



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).

National parks comprise valuable protected landscapes where long-term monitoring can detect and track anuran population trends that



A [gopher frog](#) (*Lithobates capito*), one of several species detected during monitoring in 2022. Photo by ©John Serrao, [CC BY-NC](#).

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 Canaveral National Seashore 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 brief summarizes data collected in 2022 at Canaveral National Seashore 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 nine spatially-balanced random sampling locations.

Significant Results (continued)

- We extracted 8,542 potential audio signals from 3,888 minutes of audio recordings. We manually reviewed a systematically selected subset of 1,144 (13.4%) of the extracted signals and classified to species any identifiable anuran vocalizations found within that subset.
- Anurans were observed at all sampled locations.
- We identified 15 species of anurans, each previously documented at the park. The 15 anuran species consisted of 13 native species and 2 non-indigenous species, Cuban treefrog (*Osteopilus septentrionalis*) and greenhouse frog (*Eleutherodactylus planirostris*).
- The most frequently detected species was greenhouse frog, which occurred at 100% of sampled locations. Green treefrog (*Dryophytes cinereus*) and Cuban treefrog both occurred at 83.3% of sampled locations.
- 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/2306019) (https://irma.nps.gov/DataStore/Reference/Profile/2306019)
- [Species distribution maps](https://irma.nps.gov/DataStore/Reference/Profile/2305467) (https://irma.nps.gov/DataStore/Reference/Profile/2305467)
- [Full dataset and metadata](https://irma.nps.gov/DataStore/Reference/Profile/2302261) (https://irma.nps.gov/DataStore/Reference/Profile/2302261)

Study Area

Canaveral National Seashore lies on the east coast of central Florida, in Volusia and Brevard Counties, just north of Kennedy Space Center. The seashore protects the longest stretch of undeveloped coastline in Florida. The park is approximately 23,335 hectares (57,661 acres), including Mosquito Lagoon. The southern portion of the seashore is jointly managed by the NPS and the U.S. Fish and Wildlife Service's (USFWS) Merritt Island National Wildlife Refuge. The natural resources at the seashore include a diverse assemblage of wildlife, vegetation communities, geophysical features, and natural processes that reflect the complexity of the land/lagoon/sea interface of east-central Florida. Mosquito Lagoon, extending along the backside of the barrier island, is the northernmost part of the Indian River Lagoon and was designated an Estuary of National Significance by the U.S. Environmental Protection Agency (EPA) in 1991. The lagoon acts as an important nursery area for a wide variety of wildlife species.



A barking treefrog (*Dryophytes gratiosus*), one of several species detected during monitoring in 2022. NPS Photo / Briana Smrekar

Unlike many barrier islands, Canaveral National Seashore has a simplified dune system separating the lagoon from the ocean, generally consisting of a single primary dune averaging 3.7 meters (12 feet) in height. Surface water, including the nearshore Atlantic Ocean, comprises 68% of the Seashore's total area, while five dominant vegetative classes make up 22.7% of the remaining area: mangroves, oak-palmetto shrubland, pine woodlands, oak-cabbage palmetto hammock, and salt wort-salt grass (Cotten et al. 2020). The distribution of vegetation community types at the park generally follows subtle variations in topography, salinity gradients, and differences in hydrologic properties. The seashore's unique and complex habitat mosaic supports a high species diversity in many taxa.

Canaveral National Seashore had 18 previously reported anuran species when sampling occurred in 2022 (Table 1; NPS 2023). Spring peeper (*Pseudacris crucifer*) and green frog (*Lithobates clamitans*) were reported in 2009 (Byrne et al. 2010); however, both records were unvouchered and the species appear to be out of range for the park (Krysko et al. 2019). The report of a vocalizing spring peeper was also unusual, given that audio sampling occurred in April (Byrne et al. 2010), when the species is typically silent. Because of the weak evidence for either species occurring at Canaveral National Seashore, we hesitate to accept either record at present.



Audio Sampling Locations

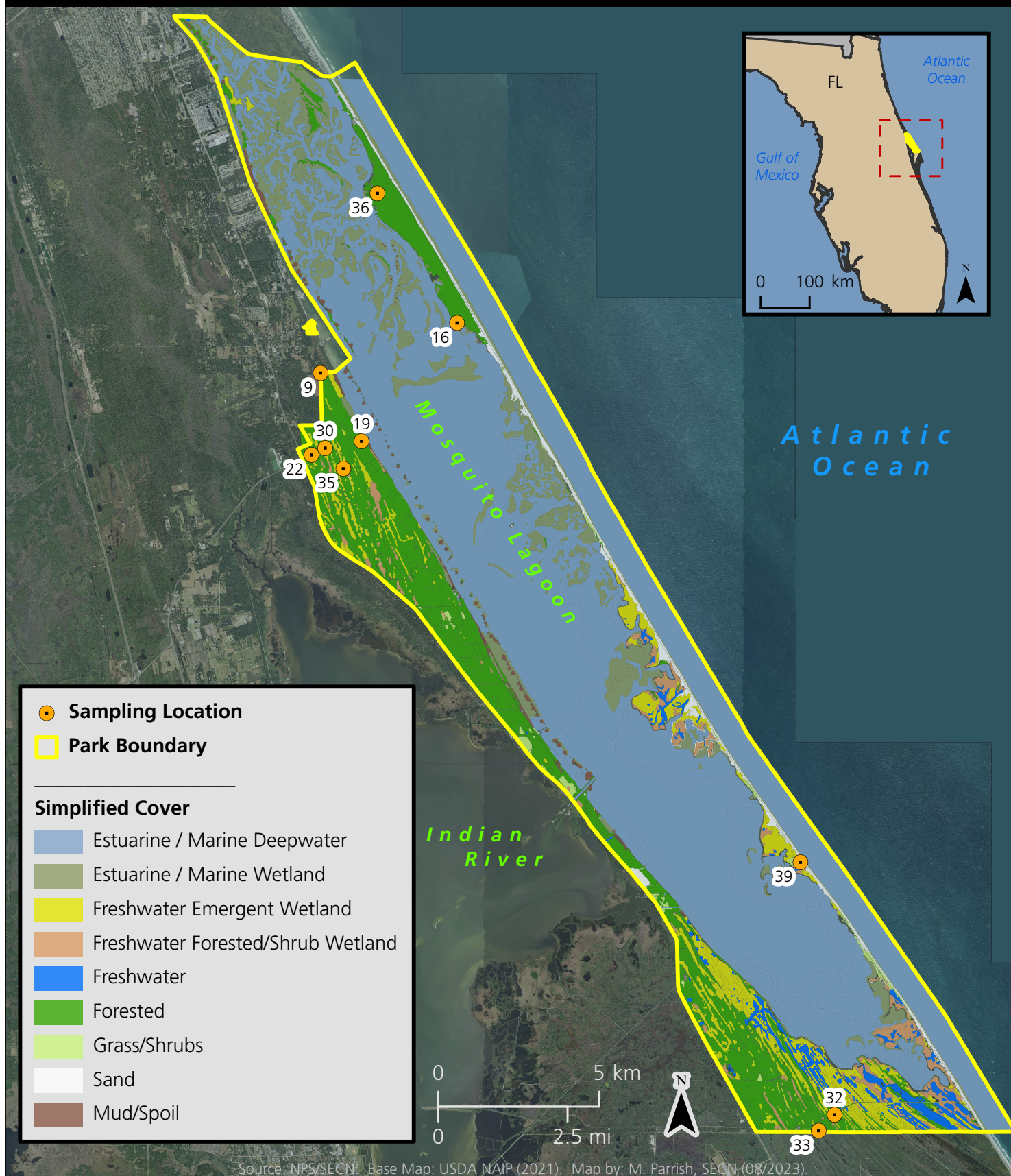


Figure 1. Permanent audio sampling locations ($n = 10$) at Canaveral National Seashore. Sampling location ID numbers are indicated at each point.

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

Order	Family	Species	Authority	Common Name	NPSpecies (2023)	SECN Monitoring (2022)
Anura	Bufonidae	<i>Anaxyrus quercicus</i>	Holbrook 1840	Oak toad	X	X
		<i>Anaxyrus terrestris</i>	Bonnaterre 1789	Southern toad	X	X
	Hylidae	<i>Acris gryllus</i>	LeConte 1825	Southern cricket frog	X	X
		<i>Dryophytes cinereus</i>	Schneider 1799	Green treefrog	X	X
		<i>Dryophytes femoralis</i>	Daudin 1800	Pine woods treefrog	X	X
		<i>Dryophytes gratiosus</i>	LeConte 1856	Barking treefrog	X	X
		<i>Dryophytes squirellus</i>	Daudin 1800	Squirrel treefrog	X	X
		<i>Osteopilus septentrionalis</i> ¹	Duméril and Bibron 1841	Cuban treefrog	X	X
		<i>Pseudacris crucifer</i> ²	Wied-Neuwied 1838	Spring peeper	X	–
		<i>Pseudacris nigrita</i>	LeConte 1825	Southern chorus frog	X	X
		<i>Pseudacris ocularis</i>	Bosc and Daudin 1801	Little grass frog	X	X
	Leptodactylidae	<i>Eleutherodactylus planirostris</i> ¹	Cope 1862	Greenhouse frog	X	X
	Microhylidae	<i>Gastrophryne carolinensis</i>	Holbrook 1835	Eastern narrow-mouthed toad	X	X
	Ranidae	<i>Lithobates capito</i>	LeConte 1855	Gopher frog	X	X
		<i>Lithobates clamitans</i> ²	Latreille 1801	Green frog	X	–
		<i>Lithobates grylio</i>	Stejneger 1901	Pig frog	X	X
		<i>Lithobates sphenoccephalus</i>	Cope 1886	Southern 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 *Pseudacris crucifer* and *Lithobates clamitans* are unvouchered and lack strong evidence for occurrence within Canaveral National Seashore.

Methods

Sampling Design

The Southeast Coast Network established a randomly-selected, spatially-balanced set of sample locations ($n = 30$) 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. In 2022, Canaveral National Seashore requested we discontinue sampling at 20 sites in Merritt Island National Wildlife Refuge, reducing the set of permanent sampling locations to $n = 10$. 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 nine of 10 permanent sampling locations (Figure 1) from March 14 to June 15 (one site was inaccessible due to high water). One ARD was subsequently vandalized, and two other units experienced equipment failure, reducing our final sample size to $n = 6$. 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 a total of 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.

Methods (continued)

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.

An 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 3,888 minutes of audio from recordings captured across six sample locations. We extracted 8,542 potential signals from the audio recordings, of which we manually classified 1,144 (13.4% of signals). We included in 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.

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 Canaveral National Seashore in 2022 was 13 (Table 1). We detected two non-indigenous anuran species, Cuban treefrog (*Osteopilus septentrionalis*) and greenhouse frog (*Eleutherodactylus planirostris*). Mean $\pm$ SD observed species richness of native anurans per sample location was 6.83 ± 4.92 (range: 0–10), and observed species richness of native and non-indigenous anurans was 8.67 ± 5.16 (range: 2–12; Table 2; Figure 2). Anurans were detected at all sampled locations; however, at sample location 16 (Figure 1), only non-indigenous anurans were detected.

Occupancy and Spatial Distribution

Naïve occupancy was greatest for greenhouse frog, which occurred at 100% of sampled locations, and was similarly high for green treefrog (*Dryophytes cinereus*) and Cuban treefrog, which both occurred at 83.3% of sampled locations (Tables 2 and 3). Gopher frog (*Lithobates capito*), a species formerly on the Florida Imperiled Species Management Plan (delisted in 2017), was observed at two of six sampled locations, where it co-occurred with both Cuban treefrog and greenhouse frog (Tables 2 and 3). Squirrel treefrog (*D. squirellus*) and southern chorus frog were both observed on only one sample location each (Tables 2 and 3).



Species Richness at Sampling Locations

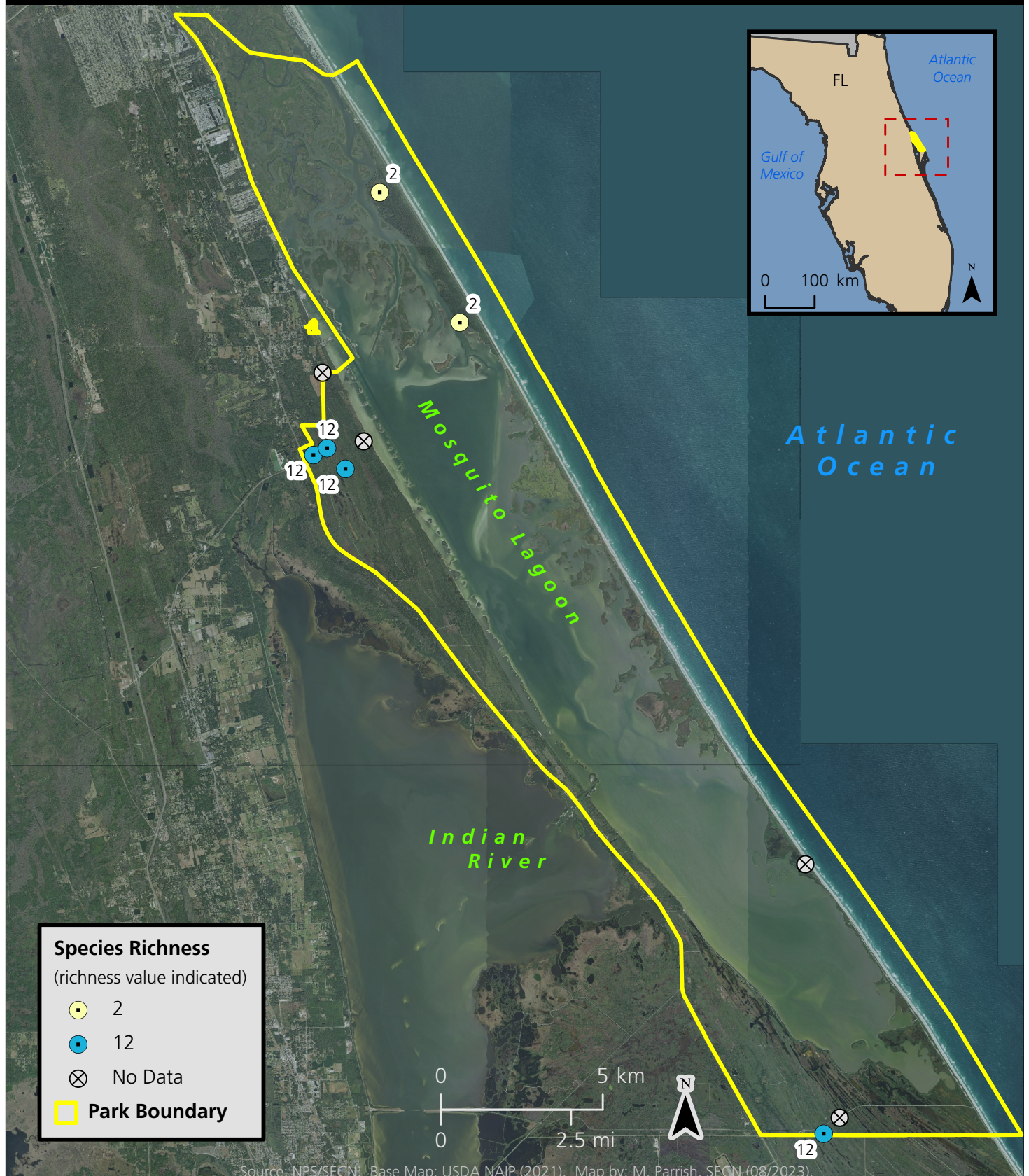


Figure 2. Vocal anuran species richness at sampling locations ($n = 10$) at Canaveral National Seashore based on audio recording detections in 2022.

Results (continued)

Table 2. Species detections (indicated with “X”) and observed species richness (native-only and inclusive of non-indigenous species) at each sampling location within Canaveral National Seashore in 2022. Refer to Figure 1 for labeled sampling locations. Ø = No data. Site 09 was vandalized and its ARD was destroyed. Site 19 could not be accessed in 2022. Sites 32 and 39 experienced equipment failure.

Common Name	09	16	19	22	30	32	33	35	36	39
Oak toad	Ø	–	Ø	X	–	Ø	X	–	–	Ø
Southern toad	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Southern cricket frog	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Green treefrog	Ø	–	Ø	X	X	Ø	X	X	X	Ø
Pine woods treefrog	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Barking treefrog	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Squirrel treefrog	Ø	–	Ø	–	–	Ø	X	–	–	Ø
Cuban treefrog	Ø	X	Ø	X	X	Ø	X	X	–	Ø
Southern chorus frog	Ø	–	Ø	–	–	Ø	–	X	–	Ø
Little grass frog	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Greenhouse frog	Ø	X	Ø	X	X	Ø	X	X	X	Ø
Eastern narrow-mouthed toad	Ø	–	Ø	X	X	Ø	–	–	–	Ø
Gopher frog	Ø	–	Ø	–	X	Ø	–	X	–	Ø
Pig frog	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Southern leopard frog	Ø	–	Ø	X	X	Ø	X	X	–	Ø
Observed Species Richness (natives only)	Ø	0	Ø	10	10	Ø	10	10	1	Ø
Observed Species Richness (native and non-indigenous)	Ø	2	Ø	12	12	Ø	12	12	2	Ø

Table 3. Naïve occupancy estimates (i.e., proportion of permanent sampling locations where a species was detected) for vocal anurans at Canaveral National Seashore in 2022, ranked by descending proportion of locations occupied.

Common Name	Scientific Name	Naïve Occupancy ¹
Greenhouse frog ²	<i>Eleutherodactylus planirostris</i>	100.0%
Green treefrog	<i>Dryophytes cinereus</i>	83.3%
Cuban treefrog ²	<i>Osteopilus septentrionalis</i>	83.3%
Southern toad	<i>Anaxyrus terrestris</i>	66.7%
Southern cricket frog	<i>Acris gryllus</i>	66.7%
Pine woods treefrog	<i>Dryophytes femoralis</i>	66.7%
Barking treefrog	<i>Dryophytes gratiosus</i>	66.7%
Little grass frog	<i>Pseudacris ocularis</i>	66.7%
Pig frog	<i>Lithobates grylio</i>	66.7%
Southern leopard frog	<i>Lithobates sphenoccephalus</i>	66.7%
Oak toad	<i>Anaxyrus quercicus</i>	33.3%
E. narrow-mouthed toad	<i>Gastrophryne carolinensis</i>	33.3%
Gopher frog	<i>Lithobates capito</i>	33.3%
Squirrel treefrog	<i>Dryophytes squirellus</i>	16.7%
Southern chorus frog	<i>Pseudacris nigrita</i>	16.7%

¹ Percent of sampling location where species observed.

² Non-indigenous species; arrived in region via anthropogenic means.

The 15 anuran species we detected in 2022 were previously documented at Canaveral National Seashore (NPS 2023, Table 1).

We did not observe spring peeper, green frog, or eastern spadefoot (*Scaphiopus holbrookii*). As previously discussed, we are reluctant to accept previous records of spring peeper or green frog. Eastern spadefoot tends to be challenging to capture on ARD recordings, due to low detectability of its calls coupled with its habit of vocalizing during narrow windows associated with precipitation events.

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/2306019) (<https://irma.nps.gov/DataStore/Reference/Profile/2306019>).

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

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.



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

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>)

Data Downloads via the [Natural Resource Information Portal](https://irma.nps.gov/portal/)

(<https://irma.nps.gov/portal/>)



A squirrel treefrog (*Dryophytes squirellus*), one of several species detected during monitoring in 2022. NPS Photo / NPgallery.