

# Fort Pulaski National Monument

National Park Service  
U.S. Department of the Interior

Inventory & Monitoring Program  
Southeast Coast Network



## Inventory & Monitoring Program Status Report, 2012

### Program Overview

In 1999, the National Park Service (NPS) initiated a long-term ecological Inventory & Monitoring (I&M) program to develop scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems, and determine how well current management practices are sustaining those ecosystems.

To accomplish this, 32 “networks” of park system units were created to develop or acquire key baseline natural resource datasets, and to begin long-term monitoring of select measurements of resource condition (Fancy et al. 2009). The overarching purpose of natural resource monitoring in parks is to support science-based management of NPS resources by:

- Determining the status and trends in selected indicators of the condition of park ecosystems.
- Providing early warning of abnormal conditions.
- Providing data to better understand the dynamic nature and condition of park ecosystems and provide reference points for comparisons with other, altered environments.
- Providing data to meet legal and Congressional mandates.
- Providing means for measuring progress toward management goals.

The Southeast Coast Network (SECN) is one of 32 NPS Networks established to implement an integrated monitoring program under the Natural Resource Challenge. In 2001, the SECN began planning and implementing its long-term Vital Signs Monitoring Program, and completed its long-term monitoring plan in 2008 (DeVivo et al. 2008, 2011). Fort Pulaski National Monument (FOPU) is one of 17 SECN parks with significant natural resources and is on the Georgia coast near Savannah (Figure 1).

### About the Park

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



Figure 1. Location of Fort Pulaski National Monument, GA.

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 1700s. In the 1800s, 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 later 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 1800s, 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 shrub land 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 provide 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. 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.

Baseline Inventories

The primary purpose of natural resource inventories is to document the presence of resources in parks, and to assess and document the current condition and knowledge of natural resources in the parks. Inventories allow comparison of existing conditions to the natural or desired state of parks and establish a solid baseline for making scientifically sound management decisions and for designing long-term monitoring plans that track the health of key park resources.

**Table 1. Status of 12 baseline inventories at Fort Pulaski National Monument [● – Complete; ◐ – In Progress]**

| Inventory                              | FOPU |
|----------------------------------------|------|
| Air Quality Data                       | ●    |
| Air Quality Related Values             | ●    |
| Base Cartography Data                  | ●    |
| Baseline Water Quality Data            | ●    |
| Climate Inventory                      | ●    |
| Geologic Resources Inventory           | ◐    |
| Natural Resource Bibliography          | ●    |
| Soil Resources Inventory               | ●    |
| Species Lists                          | ●    |
| Species Occurrence and Distribution    | ●    |
| Vegetation Map Inventory               | ◐    |
| Water Body Location and Classification | ●    |

The NPS I&M Program developed a strategy in 1992 for developing and delivering a minimal set of products for 12 “basic” natural resource inventories that were common to all park units containing significant natural resources, all of which are either complete or underway for FOPU (Table 1, see Tuberville et al. 2005, Webster 2010).

**Additional Inventories**

In addition to the 12 basic inventories, the SECN has conducted or contributed to two additional natural resource inventories at FOPU: Marine Benthic Invertebrates, and a Watershed Condition Assessment.

**Marine Benthic Invertebrates**

Hymel (2009) conducted a review of existing benthic macroinvertebrate (BMI) records found within or adjacent to SECN coastal parks. A list of 74 BMI taxa was compiled and eight sampling stations were summarized for FOPU. One station was sparsely populated, and the three most abundant taxa at that location were the polychaetes *Heteromastus filiformis*, *Streptosyllis pettiboneae*, and those from the family Paraonidae (Figure 2). At another nearby station, unidentified oligochaetes were the dominant taxa, with the polychaetes *Paraprionospio longicirrata* and *Streptosyllis* spp. also among the three most abundant taxa. At least one station exhibited low BMI abundances, with unidentified oligochaetes and nemerteans the dominant taxa. The polychaete *Streblospio benedicti* and unidentified oligochaetes, along with the amphipod *Batea catharinensis*, were the three most abundant taxa at a fourth sampling location. Diversity was considered

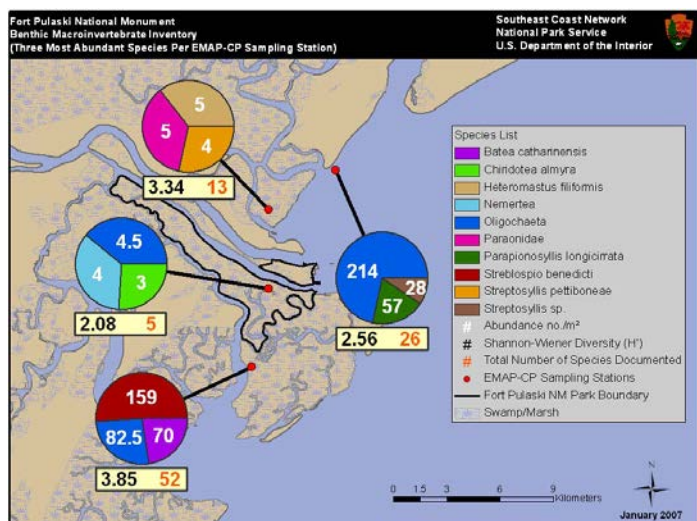


**Figure 2. BMI abundance data from stations near FOPU. Three most abundant taxa and Shannan-Wiener Diversity (H').**

moderate for two additional stations and low diversity was found at two other sampling locations.

### Watershed Condition Assessment

Although there are no real sources of pollutants at Fort Pulaski itself, both point and nonpoint sources of pollutants can be found nearby that have the potential to affect its water resources. Wastewater treatment plants and pulp and paper mills are the primary point sources of organic matter and nutrient loading in the lower Savannah River watershed. Numerous industries (including 20 Superfund sites) release contaminants to the groundwater, soil, or air, and there are also contaminants associated with dredge spoil sites. Non-point loading of pollutants occurs via storm water runoff and atmospheric deposition. In addition, two major nuclear facilities and the Port of Savannah are located upstream of the Fort Pulaski study area.

The largest water quality issue identified in the condition assessment was low dissolved oxygen in the Savannah River Estuary due to the large amount of organic material released into the water, coupled with stratification (McFarlin and Alber 2005). Metals and contaminants were identified as existing or potential problems based on the large amount of material released into the area and observations of contaminated sediment and animal tissue. Fecal coliform are considered a moderate problem in the areas upstream of Fort Pulaski. Nutrient concentrations are also higher in upstream areas, but this information was not compiled for the most recent report (McFarlin and Alber 2005). However, they are considered an existing problem in and around the park due to the large number of observations classified as *fair* or *poor* by the criteria developed by EPA for the National Coastal Assessment.

Salinity effects and other types of habitat alteration have occurred in the past due to channel alterations. These effects will be exacerbated if the area is deepened, particularly in the main channel of the estuary. Salinity in groundwater is also listed as an existing problem due to saltwater intrusion into the aquifer. In terms of population-level effects, the potential exists for the introduction of non-native species, particularly in light of the large amount of ship traffic associated with the Port.

## Vital Signs Monitoring

The SECN has selected sixteen indicators of ecosystem condition, or *Vital Signs*, to be monitored at FOPU, of which fourteen have been wholly or partially implemented by the Network. These Vital Signs include a combination of field efforts being conducted by NPS and its partners as well as the analysis and interpretation of data being collected by other state and federal programs.

### Air Quality

Data from various air quality monitoring programs are summarized regularly including the National Atmospheric Deposition Program - National Trends Network (NADP/NTN), the Environmental Protection Agency's Clean Air Status and Trends Network (CASTNET), and the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Data from 2005–2009 show that ozone levels were considered to be of moderate concern at FOPU, while total-N wet deposition, total-S deposition and visibility levels were considered to be of significant concern (Table 2).

**Table 2. Air quality interpolation values for the period 2005–2009 at Fort Pulaski National Monument. Yellow indicates values of moderate concern. Red indicates values of significant concern.**

| Ozone Concentration (ppb) | Total-N Wet Deposition (kg/ha/yr) | Total-S Wet Deposition (kg/ha/yr) | Group50 Visibility (dv) |
|---------------------------|-----------------------------------|-----------------------------------|-------------------------|
| 67.7                      | 3.13                              | 3.94                              | 11.7                    |

A 2011 analysis of acid deposition showed FOPU to be at high risk of pollutant exposure, and a moderate risk of acid deposition (Sullivan et al. 2011a). Although considered to be at a moderate risk of nutrient exposure, the overall risk of atmospheric nutrient enrichment at is high at FOPU. The overall high risk is due to the presence of a high amount of vegetation types expected to be sensitive to nutrient enrichment from nitrogen deposition (Sullivan et al. 2011b).

## Weather and Climate

Weather and climate are key drivers for ecosystem patterns and processes, affecting both biotic and abiotic components alike. Continuous weather monitoring is an important factor in separating the effects of climate from the effects of human-induced disturbance on other Vital Signs (e.g., plant and animal communities and population dynamics). In support of these efforts, the SECN has compiled and analyzed data from existing sources to (1) determine status, trends, and variability of precipitation and temperature over time inside and around SECN park units; (2) determine the status, trends, and variability of derived weather data (i.e., drought indices) inside and around SECN park units; (3) track the location, magnitude, and frequency of extreme weather events that affect SECN park resources (Wright et al. 2011).

Average monthly temperatures at weather stations near FOPU ranged from a low of 43.7°F to a high of 84.2°F. Average monthly temperatures were above normal at most locations during summer months and below normal during the winter. The average annual temperature was below normal.

Average monthly precipitation was above average during January, February, and May but below average for most of the rest of the year (Figure 3).

Average monthly maximum relative humidity ranged 81–94% with the lows maximum occurring in December. Average monthly minimum relative humidity ranged 36–53% with the lowest occurring in April and December.

Derivative climate measures indicated that the growing season length ranged 245–293 days across both weather stations used in this analysis and derived climate measures such as date of

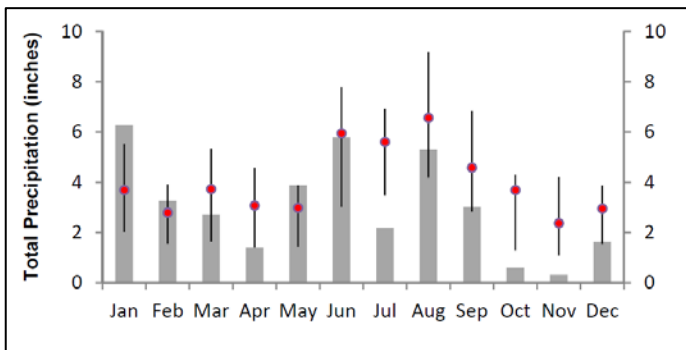


**Figure 3.** Total monthly precipitation during 2010 and the 30-year (1981 - 2010) monthly averages for Savannah International Airport station. The gray columns represent 2010 total monthly precipitation. The red circles represent the 30-year average; the lines indicate the 25th and 75th percentile of the 30-year normal data for each month.

last spring freeze varied between stations.

## Land Birds

Birds are an important component of park communities and their ecological position in most food webs allows them to be good indicators of local and regional ecosystem changes. Long-term trends in the community composition, relative abundance, distribution, and occurrences of breeding-bird populations provide a measure for assessing the ecological integrity and sustainability in southeastern systems. Further, long-term patterns in community composition, relative abundance, distribution, and occurrences in relation to current management practices will improve our ability to implement effective management strategies in the future.

More than 200 birds representing 46 species were detected at Fort Pulaski National Monument during surveys in 2010 (Byrne et al. 2011a).

- The majority of the detections consisted of laughing gull (14.5%), Northern Cardinal (7.8%), red-winged blackbird (7.4%), and barn swallow (6.6%).
- House finch and European starling were the only non-native bird species detected
- Three new species were added to the Monument's official list: common moorhen, red-headed woodpecker, and house finch.
- Several priority species were detected including common tern, chimney swift, seaside sparrow, red-headed woodpecker, Eastern wood-pewee, tricolored heron,



**Figure 4.** Snowy egret (*Egretta thula*) was a priority species detected at Fort Pulaski in 2010. Photo by Katherine Whittemore, USFWS.

willet, snowy egret (Figure 4), common moorhen, brown pelican, great egret, spotted sandpiper, yellow-throated warbler, pine warbler, royal tern, and indigo bunting.

## Amphibians

FOPU has seven known amphibian species, all in Anura (frogs and toads; NPSpecies 2012). Because of their complex life histories, habitat requirements, anatomy, and physiology, amphibians are considered to be good indicators of changes in ecosystem conditions as they are affected by climate change, land use development and conversion, contaminants, and changes in hydrology.

During monitoring efforts conducted in 2010, SECN crew found only one amphibian of one species, the southern toad (*Bufo terrestris*; Figure 5). They also found four reptiles of one species: green anole (*Anolis carolinensis*). No non-native species were detected (Byrne et al. 2011b).

All of the species detections at FOPU occurred at a single location and twenty percent of all survey locations were occupied by southern toad and green anole. Because the sample collected only represented one of the seven amphibian species known to occur at FOPU, sample adequacy and other factors will be evaluated prior to resampling the Monument in 2013.

## Plant Communities

Plant communities are the primary drivers for a range of

ecological processes and are integral to the proper function of park ecosystems. They serve as the foundation for food webs and wildlife habitat for many species, and function as a carbon sink, produce oxygen, cycle nutrients and energy through an ecosystem, influence the local climate, improve water quality, and moderate flooding and erosion. Given the widespread anthropogenic influences in SECN parks and the importance of vegetation communities, determining trends in vegetation communities is vital to understanding the ecological processes and identifying stressors and their impacts.

FOPU has 307 known vascular-plant species, subspecies, and varieties (NPSpecies 2012). Monitoring efforts resulted in the addition of nine species, subspecies, or varieties to the Monument's species list. Absolute canopy cover across the study area was approximately 22% (Byrne et al. 2012).

Chinaberry (*Melia azederach*) had the largest average diameter of any canopy species sampled at the park. Brushy seaside tansy (*Borrchia frutescens*) was the most frequently encountered seedling species. Bermuda grass (*Cynodon dactylon*) was one of the most frequently encountered groundcover species and Yaupon holly (*Ilex vomitoria*) had the highest relative cover in the shrub stratum.

## Fire Fuels and Dynamics

The SECN will conduct fire fuel surveys during the summer of 2014 and a summary data report is expected by summer 2015.

## Fixed-Station Water Quality

In 2006, the SECN Inventory and Monitoring Program began collecting water-quality data in the estuarine waters near FOPU as part the NPS Vital Signs monitoring program. Methods used are adapted from, or compatible with, the water-quality monitoring program established by the National Estuarine Research Reserve Program. This water quality monitoring site is part of the SECN estuarine water quality monitoring program, which collects data in the vicinity of nine coastal parks along the Southeastern U.S. coast. Information collected by this monitoring program will be used to help managers make better informed decisions by understanding trends and variability related to water-quality conditions in park waters.

Continuous and discrete water-quality data collected at FOPU during 2010 includes partial-year data from one site (Figure 6). Data collected in 2010 showed (from Gregory et al. 2010a).



**Figure 5. Southern Toad (*Bufo terrestris*) was the only amphibian species found at FOPU during the 2010 surveys.**

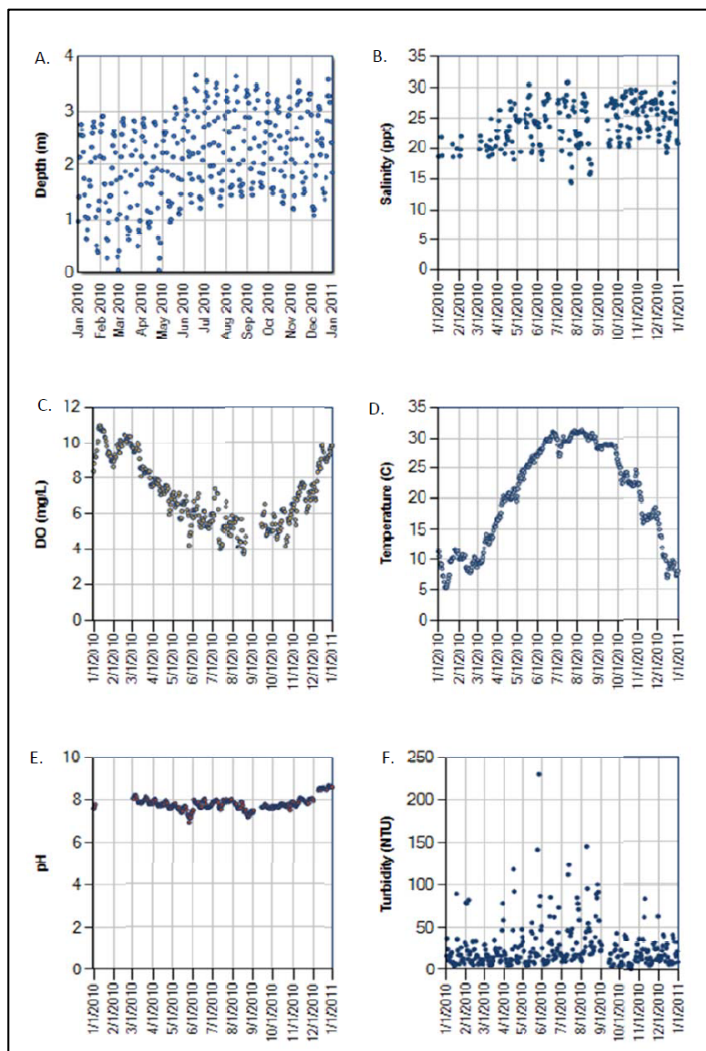


**Figure 6. Mean daily water quality parameters on Lazaretto Creek near Fort Pulaski National Monument during 2010: A) relative depth/tidal range, B) salinity, C) dissolved oxygen (DO), D) temperature, E) pH, and F) turbidity (NTU). Breaks in data record indicate missing and/or flagged data.**

- High levels of total dissolved phosphorus (TDP) were the most common cause of *poor* water-quality ratings during 2010.
- Dissolved oxygen concentrations measured by monthly sampling indicated *good* conditions although continuously-collected data indicated levels below 5mg/L from May to October when nighttime temperatures were warmest.
- Water clarity conditions ranged from *good* to *fair* on sample collection dates with most assessment indicating *good* water clarity.
- The range in salinity levels generally varied from 18 to 28 parts per thousand (ppt) through the spring and from 12 to 33 ppt during summer and fall periods. The increase in the variability throughout the year is due to decreased freshwater inputs during the periods of low rainfall and the tidal nature of the estuary near FOPU.

- Mean monthly pH values ranged between 7.4 and 8.6 units throughout the year with the most acidic conditions occurring episodically throughout the summer months.

## Coastal Sediment and Water Quality Assessment

In August 2007, the SECN—in cooperation with the University of Georgia Marine Extension Service—conducted a water quality assessment at 30 sites (Figure 7) at Fort Pulaski National Monument as a part of the NPS Vital Signs Monitoring Program. Monitoring was conducted following methods developed by the U.S. Environmental Protection Agency as a part of the National Coastal Assessment Program and included field measurements of water clarity and dissolved oxygen. Benthic sediment was assessed for metals, organic contaminants and total organic carbon (Gregory et al. 2011b).

Overall surface water conditions indicate general *good* water clarity conditions and *fair* to *good* dissolved oxygen conditions. No sites were rated as poor with respect to either of these parameters.

Sediment concentration of most metals ranged from below detection levels to levels considered unlikely to have a significant impact on aquatic life. Only concentrations of arsenic and nickel were detected at levels shown to occasionally have impacts on aquatic life.

Organic contaminants were detected at only six sites. Overall organic contaminant levels ranged from below detectable levels to concentrations that have rarely been shown to have

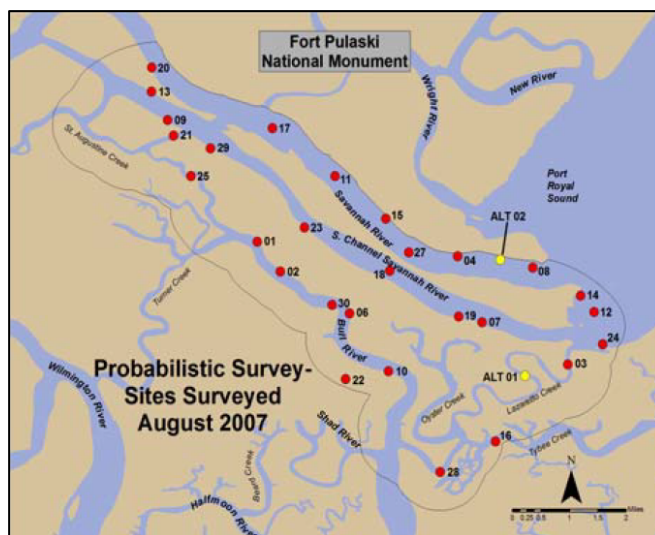


**Figure 7. Locations of coastal sediment and water quality monitoring sites at Fort Pulaski National Monument, 2007.**

significant impact on aquatic life. At one site total PCBs (summed concentration of all PCBs) were detected at levels shown to occasionally have an impact on aquatic life.

No discernible spatial patterns were noted among individual water-quality parameters or the generalized site condition ratings which would indicate specific areas of concern or areas where additional investigations or management actions would be warranted based on this assessment.

## Groundwater

All Southeast Coast Network parks and ecosystems are linked to the groundwater system (i.e., aquifers). These aquifers are affected by modifications to surface waters (e.g., impoundments), long-term weather patterns (e.g., flooding and drought), and extraction (e.g., anthropogenic influences). Because aquifers serve as a water supply for industrial, commercial, residential, and agricultural needs, anthropogenic demands on this freshwater resource are high. Aggregate influences of changes in groundwater can influence hydrologic processes, wetland function, freshwater availability or fish and wildlife, plant-community species distribution, composition, diversity, and structure, and potentially affect the integrity of park ecosystems. An inventory of existing wells that are within or in proximity to SECN parks has been conducted and applications to retrieve and analyze existing long-term periods of record have been developed (Rasmussen et al. 2009).

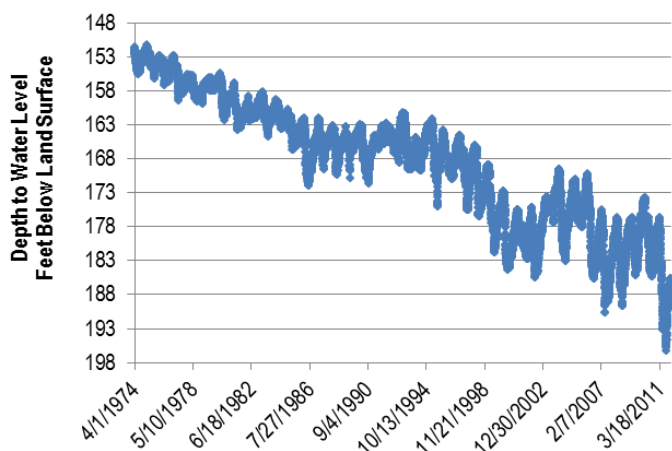


**Figure 8. Ground-water levels and calculated trend line for well 321302082243601 (Upper Floridan Aquifer near FOPU).**

Fort Pulaski National Monument had three relevant groundwater wells included in the groundwater trend analysis (Wright, 2012). Two wells showed a significant trend for groundwater levels over the period of record, with one declining (within the Upper Floridan aquifer [Figure 8]) and

one well increasing (within the Southeastern Coastal Plain Aquifer). All three wells have a long period of record (> 10 years) and collect a significant number of observations (>12 per year).

## Salt Marsh Elevation

The Southeast region is characterized by vast expanses of coastal marshland, large beds of sea grasses, and some of the most highly productive fisheries in the country. Within SECN parks, these areas are threatened by visitor uses, commercial and recreational fishing, as well as landscape changes inland and upstream.

Changes in salt marsh elevation are being monitored at FOPU to evaluate the resilience of these systems to projected changes in freshwater inputs/ availability and sea-level rise. In 2011, the SECN completed site assessments at FOPU, and installations



**Figure 9. NPS staff installing a RSET monitoring station.**

are scheduled for 2012 (Figure 9).

## Other Monitoring Efforts

NPScape is a landscape dynamics monitoring project that produces and delivers to parks a suite of landscape-scale data sets, maps, reports, and other products to inform resource management and planning at local, regional, and national scales. Changes in the composition and configuration of different land cover types within and adjacent to national parks has been shown to greatly affect biological and physical processes within those parks, such as habitat availability, animal movements, potential for invasion by non-native plants, water quality, and in-stream habitat for fish and other aquatic organisms. Information about changes and trends in landscape-scale indicators in and around parks can help park

managers anticipate, plan for, and manage associated effects to park resources.

At its core, NPScape delivers a suite of products that focus on a set of information-rich, landscape-scale indicators for 270+ parks with significant natural resources. The initial analyses summarized and delivered measures in six major categories (population, housing, roads, land cover, pattern, and conservation status) that broadly address the environmental drivers, natural attributes, and conservation context of NPS units (Figure 8). In aggregate, these measures contribute to assessments of current natural resource status, potential threats, and conservation vulnerability and opportunity.

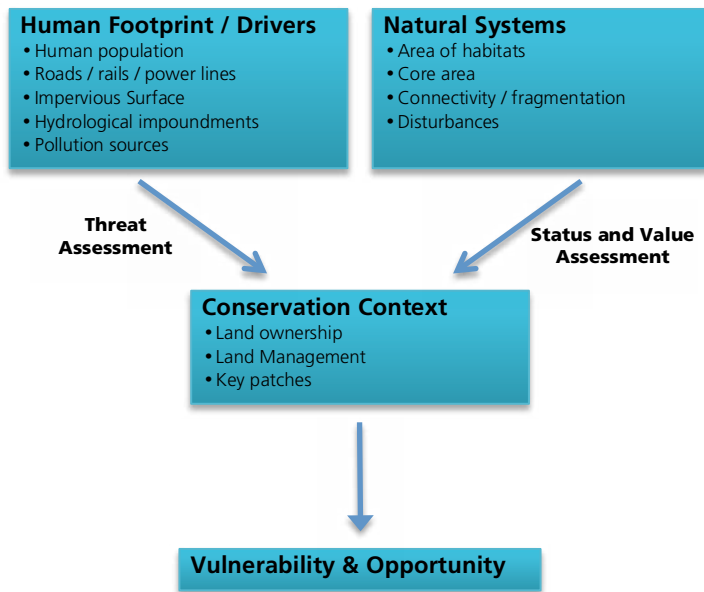


**Figure 10. Example measures of landscape dynamics included in the NPScape program**  
(<http://science.nature.nps.gov/im/monitor/npscape/>).

Example products for the landscape surrounding CONG include:

- Source and processed GIS data and associated metadata,
- An interpretive guide report (under review) describing the ecological relevance of NPScape data and measures as they relate to our understanding of current and anticipated landscape dynamics,
- An example draft report demonstrating the applicability of NPScape to management and planning,
- A Standard Operating Procedure (SOP) for each metric consistent with I&M protocols, as well as data processing scripts and tools for parks and networks to efficiently generate new customized products,

- Park-based maps of each measure in multiple formats for non-GIS specialists, including interactive kml files for Google Earth and geo-pdf files for Adobe Acrobat, and
- Graphical summaries of the measures to enable parks and networks to understand their results in a comparative context.

Further information on NPScape, including access to all products, is available through the NPScape website (<http://science.nature.nps.gov/im/monitor/npscape/>) and the NPS Integrated Resource Management Applications (IRMA) data system (see below).

### Where to Find Information

The NPS I&M Program was created as part of the National Park Service's effort to "improve park management through greater reliance on scientific knowledge." A primary role of the I&M Program is to collect, organize, and make available natural resource data and to contribute to the Service's institutional knowledge by facilitating the transformation of data into information through analysis, synthesis, and modeling. Information about the program can be found at <http://science.nature.nps.gov/im/index.cfm>.

### About the Southeast Coast Network

The SECN includes 20 parks, 17 of which contain significant and diverse natural resources. In total, SECN parks encompass more than 184,000 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 an 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 NPS, the Network encompasses more than 253,000 acres.

Information on activities of the SECN can be found at <http://science.nature.nps.gov/im/units/secn/>, including the Network's monitoring plan, descriptions of inventory and monitoring efforts, and links to data and final project reports.

### Get Data

The NPS Integrated Resource Management Applications (IRMA) portal (<http://irma.nps.gov>) is the start of a web-based "one-stop" for data and information related to National Park

Service natural and cultural resources. IRMA allows users to search, view, download, and print information from multiple sources and systems, all from a consistent user interface. No logins or passwords are required.

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