottomland hardwood forests and deepwater alluvial swamps (Sharitz and Mitsch 1993); 12 major forest types have been recognized. The vegetation of these forests varies in composition and structure according to flooding duration (Larson et al. 1981).

Harris (1989) listed characteristics of these ecosystems that are beneficial to wildlife: hard mast production and a phenology (that is, periodic biological phenomena, such as flowering and breeding, in relation to climate) that is not synchronous with surrounding upland communities, frequent cavity trees, high abundance and biomass of invertebrate wildlife, and a linear distribution throughout the landscape that aids local and regional movement of animals. The seasonal flooding of these habitats makes them less suitable for agriculture; thus, in agricultural landscapes, they are often the only forest refuges available for many mammals, birds, and other species. Bottomland forests were and are very important to many birds in the Southeast, and the extinction of one species, the Carolina parakeet, and the extirpation of another, the ivory-billed woodpecker, are partially the result of fragmentation of this habitat.

Southern floodplain forests may have the largest remaining area of any riparian habitat in the United States (Klopatek et al. 1979, Keeland et al. 1995). Estimates of extent vary widely, however, from 6,600,000 hectares (Klopatek et al. 1979) to 13,000,000 hectares (Abernathy and Turner 1987). This areal extent is decreasing (0.51% per year from 1954 to 1974; Harris and Gosselink 1990), with a total loss of about 63% (Klopatek et al. 1979) to 78% (Noss et al. 1995). These forests have been converted to farmland, industrial parks, and urban areas. Surviving stands are influenced by levee construction, channelization, agricultural runoff, cattle grazing, timber extraction, and invasions of nonindigenous species. Restoration has been attempted, with 65,000 hectares of bottomland forest replanted since 1985, but it is too early to tell if these efforts will be successful (Keeland et al. 1995).

Species and population losses accompany these trends in habitat loss. For example, in Louisiana, Burdick et al. (1989) showed that the number of forest bird species was 15% lower and the number of individual birds 33% lower on transects with 26% forest cover compared with those areas that had 46% forest cover.

Congaree National Park contains the largest contiguous tract of old-growth bottomland floodplain forest in the nation.

Longleaf Pine and Southern Pinelands – modified from White et al. (1998)
The pinelands of the Coastal Plain once extended from the James River in southeastern Virginia to the Trinity River in eastern Texas and covered 24 to 35 million hectares (Frost et al. 1986, Stout and Marion 1993). Longleaf pine savanna was the most common community--the trees, which were thinly distributed, flat-topped, and had limbless lower trunks, occurred in a sea of grasses and diverse wildflowers and carnivorous plants. The historical distribution of pineland communities was determined by moisture supply and fire (Frost et al. 1986). Pines were dominant in habitats ranging from pine flatwoods and mesic savannas to the longleaf pine-turkey oak association in the dry Carolina Sandhills. Longleaf pine was the leading species, with slash pine increasing southward. Both

species are now outnumbered by loblolly pine because of fire suppression, conversion to farmland, and commercial timber production (Ware et al. 1993).

The most widespread of the pineland communities, the longleaf pine savanna, occurred widely on the moisture gradient from wet areas and mesic savannas to the dry sandhills and turkey oak associations. The vast, parklike longleaf pine savanna had an herbaceous layer dominated by wiregrass in the southeastern states and by bluestems in Louisiana and eastern Texas. At small scales (1-100 square meters), this herb layer is one of the most diverse in the world; 40 to 75 species of vascular plants have been reported for a single 1-square-meter quadrat and 130 for a 0.1-hectare plot (Clewell 1989). Today, only 14% of the expansive longleaf pine forest remains, with just 3% surviving as old-growth habitat, a loss comparable with or exceeding that of many of the other unique communities in North America (Noss 1989). The dry longleaf pine-turkey oak stands of the sandhills are the most poorly protected areas of this endangered ecosystem (Stout and Marion 1993).

Species that inhabit longleaf pinelands exhibit a high incidence of rarity and endemism. The longleaf pine-wire-grass community includes 191 species of rare plants. Pine communities on the Atlantic Coastal Plain are more diverse and contain a greater number of rare plants. The southeastern pineland community harbors large numbers of federally listed species: 18 plants, 4 reptiles, 4 birds, and 1 mammal, as well as 100 candidates for federal listing (Noss et al. 1995). In addition, the pinelands serve as a major corridor for a large number of migratory birds that winter in the West Indies and South America (Stout and Marion 1993), and they support 170 species of reptiles and amphibians (Dodd, Jr. 1995b). High percentages of these reptile and amphibian species are imperiled (endangered, threatened, or declining): 22% of the salamanders, 15% of the frogs, 34% of the turtles, 31% of the lizards, and 19% of the snakes fall in this category (Dodd, Jr. 1995a).

Lightning fires, occurring at about 1- to 3-year intervals throughout the area, were carried over large areas by wire-grass and pine duff and were stopped only by excessive moisture or abrupt changes in topography. Historically, 10%-30% of the southeastern pinelands burned each year (Ferry et al. 1995); these frequent fires reduced litter accumulation and invasion by competing woody species. Pine seedlings and many of the grasses and forbs present in longleaf pine communities are shade-intolerant, and many require bare mineral soil and reduced competition for germination and early growth. Longleaf pine has several adaptations to minimize fire injury and a large annual needle cast that provides good fuel for future fires (Stout and Marion 1993). The reduction of litter accumulation is essential for the survival of small, rare herbaceous species such as the unique Venus flytrap.

By the time European explorers and settlers arrived in this region, Native Americans had already been augmenting the natural lightning-caused fire regime with annual burning. Set in fall and winter, these fires were used to drive game and improve browse. Early settlers also used fire in winter to improve forage for their livestock, which roamed freely in the forested land.

The longleaf pine forest remained largely intact until the mid-seventeenth century, when the Naval stores industry (that is, products such as turpentine or pitch, originally used to caulk the seams of wooden ships) started to develop in Virginia and then reached its full development in North Carolina in the mid-eighteenth century. Demand then turned to timberland, and despite warnings from late nineteenth-century foresters concerned with regeneration, much of the old-growth forest was cut by the 1920's (Ware et al. 1993).

With much of the timberland being converted to agriculture and much of the wiregrass understory disturbed and fragmented by logging roads and fields, the era of unrestricted ground fires ended. In the absence of fire, other species of pines and woody plants invaded, shading out the regenerating longleaf pine and the sun-loving herbaceous layer. The introduction of livestock also contributed to the end of regeneration by longleaf pine; the nonresinous, carbohydrate-rich meristems of longleaf pine seedlings became favorite livestock forage. In the mesic regions along the coast, extensive areas of longleaf pine were cut, drained, and converted to commercial pine plantations. Finally, the initiation of government-sponsored fire suppression in the 1920's completed the demise of fire-maintained longleaf pinelands in all but a few locations. By 1946 the range of longleaf pinelands had decreased to one-sixth of their former extent, and today only 14% of the original total remains (Frost et al. 1986).

Much of the remaining 2 million hectares of longleaf pine are fragmented and located near developed areas. Winter burning can actually promote woody invasion of the wiregrass understories, but summer burning (the natural fire

regime) is considered hazardous near human property. Prescribed burning relies on firebreaks and roads, which further fragment the herbaceous understory and alter local hydrology (Noss 1989). Even though some rare native species respond to other types of disturbance, fire is the most universally important disturbance (Hardin and White 1989).

Of the animals dependent on longleaf pinelands, the best known is the red-cockaded woodpecker, a federally listed species unique for its use of live old-growth or mature second-growth pine trees for cavity excavation (Costa and Walker 1995). The red-cockaded woodpecker is the prime cavity builder in an environment largely free of snags and natural cavities. This species has declined with the loss of longleaf pine habitat; however, intensive management has stabilized several populations (Costa and Walker 1995). Bachman's sparrow, federally listed as threatened, nests in the wire-grass tussocks. The fox squirrel is dependent on the longleaf pine for forage in late summer (Ware et al. 1993). The gopher tortoise, a species whose populations have declined by 80% in the past 100 years (Auffenberg and Franz 1982), is a keystone species in longleaf pine savannahs--more than 300 species of invertebrates and 65 species of vertebrates use burrows dug by gopher tortoises, the only species that creates this microhabitat (Dodd, Jr. 1995a). Recent regional trends are not available for this species. A study in Florida showed that gopher tortoise populations had increased on one study site, decreased on another, and remained stable on three others (data from 1987 to 1988 compared with 1978 to 1979; Mccoy and Mushinsky 1992).

Barrier Island Communities and Maritime Forests – modified from White et al. (1998)

The Southeast supports over 200 individual barrier islands with a total area of over 610,000 hectares (Bellis and Keough 1995). The ecosystems of these islands are diverse and dynamic, a product of regional climate, geomorphology, local sediment deposition, and the forces of ocean currents, tides, wind, salt spray, erosion, and violent ocean storms (Bellis 1992, Stalter and Odum 1993, Bellis and Keough 1995). The islands are grouped into five geographical categories: the mid-Atlantic region, extending from New Jersey to Cape Hatteras, North Carolina; the Sea Islands, bordering the coasts of South Carolina and Georgia; the Florida Atlantic; the eastern Gulf of Mexico coast; and the Louisiana-Texas Gulf of Mexico coast (Stalter and Odum 1993).

Human activities have only had a major effect on the barrier islands in the past 50 years. Eighteenth- and nineteenth-century settlements were small, scattered, and difficult to reach. Most activities were confined to forestry, livestock grazing, and subsistence agriculture, except in the Georgia and South Carolina Sea Islands, where cotton and rice plantations were widespread. The construction of bridges and causeways and the improvement of transportation in the early part of the 20th century brought new opportunities for recreation, tourism, and second-home development. Development has meant the construction of jetties and sea walls, filling and draining of marshes, and extensive dune stabilization and beach nourishment programs, all of which obstruct the natural fluctuations of the barrier island communities. Despite limited fresh water and the constant threat of storm damage, development continues at an accelerating pace (Stalter and Odum 1993). Barrier island development in the Southeast has increased more than 300% in the past 50 years, and coastal Florida's development proceeds at a rate nearly twice that of the entire Atlantic and Gulf of Mexico coasts combined (Johnson and Barbour 1990). Although there are stretches of protected barrier island beaches and dunes and intact salt- and freshwater marshes, close to half of the area of these communities is estimated to have already been lost (Noss et al. 1995).

Development, of course, has many effects. Beach traffic disturbs nesting birds and sea turtles, compacts the soil, and disrupts dune-building activities. Jetties, sea walls, inlet stabilization, and artificial dunes disrupt normal overwash activities, altering normal dune development and increasing erosion in some areas and sand deposition in others. Development within the foredune zone and forest clearing destroy natural protective barriers to salt spray and wind damage. Pollution of marshes, estuaries, and creeks is a common result of inputs of treated and untreated sewage, fertilizer runoff from developments such as golf courses, and numerous contaminants from marinas, fish-processing plants, highways, and small industries (Stalter and Odum 1993). Finally, fragmentation of vegetation interferes with natural migration patterns.

Experience with severe storm damage on coastal structures has modified development activities to some extent. Today, setback requirements in effect in many areas prohibit the destruction of the foredunes and reduce effects on beach areas. Existing structures, however, still require protection from beach migration, as well as regular, costly,

beach nourishment projects (Johnson and Barbour 1990). About one-third of the barrier islands lining the Atlantic and Gulf of Mexico coasts have been protected by being set aside as parks, wildlife management areas, and national seashores (Stalter and Odum 1993). Areas that are open for development, however, are largely at risk for continued severe habitat degradation and other environmental losses. Most of the Atlantic coast of Florida is unprotected and very little natural coastline remains.

Maritime communities have decreased in areal extent since settlement, but the magnitude is known only for local areas. For example, coastal wetlands around Tampa Bay have decreased by 44% (Johnston et al. 1995). From 1950 to the present, the area of coastal wetlands along the Gulf of Mexico decreased by 20%-35% (Johnston et al. 1995); the largest losses were in Louisiana, where coastal impoundments flooded wetlands. In general, freshwater wetlands have decreased to a much greater extent than estuarine wetlands. In 1982 the Coastal Barrier Resources Act restricted the use of federal funds for development of barrier islands. An extensive monitoring system has shown that the area of undeveloped barrier islands has been stable since that law was passed (Williams and Johnston 1995).

Bellis and Keough (1995) estimated that 39,000 hectares of maritime forest occurred in North Carolina, Georgia, and Florida, the three states with the best inventories. This represents an unknown fraction of the original extent of these forests. About half of the remaining forests are unprotected and likely to be developed within the next decade (Bellis and Keough 1995). The degree of human disturbance and changes within the small forest fragments that remain (for example, edge effect and the fact that fragments may not be large enough to support a population big enough to convey long-term persistence) produce declines in the numbers and species of many animals (Gaddy and Kohlsaat 1987, Bellis and Keough 1995).

Several investigators noted the inadequacy of existing data for detection of trends. Bellis and Keough (1995) suggested the need for a complete survey and assessment of maritime forests. Besides effects of development and nonindigenous species, maritime communities will probably be influenced by sea-level rise and drawdown of freshwater supplies (Bellis and Keough 1995). Daniels et al. (1993) modeled the influence of sea-level rise on endangered species in South Carolina and showed that 52% of the regionally endangered species were found within 3 meters of current mean sea level and that several scenarios of sea-level rise would drastically reduce the habitat for these species.

Overgrazing is also a problem on barrier islands, not only because of a large white-tailed deer population but also because of the large numbers of feral animals introduced to the islands, including horses, cattle, goats, pigs, and sheep (Stalter and Odum 1993). Eradication of some of the larger feral species has been successful on some islands, but other introduced animals, especially feral dogs and cats, negatively affect small mammal populations. Other introduced species include European rats and nutria (Stalter and Odum 1993).

Large numbers of migratory and nesting bird species are found on barrier islands (Stalter and Odum 1993); for example, 350 species have been recorded on barrier islands in North Carolina alone (Parnell et al. 1992). Coastal marshes are critical to overwintering populations of many waterbirds. In addition, migration routes of many raptor species include southeastern barrier islands. Neotropical migrants use the islands as a point of departure and arrival in their travels to and from their winter habitats in the tropics (Stalter and Odum 1993).

Many birds have been negatively affected by development and human encroachment. Species that nest in bare sand can be disturbed by pedestrian and off-road vehicle traffic and by the construction of artificial dunes. Harrington (1995) reported that for 27 species of eastern shorebirds, 12 had stable populations, 1 was increasing, and 14 were decreasing. Surveys initiated off the North Carolina coast in the early 1970's tracked the fluctuations in nesting bird populations (Parnell et al. 1992). Eight species were increasing strongly (brown pelican, cattle egret, white ibis, glossy ibis, laughing gull, herring gull, royal tern, and Sandwich tern), three were increasing (yellow-crowned night-heron, great black-backed gull, and caspian tern), four were declining (gull-billed tern, common tern, least tern, and black skimmer), and seven were presumed stable. Some of the species have even shifted locations; Parnell et al. (1992) suggested that cutting of coastal swamps during the last 50 years resulted in movement to the estuaries. Further, creation of new habitat from dredged material may have caused populations to shift from one estuary to another.

Stalter and Odum (1993) listed nine endangered species of birds that are wholly or partially dependent on habitat on southeastern barrier islands: whooping crane, Eskimo curlew, bald eagle, Arctic peregrine falcon, eastern brown pelican, Cape Sable seaside sparrow, Bachman's warbler, Kirtland's warbler, and red-cockaded woodpecker. These species use the barrier islands in a variety of ways: nesting (five species), migration (four species), wintering (five species), feeding (seven species), and resting-roosting (seven species). Stalter and Odum (1993) attributed population losses in these species to development (direct loss of nesting, resting, and foraging habitat), dredging and filling of marshlands (loss of community structure and composition used by the birds), pollution, and direct disturbance on recreational beaches.

Five species of sea turtles are found in the open ocean and coastal waters of the Southeast, and all nest on open beaches: the green sea turtle (status: endangered/threatened; U.S. Department of Commerce 1994), the hawksbill (endangered), Kemp's ridley (endangered), the leatherback (endangered), and the loggerhead (threatened). Sea turtles are difficult to census in open waters and, because of the concentration of female turtles nesting on the beach strand and the apparent faithfulness of their return to specific beaches, the number of nesting females is considered the single best indicator of population trends (Committee on Sea Turtle Conservation 1990). The Kemp's ridley nests annually, but the other species nest less regularly. Long-term data sets (that is, over a decade of observations) are essential to detecting trends (Committee on Sea Turtle Conservation 1990). The dependence of sea turtle species on the narrow beach strand also makes them vulnerable to a host of human-caused problems, including beach development and recreation, artificial lighting (which disorients hatchlings), and increases in nest predators such as raccoons. Recently, federal law has mandated that shrimp trawlers use turtle exclusion devices, which should decrease mortality in a critical life stage for reproduction (Committee on Sea Turtle Conservation 1990).

Population estimates are available for only two of the five species of sea turtles (U.S. Department of Commerce 1994): 20,000-28,000 loggerheads and 400-500 green sea turtles nest in the United States. Although the number of nesting loggerheads has declined by 3% annually at a site in Georgia and by 26% during the 1980's at a site in South Carolina, it has increased at several sites in Florida (Committee on Sea Turtle Conservation 1990, Dodd, Jr. 1995a). Summed across the Southeast, loggerheads increased from 1982 to 1990 and decreased from 1990 to 1993 (Dodd, Jr. 1995a), although the recent decline has been relatively mild, leaving the species at higher levels than in the early 1980's. A recent review concluded that the overall status of loggerhead population size was stable (U.S. Department of Commerce 1994). This study also concluded that there was inadequate data to report an overall trend in green sea turtle populations, but numbers at one Florida site had increased from 1971 to 1989, and the species is presumed to be recovering. The green sea turtle was drastically reduced by fishing (it was served in turtle soup) during the early 1900's.

At one study site in Mexico, Kemp's ridley is presumed to have declined sharply from 1947 to 1990, to 1% of original levels (Committee on Sea Turtle Conservation 1990). Data collected at that site from 1977 to 1990 suggested a continued but much less drastic downward trend. Very few hawksbills and leatherbacks nest in the United States, and data are inadequate for precise statements of trends of these species, although expert opinion holds that the hawksbill is declining (U.S. Department of Commerce 1994).

Coastal Wetlands and Salt Marshes –from Minello and Zimmerman (1995)

Most fishery species within the Southeast shelf ecosystem spend part of their life cycle in estuaries, where there appears to be an important linkage between coastal wetlands and fishery productivity. The Southeast region is characterized by vast expanses of coastal marshland, large beds of seagrasses, and some of the most highly productive fisheries in the country. On a global scale, a positive relationship has long been recognized between the extent of coastal wetlands and fishery landings (Turner 1977). On a smaller scale, investigations of animal distributions within estuaries have documented high densities of juvenile fishes, shrimps, and crabs in seagrass and marsh habitats compared with sites lacking bottom vegetation (Zimmerman and Minello 1984, Hoss and Thayer 1993, Peterson and Turner 1994). These patterns indicate that wetlands provide important nursery functions. Indeed, other research has shown that wetland habitats provide young fishery species with both an abundant source of food to support rapid growth and also protective cover to reduce mortality from predators (Boesch and Turner 1984, Kenworthy et al. 1988, Minello et al. 1989, Minello and Zimmerman 1991).

The linkages between wetlands and fishery productivity, however, can be complex. For example, the importance of marsh availability has only been fully recognized within the last decade. Availability of coastal marshes to fishery organisms is determined by tidal flooding patterns, the amount of marsh-water edge, and the extent of connections between interior marsh and the sea. Within the Southeast, low-elevation marshes in the northern Gulf of Mexico are flooded almost continually during some seasons and are extensively fragmented, providing maximum access for young fishery organisms. In contrast, marshes along the South Atlantic coast have relatively little marsh-water edge and appear to be infrequently flooded. The density of fishery species using the marsh surface also varies between these areas; densities in the Gulf of Mexico marshes are generally an order of magnitude greater than those on the Atlantic coast (Rozas 1993). Researchers now believe that these differences in wetland availability and use are at least partially responsible for the higher landings of estuarine-dependent species in the Gulf of Mexico compared with the South Atlantic.

One major function of wetlands is to provide food for fishery species, and there is evidence that this function also varies regionally. Historically, salt marshes were thought to contribute mainly to detrital food webs by outwelling plant debris into downstream estuaries (Nixon 1980). Such an indirect use of marsh plant production is consistent with the high elevations and large tidal regimes characteristic of Atlantic coast marshes. In the northern Gulf of Mexico, however, direct use of the marsh surface appears more common and is fostered by low marsh elevations and extensive flooding with small tidal regimes. If organisms have access to the marsh surface, primary producers such as benthic and epiphytic algae, along with abundant small consumers, provide plenty of the high-quality food necessary for young fishery species. Thus, the relative importance of different trophic pathways is probably controlled by wetland availability (McIvor and Rozas 1996).

Overlying and perhaps overshadowing these concepts of relative wetland value are the extensive rates of coastal marsh loss occurring in the Southeast, mainly in the northern Gulf of Mexico. Because of the linkages between wetlands and fishery production, we might expect dramatic declines in estuarine-dependent fisheries as marsh habitats are lost. However, over the last 20 to 30 years, productivity and landings of three dominant fishery species (brown shrimp, white shrimp, and menhaden) in the northern Gulf of Mexico have increased (Klima et al. 1990, Smith 1991). In contrast, production of these species did not increase on the Atlantic coast where wetland loss was low compared with the Gulf of Mexico. We are left with a paradox--increased production of fishery species appears correlated with the degradation of their habitat. The explanation may lie in understanding the process of wetland degradation. Wetland loss in the northern Gulf of Mexico is mainly caused by coastal submergence, canal dredging, levee construction, and erosion (Rozas and Reed 1993, Turner 1997). Concurrently, marsh flooding increases, fragmentation and habitat edge increase, zones of saline and brackish wetland expand, and connections with the sea are shortened. These processes increase the availability and value of the remaining marsh and may be supporting short-term increases in fishery production (Zimmerman et al. 1991, Rozas 1995). If this hypothesis is true, enhanced levels of fishery productivity in the Gulf of Mexico are temporary. Continued wetland loss will overcome any benefits of habitat degradation and result in future declines in fishery production dependent on these coastal wetlands.

Landscapes

Corridors

Corridors are habitats that join two or more “patches” within the landscape, and are a widely-accepted and popular management tool in conservation biology to facilitate movement of organisms and gene flow among populations that might be otherwise isolated within the landscape (Lewis, Jr. 1964, Puth and Wilson 2001). Although often used, little research has been done to study whether corridors actually meet their design goals. Recent studies have shown that although corridors can increase the exchange of organisms between patches, the rate of that exchange is largely dependent on factors such as corridor design / habitat characteristics, natural migration rates, population growth rates, and home ranges of target species (Hudgens and Haddad 2003, McDonald and St.Clair 2004). Because these factors vary among species, the degree to which any given corridor is used is largely species dependent, and can have differing benefits over both the short and long term. In general, though, corridors are used

by broad suites of species with varying life histories and can facilitate key ecosystem function (such as seed dispersal and pollination) in addition to migration (Tewksbury et al. 2002, Haddad et al. 2003).

Several parks within the Network contain significant habitat corridors within the larger landscape, particularly where local green space initiatives are acquiring land to connect lands along riparian river corridors (i.e., CHAT, KEMO, and OCMU). The EPA's Southeastern Ecological Framework provides guidance to regional planners for strategically protecting lands to increase connectivity among natural areas by purchasing or creating easements that can act as corridors (Carr et al. 2002).

Agents of Change

Individuals & Populations

Wildlife Disease – modified from U.S. Geological Survey (2004)
Disease has long been recognized as one of the potentially limiting factors on wildlife populations. Now, the rapid spread of established diseases; the emergence of new diseases in humans, domestic animals, and wildlife; and the threats of bioterrorist attacks have attracted considerable public attention, as well as generated a call for action. In addition, convincing evidence has been presented advocating the usefulness of wildlife as sentinels for public and domestic animal health threats. Emerging zoonotic diseases (transmissible between animals and humans) have been identified as significant public health threats.

Further, animal disease can be included as one of the threats to global biodiversity. International trade in animal and plant species (including invasive pathogens), human population increases, and reduced wildlife habitat all create situations in which disease outbreaks may occur with increased frequency. Additionally, intermingling of livestock and wildlife creates new opportunities for disease transmission. Recent outbreaks of Chronic Wasting Disease (CWD), West Nile Virus, and House Finch Mycoplasmosis are notable examples of diseases of concern.

Species, Assemblages, & Communities

Exotic / Invasive Species – modified from Williams and Meffe (1998)
Invasion by nonindigenous species is one of the most important issues in natural resource management and conservation biology today. The ability of nonindigenous species to alter population, community, and ecosystem structure and function is well documented (Elton 1958, Mooney and Drake 1986, Vitousek et al. 1987, Drake et al. Drake et al. 1989). Ecosystem-level changes that alter water, nutrient, and energy cycles; productivity; and biomass directly affect human society. Ecosystem-level consequences of invasive nonindigenous species have major ecological and economic implications and directly affect human health. Complex technology has addressed the cleanup of chemical pollutants and contaminants and has reversed some of the damage from physical alteration of the environment. However, little attention has been paid—and almost no progress has been made—In addressing the problem of nonindigenous species.

The problem of biological invasion of the United States is not new. In the continental United States, it began with the arrival of the first European settlers more than 500 years ago and has continued at an increasing rate. In Hawaii, it began more than a thousand years ago with the arrival of the Polynesians, who introduced several plants into their new landscape. Many of the early introductions of plants and animals were intentional and generally viewed as a welcome enrichment of the American biota. Among early introductions were the domesticated animals and plants, which were essential to the survival of settlers as dependable sources of food and fiber. As invasive nonindigenous species have increased and their effects on native biota have become apparent, the perception about many introductions has shifted from welcome additions to pests. Today, although the economic and recreational benefits of selected nonindigenous species are considerable, evaluation of the economic and ecological costs reveals that introductions of nonindigenous species can also be expensive. The nonindigenous species problem has reached proportions that demand development of a coherent national policy to guide future actions.

Definitions of invasive nonindigenous species have been inconsistent, leading to confusion in lay and scientific literatures. First, the distinction between natural biological invasions, which are generally considered as range expansions, and introductions involving human activities is important. Exotic, alien, transplanted, introduced, nonindigenous, and invasive are words that have been used to describe plants and animals that were moved beyond their native ranges by humans. For consistency, we adopted the definition from the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646, 16 USC 4701-4741, approved 29 November 1990), which defines nonindigenous species as, "The condition of a species being moved beyond its natural range or natural zone of potential dispersal, including all domesticated and feral species and hybrids." This definition embodies the most critical biological aspect of nonindigenous species—the movement or introduction of a species beyond its native range by humans. Some resource managers have used political boundaries, such as state or national borders, as a standard to determine the status of an introduction (Shafland 1986); however, they did not consider that species moved beyond their native ranges within state boundaries or within the United States (for example, from the east coast to the west coast) as nonindigenous species. Regardless, ecosystems receiving nonindigenous introductions respond based on a suite of biological and ecological interactions irrespective of the political boundaries from which the species originated. Today, many biologists recognize that any species moved beyond its native range by human activities is a nonindigenous species, and they realize that when such an action is taken, it is hazardous to the economic and ecological foundations of the country (Office of Technology Assessment, United States Congress Office of Technology Assessment, United States Congress 1993).

An examination of the origin of nonindigenous species introductions helps us understand the problem. Nonindigenous species can be divided into three categories: intentional introductions, intentional introductions with subsequent escape, and unintentional introductions. Intentional introductions are those nonindigenous species transported beyond their native range and released into the wild with the purpose and intention that they will become established; these include the house sparrow and the common carp. Intentional introductions with subsequent escape are those nonindigenous species transported beyond their native range under captive conditions and which subsequently escape into the wild, where they may establish reproducing populations; these include aquarium fishes and the African clawed frog. Unintentional introductions are those nonindigenous species that are transported, usually unnoticed or without detection, beyond their native range in the course of some unrelated activity; these include zebra mussels in ballast water or imported red fire ants on cattle boats.

Nonindigenous species are a major threat to endangered and threatened biota. Invasive nonindigenous plants and animals should be treated as biological pollutants that can, in the presence of physical habitat alteration or chemical pollution, push native biota to or past the brink of extinction. In some environments, the association of nonindigenous species and disturbed habitat makes the evaluation of the effects of invaders on threatened biota difficult to assess. There is no question, though, that invasive nonindigenous species represent an additional stress to threatened biota.

Brown (1989) presented five rules of biological invasions that are broad generalizations about the conditions under which nonindigenous invasions may succeed. These rules, he believed, are broadly applicable to vertebrates, invertebrates, and plants. Of vital importance among these rules is the ecological isolation of the invaded habitat, which seems to be critical to its vulnerability to invasion by nonindigenous species. It also helps if the physical characteristics of the new environment are similar to those in the native environment of the invasive nonindigenous species and if other species are not present in similar niches of the invaded habitat. Finally, disturbance and close association with humans are common characteristics of a community that is vulnerable to invasion by nonindigenous organisms.

Nonindigenous species do contribute to a significant proportion of listings of threatened and endangered species in the United States; about 315 native species and subspecies listings are attributed, at least in part, to nonindigenous species. Based on U.S. Fish and Wildlife Service Federal Register listing documents for endangered and threatened species, nonindigenous species have contributed to the decline of approximately 35% of listed taxa. One-third of the 35% of the listed taxa affected by nonindigenous species are from island ecosystems, primarily Hawaii and Puerto Rico. Although island taxa seem to be more susceptible to the adverse effects of nonindigenous species, the mainland biota is far from immune.

Of the approximately 300 freshwater mussels found in the United States, about 73% are considered imperiled (Williams et al. 1993). Scientists believe that two nonindigenous bivalve mollusks, Asian clams and zebra mussels, have contributed to the decline of native mussels (Ricciardi et al. 1995). Asian clams, the most widespread nonindigenous mollusks in the United States, entered the west coast in the 1930's and invaded the southeastern United States in the 1950's (McMahon 1983). In some areas, Asian clams carpet stream bottoms, reaching densities of several thousand individuals per square meter.

Feral Cats – modified from Queensland Department of Natural Resources, Mines and Energy (2003)

A descendant of the African wild cat (*Felis silvestris lybica*), the common 'house' cat (*Felis catus*) has now been domesticated for about 4,000 years. Although the domestic cat has a long history of association with man, it retains a strong hunting instinct and can easily revert to a wild (feral) state when abandoned or having strayed from a domestic situation.

Semi-feral cats live around dump sites, alleys or abandoned buildings, relying on humans by scavenging rubbish scraps and sheltering in abandoned structures. The true feral cat does not rely on humans at all, obtaining its food and shelter from the natural environment.

The feral cat differs little in appearance from its domestic counterpart; however, when in good condition, the feral cat displays increased overall muscle development, which is especially noticeable around the head, neck and shoulders, thus giving the animal a more robust appearance. The average body weight of male feral cats is from 3 kg to 6 kg, while that of females varies from 2 kg to 4 kg. Body weights vary with condition, with some extremely large specimens having been documented.

The feral cat is most active at night, with peak hunting activity occurring soon after sunset and in the early hours before sunrise. At night the cat displays a distinctive green eyeshine under spotlight, making it easily distinguishable from other animals. During the day it will rest in any number of den sites, which may include hollow logs, dense clumps of grass, piles of debris, rabbit burrows, and even the hollow limbs of standing trees.

Male cats attain sexual maturity at about 12 months of age, whereas females are capable of reproduction at approximately 7 months. Annually, and under ideal conditions, an adult female can produce up to three litters—each of usually four kittens, but varying from two to seven.

As the breeding instinct is triggered by the increasing length of daylight, litters are less frequent in winter. Most reproduction occurs during the spring and summer months, and is generally limited to two litters per year. Birth follows a gestation period of 65 days, and kittens may be reared in a single den site or may be frequently shifted to other sites within the female's home range. Family and litter bonding begin to break down when the kittens are approximately seven-months old. The female's ability to bear litters does not decrease with age, so reproduction continues for the course of her life.

The energy expended by an adult male cat requires it to consume 5% to 8% of its body weight in prey per day, while females raising kittens require 20%. Based on these figures, one study concluded that 375 feral cats on Macquarie Island would consume 56,000 rabbits and 58,000 sea-birds per year. Where present on the mainland, rabbits may comprise up to 40% of the diet of feral cats. Cats are successful as a control mechanism only when rabbit densities are low. At other times cat predation does little to halt the build-up or spread of rabbit populations; rabbits merely help to support a larger number of cats. When seasonal shortages of rabbits occur there is a corresponding rise in the number of native animals taken by cats.

The feral cat is an opportunistic predator, and dietary studies have shown that small mammals, birds, reptiles, amphibians, insects and even fish can be taken as prey. Cat predation is particularly harmful in island situations, and a number of species have become extinct due to the introduction of cats by early sealers and lighthouse keepers. On the mainland, native animals—which already suffer due to the destruction of their habitats by man and other introduced animals—may be endangered further by cat predation. Actual competition for prey can cause a decline in the numbers of native predatory species such as, eagles, hawks and reptiles.

Forest Pest Species

Southern Pine Beetle – modified from Meeker et al. (1995)

The southern pine beetle (SPB), *Dendroctonus frontalis*, is the most destructive insect pest of pine in the southern United States. A recent historical review estimated that SPB caused $900 million of damage to pine forests from 1960 through 1990 (Price et al. Price et al. 1992). This aggressive tree killer is a native insect that lives predominantly in the inner bark of pine trees. Trees attacked by SPB often exhibit hundreds of resin masses (i.e., pitch tubes) on the outer tree bark. SPB feed on phloem tissue where they construct winding S-shaped or serpentine galleries. The galleries created by both the adult beetles and their offspring can effectively girdle a tree, causing its death. SPB also carry, and introduce into trees, blue-stain fungi. These fungi colonize xylem tissue and block water flow within the tree, also causing tree mortality (Thatcher and Conner 1985). Consequently, once SPB have successfully colonized a tree, the tree cannot survive, regardless of control measures. When beetle populations are low (endemic), attacks are generally restricted to senescent, stressed or damaged pines; however, epidemics periodically occur (Thatcher et al. Thatcher et al. 1980). During epidemics, SPB infestations often begin in weakened or injured trees, but the high beetle populations can invade and overcome healthy vigorous trees by attacking in large numbers over a short period of time (Thatcher et al. Thatcher et al. 1980). Widespread and severe tree mortality can occur during epidemics. SPB spots (groups of infested trees) may expand at rates up to 50 ft. (15 m)/day, and uncontrolled infestations may grow to thousands of acres in size (Ron Billings, Texas Forest Service, personal communication). SPB attacks are not limited to conventional forest sites; they also may kill high-value trees in yards, parks, and other ornamental settings (Thatcher et al. 1978). Because of the seriousness of SPB infestations, care should be taken not to confuse SPB with the less aggressive but more common pine bark beetles of Florida, the pine engravers (*Ips* spp.) and the black turpentine beetle (*D. terebrans*) (Dixon 1984, Dixon 1986).

Outbreaks of this insect tend to be cyclical in occurrence. Outbreaks have occurred on 6-12 year intervals and generally last for 2-3 years in areas were SPB has long been a problem. Throughout the South, the time between outbreaks has decreased while the intensity and distribution of each outbreak has increased since 1960 (Price et al. Price et al. 1992, Belanger et al. 1993). In Florida, infestations have been relatively few and small in the past (Chellman and Wilkinson 1975, Chellman and Wilkinson 1980). Many factors are involved in the development of outbreak conditions, such as the abundance and susceptibility of preferred hosts, and weather patterns and events (*e.g.*, drought, storms). Historically, Florida has not experienced many destructive SPB episodes probably because of the lack of large contiguous areas of loblolly and shortleaf pine in susceptible stages. However, an epidemic in and around Gainesville in Alachua Co. during 1994, warrants reconsideration of the serious threat SPB poses to Florida's pine forests. Forest inventory statistics indicate that over the last 25 years, the acreage of loblolly pine forest in Florida has more than doubled from a mere 337,000 ac. (136,380 ha) to more than 750,000 ac. (303,515 ha) (Knight 1969, McCluer 1970, Brown 1987, Clark, Jr. and Sheffield 1994). The current acreage of loblolly pine also represents an all-time high since inventory statistics were reported in 1949. This alarming increase and current level of preferred host material suggests that SPB epidemics in Florida may be more frequent, widespread and destructive in the future.

Aquaculture & Fisheries

Invertebrate Fisheries – modified from Nance and Harper (1999)

Important recreational and commercial marine invertebrates in the southeastern United States include shrimp, spiny lobster, stone crab, and conch. Some fisheries, as for coral, are almost nonexistent. Others, like the penaeid shrimp fishery, are both extensive and extremely valuable. The southeast region’s shrimp fisheries are one of the most valuable U.S. fisheries based on ex-vessel revenue. Some fisheries, such as those for spiny lobster and stone crab, have only moderate value on a national basis but are important locally or regionally. Because of the diversity in species, fisheries, geographic locations, yields, values, etc., each species group in the marine invertebrates unit must be examined separately for proper perspective.

Penaeid shrimp have been fished commercially since the late 1800’s. The first fishery used long seines in shallow waters, until the otter trawl, introduced in 1915, extended shrimping to deeper waters. At first, most vessels towed one large trawl, sometimes 120 feet wide at the mouth. Soon, a two-trawl arrangement (each about 40–75 feet wide

at the mouth) was found more effective. Some shrimpers are using a twin-trawl system which tows four trawls of about 40 feet wide at the mouth. The twin-trawl system is now very common gear on commercial offshore shrimpers.

In the South Atlantic, white shrimp stocks are centered off the Georgia and South Carolina coasts. Brown shrimp are centered off the North and South Carolina coasts. The Atlantic fishery is much smaller than that of the Gulf and currently is managed under a Federal fishery management plan implemented in November 1993. This provides for compatible state and Federal closures if needed to protect overwintering shrimp stocks. A subsequent amendment added rock shrimp to the fishery management plan.

Brown, white, and pink shrimp account for 90% of the total Gulf of Mexico shrimp catch. In 1997 alone, these three important species produced 84,967 t valued at over $437 million in ex-vessel revenue. They are found in all U.S. Gulf waters inside 120 m depths. Most of the offshore brown shrimp catch is taken at 20-40 m depths, white shrimp are caught in 10 m or less, and pink shrimp in 20-30 m. Brown shrimp are most abundant off the Texas-Louisiana coast, and the greatest concentration of pink shrimp is off southwestern Florida. In the South Atlantic, white shrimp landings are about 21% of their Gulf counterparts, while brown and pink shrimp are around 6% of the Gulf yield. Current, recent, and long-term potential yields for these species are given in.

The shrimp fisheries are currently overcapitalized, with more fishing effort being expended than needed to harvest the resource. In addition, the harvesting of small shrimp inshore is sacrificing yield and value of the catch by cutting short future growth.

Shrimp fisheries use small-mesh nets and can catch non-target species such as red snappers, croakers, seatrouts, and sea turtles. Juvenile finfish are often harvested, and this may be a major source of mortality for them. Some fish caught by shrimpers are currently at low stock levels. This bycatch may slow or prevent recovery if not mitigated.

As sea turtles are all listed as endangered or threatened under the Endangered Species Act, shrimp vessels have been required to use turtle excluder devices in their nets since 1988 to avoid capturing sea turtles and thus protect the stocks.

Table A7-1. Productivity in metric tons and status of Caribbean invertebrate fisheries (Nance and Harper 1999).

Species and area	Recent average yield (RAY)[1]	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Brown shrimp, Gulf of Mexico	53,080	Unknown	57,653[2]	Full	Near
Brown shrimp, Atlantic	2,645	Unknown	3,447[2]	Full	Near
White shrimp, Gulf of Mexico	28,942	Unknown	29,980[2]	Full	Near
White shrimp, Atlantic	6,045	Unknown	6,305[2]	Full	Near
Pink shrimp, Gulf of Mexico	11,009	Unknown	7,469[2]	Full	Near
Pink shrimp, Atlantic	730	Unknown	955[2]	Full	Near
Royal Red Shrimp	250	Unknown	Unknown	Unknown	Unknown
Seabob Shrimp	3,947	Unknown	Unknown	Unknown	Unknown
Rock Shrimp	6,240	Unknown	Unknown	Unknown	Unknown
Spiny lobster, SE United States[3]	3,325	2,400	3,565	Over	Below
Spiny lobster, Caribbean	111	Unknown	Unknown	Unknown	Unknown
Stone crab[4]	2,961	1,121	976	Full	Near
Queen conchs[5]	91	55	Unknown	Over	Below
Coral[6]	0	0	Unknown	Unknown	Unknown
Total	119,376	116,575	120,953		

[1]1995–97 average for shrimp; 1994–96 average for other species.

[2]Long-term potential of brown, white, and pink shrimp based upon last observed 10-year average annual yield (1988–97).

[3]Yields based upon commercial catches; recreational catch is unknown but may be significant.

[4]Yields are in tons of claws; declawed crabs regenerate new claws.

[5]Landings from Puerto Rico. Fishing prohibited in Florida.

[6]Coral harvests prohibited except for a small take allowed for use in aquarium and pharmaceutical industries.

Other Nearshore Fisheries – modified from Anderson et al. (1999)

In the southeast as in the northeast, the recent average yields reported here are underestimated, because they can generally be based only on commercial landings. Recreational landings, which may be considerable, are generally unavailable for the invertebrates that dominate the southeast nearshore fisheries. Bycatch mortality is not estimated, or is incompletely estimated, for many species.

Blue crabs dominate the nearshore catch by weight. Recent landings have fluctuated around 60,000 tons (Table A7-1. Productivity in metric tons and status of Caribbean invertebrate fisheries (Nance and Harper 1999).). Oyster harvests have trended downward over the last decade, but recent landings have been steady with a recent average yield of 10,440 tons. Calico scallop has been important in the landings in the past (20,000 t in 1984), but recent landings have averaged 1,184 tons.

Mullet landings in the region have been affected by a ban on nets over 500 square feet in Florida's waters. This ban took effect July 1, 1995. Recent average yield is down to 12,558 t, but more telling are the landings for 1996, which were reported at 9,484 t. Commercial landings outweigh the recreational catch by slightly more than 10:1. Herrings (not including American shad, alewife, or blueback herring) and Spanish sardine recent average yields total 6,040 t in the southeast, almost all from commercial landings. Bait fisheries for species such as ballyhoo and bigeye scad (goggle-eye) exist primarily in south Florida, with a net fishery for bigeye scad in the Florida panhandle. A major portion of the bigeye scad were landed in Palm Beach County prior to the state-issued net ban. Present landings in that area are a result of a live-bait fishery and have a high value. Ballyhoo landings from the Palm Beach area also dropped, but those in the Florida Keys have been steady. Flying fish are often landed with the ballyhoo.

Table A7-2. Productivity in metric tons and status of southeast nearshore fishery resources (Anderson et al. 1999).

Species	Recent average yield (RAY[1])	Commercial RAY[1]	Recreational RAY[1]	Fishery utilization level	Stock level relative to LTPY[2]
Blue crab	59,876	59,876	Unknown	Unknown	Unknown
Mullet	12,558	11,537	1,021	Unknown	Unknown
Oysters	10,440	10,440	Unknown	Unknown	Unknown
Other herring & Spanish sardine	6,040	5,980	60	Unknown	Unknown
Flounder (southern & Gulf)	1,514	609	905	Unknown	Unknown
Bait shrimp	1,264	1,264	Unknown	Unknown	Unknown
Calico scallops	1,184	1,184	Unknown	Unknown	Unknown
Ballyhoo, bigeye scad, flyingfish	664	644	20	Unknown	Unknown
Total	93,540	91,534	Unavailable		

[1]RAYs are for 1994–1996. Recreational data are estimates based on surveys.

[2]LTPY = Long-term potential yield.

Mosquito Control – modified from (U.S. Environmental Protection Agency 2002d)

The first step in mosquito control is surveillance. Mosquito specialists conduct surveillance for diseases harbored by domestic and nonnative birds, including sentinel chickens (used as virus transmission indicators), and

mosquitoes. Surveillance for larval habitats is conducted by using maps and aerial photographs, and by evaluating larval populations. Other techniques include various light traps, biting counts, and analysis of reports from the public. Mosquito control programs also put high priority on trying to prevent a large population of adult mosquitoes from developing so that additional controls may not be necessary. Because mosquitoes must have water to breed, methods of prevention include controlling water levels in lakes, marshes, ditches, or other mosquito breeding sites, eliminating small breeding sites if possible, and stocking bodies of water with fish species that feed on larvae. Both chemical and biological measures may be employed to kill immature mosquitoes during larval stages. *Larvicides* target larvae in the breeding habitat before they can mature into adult mosquitoes and disperse. Larvicides include the bacterial insecticides *Bacillus thuringiensis israelensi*s and *Bacillus sphaericus*, the insect growth inhibitor methoprene, and the organophosphate insecticide temephos. Mineral oils and other materials form a thin film on the surface of the water that causes larvae and pupae to drown. Liquid larvicide products are applied directly to water using backpack sprayers and truck or aircraft-mounted sprayers. Tablet, pellet, granular, and briquet formulations of larvicides are also applied by mosquito controllers to breeding areas.

Adult mosquito control may be undertaken to combat an outbreak of mosquito-borne disease or a very heavy nuisance infestation of mosquitoes in a community. Pesticides registered for this use are *adulticides* and are applied either by aircraft or on the ground employing truck-mounted sprayers. State and local agencies commonly use the organophosphate insecticides malathion and naled and the synthetic pyrethroid insecticides permethrin, resmethrin, and sumithrin for adult mosquito control.

Mosquito adulticides are applied as ultra-low volume (ULV) sprays. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill flying mosquitoes on contact. ULV applications involve small quantities of pesticide active ingredient in relation to the size of the area treated, typically less than 3 ounces per acre, which minimizes exposure and risks to people and the environment.

Habitats & Ecosystems

Visitor Use Impacts

Visitor uses of natural resources, though appropriate within the Natural Park System, can cause a number of direct and indirect changes within the ecosystem. Use of natural areas has increased steadily since 1965 (Cole 1996) and will likely continue as protected lands become increasingly rare in the rapidly developing landscape within the Southeast. Most visitor use impacts are assumed to increase as visitation rates increase.

Of great concern within the SECN are the effects of off-road and recreational vehicles. Several parks allow access vehicular access (such as Cape Hatteras NS), and are potentially affected by increased mortality of sensitive species (sea turtles, ground-nesting shore birds). Also, vehicles can potentially cause changes in vegetation stability, and increased soil erodibility (Grantham et al. 2001). These impacts are potentially of highest concern in areas with loosely-consolidated soils such as coastal dunes. Additional visitor use impacts include degraded air quality (associated with vehicle and off-road vehicle use), litter, trampling, poaching, species introductions, and social trail creation. Also, visitor use impacts can cause changes in animal ranges, particularly large mammals through avoidance behaviors (Papouchis et al. 2001). Human-animal interactions might be of high importance in wilderness areas during breeding times. Also, trails have been shown to be a vector for dispersion of exotic plant species (Patel and Rapport 2000).

Landscapes

Natural Disturbances – modified from White et al. (1998)

The Southeast's frequent thunderstorms provide an ignition source for natural fires. In the past, Native Americans and European settlers also burned natural vegetation regularly. Regardless of ignition source, fire frequency and intensity have been dominant forces throughout the Southeast on all but the wettest and coldest (high mountain) sites. The mid- to late 1900's represent a period of reduced fire frequency, size, and intensity, a shift that is a major source of change in the region's ecosystems, leading to increases in mesic species (that is, species adapted to

moister conditions), increased understory stem density, increased woody cover in formerly open habitats, and decreases in fire-dependent species and ecosystems.

Tropical storms are also a major recurrent disturbance, with much of the area experiencing about two damaging storms per decade. Between 1871 and 1981, 138 tropical storms affected south Florida (Davis and Ogden 1994). Although storm incidence declines from coastlines to the interior, tornadoes are more frequent in interior areas, where nearly 10 violent tornadoes per year have occurred over the last 100 years (Grazulis 1984, Martin and Boyce 1993).

The heavy rainfall that accompanies these and less violent storms is an important natural disturbance, especially in the Appalachian Mountains, where debris avalanches create open habitats in the forested matrix and flash floods scour stream banks and affect stream biota. Throughout the Southeast, the natural flooding and erosional dynamics of rivers were and are an important natural process for biological diversity; impoundments, changes in the quality and quantity of water, draining of bottomlands, and channelization of rivers are major causes of loss in the biological diversity dependent on dynamic stream and river systems.

Fire / Fire Suppression – modified from White et al. (1998)

Fire was and is important to many southeastern ecosystems, including many Coastal Plain and south Florida ecosystems, pine-dominated forests of the Coastal Plain and Appalachian Highlands, oak and oak-hickory forests, oak savannas, glades, barrens, and prairies. Because most natural communities in the Southeast are dependent on fire, more than 50% of the rarest plants in the region also possess this dependence. Fire may also explain the occurrence of canebrakes, dense stands of the Southeast's only native bamboo, which were frequently described by earlier travelers but which have vanished from the landscape except for small remnant patches (Noss et al. 1995). Although natural fires were quite important, Native Americans and European settlers also set fires frequently. When fire suppression became effective in the 1940's, dramatic changes in ecosystem composition and structure began.

Pine dominance was produced by intense fires, with subsequent lower intensity fires reducing competing hardwoods in the pine understories. Given the age of pine stands, intense, stand-initiating fires must have occurred at least once every 100-200 years; less intense fires occurred much more frequently--every 2-12 years. In the absence of fire, oak, hickory, and pine replace longleaf pine on the Coastal Plain (Stout and Marion 1993), and oak-dominated forests replace pitch pine and Table Mountain pine on the dry ridges of the Appalachians. The net trend of these landscapes is away from pine-dominated ecosystems, leading to declines in species associated with those systems.

Outbreaks of the native southern pine beetle can not only hasten the succession from pine to hardwoods but can also result in high fuel loads. On dry topographic sites and in drought years, high-intensity fires can occur because of these fuel loads. Such hot summer fires are critical to pine regeneration.

Although oaks and hickories increase on the driest sites with reductions in fire, these trees are declining on moister sites where fire was important in limiting mesic hardwoods (Christensen 1977). Thus, throughout the Southeast, there is a general trend toward an expansion of mesic species and a contraction of dry-adapted and fire-dependent species. Understory stem densities have also increased. A failure of oak to regenerate on sites where the species now dominates is a widely observed phenomenon in the eastern United States. McGee (1986) and other researchers hypothesized that this change is caused not only by fire suppression but also by other factors such as air pollution (Kessler, Jr. 1989). Low fire frequencies have also allowed woody plants to invade the glades, barrens, and prairies once associated with oak and hickory forests. Early descriptions of the southeastern landscape suggest frequent forest openings, larger areas of grassland and savanna, and upland forests with open understories (Skeen et al. 1993).

Flooding – modified from White et al. (1998)

The dynamics of flooding and meandering rivers are a major natural process in southeastern ecosystems. Many plant and animal species are dependent on the natural dynamics of water flow. The overall tendency is for human influence to make a dynamic environmental factor less variable. Succession favors the species best adapted to the

more uniform conditions, and diversity decreases. In natural systems, however, extreme hydrological events are an important agent in the maintenance of species diversity.

Changes in Hydrology – modified from White et al. (1998)
Alteration to the hydrological regime is a common disturbance in a variety of southeastern ecosystems: bottomland and floodplain forests, mountain bogs, rocky stream gorges, longleaf pine savanna, Carolina bays, pocosins, Atlantic white-cedar swamps, barrier-island communities, mangrove forests, rivers, streams, caves, lakes, and the Everglades mosaic of communities. Hydrological change has altered flood depth, duration, frequency, and seasonal timing in many of these systems, leading to a raising and lowering of the water table in specific cases.

Hydrological change is caused by sedimentation, construction of dams and other barriers, and channelization (Adams and Hackney 1992). Portions of almost all major southeastern rivers have been impounded during the last 75 years. For example, a 1974 stream survey in Maryland showed that all 14 drainages in 17 tidewater counties had dams (258) or other blockages (89; Lee et al. 1984). Other barriers include farm or mill pond dams, weirs, and raised culverts. Dams result in changes to water temperature and unpredictable releases of water. Channelization, which includes straightening the streambed, smoothing bottom contours, and removing logs, obstructions, and plants, alters the rate and timing of water flow (the local water table is lowered, resulting in increased flooding downstream), aquatic productivity, microhabitats within the channel, and food webs. Sedimentation, blockages, and channelization often occur within one river system, leading to decreases in native fishes and other aquatic species, a loss of species intolerant of such changes, and increases in tolerant species and nonindigenous species (Crumby et al. 1990).

Changes in Water Quality – modified from White et al. (1998)
In recent years, the Clean Water Act has done much to reduce point sources of pollution by requiring water treatment. Nonpoint-source pollution and sedimentation are harder to control, though. Sedimentation is a serious problem for most aquatic organisms, particularly primary producers as well as benthic (bottom-dwelling) macroinvertebrates and fishes that require gravel or rock substrates. Medium-sized rivers are particularly vulnerable to alteration of substrate composition and texture (Etnier and Starnes 1991).

Other factors responsible for depletion of aquatic faunas are pollution (including chemical and thermal pollution) and introduction of non-indigenous fishes and aquatic plants. Invasive non-indigenous plants that are capable of altering function (for example, hydrology, amount of photosynthesis, and food webs) in aquatic systems in the Southeast include parrot feather watermilfoil (*Myriophyllum aquaticum*), Eurasian watermilfoil (*M. spicatum*), waterthyme (*Hydrilla verticulata*), curlyleaf pondweed (*Potamogeton crispus*), water hyacinth (*Eichhornia crassipes*), and water chestnut (*Trapa natans*) (Hotchkiss 1967, Lachner et al. 1970).

Changing Land Use and Watershed Development – modified from White et al. (1998)
The Southeast has one of the country's most rapidly growing human populations. Population growth was 20% from 1970 to 1980, 13.4% from 1980 to 1990, and an estimated 10%-19% for the 1990's (U.S. Bureau of the Census 1994). The continued growth of the human population and changes in the way humans interact with the natural landscape present a challenge to conservationists concerned with the survival of diversity in this biologically rich region.

Destructive logging and soil erosion in the Southeast were major stimuli to the conservation movement in the early twentieth century; this movement led to the creation of national forests, national parks, state parks, research stations, and other protected areas. In contrast to the western United States, the Southeast had little public land--less than 10%--and these areas had to be created by purchase of private lands. Today, public land is mostly in the mountains, with less public land in the Piedmont and Coastal Plain (Boyce and Martin 1993).

Data from 1987 show that although 55% of the land was forested then, the trend was downward, with a decline of 5% since 1960 (U.S. Forest Service 1988, Martin and Boyce 1993). The rest of the land was used for crop and pasture (31%) and miscellaneous purposes (roads, towns, cities, airports; 14%). Urban areas are growing at the fastest rate, but the rate of growth varies by region. For example, in North Carolina, urbanization occurred three

times faster in the Piedmont than in either the mountains or Coastal Plain (see review in Boyce and Martin 1993). Although the high total of forested land indicates potential for the survival of biological diversity, these forests are largely privately owned; less than 10% of the forested land is in federal ownership (U.S. Forest Service 1988) and the remainder are not managed for biological diversity per se. Further, because these lands have almost all been disturbed by logging and agriculture, they have already lost communities and species.

Forestland has been predicted to decline by 15% over the next 50 years (with additional forestland converted from natural to plantation forests), agricultural land to decline slightly (with a continued shift from small to large farming operations), and urban areas to increase in area (see discussion in Boyce and Martin 1993), suggesting that further habitat loss and fragmentation will occur near human population centers. We know too little about the survival of biological diversity in human-dominated landscapes, but we do know that the biodiversity of these areas will generally decrease with habitat fragmentation (Harris 1984). Some human-dominated landscapes, however, have the potential to support the diversity of some groups. For example, some crop systems support bird diversity(Allen 1995) by cultivating marginal lands, including some wetlands.

Atmospheric Deposition

Atmospheric deposition is the process by which airborne pollutants are deposited to the earth. These pollutants include, but are not limited to, sulfur dioxide, nitrogen oxides, ammonia, and mercury. Total deposition consists of both wet and dry components.

Wet deposition occurs when pollutants are deposited in combination with precipitation, predominantly by rain and snow, but also by clouds and fog. The NPS monitors wet deposition through the National Atmospheric Deposition Program (NADP). In general, atmospheric deposition is higher in the eastern U.S. due to higher emissions of SO_2, NO_x, and NH_3. Deposition of ammonium is highest through the Midwest and over the Great Plains region, the result of high ammonia emissions associated with agricultural activities, such as fertilizer use and livestock production.

Atmospheric deposition in the U.S. has changed significantly since the 1980s. Sulfate deposition has declined significantly in the East, with the most dramatic decrease in the Northeast. Despite these declines, which resulted from the SO_2 emission reductions required by Title IV of the Clean Air Act, sulfate concentrations in surface waters have not decreased, showing that ecosystems may take several years to recover.

In contrast to the declines in sulfate deposition, nitrate deposition has not changed significantly, although areas of high deposition appear to be shifting west. However, ammonium deposition has increased dramatically in the past 10 to 15 years, affecting the east and the west.

Dry deposition of particles and gases occurs by complex processes such as settling, impaction, and adsorption. Dry deposition is monitored through the Clean Air Status and Trends Network (CASTNet). Total sulfur deposition is much higher in the Eastern U.S. than in the Western states. With few exceptions, wet deposition is the major contributor to total deposition of sulfur. Total deposition of nitrogen is also higher in the Eastern U.S., however higher rates are also estimated for the Rocky Mountains. Again, most sites are dominated by wet deposition, however the majority of nitrogen deposition to Joshua Tree NP and Death Valley NP in southern California occurs as dry deposition. Annual reports for individual park service stations are available from the NPS, and annual network reports are available from the CASTNet web site.

Water Use – modified from Hermann et al. (1998)

From 1950 to 1990, both the population and domestic water use in the United States increased steadily. Withdrawals of fresh and salt waters increased to a peak of 1.7 billion cubic meters per day in 1980, and by 1990 daily freshwater withdrawals were 1.5 billion cubic meters. Rural use of water for households and livestock increased from 1960 to 1990. Irrigation increased from 1950 to 1980, to a maximum of 570 million cubic meters per day, while per capita water use in the United States decreased from 6.8 million cubic meters per day in 1970 to 5.9 million cubic meters per day in 1990. Commercial and industrial uses of water, including self-supplied industrial use and withdrawals of water for mining, increased to a plateau in 1975-1980 before declining by 14%. The estimated use of fresh groundwater—fresh water drawn from below the ground—was 130 million cubic meters

per day in 1950. Use of groundwater increased to 310 million cubic meters per day by 1975, decreased during the 1980's to 280 million cubic meters per day, and then increased again to 300 million cubic meters per day in 1990. The use of fresh surface water peaked in 1980 at 1.1 billion cubic meters per day and declined to 980 million cubic meters per day by 1990. Consumptive use—water that is withdrawn from a water source and does not eventually return to the water source—of fresh water followed the same patterns as withdrawals. The reduction of withdrawals during 1980-1985 reflected conservation but could also relate to climate or the economic slowdown (Solley and Pierce 1988, van der Leeden et al. van der Leeden et al. 1990, Solley et al. 1993).

Fresh water is now a limited ecological (physical and biological) and economical resource. The trend in the present use of water reflects its limited availability. Krusé (1969) estimated that by 1965, withdrawals of 1.3 billion cubic meters per day were exceeding the available dependable water supply by 13%. The deficit reflected the need for reusing water, the increased use of salt water, and the lack of new water development opportunities.

Effects of Water Use on Watersheds

The withdrawal of water or the alteration of water quality elicits responses in watersheds—the area drained by a stream or river. These alterations occur even in the most remote places, and responses include changes in biological diversity and ultimately in the entire landscape (Ward and Stanford Ward and Stanford 1979, Becker and Neitzel Becker and Neitzel 1992, Pederson Pederson 1994). In fact, few wild rivers are completely wild, and few native populations are not affected by humans. Benke (1990) etimated that during the past century, 98% of the 5.2 million kilometers of streams in the contiguous 48 states were altered sufficiently by human activities so that they did not meet the more stringent requirements for protection under the Federal Wild and Scenic River provisions. For example, as human population and water use increased, the species diversity of fish communities decreased (Moyle and Leidy 1992). Thus, by 1989, in spite of conservation and restoration, over 100 species of freshwater fishes were added to the threatened or endangered list and more than 250 freshwater fish species were in danger of disappearing (Deacon et al. 1979, Williams et al. 1989, Johnson 1995). The endangerment of freshwater fishes in several regions of the United States has been linked to dams, the straightening of channels of large rivers, the building of cities, the expansion of agriculture, the logging and clearing of headwaters, the erosion of river channels, the pollution of water, and the introduction of nonindigenous species. The total effect of these developments is the alteration of stream ecology as evidenced by changes in the migration patterns of fishes, in stream water temperature and nutrient levels, in water chemistry, and in biological diversity (Warren, Jr. and Burr 1994).

The terrestrial part of the watershed ecosystem is also threatened. Before European settlement, the estimated amount of riparian land in the 100-year floodplains of the lower 48 states was 49 million hectares. By the 1980's it was reduced by 81%, to 9.3 million hectares (Brinson et al. 1981); 22 states had lost more than 50% of their wetlands. Although the rate of change in wetland areas slowed between the mid-1970's and mid-1980's, there was still a net loss, which created a major shift and reduction in the variety of plants and animals in riparian lands (Johnson and McCormick 1979, Petts 1984, U.S. Office of Technology Assessment 1984, Mathias and Moyle 1992).

The total effects of human activities in aquatic and riparian lands are not nearly understood. The change in biological diversity, however, can be linked to habitat change and to the loss of species (Hunt 1988). From alpine and mountain streams to estuaries and deltas, anthropogenic changes have accumulated, and many of the nation's watershed ecosystems have been drastically altered by these changes.

Nature of Water Development and Use

The development of freshwater resources for human use has many consequences for aquatic biota and for riparian and terrestrial species that depend on aquatic ecosystems for food or habitat. Direct human effects include changes in stream and river flows and lake water levels from dams and irrigation (Mesa 1994), the introduction of pollutants (Crowder and Bristow 1988), both intentional and inadvertent introductions of nonindigenous species by providing access pathways (Kitchell 1990, Cloern and Alpine 1991, Mackie 1991) exploitation of selected species, especially fishes and mussels (Hedgecock et al. 1994). Indirect effects on aquatic biota include introductions of extensive atmospheric contaminants (Schindler et al. 1985), widespread use of salts on roads (Likens 1985), change in aquatic species composition from UV-B radiation, change in water nutrient content and temperature from livestock grazing

in the riparian zone (Armour et al. 1991), and change in water quality from human development in upstream watersheds (Byron and Goldman 1989, Fisher 1994, O'Dell 1994).

Water developments have single or multiple purposes. For example, stored water may be withdrawn for cooling of electrical power plants, or it may be released for the generation of electric power. A development may provide water for municipal, agricultural, and industrial withdrawals, as well as for recreational uses (boating, fishing, swimming). The American Rivers group (1995) attributed the most frequent threats to the 30 endangered and threatened rivers on their list to dams (13), agricultural (10) and urban (10) runoff, mining (6), and flood-control or navigation demands (6). Other problems include overgrazing, logging, overuse, and sewage. Water projects often must balance competitive uses that can have different direct or indirect effects on aspects of the biological, physical, or chemical environment.

Coastal Barrier Island Evolution / Shoreline Erosion – ***Modified from Williams and Johnston (1995)***
Long-term survey data by the U.S. Geological Survey and others, based on analyses of archive maps, reports, and aerial photographs, demonstrate that coastal erosion is affecting each of the 30 coastal states (Williams et al. 1991). About 80% of U.S. coastal barriers are undergoing net long-term erosion at rates of less than 1 m (3.3 ft) to as much as 20 m (65.6 ft) per year. Natural processes such as storms, rise in relative sea level, and sediment starvation (a reduction in volume of sediment transported by rivers reaching the coast), which may also be a result of human interference, are responsible for most of this erosion; but human factors such as mineral extraction, emplacement of hard coastal-engineering structures, and dredging of sand from navigation channels are now recognized as having major effects on shoreline stability.

As the coastal population grows and barriers become urbanized, valuable habitats are being destroyed, and associated negative impacts such as waste disposal, pollution, and changes in freshwater and fine-grained sediment dispersal are altering entire coastal marine and maritime ecosystems. Protecting all remaining undeveloped coastal barriers should be a national priority. Some protection occurs through the Coastal Barrier Resources System, as well as other local, state, and federal programs, including acquisition, restoration, protection, and management programs.

Beach Renourishment – modified from National Oceanic and Atmospheric Administration (2004)
Policy makers recognize the need to manage, protect, and preserve beach environments, many of which have been subject to severe erosion due to storm events, natural longshore and offshore transport, and development. However, it is difficult to establish a standard management strategy or approach to the problem since erosion rates and sand transport patterns are highly variable along the coastline. Current projects rely primarily on "soft stabilization" measures such as beach nourishment and dune stabilization. These techniques reduce the negative "downdrift" effect associated with hard stabilization and create more attractive beach profiles and dune ecosystems that can promote tourism.

Coastal programs and initiatives exist at both the federal and state levels. Programs at the federal level are administered by the Coastal Programs Division of the Office of Ocean and Coastal Resource Management; however, each state within the OPIS study area maintains its own management program to conserve and protect state coastal resources. The Florida Coastal Management Program, Georgia Coastal Management Program, North Carolina Division of Coastal Management, and South Carolina Coastal Programs Division maintain primary responsibility for coordinating these efforts in their respective states. However, beach renourishment projects tend to be quite complex, involving additional federal and state agencies and associated legislation. The sections listed above will address these complexities.

The coastal environment contains many sensitive habitats and species that can be adversely affected when the system is subject to disturbance. A wide range of impacts are possible during the process of either mining offshore sand sources or depositing the sand on an erosional beach. These impacts must be considered within the project planning process to ensure that negative effects are mitigated. Three main categories of impacts will be discussed in the following sections, along with the related laws and regulations.

Dredging projects can disturb critical habitat for fish species or adversely affect bottom dwellers such as crabs, bivalves, lobsters, and other commercially valuable species. In the nearshore area, dredging can also disturb seagrass bed life cycles. In addition to their photosynthetic properties, seagrass beds are known to serve as a protective environment for the larval development of many marine species. A temporary increase in turbidity and sedimentation could negatively impact ambient water quality.

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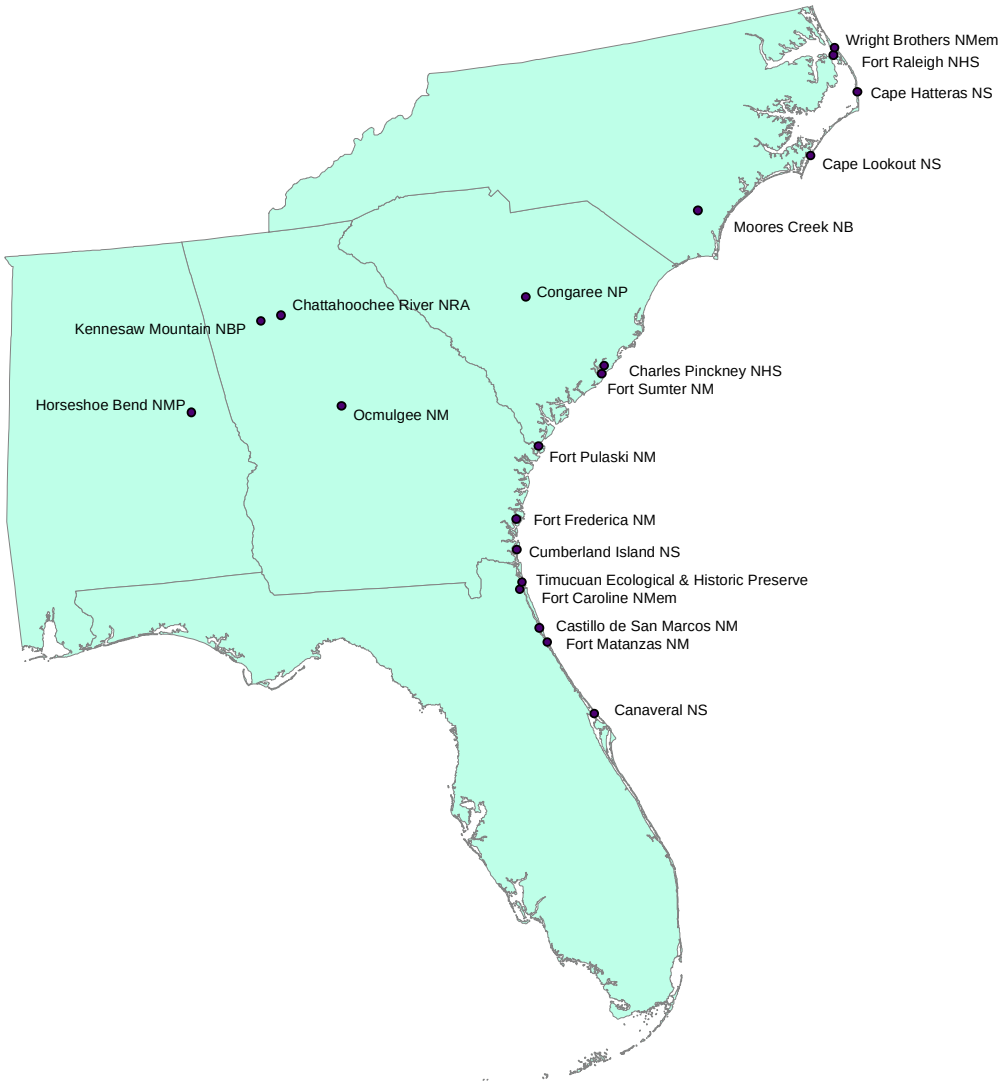
Appendix 8: Water Resources in the Southeast Coast Network



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Water Resources

Water Bodies

Ten percent (27/262) of water resources within or adjacent to SECN Parks are 303(d)-listed waters, with one-third (9/27) of those occurring at CHAT. 303(d)-designated waters are considered to be relevant to park managers if (a) they pass through, enter or are contained within Park boundaries as EPA-designated 303(d) waters or (b) they are designated 303(d) waters upstream within the same twelve- or fourteen-digit HUC boundaries as each respective Park. Twelve-digit HUC coverages were available for AL (in draft form), FL and GA; fourteen-digit HUC coverages were available for NC and SC. All 303(d) designations are based on the most recent (2002) EPA and state listings of impaired waters and GIS coverages (http://www.epa.gov/waters/data/downloads.html).

Various GIS coverages [e.g., Digital Raster Graphics, National Hydrography Dataset, EPA 303(d) listed waters] and existing Park narratives were reviewed for all available information regarding documented SECN Park water bodies. Special designations of Park waters were also noted (Tables A8-1- A8-9). FOCA and WRBR have no documented water resources within Park boundaries.

Table A8-1. Water features, EPA-defined waterbody types, designations, and water-quality parameter exceeded at CAHA [a].

Water Feature	Waterbody Type	Designation	Parameter exceeded
Albemarle Sound	Bay/Estuary	EPA and Association of National Estuary Programs (ANEP) Sponsored Estuary	
Atlantic Ocean	Coastal	303(d) [b]	Fecal coliform
Austin Creek	Bay/Estuary		
Beach Slue	Bay/Estuary		
Blackmar Gut	Bay/Estuary		
Boat Creek	Bay/Estuary		
Buxton Woods	Wetland		
Cape Creek	Bay/Estuary		
Clarks Bay	Bay/Estuary		
Cockrel Creek	Bay/Estuary		
Coff Cape Point	Bay/Estuary		
Davis Channel	Bay/Estuary		
Deamont Shoals	Bay/Estuary		
Eagle Nest Bay	Bay/Estuary		
Goat Island Bay	Bay/Estuary		
Goose Creek	Bay/Estuary		
Green Island Channel	Bay/Estuary		
Gull Island Bay	Bay/Estuary		
Hatteras Bight	Bay/Estuary	303(d) [c]	Fecal coliform
Hatteras Inlet	Bay/Estuary		
Island Creek	Bay/Estuary		
Jennette Sedge	Bay/Estuary		
Knoll Creek	Bay/Estuary		
Knoll House Creek	Bay/Estuary		
Little Swash Opening	Bay/Estuary		
Long Point Creek	Bay/Estuary		
Mary Anns Pond	Bay/Estuary		
Midgett Cove	Bay/Estuary		
No Ache Bay	Bay/Estuary		
North Bitterswash Creek	Bay/Estuary		
North Drain	Bay/Estuary		
Northern Pond	Bay/Estuary		
Ocracoke Inlet	Bay/Estuary		
Old Hammock Creek	Bay/Estuary		
Old Slough	Bay/Estuary		
Oregon Inlet	Bay/Estuary		

Water Feature	Waterbody Type	Designation	Parameter exceeded
Oregon Inlet Channel	Bay/Estuary		
Pamlico Sound	Bay/Estuary	EPA and Association of National Estuary Programs (ANEP) Sponsored Estuary	
Pauls Ditch	Bay/Estuary		
Pea Island Bay	Bay/Estuary		
Phipps Cove	Bay/Estuary		
Roanoke Sound	Bay/Estuary		
Round Hammock Bay	Bay/Estuary		
Sand Bay	Bay/Estuary		
Sand Hole Creek	Bay/Estuary		
Silver Lake	Bay/Estuary		
South Bitterswash Creek	Bay/Estuary		
Terrapin Creek Bay	Bay/Estuary		
The Drain	Bay/Estuary		
The Slash	Bay/Estuary		
The Trench	Bay/Estuary		
The Yard Creek	Bay/Estuary		
Wreck Creek	Bay/Estuary		
Unnamed Waterbody [d]	Lake/Reservoir/Pond		
Unnamed waterbody	Lake/Reservoir/Pond		
Unnamed Waterbody	Bay/Estuary	303(d) [d]	Fecal coliform

[a] CAHA is designated a NOAA Marine Protected Area
[b] approximately 2.5km of shoreline at southern tip of Hatteras Island, approximately 6.5km of shoreline east of Jimmys Landing
[c] approximately 19km of shoreline on southern coastline of Hatteras Island
[d] freshwater resources associated with reverse-osmosis plant on Ocracoke Island
[e] 8 small inlets of waterbody east of Herring Shoal Island

Table A8-2. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded at CALO [a].

Water Feature	Waterbody Type	Designation	Parameter exceeded
Atlantic Ocean	Coastal	303(d) [b]	Fecal coliform
Back Sound	Bay/Estuary		
Bald Hill Bay	Bay/Estuary		
Barden Inlet	Bay/Estuary		
Baymarsh Thorofare	Bay/Estuary		
Beaufort Inlet	Bay/Estuary		
Big Marsh	Wetland		
Blinds Hammock Bay	Bay/Estuary		
Cabs Creek	Bay/Estuary		
Caggs Creek	Bay/Estuary		
Cassy Bay	Bay/Estuary		
Cedar Inlet	Bay/Estuary		
Codds Creek	Bay/Estuary		
Core Sound	Bay/Estuary		
Cross Shoal Channel	Bay/Estuary		
Daniel Swash	Bay/Estuary		
Deer Pond	Bay/Estuary		
Drum Inlet	Bay/Estuary		
Evergreen Slough	Bay/Estuary		
Fortin Bay	Bay/Estuary		
Great Island Bay	Bay/Estuary		
Great Island Creek	Bay/Estuary		
Gutter Creek	Bay/Estuary		
Head of the Hole	Bay/Estuary		
High Hills Inlet	Bay/Estuary		
Hogpen Bay	Bay/Estuary		
Horse Island Cove	Bay/Estuary		
Horse Island Creek	Bay/Estuary		
Horsepen Creek	Bay/Estuary		
Iron Creek	Bay/Estuary		
Johnson Bay	Bay/Estuary		
Johnson Creek	Bay/Estuary		
Lewis Creek	Bay/Estuary		
Lighthouse Bay	Bay/Estuary		
Lighthouse Channel	Bay/Estuary		
Lookout Bight	Bay/Estuary	303(d) [c]	Fecal coliform
Mullet Cove	Bay/Estuary		
Mullet Pond	Bay/Estuary		

Water Feature	Waterbody Type	Designation	Parameter exceeded
Negro Creek	Bay/Estuary		
Ocrakoke Sound	Bay/Estuary		
Old Channel	Bay/Estuary		
Onslow Bay	Bay/Estuary	303(d) [d]	Fecal coliform
Pamlico Sound	Bay/Estuary	EPA and Association of National Estuary Programs (ANEP) Sponsored Estuary	
Point of Grass Creek	Bay/Estuary		
Rawson Creek	Bay/Estuary		
Royal Point Bay	Bay/Estuary		
Sand Island Inlet	Bay/Estuary		
Shackleford Slue	Bay/Estuary		
Sheep Island Slue	Bay/Estuary		
Sheep Pen Creek	Bay/Estuary		
Swash Inlet	Bay/Estuary		
The Ditch	Bay/Estuary		
The Haulover	Bay/Estuary		
The Swash	Bay/Estuary		
Try Yard Creek	Bay/Estuary		
Whale Creek	Bay/Estuary		
Yaupon Hammock Gut	Bay/Estuary		
Zack Creek	Bay/Estuary		

[a] CALO is designated a NOAA Marine Protected Area
[b] approximately 27.5km of eastern shoreline of Core Banks
[c] approximately 2.2km of shoreline of Lookout Bight east of Wreck Point
[d] approximately 2.0km of shoreline of Onslow Bay at Cape Lookout

Table A8-3. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded at CANA[a].

Water Feature	Waterbody Type	Designation	Parameter exceeded
Atlantic Ocean	Coastal		
Bissitte Bay	Bay/Estuary		
Bittersweet Cove	Bay/Estuary		
Blue Hole	Bay/Estuary		
Brickhouse Cove	Bay/Estuary		
Cucumber Slough	Bay/Estuary		
East Channel	Bay/Estuary		
East Max Hoeck Creek	Bay/Estuary		
Eddy Creek	Bay/Estuary		
Gaines Slough	Bay/Estuary		
Gallinipper Basin	Bay/Estuary		
Georges Slough	Bay/Estuary		
Glory Hole	Bay/Estuary		
Max Hoeck Back Creek	Bay/Estuary		
Max Hoeck Creek	Bay/Estuary		
Mosquito Lagoon [b]	Bay/Estuary	EPA - Estuary of National Significance, 303(d) [c]	Total coliform
Orange Island Creek	Bay/Estuary		
Pardon Slough	Bay/Estuary		
Slippery Creek	Bay/Estuary		
Turner Flats	Bay/Estuary		
Vanns Slough	Bay/Estuary		
Widgeon Bay	Bay/Estuary		

[a] CANA is designated a NOAA Marine Protected Area
[b] includes all listed Park water features, except Atlantic Ocean
[c] approximately 8.3km of NW Park boundary

Table A8-4. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded at CHAT[a].

Water Feature	Waterbody Type	Designation	Parameter exceeded
Big Creek	Stream/Creek/River	303(d)	Fecal coliform
Chattahoochee River	Stream/Creek/River	303(d)	Mercury, PCBs
Crooked Creek	Stream/Creek/River	303(d)	Fecal coliform
Haw Creek	Stream/Creek/River		
James Creek	Stream/Creek/River		
Long Island Creek	Stream/Creek/River	303(d)	Fecal coliform
Morgan Falls Reservoir	Lake/Reservoir/Pond	303(d)	Mercury, PCBs
Peachtree Creek	Stream/Creek/River	303(d)	Fecal coliform
Richland Creek	Stream/Creek/River		
Rottenwood Creek	Stream/Creek/River	303(d)	Fecal coliform
Sope Creek	Stream/Creek/River	303(d)	Fecal coliform
Suwanee Creek	Stream/Creek/River	303(d)	Fecal coliform

[a] Five additional 303(d)-listed Stream/Creek/Rivers drain into the Chattahoochee River within Park boundaries, but were not considered significant Park water resources (March Creek, Willeo Creek, Hog Wallow Creek, Ball Mill Creek, Johns Creek); all exceed established Fecal coliform levels

Table A8-5. Water features, EPA-defined waterbody types and designations at CONG.

Water Feature	Waterbody Type	Designation
Bates Old River	Lake / Reservoir/Pond	
Big Lake	Lake/Reservoir/Pond	
Cedar Creek	Stream/Creek/River	
Congaree River	Stream/Creek/River	
Congaree River Dry Branch	Stream/Creek/River	
Fork Swamp	Wetland	
Griffins Creek	Stream/Creek/River	
Old Dead River	Stream/Creek/River	
Running Lake	Lake/Reservoir/Pond	
Singleton Creek	Stream/Creek/River	
Toms Creek	Stream/Creek/River	
Weston Lake	Lake/Reservoir/Pond	
Wise Lake	Lake/Reservoir/Pond	

Table A8-6. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded at CUIS [a].

Water Feature	Waterbody Type	Designation	Parameter exceeded
Ashley pond	Lake/Reservoir/Pond		
Atlantic Ocean	Coastal		
Beach Creek	Bay/Estuary		
Brickhill River	Bay/Estuary	303(d)	Shellfishing ban [b]
Brockington Creek	Bay/Estuary		
Christmas Creek	Bay/Estuary		
Crooked River	Bay/Estuary		
Cumberland River	Bay/Estuary	303(d)	Shellfishing ban [b]
Cumberland Sound	Bay/Estuary		
Hawkins Creek	Bay/Estuary		
Johnson Pond	Wetland		
Lake Retta	Lake/Reservoir/Pond		
Mallkintooh Creek	Bay/Estuary	303(d)	Shellfishing ban [b]
McCall Pond	Wetland		
Mud Creek	Bay/Estuary	303(d)	Shellfishing ban [b]
Mumford Creek	Bay/Estuary		
Oldhouse Creek	Stream/Creek/River	303(d)	Shellfishing ban [b]
Saint Andrew Sound	Bay/Estuary		
Saint Marys Entrance	Bay/Estuary		
Shell Creek	Bay/Estuary		
South End Ponds	Lake/Reservoir/Pond		
Sweetwater Lakes Complex	Lake/Reservoir/Pond		
White Branch	Lake/Reservoir/Pond		
Whitney Lake	Lake/Reservoir/Pond		
Willow Pond	Wetland		

[a] CUIS is designated a NOAA Marine Protected Area
[b] Unknown parameters violated

Table A8-7. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded at FOPU.

Water Feature	Waterbody Type	Designation	Parameter exceeded
Bull River	Bay/Estuary		
Lazaretto Creek	Bay/Estuary		
The Moat	Artificial Canal		
Oyster Creek	Bay/Estuary		
Savannah River	Bay/Estuary	303(d)	Mercury
South Channel	Bay/Estuary		
Unnamed Waterbody (n=2)	Lake/Reservoir/Pond		

Table A8-8. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded at TIMU[abc].

Water Feature	Waterbody Type	Designation	Parameter exceeded
Atlantic Ocean	Coastal		
Back River	Bay/Estuary		
Bogey Branch	Bay/Estuary		
Broward Creek	Bay/Estuary		
Browns Creek	Bay/Estuary		
Buckhorn Creek	Bay/Estuary		
Burton Creek	Bay/Estuary		
Cabbage Hammock Swamp	Bay/Estuary		
Cedar Point Creek	Bay/Estuary		
Chicopit Bay	Bay/Estuary		
Clapboard Creek	Bay/Estuary		
Colorinda Creek	Bay/Estuary		
Deep Creek	Bay/Estuary		
Deese Creek	Bay/Estuary		
Edwards Creek	Bay/Estuary		
Fitzpatrick Creek	Bay/Estuary		
Fort George Inlet	Bay/Estuary		
Fort George River	Bay/Estuary		
Garden Creek	Bay/Estuary		
Grandaddy Branch	Bay/Estuary		
Greys Swamp	Bay/Estuary		
Gunnison Cut	Bay/Estuary		
Hannah Mills Creek	Bay/Estuary		
Haulover Creek	Bay/Estuary		

Water Feature	Waterbody Type	Designation	Parameter exceeded
Horseshoe Creek	Bay/Estuary		
Inconstantion Creek	Bay/Estuary		
Lake Timucuan	Lake/Reservoir/Pond		
Mesa Marsh	Bay/Estuary		
Mill Branch	Bay/Estuary		
Mink Creek	Bay/Estuary		
Mount Pleasant Creek	Bay/Estuary		
Mud Flats	Bay/Estuary		
Mud River	Bay/Estuary		
Myrtle Creek	Bay/Estuary		
Nassau River	Stream/Creek/River	303(d)	Total coliform, Turbidity
Nassau Sound	Bay/Estuary		
Pablo Creek	Bay/Estuary		
Pumpkin Hill Creek	Bay/Estuary		
Round Pond	Bay/Estuary		
Saint Johns Creek	Bay/Estuary		
Saint Johns River	Stream/Creek/River	EPA - American Heritage River, 303(d)	Total coliform, Turbidity, Total suspended solids
Samples Creek	Bay/Estuary		
Sawpit Creek	Bay/Estuary		
Seaton Creek	Bay/Estuary		
Sherman Creek	Bay/Estuary		
Simpson Creek	Bay/Estuary		
Sisters Creek	Bay/Estuary		
Spanish Pond	Lake/Reservoir/Pond		
Starrett Creek	Bay/Estuary		
Thomas Creek	Bay/Estuary		

[a] TIMU is designated a NOAA Marine Protected Area
[b] TIMU is designated Outstanding Florida Waters by Florida Department of Environmental Protection
[c] Approximately 15% of TIMU is in the St. Johns – Nassau River State Aquatic Preserve.

Table A8-9. Water features, EPA-defined waterbody types, designations and water-quality parameter exceeded for CASA, CHPI, FOFR, FOMA, FORA, FOSU, HOBE, KEMO, MOCR and OCMU.

Park	Water Feature	Waterbody Type	Designation	Parameter exceeded
CASA	Matanzas River	Bay/Estuary		
CASA	San Sebastian River	Bay/Estuary		
CHPI	Horlbeck creek	Stream/Creek/River		
FOFR	Frederica River	Bay/Estuary		
FOMA	Atlantic Ocean	Coastal		
FOMA	Matanzas Inlet	Bay/Estuary		
FOMA	Matanzas River	Bay/Estuary		
FORA	Albemarle Sound	Bay/Estuary		
FORA	Dough Point	Bay/Estuary		
FORA	Roanoke Sound	Bay/Estuary		
FOSU	Atlantic Ocean	Coastal		
FOSU	Charleston Harbor	Bay/Estuary		
FOSU	Cooper River	Bay/Estuary		
FOSU	The Cove	Bay/Estuary		
HOBE	Tallapoosa River	Stream/Creek/River		
KEMO	Allatoona Creek	Stream/Creek/River		
KEMO	Noses Creek	Stream/Creek/River		
KEMO	Ward Creek	Stream/Creek/River	303(d)	Lead
MOCR	Moores Creek	Stream/Creek/River		
OCMU	Ocmulgee River	Stream/Creek/River	303(d)	Fecal coliform
OCMU	Walnut Creek	Stream/Creek/River	303(d)	Biological

[a] FOMA included in NOAA National Estuarine Research Reserve System

Water Quality

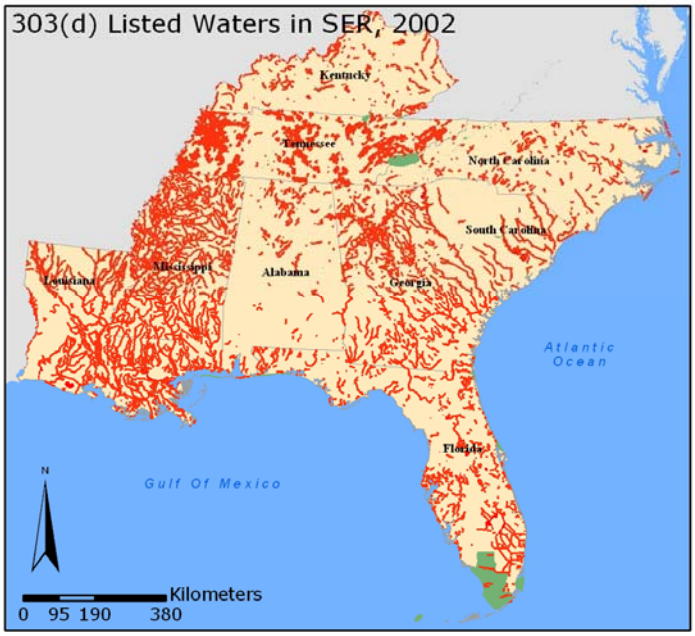
Despite the Federal Water Pollution Control Act of 1956, subsequent amendments in 1972, the Federal Water Pollution Control Act of 1972, the Clean Water Act of 1977 and the Safe Drinking Water Act of 1977, the chemical, biological and physical integrity of the nation's waters remains threatened (Hermann et al. 1998). Compromised water quality is largely the result of poor management of chemical, biological and physical discharge/waste from urbanization/population growth and agricultural and industrial activities. Adverse effects of impeded water quality on biota include altered floral- and faunal- species composition, reduced fecundity, low fitness, and bioaccumulation. The Southeastern U.S. is one of the fastest growing areas in the nation; consequently, marine and freshwater water quality throughout Southeast Region Parks has been impacted (White et al. 1998). Despite the abundance of 303(d)-listed waters in the Southeast Region, only ten percent of SECN water resources are 303(d) listed (Figure A8-1) (Tables A8-1 – A8-9). However, most of the SECN parks are downstream from multiple 303(d) listed waters outside NPS jurisdiction (Figure A8-1).

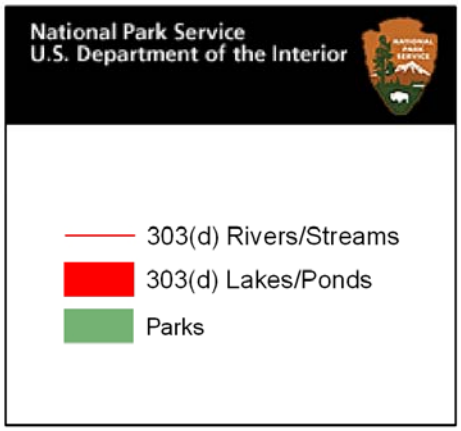
Water quality data in most SECN Parks, and adjacent lands, have been collected by a variety of governmental and private entities. Existing data were compiled and summarized by the Inventory and Monitoring Program and Water Resources Division of the USDI National Park Service (NPS) and Horizon Systems Corporation (HSC) into documents referred to as the Horizon Reports (National Park Service 1994a, National Park Service 1994b, National Park Service 1994c, National Park Service 1994d, National Park Service 1994e, National Park Service 1994f, National Park Service 1997, National Park Service 1998a, National Park Service 1998b, National Park Service

2001, National Park Service 2002a, National Park Service 2002b). Although the Horizon Reports provide a very thorough summary of baseline water quality data in SECN Parks, the data compiled and summarized for this endeavor included data only as recent as 1990 and 1992 for FOFR and CAHA, respectively, or 1998 for FOMA, FOPU, FOSU and TIMU (Table A8-10). As a result, recent trends in water quality are unknown. The SECN Inventory and Monitoring team is currently acquiring these data to establish recent trends in water quality at SECN Parks.

Thoroughness of water quality data varies from park to park. However, data are adequate to establish trends in waterbodies adjacent to parks, and infer status in parks if data within park boundaries are limited. Nonetheless, gaps in the datasets, in terms of evaluations of all significant water resources in each Park, do exist (e.g., no water-quality sampling has occurred on two freshwater ponds at FOPU that account for 67% of freshwater resources at the Park) and attempts to rectify these issues will be incorporated into future water-quality sampling design. Because many agencies, organizations and individuals have contributed to existing long-term water-quality data (in regard to data collection and laboratory analyses), estimates of data accuracy, precision, and subsequent reliability, are currently unknown.

Results from the Horizon reports were qualitatively summarized in order to determine potential “red flags”, or parameters that consistently exceed established water quality criteria, in SECN park water resources and assist in determining focal points (i.e., water-quality parameters) for future water-quality sampling design (Table A8-11). Total Coliform (TC) measurements commonly exceeded EPA standards in SECN parks, although Fecal Coliform was not consistently differentiated from TC, and several forms of TC are naturally occurring. High levels of Coliform (Fecal and Total) continue to be an issue, as 63% (17/27) of 2002 303(d)-listed waters in SECN Parks had Coliform levels in excess of EPA standards (Tables A8-1 – A8-9). Although no other “red flags” are evident in existing Network-wide data, Chloride and Copper levels exceeded EPA standards in several Parks. CHAT appears to have the most “red flags” of any SECN Park, and exceeds Georgia and EPA standards for Turbidity, Total Dissolved Solids, Fecal Coliform, Copper, Lead, Mercury, Zinc, PCBs and Chlordane (Table A8-11) (Kunkle and Vana-Miller 2000). Current EPA guidelines for select water quality parameters are also presented (Tables A8-12 – A8-14).





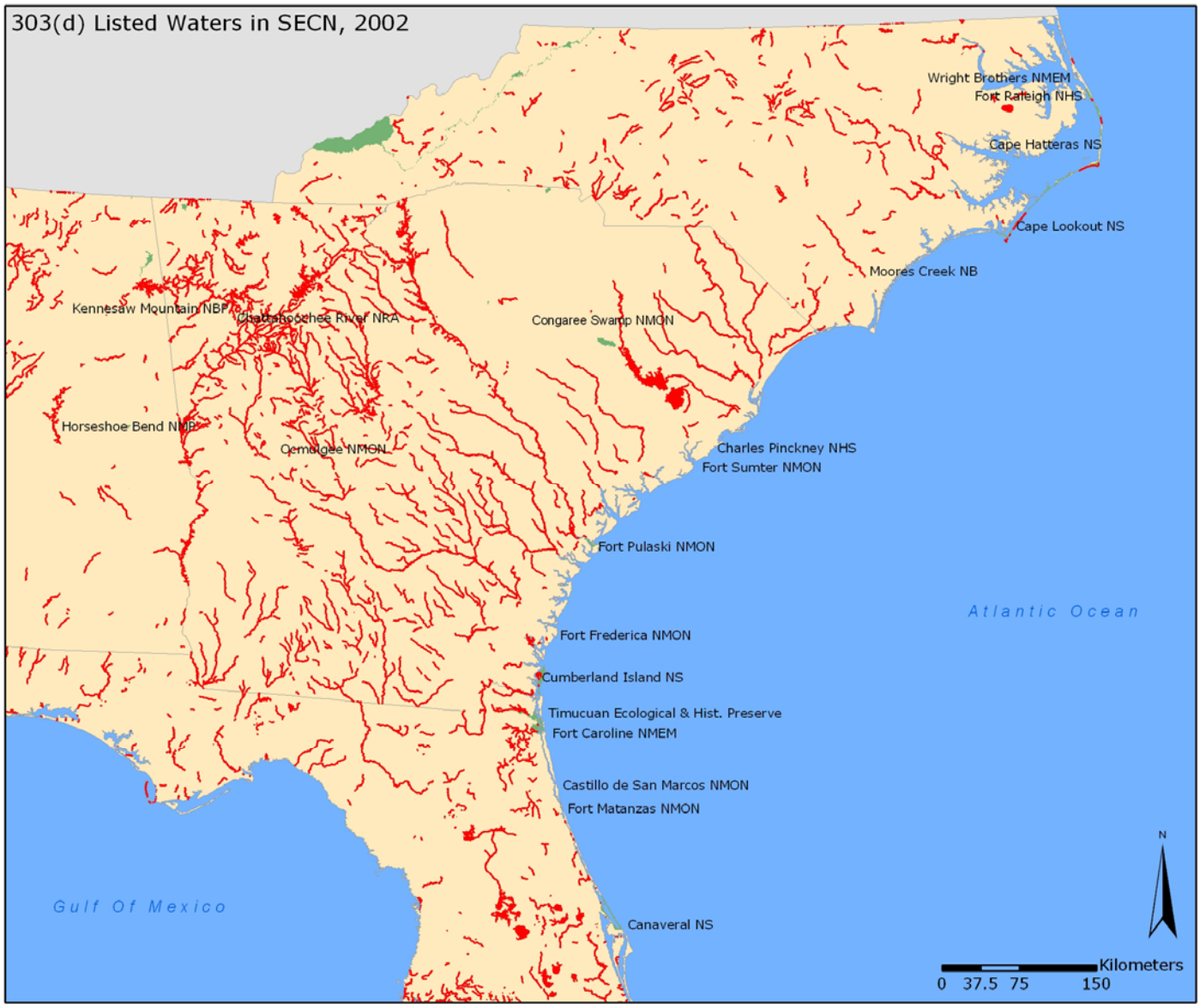


Figure A8-1. 303(d) waters in SER and SECN, 2002.

Table A8-10. Years water quality data summarized for baseline estimates in SECN parks and immediately adjacent areas (National Park Service 1994a, National Park Service 1994b, National Park Service 1994c, National Park Service 1994d, National Park Service 1994e, National Park Service 1994f, National Park Service 1997, National Park Service 1998a, National Park Service 1998b, National Park Service 2001, National Park Service 2002a, National Park Service 2002b).

Park	Years Data Summarized
CAHA	1968-1992
CANA	1956-1995
CALO	1966-1994
CASA / FOMA	1973-1997 / 1971-1998
CHAT	n/a
CONG	1957-1997
CUIS	1965-1993
FOFR	1967-1990
FOPU	1960-1998
FOSU / CHPI	1955-1998
HOBE	1962-1997
KEMO	1976-1997
MOCR	1973-1997
OCMU	1937-1998
TIMU / FOCA	1961-1998

Table A8-11. Baseline water quality summary for SECN Parks and immediately adjacent areas ("-", Not detected or unknown occurrence; ○, Recorded occurrence; ●, Potential Red Flag) (National Park Service 1994a, National Park Service 1994b, National Park Service 1994c, National Park Service 1994d, National Park Service 1994e, National Park Service 1994f, National Park Service 1997, National Park Service 1998a, National Park Service 1998b, Kunkle and Vana-Miller 2000, National Park Service 2001, National Park Service 2002a, National Park Service 2002b).

Parameter	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU / CHPI[i]	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
General															
Dissolved Oxygen	-	○	-	○	○	○	○	-	●	○	○	○	○	-	○
Specific Conductance	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Water Temperature	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Air Temperature	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flow	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Turbidity	-	○	-	○	●	○	○	-	○	○	○	-	○	○	○
Total Dissolved Solids	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-
pH	○ [a]	-	○ [d]	○	-	●	○	-	○ [h]	○	●	●	●	○	○
Biological															
Total Coliform and Fecal Coliform	● [b]	● [c]	●	●	●	●	● [g]	-	●	●	●	●	○ [j]	●	●
Index of Biological Integrity (IBI) (Karr et al. 1986)	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Invertebrate Community Index (ICI) (Ohio EPA 1987a, Ohio EPA 1987b, Ohio EPA 1989a, Ohio EPA 1989b, Ohio EPA 1990)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Estuarine Invertebrate Indices (U.S.Environmental Protection Agency 1993, Engle et al. 1994, U.S.Environmental Protection Agency 1994a, U.S.Environmental Protection Agency 1994b)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rapid Bioassessment Protocols (RBP) (Plafkin et al. 1989)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biological Oxygen Demand (BOD)	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Nutrients															
Nitrite plus Nitrate	-	-	-	-	○	○	-	-	-	-	-	-	-	-	-
Total Nitrogen	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Phosphorus	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-
Chlorophyll *a*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals															
Antimony	○	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	-	-	-	● [e]	-	-	-	-	-	-	-	-	-	-	○
Beryllium	-	-	-	-	-	●	-	-	-	-	-	-	-	-	-

Parameter	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU / CHPI[i]	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Metals (cont.)															
Cadmium	○	-	○	○	-	○	-	-	-	○	-	○	-	-	○
Chromium	-	-	-	-	-	○	-	-	○	○	-	○	-	-	○
Copper	●	○	●	●	●	○	-	●	-	○	-	○	○	○	●
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead	○	-	●	○	●	○	-	-	○	●	-	●	○	○	○
Mercury	○	-	○	-	●	○	-	-	-	○	-	-	-	-	○
Nickel	●	○	○	○[e]	-	○	-	-	-	○	-	-	-	-	○
Selenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	-	●	-	○[e]	-	-	○	-	-	○	-	-	-	-	●
Thallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	○	○	○	●	●	○	-	-	-	○	-	○	○	○	○
Organics															
Indeno (1,2,3-cd) pyrene	-	-	-	-	-	-	-	-	-	○	-	-	-	-	-
Methylene Chloride (Dichloromethane)	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-
Hydrogen Sulfide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	-	-	-	-	-	-	-	-	-	-	-	○	-	-	-
Tributyltin (TBT)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics															
Chloride	-	●	-	●	-	○[f]	●	-	-	●	-	○[f]	-	○[f]	●
Chlorine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide	-	-	-	-	-	-	-	-	-	○	-	-	-	-	-
Fluoride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○
Polychlorinated Biphenyls (PCBs)	-	○	-	-	●	-	-	-	-	-	-	-	-	-	-
Sulfate	-	-	-	●	-	-	●	-	●	○	-	-	-	-	●
Toxaphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pesticides															
4,4'-DDT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
alpha-Endosulfan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
beta-Endosulfan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlordane	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-
Chloropyrifos	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-

Parameter	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU / CHPI[i]	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Pesticides (cont.)															
Demeton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dieldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gamma-BHC (Lindane)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Guthion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor Epoxide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malathion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methoxychlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mirex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parathion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[a] 8/311 observations exceeded Criterion Continuous Concentration (CCC)
[b] primarily in Pamlico Sound, Roanoke Sound and Shallow Bag Bay
[c] primarily in Indian River Lagoon
[d] 32/475 observations exceeded Criterion Continuous Concentration (CCC)
[e] only detected at CASA
[f] total residual chlorine
[g] primarily in Amelia River
[h] 599/4685 observations exceeded Criterion Continuous Concentration (CCC)
[i] results for FOSU only, no water resources at CHPI
[j] only one year of data collected

Table A8-12. U.S. Environmental Protection Agency water quality guidelines for general water attributes and fecal coliform (U.S.Environmental Protection Agency 1986, U.S.Environmental Protection Agency 2002, U.S.Environmental Protection Agency 2003).

Parameter	Aquatic	Marine
Dissolved Oxygen (mg/L)	6.5 [a]; 5.5 [b]	5.0
Specific Conductance	[c]	[c]
Water Temperature	[d]	[d]
Air Temperature	[e]	[e]
Depth	[e]	[e]
Flow	[e]	[e]
Turbidity (FTU) [f]	5.7 [gh], 1.9 [ij], 3.04 [kh]	[c]
pH	6.5-9 [l]	6.5-8.5 [l]
Fecal Coliform [m]	200	100 [nop]; 200 [qr]

[a] cold water
[b] warm water
[c] variable, state-specific
[d] variable, species-specific
[e] variable, no specific requirements
[f] (U.S.Environmental Protection Agency 2000a, U.S.Environmental Protection Agency 2000b, U.S.Environmental Protection Agency 2000c)
[g] EPA Ecoregion IX [SECN Parks in EPA Ecoregion IX (Southeastern Temperate Forested Plains and Hills) – CHAT, CONG, HOBE, KEMO, OCMU]
[h] FTU
[i] EPA Ecoregion XII [SECN Parks in EPA Ecoregion XII (Southern Coastal Plain) – CANA, CASA, CUIS, FOCA, FOFR, FOMA, FOPU, TIMU]
[j] NTU
[k] EPA Ecoregion XIV [SECN Parks in EPA Ecoregion XIV (Eastern Coastal Plain) – CAHA, CALO, CHPI, FORA, FOSU, MOCR, WRBR]
[l] Criterion Continuous Concentration
[m] geometric mean (Most Probable Number - MPN) of Fecal Coliform Units per 100 ml, FCU/100ml
[n] Alabama
[o] Florida
[p] Georgia
[q] North Carolina
[r] South Carolina

Table A8-13. U.S. Environmental Protection Agency water quality guidelines for nutrient parameters (U.S.Environmental Protection Agency 2000a, U.S.Environmental Protection Agency 2000b, U.S.Environmental Protection Agency 2000c, U.S.Environmental Protection Agency 2000d, U.S.Environmental Protection Agency 2000e, U.S.Environmental Protection Agency 2000f).

	Reference Condition (25th percentiles)					
	Lakes/ponds			Rivers/streams		
EPA Ecoregion	**IX [a]**	**XII [b]**	**XIV [c]**	**IX [a]**	**XII [b]**	**XIV [c]**
Parameter						
Total Nitrogen (mg/L)	0.36	0.52	0.32	0.69	0.9	0.71
Total Phosphorus (μg/L)	20.0	10.0	8.0	36.56	40.0	31.25
Chlorophyll *a* (μg/L)	4.93 [d]	2.6 [e]	2.9 [d]	0.93 [e]	0.40 [e]	3.75 [e]

[a] SECN Parks in EPA Ecoregion IX (Southeastern Temperate Forested Plains and Hills) – CHAT, CONG, HOBE, KEMO, OCMU
[b] SECN Parks in EPA Ecoregion XII (Southern Coastal Plain) – CANA, CASA, CUIS, FOCA, FOFR, FOMA, FOPU, TIMU
[c] SECN Parks in EPA Ecoregion XIV (Eastern Coastal Plain) – CAHA, CALO, CHPI, FORA, FOSU, MOCR, WRBR
[d] Fluorometric method
[e] Spectrophotometric method

Table A8-14. U.S. Environmental Protection Agency water quality guidelines for trace element and organic parameters (U.S.Environmental Protection Agency 1986, U.S.Environmental Protection Agency 2002).

	Freshwater		Saltwater	
Parameter	**CMC (µg/L)**	**CCC (µg/L)**	**CMC (µg/L)**	**CCC (µg/L)**
Metals				
Antimony	9000.0	1600.0	ne[a]	ne
Arsenic	340.0	150.0	69.0	36.0
Beryllium	130.0	5.3	ne	ne
Cadmium	2.0	0.25	40.0	8.8
Chromium (III)	570.0	74.0	ne	ne
Chromium (IV)	16.0	11.0	1100.0	50.0
Copper	13.0	9.0	4.8	3.1
Iron	ne	1000	ne	300
Lead	65.0	2.5	210.0	8.1
Mercury	1.4	0.77	1.8	0.94
Nickel	470.0	52.0	74.0	8.2
Selenium	ne	5.0	290	71
Silver	3.2	ne	1.9	ne
Thallium	1400.0	40.0	2130.0	ne
Zinc	120.0	120.0	90.0	81.0
Organics				
Indeno (1,2,3-cd) pyrene	ne	ne	ne	ne
Methylene Chloride	ne	ne	ne	ne
Hydrogen Sulfide	ne	2.0	ne	2.0
Tetrachloroethylene	ne	ne	ne	ne
Tributyltin (TBT)	0.46	0.063	0.37	0.010
Inorganics				
Chloride	860000.0	230000.0	ne	ne
Chlorine	19.0	11.0	13.0	7.5
Cyanide	22.0	5.2	1.0	1.0
Fluoride	ne	2.0	ne	ne
Polychlorinated Biphenyls (PCBs)	ne	0.014	ne	0.03
Sulfate	ne	250.0	ne	ne
Toxaphene	0.73	0.0002	0.21	0.0002
Pesticides				
4,4'-DDT	1.1	0.001	0.13	0.001
Aldrin	3.0	ne	3.0	ne

	Freshwater		Saltwater	
alpha-Endosulfan	0.22	0.056	0.034	0.0087
beta-Endosulfan	0.22	0.056	0.034	0.0087

Parameter	CMC (µg/L)	CCC (µg/L)	CMC (µg/L)	CCC (µg/L)
Pesticides (cont.)				
Chlordane	2.4	0.0043	0.09	0.004
Chloropyrifos	0.083	0.041	0.011	0.0056
Demeton	0.1	ne	0.1	ne
Dieldrin	0.24	0.056	0.71	0.0019
Endrin	0.086	0.036	0.037	0.0023
gamma-BHC (Lindane)	0.95	ne	0.16	ne
Guthion	ne	0.01	ne	0.01
Heptachlor	0.52	0.0038	0.053	0.0036
Heptachlor Epoxide	0.52	0.0038	0.053	0.0036
Malathion	ne	0.1	0.1	ne
Methoxychlor	ne	0.03	ne	0.03
Mirex	ne	0.001	ne	0.001
Parathion	0.065	0.013	ne	ne
Pentachlorophenol	19.0	15.0	13.0	7.9

[a] **none established**

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National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 9: Monitoring Program Priorities for Southeast Coast Network Parks

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Overview & Methods

Identification and prioritization of specific monitoring questions is critical to the identification of Vital Signs. Because the Southeast Coast Network (SECN) is taking a resource-allocation approach to selecting vital signs (see Appendix 4), parks' individual priorities of monitoring questions comprise one of three primary data sets to be used in the analysis and selection of vital signs (Figure A9-1).

Monitoring questions included in the tables were compiled from the Phase I and Phase II reports from the first twelve Inventory and Monitoring Networks to receive funding where specific monitoring questions were clearly identified (Milstead and Stevens 2003, Emmott et al. 2003, Hubbard et al. 2003, Leibfreid 2003, Welch 2003, Weber 2003). Where appropriate, monitoring questions were also included from EPA's Draft Report on the Environment 2003 (United States Environmental Protection Agency 2003).

Questions are divided into three broad categories: Environmental Setting, Park Resources, and Agents of Change. Questions in the "Environmental Setting" category include resources that provide the primary drivers of ecosystem structure, function, and composition, though in most cases they are not actively managed by the parks due to the spatial and time scales involved (i.e., water, air, geologic, and weather resources). Park resources refer to those that are managed at one or more spatial and temporal scales ranging from individuals to ecosystems. Agents of change include both natural and anthropogenic drivers.

Monitoring questions were reviewed by all fifteen management units in the network and categorized into standardized priority rankings ranging (Table A9-1). In each case, the goal of the scoping meetings was to determine the degree of importance the *answer* to any given question from conservation and a park management / mission standpoints. Initial rankings were established during scoping meetings between Network and Park staff between February and July 2004 (Table A9-2). Additional questions were added to the list during scoping sessions with individual parks. Follow-up phone interviews were conducted with park staff during July 2004 to complete the data set. For each question the overall average score was calculated, as well as an adjusted average score based only on scores at which a monitoring question would be considered relevant (i.e., scores for marine or coastal issues were only averaged among coastal parks). Individual park scores, average scores, and adjusted average scores are presented in Table A9-3.

Monitoring questions and the Park priorities thereof are expected to be revised based on feedback received from conceptual modeling workshops, ongoing data mining, and refinement of decision-making models during the development of the Network's Phase I and Phase II reports. Furthermore, as parks continue with adaptive management of their natural resources, priorities might also change; reassessment of these priorities are likely to be a component of the Network's five-year programmatic review of the overall monitoring program.

Key Findings

Issues of highest importance to parks in the Southeast Coast Network fall into seven broad categories (Table A9-3). Notes as to the justifications for scores are included in Table A9-4.

1. Exotic Plant Management and Control. Monitoring questions related to exotic plant management were the only questions consistently of high priority across all parks within the network. Currently only parks within Florida are included in an operation exotic plant management program: Canaveral National Seashore (CANA), Timucuan Ecological & Historic Preserve (TIMU), Fort Caroline National Monument (FOCA), Castillo de San Marcos National Monument (CASA), and Fort Matanzas National Monument (FOMA). Beginning in FY 2005, the remaining parks within the network will be included in a three-year pilot program to identify and remove exotic plant species. Monitoring needs related to identification of sites of existing exotic plants and tracking the success of management actions will be

critical for the long-term success of this program.

2. Water Quality. In general, questions relating to water quality were high across all parks also, but the water bodies among the park vary substantially across the Network.

   a. Estuarine / Lagoonal. Nine parks within the network contain significant estuarine or marine waters: Cape Hatteras National Seashore (CAHA), Cape Lookout National Seashore (CALO), Fort Sumter National Monument (FOSU), Fort Pulaski National Monument (FOPU), Fort Frederica National Monument (FOFR), Cumberland Island National Seashore (CUIS), TIMU, FOMA, and CANA. Mosquito Lagoon at CANA is another significant brackish water body. Water quality in these systems is almost entirely driven by upstream or up-shore factors outside National Park Service boundaries or jurisdiction, and water quality monitoring is in general conduced by the various coastal states. Currently University of North Carolina at Wilmington, The University of Georgia, and The University of Florida are investigating watershed / landscape level influences of estuarine water quality at CAHA, CALO, FOPU, CUIS, TIMU, and CANA.

   b. Coastal. Six parks (CAHA, CALO, CUIS, TIMU, FOMA, and CANA) contain significant areas with access to marine / ocean waters. In all cases except CANA, NPS jurisdiction extends only to mean high tide; CANA's jurisdiction extends ½ mile east of the shore line. Threats to coastal water quality include non-point source chemical contaminants from up-shore as well as marine debris.

   c. Riverine. Six parks within the network contain or are bordered by significant river systems ranging from upland to coastal plain drainages: Chattahoochee River National Recreation Area (CHAT), Kennesaw Mountain National Military Park (KEMO), Horseshoe Bend National Military Park (HOBE), Ocmulgee National Monument (OCMU), Congaree National Park (CONG), and Moores Creek National Battlefield (MOCR). With the exception of the rivers contained within CONG, all other parks contain limited portions of the watersheds that the rivers drain. Adjacent land use and upstream development pressures are consistent threats to water quality among the river parks, but the types of land use and development pressures range widely from agriculture / animal husbandry operations, to extremely dense urban and suburban landscapes.

3. Geology & Geomorphology

   a. Coastal Geomorphology. All coastal parks are experiencing geomorphic changes either through accretion or erosion. Though these processes are natural in barrier island ecosystems, the current rates and locations of accretional and erosional zones are likely outside natural norms. Non-natural factors that are suspected to influence erosion and deposition rates include dredging operations, jetty and pier construction / placement, and hardening of shorelines.

   b. Stream Bank Erosion. Stream bank erosion and stability is a major concern at CHAT, HOBE, KEMO, and OCMU where hydrologic modification resulting from upstream watershed development and hydropower facility management has resulted in altered riverine flow regimes.

4. Water Quantity. Water quantity issues in general are currently of concern, but will likely become larger during the next 10-20 years as water demands in the Southeast increase.

   a. Surficial. River systems provide the majority of drinking water for the southeast. Major water supply reservoirs are located upstream of HOBE, CHAT, OCMU, and CONG, that serve the areas of Montgomery, AL, Atlanta, GA, Macon, GA, and Columbia SC respectively. The amount of fresh water that reaches estuarine systems is likely one of the major drivers that influences estuarine and salt marsh ecosystem health.

   b. Groundwater. The Floridan aquifer is the main water supply source for agricultural and industrial

needs along the southeast coast. The degree to which withdrawals affect park resources is not known, but as demand increases, the potential for impacts on park ecosystems could increase.

c. Effects of hydrologic modification. In addition to the average amount of water available within parks, the timing and distribution of flooding events is also changing due to upstream or watershed land use activities. In general flooding frequency of major floods has decreased during the last twenty years, and hydropower "peaking" operations have introduced a flow regime in riverine ecosystems that is outside expectations in natural systems. Multiple other water diversion structures occur in or near parks for agricultural, pest control, or transportation purposes.

5. Fire Management (effects, risks, and planning). Twelve of the network parks currently have or are in the process of developing fire management programs. The activities that will be conducted at each park will vary widely from suppression to routine prescribed burning. In all cases, climatic data relating to fire risk will be useful for fire management planning and risk assessment. Programs implementing prescribed burning would benefit from fire effects monitoring.

6. High Priority Ecosystems & Habitats. The Southeast Coast Network contains multiple habitat types. The following four systems / habitats had the most commonality among Network parks.

   a. Rivers. In addition to the six parks that contain large rivers, CAHA and CUIS contain smaller freshwater systems.

   b. Coastal Dunes. Coastal dunes are major habitat features at CAHA, CALO, CUIS, and CANA. Future land acquisitions at TIMU might result in the addition of dune habitats there as well. Coastal dunes are particularly important due to the fact that (a) they support a wide variety of sensitive or protected species, (b) they are fragile, (c) they are particularly threatened by visitor uses, and (d) they play a significant role in the overall stability of the island..

   c. Wetlands. Wetlands within SECN parks vary widely from intermittent interdunal pools to riparian floodplains to vast salt marshes. These systems are particularly sensitive to changes in water quantity.

   d. Intertidal zones. Intertidal zones provide critical foraging and nesting habitats for many sensitive and protected species such as shorebirds and sea turtles. These areas are threatened by visitor uses, and predation from both native and non-native species.

7. Threatened, Endangered, and other Species of Management Concern. More than twenty species were identified for potential monitoring across the Network, though with very few exceptions, those needs were only relevant at 1-2 parks due to limited species' ranges. In general, species-specific monitoring questions had the largest difference between overall average scores and adjusted average scores. In nearly all cases, floral and faunal differences among parks were large enough that few species' ranges span more than three parks. Exceptions include shorebirds, marine turtles, and multiple exotic plant and animal species. The following include species whose distribution occurs across six or more parks *or* whose impacts are large.

   a. Feral Hogs. Eight parks in the network have current, historic, or potential infestations of feral hogs: CAHA, CANA, CASA, CONG, CUIS, FOFR, OCMU, TIMU. Active eradication programs are occurring at OCMU and CUIS.

   b. Shorebirds. Plovers, oyster catchers, least terns, and wood storks are of large concern at all coastal beach parks. Active monitoring occurs at CANA, CUIS, CAHA, CASA, and CALO, those these efforts are not currently coordinated.

   c. Marine turtles. Marine turtles are monitored and protected at seven Network parks (CAHA,

CALO, CANA, CASA, CUIS, FOPU, and FOSU). These monitoring programs are currently coordinated with other state and federal agencies though not with one another. In addition to turtle monitoring, other related monitoring needs include predator, beach habitat, and light pollution monitoring.

d. Feral Horses. Feral horses are present at CUIS, CALO, and CAHA. In addition to the need to monitor aspects of horse populations (i.e., demography, disease incidence rates), the effects of the horses on other park resources.

Tables

Table A9-1. Criteria for prioritizing potential monitoring questions.

Rank	Park Question	Example
5	Mandated (for the Park). The park is required to know the answer to the monitoring question as per legal or contractual obligations.	• Monitoring red cockaded woodpeckers. If breeding pairs are present on the park, required under the recovery plan to conduct 100% census of population on an annual basis
4	Mission Critical. The Park should know the answer to this question to effectively manage its resources. Effectively answering this question through a monitoring program will shed light on multiple resource issues.	• Anything directly or explicitly mentioned in Park legislation or current / future management plans. Examples might include the size and impacts of horse populations at CUIS, water quality trends at CHAT, etc. • Success of NR Management, such as fire effects monitoring.
3	Mission Support. Answering this question would help the Park to better manage its resources, but is not necessary. Effectively answering this question through a monitoring program will shed light on multiple resource issues.	• Trends in external / adjacent land use • Trends and impacts of Air Quality (for some parks) • Habitat fragmentation
2	Answering this question is of interest to the Park, but is not necessary for natural resource management. Effectively answering this question through a monitoring program might or might not shed light on multiple resource issues.	• Research • Biological Inventories • Protocol Development
1	Not the responsibility of the Park.	• Marine Fisheries at CAHA (perhaps).
0	Not applicable to the Park.	• Estuarine processes at HOBE

Table A9-2. Purpose and participants of scoping meetings for prioritization of potential monitoring questions to be answered in the Southeast Coast Network Vital Signs Monitoring program.

Meeting Date	Meeting Location / Parks Involved	Meeting Participants
06 February 2004	Timucuan Ecological & Historic Preserve Fort Caroline National Monument	Shauna Ray Allen, Resource Management Specialist
18 March 2004	Canaveral National Seashore	John Stiner, Chief of Resource Management
19 March 2004	Fort Matanzas National Monument Castillo de San Marcos National Monument	Gordon Wilson, Superintendent Dave Parker, Site Supervisor
09 April 2004	Horseshoe Bend National Military Park	Mark Lewis, Superintendent Roy Appugliese, Park Ranger (Protection)
04 May 2004	Chattahoochee River National Recreation Area	David Lairson, Biological Technician Nina Hemphill, Biologist Sara McCort, SCA Intern / SECN Data Technician Christina Wright, SECN Data Manager
07 May 2004	Congaree National Park	Martha Bogle, Superintendent Bill Hulslander, Integrated Resource Program Manager
21 May 2004	Ocmulgee National Monument	Jim David, Superintendent Guy Lachine, Chief Ranger
26 May 2004	Moores Creek National Battlefield	Ann Childress, Superintendent Linda Brown, Park Ranger (Interpretation)
27 May 2004	Cape Lookout National Seashore	Michael Rikard, Chief of Resource Management
28 May 2004	Cape Hatteras National Seashore Wright Brothers National Memorial Fort Raleigh National Historic Site	Jim Ebert, Resource Management Specialist
09 June 2004	Fort Frederica National Monument	Denise Spear, Cultural Resource Specialist
09 June 2004	Cumberland Island National Seashore	John Fry, Chief of Resource Management
14 June 2004	Kennesaw Mountain National Military Park	Willie Johnson, Park Historian
16 June 2004	Fort Pulaski National Monument	John Breen, Superintendent Cliff Kevill, Park Ranger
17 June 2004	Fort Sumter National Monument Charles Pinckney National Historic Site	Sandy Pusey, Cultural Resource Program Manager

Table A9-3. Potential monitoring questions to be answered through monitoring in the Southeast Coast Network, and park priorities for answering those questions. Scores for each question range from 5 (most important) to 0 (least important). Definitions and examples of scoring criteria can be found in Table A9-4. Adjusted averages are based only on non-zero scores, and therefore represent average priority only for those parks where relevant. Questions highlighted in green indicate those where adjusted averages were greater than 3.

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Environmental Setting	Water Resources	Freshwater Streams & Rivers	What are the status and trends of surficial water quantity?	3	0	0	0	4	4	3	0	0	0	4	3	2	2	0	1.67	3.13
			Does changing water quality impact natural and cultural resources and visitor use?	3	0	0	0	2	4	3	0	0	0	4	2	3	4	3	1.87	3.11
			Is water quantity changing in response to water withdrawal and impoundment?	3	0	0	0	4	4	2	0	0	0	4	0	2	2	0	1.40	3.00
			What are the status and trends of water quality (chemical, physical, biological)?	3	0	2	0	4	4	3	0	0	0	4	3	3	4	4	2.27	3.40
		Freshwater Ponds & Lakes	Does changing water quality impact natural and cultural resources and visitor use?	3	2	2	0	2	4	4	0	3	0	2	0	0	4	3	1.93	2.90
			What are the status and trends of water quality (chemical, physical, biological)?	3	2	2	2	2	4	4	0	3	0	3	0	0	4	0	1.93	2.90
			What are the status and trends of surficial water quantity (water levels)?	2	2	2	2	2	3	4	0	3	0	3	0	0	2	3	1.87	2.55
			What are the effects of human-induced (visitors) disturbances on freshwater resources?	2	2	0	0	2	2	2	0	2	0	2	0	0	2	4	1.33	2.22
			To what extent is air chemistry affecting freshwater resources, and how is that changing over time?	2	2	0	0	2	2	3	0	2	0	2	0	0	2	2	1.27	2.11
		Marine	What are the distribution, frequency, type, and sources of marine debris?	2	3	2	2	0	0	3	0	3	0	0	0	0	0	2	1.13	2.43
			Is water quality suitable to support swimming / public access?	3	2	4	1	0	0	3	3	0	0	0	0	0	0	3	1.27	2.71

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Environmental Setting	Water Resources	Marine	Are levels of contaminants changing in coastal waters?	2	3	3	2	0	0	3	3	2	3	0	0	0	0	4	1.67	2.78
			Are marine water bodies at risk for harmful algal blooms?	3	2	1	1	0	0	3	2	1	2	0	0	0	0	0	1.00	1.88
		Estuarine / Tidal Marsh	Are frequency / duration of algal blooms changing over time?	2	2	2	2	0	0	3	2	4	0	0	0	0	0	0	1.13	2.43
			What are the status and trends of turbidity?	2	2	4	2	0	0	3	2	3	0	0	0	0	0	3	1.27	2.38
			Is water quality degradation causing water bodies to be at an increasing risk for eutrophication?	3	2	2	2	0	0	2	2	3	0	0	0	0	0	2	1.20	2.25
			What are the status and trends of nutrient levels?	2	3	4	2	0	0	3	3	3	0	0	0	0	0	4	1.53	2.88
			Are freshwater inputs changing over time?	2	2	2	2	0	0	2	2	3	0	0	0	0	0	4	1.27	2.38
			Are estuarine water bodies at risk for harmful algal blooms (red tides)?	3	2	2	2	0	0	2	2	2	0	0	0	0	0	0	1.00	2.14
			What are the status and trends of surficial water quantity entering the estuarine system?	2	3	2	2	0	0	3	2	3	0	0	0	0	0	4	1.40	2.63
			Are concentrations of freshwater and saltwater changing at tidally influenced sites? i.e., is the gradient shifting over time?	2	2	2	2	0	0	3	2	3	0	0	0	0	0	3	1.27	2.38
			Are levels of contaminants changing in coastal waters?	3	3	3	2	0	0	3	3	3	3	0	0	0	0	4	1.80	3.00
		Groundwater	Are the discharge and chemical properties of existing wells changing?	2	2	1	1	2	4	3	3	4	2	3	0	2	0	3	2.13	2.46

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Environmental Setting	Water Resources	Groundwater	Is groundwater quality changing over time?	3	2	3	2	2	4	3	2	4	2	3	2	2	2	3	2.60	2.60
			Is groundwater quantity changing over time?	3	2	2	2	2	4	3	3	4	2	2	3	2	2	3	2.60	2.60
			Are freshwater groundwater table levels changing?	3	2	2	2	2	4	3	2	4	2	2	2	2	2	3	2.47	2.47
			Are saltwater groundwater table levels changing (i.e., saltwater intrusion)?	2	2	2	2	0	0	3	2	4	2	0	0	2	0	3	1.60	2.40
			Are water storage levels in existing natural aquifers decreasing?	2	2	2	2	0	2	3	2	4	2	2	2	2	2	3	2.13	2.29
			Are changes in groundwater levels or quality affecting riparian / salt marsh habitat or wildife?	2	2	2	2	2	4	3	2	3	2	3	2	2	2	2	2.33	2.33
	Air Resources	Ozone	Are ozone air quality standards being met?	2	2	3	3	4	3	3	2	2	2	2	3	2	3	3	2.60	2.60
			Are ozone concentrations increasing, decreasing, or remaining constant over time?	2	2	3	3	4	3	3	2	2	2	2	3	2	3	2	2.53	2.53
		Particulates	What are the status and trends of measurable airborne contaminants in lichens?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	1.87	2.00
			What are the status and trends of visibility impairment as a result of air pollutants?	2	2	2	2	0	2	3	2	3	2	2	3	2	3	2	2.13	2.29
		Toxics	What are the status and trends in deposition of air pollutants in the park?	2	2	2	2	2	3	3	3	2	2	3	3	3	2	2	2.40	2.40
			What are the status and trends of Nitrogen and Sulfur deposition within the park?	2	2	3	3	2	3	3	3	2	2	2	3	3	2	2	2.47	2.47

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Environmental Setting	Air Resources	Toxics	What effect is air quality having on park monuments, plaques, tablets, cannons, and other classified historic structures?	3	2	3	3	2	0	4	3	3	4	2	2	4	2	2	2.60	2.79
			Is there a measurable rate of change in air quality?	2	2	2	2	3	3	3	3	3	2	3	3	3	2	3	2.60	2.60
		Other	What are the status and trends of light pollution?	3	3	2	2	2	4	4	2	0	0	2	2	0	3	0	1.93	2.64
			Are there trends in UV radiation interception?	3	2	2	2	2	2	2	2	2	2	2	2	2	2	0	1.93	2.07
			What are the status and trends of the soundscape?	2	3	3	4	2	4	4	2	3	2	3	3	3	4	0	2.80	3.00
	Geologic Resources	Coastal Geology	What is the rate of shoreline erosion, and is it changing over time?	3	4	4	3	0	0	4	0	4	4	0	0	0	0	4	2.00	3.75
			What is the spatial and temporal variation of the frequencies and magnitudes of coastal change?	3	3	3	2	0	0	4	0	4	3	0	0	0	0	2	1.60	3.00
			What is the rate of change in longshore sediment transport / sand budgets over time?	3	2	3	2	0	0	3	0	3	3	0	0	0	0	3	1.47	2.75
		Geomorphology	Are changes in geomorphology affecting flow or sediment transport?	2	0	0	0	4	2	2	2	2	2	3	3	3	4	3	2.13	2.67
			What are the effects of geomorphic changes on riparian vegetation.	2	0	0	0	4	2	2	2	0	0	3	3	3	2	0	1.53	2.56
			What is the quality of bed sediments (chemical / biological) and is it changing over time? Includes soft muck in salt marshes, too.	2	2	2	3	2	3	4	3	3	2	2	2	2	4	3	2.60	2.60

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Environmental Setting	Geologic Resources	Geomorphology	Is stream channel shape and size changing?	2	0	0	0	4	3	2	3	0	0	3	3	4	3	3	2.00	3.00
			Is the stability of riverbanks changing?	0	0	0	0	4	2	4	3	4	0	3	3	4	3	2	2.13	3.20
			Are sediment erosion and deposition rates changing over time in estuaries and lagoonal systems?	2	2	2	2	0	0	2	2	2	2	0	0	0	0	4	1.33	2.22
			Are sediment erosion and deposition rates changing over time in freshwater and tidal stream channels and banks?	2	2	3	4	4	2	4	2	2	2	2	3	4	4	4	2.93	2.93
		Soils	How do the physical, chemical, and biological properties of soils vary spatially and temporally across varied landforms, parent materials, vegetative types, and watersheds? (This is the soils inventory)	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2.07	2.07
			What are the effects of human-induced disturbances and modifications on soils?	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2.13	2.13
			What are the effects of air quality on soil resources?	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2.07	2.07
			What are the status and trends of soil erosion?	3	2	0	0	3	2	4	2	2	2	2	2	2	2	2	2.00	2.31
			What are the status and trends of soil fertility?	3	2	2	2	2	2	3	2	2	2	3	2	2	2	0	2.07	2.21
			What are the concentrations of toxic substances present in soils?	3	2	2	2	2	3	4	2	2	3	2	2	2	2	2	2.33	2.33
		Structural Geology	What are the impacts of earthquakes on park resources?	0	0	0	0	2	2	0	2	0	3	2	2	2	0	0	1.00	2.14
			What is the risk of earthquake occurrence?	0	0	0	0	2	2	0	2	0	4	2	2	2	0	0	1.07	2.29

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Environmental Setting	Weather and Climate	General	What are the frequency and distribution of lightning strikes?	3	2	4	2	2	2	3	2	2	2	2	3	2	3	2	2.40	2.40
			What are the effects of global warming on park resources?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.00
			What are the effects of sea level change on Park resources?	3	3	2	2	0	2	3	2	3	4	0	0	2	0	3	1.93	2.64
			What are the severity and frequency of droughts?	3	2	2	2	3	2	3	3	2	2	3	2	2	2	3	2.40	2.40
			What is the rate of sea level change?	3	3	3	2	0	0	3	2	3	4	0	0	0	0	2	1.67	2.78
			What is the temperature, and is it changing over time?	3	2	2	2	2	3	3	3	2	2	3	3	3	3	2	2.53	2.53
			What is the precipitation rate, and is it changing over time?	3	2	2	2	2	3	3	3	2	2	3	3	3	3	3	2.60	2.60
			What is the frequency of hurricanes, tropical storms, and other high-energy storm events, and is it changing over time?	3	3	3	2	2	2	2	2	2	4	2	2	2	2	1	2.27	2.27
Park Resources	Species of Concern	Species Groups	What are the status and trends of state and federally listed rare plants (not listed plants) and species of local concern?	3	4	3	2	3	4	2	2	2	2	2	2	4	3	3	2.73	2.73
			What are the status and trends of rare and listed bird species in the park?	4	4	3	4	2	4	4	2	2	2	2	4	3	3	3	3.07	3.07
			Are the abundance of rare bird species and their habitats changing?	4	3	3	4	2	4	4	2	2	2	2	4	3	3	4	3.07	3.07
			How do the distribution and abundance of rare plant species change over time?	3	3	2	2	3	4	3	2	2	2	3	2	4	3	2	2.67	2.67

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Park Resources	Species of Concern	Species	What are the status and trends of Bachman's Warbler populations and are they changing over time?	0	0	0	0	2	2	2	0	0	0	2	0	0	2	2	0.80	2.00
			What are the status and trends of Carolina bog mint?	0	0	0	0	0	3	0	0	0	0	0	0	4	0	0	0.47	3.50
			What are the status and trends of alligator populations?	2	2	3	0	0	2	3	2	3	2	0	0	0	2	3	1.60	2.40
			What are the status, trends, and distribution of Grass of Parnassus (spelling?) populations?	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0.13	2.00
			What are the status and trends of sensitive joint vetch?	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	2.00
			What are the status, trends, and distribution of Atlantic sturgeon?	2	0	2	0	0	3	1	2	3	2	0	0	2	2	2	1.36	2.10
			What are the status and trends of marine turtles?	4	5	5	4	0	0	5	0	3	2	0	0	0	0	0	1.87	4.00
			What are the status, trends, and distribution of Georgia aster populations?	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0.40	3.00
			What are the status, trends and distribution of Diamondback Terrapin populations?	3	3	4	3	0	0	3	2	3	2	0	0	0	0	3	1.73	2.89
			What are the status, trends and distribution of Atlantic Salt marsh snake populations?	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0.40	3.00
			What are the status, trends and distribution of Sand Heather (Hudsonia tomentosa)?	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	2.00
			What are the status, trends and distribution of Red Cockaded Woodpecker populations?	0	0	2	0	0	2	2	2	0	2	2	0	3	0	0	1.00	2.14

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Park Resources	Species of Concern	Species	What are the status, trends and distribution of Manatee populations?	2	0	4	2	0	0	1	2	3	2	0	0	0	0	4	1.30	2.50
			What are the status, trends and distribution of Atlantic / Southeastern Beach Mouse populations?	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0.53	4.00
			What are the status, trends and distribution of Florida Scrub Jay populations?	0	0	4	2	0	0	0	0	0	0	0	0	0	0	2	0.53	2.67
			What are the status, trends and distribution of Eastern Indigo Snake populations?	0	0	4	4	0	0	0	0	0	0	2	0	0	0	4	0.93	3.50
			What are the status, trends and distribution of Painted Bunting populations?	0	2	3	4	2	2	2	2	3	2	2	0	2	2	3	2.07	2.38
			What are the status, trends and distribution of Least Tern populations?	4	3	3	4	0	0	3	0	2	0	0	0	0	0	2	1.40	3.00
			What are the status, trends and distribution of Bald Eagle populations?	2	2	2	2	3	3	1	2	2	2	0	2	0	2	3	1.87	2.15
			What are the status, trends and distribution of Wood Stork populations?	0	0	3	3	0	3	3	2	2	0	0	0	0	2	4	1.47	2.75
			What are the status, trends and distribution of Gopher tortoise populations?	0	0	4	4	0	0	4	0	0	0	0	0	0	0	4	1.07	4.00
	Exotics Invasives Nuisance and Others	Plants	What are the effects of exotic plant species on cultural landscapes / resources?	3	2	2	2	3	2	2	2	3	3	4	2	4	4	4	2.80	2.80

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Park Resources	Exotics Invasives Nuisance and Others	Plants	What are the trends and impacts of exotic aquatic plants on native communities?	0	2	2	2	3	2	4	2	0	0	2	2	2	2	4	1.93	2.42
			What are the trends in the distribution and abundance of exotic plants?	3	3	4	4	4	4	4	3	3	2	3	4	4	4	3	3.47	3.47
		Vertebrates	How are native species' limits of geographical or ecological range changing (i.e., armadillo, red foxes, beaver...)?	4	3	2	2	2	2	3	2	3	2	3	2	2	2	2	2.40	2.40
			What are the status, and trends in populations of raccoons?	4	3	4	2	2	2	2	2	3	2	2	2	3	2	2	2.50	2.47
			How are population trends, habitat, and movement patterns of horses changing over time?	3	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0.73	3.67
			Are the distribution and abundance of feral hogs changing over time?	2	0	4	2	0	4	4	2	0	0	0	0	0	4	4	1.73	3.25
			What are the effects of exotic (and other) animals on cultural landscapes / resources?	2	2	3	2	0	4	4	2	3	2	3	0	0	4	4	2.33	2.92
			What are the trends and impacts of exotic fishes on native fish communities?	2	2	2	2	3	2	2	2	2	2	2	2	2	2	3	2.13	2.13
			What are the trends in non-native bird populations over time?	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2.07	2.07
			Are the distribution and abundance of nonnative mammal populations changing (not just hogs)?	3	0	2	2	2	3	4	2	2	2	2	2	2	2	2	2.13	2.29
			Are the distribution and abundance of feral dogs changing over time?	2	0	2	2	2	2	0	2	0	0	2	2	0	2	2	1.33	2.00
			Are the distribution and abundance of feral cats changing over time?	4	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2.33	2.33

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Park Resources	Exotics Invasives Nuisance and Others	Vertebrates	What is the magnitude and extent of hog-induced habitat degradation?	2	0	4	2	0	4	2	0	0	0	0	0	0	4	3	1.40	3.00
			How are population trends, habitat, and movement patterns of deer changing over time?	2	0	2	2	2	2	3	3	3	2	3	3	2	3	0	2.13	2.46
		Invertebrates	Are populations of nuisance / pest insect species changing over time (i.e., mosquitoes, ticks, fire ants)?	4	0	2	2	2	3	3	3	3	3	3	3	2	4	2	2.60	2.79
			Are population trends or outbreaks of destructive insects changing over time (forest pests)?	2	3	2	2	3	3	2	3	3	2	3	4	2	2	2	2.53	2.53
			What are the status and trends of exotic mussels?	0	0	3	3	2	3	3	2	2	2	2	2	2	2	0	1.87	2.33
	Communities	Fish	What are the status and trends in native resident fish populations (as opposed to migratory or non-native fishes)?	2	3	4	2	3	3	2	2	2	2	2	2	2	2	3	2.40	2.40
			What are the status and trends in fish health?	2	3	3	2	2	2	3	2	2	2	2	2	2	2	4	2.33	2.33
			Are species composition and distribution of fish changing?	2	2	3	2	3	3	3	2	3	2	2	2	2	2	4	2.47	2.47
			What is the trend in seasonal habitat use by anadromous fish species?	2	3	2	2	2	2	2	2	2	2	0	0	2	2	2	1.80	2.08
		Invertebrates	Are the species composition and distribution of freshwater invertebrates changing?	2	2	2	2	3	3	3	0	2	2	2	2	2	2	2	2.13	2.29
			Is intertidal community composition changing over time (i.e., inverts, macroalgae, intertidal fish, hardshell clams…)?	2	2	3	2	0	0	3	2	3	2	0	0	0	0	4	1.53	2.56

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Park Resources	Communities	Invertebrates	Are the species composition and distribution of marine invertebrates changing?	2	2	3	2	0	0	2	0	3	2	0	0	0	0	0	1.00	2.14
			Is there a shift in invertebrate species richness and abundance in intertidal and subtidal (nearshore) habitats?	2	2	3	2	0	0	3	2	2	2	0	0	0	0	4	1.47	2.44
			Is the assemblage of pollinators changing?	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2.07	2.07
			Is the species composition and distribution of terrestrial invertebrates changing?	3	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2.20	2.20
			What are the present and historical assemblages of plankton in park lakes and estuaries, and are they changing over time?	2	2	2	2	2	2	2	0	2	0	2	0	0	2	2	1.47	2.00
		Plants	Are plant communities displaying symptoms of ozone injury?	2	2	2	2	2	3	2	2	2	2	2	3	2	3	2	2.20	2.20
			Is there a shift in sea grass abundance and distribution in intertidal and subtidal (nearshore) habitats?	2	3	4	0	0	0	0	0	0	2	0	0	0	0	0	0.73	2.75
			Is there a shift in the distribution or relative abundance of salt marsh grass species (Juncus and Spartina spp.)?	3	2	2	2	0	0	4	2	3	2	0	0	0	0	4	1.60	2.67
			Are the diversity and extent of shell midden plant communities changing over time?	2	2	4	0	0	0	2	0	0	0	0	0	0	0	3	0.87	2.60
			Are the diversity and extent of coastal dune communities changing over time?	4	2	3	3	0	0	4	0	0	0	0	0	0	0	2	1.20	3.00

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Park Resources	Communities	Plants	Are the distribution, structure and composition of inland/upland forests changing over time?	2	2	2	2	3	4	4	2	2	2	4	3	2	3	2	2.60	2.60
			Is the health of heritage / champion trees changing in the park?	0	0	0	0	0	3	2	0	0	0	2	0	0	0	0	0.47	2.33
			What is the composition, structure, distribution, and abundance of vegetation communities on a large scale, and how do these characteristics change over time?	2	2	2	2	3	4	4	2	2	2	4	2	2	2	4	2.60	2.60
			How is the pattern of mortality, disease, and insect pests (native and non-native) in forest communities changing over time?	2	2	2	2	3	3	3	3	2	2	4	4	2	2	2	2.53	2.53
			What is the trend in plant phenology over time?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.00
			What are the effects of (over) browsing pressure on plant communities?	3	3	2	2	2	2	4	2	3	2	2	2	2	3	0	2.27	2.43
			What are the status and trends of fire-adapted communities as a result of fire suppression, reintroduction, or other alterations of natural fire regimes?	3	0	3	3	3	3	4	3	0	2	4	2	2	2	4	2.53	2.92
			To what extent is rooting pressure (from feral hogs) affecting plant communities?	3	0	4	2	0	4	3	0	0	0	0	0	0	2	4	1.47	3.14
			Are the diversity and extent of maritime forest communities changing over time?	3	3	2	2	0	0	4	2	2	2	0	0	0	0	3	1.53	2.56

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Park Resources	Communities	Mammals	What is the status of small mammal diversity, abundance and distribution, and are they changing over time?	2	2	3	3	3	3	3	2	2	2	3	2	2	2	3	2.47	2.47
			What is the status of bat diversity, abundance and distribution, and are they changing over time?	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2.07	2.07
		Reptiles & Amphibians	Are the abundance and distribution of aquatic breeding amphibians changing?	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3	2.20	2.20
			What are the status and trends in amphibian health?	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2.07	2.07
			What is the incidence rate of Gopher Tortoise upper respiratory disease?	0	0	4	4	0	0	3	0	0	0	2	0	0	2	3	1.20	3.00
			Are selected amphibians or reptiles reproducing successfully?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.00
			What are the status of reptile and amphibian diversity, abundance and distribution, and are they changing over time?	2	3	3	3	3	3	4	2	2	2	3	2	2	2	4	2.67	2.67
		Birds	What are the trends of common bird populations over time?	2	2	2	2	2	3	4	2	2	2	2	3	2	2	2	2.27	2.27
			What are the status of breeding bird diversity, abundance and distribution, and are they changing over time?	4	3	3	3	3	4	4	2	3	2	2	3	2	2	3	2.87	2.87
			What are the status and trends of migratory birds (neotropical and shorebirds)?	4	3	3	3	2	4	4	2	2	2	2	3	2	2	4	2.80	2.80
			Are there changes in species composition of land bird communities?	2	2	2	2	2	3	3	2	2	2	3	3	2	2	4	2.40	2.40

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Park Resources	Communities	Birds	Are changes in habitat quality and availability affecting breeding land birds / shore birds?	4	2	2	2	3	3	4	2	2	3	3	3	2	2	2	2.60	2.60
			What is the status of wading / shorebird diversity, abundance and distribution, and are they changing over time?	4	3	4	4	3	2	4	2	3	2	2	3	2	0	4	2.80	3.00
			Are populations of nesting diurnal raptors changing?	2	2	2	2	2	3	3	2	3	2	2	3	2	2	3	2.33	2.33
		Non-Vascular Plans & Fungi	Are abundance and diversity of fungi changing?	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2.07	2.07
			How are lichen and moss populations changing over time?	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2.07	2.07
	Habitats & Systems	Beaches & Dunes	What are the status and trends of the amount of large woody debris on beaches?	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0.40	2.00
			What are the status and trends of shells on beaches?	2	2	0	0	0	0	2	0	0	0	0	0	0	0	2	0.53	2.00
			What is the grainsize distribution, content, color, and mineral composition of sand on beaches, and is it changing over space and time?	4	2	2	2	0	0	3	0	0	0	0	0	0	0	0	0.87	2.60
			What are the status, trends, and quality of wrack on beaches?	4	2	2	2	0	0	3	0	0	0	0	0	0	0	0	0.87	2.60
		Wetlands	Are the frequency, duration, and spatial extent of seasonally intermittent pools changing over time?	3	2	0	0	2	2	4	0	0	0	2	0	2	3	0	1.33	2.50
			What are the structure, diversity, and extent of wetlands and riparian zones, and are they changing over time?	4	3	3	0	4	3	4	3	3	2	2	3	3	3	4	2.93	3.14

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Park Resources	Habitats & Systems	Wetlands	How is the distribution of wetlands changing over time? (patchiness)	3	2	0	0	2	3	3	3	3	2	2	2	2	3	2	2.13	2.46
		Rivers, Streams & Lakes	What is the biological integrity of streams (inverts, fishes, and algae...)?	2	0	0	0	4	4	3	2	3	2	3	3	2	3	3	2.27	2.83
			What are the density and distribution of woody debris in streams, and how are they changing over time?	2	0	0	0	2	2	2	2	0	2	2	2	2	2	0	1.33	2.00
			Are there changes in parameters describing physical habitat-related characteristics of lakes and streams? Includes tidal streams.	2	0	0	0	4	2	2	2	2	2	2	2	2	2	3	1.80	2.25
			What are the status and trends of instream habitat conditions?	2	0	0	0	4	3	3	2	2	2	2	2	2	2	3	1.93	2.42
			What are the status and trends of shoreline habitat characteristics in the littoral zone and the terrestrial shoreline in lakes and ponds?	2	0	0	0	4	2	3	0	0	2	2	0	0	2	3	1.33	2.50
			To what extent is sedimentation affecting the status and trends of stream habitats?	2	0	0	0	4	3	4	2	2	2	2	3	2	3	4	2.20	2.75
		Estuaries	Are physical and chemical features of the intertidal environment changing?	3	2	2	2	0	0	3	0	3	2	0	0	0	0	3	1.33	2.50
			What are the status and trends of shoreline habitat characteristics in the littoral zone and the terrestrial shoreline in lagoonal / estuarine systems?	3	2	2	2	0	0	4	0	2	2	0	0	0	0	4	1.40	2.63
			Are the distribution and use of fish spawning & nursery habitats changing over time?	2	3	4	2	0	0	3	0	2	2	0	0	0	0	4	1.47	2.75

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Park Resources	Habitats & Systems	Terrestrial System	Is forest structure changing over time?	2	2	2	2	2	4	4	2	2	2	4	3	2	3	4	2.67	2.67
			Are coastal dune habitats suitable to support dependent animal communities?	4	2	4	4	0	0	4	0	0	0	0	0	0	0	0	1.20	3.60
		Marine Systems	Is distribution, relative abundance, or species composition changing in subtidal habitats?	3	2	2	0	0	0	3	0	0	2	0	0	0	0	1	0.87	2.17
			Does climate change affect the distribution and species composition of subtidal species?	3	2	2	0	0	0	2	0	0	2	0	0	0	0	1	0.80	2.00
			Is the distribution, relative abundance, or species composition changing in intertidal habitats?	4	3	4	3	0	0	4	0	0	2	0	0	0	0	4	1.60	3.43
		General	Are land use or land cover types within Park boundaries changing over time?	3	2	2	2	2	2	2	2	2	2	4	3	2	3	4	2.47	2.47
Agents of Change	Park Resource Management	Maintenance / Trail Management	Does mechanical removal of hazard trees negatively impact natural ecosystem processes?	3	0	2	2	2	2	2	3	0	2	2	3	2	3	3	2.07	2.38
			Are park management actions affecting sensitive plant communities (trail clearing, vegetation trimming, boardwalk construction)?	3	2	2	2	2	2	2	2	0	2	2	2	2	3	2	2.00	2.14
			Are “down and dead” clearing activities affecting populations of animals that depend on forest litter for habitat, and are they best designed to mimic natural population and distribution dynamics?	2	0	2	2	2	0	2	2	0	2	2	2	2	3	2	1.67	2.08

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Agents of Change	Park Resource Management	Exotic Plant Management	To what extent are management activities effective in eliminating or slowing the invasion of exotic species?	3	3	4	4	4	3	4	3	3	3	4	4	4	4	3	3.53	3.53
			What are the effects of exotic plant species on Park resources?	3	2	3	3	3	4	2	2	3	3	4	3	4	4	2	3.00	3.00
		Cultural Resource Management	To what extent are plants affecting Cultural resources?	3	2	2	4	3	2	2	2	3	3	3	2	4	4	4	2.87	2.87
		Fire Management	To what extent are tree densities, understory composition, and fuel loads changing over time in areas of (historically) natural fire? i.e., what is the level of fuel loading…	3	2	3	2	4	4	4	3	2	0	4	4	4	3	2	2.93	3.14
			To what extent does prescribed burning (or lack thereof) affect status and trends of fire-dependent, sensitive, and non-native plant populations?	2	2	3	0	3	4	4	3	2	0	4	2	4	2	0	2.33	2.92
			Does mechanical fuel reduction appropriately mimic natural ecosystem processes?	2	2	3	0	2	2	2	3	2	0	4	2	2	2	4	2.13	2.46
		Restoration	What are the status and trends in distribution of native and restored longleaf / flatwoods pine forests?	0	0	0	0	0	3	0	0	0	0	4	2	4	0	4	1.13	3.40
			Are actions to remove water control / blockage structures having the desired effect on wetland hydroperiod and hydropattern? (or other wetlands restoration efforts)	2	0	3	0	4	2	2	0	0	0	0	0	4	0	0	1.13	2.83
	External Stressors (Anthropogenic)	Land Use & Development	What is the rate of change in adjacent land use?	3	2	2	2	3	3	2	2	2	2	2	3	3	3	3	2.47	2.47

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Agents of Change	External Stressors (Anthropogenic)	Land Use & Development	What is the relationship between non-point contaminants and land use? This is a true research question…	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	1.87	2.00
			To what extent is adjacent land use affecting sensitive species within the park?	4	2	3	3	3	2	4	2	3	2	2	2	2	3	3	2.67	2.67
			What is the pattern of land use types within the landscape that might have an impact on Park resources?	3	2	2	2	3	2	3	2	2	2	3	3	3	3	2	2.47	2.47
			What is the degree of habitat fragmentation within the landscape (of which the park is a part)? And how is it changing over time?	2	2	2	2	3	2	2	2	2	2	2	3	2	3	2	2.20	2.20
			To what extent is air chemistry affecting water resources, and how is that changing over time?	2	2	2	2	2	3	2	2	2	2	2	2	2	2	0	1.93	2.07
			How do roads throughout and surrounding the Park affect water flow, run-off, flooding, surface waters, and plant and animal communities within the Park?	2	0	2	2	2	3	4	2	4	2	2	2	2	3	2	2.27	2.43
			What are the status and trends of road density within and surrounding the park?	2	0	2	2	3	2	2	2	4	2	2	3	2	4	3	2.33	2.50
			Is local air quality near road corridors, campgrounds or areas of high visitor use changing?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.00

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Agents of Change	External Stressors (Anthropogenic)	Land Use & Development	What are the status and trends in upslope conditions that affect hydrology and delivery of sediments, large woody debris, and contaminants to streams and estuaries?	2	2	2	2	3	3	2	2	2	2	2	3	3	4	4	2.53	2.53
			What are the status and trends in contaminant emissions (air quality)?	2	2	2	2	2	3	3	3	3	2	3	3	2	2	2	2.40	2.40
			What are the effects of human-induced disturbances on freshwater resources?	2	3	0	0	3	3	2	2	2	2	4	3	3	2	0	2.07	2.58
			What are the status and trends of culverts and other flow restrictions within and surrounding the park?	2	0	3	0	3	2	4	2	2	2	2	2	2	4	4	2.27	2.62
			What is the direction and rate of change of land use within the watershed?	3	2	2	2	3	3	4	2	3	2	3	3	3	3	4	2.80	2.80
		Adjacent NR management	Are Park populations of deer, turkeys, hogs, waterfowl, and feral dogs changing in response to changes in hunting regulations outside the park?	0	0	2	2	0	0	0	0	0	0	2	0	2	0	0	0.53	2.00
			What are the incidence rates of wildlife disease to which humans are at risk?	3	2	2	2	2	2	3	2	3	2	3	2	2	2	3	2.33	2.33
			What are the incidence rate, virulence, and impacts of wildlife diseases on animal populations? (on adjacent lands)?	3	2	2	2	2	2	3	2	3	2	3	2	2	2	2	2.27	2.27
			To what extent are external hunting pressures affecting animal populations within Park boundaries?	2	2	2	2	0	3	0	2	2	0	3	2	2	0	2	1.60	2.18

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Agents of Change	External Stressors (Anthropogenic)	Adjacent NR management	To what extent are off-shore and adjacent fishing pressures affecting Park populations?	2	2	3	3	0	0	3	0	3	2	0	0	2	2	3	1.67	2.50
		Other	To what extent do mosquito control structures and other flow restrictions affect water resources?	4	0	3	0	0	2	4	0	4	0	0	0	0	4	0	1.40	3.50
			What are the effects of beavers on natural hydrology?	0	0	0	0	3	2	0	0	0	0	3	3	4	3	0	1.20	3.00
			To what extent do docks, piers, bulkheads and other shoreline stabilization structures affect natural hydrology and adjacent communities?	4	3	2	2	4	2	2	2	4	2	0	0	2	0	4	2.20	2.75
			To what extent do regional / adjacent stormwater management activities affect Park resources?	2	2	2	2	4	3	2	2	2	2	2	2	3	4	3	2.47	2.47
			To what extent are jetties affecting sediment transport budgets?	4	2	2	0	0	0	4	0	3	3	0	0	0	0	3	1.47	3.14
			To what extent are large impoundments and water diversion structures affecting water resources within Park boundaries?	4	0	3	0	4	4	0	2	3	0	4	0	2	2	0	1.87	3.11
			To what extent are shoreline erosion control structures (revetments) affecting erosion rates?	4	0	3	0	2	2	0	3	4	3	0	0	3	0	4	1.87	3.11
	Ecosystem Function	Energy / Material Flow	Are rates of nutrient or carbon cycling in riverine ecosystems changing over time?	2	2	0	0	2	2	2	2	2	2	2	2	2	2	2	1.73	2.00
			Are detrital loads from riparian zones into riverine ecosystems changing over time?	2	2	0	0	2	2	2	2	2	2	2	2	2	2	2	1.73	2.00

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Agents of Change	Ecosystem Function	Energy / Material Flow	Are chemical, physical, or biological processes in wetlands changing over time?	3	2	2	0	2	2	3	2	3	2	2	2	3	3	3	2.27	2.43
			What are the extent and impacts of bioaccumulation and biomagnification on park resources and visitor experience?	3	2	2	2	2	3	2	2	3	2	2	2	2	3	2	2.27	2.27
		Disturbance / Recovery	To what extent are flow dynamics and hydroperiod of aquatic systems changing over time (including rivers, lakes and ponds, wetlands, and estuaries, ditches)?	2	2	2	2	4	4	3	2	2	2	2	2	3	3	4	2.60	2.60
			To what extent are the magnitude, frequency, and extent of flooding events changing over time?	2	2	0	0	2	4	2	2	2	2	3	2	3	3	2	2.07	2.38
			To what extent are the magnitude, frequency, and extent of high tide events (storm surges, seasonal changes) changing over time?	3	2	3	3	0	0	4	2	2	2	0	0	0	0	4	1.67	2.78
			Are species associated with early successional stages of major (natural) disturbances adequately represented within the park?	2	2	0	0	2	3	3	2	2	2	3	2	2	2	3	2.00	2.31
		Trophic Structures	What is the status and trends of large carnivores (bobcat or bigger)?	2	2	2	2	2	2	4	0	2	2	3	2	2	3	0	2.00	2.31
			What are the status and trends of natural predators?	3	3	3	2	2	2	4	2	2	2	2	2	2	2	2	2.33	2.33
			Are there changes in functional groups of terrestrial invertebrates and vertebrates over time?	2	2	2	2	2	2	3	2	2	2	2	2	2	3	4	2.27	2.27
			What is the status and trends of large carnivore prey base?	3	2	2	2	2	2	2	2	2	2	3	2	2	2	0	2.00	2.14

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Agents of Change	Ecosystem Function	Animal Behavior	What are the status and trends of pollinators within the Park?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.00
	Other Issues	Visitor Use	To what extent are boating activities affecting submerged aquatic vegetation beds & associated communities?	2	3	4	0	0	0	0	0	0	0	0	0	0	0	2	0.73	2.75
			To what extent are personal watercrafts, canoes, or other boats impacting natural resources?	2	3	4	0	2	0	4	2	2	2	2	0	2	0	2	1.80	2.45
			To what extent are off-road vehicles impacting natural resources?	4	4	2	2	2	0	3	0	0	0	2	0	0	0	2	1.40	2.63
			To what extent do human uses of natural areas affect behavior, distribution, and abundance of natural animal populations?	4	4	4	4	2	2	2	2	2	2	2	2	2	2	2	2.53	2.53
			To what extent do human-animal interactions affect behavior, distribution, and abundance of natural animal populations?	4	3	4	4	2	2	2	0	2	2	2	2	2	2	3	2.40	2.57
			To what extent is use of backcountry / Wilderness areas affecting Park resources?	2	3	0	0	0	2	2	0	0	0	2	0	0	0	2	0.87	2.17
			Are the number and activities of concessionaires, Incidental Business Permit (IBP) users, and special use permits changing?	3	2	4	3	2	2	3	0	2	2	2	2	2	0	3	2.13	2.46
			Are visitor uses impacting native vegetation?	3	2	4	4	2	3	2	2	2	2	2	3	2	2	2	2.47	2.47
			To what extent are patterns of water-runoff, sedimentation, and erosion changing or increasing in areas of high recreation use?	3	2	3	3	3	2	2	0	0	0	2	3	2	0	4	1.93	2.64

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Agents of Change	Other Issues	Visitor Use	What type and extent of natural resource degradation are occurring due to visitor uses?	4	4	4	4	3	2	4	2	2	2	2	3	2	2	4	2.93	2.93
			How are the type, amount, and distribution of visitor uses changing over time?	2	3	4	4	3	2	3	2	2	2	2	3	2	2	3	2.60	2.60
			How are the number, distribution, and size of human-impacted sites changing over time? (incl. trails, campsites, boat launches…)	3	3	4	4	3	2	3	0	2	2	2	4	2	0	4	2.53	2.92
			Are human uses within the park (Non NR management) affecting surficial hydrology?	2	0	2	2	0	0	2	0	2	0	2	0	2	0	3	1.13	2.13
			Are visitors' desires for, expectations of, and actual experiences in the park changing?	2	3	4	4	3	2	3	2	2	2	2	3	2	2	2	2.53	2.53
			To what extent is horseback riding on trails affecting natural resources	2	0	2	0	2	0	0	0	0	0	2	3	0	0	0	0.73	2.20
		Resource Extraction	What are the effects of commercial and recreational shellfish harvesting on park aquatic habitats?	2	3	4	2	0	0	3	3	3	0	0	0	0	0	4	1.60	3.00
			Are levels of native vegetation harvesting changing?	2	0	2	2	0	0	0	0	0	0	2	0	0	0	0	0.53	2.00
			Are commercially valuable plant species (i.e., ginseng, goldenseal, bloodroot) being impacted by illegal harvesting?	2	0	2	2	2	0	0	0	0	0	2	0	0	0	0	0.67	2.00
			What is the frequency and intensity of sand dredging?	4	2	2	2	3	0	2	0	0	2	0	0	0	0	2	1.27	2.38

Category			Question	CAHA	CALO	CANA	CASA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU	Average	Adjusted Average
Agents of Change	Other Issues	Resource Extraction	How do beach re-nourishment projects affect hydrography (i.e., residence time, wave climate, loss of shoals, overland flow, sediment budget)?	4	2	2	2	0	0	4	0	0	2	0	0	0	0	2	1.20	2.57
			What are the effects of surface water extraction on Park resources?	2	0	0	0	4	3	0	0	0	0	2	0	0	2	2	1.00	2.50
			What are the impacts of specimen collecting on sensitive plant populations (scientific collection and poaching)?	2	2	2	2	2	2	0	2	2	2	2	2	2	2	3	1.93	2.07
			To what extent does hunting pressure within the park affect populations / communities (permitted and poaching)?	2	3	2	0	2	2	3	0	2	0	3	0	0	0	2	1.40	2.33
			What are the effects of channel dredging on natural systems?	3	3	2	2	3	2	4	0	4	3	2	0	0	0	4	2.13	2.91
			To what extent does groundwater extraction affect water tables, uplands, estuaries, wetlands, and surface water availability?	3	3	2	2	2	4	3	2	3	2	2	0	0	2	3	2.20	2.54
			To what extent do finfishing and shellfishing affect native populations (within park boundaries)?	2	3	4	2	0	2	3	3	3	2	2	0	2	2	4	2.27	2.62
			Is water quantity changing in response to (regional) water withdrawal and impoundment?	3	3	0	0	4	4	0	2	3	2	2	0	0	2	0	1.67	2.78
			Are dredging operations changing hydrology?	2	3	2	0	0	0	4	0	4	0	0	0	0	0	3	1.20	3.00
			What are the effects of sand mining on natural systems?	2	0	0	0	3	0	2	0	0	0	2	0	0	0	2	0.73	2.20

Table A9-4. Park Notes about score justifications from scoping meetings. Questions highlighted in green indicate those where adjusted averages were greater than 3.

Category			Question	Park	Notes
Environmental Setting	Water Resources	Freshwater Streams & Rivers	Does changing water quality impact natural and cultural resources and visitor use?	OCMU	yes. Not currently in any management plans (no GMP at this point). Should be included in future documents due to potential public health hazards.
				CHAT	water quality issues cause changes inv \visitor use patterns
				MOCR	upstream development pressure
				CAHA	certainly for visitor use
				CUIS	impacts of horses
				KEMO	visitor uses not in water here.
			Is water quantity changing in response to water withdrawal and impoundment?	CHAT	tri-state related. Also related to FERC issues with the Morgan Falls Dam hydropower facility.
				CAHA	Okrakoke, the town, the wastewater treatment plant is on park property
				CONG	Lake Murray dam upstream on Saluda River. With boundary expansion Catawba-Wateree watershed now included.
				HOBE	gage in park (USGS).
				MOCR	USACE facility management upstream for flood control. Score might go up to 3 or 4 with FERC relicensing or if impacts found to be negative.
				OCMU	not high priority, but reservoirs are upstream. (Macon Water Authority)
			What are the status and trends of surficial water quantity?	CAHA	Couple of creeks (freshwater) on Okracoke. Some tidal creeks, too.
				OCMU	have an issue with water level;
				MOCR	Water quantity is heavily influenced by tides. Water level changes 2-3 feet per day with tides.
				KEMO	two creeks on site. Get out of their banks, but no extended flooding.
				HOBE	dam proposal upstream.
				CHAT	related to tri-state issues
			What are the status and trends of water quality (chemical, physical, biological)?	FOFR	brackish
				CHAT	sewage-related issues a re a huge issue for the park

Category			Question	Park	Notes
Environmental Setting	Water Resources	Freshwater Streams & Rivers	What are the status and trends of water quality (chemical, physical, biological)?	MOCR	salinity important, particularly during storm events.
				OCMU	Same reason as above
				CUIS	horses have a potential impact
				KEMO	lots of development; chemical plant upstream. Other urban effects. Might need to be upgraded to 4.
		Freshwater Ponds & Lakes	Does changing water quality impact natural and cultural resources and visitor use?	OCMU	Upstream of turtle pond, a junkyard is potentially leaching heavy metals and other contaminants. Priority would change to "4" pending findings of contamination.
				CUIS	b/c most of freshwater is in a closed system
				KEMO	only beaver ponds are present.
				FOPU	gators use the ponds in the winter months. We are considering the moat around the fort as a part of the "ponds" section.
				CONG	Wise lake, Weston Lake, Bates Old River (massive oxbow in new section).
				CAHA	freshwater ponds are present perhaps as many as three
			To what extent is air chemistry affecting freshwater resources, and how is that changing over time?	CONG	we know that mercury is getting into the water and into the fish (atmospheric deposition). Methyl mercury contamination appears to be an issue. Right now being studied by SCDNR. Might change to a 3 or 4 based on results.
				FOPU	likely not an issue.
				CUIS	nearby paper mills could be a source of contaminants.
			What are the effects of human-induced (visitors) disturbances on freshwater resources?	OCMU	they're fishing. During floods, connected to the river so some debate as to whether or not that's an issue. Number of fishermen changes drastically over time.
				FOPU	have some issues with litter, and potentially wildlife.
				CONG	fishing impacts. Litter. Overuse of banks. Bates old river, once acquired, will have a ton of use. Right now overused and not public property.
				CUIS	not a big problem because of low visitation
			What are the status and trends of surficial water quantity (water levels)?	CUIS	many species dependent on habitat. Necessary for wood stork nesting / management
				CHAT	not considering bull sluice lake as part of the lake system (included with rivers)
				FOPU	if they go down, habitat gets lost for alligators and fish. Also won't be serving their purpose without water.

Category			Question	Park	Notes
Environmental Setting	Water Resources	Freshwater Ponds & Lakes	What are the status and trends of water quality (chemical, physical, biological)?	CHAT	two small isolated fish ponds that are not connected to the river system; water quality not thought to be a significant problem for management
				CONG	Lakes, ponds & rivers are all included in management plans in all-encompassing "water resources". When flooded, all the same.
				FOPU	have two ponds. Mosquito control ponds. One has saltwater intrusion. Changing water chemistry can affect species distribution both in the water and in riparian areas.
				HOBE	the "beaver pond" on site is about 10 acres.
				OCMU	Upstream of turtle pond, a junkyard is potentially leaching heavy metals and other contaminants. Priority would change to "4" pending findings of contamination.
				CALO	Need to pay attention to salinity; not sure the degree to which they're tidally influenced
			Are levels of contaminants changing in coastal waters?	FOSU	have had oil spills in the past. River discharge comes from Charleston area.
				CALO	Park sits on science advisory panel for the Albemarle Pamlico Sound.
				CUIS	including both biological and chemical
				FOPU	particularly during high tide events.
				FOFR	marsh has sewage-related bacteria problems that have been found by GA DNR that have resulted in beach closings
				CASA	NER on the Intracoastal Waterway is doing some monitoring.
			Are marine water bodies at risk for harmful algal blooms?	CALO	Haven't had any that we know of yet, but *Pfiesteria* is a potential issue. Potentially after hurricanes?
				FOPU	GADNR is responsible for monitoring for coliform and oxygen etc. in coastal waters.
				CUIS	none have been recorded here.
				CAHA	includes *Pfiesteria*
		Marine	Is water quality suitable to support swimming / public access?	CALO	NC monitors on te sound side. The park "does not recommend" swimming
				CASA	Not sure who, if anyone, is doing this.
				FOFR	not happening (no public access)
				TIMU	Do have objectives in the WMP to maintain Class II waters (recreation)
				CUIS	state involved in EPA's BEACHES program. As a result, we know water quality is good
				FOSU	no swimming areas within the park.

Category			Question	Park	Notes
Environmental Setting	Water Resources	Marine	Is water quality suitable to support swimming / public access?	CANA	Needed for health reasons. Swimming is one of our greatest resource activities
			What are the distribution, frequency, type, and sources of marine debris?	TIMU	An issue in the estuarine side, but not on beaches because not in jurisdiction.
				CUIS	no marine debris monitoring happening at this time
				FOSU	~200 acres near Fort Sumter. Park doesn't have any beach property.
				FOPU	Savannah state did a study on marine debris for the county that occurred two sites on the park. Sources primarily from boating and shipping (offshore)
				CASA	military waste can be a problem sometimes.
				CANA	medical waste, hazardous materials, plastics. Detrimental to both humans and wildlife.
				CALO	Problem exists; marine debris surveys underway
			Are levels of contaminants changing in coastal waters?	CANA	Potential impacts to swimmers
		Estuarine / Tidal Marsh	Are concentrations of freshwater and saltwater changing at tidally influenced sites? i.e., is the gradient shifting over time?	CASA	no salinity gradient really present on site; system is primarily rainfall driven.
				CANA	dictates habitat suitability for all species.
			Are frequency / duration of algal blooms changing over time?	FOPU	have algal blooms in the \moat. Potentially of concern in the marsh as well. When it happens it's a big issue that halts all other park ops.
				CAHA	no idea what goes on in tidal marshes
			What are the stats and trends of turbidity	CANA	affects seagrass-the basis of the Mosquito Lagoon ecosystem
			Are freshwater inputs changing over time?	FOPU	related to marsh grass die-off. Could become higher if die-off starts occurring on the park.
			Are levels of contaminants changing in coastal waters?	CALO	Park sits on science advisory panel for the Albemarle Pamlico Sound.
				FOFR	bacterial counts; possible public health concerns.
				FOPU	we're in pretty good shape here
				FOSU	CHPI has one historical tidal creek that is currently fed by runoff from nearby golf courses
			Is water quality degradation causing water bodies to be at an increasing risk for eutrophication?	CALO	no

Category			Question	Park	Notes
Environmental Setting	Water Resources	Estuarine / Tidal Marsh	Is water quality degradation causing water bodies to be at an increasing risk for eutrophication?	CUIS	lots of moving water
				TIMU	not really a problem because of diurnal flushing.
			What are the status and trends of nutrient levels?	CALO	state currently monitors shellfish. Waters have been closed due to contamination from septic systems
				FOFR	no upstream wastewater treatment plants. Perhaps nutrient loads are linked to bacterial levels, though.
			What are the status and trends of surficial water quantity entering the estuarine system?	CUIS	hydrology possibly affected by dredging operations
			What are the status and trends of turbidity?	CAHA	no issues that the Park is aware of
				FOFR	haven't noticed any problems
				TIMU	monitored by the city and part of the florida inland marine fisheries monitoring.
				CUIS	horses and consequent effects on erosion rates.
				CANA	Affects seagrass – the basis of the Mosquito Lagoon ecosystem
			Are levels of contaminants changing in coastal waters	CANA	Again, health effects for fishing, shellfishing, etc.
		Groundwater	Are changes in groundwater levels or quality affecting riparian / salt marsh habitat or wildlife?	CUIS	Only interested in the shallow aquifer; deep (Floridan) not an issue.
				HOBE	if they were, it would be high priority. This might become a two.
				FOPU	this is more driven by surficial aquifer and not at as much risk due to dredging operations.
				FOFR	don't see this yet.
				CHAT	we don't know if this is an issue, but it might be at the groundwater-river interface where the park's wetlands primarily exist.
				CAHA	don't know if there's an issue yet.
				CONG	Required to know as a part of the FERC relicensing process upstream.
			Are freshwater groundwater table levels changing?	CHAT	no indication that this is a problem because the river's base flows haven't changed over time.
			Are saltwater groundwater table levels changing (i.e., saltwater intrusion)?	MOCR	potentially raise to 3 if a reason is found to be concerned.

Category			Question	Park	Notes
Environmental Setting	Water Resources	Groundwater	Are saltwater groundwater table levels changing (i.e., saltwater intrusion)?	TIMU	WRD recommended starting a groundwater monitoring program b/c of exteranal threats to water quality and quantity.
			Are the discharge and chemical properties of existing wells changing?	MOCR	three wells on site, with pipes in them
				CASA	Saint Johns Water Management District has one test well on site.
				KEMO	no wells on site
				FOSU	irrigation well at Fort Moultrie. Not used for anything else right now. Don't know which aquifer it's tapped into.
				FOPU	have three existing wells. Five total on the island. All go down to the Upper Floridan aquifer. Scored a 4 with the proposed dredging work.
				FOFR	three artesian wells on site. Another well used for watering. None are used for drinking water.
				CHAT	only historic wells on site. Not currently being used.
				CONG	so closely tied to surface water system is very important.
				CANA	NASA responsible.
				CALO	no problems have yet been identified.
			Are water storage levels in existing natural aquifers decreasing?	CONG	don't know how integrated aquifer systems might be with surface water systems at park.
				FOSU	but if the wells run dry…
				FOFR	haven't noticed anything yet.
				CHAT	park is dependent on surface water for supplies; aquifers not an issue at this point.
				FOFR	raise to 3?
			Is groundwater quality changing over time?	CANA	groundwater not mentioned in WMRP; of growing concern, however as Indian Lagoon is largely groundwater fed. Recent research has shown groundwater influx to be considerable in Mosquito Lagoon.
				CHAT	we might reprioritize this with some additional research.
				CUIS	more interested in shallow than in deep groundwater
				TIMU	don't really know. USGS is doing GW monitoring as well as SJWMD.
				OCMU	Need to check the degree to which the pond or river are groundwater fed. Possibly some leaching issues from the upstream junkyard. Also affects from adjacent urban pesticide / herbicide treatments
				CAHA	although groundwater quality in shallow not good, most drinking water comes from deeper aquifer

Category			Question	Park	Notes
Environmental Setting	Water Resources	Groundwater	Is groundwater quantity changing over time?	CONG	USGS is currently monitoring this. 6 or 8 additional wells were put in to study the run of river effects to determine interplay between surface and groundwater. Don't yet know the specifics, but we know enough to make this a high priority.
				KEMO	a bunch of unmapped springs on the mountain. Discharge varies with precipitation.
				TIMU	big concern because of the amount withdrawals regionally.
	Air Resources	Ozone	Are ozone air quality standards being met?	FOPU	GADNR is doing ozone monitoring. Double check with ARD report.
				CHAT	the answer is no. Is being monitored.
				CONG	air quality has been monitored for more than 20 years by SCDHEC. Long-term data set makes this a very valuable question to continue tracking. Park is a class II park.
				KEMO	we know we're in an non-attainment area right now. Does this need to be a 4? Check on this.
				OCMU	Macon is a non-attainment area
				CUIS	Class II airshed.
			Are ozone concentrations increasing, decreasing, or remaining constant over time?	CHAT	out of compliance. Getting data already from regional monitoring network. Ozone sensitive resources have been identified.
				KEMO	Atlanta is doing the monitoring for this.
				OCMU	monitoring station in Macon. Check for consistency with CHAT.
				FOFR	risk of ozone injury to plants is low (ARD)
				CONG	same as above.
				HOBE	need to check with Tonnie's report to see if this should be a three or four. Same with all air quality
		Particulates	What are the status and trends of visibility impairment as a result of air pollutants?	OCMU	One of the visitor experience things is to stand on the Great Temple Mound and enjoying the vista. Might need to be a 4.
				KEMO	Urban smog is limiting visibility. Increasingly, you can't see Atlanta or Marietta from the mountain. Huge negative impact to visitor experience.
				HOBE	because there's no altitude on site, haze-related issues.
				FOSU	no issues because of proximity to coast.
				FOFR	haven't noticed any.
				CHAT	no vistas available; maximum sight lines for natural areas is across the river.
				CONG	non-issue

Category			Question	Park	Notes
Environmental Setting	Air Resources	Toxics	What are the status and trends of visibility impairment as a result of air pollutants?	FOPU	Of concern. Industrial effluent upstream and west. When prevailing winds (typically easterlies) shift, this becomes a bigger problem. Also affects visitor experience.
			Is there a measurable rate of change in air quality?	CONG	yes…
				FOPU	also paper mills are nearby.
			What are the status and trends in deposition of air pollutants in the park?	CONG	because of mercury deposition, links to water quality issues.
				FOSU	don't have any problems right now, but if conditions change as Charleston grows, we might want to elevate scores. Primary sources of contaminants are from shipping industry and paper mills. Bigger boats expected in the future.
				FOFR	Herculean chemical plant in Brunswick; paper mill nearby or well. On rare occasion, a noticeable odor is observed in the park (once or twice per year). Effects on resources unknown.
				KEMO	not sure right now if there's anything we can do at this point.
				HOBE	see previous notes.
			What effect is air quality having on park monuments, plaques, tablets, cannons, and other classified historic structures?	CUIS	don't know susceptibility of tabby to toxics
				CHAT	don't know of any air-quality related effects on park CR
				CONG	no structures at risk.
				FOPU	doesn't seem like it's a problem at this point, but effluent from nearby industry present a potential risk.
				FOSU	doesn't seem like it's a problem at this point, but effluent from nearby industry present a potential risk.
				HOBE	park has three historic structures. Actually more than that. No AQ issues identified to date.
				KEMO	haven't noticed any environmentally-related degradation yet. Two main monuments are granite. One marble.
				MOCR	responsibility of park to keep monuments in good repair. Six total on site.
				CASA	Acid rain impacts are of concern to prevent dissolution of coquina structures (such as the fort at CASA).
				OCMU	no degradation yet observed. Potentially at historic structures…

Category			Question	Park	Notes
Environmental Setting	Air Resources	Other	Are there trends in UV radiation interception?	CAHA	because of visitor use health impacts. (public safety)
			What are the status and trends of light pollution?	MOCR	day use area only. No light-sensitive species on site.
				KEMO	has definitely increased over the last 30 years (anecdotal). Day use only park, though. Maybe a 0?
				HOBE	not a big issue at this point.
				FOSU	We don't own the beach, though it's a big problem for adjacent areas. Primarily day use areas; occasional night use at most.
				OCMU	will be putting lights on I-16 through the park. 35 foot high lights with "non-polluting" types of heads. Not sure what, if any, effects might be on wildlife, though. DOT will be doing this study.
				CONG	important due to wilderness designation.
				CANA	directional light sources b/c of interference with turtle disorientation during nesting and hatching
				CALO	not a big issue with turtles because of the lack of adjacent residential properties
				CUIS	sea turtles
				FOPU	day use only area. Astronomy clubs do use the park at night.
			What are the status and trends of the soundscape?	KEMO	in flight path for Lockheed Dobbins AFB in the Cheetham section of the park. Some railroads, too. Traffic noise typical of the metro area, but far enough away from interstate for that to be a problem.
				OCMU	getting louder, especially with I-16. Park has lost it's "sound of the swamp." Can be partially driven by losses in trees due to standing water & changes in hydrology. Major road widening of I-16 will allow for more traffic. Could provide info for the
				HOBE	because of park mission to preserve the sanctity of the battlefield, this is an important issue. Might be upgraded to 4 with a new management plan.
				FOSU	might increase as larger ships come in.
				FOPU	noise from HWY 80, overflights, shipping. Elevated to 3 because of the potential widening to HWY 80.
				CASA	interferes with the cultural mission of the park.
				CALO	increasing effects of military overflights and those of privately owned aircraft. Baseline information would be very helpful.
				CUIS	because of wilderness area and consequent need to maintain natural quiet.
				CONG	important due to wilderness designation.
				CANA	flyovers are a disturbance, but doesn't warrant a 4.

Category			Question	Park	Notes
Environmental Setting	Geologic Resources	Coastal Geology	What is the rate of change in long shore sediment transport / sand budgets over time?	FOSU	tied into the accretion issue.
				FOPU	we are having aggradation on the north shore of oyster shells (about a foot a week) and the source is unknown. Highly dynamic, but not sure if it's a problem.
			What is the rate of shoreline erosion, and is it changing over time?	FOPU	Active erosion happening along north shoreline. Potentially impacted by armoring and dredging operations. Also concerned about the lighthouse. If dredging happens, then new (bigger) ships will be coming through the shore.
				FOSU	Active erosion at Fort Sumter on (almost) all sides.
				CALO	Park is doing beach renourishment to protect the lighthouse and other structures on the sound side. Already, one historic structure has been lost (coal shed) in the last hurricane. Renourishment site will be 100' x 1,700'.
				CAHA	active erosion at / near FORA.
				CANA	erosion causes loss of T&E habitat for beach mouse, etc.
				CUIS	State of Florida wants to dredge portions of the south end of the Island to benefit lands to the south within Florida; Back barrier Erosion; Habitat for T&E species. Most beaches on CUIS are accretional.
			What is the spatial and temporal variation of the frequencies and magnitudes of coastal change?	CANA	same question as above?
				FOSU	Maybe a 4? Fort Sumter is actively accreting. Current management plans don't address this because it wasn't an issue at that time. Accretion has really become a noticeable structure in last 7-10 years.
		Geomorphology	Are changes in geomorphology affecting flow or sediment transport?	CANA	river question, so not applicable
				CHAT	same note as above
				FOSU	Perhaps with sediment sources upstream of the Charleston Harbor. Might be more driven by dredging, though.
				CAHA	perhaps would be important at streams at Okracoke
				OCMU	yes, it is, and it's a problem.
				FOPU	potentially an issue as geomorphic changes in Savannah River. Probably no changes in Oyster Creek.
				KEMO	some erosion happening on both Ward and Noses Creeks.

Category	Question	Park	Notes
Environmental Setting Geologic Resources Geomorphology	Are sediment erosion and deposition rates changing over time in estuaries and lagoonal systems?	MOCR	because of potential threats to bridge over Moores Creek.
		FOSU	ties into accretion area near Fort Sumter.
		FOPU	potential for sediment inputs from Wilmington Island area upstream in Oyster Creek drainage.
		CASA	Of interest to the Guanatanalano Matanzas estuarine reserve (NER), but not directly an issue for park resources.
		CALO	driven by hurricanes
		TIMU	thinking specifically in Fort George area. Both erosion and sedimentation where channel is being choked off. Also sediment losses in areas adjacent to the dredge areas. Fairly massive geomorphic changes as a result.
	Are sediment erosion and deposition rates changing over time in freshwater and tidal stream channels and banks?	CANA	Active erosion in lagoon due to boat wakes. Also concerns about Intracoastal Waterway dredging
		CHAT	tied into both tri-state water issues and hydropower facility management upstream. Water releases are causing erosion of riverbanks within the park boundaries.
		OCMU	stream that goes between the mounds is filling up very quickly; had to move footbridge due to sedimentation. During high rain events, roads have been close to being washed over. Will likely lose road at some points.
	Is stream channel shape and size changing?	CHAT	tied into both tri-state water issues and hydropower facility management upstream. Water releases are causing erosion of riverbanks within the park boundaries.
		CANA	river question
		MOCR	because of potential threats to bridge over Moores Creek.
		CONG	important piece of the puzzle to guide both research and management.
		FOFR	erosion concerns
		FOPU	not counting the Savannah because it's not within jurisdiction.
		KEMO	City of Marietta has proposed water management plans that would have altered stream channel geomorphology.
		OCMU	this could be a four because of road placement issues.
	Is the stability of riverbanks changing?	CONG	tied to hydropower generation in addition to natural processes.
		CANA	river question, so not applicable
		MOCR	because of potential threats to bridge over Moores Creek.

Category	Question	Park	Notes
Environmental Geologic Resources Geomorphology Setting	Is the stability of riverbanks changing?	HOBE	likely far less erosion than historically present due to hydropower generation facility upstream.
		OCMU	hydrologic modifications might be causing changes. There was a relatively large change in stream flow in 1994 following TS Alberto. Now a braided system
		FOFR	buckling of wood revetment; hardened shoreline near fort built in the 1950s. No signs of current erosion at the Fort site, though.
		CUIS	soundside erosion and effects on cultural resources
		FOPU	north shore.
		CHAT	tied into both tri-state water issues and hydropower facility management upstream. Water releases are causing erosion of riverbanks within the park boundaries.
	What are the effects of geomorphic changes on riparian vegetation.	KEMO	Vegetated to the stream banks just about everywhere. We are losing vegetation in some areas.
		FOPU	not applicable to tidal creeks…
		FOFR	no riparian vegetation.
		CHAT	WRD has identified this is a need related tristate issues.
	What is the quality of bed sediments (chemical / biological) and is it changing over time? Includes soft muck in salt marshes, too.	CANA	Haven't found either metals or DDT in sediment samples during dredging operations.
		CHAT	could lead to other questions or changes in priorities if effectively answered.
		CONG	another important piece of the puzzle… Important for water quality questions.
		FOPU	two year study was done.
		KEMO	we don't know if this is an issue or not.
		OCMU	because of both urban and junkyard-related contaminants.
		TIMU	have had some sediment contaminant work done. Found metals both inside and outside the park (known issue). People are doing restoration work in areas of contamination where it might be contaminated. Perhaps elevate to 4 as a result?
		CUIS	related to salt marsh and the large salt marsh shrimpery
		FOSU	At CHPI because of non-point sources of contaminants.
		FOFR	bacteria?

Category			Question	Park	Notes
Environmental Setting	Geologic Resources	Soils	How do the physical, chemical, and biological properties of soils vary spatially and temporally across varied landforms, parent materials, vegetative types, and watersheds? (This is the soils inventory)	CHAT	have all but Fulton County soils maps.
			What are the concentrations of toxic substances present in soils?	CUIS	Have some potentially hazardous material sites from cattle dips
				FOSU	we do have some lead contaminated issues around the Coast Guard facilities (lead paint based). No abatement planned. Liberty square has an abated superfund site. Monitoring wells installed at Liberty Squre. Monitored as a part of the cleanup activitie
				FOPU	potential contaminants from former Navy dump sites???
				CONG	mercury
				CAHA	two superfund sites. Also impacts from tires / oil, from ORVs.
				CANA	Will help complete the geologic map.
			What are the effects of air quality on soil resources?	CONG	related to mercury deposition. Wetlands like CONG are mercury sinks.
				CUIS	don't know if this is an issue at this point
			What are the effects of human-induced disturbances and modifications on soils?	OCMU	could be an interesting question here because it's been going on for more than 1000 years.
				KEMO	haven't been farmed in fifty years.
				CHAT	but interested…
				CAHA	orv impacts
				FOPU	two types of soils on site: marsh & man-made (dredge)
			What are the status and trends of soil erosion?	CHAT	this is a trail-management related issue.
				CAHA	orv impacts
				FOPU	don't know of any issues.
				FOSU	We have soil erosion on the forts, but it's more of a cultural issue.
				HOBE	High priority because adjacent logging activities have potentially increased erosive power of overland sheet flow on park resources.
				CUIS	dunes

Category			Question	Park	Notes
Environmental Setting	Geology	Soils	What are the status and trends of soil erosion?	CAHA	Dr. Parry showed that ORV affects breaks down grains of sand and impacts the ability to support natural vegetation.
				HOBE	legacy of cotton and forest agriculture have impacted soil fertility, and thus might impact the ability of managers to restore the forest back to natural conditions.
		Structural Geology	What are the impacts of earthquakes on park resources?	FOSU	1886 Charleston had largest earthquake on record east of the Mississippi.
				CHAT	Chattahoochee is on Brevard fault. Not very active if at all…
				CAHA	check for concurrence with CALO.
			What is the risk of earthquake occurrence?	CAHA	check for concurrence with CALO.
	Weather and Climate	General	What are the effects of global warming on park resources?	CALO	related to sea level change
			What are the effects of sea level change on Park resources?	FOSU	it is changing and we're worried about the Fort. In management documents frequently.
			What is the rate of sea level change	CANA	affects dune and beach mouse habitat, stability of the island, etc.
			What are the frequency and distribution of lightning strikes?	FOFR	Pretty frequent; lose about one tree per year.
				CANA	already being done; weather people doing it at NASA. Need to know for determination of fire management strategies and prescriptions.
				CONG	could be important to help set proper burn frequency.
				FOSU	we have quite a few of them here…
				KEMO	we have some… last fatality here was a lightning strike on the trail. Look toward modeling lightning strike risk for visitors.
				OCMU	could be relevant to fire planning.
				CUIS	fire
				CHAT	could have some side benefits for tracking trends in arson frequency.
			What are the severity and frequency of droughts?	CONG	certainly of concern. Useful data set because multiple components of ecosystem are affected.
				OCMU	have been in a prolonged drought except for 2003.
				MOCR	because of fire management / risk.
				KEMO	fire. Park mgmt is suppression and mechanical removal (no prescribed burning). Other than that, no observed long-term impacts of drought.
				FOFR	will be doing controlled burns once fire management plan is in place.

Category			Question	Park	Notes
Environmental Setting	Weather and Climate	General	What are the severity and frequency of droughts?	CHAT	Drives fire management at the Park. Also affects river flow, sewage overflows, forest health…
				CANA	important for fire management
			What is the frequency of hurricanes, tropical storms, and other high-energy storm events, and is it changing over time?	KEMO	have had some hurricane damage from Opal. One tornado in the last 30 years.
				CHAT	probable interaction with trees and forest management.
				CONG	CONG is in hurricane alley, so it gets hit by both hurricanes and tropical storms;
				FOSU	we have a hurricane plan. Potential to do the most damage to the park.
				HOBE	hurricane damage happens as far inland as HOBE.
				CANA	affects dune and beach mouse habitat, stability of the island, etc.
			What is the precipitation rate, and is it changing over time?	FOFR	related to fire management
				KEMO	fire management / fire risk
				MOCR	because of fire management
				CUIS	Getting climate network station; Fire management.
				CAHA	fire program at FORA.
				CHAT	affects river flow, sewage overflows, forest health…
				CONG	fire program related.
			What is the temperature, and is it changing over time?	FOFR	related to fire management
				CONG	fire program related
				FOPU	no prescribed burning; only suppression.
				KEMO	fire management.
				MOCR	because of fire management
				CUIS	Getting climate network station; Fire management.
				CAHA	fire program
Park Resources	Species of Concern	Species Groups	Are the abundance of rare bird species and their habitats changing?	CHAT	management at the park is eliminating early-successional habitats on which several rare birds depend.
				CONG	park is a globally important bird area. And South Atlantic Coastal Plain Biosphere Reserve
				HOBE	no known rare bird species.

Category			Question	Park	Notes
Park Resources	Species of Concern	Species Groups	Are the abundance of rare bird species and their habitats changing?	KEMO	IBA designation
			How do the distribution and abundance of rare plant species change over time?	FOFR	revise if identified during inventories
				CUIS	habitats for many spp.
				CHAT	includes species like the pink lady-slipper that is of concern because of poaching.
				CALO	don't know what or if we have any.
			What are the status and trends of rare and listed bird species in the park?	FOFR	wood storks have been sighted. Only one or two species present (if at all)
				CHAT	don't know much about the bird community as a whole.
				FOPU	migratory. None nesting here.
				CAHA	got lots of them
				KEMO	IBA designation.
				CALO	piping plover monitoring important due to declining population
				OCMU	lots of migrants.
				MOCR	might need to be lower because none are present within the parks. RCWs, however are located within the County and habitat is being restored at the park.
			What are the status and trends of state and federally listed rare plants (not listed plants) and species of local concern?	FOFR	revise if some are identified during the inventory
				CHAT	several / many state-listed species for which monitoring would be beneficial.
				FOPU	none have been identified. Elevate if one or more is found.
				KEMO	not aware of any on site. Rescore to 3 if we find some.
				OCMU	don't know if any have been found yet. Are some plants. None present that we know of.
				CUIS	only one plant that is state listed
				CASA	no TER plants known on site.
		Species	What are the status and trends of alligator populations?	OCMU	evidence of them from SREL. Might increase if evidence of a larger population exists.

Category	Question	Park	Notes
Park Resources Species of Concern Species	What are the status and trends of alligator populations?	FOSU	at CHPI, we have one (Charlie).
		FOPU	reproducing on site.
		TIMU	have large ones with babies. Areas where located are not commonly visited, but they are located throughout the park.
	What are the status and trends of Bachman's Warbler populations and are they changing over time?	TIMU	Park does employee that does bird counts. Also Audubon does regular counts in the park.
		OCMU	don't know if it's here
		FOFR	don't think it should be there.
		KEMO	rescore if present.
		CASA	never heard of any mention of them.
		CHAT	not showing up on any species lists at this point.
		CONG	don't know if it's present.
	What are the status and trends of Carolina bog mint?	CONG	we know it's present on the park. Largest populations around!!
		MOCR	Research / Monitoring currently being conducted by TNC to assess fire tolerance, but not population health / status. The FMP EA states that MOCR contains the largest population in the world.
		OCMU	don't think it's here
	What are the status and trends of marine turtles?	FOSU	it could be in the harbor, but nothing resident.
		FOPU	don't nest on site.
		TIMU	State park does the monitoring because we don't have the nesting sites.
		CUIS	Part of the Index Network? (field data cards suggest "index" status)
		CALO	CALO is an index beach, and under agreement with USFWS has monitoring requirements as a result.
		CASA	we do have them nesting there.
	What are the status, trends and distribution of Atlantic / Southeastern Beach Mouse populations?	TIMU	we think we're outside the habitat / range.
		CUIS	not aware of any on site.

Category	Question	Park	Notes
Park Resources Species of Concern Species	What are the status, trends and distribution of Atlantic Salt marsh snake populations?	CANA	Entire range consists of two counties
		CASA	need to check with the reptile & amphibian inventory on whether this species is in range at FOMA/CASA. Might need to downgrade to 0.
		TIMU	FWS has it on the list, but our inventory says not.
	What are the status, trends and distribution of Bald Eagle populations?	CHAT	park is a major flyway corridor with potential nesting habitat. Eagles have been spotted for foraging infrequently.
		TIMU	nests present on the park.
		CASA	no nests on site, but present.
		CUIS	Some nesting on site. State monitors.
		OCMU	increase score if land expansion occurs.
		FOSU	it could be in the harbor, but nothing resident.
		CONG	don't know if we have any breeding pairs, though.
		CANA	nesting in the park (already monitored at CANA by FWS).
		CALO	no nests on site
	What are the status, trends and distribution of Diamondback Terrapin populations?	TIMU	not nesting on NPS land, but within the authorized boundary.
		FOSU	have been identified at the shoals at Fort Sumter, perhaps.
		CUIS	documented site.
		CANA	Population crashed at some point since 1979.
		FOPU	State species of concern.
	What are the status, trends and distribution of Eastern Indigo Snake populations?	KEMO	don't think we're in range for this one.
		TIMU	has been sighted. Commensal with the gopher tortoise.
	What are the status, trends and distribution of Florida Scrub Jay populations?	CASA	not sighted in years at CASA
		TIMU	Historically there, but the habitat is disappearing. Maybe score a 0. The scrub habitat present is marginal, and might improve with a fire program.

Category	Question	Park	Notes
Park Resources Species of Concern Species	What are the status, trends and distribution of Gopher tortoise populations?	HOBE	check with Whit's inventory to see if park is in range.
		KEMO	don't think we're in range for this one.
		CUIS	may be having a habitat loss problem; burrows vital to a number of other species.
	What are the status, trends and distribution of Least Tern populations?	TIMU	might be nesting in the mud flats
		FOSU	perhaps in range, but habitat not in park.
	What are the status, trends and distribution of Manatee populations?	CASA	in the river, but not within park boundaries.
		FOSU	it could be in the harbor, but nothing resident.
		CUIS	State monitors them
		FOFR	haven't been spotted yet, but at CUIS
	What are the status, trends and distribution of Painted Bunting populations?	CONG	need to check with species list.
		OCMU	strong active audubon group that could probably shed some light on that. If in NPSpecies, potentially a 3.
		FOPU	nest on site
		FOSU	Perhaps in range.
		CHAT	don’t know if it's here.
		HOBE	don't know if the species is present, but might migrate through.
		CASA	state species of special concern (FL)
		CALO	check on distribution
		CANA	State species of special concern
	What are the status, trends and distribution of Red Cockaded Woodpecker populations?	CUIS	don't know if they're here
		CASA	only have a handful of pines.
		CONG	no active colonies, but might at some point because habitat is available.
		CANA	Not known within the Park, but is within range in Brevard County. Might need to elevate to 3 if habitat is deemed to be present.

Category	Question	Park	Notes
Park Resources Species of Concern Species	What are the status, trends and distribution of Red Cockaded Woodpecker populations?	FOSU	in the area, but we don't have any nesting in the park that we're aware of.
		MOCR	need to be aware of these if they settle. Habitat is present / being restored.
		TIMU	no habitat at the Park.
		FOFR	pileated woodpeckers, too.
	What are the status, trends and distribution of Sand Heather (*Hudsonia tomentosa*)?	CAHA	not sure of common name; located at WRBR.
	What are the status, trends and distribution of Wood Stork populations?	CASA	no nests on site; no habitat management planned.
		OCMU	no nests on site.
		CONG	on new property (dozens sited)
		FOFR	used to nest down the road. Have been sighted since. Don't have a rookery on site (or habitat for one??)
		CUIS	State does that
	What are the status, trends, and distribution of Atlantic sturgeon?	CASA	Boundaries are the high tide line, so they shouldn't be an issue unless some nursery area is identified.
		CONG	has come up in proceedings with bridge reconstruction.
		FOPU	also potentially shortnose sturgeon.
		FOSU	it could be in the harbor, but nothing resident.
		MOCR	haven't seen any there. Think it's in range though. Might be too small of a system.
		OCMU	Historically present, but likely don't come up that far. No impoundments between the Park and the Atlantic, though.
	What are the status, trends, and distribution of Georgia aster populations?	CHAT	We think that the recovery plan says that if you have it you ought to be monitoring it. Candidate species. Extremely limited range
		HOBE	don't think in range.
		KEMO	It's at CHAT so it might be here.
	What are the status, trends, and distribution of Grass of Parnassus (spelling?) populations?	MOCR	people have been sighted collecting seeds without permits.

Category			Question	Park	Notes
Park Resources	Exotics Invasives Nuisance and Others	Plants	What are the effects of exotic plant species on cultural landscapes / resources?	CASA	could be a problem at Castillo
				CAHA	at FORA, Elizabethan Gardens is expanding into parks.
				CHAT	cultural landscape is exotic plants. No defined cultural landscape that is currently being managed for.
				FOPU	have changed cultural landscapes (tallow). Getting close to 4.
				FOSU	Wisteria at CHPI has been a problem, but a good portion has been removed.
				HOBE	privet etc., will have affect on the cultural landscape and could impact the ability of the park to meet its cultural mission.
				KEMO	we have kudzu, mimosa, privet, that mustard… not in cultural areas yet.
				MOCR	privet, Japanese honeysuckle…
				OCMU	problem on mounds with both plants and animals. Privet and tree of heaven both problems. Kudzu…
			What are the trends and impacts of exotic aquatic plants on native communities?	CHAT	we know that they're there - in the mainstem, isolated ponds, AND bull sluice lake.
				OCMU	don't know if there are any.
				CALO	don't know if this is a problem
				HOBE	milfoil is not in the area yet, but could become a huge issue if it found its way into the beaver pond.
				CUIS	do have alligator weed in freshwaters.
				CONG	Alligatorweed, water primrose, and Asian spiderwort on site.
			What are the trends in the distribution and abundance of exotic plants?	KEMO	we've got some areas that if we don't watch and nip it, we'll have a huge problem.
				FOFR	both privet and Chinese tallow are present.
				CHAT	Park has MANY exotic plants that need to be eradicated.
				CALO	*Phragmites* on site.
		Vertebrates	Are the distribution and abundance of feral cats changing over time?	FOSU	some at CHPI.
				CAHA	affect piping plovers.
				CANA	could be a problem with southeastern beach mouse
				CASA	could be a problem with the Anastasia beach mouse.

Category			Question	Park	Notes
Park Resources	Exotics Invasives Nuisance and Others	Vertebrates	Are the distribution and abundance of feral cats changing over time?	CHAT	we know they're at CHAT, but we don't know what, if any, affect they're having on resources.
				FOPU	not a big problem with them right now; not a reproducing population.
				OCMU	feral cats present, but no identified issues.
				CUIS	none present that we're aware of at this point
				FOFR	have some
			Are the distribution and abundance of feral dogs changing over time?	HOBE	external hunting dogs, primarily
				KEMO	some loose neighborhood dogs, but that's all.
				CONG	do have free-ranging feral dogs in the park.
				MOCR	dogs "dumped" on site
			Are the distribution and abundance of feral hogs changing over time?	FOFR	historically had some. No current evidence of presence.
				KEMO	none spotted. Never been an issue here.
				CANA	Having a big impact
			Are the distribution and abundance of nonnative mammal populations changing (not just hogs)?	CANA	Basically hogs and cats; coyote should arrive soon.
				CAHA	including nutria
				KEMO	one list says we have feral cats, but none have been recently seen. Coyotes have probably taken care of that.
				FOSU	nothing other than cats present or noted to date.
				FOPU	also have black rats.
				FOFR	hogs and cats. Prior hog damage recorded, but none currently.
				CHAT	don't know what others might be there / be a problem.
				CASA	none present other than hogs and cats (addressed in other questions)
			How are native species' limits of geographical or ecological range changing (i.e., armadillo, red foxes, beaver...)?	MOCR	coyotes recently spotted across SR421
				KEMO	yes on the coyotes.
				FOPU	potentially coyote, too. Cattle egrets as well.
				CAHA	piping plover predation effects.
				CONG	beaver is important.

Category			Question	Park	Notes
Park Resources	Exotics Invasives Nuisance and Others	Vertebrates	How are native species' limits of geographical or ecological range changing (i.e., armadillo, red foxes, beaver...)?	OCMU	more coyotes present on the park.
				FOSU	only because of red fox.
			How are population trends, habitat, and movement patterns of deer changing over time?	FOPU	Park is currently monitoring.
				FOFR	if anything, going away on the island. Could increase as the island is developed. Hunting is happening nearby.
				FOSU	there are over at CHPI and at Fort Moultrie, but not an issue at this point.
				HOBE	probably have an overabundance of deer.
				KEMO	it is increasing. Haven't noticed any damage related to over browsing yet, though.
				OCMU	pretty sizable population and there might need to be some mgmt action in the future. Hunting along boundary.
				CUIS	maybe a 4
				CHAT	some areas have high densities of deer; park not doing any active management though. After research, this might need to be reassessed.
			How are population trends, habitat, and movement patterns of horses changing over time?	CALO	required by enabling legislation
				HOBE	armadillos are everywhere. Not sure the extent to which rooting is effecting, but they're everywhere.
				CALO	Nutria do some digging.
			What are the effects of exotic (and other) animals on cultural landscapes / resources?	KEMO	no species present that are doing this damage.
				FOSU	pigeons nest in Case Mates at FOSU.
				FOPU	Exotic bird and rat issues. If Armadillo get estabilished, perhaps elevate to 4.
				FOFR	not much rooting going on.
				CONG	hogs.
				CUIS	hog rooting; horses (trampling, rubbing against structures)
				OCMU	Hogs
				CANA	rooting of archeological sites

Category			Question	Park	Notes
Park Resources	Exotics Invasives Nuisance and Others	Vertebrates	What are the status, and trends in populations of raccoons?	CALO	piping plover predation
				CAHA	piping plover predation effects
				CANA	sea turtle and diamondback terrapin predation.
				CASA	don't seem to have any impacts other than getting into garbage. No known impacts on turtles.
				FOFR	they rule the area
				FOPU	have an issue with raccoons; also monitored during the deer counts. Have had rabies documented. Probably controls population, though.
				TIMU	they're always around because it's an urban park.
				CUIS	current management would not change.
				HOBE	got them, but not a big deal for us.
				KEMO	they're here, but not causing any problems.
				MOCR	higher because of human interactions in public areas.
				OCMU	as far as we know we don't have very many. Never seen one in the daylight, and rarely at night.
			What are the trends and impacts of exotic fishes on native fish communities?	CHAT	recurrent issue, and some particularly nasty species (i.e., rice eels).
				OCMU	unknown
				FOPU	don't know of any exotic fish here.
				KEMO	don't know if we have any or what their impacts are. Cyprinella lutrensis (red shiner) is probably present, though.
			What are the trends in non-native bird populations over time?	CONG	Emus!
				KEMO	brown-headed cowbirds, European starling both recorded. Rare and or incidental, though.
				FOSU	within the park we don't have an issue.
				CHAT	don't know if starlings are a problem here.
				FOPU	becoming an issue. Lots of rock doves and starlings. Use cultural resources (cannons) as nest sites. Pigeons in the fort, too.
				CUIS	not an issue at this point

Category			Question	Park	Notes
Park Resources	Exotics Invasives Nuisance and Others	Vertebrates	What is the magnitude and extent of hog-induced habitat degradation?	CUIS	wouldn't change management
				HOBE	as far as known, not present at HOBE
				OCMU	play bloody hell with CR.
				CHAT	no hogs on site.
				CANA	again, hog impacts are a big problem; especially on wetlands and dependent amphibians. Some of these areas and associated species are rare in the park
		Invertebrates	Are population trends or outbreaks of destructive insects changing over time (forest pests)?	CALO	huge tick population at Shallowford Banks. WNV and Limes Disease are both of growing concern.
				FOPU	shipping channel is a source of invasives.
				HOBE	southern pine beetle.
				FOSU	park does monitor for gypsy moths.
				CANA	newly discovered moth that eats prickly pears might be a growing problem in the future. Also the bromeliad weevil
				KEMO	pine bark beetle is a problem. Getting hammered. Perhaps a 3?
				FOFR	have had outbreaks in the past
				CHAT	southern pine beetle. Because CHAT is such an isolated area, the impacts could be changing over time regardless of changes in frequency. Might need to reassess the ranking depending on when / if sudden oak death syndrome shows up.
			Are populations of nuisance / pest insect species changing over time (i.e., mosquitoes, ticks, fire ants)?	MOCR	of interest, but not relevant to NR.
				CANA	monitoring being done by East Volusia County mosquito control
				CHAT	southern pine beetle, potentially mosquitoes and WNV in the future. Gypsy moth has been monitored by USFS in the past.
				CONG	fire ants, ips, southern pine…
				FOFR	visitor effects
				FOPU	Mosquito control ponds on site. Also fire ants.
				FOSU	mosquitoes and fire ants are a big problem here. Have worked with the County for pest control.
				KEMO	got em all.
				OCMU	visitor, employee, and destruction to CR.

Category			Question	Park	Notes
Park Resources	Exotics Invasives Nuisance and Others	Invertebrates	Are populations of nuisance / pest insect species changing over time (i.e., mosquitoes, ticks, fire ants)?	TIMU	county monitors on site at FOCA for mosquitoes.
				CUIS	fire ants, definitely
				CAHA	West Nile Virus and lime disease
				HOBE	huge tick problem. Might get better with prescribed burning.
			What are the status & trends (presence / absence) of Australian Jellyfish	CANA	not yet present at CANA
			What are the status and trends of exotic mussels?	HOBE	I assume that corbicula is there, but at what cost to native resources.
				CUIS	green mussel has been found at the jetty
				CASA	green mussel is present
				FOFR	rescore to 0 if green mussels or Corbicula are not possible in system.
				FOSU	Green mussel? If not rescore to 0.
				MOCR	no documented Corbicula, but possible.
				CHAT	Corbicula corbicula within the river.
				FOPU	Green mussel is out there…
	Communities	Fish	Are species composition and distribution of fish changing?	FOFR	reassess after the fish inventory
				FOPU	don't know currently. Perhaps a good indicator for marsh health.
				CANA	outstanding fishery in Mosquito Lagoon
			What are the status and trends in fish health?	HOBE	no reported fish kills that we're aware of. If there's a significant change, we would be getting information from the State.2
				FOFR	reassess after the fish inventory
				CONG	could be of issue because of mercury.
				CANA	we need to protect outstanding fishery in Mosquito Lagoon
			What are the status and trends in native resident fish populations (as opposed to migratory or non-native fishes)?	MOCR	reassess all fish questions after inventory is complete.
				FOFR	reassess after the fish inventory
				CANA	we need to protect outstanding fishery in Mosquito Lagoon

Category			Question	Park	Notes
Park Resources	Communities	Fish	What is the trend in seasonal habitat use by anadromous fish species?	KEMO	extirpated.
				HOBE	no anadromous fishes make it up this far in the river system.
				MOCR	eels present.
				FOFR	reassess after the fish inventory
				OCMU	no dams between OCMU and the Atlantic.
				FOPU	most would be in the Savannah River
		Invertebrates	Are the species composition and distribution of freshwater invertebrates changing?	CASA	ditches with freshwater are the only freshwater resources on site. Don't know what resources, if any, are present. Might need to be downgraded to 0 with more information.
				CHAT	we know the invertebrate data will be and currently are useful for policy-related decisions.
				FOSU	at CHPI maybe, unless it's not really freshwater.
			Are the species composition and distribution of marine invertebrates changing?	FOPU	blue crabs and shrimp an issue.
				CANA	oysters, clams, crabs. Very important to commercial and recreational harvesters
			Is intertidal community composition changing over time (i.e., inverts, macroalgae, intertidal fish, hardshell clams…)?	CUIS	maybe a 4 because of marsh health concerns
				FOSU	New accretion area falls in this category. Don't know ecological importance yet for shorebirds.
				FOPU	includes all those in the marsh. Have had a clam seeding project.
			Is the assemblage of pollinators changing?	CHAT	no inventory done yet.
				HOBE	many of the local bee harvesters were affected by a bee fungus that might or might not have affected native species. could be bumped up if we find out thagt the bee fungus is affecting pollinator communities.
			Is the species composition and distribution of terrestrial invertebrates changing?	CAHA	ghost crab populations, if they grow too high, could be a problem.
			Is there a shift in invertebrate species richness and abundance in intertidal and subtidal (nearshore) habitats?	FOFR	Bloody Marsh

Category			Question	Park	Notes
Park Resources	Communities	Invertebrates	What are the present and historical assemblages of plankton in park lakes and estuaries, and are they changing over time?	CHAT	might be a 0
		Plants	Are plant communities displaying symptoms of ozone injury?	CUIS	check with ARD report
				HOBE	might need to be higher based on Tonnie's report.
				FOFR	not at high risk.
				CONG	would bump up to a four if there is evidence or reason to believe ozone injury is occurring due to mission of park.
				CHAT	don't know yet if this is an issue.
			Are the distribution, structure and composition of inland/upland forests changing over time?	FOSU	don't know if we can classify areas at CHPI as forest.
				HOBE	would be managing for both species composition and forest structure under FMP.
				CHAT	of issue because of forest pest oubreaks and fire management
				KEMO	we are losing pines because of pine beetle; community changes will likely occur as a result.
				CONG	feral hogs might be having an effect on this by reducing oak regeneration.
				CASA	most of forested areas are maritime. Might need to be up- or down-graded after a vegetation map is complete for the park.
				OCMU	loblolly pine is giving way to hardwoods and exotics.
			Are the diversity and extent of coastal dune communities changing over time?	CANA	has impacts for T&E species
				FOSU	we don't own that
				CUIS	stabilize dunes
			Are the diversity and extent of maritime forest communities changing over time?	FOSU	we don't own the maritime forest community, but it's a part of the viewshed behind Battery Logan. Perhaps elevate score because viewshed is a cultural resource mentioned in GMP or CMP.
				CUIS	in enabling legislation
				FOPU	yes. It is evolving now, but historically wasn't there.
				FOFR	would be of interest; wouldn't change management
				CALO	on Shackleford Banks, a horse-related issue. Forest distribution potentially being driven by grazing patterns.

Category			Question	Park	Notes
Park Resources	Communities	Plants	Are the diversity and extent of shell midden plant communities changing over time?	CUIS	Many shell middens on site.
				FOFR	no known shell middens on site
				HOBE	no shell middens on site.
				CANA	Unique plant community (combination of temperate and subtropical species) on Turtle mound and several other middens. Of historical importance as well.
			How is the pattern of mortality, disease, and insect pests (native and non-native) in forest communities changing over time?	KEMO	we know we have a huge problem with this and are losing forest trees.
				HOBE	same as above.
				FOPU	don't think impacts are that great at this point. Other question included public health concerns.
				FOFR	currently monitoring for gypsy moths.
				CHAT	forest is highly stressed; degree of vulnerability to stressors would be helpful to mgmt.
			Is the health of heritage / champion trees changing in the park?	FOSU	we do have some very old trees, though at CHPI.
				CUIS	have a state record live oak
				KEMO	had one; it fell down.
				HOBE	some very large trees on site, but none formally designated as heritage trees.
			Is there a shift in sea grass abundance and distribution in intertidal and subtidal (nearshore) habitats?	FOSU	don't know if we have any seagrass in the submerged area. If not, need to change to 0. Probably elevate score if we do have it.
				CANA	A lot of time and effort is spent by several agencies monitoring seagrass in Mosquito Lagoon. It is the basis of the lagoon ecosystem.
			Is there a shift in the distribution or relative abundance of salt marsh grass species (Juncus and Spartina spp.)?	FOFR	rescore to 3?; re: regional salt marsh die-off concerns
				FOSU	Salt marsh grasses over at CHPI.
				CUIS	salt marsh die-off an issue / concern

Category			Question	Park	Notes
Park Resources	Communities	Plants	To what extent is rooting pressure (from feral hogs) affecting plant communities?	CUIS	getting rid of hogs no matter what
				OCMU	focus Is primarily on CR, but if there's plant impacts,
				FOFR	non at site now.
				CANA	having a dramatic effect on swales.
				CAHA	doing damage along the runway
			What are the effects of (over) browsing pressure on plant communities?	OCMU	not yet seen, but deer populations are growing. Could be an issue down the line that we need to keep on the radar screen.
				CUIS	horses and deer, particularly on salt marsh.
				KEMO	don't know of any right now. If deer populations grow, might need to elevate score.
				HOBE	probably don't have an issue at this point, but could get worse if deer populations continue to grow.
				FOPU	we have noted that there could be a problem.
				FOSU	don't have a browsing problem.
				FOFR	none right now.
				CASA	some browsing pressure from deer is present.
				CALO	all plant communities on Shackleford
			What are the status and trends of fire-adapted communities as a result of fire suppression, reintroduction, or other alterations of natural fire regimes?	CHAT	we know they're in decline. Many TER species are typical of fire-adapted ecosystems (Georgia aster, pink lady-slipper).
				FOPU	not a fire adapted community here.
				HOBE	goal of fire management plan is to bring back the longleaf pine community.
				KEMO	we don't know the answer to this yet. Don't know if we have fire adapted communities on site.
				OCMU	fire not to be reintroduced except to burn off the mound.
				CASA	this might change priority after the FMP is complete.

Category			Question	Park	Notes
Park Resources	Communities	Plants	What is the composition, structure, distribution, and abundance of vegetation communities on a large scale, and how do these characteristics change over time?	MOCR	not very large scale.
				CANA	How might a vegetation map change over time?
				CHAT	CHAT is a series of patches, some of which represent relict populations. How those change over time might provide critical data to future management decisions.
				HOBE	needs to be addressed to determine whether the park is meeting objectives outlined in the fire management plan and the mission goals.
		Mammals	What is the status of bat diversity, abundance and distribution, and are they changing over time?	CHAT	might change priority once more info is obtained from bat inventory. We know there has been a change over time.
				FOFR	reassess after mammal inventory if necessary
			What is the status of small mammal diversity, abundance and distribution, and are they changing over time?	FOFR	reassess after mammal inventory if necessary
				CHAT	small mammal communities tied to wetlands restoration and exotic plant management activities.
				CASA	beach mouse bumps this one up.
				CALO	does not include raccoons (too big)
		Reptiles and Amphibians	Are selected amphibians or reptiles reproducing successfully?	CHAT	likely some species are not successful due to the lack of finding during inventories. Not sure if this is a reproductive issue or a habitat issue…
			Are the abundance and distribution of aquatic breeding amphibians changing?	CHAT	currently unknown
				HOBE	could be heavily impacted by water quality degradation and loss of suitable riparian habitat. Might need to be adjusted to a 2.
			What are the status of reptile and amphibian diversity, abundance and distribution, and are they changing over time?	CALO	would be interesting to know. Don't know if communities are affected by the dynamic landscape at CALO. Might need to be rescored as a high 2.
				CHAT	Reptile and amphibian communities tied to wetlands restoration and exotic plant management activities.
				CUIS	Turtles

Category			Question	Park	Notes
Park Resources	Communities	Reptiles and Amphibians	What is the incidence rate of Gopher Tortise upper respiratory disease?	CASA	important for the management of gopher tortoises on site.
				HOBE	don't even know if gopher tortoises are present.
				TIMU	don't think it's moved this far north. If detected in the County then elevate.
		Birds	Are changes in habitat quality and availability affecting breeding land birds / shore birds?	MOCR	some nesting species are present that visitors come explicitly to see (i.e., prothonotory warbler).
				HOBE	driven by FMP
				FOSU	Fort Sumter accretion area could be important bird habitat.
				FOPU	Not a lot of dynamics here in the park.
			Are populations of nesting diurnal raptors changing?	CHAT	increasing. State is monitoring falcons.
				CUIS	includes osprey
				FOSU	don't know if we have any.
			Are there changes in species composition of landbird communities?	HOBE	driven by FMP
				FOPU	we know there is, primarily in the realm of exotics.
			What are the status and trends of migratory birds (neotropical and shorebirds)?	CONG	globally important bird area. Already monitored by SC DNR.
				CANA	not much habitat. Wilsons plovers are nesting at Merritt Island NWR, though so they might be present at CANA.
				FOPU	with migratory birds, they're only here for a short period of time. Not much management to do.
				CAHA	plovers
			What are the status of breeding bird diversity, abundance and distribution, and are they changing over time?	CAHA	plovers, oystercatchers
				CHAT	implies certain types of habitat (and quality)
				CONG	globally important bird area.
				FOPU	painted buntings fall in this category.

Category			Question	Park	Notes
Park Resources	Communities	Birds	What are the status of breeding bird diversity, abundance and distribution, and are they changing over time?	FOSU	don't know what, if anything is nesting at the park. As nearby areas develop, park might become a refuge and score might need to be elevated.
			What are the trends of common bird populations over time?	FOFR	not much active birdwatching at FOFR
				KEMO	tied to visitor uses.
			What is the status of wading / shorebird diversity, abundance and distribution, and are they changing over time?	FOSU	maybe if shoal at Fort Sumter sees increased usage.
				CHAT	in decline and CHAT has some of the last remaining habitat in the area for these species.
				HOBE	none nesting, but we get them during the migration season. Probably herons and storks present too.
				FOFR	wood storks?
				CONG	will be gaining wading bird habitat with new lands.
				CAHA	plovers…
				MOCR	great blue herons.
				CASA	least terns and plovers are being monitored by the state with assistance from NPS staff. Screening off of nesting habitats is also done when found.
		Non-Vascular Plans & Fungi	How are lichen and moss populations changing over time?	CALO	have some nice lichen communities.
	Habitats & Systems	Beaches & Dunes	What are the status and trends of the amount of large woody debris on beaches?	CALO	have some, but not much
				CASA	would be mildly useful.
				CUIS	habitat for shorebird nesting and foraging
				CAHA	Critical for shorebirds and dune habitats.
				CALO	don't really have big wrack lines down here. Only minimally have wrack, so maybe a 0.
			What is the grainsize distribution, content, color, and mineral composition of sand on beaches, and is it changing over space and time?	CAHA	Beach renourishment is likely to be happening in large amounts upstream, particularly in communities. Need background data before that happens.

Category			Question	Park	Notes
Park Resources	Habitats & Systems	Beaches & Dunes	What is the grainsize distribution, content, color, and mineral composition of sand on beaches, and is it changing over space and time?	CALO	nothing abnormal going on currently, but possibly an issue with lighthouse area renourishment on the sound side.
				CANA	not an issue as long as no beach renourishment projects are happening.
				CASA	there is some up shore beach renourishment going on that can impact the beach. The source sand seems to be pretty similar, though. Perhaps a 3?
		Wetlands	How is the distribution of wetlands changing over time? (patchiness)	FOPU	are we losing wetlands due to filling in?
				CONG	all wetlands; talking about changes in types of wetlands which could impact other components of ecosystem.
			Is the frequency, duration, and spatial extent of seasonally intermittent pools changing over time?	CAHA	almost a 3.5
				HOBE	they do happen depending on the river level; might be important for herp reproduction.
				CHAT	some seasonally flooded impoundments within historic agricultural landscapes. Might provide habitat for wading birds and herps.
				CANA	primarily located in the swales between dune ridges. Provide habitat for many amphibian species not found elsewhere at CANA.
			What are the structure, diversity, and extent of wetlands and riparian zones, and are they changing over time?	CAHA	wetlands at Cape Point have been ditched, flood gated… No longer a natural habitat. Presenting the 3rd highest priority for mgmt.
				FOFR	includes salt marsh, Bloody marsh too.
				MOCR	in the process of doing wetland restoration
				KEMO	one intermittent wetland on the western boundary of the park. One more on the south end of the park
				HOBE	can be largely driven by beaver population.
				FOPU	could be an issue with saltmarsh die-off.
				CHAT	related to tristate issues.
				CASA	no freshwater wetlands on site.
				CALO	salt marsh loss over time
				CANA	Are efforts at saltmarsh restoration succeeding?

Category			Question	Park	Notes
Park Resources	Habitats & Systems	Rivers, Streams & Lakes	Are there changes in parameters describing physical habitat-related characteristics of lakes and streams? Includes tidal streams.	CHAT	again, tied to FERC and water allocation issues. Sedimentation effects are a major driver.
			To what extent is sedimentation affecting the status and trends of stream habitats?	HOBE	depends on the amount of logging in the area.
				CUIS	horse driven effects in tidal creeks.
				KEMO	3 due to the amount of development upstream that's contributing sediment.
				CHAT	this is the major issue facing the park.
				FOPU	potential upstream development related inputs.
			What are the density and distribution of woody debris in streams, and how are they changing over time?	FOSU	probably a low priority.
				MOCR	storms that cause lots of CWD cause stoppage of flows.
			What are the status and trends of shoreline habitat characteristics in the littoral zone and the terrestrial shoreline in lakes and ponds?	CHAT	habitats highly degraded by discharge operation upstream. Tied to tri-state issues.
				CONG	visitor impacts could be of concern.
			What is the biological integrity of streams (inverts, fishes, and algae...)?	FOPU	stream here is oyster creek, which isn't freshwater.
				CHAT	tied to both the enabling legislation and GMP.
				CONG	water resource management plan calls for maintaining biological integrity of WR.
		Estuaries	Are physical and chemical features of the intertidal environment changing?	FOPU	at least 3.
				FOSU	2 right now. Could go up.
			Are the distribution and use of fish spawning & nursery habitats changing over time?	CAHA	it's all nursery habitat, but nobody knows what for.
				CALO	SAV. Same reasons as for sea grass question.
				CANA	drives closing actions / protection strategies. Important for outstanding fishery.
				FOPU	don't think this is an issue right now.

Category			Question	Park	Notes
Park Resources	Habitats & Systems	Estuaries	Are the distribution and use of fish spawning & nursery habitats changing over time?	FOSU	don't know if we have either spawning or nursery habitats (probably not, though).
				CUIS	don't own those areas.
		Terrestrial System	Are coastal dune habitats suitable to support dependent animal communities?	CUIS	also stability of the dunes
				CAHA	this is in the enabling legislation for areas without recreation values. "wilderness"
				TIMU	all dune questions will change priorities when TIMU acquires American Beach.
				CALO	no T&E species of concern.
			Is forest structure changing over time?	FOPU	no historic forest.
				FOSU	not a heck of a lot of forest.
				HOBE	needs to be known for FMP. Vertical structure necessary for burn planning.
				KEMO	impact of beetles
				OCMU	related to the wetland issues and effects on historically dry-land species.
				CALO	related to horse grazing
				FOFR	rescore if necessary for the FMP
		Marine Systems	Is distribution, relative abundance, or species composition changing in subtidal habitats?	FOSU	we have the submerged area.
				CASA	do have a good least tern nesting area. Good habitat for them.
				CUIS	critical nursery / foraging habitat.
			Is the distribution, relative abundance, or species composition changing in intertidal habitats?	CAHA	Off-road vehicle use and bird foraging
				CANA	Concerned about the oyster reefs. Boat wakes, disease, predators, and competition from barnacles all issues.
				CALO	foraging area for shorebirds; affected by ORV use.
		General	Are land use or land cover types within Park boundaries changing over time?	HOBE	FMP and GMP driven.
				KEMO	important because of changes to earthworks. If we have changes in forest type, accompanied by uprooting, etc. can do some potential damage. Currently no changes, though.

Category			Question	Park	Notes
Park Resources	Habitats & Systems	General	Are land use or land cover types within Park boundaries changing over time?	CAHA	maybe 3.5
				OCMU	land cover changes have been significant since 1994; changes in future might also be helpful to monitor.
Agents of Change	Park Resource Management	Maintenance / Trail Management	Are “down and dead” clearing activities affecting populations of animals that depend on forest litter for habitat, and are they best designed to mimic natural population and distribution dynamics?	MOCR	not doing this. Burning them.
				FOFR	some done for fire prep.
				FOSU	actions primarily limited to removal of trees in cultural / maintained landscapes.
			Are park management actions affecting sensitive plant communities (trail clearing, vegetation trimming, boardwalk construction)?	FOSU	don't really have sensitive plants at CHPI (probably), and we only do minimal trail clearing.
				CALO	building a boardwalk
				FOFR	not doing much of this
				KEMO	not that we know of.
				CHAT	in some cases positively affecting them.
			Does mechanical removal of hazard trees negatively impact natural ecosystem processes?	CHAT	recent EA said no; if that changes, we need to reassess.
				FOPU	not doing that
				OCMU	large amounts of wood is removed as part of the FMP; as it's the primary method of fuel reduction.
				FOSU	maybe a 3, but we're not doing a lot of this.
		Exotic Plant Management	To what extent are management activities effective in eliminating or slowing the invasion of exotic species?	CALO	park currently sprays for Phragmites, but other than that exotic plants are not a big issue for the park.
				OCMU	given impact to CR and amount of effort spent on this particular issue.
				FOSU	don't have a lot of exotics in the park, though. Low 3 at best.

Category			Question	Park	Notes
Agents of Change	Park Resource Management	Exotic Plant Management	What are the effects of exotic plant species on Park resources?	CHAT	We know that exotic plants are affecting native plant populations (competition / displacement).
				CANA	not limited to cultural resources
				FOSU	Wisteria was growing on the cultural landscape.
				HOBE	Some populations taking over areas at the expense of native species.
				KEMO	right now not significant, but if unchecked, it could be.
		Cultural Resource Management	To what extent are plants affecting Cultural resources?	TIMU	plants growing on structures all over the place. Some ruins are overrun with plants.
				MOCR	used as erosion control on battle lines. Mold, mildew, fungus… also of concern.
				HOBE	Privet expanding into cultural areas / landscape.
				FOSU	biggest issue is grass growing between the bricks. When removed it does damage to the historic structure.
				CANA	There is some plant damage to our archeological sites (roots growing into the mounds, etc.)but it is not a major problem and can be easily monitored. They actually provide more benefit by curbing erosion.
				CHAT	some NHR sites that have plants-on-structure issues. Info could help guide management decisions / planning.
				FOPU	ferns growing in mortar and brick. Removed. Don't know of the effects of removal practices on mortar and brick.
		Fire Management	Does mechanical fuel reduction appropriately mimic natural ecosystem processes?	KEMO	where this is done, it's the only management option.
				CHAT	very important issue because mechanical fuel reduction is happening for safety reasons.
				CASA	no mechanical fuel reduction program
			To what extent are tree densities, understory composition, and fuel loads changing over time in areas of (historically) natural fire? i.e., what is the level of fuel loading…	HOBE	FMP driven.
				CALO	no fire mgmt program
				FOSU	not called for in the FMP. Might need to be elevated to a 2 if it is an area of natural fire.
				KEMO	FMP. Park hasn't had natural fire in roughly 30 years. There have been some human activity related fires. Also some set by cigarettes and railroads. Fuel loads are increasing with pine beetle damage.

Category			Question	Park	Notes
Agents of Change	Park Resource Management	Fire Management	To what extent are tree densities, understory composition, and fuel loads changing over time in areas of (historically) natural fire? i.e., what is the level of fuel loading…	OCMU	might go lower after current round of reduction is compete and fuels are removed.
			To what extent does prescribed burning (or lack thereof) affect status and trends of fire-dependent, sensitive, and non-native plant populations?	CASA	no prescribed burning program
				CHAT	will get worse with time due to history of fire suppression. Might become a 4 with more information.
		Restoration	Are actions to remove water control / blockage structures having the desired effect on wetland hydroperiod and hydropattern? (or other wetlands restoration efforts)	CAHA	could be an issue with Cape Point, and wit potential mitigation work around Oregon Inlet.
				CHAT	tied to Johnson Ferry wetlands \restoration project.
				CONG	historic hunt-club ditches that are affecting flows that someday might be restored.
				MOCR	wetland restoration taking place in the Savannah.
				CUIS	will be doing this in the future in the historic rice fields and causeways.
				CANA	need to know to evaluate wetland restoration efforts
			What are the status and trends in distribution of native and restored longleaf / flatwoods pine forests?	KEMO	have planted some pine trees on the eastern boundary near Bernhickey Road. Have done some plantings on the south portion of Little Kennesaw Mountain for erosion control purposes.
				MOCR	planting longleaf
	External Stressors (Anthropogenic)	Land Use & Development	How do roads throughout and surrounding the Park affect water flow, run-off, flooding, surface waters, and plant and animal communities within the Park?	CHAT	very high priority because it will have direct affects on water resources. Will likely cause other priorities to change.
				CUIS	flow restrictions on causeways
				KEMO	roads probably don't impact water resources within the park.
				FOSU	no new roads planned for the area.
				FOPU	turtles and widening of HWY 80.
				OCMU	16 has messed up a lot. Railroad too.

Category			Question	Park	Notes
Agents of Change	External Stressors (Anthropogenic)	Land Use & Development	Is local air quality near road corridors, campgrounds or areas of high visitor use changing?	CALO	vehicles on beach
				CHAT	local air quality not as big of an issue as regional air quality.
				FOFR	no campgrounds
				KEMO	metro area AQ is likely much bigger impact.
			To what extent is adjacent land use affecting sensitive species within the park?	FOFR	probably not at all.
				FOSU	we don't know if we have any sensitive species.
				CHAT	almost all of park is directly affected by adjacent land use.
				CALO	Park sits on science advisory panel for the Albemarle Pamlico Sound. No big effects expected, though.
				HOBE	could easily be talked up to a three if there were an identified sensitive species that might or might not be affected by adjacent land use.
			To what extent is air chemistry affecting water resources, and how is that changing over time?	KEMO	we don't know the answer right now.
			What are the effects of human-induced disturbances on freshwater resources?	CALO	Park sits on science advisory panel for the Albemarle Pamlico Sound.
				MOCR	hog lagoon overflows
				HOBE	property to the north has a water withdrawal structure on a freshwater spring (culvert type of thing). Cistern type of thing.
				CHAT	nice vague question… lots of impacts, though.
			What are the status and trends in contaminant emissions (air quality)?	CONG	local paper mills.
				FOPU	paper mills, shipping.
				CHAT	only ozone is known to be a problem.
				HOBE	Aniston Army Depot (fort McClellan) has an incineration facility that started up in March 2004 that is disposing of weapons-grade materials (i.e., nerve & biological agents). Located 45 miles away from the park.
				FOSU	from things like paper mills and shipping.

Category			Question	Park	Notes
Agents of Change	External Stressors (Anthropogenic)	Land Use & Development	What are the status and trends in upslope conditions that affect hydrology and delivery of sediments, large woody debris, and contaminants to streams and estuaries?	FOSU	Combination of concerns with golf course and potential impacts if Boone Hall is developed.
				OCMU	post-rain peaking due to higher levels of impervious surface. Lots of urban development. Walnut creek on 303d list.
				CHAT	3+
				CUIS	could be a 0
			What are the status and trends of culverts and other flow restrictions within and surrounding the park?	CASA	none impacting park resources.
				OCMU	lots of trash entering as a result (from entire northern urban area). Trash removal / remediation.
				CUIS	causeways
				CONG	development pressure is coming; could be bumped up in the future.
				FOPU	widening of HWY 80
				FOSU	not likely to change at this point.
				KEMO	pressure to widen and increase roads to support growing traffic needs.
				OCMU	Fall line freeway is big issue facing the park.
				CANA	will help with evaluating wetland / impoundment reconnection efforts
			What is the degree of habitat fragmentation within the landscape (of which the park is a part)? And how is it changing over time?	FOSU	If Boone Hall next to CHPI (roughly 800 acres), this could affect resources at CHPI.
				FOFR	possibly affecting deer and wood storks.
			What is the direction and rate of change of land use within the watershed?	FOSU	Boone Hall.
				MOCR	hog farm upstream has had a spill.
				CUIS	"watershed" not necessarily important for this system.

Category			Question	Park	Notes
Agents of Change	External Stressors (Anthropogenic)	Land Use & Development	What is the pattern of land use types within the landscape that might have an impact on Park resources?	CUIS	marinas
				MOCR	because of sound and visual aspects.
				HOBE	external land use is changing, and could have large effects on water quality over time if/when changes occur (i.e., increases in high density chicken farming can affect water quality.)
				FOSU	primarily urban in all directions.
				CAHA	3.5
			What is the rate of change in adjacent land use?	FOFR	changing to residential and golf.
				FOSU	could become a bigger issue if Boone Hall is ever developed.
				MOCR	related to land protection plans.
				OCMU	Macon is growing.
				CUIS	rate is FAST
		Adjacent NR management	Are Park populations of deer, turkeys, hogs, waterfowl, and feral dogs changing in response to changes in hunting regulations outside the park?	HOBE	changes in hunting regulations (upcoming) will likely reduce feral dogs and consequently increase deer populations. Could be upgraded to three depending on observed changes.
			To what extent are external hunting pressures affecting animal populations within Park boundaries?	KEMO	only hunting allowed in Cobb County is bow hunting. Impact is likely too low to be an issue for KEMO.
				FOFR	we have had a shot deer at FOFR. Other than that no game species present.
				CALO	ducks only species of concern at this point.
				CHAT	might be some adjacent hunting neare the northern units, but the affects (if any) on park resources are unknown. Might need to change to a 2, but as the area urbanizes, this problem will disappear.
				CANA	probably not an issue at CANA
				FOPU	no adjacent hunting. Except for marsh hens around our boundary.
			To what extent are off-shore and adjacent fishing pressures affecting Park populations?	CANA	particularly large problem with sea turtles

Category			Question	Park	Notes
Agents of Change	External Stressors (Anthropogenic)	Adjacent NR management	To what extent are off-shore and adjacent fishing pressures affecting Park populations?	FOPU	adjacent shellfishing, crabbing. Do have some crabbing (commercial) on adjacent lands that does spill over inside park boundaries.
				FOSU	likely minimal because park habitat is so small.
				CUIS	there are turtle effects.
			What are the incidence rate, virulence, and impacts of wildlife diseases on animal populations? (on adjacent lands)?	FOSU	not a high 2.
				CHAT	rabies???
				FOPU	could be some impacts with avian virus. Maybe sea turtles, too.
				HOBE	bee fungus, rabies is rampant in raccoon and skunk populations. Due to potential public health issues, this might become a four. Monitoring will be done by the State if bumped up.
				CAHA	equine encephalitis, wnv
			What are the incidence rates of wildlife disease to which humans are at risk?	FOSU	WNV has been reported in Charleston.
				CALO	WNV and Limes disease; none reported yet, though
				CHAT	rabies???
				FOPU	rabies in raccoons. Hantavirus also has been identified. WNV, Lyme.
				HOBE	see rabies note above.
				KEMO	Lime, WNV. No indication that this has been an issue. Ticks and mosquitoes are there, though.
				CAHA	wnv
				FOFR	lyme disease, WNV. None yet found at FOFR, but have been found w/in animals in County
		Other	To what extent are jetties affecting sediment transport budgets?	CAHA	Oregon Inlet
				FOSU	we know the jetties are leading to accretion.
				CUIS	because of Florida
				CANA	Ponce Inlet to the North of CANA may be affecting sand transport

Category			Question	Park	Notes
Agents of Change	External Stressors (Anthropogenic)	Other	To what extent are large impoundments and water diversion structures affecting water resources within Park boundaries?	CAHA	cape point
				FOPU	we have a dyke inside the park that controls the water levels within the park. (Water control structure for the moat)
				HOBE	Large dam upstream. Affects hydroperiod and potentially water quality.
				OCMU	could be of greater importance as Atlanta grows.
				CANA	need to know for impoundment reconnection and wetlands restoration occurring within the park
			To what extent are shoreline erosion control structures (revetments) affecting erosion rates?	FOSU	beach by Fort Moultrie has revetments as does Fort Sumter. Combination of all structures is likely affecting erosion rates at the Fort.
				FOPU	if we find out it's not an issue we can downgrade priority.
				CHAT	some rip-rapped areas.
				MOCR	because of cultural resources.
				CONG	bridges, Cedar Creek Canoe access has some revetment work that might have erosion issue.
				CANA	Revetment immediately north of park may be causing erosion
			To what extent do docks, piers, bulkheads and other shoreline stabilization structures affect natural hydrology and adjacent communities?	CAHA	at FORA
				FOSU	we have nearby docks and riprap around the fort. Don't know if they're affecting hydrology, though. Perhaps sediment transport, though.
				CALO	b/c of new renourishment project.
				FOPU	dredging / channel deepening proposal in process.
				CHAT	many docks that are out of compliance. Impacts need to be quanitified.
				CASA	implications for the Fort (structure) at FOMA.
			To what extent do mosquito control structures and other flow restrictions affect water resources?	FOPU	Ditches on park.
				CONG	need to check with what we said at CHAT.
				HOBE	none exist at this time.

Category			Question	Park	Notes
Agents of Change	External Stressors (Anthropogenic)	Other	To what extent do mosquito control structures and other flow restrictions affect water resources?	CAHA	cape point
				CANA	many current and historic mosquito control activities occurring within park
			To what extent do regional / adjacent stormwater management activities affect Park resources?	OCMU	All the garbage and highly polluted water into thepark. High fecal coliform readings after big rain events. Several sewage spills within the park.
				FOPU	stormwater runoff from Wilmington Island.
				CASA	has implications for water quality in the salt marsh
				HOBE	as development happens, treatment facilities might increase.
				KEMO	might be some areas on the eastern boundaries of the park.
				MOCR	Corps lock & Dam upstream manages for flood control. Don't know whether effects are CORPS driven or rain driven. Potentially downgrade to a 2.
			What are the effects of beavers on natural hydrology?	HOBE	have a decent beaver issue.
				KEMO	perhaps a 4. No resources at risk. Might have an impact on trail system.
				CONG	don't know what the status of beaver in the park is at this point. Not a nuisance at this point.
				CHAT	we do receive complaints about them from adjacent neighbors. County receives complaints.
				MOCR	Because of potential impacts on CR, this might need to be elevated to a 4. Beavers are newly active in the last 6-7 years. County has a beaver management specialist. Beavers are also affecting riparian trees. Elevated to 4 on 7/12 due to renewed impac
				TIMU	might have beavers on the north side, but not in the park at this point. Maybe a 2?
				CUIS	none present
	Ecosystem Function	Energy / Material Flow	Are chemical, physical, or biological processes in wetlands changing over time?	OCMU	large amount of wetlands on site.
				MOCR	w / restoration, this becomes of hither interest.
			What are the extent and impacts of bioaccumulation and biomagnification on park resources and visitor experience?	CUIS	don't know if this is an issue.
				CONG	could go up to a four based on results of current research.
				FOPU	Mercury issue. We have a lot of recreational shellfish harvesting.

Category			Question	Park	Notes
Agents of Change	Ecosystem Function	Energy / Material Flow	What are the extent and impacts of bioaccumulation and biomagnification on park resources and visitor experience?	OCMU	junkyard effects.
		Disturbance / Recovery	Are species associated with early successional stages of major (natural) disturbances adequately represented within the park?	CAHA	2.5
				HOBE	tied to fire management program. Could be higher.
				FOPU	primarily early succession on dredge spoil islands (no more than 100 years old)
				CHAT	management actively selects against early successional species. Don't know what species would realistically be expected to exist within the 2000 ft. corridor.
			To what extent are flow dynamics and hydroperiod of aquatic systems changing over time (including rivers, lakes and ponds, wetlands, and estuaries, ditches)?	CHAT	this is the tristate issue.
				KEMO	no impacts at KEMO
				MOCR	erosion during swift water.
			To what extent are the magnitude, frequency, and extent of flooding events changing over time?	FOFR	don't know if there are changes
				CHAT	full-on natural flooding not going to happen due to urban interface. Ecological significance of those that do happen is more of a research question. Shift in all is happening right now.
				KEMO	no impacts at KEMO
				CALO	related to hurricanes
				HOBE	affected by the dam upstream.
				OCMU	either drought or frequent 100 year floods…
			To what extent are the magnitude, frequency, and extent of high tide events (storm surges, seasonal changes) changing over time?	CALO	related to hurricanes
				CASA	FOMA structure highly susceptible to structural damage resulting from changes in sea level.
				FOPU	perhaps a 3?

Category			Question	Park	Notes
Agents of Change	Ecosystem Function	Trophic Structures	What are the status and trends of natural predators?	CHAT	receive complaints about coyotes. Fairly isolated reports, though. Don't know enough about number or distribution at this point to know how important this issue is at this point.
				OCMU	only mammal predator we have is coyote.
				MOCR	coyotes are on the rise in the county. Mammal inventory didn't find any inside the park, but tracks outside. Fox populations fairly stable.
				KEMO	coyotes have likely increased of late. Would likely be more useful to park neighbors than to us.
				FOFR	raccoons only
				CASA	they're stable. Reports of bobcat family in the area.
				CANA	bobcats, raccoons, grey foxes, ghost crabs. Effects on marine turtles.
				CALO	existing PMIS statement concerning raccoons trying to determine management thresholds for removal
			What is the status and trends of large carnivore prey base?	HOBE	bobcats are here, but we don't know how big the populations is
			What is the status and trends of large carnivores (bobcat or bigger)?	CAHA	red foxes
				CHAT	large cats and bears have been spotted. Coyotes, too!
				OCMU	bears might be soon encroaching
				FOFR	none present
				FOPU	coyotes, foxes. No more than 3.
				FOSU	we have a fox. With pups.
				HOBE	bobcats present
				MOCR	bobcat family nearby
				CUIS	bobcats are predators on oystercatcher eggs
				KEMO	Did have a mountainlion report that was probably a bobcat.
		Animal Behavior	What are the status and trends of pollinators within the Park?	HOBE	could be bumped up if we find out thagt the bee fungus is affecting pollinator communities.
	Other Issues	Visitor Use	Are human uses within the park (Non NR management) affecting surficial hydrology?	FOPU	probably just seasonal changes.
				FOFR	not an issue

Category			Question	Park	Notes
Agents of Change	Other Issues	Visitor Use	Are the number and activities of concessionaires, Incidental Business Permit (IBP) users, and special use permits changing?	FOSU	special use permits have been increasing.
				CANA	Use increasing significantly in Mosquito Lagoon. Will become a big issue.
				CUIS	more kayaks (IBPs)
			Are visitor uses impacting native vegetation?	CALO	probably not as much as horses are.
				CANA	dune impacts and sea grass impacts primary concern
				FOFR	in Bloody Marsh?
				FOPU	fishermen trampling spartina, but it comes back every year so it's probably not a big problem.
				CUIS	not a problem at this point
				CAHA	dunes
				KEMO	social trail problem exists at the park, particularly with adjacent land users.
			Are visitors' desires for, expectations of, and actual experiences in the park changing?	CALO	Yes, b/c of more visitation.
				CASA	this could change dramatically as the reosources change in response to higher visitation rates.
				KEMO	expectations probably will change due to increase due to more visitors.
			How are the number, distribution, and size of human-impacted sites changing over time? (incl. trails, campsites, boat launches…)	CASA	boating access and socatial trail creation, particularly in due system.
				CHAT	social trails and encroachments make this a large evolving issue.
				FOFR	not changing
				FOSU	could become of higher interest as visitation increases. Primary concern is litter.
				HOBE	no campsites, boat launches… no noticeablesignificant impacts from overuse of trails or other high use areas. Could change if visitation increases.
				KEMO	social trail creation
				CUIS	increased boating activity is happining and is expected to continue.

Category			Question	Park	Notes
Agents of Change	Other Issues	Visitor Use	How are the type, amount, and distribution of visitor uses changing over time?	KEMO	more of 'em. If there is a change, it's an increase in usage of the trail system.
				CANA	boaters of concern, in particular
				FOPU	are seeing an increase in jetskis and kayaks.
				HOBE	this will change as the area around develops and trail use increases. Horse use is starting to increase.
				FOSU	visitation has been increasing.
			To what extent are boating activities affecting submerged aquatic vegetation beds & associated communities?	FOSU	unless we find out that we have seagrass beds somewhere where we have jurisdiction.
				CALO	also commercial boating activities.
				CANA	big impact to oyster beds and seagrass beds
			To what extent are off-road vehicles impacting natural resources?	KEMO	no significant damage being done. b/c not allowed.
				CALO	ORV EA in process.
				CASA	this is an known problem and is not allowed.
				CHAT	an issue within the easements in the northern park units. Need management actions more than anything.
				FOPU	we occasionally have this issue. No trail.
				HOBE	occasionally happens, but infrequently (two within the last year, and primarily kept to roadways). Park could become more vulerable to ORV use after clearing actions related to the FMP. Might need to be later reevaluated.
				CUIS	includes both residents and NPS
			To what extent are patterns of water-runoff, sedimentation, and erosion changing or increasing in areas of high recreation use?	MOCR	with canoe access this could become an issue in the future.
				KEMO	trail on little Kennesaw is a problem.
				FOSU	no high recreation use areas.
				CONG	may become an issue in the new area.
				CHAT	high visitor use having known impacts.
				CUIS	not a problem at this point

Category			Question	Park	Notes
Agents of Change	Other Issues	Visitor Use	To what extent are personal watercrafts, canoes, or other boats impacting natural resources?	CHAT	some areas don't allow motorized vehicles. Lots of questions…
				MOCR	canoe and kayak use on the rise.
				CANA	big impact to oyster beds and seagrass beds
				CUIS	will be increasing with addition of marina.
				FOPU	starting to get a little more of this. JetSkis are not permitted within the park.
				FOSU	minimal, but people bring their own vehicles to sandy shoal at Fort Sumter.
			To what extent do human uses of natural areas affect behavior, distribution, and abundance of natural animal populations?	CALO	ORV effects.
				CANA	shorebird interactions. Rookeries in jointly managed areas have had problems with people scaring off birds
				CHAT	could be important for trails management, especially since CHAT's humans come with dogs.
				FOFR	not a known issue
			To what extent do human-animal interactions affect behavior, distribution, and abundance of natural animal populations?	FOSU	we don't have a whole lot (if any) human-animal interactions.
				FOFR	not happening
				CHAT	goose feeding.
				CASA	Of concern with birds on the beach
				FOPU	alligators in the moat.
				CALO	raccoon feeding a problem
				CANA	raccoon feeding a problem. Manatees threatened by speeding boats.
			To what extent is horseback riding on trails affecting natural resources	KEMO	is allowed, but limited to certain areas of the trail system. Potential issues at stream crossings.
				HOBE	horseback riding is soon to be officially permitted on service roads and restricted to certain trails.
				CASA	some occasional riding on the beaches but not often.
				CANA	limited only to beaches right now. Might expand to Bill's Hill in the future in which case we might want to elevate to a 3.

Category			Question	Park	Notes
Agents of Change	Other Issues	Visitor Use	To what extent is use of backcountry / Wilderness areas affecting Park resources?	OCMU	Lamar unit might be considered backcountry
				HOBE	no designated wilderness. Backcountry areas are not very well utilized.
				CANA	Minor impact
				CALO	Shackleford is a proposed wilderness area. Growing number of boats accessing island, though (as many as 400-500 on the 4th of July).
				MOCR	none designated at Park.
			What type and extent of natural resource degradation are occurring due to visitor uses?	FOFR	potentially cultural impacts only
				CALO	ORVs
				FOSU	don't really have any natural resource degradation; only cultural.
				KEMO	we know this is primarily on the trails, also impacts on earthworks.
		Resource Extraction	Are commercially valuable plant species (i.e., ginseng, goldenseal, bloodroot) being impacted by illegal harvesting?	HOBE	there are some local ginseng harvesters in the area…
				FOFR	don't think any are present
			Are dredging operations changing hydrology?	CAHA	Dredging is all done outside of our boundaries. Dumping of sediments and noise are bigger issues.
				CALO	going to be dredging this february. Beaufort Inlet is dredged.
				CASA	not noticing or concerned with hydrologic issues at this time.
				HOBE	don't know if this is even happening.
				OCMU	Ocmulgee is navigable to Macon, but USACE has not dredged for many many years. Not likely to happen any time soon for political reasons.
			Are levels of native vegetation harvesting changing?	CAHA	blueberries
				HOBE	some poaching going on, but not at a significant level (as far as we know)
				FOSU	not happening within the park
				CANA	sea oats harvesting?
				CONG	paw paw and muscadine

Category			Question	Park	Notes
Agents of Change	Other Issues	Resource Extraction	How do beach re-nourishment projects affect hydrography (i.e., residence time, wave climate, loss of shoals, overland flow, sediment budget)?	FOSU	not happening as much as historically.
			Is water quantity changing in response to (regional) water withdrawal and impoundment?	FOSU	In Charleston area, definitely an issue. Not an issue right now at the Park.
				FOPU	groundwater extraction effects.
				FOFR	mostly gw-fed system
				KEMO	all regional withdrawl is occurring downstream.
				CHAT	this really is the tristate issue.
			To what extent do finfishing and shellfishing affect native populations (within park boundaries)?	FOFR	fiddler crabbing at Bloody Marsh
				FOPU	crabbing.
				CANA	Increasing to alarming levels and may already be negative impact
				FOSU	FOSU is an active recreational fishing area. Don't know the impacts, but they're assumed to be low compared to overall Charleston Harbor.
				MOCR	after fish survey?...
				HOBE	lots of summertime fishing goning on.
			To what extent does groundwater extraction affect water tables, uplands, estuaries, wetlands, and surface water availability?	CUIS	Maybe a 4?
				FOFR	mostly gw-fed system
			To what extent does hunting pressure within the park affect populations / communities (permitted and poaching)?	HOBE	Poaching does happen, but the extent of impacts is not known.
				FOPU	we do have some poaching, but not much.
				CANA	Good to know impact on duck populations since some are decreasing on a continental basis
				FOFR	not permitted / happening
				CHAT	poaching happens

Category			Question	Park	Notes
Agents of Change	Other Issues	Resource Extraction	To what extent does hunting pressure within the park affect populations / communities (permitted and poaching)?	CUIS	hunting is allowed; deer and hogs only
			What are the effects of channel dredging on natural systems?	CONG	dredging of Congaree River has been proposed for sight-seeing boat traffic.
				FOSU	potential effects on shoal generation at Fort Sumter.
				CASA	has ramifications for both water quality and sound quality.
				HOBE	don't think there is any dredging going on at this time.
			What are the effects of commercial and recreational shellfish harvesting on park aquatic habitats?	CASA	could be some shellfishing issues, but magnitude (if any) is unknown at this time.
				FOSU	not happening within the Park.
				FOPU	crabbing. Only approved area for recreational shellfish harvesting in Chatham County.
				CANA	All we know is that it's significant and increasing
			What are the effects of sand mining on natural systems?	CUIS	Sand mining happens on Raccoon Keys
				HOBE	don't know of any that might be going on.
				CHAT	maybe a four?
				CAHA	not a current issue
			What are the effects of surface water extraction on Park resources?	CHAT	tristate
				CAHA	0?
				HOBE	not sure the extent to which this is a problem but at least one adjacent landowner is withdrawing surface water from local springs.
				MOCR	not aware of any issues.
			What are the impacts of specimen collecting on sensitive plant populations (scientific collection and poaching)?	FOSU	potential is there, but not an issue right now.
				HOBE	some poaching going on, but not at a significant level (as far as we know)
				MOCR	poaching has happened

Category			Question	Park	Notes
Agents of Change	Other Issues	Resource Extraction	What is the frequency and intensity of sand dredging?	CAHA	Isabel Inlet
				CHAT	some sand dredging areas happening.
				FOSU	For Fort Moultrie area, this happens once ever 7-10 years. Dredging happens in the harbor all the time. Definitely affects resources at the park.

Figures

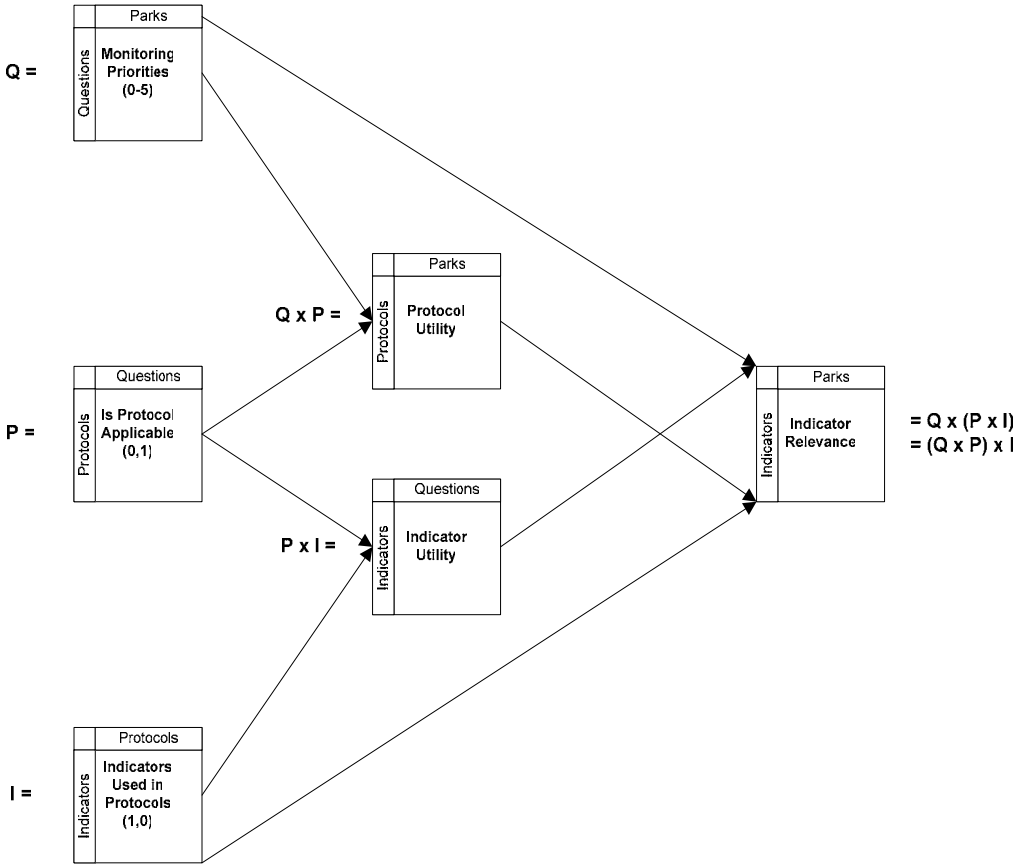

Figure A9-1. Data sets used for analysis of indicator relevance in the Southeast Coast Network.

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National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix 10: Protected Species of the Southeast Coast Network

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Overview *3*

Federally Threatened & Endangered Species *3*

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Overview

Based on uncertified data, fifty nine species with designated federal conservation status (i.e., Threatened, Endangered, or Candidate) are known to be present in Southeast Coast Network Parks. A total of 206 species with State listing status have also been identified within Network parks. In both cases the number is likely *under*estimated and will be revised as baseline inventories of vertebrates and vascular plants are completed during the next three years. Species of conservation status that are found on more than two parks include Red Cockaded Woodpecker, gopher tortoise, eastern indigo snake, piping plover and other shorebirds, wood stork, bald eagle, and all sea turtle species. Seven cetacean species, all of which are listed as "Endangered," have also been documented at coastal parks within the network but management of those species is limited to beaching events rather than of overall species conservation. Declines of the majority of these species are related to changes in available habitat, primarily in longleaf pine forest and coastal dune ecosystems. Agents of change include fire suppression, visitor use, and adjacent or historical land uses (primarily residential and forestry).

Federally Threatened & Endangered Species

Table A10-1. Federal Conservation status of species within Southeast Coast Network Parks. Species presence is based on inclusion in the National Park Service NPSpecies database as of 26 August 2004, and is subject to revision following the completion of ongoing biological inventories, database quality assurance procedures, and any updates to Federal Listing status. Only species designated as "Present in Park" or "Historic" in NPSpecies are included for certified species lists (reptile and amphibian only), otherwise all species (except 'false report') in NPSpecies are included. [E – Endangered; T – Threatened; C – Candidate (formerly C1); PT – Proposed Threatened; X – Presumed Extinct].

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Birds															
Bald Eagle (*Haliaeetus leucocephalus*)	T	T	T	T	T	T	T		T	T	T	T		T	T
Piping Plover (*Charadrius melodus*)	T	T	T				T		T	T					T
Mountain Plover (*Charadrius montanus*)							PT								
Roseate Tern (*Sterna dougallii dougallii*)	E														
Wood Stork (*Mycteria americana*)		E		E	E	E	E	E	E	E				E	E
Scrub Jay (*Aphelocoma coerulescens*)		T		T		T			T						
Bachman's Warbler (*Vermivora bachmanii*)				E		E	E		E	E					
Dusky Seaside Sparrow (*Ammodramus maritimus*)		X													
Kirtland's Warbler (*Dendroica kirtlandii*)		E		E			E		E						
Ivory-Billed Woodpecker (*Campephilus principalis*)						E			E						
Red Cockaded Woodpecker (*Picoides borealis*)		E			E	E	E			E			E	E	E
Atlantic Grebe (*Podilymbus gigas*)	E														
Band-rumped Storm-petrel (*Oceanodroma castro*)	C		C						C						
Whooping Crane (Grus Americana)									E						
Fish															
Shortnose Sturgeon (*Acipenser brevirostrum*)	E		E	E		E			E	E					E

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Mammals															
Red Wolf (*Canis rufus*)		E													
Black Right Whale (*Balaena mysticetus*)	E														
Northern Right Whale (*Eubalaena glacialis*)	E	E					E		E						
Sei Whale (*Balaenoptera borealis*)	E	E													
Blue Whale (*Balaenoptera musculus*)	E														
Fin Whale (*Balaenoptera physalus*)	E	E	E												
Humpback Whale (*Megaptera novaeangliae*)	E		E				E		E						
Sperm Whale (*Physeter catodon*)	E	E													
Indiana Bat (*Myotis sodalis*)		E									E			E	
Gray Bat (*Myotis grisescens*)					E										
Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)		T													
Anastasia Island Beach Mouse (*Peromyscus polionotus phasma*)				E											
West Indian Manatee (*Trichechus manatus*)	E	E	E	E			E	E	E						E
Reptiles & Amphibians															
Eastern Indigo Snake (*Drymarchon corais couperi*)		T		T											T
Atlantic Salt Marsh Snake (*Nerodia clarkii taeniata*)		T													
Pine Snake (*Pituophis melanoleucus*)		C					C								C
Loggerhead Sea Turtle (*Caretta caretta*)	T	T	T	T			T								
Green Sea Turtle (*Chelonia mydas*)	T	E	T				T								
Hawksbill Sea Turtle (*Eretmochelys imbricata*)		E					E								
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	E	E	E				E								
Leatherback Sea Turtle (*Dermochelys coriacea*)		E	E	E			E								
American Red-bellied Turtle (*Pseudemys rubiventris*)	E														
Non-Vertebrates															
Finelined Pocketbook *(Lampsilis altilis)*											T				
Gulf Moccasinshell (*Medionidus penicillatus*)					E										
Southern Clubshell (*Pleurobema decisum*)											E				
Ovate Clubshell (*Pleurobema perovatum*)											E				
Vascular Plants															
Fragrant prickly-pear (*Cereus eriophorus var. fragrans*)		E													
Caribbean applecactus (*Harrisia fragrans*)		E													
Seabeach Amaranth (*Amaranthus pumilus*)	T		T							T					
Virginia jointvetch (*Aeschynomene virginica*)	T														
Georgia Aster (*Symphyotrichum georgianus*)					C					C					
Little Amphianthus (*Amphianthus pusillus*)					T										
White Birds-in-a-nest (*Macbridea alba*)															T
American Chaffseed (*Schwalbea americana*)										E			E		E

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Georgia Rockcress (*Arabis georgiana*)					C										
Smooth Purple Coneflower (*Echinacea laevigata*)					E										
Black-spored Quillwort (*Isoetes melanospora*)					E										
Pondberry (Lindera melissifolia)															
Roughleaf Yellow Loosestrife (*Lysimachia asperulifolia*)													E		
Canby's Cowbane (*Oxypolis canbyi*)										E					
Monkeyface (*Platanthera integrilabia*)					C										
Chapman's Rhododendron (*Rhododendron chapmanii*)															E
False Poison Sumac (*Rhus michauxii*)					E										
Cooley's Meadow-rue (*Thalictrum cooleyi*)													E		
Total (59)	**20**	**25**	**12**	**11**	**12**	**7**	**16**	**2**	**13**	**10**	**5**	**1**	**4**	**4**	**11**

State Listed Species

Table A10-2. State Conservation status of species within Southeast Coast Network Parks. Species presence is based on inclusion in the National Park Service NPSpecies database as of 26 August 2004, and is subject to revision following the completion of ongoing biological inventories, database quality assurance procedures, and any updates to State Listing status. Only species designated as "Present in Park" or "Historic" in NPSpecies are included for certified species lists (reptile and amphibian only), otherwise all species (except 'false report') in NPSpecies are included. [E – Endangered, T – Threatened, R – Rare, U – Unusual, SP – State Protected, SCa – Special Concern Animal Species, SCp – Special Concern Plant Species, Ta, Threatened Animal, Tp – Threatened Plant, Ea – Endangered Animal, Ep – Endangered Plant, SC – Species of Concern, SE – Endangered, ST – Threatened, NC – Species of National Concern, RC – Species of Regional Concern, LS – Species of Special Concern, PS – Proposed for Listing as Species of Special Concern, LT Threatened, LE - Endangered].

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Birds															
Cooper's Hawk (*Accipiter cooperii*)	SCa		SCa			SC					SP		SCa		
Northern Saw-whet Owl (*Aegolius acadicus*)	SCa		SCa												
Bachman's Sparrow (*Aimophila aestivalis*)	SCa				R	SC	R		R	SC					
Roseate Spoonbill (*Ajaia ajaja*)		LS		LS											LS
Limpkin (*Aramus guarauna*)		LS		LS											LS
Crested Caracara (*Caracara plancus*)		LT													
Bald Eagle (*Haliaeetus leucocephalus*)		LT	T	LT	E	SE	E		E	SE	SP	E		E	LT
Snowy Plover (*Charadrius alexandrinus*)															LT
Piping Plover (*Charadrius melodus*)		LT					T		T	T					LT
Wilson's Plover (*Charadrius wilsonia*)							R		R						
Olive-sided Flycatcher (*Contopus lorealis*)	SCa														
Black Vulture (Coragyps atratus)	SCa		SCa										SCa		
Kirtland's Warbler (*Dendroica kirtlandii*)		LE		LE			E		E						
Black-throated Green Warbler (*Dendroica virens*)						SC									
Little Blue Heron (*Egretta caerulea*)	SCa	LS	SCa	LS											LS
Reddish Egret (Egretta rufescens)		LS													LS
Snowy Egret (*Egretta thula*)	SCa	LS	SCa	LS											LS
Tricolor Heron (*Egretta tricolor*)	SCa	LS	SCa	LS											LS
Swallow-tailed Kite (*Elanoides forficatus*)					R	SE	R		R						
White Ibis (*Eudocimus albus*)		LS		LS											LS
Peregrine Falcon (*Falco peregrinus*)		LE		LE	E		E		E			E		E	LE
Southeastern American Kestrel (*Falco sparverius paulus*)		LT		LT											LT
Gull-billed Tern (*Sterna nilotica*)	Ta						T		T						
Florida Sandhill Crane (*Grus canadensis pratensis*)		LT													
American Oystercatcher (*Haematopus palliates*)		LS		LS			R		R						LS
Mississippi Kite (*Ictinia mississippiensis*)						SC									
Loggerhead Shrike (*Lanius ludovicianus*)	SCa					SC									

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Swainson's Warbler (*Limnothlypis swainsonii*)						SC									
Red-headed Woodpecker (*Melanerpes erythrocephalus*)						SC									
Wood Stork (*Mycteria americana*)		LE		LE	E	SE	E	E	E	SE				E	LE
Florida Scrub Jay (*Aphelocoma coerulescens*)		LT		LT											
Bachman's Warbler (*Vermivora bachmanii*)				LE			E		E						
Osprey (*Pandion haliaetus*)		LS		LS											LS
Brown Pelican (*Pelecanus occidentalis*)	SCa	LS	SCa	LS											LS
Ivory-Billed Woodpecker (*Campephilus principalis*)									E						
Red Cockaded Woodpecker (*Picoides borealis*)		LT		LT	E	SE	E		E	SE				E	LT
Glossy Ibis (*Plegadis falcinellus*)	SCa		SCa			ST									
Golden-crowned Kinglet (*Regulus satrapa*)	SCa		SCa										SCa		
Black Skimmer (*Rynchops niger*)	SCa	LS	SCa	LS											LS
Florida Burrowing Owl (*Speotyto cunicularia floridana*)		LS													
Least Tern (*Sterna antillarum*)		LT		LT			R		R						LT
Roseate Tern *(Sterna dougallii)*		T													
Bewick's Wren (*Thryomanes bewickii*)	Ea				R	SE	R		R						
Barn Owl (*Tyto alba*)						SC									
Fish															
Shortnose Sturgeon (*Acipenser brevirostrum*)						SE			E	SE					E
Atlantic Sturgeon (*Acipenser oxyrinchus*)	SCa		SCa												
Alabama Shad (*Alosa alabamae*)					U										
Bluestripe Shiner (*Cyprinella callitaenia*)					T										
Carolina Pygmy Sunfiah (*Elassoma boehlkei*)						ST									
Cherokee Darter (Etheostoma scotti)					T							T			
Bluefin Killifish (*Lucania goodei*)									U						
Highscale Shiner (*Notropis hypsilepis*)					T							T			
Frecklebelly Madtom (*Noturus munitus*)					E										
Mammals															
Star-nosed Mole (*Condylura cristata*)						SC									
Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*)									R		SP				
Northern Right Whale (*Eubalaena glacialis*)		LE					E		E						
Florida Panther (*Puma concolor coryi*)		LE													LE
Hoary Bar (*Lasiurus cinereus*)						SC									
Meadow Vole (*Microtus pennsylvanicus*)						SC									
Humpback Whale (*Megaptera novaeangliae*)							E		E						
Long-tailed Weasel (*Mustela frenata*)											SP				
Southern Mink (*Mustela vison*)				LT											LT
Southeastern Bat (*Myotis austroriparius*)						ST				ST					
Gray Bat (*Myotis grisescens*)					E										

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Little Brown Bat (*Myotis lucifugus*)						SC									
Indiana Bat (*Myotis sodalis*)		LE									SP			E	
Round Tailed Muskrat (*Neofiber alleni*)							T								
Eastern Woodrat (*Neotoma floridana*)						SC									
Rice Rat (*Orysomys palustris*)		LE		LE											LE
Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)		LT													
Anastasia Beach Mouse (*Peromyscus polionotus phasma*)				LE											
Florida Mouse (*Podomys floridanus*)		LS		LS											LS
Eastern Fox Squirrel (*Sciurus niger*)						SC									
Swamp Rabbit (*Sylvilagus aquaticus*)						SC									
Florida Manatee (*Trichechus manatus*)		LE		LE			E	E	E						LE
Black Bear (*Ursus americanus)*						SC									
Florida Black Bear (*Ursus americanus floridanus*)		LT													LT
Meadow Jumping Mouse (*Zapus hudsonius*)											SP				
Reptiles & Amphibians															
Gopher Frog (*Rana capito*)		LS													
Pickerel Frog (*Rana palustris*)						SC									
American Alligator (*Alligator mississippiensis)*		LS		LS											LS
Loggerhead Sea Turtle (*Caretta caretta*)		LT		LT											LT
Green Sea Turtle (*Chelonia mydas*)		LE		LE											LE
Spotted Turtle (*Clemmys guttata*)						SC									
Timber Rattlesnake (*Crotalus horridus*)						SC									
Leatherback Sea Turtle (*Dermochelys coriacea*)		LE		LE											LE
Eastern Indigo Snake (*Drymarchon corais couperi*)		LT		LT											LT
Rat Snake (*Elaphe guttata*)		LS		LS											LS
Gopher Tortoise (*Gopherus polyphemus*)		LS		LS											LS
Southern Hognose Snake (*Heterodon simus*)						SC									
Mud Turtle (*Kinosternon baurii*)		LE		LE											LE
Outer Banks Kingsnake (*Lampropeltis getula sticticeps*)	SCa		SCa												
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)		LE		LE											LE
Atlantic Salt Marsh Snake (*Nerodia clarkii taeniata*)		LT		LT											LT
Carolina Salt Marsh Snake (*Nerodia sipedon williamengelsi*)	SCa		SCa												
Snapping Turtle (*Macroclemys temminckii*)		LS		LS							SP				LS
Diamondbacked Terrapin (*Malaclemys terrapin*)	SCa		SCa												
Florida Pine Snake (*Pituophis melanoleucus mugitus*)		LS		LS											LS
Dekay's Brown Snake (*Storeria dekayi*)		LT													
Lower Keys Ribbon Snake (*Thamnophis sauritus*)		LT		LT											LT
Vascular Plants															

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Ball Moss (*Tillandsia recurvata*)							T	T							
Bartram's Ixia (*Calydorea coelestina*)															LE
Bay Starvine (*Schisandra glabra*)					T							T			
Beach Morning-glory (*Ipomoea imperati*)										SC					
Black-spored Quillwort (*Isoetes melanospora*)					E										
Blunt-leaved Peperomia (*Peperomia obtusifolia*)		LE													LE
Canada Moonseed (*Menispermum canadense*)							SC								
Canby's Dropwort (*Oxypolis canbyi*)										SE					
Carolina Bogmint (*Macbridea caroliniana*)						SC							Tp		
Carolina Grass-of-parnassus (*Parnassia caroliniana*)													Ep		
Carolina Least Trillium (*Trillium pusillum*)													Ep		
Carolina Lilaeopsis (*Lilaeopsis carolinensis*)	Tp		Tp												
Cayaponia (*Cayaponia quinqueloba*)						SC									
Chaffseed (*Schwalbea americana*)										SE			Ep		LE
Chapman's Rhododendron (*Rhododendron chapmanii*)															LE
Cherokee Sedge (*Carex cherokeensis*)						SC									
Coastal Hoary Pea (*Tephrosia angustissima* var. *curtissii*)		LE													
Coastal Vervain (*Glandularia maritima*)		LE													
Cooley's Meadow-rue (*Thalictrum cooleyi*)													Ep		
Crested Fringed Orchid (*Pteroglossaspis ecristata*)										SC					
Croomia (*Croomia pauciflora*)									T						
Curtiss' Milkweed (*Asclepias curtissii*)		LE													LE
Curtiss' Sandgrass (*Calamovilfa curtissii*)		LT													LT
Cypress Panicgrass (*Dichanthelium dichotomum* var. *dichotomum*)		LT													
Dwarf Granite Stonecrop (*Sedum pusillum*)					T							T			
Dwarf Sumac (*Rhus michauxii*)					E										
Elliott's Sedge (*Carex elliottii*)						SC									
Enchanter's Nightshade (*Circaea lutetiana* ssp. *canadensis*)						SC									
Fall-flowering Ixia (*Nemastylis floridana*)															LE
Flatrock Onion (*Allium speculae*)					T										
Florida Anise Tree (*Illicium floridanum*)					E										
Florida Beargrass (*Nolina atopocarpa*)															LT
Florida Lantana (*Lantana depressa* var. *floridana*)		LE													LE
Florida Mountain-mint (*Pycnanthemum floridanum*)															LT
Florida Spiny-pod (*Matelea floridana*)															LE
Florida Toothache Grass (*Ctenium floridanum*)															LE
Florida Willow (*Salix floridana*)															LE
Fragrant Prickly Apple (*Harrisia fragrans*)		LE													
Georgia Aster (*Symphyotrichum georgianus*)										SC					

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Georgia Rockcress (*Arabis georgiana*)					T										
Giant Spiral Orchid (*Spiranthes longilabris*)													Tp		
Godfrey's Privet (*Forestiera godfreyi*)															LE
Golden Leather Fern (*Acrostichum aureum*)		LT													
Goldenseal (*Hydrastis canadensis*)					E										
Green Ladies-tresses (*Mesadenus polyanthus*)															LE
Green-fly Orchid (*Epidendrum conopseum*)							U								
Hairly Sweet Cicely (*Osmorhiza claytonii*)						SC									
Hartwrightia (*Hartwrightia floridana)*							T								LT
Hooded Pitcherplant (*Sarracenia minor*)							U	U	U						
Incised Groove-bur (*Agrimonia incisa*)										NC					LE
Indian Olive (*Nestronia umbellula*)					T							T			
Keys Hopbush (*Dodonaea viscosa*)		LE													
Lake-side Sunflower (*Helianthus carnosus)*															LE
Large-flowered Rosemary (*Conradina grandiflora*)		LE													
Large-flowered Yellow Ladyslipper (*Cypripedium pubescens var. pubescens*)					U										
Lax Water-milfoil (*Myriophyllum laxum*)														T	
Littleleaf Sneezeweed (*Helenium brevifolium*)													Ep		
Low Wild Petunia (*Ruellia caroliniensis var. cinerascens*)													Tp		
Meadow Sedge (*Carex granularis*)						SC									
Monkeyface Orchid (*Platanthera integrilabia*)					T										
Narrowleaf Sedge (*Carex amphibola*)						SC									
Nodding Pinweed (*Lechea cernua*)		LT													
Open-ground Widow-grass (*Draba aprica*)					E							E			
Pale Beakrush (*Rhynchospora pallida*)						SC									
Piedmont Barren Strawberry (*Waldsteinia lobata*)					T										
Pigmy Pipes (*Monotropsis reynoldsiae*)															LE
Pink Ladyslipper *(Cypripedium acaule*)					U										
Plymouth gentian (*Sabatia kennedyana*)	Tp														
Pondberry (*Lindera melissifolia*)										SE					
Pondspice (*Litsea aestivalis*)									T	SC					LE
Pool Sprite (*Amphianthus pusillus*)						T									
Purple Balduina (*Balduina atropurpurea*)															LE
Rock False Pimpernel (*Lindernia monticola*)					E							E			
Rough Leaf Loosestrife (*Lysimachia asperulifolia*)													Ep		
Salt Spikerush (*Eleocharis halophila*)	Tp		Tp												
Sand-dune Spurge (*Chamaesyce cumulicola*)				LE											
Sandhill Golden-aster (*Pityopsis pinifolia*)							T								
Sarvis Holly *(Ilex amelanchier)*						SC				SC					
Sea Lavender (*Argusia gnaphalodes*)		LE													
Seabeach Amaranth (*Amaranthus pumilus*)	Tp		Tp							ST					

	CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Sensitive Jointvetch (*Aeschynomene virginica*)	Ep														
Shoals Spiderlily (*Hymenocallis caroliniana*)					E										
Simpson's Prickly Apple (*Harrisia simpsonii*)		LE													
Smooth Purple Coneflower (*Echinacea laevigata*)					E										
Snowy Orchid (*Platanthera nivea*)	Tp												Tp		
Southern Lip Fern (*Cheilanthes microphylla*)															LE
Southern Milkweed (*Asclepias viridula*)															LT
Spoon-leaved Sundew (*Drosera intermedia*)															LT
Spring-flowered Goldenrod (*Solidago verna*)													Tp		
St John's-Susan (*Rudbeckia nitida*)															LE
Swamp White Oak (*Quercus bicolor*)						SC									
Sweet Gale (*Myrica gale*)			Ep												
Tampa Vervain (*Glandularia tampensis*)		LE													
Terrestrial Peperomia (*Peperomia humilis*)		LE													LE
Tiny-leaf Buckthorn (*Sageretia minutiflora)*							T		T	T					
Velvet Sedge (*Carex dasycarpa*)							R								
Venus Flytrap (*Dionaea muscipula*)			SCp							RC			SCp		
Weak Nettle (*Urtica chamaedryoides*)						SC									
White Birds-in-a-nest (*Macbridea alba*)															LE
White Whicky (*Kalmia cuneata*)													Ep		
Wild Coco (*Pteroglossaspis ecristata*)		LT		LT											
Winter Grape-fern (*Botrychium lunarioides*)						SC									
Wiregrass Gentian (*Gentiana pennelliana*)															LE
Wolly Dutchman's Pipe (*Aristolochia tomentosa*)						SC									
Yellow Flytrap (*Sarracenia flava*)														U	
Yellow Fringeless Orchid (*Platanthera integra*)													Tp		LE
Total (206)	**25**	**64**	**20**	**39**	**30**	**44**	**26**	**4**	**25**	**19**	**7**	**9**	**17**	**7**	**68**

National Park Service
U.S. Department of the Interior

Southeast Coast Network
Atlanta, Georgia

Appendix II: Air Resources of the Southeast Coast Network

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Executive Summary

The National Park Service's Air Quality Division has implemented monitoring efforts in many Class 1 units, but considerably more work needs to be done if the Service is to effectively detect and respond to threats to air resources. As part of the Natural Resource Inventory and Monitoring Program, the location of EPA air quality monitoring stations within close proximity (50-100 km) to park boundaries will be noted and summarized in an air quality atlas. Data from these stations can be used to obtain a rough assessment of air quality within individual park units. Information on visibility goals and air quality-related values will also be included in the inventory. Precipitation and meteorological data in the inventory consist of basic information on annual precipitation, relative humidity, wind speed and direction, and maximum and minimum daily temperatures.

The NPS Air Resources Division (ARD) contracted with the University of Denver (DU) to produce GIS-based maps and an associated look-up table that provide baseline values for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. These maps and table will serve as the Air Inventory for the parks. Air Quality Inventory products are available on the Internet at http://www2.nature.nps.gov/ard/gas/ (see section called Air Atlas). ARD used preliminary DU products to help develop a strategy for expanding ARD-funded ambient air quality monitoring with increased funding from the Natural Resources Challenge in FY 2002. At this time, ARD does not intend to fund additional monitoring at any NPS units in the Southeast Coast Network. The ARD air monitoring strategy will be revisited in FY 2004 if additional funding becomes available.

Data from the Air Quality Inventory, national air monitoring programs described below, and other air quality sources, were used in conjunction with park-specific resource information to evaluate the following needs relative to the Southeast Coast Network: 1) the need for additional ambient air quality monitoring at any Network park, i.e., wet deposition, dry deposition, visibility, particulate matter and/or ozone monitoring, and 2) the need for air quality effects-related monitoring at any Network park. The results of this evaluation, as well as a brief summary of results

of past air quality monitoring at relevant sites, are discussed below.

Wet Deposition

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups, including the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey, U.S. Department of Agriculture, and private entities. The NPS is a major participant in NADP/NTN, and the ARD recommends that any new wet deposition site installed in a park meet NADP/NTN siting criteria and follow NADP/NTN protocols. There are currently more than 200 NADP/NTN sites spanning the continental U.S., Alaska, Puerto Rico, and the Virgin Islands.

The purpose of the network is to collect data on the chemistry of precipitation to monitor geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory in Illinois where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium). NADP/NTN's excellent quality assurance programs ensure that the data remain accurate and precise. The National Atmospheric Deposition Program has also expanded its sampling to include the Mercury Deposition Network (MDN), which currently has over 80 sites. The MDN was formed in 1995 to collect weekly samples of precipitation, which are analyzed for total mercury. The objective of the MDN is to monitor the amount of mercury in precipitation on a regional basis.

None of the Southeast Coast Network parks have an NADP/NTN monitor on-site; all have a monitor within 85 miles. Distance, as well as terrain, intervening pollution sources, and differences in meteorology affect how well a monitoring site's data represent conditions at a park. Meteorology is an important consideration for coastal parks, since wind patterns on the coast can be very different from those inland. Nevertheless, based on a rough evaluation of these factors, it appears that all Network parks are well represented by existing NADP/NTN monitors.

There are currently nine MDN sites in the Southeast Coast Network area, including one at Congaree National Park in South Carolina (site #SC19). Other stations are located at Centreville, Alabama (site #AL03); Chassahowitzka National Wildlife Refuge (NWR), Florida (site #FL05); Okefenokee NWR, Georgia (site #GA09); Fulton County, Georgia (site #GA22); Yorkville, Georgia (site #GA40); Lake Waccamaw State Park, North Carolina (site #NC08); Pettigrew State Park, North Carolina (site #NC42); and Barnwell County, South Carolina (site #SC03). MDN sites will be initiated in 2003 in Orlando, Florida (site #FL97) and Cape Romain NWR, South Carolina (site #SC05).

Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, annual average wet deposition and concentration of sulfate, nitrate, and ammonium are higher in the eastern than in the western U.S. (Figure A11-1, Figure A11-2; also see NADP/NTN maps at http://nadp.sws.uiuc.edu). At many NADP/NTN sites across the U.S., concentration and deposition of sulfate have declined in recent years as sulfur dioxide emissions have decreased. Trends have been variable for nitrate and ammonium, with concentration and deposition at various sites increasing, decreasing, or showing no overall change. Results from NADP/NTN sites in and near Southeast Coast Network parks are summarized below. Both the Clinton, North Carolina, and Santee NWR, South Carolina, sites show an increase in wet ammonium concentration that may be due to increased hog farming in the area.

MDN sites within the Southeast Coast Network are as follows:

Crossville, AL The Crossville, Alabama, NADP/NTN site at Sand Mountain Experiment Station (site #AL99) was installed in 1984. Wet concentration and deposition of sulfate have decreased at the site, while wet

concentration of ammonium, wet concentration of nitrate, and wet deposition of nitrate have increased. There has been no overall trend in wet ammonium deposition.

Dallas County, AL A NADP/NTN site has been operating in Dallas County, Alabama (site #AL10 (Black Belt Substation)) since 1983. Site data show a decrease in concentration and deposition of wet sulfate, but no overall trends in concentration and deposition of wet nitrate and wet ammonium.

Kennedy Space Center, FL The NADP/NTN site at Kennedy Space Center, Florida (site #FL99) has been operating since 1983. Site data show an increase in concentration and deposition of wet nitrate and wet ammonium, but no overall trends in concentration and deposition of wet sulfate.

Sampson City, FL A NADP/NTN site has been operating at Sampson City, Florida (site #FL03 (Bradford Forest)) since 1978. Site data show a decrease in concentration and deposition of wet sulfate, but no overall trends in concentration and deposition of wet nitrate and wet ammonium.

Okefenokee NWR, GA A NADP/NTN site was installed at Okefenokee NWR, Georgia (site #GA09) in 1997. Trend data are not yet available from the site.

Pike County, GA The Pike County, Georgia, NADP/NTN site (site #GA41 (Georgia Station)) has been operating since 1978. Site data show a decrease in concentration and deposition of wet sulfate, but no overall trends in concentration and deposition of wet nitrate and wet ammonium.

Sapelo Island, GA A NADP/NTN site was installed at Sapelo Island, Georgia (site #GA33) in 2002. Data are not yet available from the site.

Skidaway, GA A NADP/NTN site was installed at Skidaway, Georgia (site #GA98) in 2002. Data are not yet available from the site.

Beaufort, NC A NADP/NTN site was installed at Beaufort, North Carolina (site #NC06) in 1999. Trend data are not yet available from the site.

Clinton, NC A NADP/NTN site has been operating at Clinton, North Carolina (site #NC35) since 1978. Site data show a decrease in concentration and deposition of wet sulfate and no overall trend in concentration and deposition of wet nitrate. Concentration of wet ammonium has increased, with a substantial upward trend since 1993. Deposition of wet ammonium has increased since 1987.

Cape Romain NWR, SC A NADP/NTN site was installed at Cape Romain NWR, South Carolina (site #SC05) in 2000. Data are not yet available from the site.

Fort Johnson, SC A NADP/NTN site was installed at Fort Johnson, South Carolina (site #SC99) in 2002. Data are not yet available from the site.

Santee NWR, SC A NADP/NTN site was installed at Santee NWR, South Carolina (site #SC06) in 1984. Site data show a decrease in wet sulfate concentration, but no trend in wet sulfate deposition. There has been no trend in wet nitrate concentration or deposition. There has been an increasing trend in wet ammonium concentration and deposition.

Dry Deposition

The Clean Air Status and Trends Network (CASTNet) is considered the nation's primary source for atmospheric data to estimate dry acidic deposition. Established in 1987, CASTNet now comprises over 70 monitoring stations across the U.S. The majority of the monitoring stations are operated by EPA; however, approximately 20 stations are operated by the NPS in cooperation with EPA. Each CASTNet dry deposition station measures: weekly average atmospheric concentrations of sulfate, nitrate, ammonium, sulfur dioxide, and nitric acid; hourly concentrations of

ambient ozone; and meteorological conditions required for calculating dry deposition rates. Dry deposition rates are calculated using atmospheric concentrations, meteorological data, and information on land use, vegetation, and surface conditions. CASTNet complements the database compiled by NADP/NTN. Because of the interdependence of wet and dry deposition, NADP/NTN wet deposition data are collected at or near all CASTNet sites. Together, these two long-term databases provide the necessary data to estimate trends and spatial patterns in total atmospheric deposition. The ARD recommends that all new dry deposition sites installed in parks use CASTNet siting criteria and follow CASTNet protocols.

None of the Southeast Coast Network parks have a CASTNet monitor on site. Nine of the parks have a monitor within 120 miles that can provide representative data. Eight parks (Castillo de San Marcos National Monument (NM), Cumberland Island National Seashore (NS), Fort Caroline National Memorial (NMem), Fort Frederica NM, Fort Pulaski NM, Fort Matanzas NM, Fort Sumter NM and Timucuan Ecological and Historic Reserve) have no representative dry deposition data. However, given the expense of dry deposition monitoring, unless there is a need to better quantify dry deposition in a park, the ARD does not recommend the Network fund CASTNet monitoring.

Because CASTNet uses different monitoring and reporting techniques than NADP/NTN, the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported values. Due to the small number of CASTNet sites nationwide, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected at sites closest to Southeast Coast Network parks are as follows:

Crossville, AL: The Crossville, Alabama, CASTNet site (site #SND152 (Sand Mountain Experiment Station)) has been in operation since 1988. There has been a decrease in dry sulfur deposition at the site, but no trend in dry nitrogen deposition. Total nitrogen deposition at the site is composed of 36 percent dry deposition and 64 percent wet deposition, while total sulfur deposition is 41 percent dry and 59 percent wet.

Indian River, FL: A CASTNet monitor was installed in Indian River County, Florida (site #IRL141) in 2001. Data are not yet available from the site.

Pike County, GA: The Pike County, Georgia, CASTNet site (site #GAS153 (Georgia Station)) has been operating since 1989. Site data indicate an increase in dry nitrogen deposition, and a decrease in dry sulfur deposition. Total nitrogen deposition at the site is estimated to be 58 percent wet and 42 percent dry; total sulfur deposition has the same percentages.

Beaufort, NC: A CASTNet site was installed at Beaufort, North Carolina (site #BFT142) in 1994. Data indicate no trends in dry nitrogen or sulfur deposition. Total nitrogen deposition at the site is estimated to be 68 percent wet and 32 percent dry, while total sulfur deposition is 64 percent wet and 36 percent dry.

Candor, NC: A CASTNet site has been operating at Candor, North Carolina (site #CND125) since 1990. Site data indicate no trends in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at the site is composed of 37 percent dry deposition and 63 percent wet deposition, while total sulfur deposition is 34 percent dry and 66 percent wet.

Air Toxics

Air toxics, e.g., mercury, dioxins, and benzene, may be a concern for Network parks, particularly those that are located near urban areas. Some states conduct air toxics monitoring. In most cases, the monitoring is focused primarily on urban areas and/or industrial sites. The air agencies in states with Southeast Coast Network parks were contacted regarding current and planned air toxics monitoring. The results are summarized below.

Alabama Contact: Elvin Lang, 334-271-7905. Alabama currently monitors airborne mercury near Mobile. The state may expand their toxics monitoring program in the future.

Florida Contact: Caroline Shire, Central District, 407-894-7555 and Air Program, Duvall County, 904-630-4900. According to Caroline Shire, no air toxics monitoring is conducted near Canaveral NS, and no toxics monitoring sites are planned at this time. There are two air toxics monitors currently located in Jacksonville, and three more will be installed in the near future. Site descriptions and some data from a 2001 study are available on the Duval County website (http://www.coj.net/Departments/Regulatory+and+Environmental+Services/Air+and+Water+Quality/Lab+Services.htm).

Georgia Contact: Susan Zimmer-Dauphinee, 404-363-7079. Georgia has a long history of air toxics monitoring, and monitoring has taken place in a number of locations around the state. The state prepares annual reports on its toxics monitoring program. Copies of the reports are available from Susan Zimmer-Dauphinee. Current monitoring locations include Utoy Creek in Atlanta (Chattahoochee River National Recreation Area), Brunswick (Cumberland Island NS and Fort Frederica NM), Dawsonville (Chattahoochee River NRA), Macon (Ocmulgee NM), Savannah (Fort Pulaski NM), Tucker (Chattahoochee River NRA), and Yorkville (Kennesaw Mountain National Battlefield Park (NBP)).

North Carolina Contact: Julie Kinlaw, 919-733-3843. The state conducts air toxics monitoring in a number of locations, but none are near Southeast Coast Network parks. There are no plans to add additional sites to the state's toxics monitoring program in the near future.

South Carolina Contact: Robert Schilling, 803-896-0907. The state monitors air toxics in a number of locations, including Charleston (Fort Sumter NM) and Columbia (Congaree National Park). No additional toxics monitoring sites are planned at this time.

Surface Water Chemistry

The Water Resources Division's Baseline Water Quality Data Inventory and Analysis reports were reviewed for all Southeast Coast Network parks except Chattahoochee River NRA and Fort Sumter NM. Air pollution concerns relative to surface water chemistry include acidification due to sulfur and nitrogen deposition in fresh water, eutrophication from excess nitrogen deposition in fresh or saline water, and deposition of toxic air pollutants such as mercury, other metals, and organics. In general, acid-sensitive surface waters have a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l). Results for the Network parks are summarized below.

CAHA – The 1994 Baseline Water Quality Data Inventory and Analysis report for Cape Hatteras NS suggests that all surface waters associated with the park are either saline or tidally influenced (National Park Service 1994d). If this is the case, then surface water acidification is not a concern for the park. The report did not indicate that nitrogen-associated eutrophication was an issue.

CANA – The 1996 Baseline Water Quality Data Inventory and Analysis report for Canaveral NS suggests that all surface waters associated with the park are either saline or tidally influenced (National Park Service 1994c). If this is the case, then surface water acidification is not a concern for the park. The report did not indicate that nitrogen-associated eutrophication was an issue.

CALO – The 1995 Baseline Water Quality Data Inventory and Analysis report for Cape Lookout NS suggests that all surface waters associated with the park are either saline or tidally influenced (National Park Service 1994e). If this is the case, then surface water acidification is not a concern for the park. The report did not indicate that nitrogen-associated eutrophication was an issue.

CASA / FOMA – The 1998 Baseline Water Quality Data Inventory and Analysis report for Castillo de San Marcos NM suggests that all surface waters associated with the park are either saline or tidally influenced (National Park Service 1994f). If this is the case, then surface water acidification is not a concern for the park. The report did not indicate that nitrogen-associated eutrophication was an issue.

The 1999 Baseline Water Quality Data Inventory and Analysis report for Fort Matanzas NM suggests that all surface waters associated with the park are either saline or tidally influenced (National Park Service 1994b). If this is the case, then surface water acidification is not a concern for the park. The report did not indicate that nitrogen-associated eutrophication was an issue.

CONG – The 1998 Baseline Water Quality Data Inventory and Analysis report for Congaree National Park contains data collected in the park from 1992 to 1997 (National Park Service 1998a). Samples collected in Lower Tom's Creek, Cedar Creek, and the Congaree River had average pH values of 5.9 to 6.5, with a minimum pH of 5.1. The average ANC value on Cedar Creek was 38 µeq/l, and the minimum value was 16 µeq/l. The average ANC on the Congaree River was 160 µeq/l and the minimum value was 64 µeq/l. Weston and Wise Lakes also had low pH values, with an average pH of 5.9 and a minimum of 4.0. These data indicate surface waters in Congaree National Park are extremely acid sensitive, and it's possible that they currently experience episodic acidification, i.e., precipitation events that cause the creeks and lakes to lose all buffering capacity for a short amount of time. There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

CUIS – The 1997 Baseline Water Quality Data Inventory and Analysis report for Cumberland Island NS shows that no water chemistry data have been collected in the park (National Park Service 1994a). There is no indication that nitrogen-associated eutrophication is an issue.

FOFR – The 1998 Fort Frederica NM Baseline Water Quality Data Inventory and Analysis report indicates no water quality data have been collected in the park, and no pH or ANC data are available for the study area (National Park Service 1998b). Nevertheless, based on the description of the park on the Fort Frederica NM website, it doesn't appear this surface water acidification is a concern for the park. There is no indication that nitrogen-associated eutrophication is an issue.

FOPU – The 2001 Baseline Water Quality Data Inventory and Analysis report for Fort Pulaski NM includes data collected in the park from 1971 to 1998 (National Park Service 2001). The feeder canal and Savannah River had average pH values of 7.3, and the Wilmington River had a pH of 6.5. The Savannah River had an average ANC of 504 µeq/l, and the Wilmington River had an ANC of 216 µeq/l. These data indicate surface waters in the park are not sensitive to acidification from atmospheric deposition. The report did not indicate that nitrogen-associated eutrophication was an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

HOBE – The 1997 Baseline Water Quality Data Inventory and Analysis report for Horseshoe Bend National Military Park (NMP) includes data collected in the park from the Tallapoosa River and its tributaries between 1994 and 1997. The data show an average pH of 6.7 and an average ANC of about 300 µeq/l. The data indicate surface waters in the park are not sensitive to acidification from atmospheric deposition. The report did not indicate that nitrogen-associated eutrophication was an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

KEMO – The 1997 Baseline Water Quality Data Inventory and Analysis report for Kennesaw Mountain NBP includes data collected in the park from John Ward Creek and Noses Creek from 1993 to 1997. The creeks had an average pH of 6.6, with a minimum of 6.0. While it's not possible to accurately assess acid

sensitivity without ANC data, the average pH values suggest the creeks are not likely to be sensitive to acidification from atmospheric deposition. There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

MOCR – The 1997 Baseline Water Quality Data Inventory and Analysis report for Moores Creek National Battlefield (NB) says some surface waters in the study area have been affected by mining activities. This may be the case for Moores Creek, because samples collected from 1985 to 1996 had an average pH of 5.8 (4.9 minimum) and an average ANC of 40 µeq/l (range of 16-120 µeq/l). These data indicate Moores Creek is extremely acid sensitive, and it's possible that the creek currently experiences episodic acidification. There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

OCMU – The 2002 Baseline Water Quality Data Inventory and Analysis report for Ocmulgee NM includes data collected in the park from Walnut Creek and an unnamed creek in 1994 and 1995 (National Park Service 2002b). The creeks had an average pH of about 6.6, with a minimum of 6.2. While it's not possible to accurately assess acid sensitivity without ANC data, the average pH values suggest the creeks are not likely to be sensitive to acidification from atmospheric deposition. There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

TIMU/FOCA – The 2002 Baseline Water Quality Data Inventory and Analysis report for Fort Caroline NMem shows Spanish Pond was sampled in 1997 and 1998 (National Park Service 2002a). The pond had an average pH of 6.4 with a minimum value of 5.8. While it's not possible to accurately assess acid sensitivity without ANC data, the average pH values suggest the pond is not likely to be sensitive to acidification from atmospheric deposition. All other surface waters associated with the park appear to be either saline or tidally influenced. If this is the case, then surface water acidification is not a concern for the park. There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

The 2002 Baseline Water Quality Data Inventory and Analysis report for Timucuan Ecological and Historic Reserve appeared to contain data only for surface waters that are either saline or tidally influenced. If fresh water occurs in the park, its sensitivity to acidification is unknown. There is no indication that nitrogen-associated eutrophication is an issue. Surface waters in the study area contained elevated levels of a number of heavy metals, so deposition of airborne toxics may be of concern for the park.

Particulate Matter

Small or "fine" particles in the air, typically those less than 2.5 micrometers in diameter, $PM_{2.5}$, are a leading cause of human respiratory illness. Particles are present everywhere, but high concentrations and/or specific types have been found to present a serious danger to human health. Fine particles in the air are the main contributor to human-caused visibility impairment. The particles not only decrease the distance one can see; they also reduce the colors and clarity of scenic vistas. Moisture in the air enhances the impact, so areas in the Eastern U.S., with higher relative humidity, have worse visibility than areas in the arid West (see attached Air Inventory map). In 1997, EPA finalized new stricter, human-health based, National Ambient Air Quality Standards (NAAQS) for particulate matter. Original NAAQS for particulate matter were for those particles 10 microns or less (PM_{10}). The new national standards now regulate $PM_{2.5}$.

Fort Sumter NM has a PM_{10} monitor on-site, all other Southeast Coast Network parks have representative data collected within 35 miles. None of the states with Southeast Coast Network parks have areas currently designated nonattainment for PM_{10}. Nationwide $PM_{2.5}$ monitoring was initiated in 1999; nonattainment areas will not be designated until 2004. 1999-2001 data indicate coastal Southeast Coast Network parks will be in attainment for $PM_{2.5}$, but non-coastal parks will likely be nonattainment.

In 1985, in response to the mandates of the Clean Air Act, Federal and regional/state organizations established the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to protect visibility in Class I air quality areas. Class I areas are national parks greater than 5,000 acres and wilderness areas greater than 6,000 acres, that were established prior to August 7, 1977. All other NPS areas are designated Class II. The objectives of the IMPROVE program are: to establish current visibility conditions in all Class I areas; to identify pollutants (particles and gases) and emission sources responsible for existing man-made visibility impairment; and to document long-term trends in visibility. In 1999, there were 30 official IMPROVE sites and 40 protocol sites. Because of recently enacted regulations that require improving visibility in Class I areas, the number of visibility monitors is increasing. Protocol sites are being upgraded to full IMPROVE sites and 80 new sites are being added to the IMPROVE network.

While the IMPROVE program has focused on Class I air quality areas, a great deal of visibility monitoring has been conducted in Class II areas. The ARD recommends that new visibility monitoring in NPS areas be conducted in coordination with the IMPROVE program (the IMPROVE program is managed out of the NPS ARD office in Fort Collins, Colorado). Some I&M Networks are considering monitoring visibility at scenic vistas with digital cameras. While this type of monitoring would not be adequate for regulatory purposes, it is useful for documenting visibility conditions and trends and provides an excellent means of sharing that information with the public.

None of the Southeast Coast Network parks have an IMPROVE monitor on site. Eleven parks have IMPROVE sites within 100 miles that can provide representative data. There are no nearby, Atlantic coast IMPROVE sites to provide data for Canaveral NS, Casa de San Marcos NM or Fort Matanzas NM, and there are no nearby inland sites for Horseshoe Bend NMP, Moores Creek NB or Ocmulgee NM. IMPROVE sites have been operating at Cape Romain NWR, South Carolina, since 1994 (site #ROMA); at Chassahowitzka NWR, Florida, since 1993 (site #CHAS); at Okefenokee NWR, Georgia, since 1991 (site #OKEF); and at Sipsey Wilderness Area (WA), Alabama, since 1992 (site #SIPS). Sites were installed at Cohutta WA, Georgia (site #COHU) and Swanquarter NWR, North Carolina (site #SWAN) in 2000.

Long-term visibility trends have not yet been determined for any IMPROVE sites in the Southeast Coast Network area. As for the sources of visibility impairment, 1996-1998 aerosol data from the four long-term sites show that, on an annual basis, visibility impairment is primarily due to sulfates (sources include coal combustion and oil refineries), then organics (sources include automobiles and chemical manufacturing), then soil (from windblown dust), then light absorbing carbon (sources include wood burning), and then nitrates (sources include coal and natural gas combustion and automobiles). At all sites, visibility was best in the winter and worst in the summer.

Ozone

Congaree National Park and Fort Sumter NM have ozone monitors on-site, the rest of the Southeast Coast Network parks have one or more ozone monitors within 35 miles. Chattahoochee River NRA, Congaree National Park, Kennesaw Mountain NBP, and Ocmulgee NM are in areas that will likely be designated nonattainment under EPA's new human-health based 8-hour NAAQS (Figure A11-3, Figure A11-4, Figure A11-5, Figure A11-6, Figure A11-7).

With the exception of CONG and FOSU, ambient concentrations of ozone were not monitored on-site, but were estimated by Krieging, a statistical interpolation process. The estimated hourly concentrations of ozone were then used to generate annual exposure values for the site (National Park Service 2004). The exposure values include the

Sum06 and W126 exposure indices in ppm-hr and the annual number of hours above 60, 80 and 100 ppb (N60, N80 and N100, respectively).

The uptake of ambient ozone by a plant is highly dependent upon the environmental conditions under which the exposure takes place, and the level of soil moisture is an important environmental variable controlling the process. Understanding the soil moisture status can provide insight to how effective an exposure may be in leading to foliar injury. The Palmer Z Index was selected to indicate soil moisture status since it represents the short-term departure of soil moisture from the average for each month for the site. The objectives of the assessment were to examine the relationship between high annual levels of ozone and soil moisture status, and to consider the impact reduced soil moisture status would have on the effectiveness of exposure.

The Palmer Z Index is calculated for up to 10 regions within a state and therefore is not a site-specific index. Without site-specific data, ozone/soil moisture relationships can only be estimated. Site-specific criteria such as aspect, elevation, and soil type can alter soil moisture conditions such that they depart from those determined for the region. However, in lieu of site-specific data, the Palmer Z Index is the best estimate of short-term soil moisture status and its change throughout the growing season.

Palmer Z data were compiled for the site for both the three months used to calculate the Sum06 index and for the April through October period for the W126 index for 1995 through 1999. It was not possible to identify the specific 3-month summation period for the Sum 06 index since the index was obtained by Krieging. The summation period was estimated from the 3-month periods for Sum 06 indices calculated from monitored ozone data for sites within 50 km of the park. The Palmer Z index ranges from approximately +4.0 (extreme wetness) to –4.0 (extreme drought) with ±0.9 representing normal soil moisture.

CAHA: The risk of foliar ozone injury at Cape Hatteras National Seashore is moderate. The threshold level for injury is consistently satisfied by the Sum06 index, while the W126 index satisfies the criteria on occasion. The N-values indicate that in some years there are consistent exposures to concentrations of ozone greater than 80 ppb, and significant hours of exposure at 100 ppb. The lack of a relationship between level of ozone and soil moisture suggests that conditions favorable for the uptake of ozone occur independently of the levels of exposure. This creates the possibility of reaching the threshold for injury when high levels of exposure happen to coincide with favorable soil moisture conditions.

CANA: The low levels of ozone exposure and the relatively dry soil moisture conditions at Canaveral National Seashore make the risk of foliar ozone injury to plants low. Although the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Soil moisture conditions of mild to severe drought reduce the effectiveness of the higher ozone exposures, and hourly concentrations of ozone only occasionally exceeded 80 ppb.

CALO: The risk of foliar ozone injury at Cape Lookout National Seashore is moderate. The threshold level for injury is consistently satisfied by the Sum06 index, while the W126 index satisfies the criteria on occasion. The N-values indicate that in some years there are consistent exposures to concentrations of ozone greater than 80 ppb, and significant hours of exposure at 100 ppb. The lack of a relationship between level of ozone and soil moisture suggests that conditions favorable for the uptake of ozone occur independently of the levels of exposure. This creates the possibility of reaching the threshold for injury when high levels of exposure happen to coincide with favorable soil moisture conditions such as 1996.

CASA / FOMA: The risk of foliar ozone injury at Castillo De San Marcos National Monument is moderate. The Sum06 threshold is satisfied annually while the W126 threshold is satisfied only in the highest exposure years. In these years, however, soil moisture levels are at mild to severe levels of drought that reduce the uptake of ozone. The N-values indicate that exposures to 80 to 100 ppb vary considerably among years. It

is anticipated that the risk of injury may be greatest in years when ambient levels of ozone are moderately high and soil moisture conditions favor uptake by plants. At present, no ozone-sensitive species have been identified at the site, and the risk remains unrealized.

The low levels of ozone exposure and the relatively dry soil moisture conditions at Fort Matanzas National Monument make the risk of foliar ozone injury to plants low. While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to severe drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceed 80 ppb, it is unlikely that foliar injury will be produced on plants.

CHAT: The risk of foliar ozone injury to plants at Chattahoochee River National Recreation Area is high. While the levels of ozone exposure consistently create the potential for injury, dry soil conditions may reduce the likelihood of injury in a particular year. However, levels of exposure capable of producing foliar injury also occur under conditions of minor drought. The probability of foliar injury developing may be greatest during years in which ozone levels are somewhat reduced but still exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone.

CONG: The risk of foliar ozone injury at the Congaree National Park is low. While the threshold level for injury is satisfied by the Sum06 index, the N-values indicate that there are only occasional exposures to concentrations of ozone greater than 80 ppb and exposures above 100 ppb are rare. Relationships between levels of ozone and soil moisture are inconsistent, but suggest that conditions limiting the uptake of ozone occur during most years and may be most prevalent during higher ozone years. It is anticipated that the risk of injury may be greatest in years when ambient levels of ozone are high and soil moisture conditions favor uptake by plants.

CUIS: The low levels of ozone exposure and the relatively dry soil moisture conditions at Cumberland Island National Seashore make the risk of foliar ozone injury to plants low. While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to moderate drought reduce the effectiveness of the exposures, and hourly concentrations of ozone seldom exceeded 80 ppb, it is unlikely that foliar injury will be produced on plants.

FOFR: The low levels of ozone exposure and the relatively dry soil moisture conditions at Fort Frederica National Monument make the risk of foliar ozone injury to plants low. While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to severe drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceed 80 ppb, it is unlikely that foliar injury will be produced on plants.

FOPU: The low levels of ozone exposure and the relatively dry soil moisture conditions at Fort Pulaski National Monument make the risk of foliar ozone injury to plants low. While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to severe drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceeded 80 ppb, it is unlikely that foliar injury will be produced on plants.

FOSU: The low levels of ozone exposure and dry soil moisture conditions at Fort Sumter National Monument make the risk of foliar ozone injury to plants low. While the Sum06 index meets the criteria for injury, the W126 does not since the N100 criterion is not satisfied. Since periodic soil moisture conditions of mild to moderate drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceed 80 ppb, it is unlikely that foliar injury will be produced on plants.

HOBE: The risk of foliar ozone injury to plants at Horseshoe Bend National Military Park is high. While the levels of ozone exposure generally create the potential for injury, low soil moisture may reduce the likelihood of injury developing in the higher ozone years. Because the site is subject to potentially harmful levels of

ozone in most years, the probability of foliar injury developing may be greatest during years in which ozone levels are somewhat reduced but still exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone.

KEMO: The risk of foliar ozone injury to plants at Kennesaw Mountain National Battlefield Park is high. While the levels of ozone exposure consistently create the potential for injury, low soil moisture may reduce the likelihood of injury developing in any particular year. Since the site is subject to potentially harmful levels of ozone annually, the probability of foliar injury developing may be greatest during years in which ozone exposures exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone.

MOCR: The risk of foliar ozone injury at Moore's Creek National Battlefield is moderate. The Sum06 threshold is satisfied annually while the W126 threshold is satisfied only in the highest exposure years. The N-values indicate that exposures to 80 to 100 ppb vary considerably among years. Months of low soil moisture occur independent of the level of ozone and can significantly constrain the uptake of ozone. It is anticipated that the risk of injury would be greatest in years when high levels of ozone happened to occur when soil moisture conditions favor its uptake by plants.

OCMU: The risk of foliar ozone injury to plants at Ocmulgee National Monument is high. The levels of ozone exposure consistently create the potential for injury, however dry soil conditions may reduce the likelihood of injury in a high exposure year. Levels of exposure capable of producing foliar injury also occur under conditions of minor drought and normal soil moisture. The probability of foliar injury developing may be greatest during years in which ozone levels are somewhat reduced but still exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone.

TIMU / FOCA: The low levels of ozone exposure and the relatively dry soil moisture conditions at Fort Caroline National Monument make the risk of foliar ozone injury to plants low. While the Sum06 exposures exceed the threshold levels for injury, the W126 do not since the N100 criterion is not satisfied. Since soil moisture conditions of mild to severe drought reduce the effectiveness of the higher exposures, and hourly concentrations of ozone seldom exceeded 80 ppb, it is unlikely that foliar injury will be produced on plants.

The low levels of ozone exposure and the periodically dry soil moisture conditions at Timucuan Ecological and Historic Preserve make the risk of foliar ozone injury to plants low. While the Sum06 exposures exceed the threshold level for injury, the W126 do not since the N100 criteria are not satisfied. High ozone exposures occur during periods of several continuous months of mild to severe drought significantly reduce their effectiveness. Hourly concentrations of ozone exceed 80 ppb for a few hours each year and are unlikely to produce foliar injury to plants.

Conclusions

None of the Southeast Coast Network parks have an NADP/NTN monitor on-site; all have a monitor within 85 miles. It is likely that all parks are well represented by existing monitors.

None of the Southeast Coast Network parks have a CASTNet monitor on site. Nine of the parks have a monitor within 120 miles that can provide representative data. Eight of the parks in Florida and coastal Georgia and South Carolina have no representative dry deposition data. However, given the expense of dry deposition monitoring, the existence of representative wet deposition data, and the fact that surface waters in these parks don't appear to be sensitive to atmospheric deposition, installation of a CASTNet monitor is not recommended.

Air toxics may be an issue for many Southeast Coast Network parks. States conduct air toxics monitoring near all parks except Canaveral NS, Cape Hatteras NS, Cape Lookout NS, Horseshoe Bend NMP, and Moores Creek NB.

Network staff may want to consider monitoring contaminants in biota in those parks where air toxics are a concern.

Park water quality data were reviewed for fifteen Southeast Coast Network parks. The data indicated surface waters at Congaree National Park and Moores Creek NB are extremely sensitive to acidification from atmospheric deposition. Network staff may want to consider long-term monitoring of acid deposition-related water chemistry parameters, such as pH and ANC, at these parks.

Fort Sumter NM has a PM_{10} monitor on-site, all other Southeast Coast Network parks have representative data collected within 35 miles.

None of the Southeast Coast Network parks have an IMPROVE monitor on site. Eleven parks have IMPROVE sites within 100 miles that can provide representative data. There are no nearby, Atlantic coast IMPROVE sites to provide data for Canaveral NS, Casa de San Marcos NM or Fort Matanzas NM, and there are no nearby inland sites for Horseshoe Bend NMP, Moores Creek NB or Ocmulgee NM. Installation of an IMPROVE monitor in a north Florida coastal park would fill a gap in the IMPROVE network, and would enhance data interpretation for a number of Southeast Coast Network parks. Parks with visibility concerns may want to consider using a less expensive, digital camera to document and interpret visibility degradation.

Congaree National Park and Fort Sumter NM have ozone monitors on-site, the rest of the Southeast Coast Network parks have one or more ozone monitors within 35 miles.

Ozone sensitive vascular plant species have been identified for sixteen of the parks in the Southeast Coast Network. Ozone concentrations are high enough in all parks that foliar injury surveys may be warranted. Black cherry and milkweed are good candidates for such surveys.

Relevant Websites

NPS Air Inventory (Air Atlas) - http://www2.nature.nps.gov/ard/gas/
NADP - http://nadp.sws.uiuc.edu/
CASTNet - http://www.epa.gov/castnet/
IMPROVE - http://vista.cira.colostate.edu/improve/
Ozone - http://www.epa.gov/air/data/index.html

Tables

Table A11-1. Summary of air quality issues in Southeast Coast Network Parks. ["↑", Increasing; "↓", Decreasing; "NT", No Trend; "Y", Yes; "N", No; "○", Frequent or consistently surpasses air quality thresholds; "○", surpasses or infrequently surpasses air quality thresholds; "-", either does not surpass air quality thresholds or no data are available; "L", Low; "M", Medium; "H", High].

		CAHA	CANA	CALO	CASA / FOMA	CHAT	CONG	CUIS	FOFR	FOPU	FOSU / CHPI	HOBE	KEMO	MOCR	OCMU	TIMU / FOCA
Wet Deposition																
Ammonium	Deposition		↑		NT		↑					NT		↑	NT	NT
	Concentration		↑		NT		↑					↑		↑	NT	NT
Nitrate	Deposition		↑		NT							↑		NT	NT	NT
	Concentration		↑		NT							↑		NT	NT	NT
Sulfate	Deposition		NT		↓							↓		↓	↑	↓
	Concentration		NT		↓							↓		↓	↑	↓
Dry Deposition																
Nitrogen	Overall dry deposition			NT								NT		NT	↑	
	Percentage of total N that is dry			32								36		37	42	
Sulfur	Overall dry deposition			NT								↓		NT	↓	
	Percentage of total S that is dry			36								41		34	42	
Surface Water Chemistry																
Acidification	Concern for Park	N	N	N	N		Y	N	N	N		N	N	Y	N	N
Metals	Potential aerial deposition						Y			Y		Y	Y	Y	Y	Y
Nutrients	Potential aerial deposition	N	N	N	N		N	N	N	N		N	N	N	n	N
Ozone																
Sum06	Frequency standard surpassed	●	○	●	●	●	○	○	○	○	○	●	●	●	●	○
W126	Frequency standard surpassed	○	-	○	-	●	○	-	-	-	-	●	●	○	●	-
Foliar Injury	Risk based on conditions	M	L	M	M/L	H	L	L	L	L	L	H	H	M	H	L

Table A11-2. Plant species in the Southeast Coast Network that are "very sensitive" to ozone.

Code	Scientific Name	Common Name	Family
AIAL	*Ailanthus altissima*	Tree-of-heaven	Simaroubaceae
ALRU2	*Alnus rubra*	Red alder	Betulaceae
AMAL2	*Amelanchier alnifolia*	Saskatoon serviceberry	Rosaceae
APAN2	*Apocynum androsaemifolium*	Spreading dogbane	Apocynaceae
ARDO3	*Artemisia douglasiana*	Mugwort	Asteraceae
ASAC6	*Aster acuminatus*	Whorled aster	Asteraceae
ASEN2	*Aster engelmannii*	Engelmann's aster	Asteraceae
ASEX	*Asclepias exaltata*	Tall milkweed	Asclepiadaceae
ASMA2	*Aster macrophyllus*	Big-leaf aster	Asteraceae
ASPU5	*Aster puniceus*	Purple-stemmed aster	Asteraceae
ASQU	*Asclepias quadrifolia*	Four-leaved milkweed	Asclepiadaceae
ASSY	*Asclepias syriaca*	Common milkweed	Asclepiadaceae
ASUM	*Aster umbellatus*	Flat-toppped aster	Asteraceae
FRAM2	*Fraxinus americana*	White ash	Oleaceae
FRPE	*Fraxinus pennsylvanica*	Green ash	Oleaceae
GEAM4	*Gentiana amarella*	Northern gentian	Gentianaceae
LIST2	*Liquidambar styraciflua*	Sweetgum	Hamamelidaceae
LITU	*Liriodendron tulipifera*	Yellow-poplar	Magnoliaceae
OEEL	*Oenothera elata*	Evening primrose	Onagraceae
PAQU2	*Parthenocissus quinquefolia*	Virginia creeper	Vitaceae
PHCA11	*Physocarpus capitatus*	Ninebark	Rosaceae
PHCO7	*Philadelphus coronarius*	Sweet mock-orange	Hydrangeaceae
PIJE	*Pinus jeffreyi*	Jeffrey pine	Pinaceae
PIPO	*Pinus ponderosa*	Ponderosa pine	Pinaceae
PIST	*Pinus strobus*	Eastern white pine	Pinaceae
PLOC	*Platanus occidentalis*	American sycamore	Platanaceae
POTR5	*Populus tremuloides*	Quaking aspen	Salicaceae
PRPE2	*Prunus pensylvanica*	Pin cherry	Rosaceae
PRSE2	*Prunus serotina*	Black cherry	Rosaceae
RHCO13	*Rhus copallina*	Flameleaf sumac	Anacardiaceae
RHTR	*Rhus trilobata*	Skunkbush	Anacardiaceae
RUAL	*Rubus allegheniensis*	Allegheny blackberry	Rosaceae
RUHI2	*Rudbeckia hirta*	Black-eyed susan	Asteraceae
RULA3	*Rudbeckia laciniata*	Cut-leaf coneflower	Asteraceae
SAAL5	*Sassafras albidum*	Sassafras	Lauraceae
SACA12	*Sambucus canadensis*	American elder	Caprifoliaceae
SAME5	*Sambucus mexicana*	Blue elderberry	Caprifoliaceae
SESE2	*Senecio serra*	Tall butterweed	Asteraceae
VILA8	*Vitis labrusca*	Northern fox grape	Vitaceae

Table A11-3. Plant species in the Southeast Coast Network that are "slightly sensitive" to ozone.

Code	Scientific Name	Common Name	Family
ACMA3	*Acer macrophyllum*	Bigleaf maple	Aceraceae
ACNE2	*Acer negundo*	Boxelder	Aceraceae
ACRU	*Acer rubrum*	Red maple	Aceraceae
AEGL	*Aesculus glabra*	Ohio buckeye	Hippocastanaceae
AEOC2	*Aesculus octandra*	Yellow buckeye	Hippocastanaceae
BEAL2	*Betula alleghaniensis*	Yellow birch	Betulaceae
BEPO	*Betula populifolia*	Gray birch	Betulaceae
BRTE	*Bromus tectorum*	Cheatgrass	Poaceae
CECA4	*Cercis canadensis*	Redbud	Fabaceae
CLLU	*Cladrastis lutea*	Yellowwood	Fabaceae
COFL2	*Cornus florida*	Flowering dogwood	Cornaceae
GLNU	*Glyceria nubigena*	Manna grass	Poaceae
KRMO	*Krigia montana*	Mountain dandelion	Asteraceae
LADE2	*Larix decidua*	European larch	Pinaceae
_LALE0	*Larix leptolepis*	Japanese larch	Pinaceae
PIBA2	*Pinus banksiana*	Jack pine	Pinaceae
PINI	*Pinus nigra*	Austrian pine	Pinaceae
PIRA2	*Pinus radiata*	Monterey pine	Pinaceae
PIRI	*Pinus rigida*	Pitch pine	Pinaceae
PITA	*Pinus taeda*	Loblolly pine	Pinaceae
PIVI2	*Pinus virginiana*	Virginia pine	Pinaceae
RHGL	*Rhus glabra*	Smooth sumac	Anacardiaceae
RHTY	*Rhus typhina*	Staghorn sumac	Anacardiaceae
ROPS	*Robinia pseudoacacia*	Black locust	Fabaceae
RUID	*Rubus idaeus*	Red raspberry	Rosaceae
RUNU2	*Rugelia nudicaulis*	Rugel's ragwort	Asteraceae
SAAR13	*Saxifraga arguta*	Saxifrage	Saxifragaceae
SAGO	*Salix gooddingii*	Gooding's willow	Salicaceae
SASC	*Salix scouleriana*	Scouler's willow	Saliaceae
SPAL	*Spartina alterniflora*	Smooth cordgrass	Poaceae
SPVA2	*Spiraea x vanhouttei*	Vanhoutte spirea	Rosaceae
SYAL	*Symphoricarpos albus*	Common snowberry	Caprifoliaceae
_SYCHX	*Syringa x chinensis*	Chinese lilac	Oleaceae
SYVU	*Syringa vulgaris*	Common lilac	Oleaceae
TIAM	*Tilia americana*	American basswood	Tiliaceae
_TIEU0	*Tilia euchlora*	Crimean linden	Tiliaceae
TIPL	*Tilia platyphyllos*	Bigleaf linden	Tiliaceae
TORA2	*Toxicodendron radicans*	Poison-ivy	Anacardiaceae
VEOC	*Verbesina occidentalis*	Crownbeard	Asteraceae
VIRI	*Vitis riparia*	Riverbank grape	Vitaceae

Code	Scientific Name	Common Name	Family
VIVI5	*Vitis vinifera*	European wine grape	Vitaceae

Figures

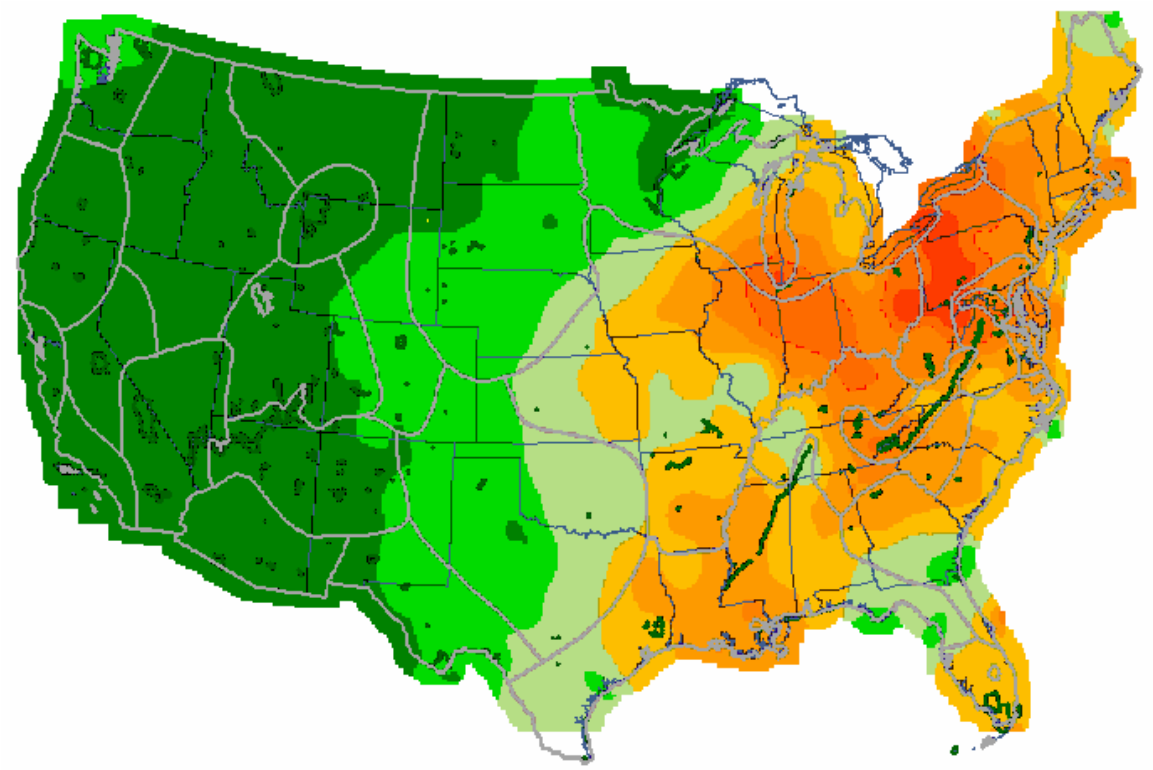

Figure A11-1. Average annual wet deposition of sulfate 1995-2000. Areas in red or orange have higher concentrations than those that are green.

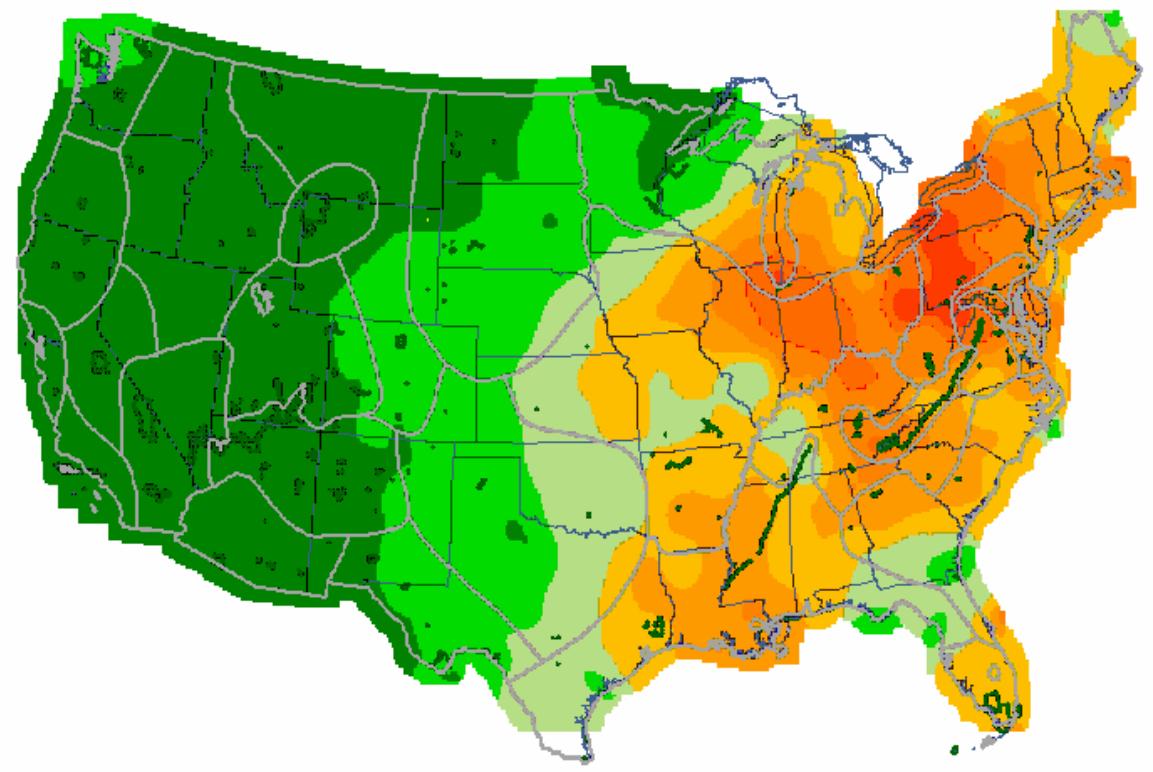

Figure A11-2. Average annual wet deposition of nitrate, 1995-2000. Areas in red or orange have higher concentrations than those that are green.

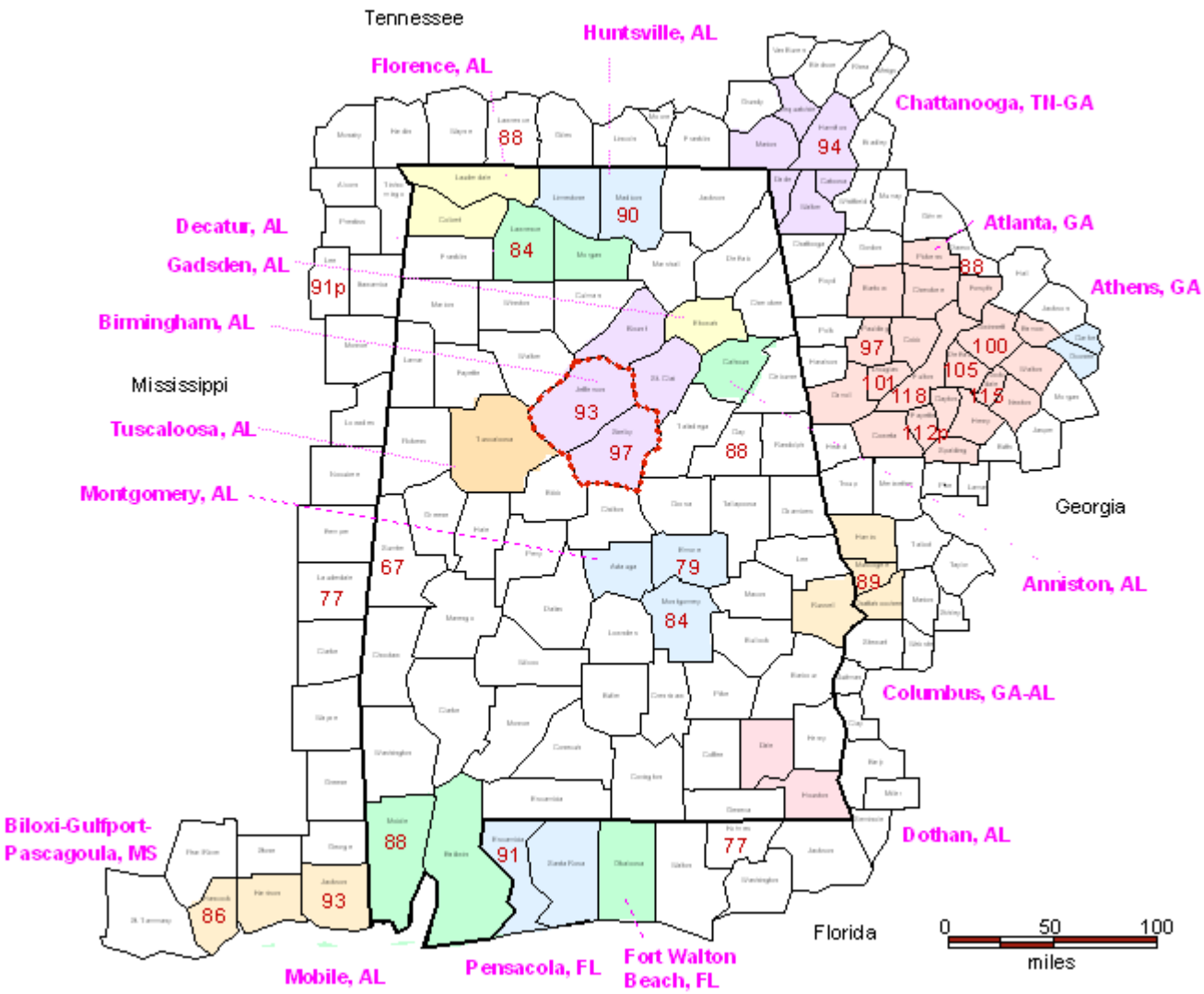

Figure A11-3. Alabama 1997-1999 8-hour Ozone design values in parts per billion. Counties with design values greater than or equal to 85 parts per billion are violating the standard. Red lines indicate counties of current or previous nonattainment. Counties in consolidated metropolitan statistical areas (C/MSAs) are shown in color. ["h", data from 1996-1998; "p", two years of data only and the county has a potential to violate].

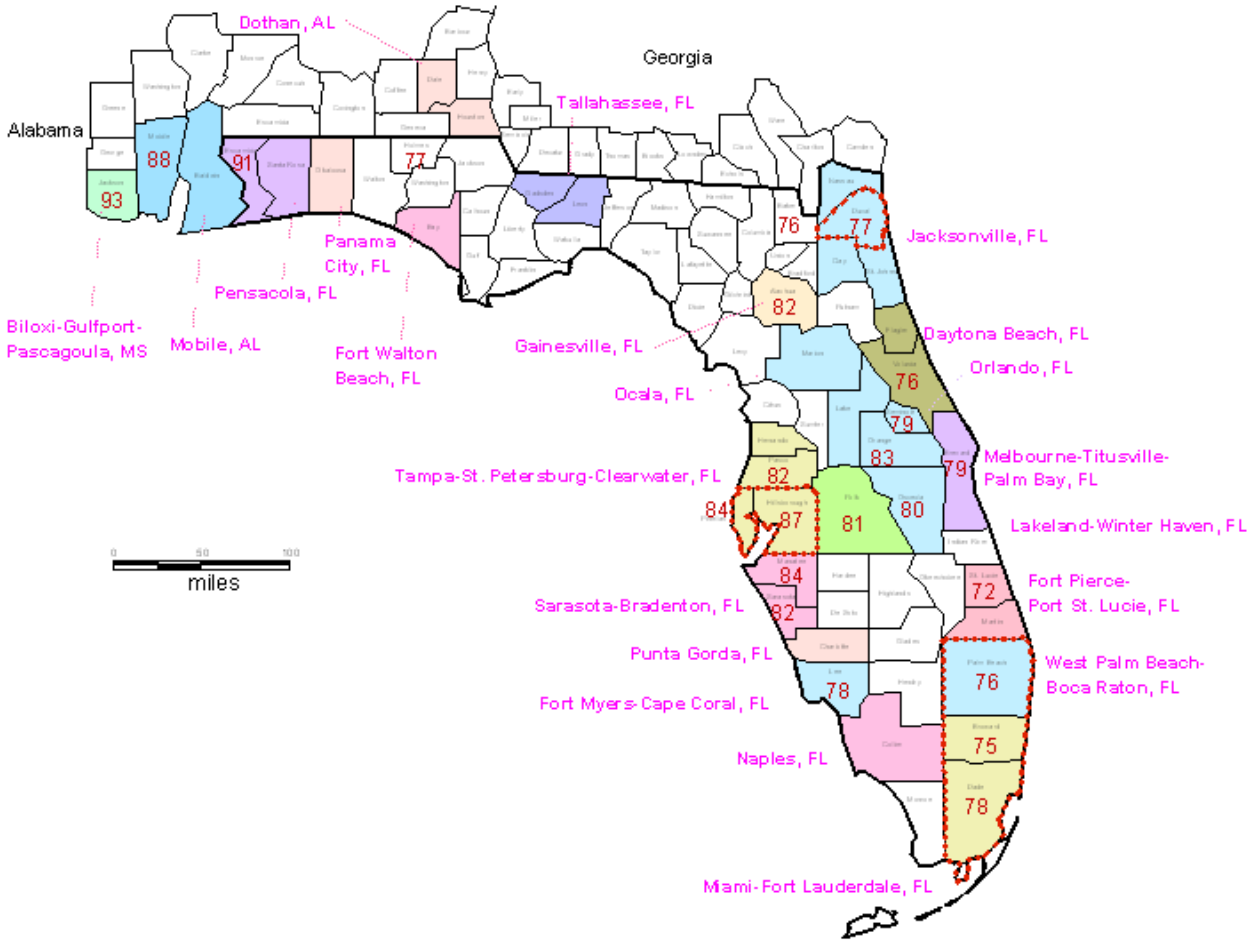

Figure A11-4. Florida 1997-1999 8-hour Ozone design values in parts per billion. Counties with design values greater than or equal to 85 parts per billion are violating the standard. Red lines indicate counties of current or previous nonattainment. Counties in consolidated metropolitan statistical areas (C/MSAs) are shown in color. ["h", data from 1996-1998; "p", two years of data only and the county has a potential to violate].

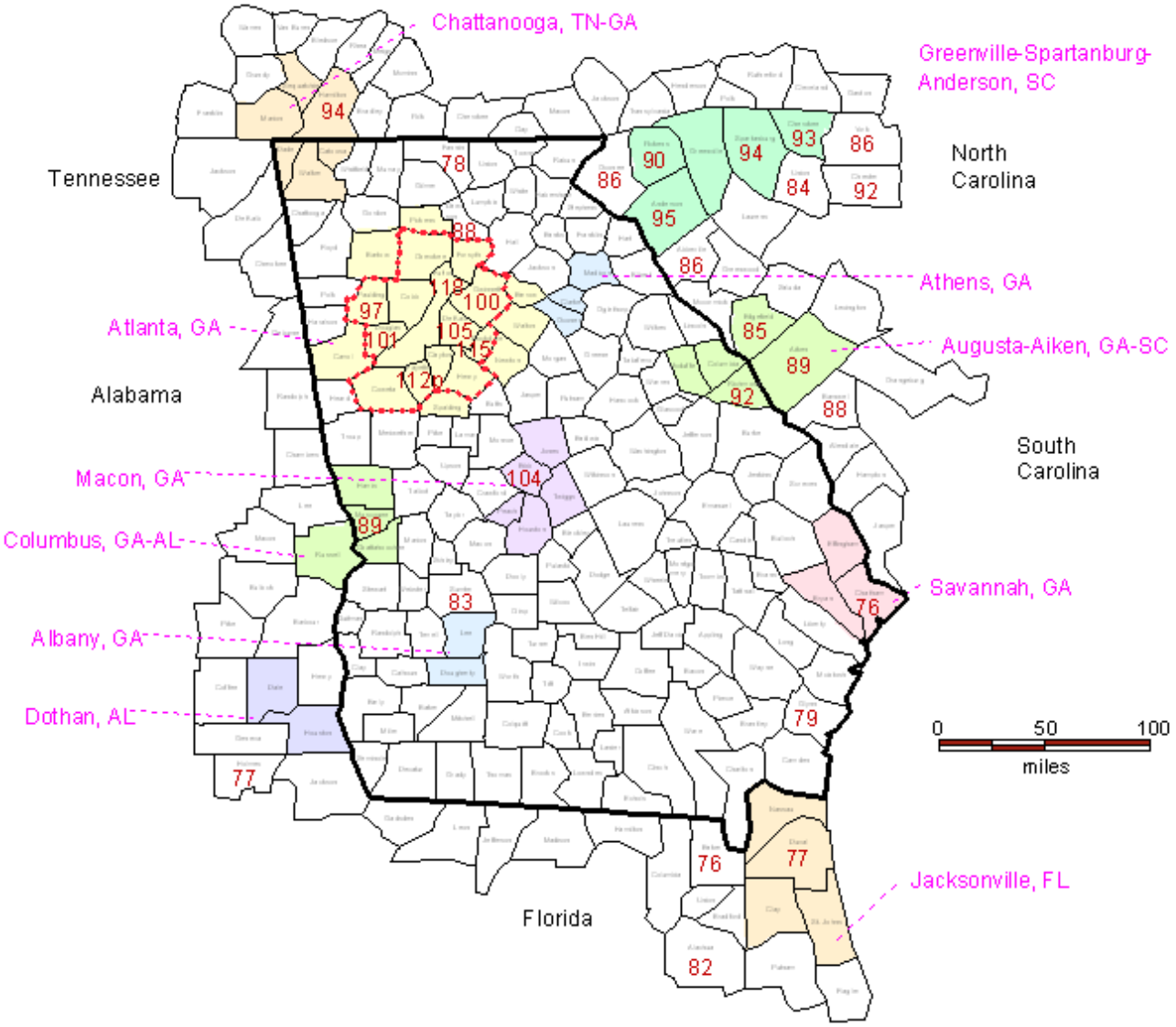

Figure A11-5. Georgia 1997-1999 8-hour Ozone design values in parts per billion. Counties with design values greater than or equal to 85 parts per billion are violating the standard. Red lines indicate counties of current or previous nonattainment. Counties in consolidated metropolitan statistical areas (C/MSAs) are shown in color. ["h", data from 1996-1998; "p", two years of data only and the county has a potential to violate].

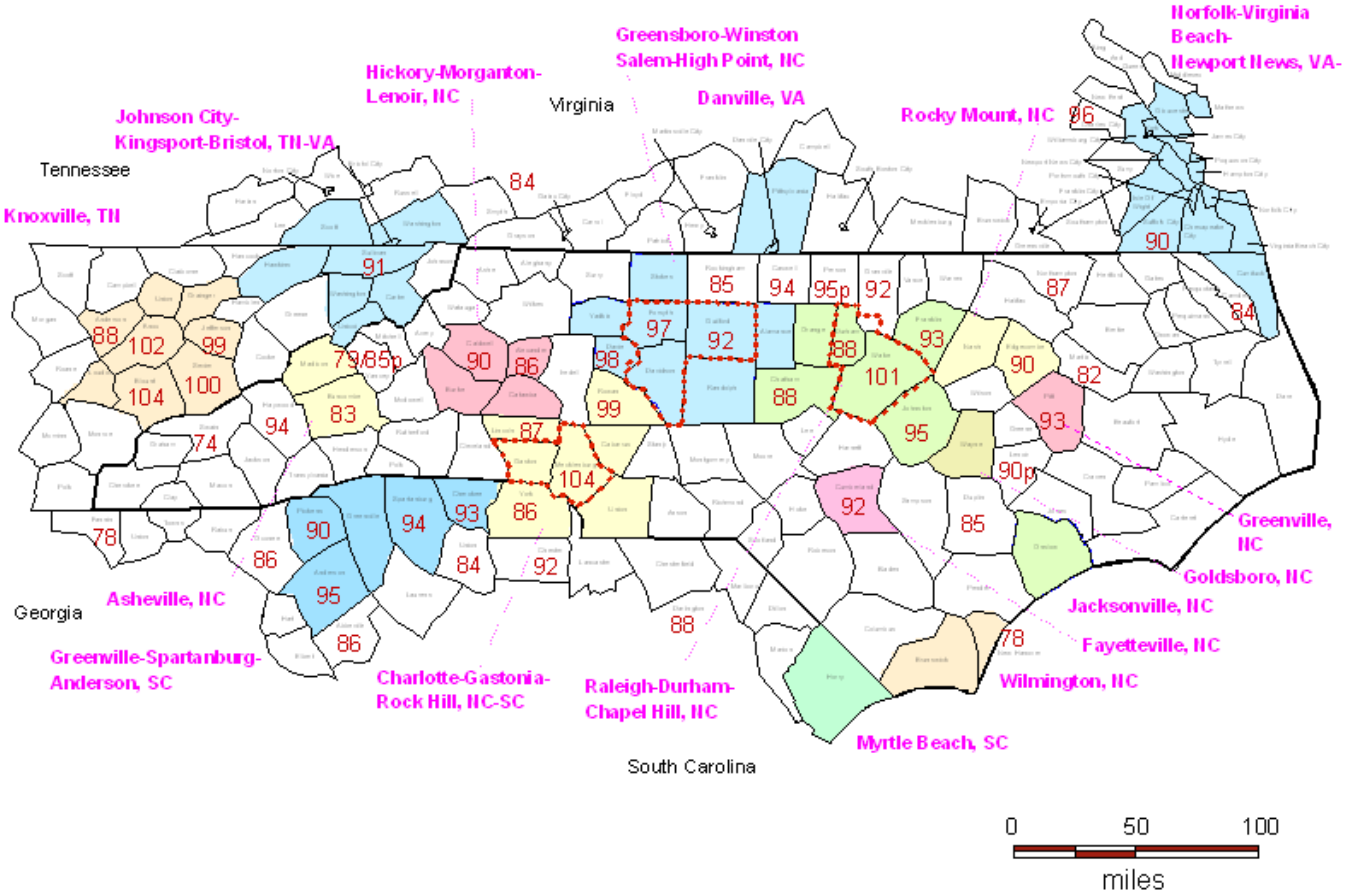

Figure A11-6. North Carolina 1997-1999 8-hour Ozone design values in parts per billion. Counties with design values greater than or equal to 85 parts per billion are violating the standard. Red lines indicate counties of current or previous nonattainment. Counties in consolidated metropolitan statistical areas (C/MSAs) are shown in color. ["h", data from 1996-1998; "p", two years of data only and the county has a potential to violate].

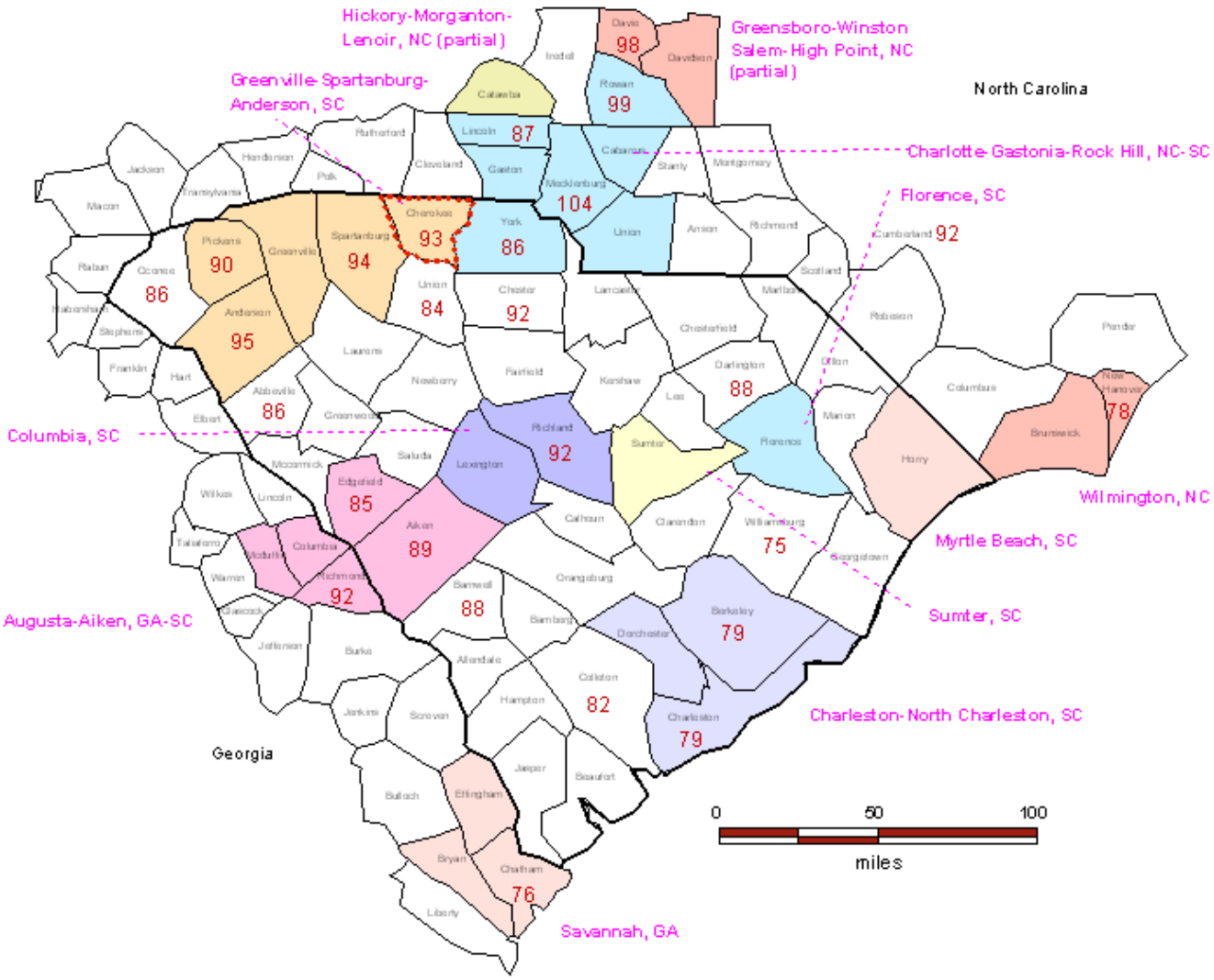

Figure A11-7. South Carolina 1997-1999 8-hour Ozone design values in parts per billion. Counties with design values greater than or equal to 85 parts per billion are violating the standard. Red lines indicate counties of current or previous nonattainment. Counties in consolidated metropolitan statistical areas (C/MSAs) are shown in color. ["h", data from 1996-1998; "p", two years of data only and the county has a potential to violate].

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