



Vocal Anuran Community Monitoring: 2022 Data Summary

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Overview

Amphibian populations have declined in North America and many other areas around the world. A variety of factors have contributed to these population declines and localized extinctions, including: anthropogenic habitat conversion and degradation, introduced non-indigenous species, water and air pollution, disease, and altered surface water conditions (Collins and Storer 2003; Muths et al. 2012). Partly due to their complex life cycles, which generally include an aquatic larval stage followed by an adult terrestrial phase, amphibians are often sensitive to perturbations of environmental conditions. Throughout their life cycle, amphibians rely heavily on availability of fresh, clean water to survive and successfully reproduce. Even apparently minor disruptions of the aquatic or terrestrial environments upon which amphibians depend may substantially impact the survival, reproduction, and persistence of a species. Many amphibian species in the United States, including those for which there is currently little or no conservation concern, may be experiencing widespread declines (Adams et al. 2013).

The southern region of the United States hosts the highest amphibian diversity in North America. The South is home to at least 45 species of anurans (i.e., frogs, toads, and treefrogs), which comprise 41% of the anuran species diversity of North America, north of Mexico (Dorcas and Gibbons 2008; SSAR 2017). Thirty-two species of anurans have been documented (NPS 2023) as occurring within the 15 park units monitored by the National Park Service's (NPS) Southeast Coast Network (SECN).

Anuran communities respond fairly quickly to environmental stressors or changes. Because of the conspicuous vocalization behavior exhibited by most species during breeding periods, anurans are relatively easy to detect and identify, compared with other amphibians. Changes in anuran species composition, richness, and distribution on the landscape may reflect alterations to underlying ecological conditions of park resources. In conjunction with other environmental measures (e.g., water quality, vegetation, fish assemblages), anuran assemblages can serve as effective indicators of ecological integrity (Zampella et al. 2006).



A greenhouse frog (*Eleutherodactylus planirostris*), one of several species detected during monitoring in 2022. Photo by Matthew Niemiller, USGS.

National parks comprise valuable protected landscapes where long-term monitoring can detect and track anuran population trends that can inform assessments of ecosystem integrity and sustainability (Halstead et al. 2022). Given the noteworthy diversity of amphibians in the Southeast, their sensitivity to environmental stressors, and their evident declines in recent decades, anuran communities represent a priority for SECN monitoring efforts. Our monitoring data contribute to understanding how park resources and natural communities respond to changing environmental conditions, informing park management decision making.

Objectives

This report summarizes data collected at Fort Frederica National Monument under the SECN Vocal Anuran Community Monitoring Protocol (Byrne et al. 2013). The data address the following protocol objectives:

1. Evaluate status of vocal anuran community species richness during the spring breeding season.
2. Assess vocal anuran occupancy and spatial distribution at sampling locations during the breeding season.

We use the term “community” to refer to an assemblage of species populations occurring together in time and space (Begon et al. 1986) and consider the vocal anuran species assemblage within the park as a *de facto* community (Byrne et al. 2013).

Significant Results

This report summarizes data collected in 2022 at Fort Frederica National Monument during implementation of the Southeast Coast Network's Vocal Anuran Community Monitoring Protocol (Byrne et al. 2013).

- Automated recording devices (ARDs) captured anuran (i.e., frog, toad, and treefrog) vocalizations from March 14 to June 15 at 11 spatially-balanced random sampling locations.
- We extracted 14,749 potential audio signals from 7,128 minutes of audio recordings. We manually reviewed a systematically selected subset of 1,840 (12.5%) of the extracted signals and classified to species any identifiable anuran vocalizations found within that subset.
- Anurans were observed at all 11 sampled locations.
- We identified nine native species of anurans and one non-indigenous species, greenhouse frog (*Eleutherodactylus planirostris*). Two native species, pine woods treefrog (*Dryophytes femoralis*) and little grass frog (*Pseudacris ocularis*) were previously undocumented at the park.
- Naïve occupancy was greatest for greenhouse frog and squirrel treefrog (*D. squirellus*), which occurred at 100% of sampled locations. Green treefrog (*D. cinereus*) and spring peeper (*P. crucifer*) were also frequently detected, occurring at 90% and 80% of sampled locations, respectively.
- The next scheduled sampling of anuran communities at this park is set for 2025.

Visit the NPS data store at the Integrated Resource Management Application portal for:

- [Data summary brief](https://irma.nps.gov/DataStore/Reference/Profile/2306020) (https://irma.nps.gov/DataStore/Reference/Profile/2306020)
- [Species distribution maps](https://irma.nps.gov/DataStore/Reference/Profile/2306016) (https://irma.nps.gov/DataStore/Reference/Profile/2306016)
- [Full dataset and metadata](https://irma.nps.gov/DataStore/Reference/Profile/2302261) (https://irma.nps.gov/DataStore/Reference/Profile/2302261)



An American bullfrog (*Lithobates catesbeianus*), one of several species detected during monitoring in 2022. NPS photo / NPgallery.

Study Area

Established on St. Simons Island, Georgia in 1736 to protect South Carolina and Georgia from the Spanish, the town of Frederica was once the southernmost outpost of the British colonies in North America. Today, Fort Frederica National Monument encompasses three land units totaling approximately 124 hectares (305 acres) on St. Simons Island (Figure 1). The monument's main unit is split by the Frederica River, one of the primary tidal rivers in the area, into a 40-hectare (99-acre) section of salt marsh on the west side of the river and a 55-hectare (137-acre) upland section east of the river. The separate Bloody Marsh Battle Site unit is approximately 7.2 kilometers (4.5 miles) to the south, and consists of a small upland area and an associated patch of tidal marsh. The salt marsh is dominated by cordgrass (*Spartina* spp.), while the uplands include a mix of coastal maritime hammock dominated by Virginia live oak (*Quercus virginiana*) and loblolly pine (*Pinus taeda*).

Fort Frederica National Monument had 11 previously documented anuran species when sampling occurred in 2022 (Table 1, NPS 2023; Parrish and Martin 2023).



A southern toad (*Anaxyrus terrestris*), one of several species detected during monitoring in 2022. NPS photo / Kristen Maxfield (NPgallery).



Audio Sampling Locations



Figure 1. Permanent audio sampling locations ($n = 11$) at Fort Frederica National Monument. Sampling location ID numbers are indicated at each point.



A spring peeper (*Pseudacris crucifer*), one of several species detected during monitoring in 2022. NPS photo / NPgallery.



A green treefrog (*Dryophytes cinereus*), one of several species detected during monitoring in 2022. NPS photo / NPgallery.

Table 1. Anurans previously known to occur at Fort Frederica National Monument based upon records in NPSpecies (NPS 2023), and those detected during our 2022 sampling. Documented species are indicated with “X.”

Order	Family	Species	Authority	Common Name	NPSpecies (NPS 2023)	SECN 2022 Monitoring
Anura	Bufonidae	<i>Anaxyrus terrestris</i>	Bonnaterre 1789	Southern toad	X	X
	Eleutherodactylidae	<i>Eleutherodactylus planirostris</i> ¹	Cope 1862	Greenhouse frog	X	X
	Hylidae	<i>Acris gryllus</i>	LeConte 1825	S. cricket frog	X	X
		<i>Dryophytes cinereus</i> ²	Schneider 1799	Green treefrog	–	X
		<i>Dryophytes femoralis</i>	Daudin 1800	Pine woods treefrog	–	X
		<i>Dryophytes graciosus</i>	LeConte 1856	Barking treefrog	X	–
		<i>Dryophytes squirellus</i>	Daudin 1800	Squirrel treefrog	X	X
		<i>Pseudacris crucifer</i> ²	Wied-Neuwied 1838	Spring peeper	–	X
		<i>Pseudacris ocularis</i>	Bosc and Daudin 1801	Little grass frog	–	X
	Microhylidae	<i>Gastrophryne carolinensis</i>	Holbrook 1835	E. narrow-mouthed toad	X	–
	Ranidae	<i>Lithobates catesbeianus</i> ²	Shaw 1802	American bullfrog	–	X
		<i>Lithobates sphenoccephalus</i>	Cope 1886	S. leopard frog	X	X
	Scaphiopodidae	<i>Scaphiopus holbrookii</i>	Harlan 1835	Eastern spadefoot	X	–

¹ Non-indigenous species; arrived in region via anthropogenic means.

² Species was detected during 2017 monitoring (Parrish and Martin 2023) but has not yet been added to NPSpecies (NPS 2023).

Methods

Sampling Design

The Southeast Coast Network established a randomly-selected, spatially-balanced set of sample locations ($n = 11$) during an initial field season in 2014 (Figure 1). Our sample size was chosen based on considerations that included park size, hypothesized variability in wildlife populations, and logistics. Sample locations are permanent and are revisited on a three-year rotation. This report pertains to 2022 sampling only. More comprehensive details regarding study design, data collection, and data analyses can be found in the SECN Vocal Anuran Community Monitoring Protocol (Byrne et al. 2013).

Data Collection

In 2022, we deployed automated recording devices (ARDs) at 11 permanent sampling locations (Figure 1) from March 14 to June 15. We programmed each ARD to record audio on every fourth night, in 60-second intervals every 20 minutes from 20:00 to 04:40, a total of 24 nights of sampling. Each ARD captured 648 minutes of audio during the recording period. The ARDs were collected from the field after recording was completed and audio files were downloaded to a computer for classification and analyses.

Manual Classification of Recordings

It is not possible, given personnel constraints, to manually review all recordings for a park. Additionally, a full manual review of all audio recordings would not be an efficient use of resources, considering that

a large proportion of the recordings do not contain signals of interest. We therefore began classification work by using computer program Kaleidoscope Pro (Wildlife Acoustics, Inc 2023) to automatically review all recordings at a sample location in the park and to extract as many signal detections as possible. Signal detections usually comprise natural or artificial acoustic departures from the background soundscape, and may include biological signals of interest (i.e., frog calls), biological signals not of interest (e.g., bird calls, insect noises, or human noises), natural environmental sounds not of interest (e.g., rain, wind, surf, or thunder), or anthropogenic noises not of interest (e.g., planes, trains, and automobiles). After extracting signals from the raw recordings, Kaleidoscope Pro then grouped the isolated signals into clusters, according to mathematical similarity. The result was a set of clusters of unclassified, but potentially interesting signals and the simultaneous elimination of much of the inconsequential noise recorded in the field.

Ideally, this process would result in "pure" clusters each containing a single class of signal (e.g., a cluster consisting only of calls belonging to a single species). However, given the complex, overlapping, natural jumble of sounds present in the background soundscape, Kaleidoscope Pro tends to produce clusters more heterogeneous than would be optimally desired. This necessitates manual classification work performed by expert listeners who are familiar with the calls of anurans of the southeastern states.

Methods (continued)

A listener who was expert in identification of anuran calls then manually reviewed the first five signals in each cluster (i.e., those closest to the mathematical center of the cluster), which represented the five signals most representative of that cluster. When a signal consisted of anuran vocalizations that could be classified to the species level, the signal was labeled accordingly. Once all manual signal reviews were completed, the listener reviewed all of the anuran classifications and selected one signal that was a representative example of each species. Each selected signal became the definitive record for a given species' occurrence at a given sample location. Later, the SECN wildlife biologist reviewed each definitive record individually to confirm species identification and to perform data quality assurance steps. The electronic records of each species occurrence were later validated, and the records were elevated to accepted status by the SECN wildlife biologist.

Taxonomic Standards

Our use of taxonomic nomenclature followed the Integrated Taxonomic Information System (ITIS 2023). The National Park Service maintains the online database NPSpecies (NPS 2023), which documents the occurrence and status of species found in parks.

Data Analysis

We analyzed species richness and related characteristics, occupancy and spatial distribution, and frequency of detection of the park's vocalizing anuran community. Our results were derived from a semi-automated evaluation of 7,128 minutes of audio captured across 11 sample locations. We extracted 14,749 potential signals from the audio recordings, of which we manually classified 1,840 (12.5% of signals). We included in our analyses only detections of anurans that were identified to the species level. We calculated metrics separately for native versus non-indigenous species if applicable.

Species Richness and Composition

We defined species richness as the number of unique species detected at least once at the scale of interest. We began by calculating anuran species richness for the park as a whole, as the total number of unique species across all sample locations. We also calculated species richness at each sample location. We determined species richness separately for native versus non-indigenous anuran species when non-indigenous species were present.

Field methods for sampling species richness (e.g., point-counts or audio sampling) inherently produce incomplete counts, due to imperfect detection of cryptic species that may be present but are difficult to record during surveys. Observed species richness, therefore, is expected to be an underestimate of true species richness, though it offers utility as an index of the true diversity of a sample unit. Various methods exist to adjust incidence data to provide an estimated species richness that includes species present, but unobserved (e.g., multispecies occupancy models or non-parametric richness estimators, such as *iChao2*); but, these approaches may show strong bias in study areas where average occupancy is low (Tingley et al. 2020). We therefore report only unadjusted species richness, with the caveat that it should be interpreted as described above.



Pine woods treefrog (*Dryophytes femoralis*), one of several species detected during 2022 monitoring. NPS photo / NPGallery.

Occupancy

We calculated naïve occupancy (i.e., frequency of occurrence) as the percent of sampling locations where a species was detected in one or more reviewed recordings. We did not adjust occupancy estimates for probability of detection (i.e., detectability). Species with greater naïve occupancy were detected at more locations than those with low values.

Spatial Distribution

We mapped species incidence records in the park to provide a means of visually assessing spatial distributions of detected anurans across the park. An understanding of anuran distribution is beneficial for informed management of species and their requisite habitats. Following future park visits, trend analysis of data is planned in order to assess changes in species distribution and community makeup. This has potential to provide insights into influences on park diversity (e.g., land use change and habitat condition, climate issues, and hydrological processes).

Results

Species Richness

Observed species richness for native anurans at Fort Frederica National Monument in 2022 was 9 (Table 1). Additionally, we detected one non-indigenous anuran species, greenhouse frog (*Eleutherodactylus planirostris*). Within the main park unit, mean $\pm$ SD observed species richness of native anurans per sample location was 4.60 ± 2.12 (range: 3–9; Table 2, Figure 2). Only one species, green treefrog (*Dryophytes cinereus*) was detected in the Bloody Marsh unit. Anurans were detected at all sampled locations in the park.



Squirrel treefrog (*Dryophytes squirellus*), one of several species detected during 2022 monitoring. NPS photo / NPGallery.



Species Richness at Sampling Locations

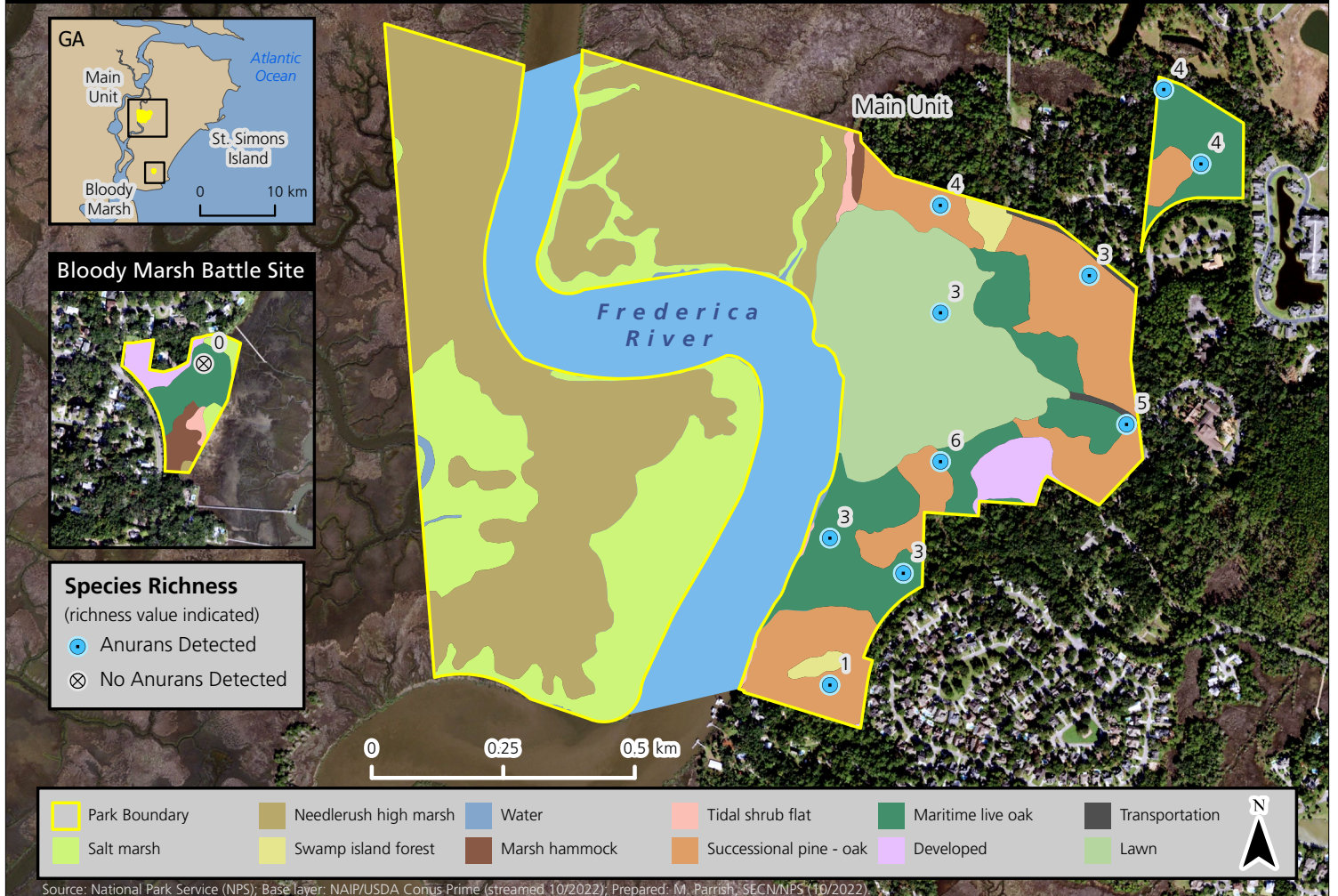


Figure 2. Vocal anuran species richness at sampling locations ($n = 11$) at Fort Frederica National Monument based on audio recording detections in 2017.

Table 2. Species detections (indicated with "X") and observed species richness (native-only and inclusive of non-indigenous species) at each sampling location within Fort Frederica National Monument in 2022. Refer to Figure 1 for labeled sampling locations.

Common Name	01	03	05	06	07	08	09	10	12	13	02 ^A
Southern toad	X	–	X	X	X	X	–	X	–	–	–
Greenhouse frog ¹	X	X	X	X	X	X	X	X	X	X	–
Southern cricket frog	–	–	X	–	–	–	–	–	–	–	–
Green treefrog	X	X	X	X	X	–	X	X	X	X	X
Pine woods treefrog	X	–	X	X	–	–	–	–	–	–	–
Squirrel treefrog	X	X	X	X	X	X	X	X	X	X	–
Spring peeper	X	X	X	X	–	X	X	X	X	–	–
Little grass frog	–	–	X	–	–	–	–	–	–	–	–
American bullfrog	X	X	X	–	–	–	–	X	–	X	–
Southern leopard frog	X	–	X	X	–	–	–	–	–	–	–
Observed Species Richness (native spp.)	7	4	9	6	3	3	3	5	3	3	1
Observed Species Richness (native and non-indigenous spp.)	8	5	10	7	4	4	4	6	4	4	1

^A Sample location 02 was located in the Bloody Marsh Battle Site subunit, away from the other sample locations reported above.

¹ Non-indigenous species; arrived in region via anthropogenic means.

Results (continued)

Occupancy and Spatial Distribution

Within the main unit, naïve occupancy was greatest for greenhouse frog and squirrel treefrog (*D. squirellus*), which occurred at 100% of sampled locations (Tables 2 and 3). Green treefrog and spring peeper (*Pseudacris crucifer*) were also frequently detected, occurring at 90% and 80% of sampled locations, respectively (Tables 2 and 3). Southern cricket frog (*Acris gryllus*) and little grass frog (*P. ocularis*) were both detected at only one sample location each (Tables 2 and 3).

Two of the 10 species of anurans we detected in 2022 were previously undocumented at Fort Frederica National Monument (Table 4). Pine woods treefrog (*D. femoralis*) was detected at three sampling locations and little grass frog was detected at one location. Both newly documented species are native to the region.

We did not observe barking treefrog (*D. gratosus*), eastern narrow-mouthed toad (*Gastrophryne carolinensis*) or eastern spadefoot (*Scaphiopus holbrookii*), which were previously documented at Fort Frederica National Monument (Tuberville et al. 2005; NPS 2023). These species may not have been active during sampling or may have had low detectability on ARDs.

Distribution Maps

Distribution maps indicating the sampling location(s) where species detections occurred are available at [Species Distribution Maps](https://irma.nps.gov/DataStore/Reference/Profile/2306016) (<https://irma.nps.gov/DataStore/Reference/Profile/2306016>).

Table 3. Naïve occupancy estimates (i.e., proportion of permanent sampling locations where a species was detected) for vocal anurans at Fort Frederica National Monument in 2022, ranked by descending proportion of locations occupied. Note: occupancy percentages only incorporate data from the main unit of the park; data from the separate Bloody Marsh Battle Site unit (consisting of a single sampling location) were omitted from occupancy calculations.

Common Name	Scientific Name	Naïve Occupancy ¹
Greenhouse frog ²	<i>Eleutherodactylus planirostris</i>	100%
Squirrel treefrog	<i>Dryophytes squirellus</i>	100%
Green treefrog	<i>Dryophytes cinereus</i>	90%
Spring peeper	<i>Pseudacris crucifer</i>	80%
Southern toad	<i>Anaxyrus terrestris</i>	60%
American bullfrog	<i>Lithobates catesbeianus</i>	50%
Pine woods treefrog	<i>Dryophytes femoralis</i>	30%
S. leopard frog	<i>Lithobates sphenoccephalus</i>	30%
S. cricket frog	<i>Acris gryllus</i>	10%
Little grass frog	<i>Pseudacris ocularis</i>	10%

¹ Percent of sampling location where species observed
² Non-indigenous species; arrived in region via anthropogenic means.

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Table 4. Newly documented species of vocal anurans at Fort Frederica National Monument in 2022, with suggested park status information.

Common Name	Scientific Name	Abundance	Residency	Native Status	Pest	Management Priority	Exploitation Concerns
Pine woods treefrog	<i>Dryophytes femoralis</i>	Unknown	Resident	Native	No	No	No
Little grass frog	<i>Pseudacris ocularis</i>	Unknown	Resident	Native	No	No	No

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About the Southeast Coast Network

In 1999, the National Park Service initiated a long-term ecological monitoring program, known as “Vital Signs Monitoring,” to provide the minimum infrastructure to allow more than 270 national park system units to identify and implement long-term monitoring of their highest-priority measurements of resource condition. Monitoring resources in parks develops scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems, and determines how well current management practices are sustaining those ecosystems.

The NPS Vital Signs Monitoring Program addresses five goals for all parks with significant natural resources:

- Determine the status and trends in selected indicators of the condition of park ecosystem,
- Provide early warning of abnormal conditions,
- Provide data to better understand the dynamic nature and condition of park ecosystems,
- Provide data to meet certain legal and Congressional mandates, and
- Provide a means of measuring progress towards performance goals.

The Southeast Coast Network (SECN) includes eighteen administrative areas containing twenty park units, fifteen 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 serve a wide diversity of cultural and natural resource missions and include: five national monuments, four national seashores, three national battlefield parks, two national historic parks, a national memorial, a national recreation area, an ecological and historic preserve, and a single national park. The parks range in size from slightly more than 20 acres to nearly 60,000 acres, and when considered with non-federal lands jointly managed with NPS, the network encompasses more than 253,000 acres.

For More Information

[SECN Home Page](https://www.nps.gov/im/secn/index.htm)

(<https://www.nps.gov/im/secn/index.htm>)

[SECN Reports and Publications](https://www.nps.gov/im/secn/reports-publications.htm)

(<https://www.nps.gov/im/secn/reports-publications.htm>)

[NPS Inventory and Monitoring Program](https://www.nps.gov/im/index.htm)

(<https://www.nps.gov/im/index.htm>)

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