



Anuran Community Monitoring: 2014 Data Summary—Version 2.0

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Revision Log

Date	Author	Changes Made	Reason for Change	Version
5/2025	M. Parrish	Complete revision of Smrekar and Byrne (2015) using modern Kaleidoscope Pro software to classify park anuran communities using 2014 recording data.	The original publication utilized now-depreciated software and classification approaches. We reviewed original 2014 recordings and classified species using modern-day software and current audio interpretation protocols to improve consistency and comparability with ongoing anuran monitoring work in the park.	2.0

Overview

Amphibian populations across all regions of North America are declining, with estimates of the mean annual trend in number of occupied sites ranging from -2.30% in the southeast US region to -5.17% for the US west coast (Grant et al. 2016). A variety of factors appear to contribute to observed population declines, often at a local scale, including: disease, aquatic and terrestrial habitat loss and conversion, changes in regional weather patterns and intensity, air and water pollution, and introduction of non-indigenous species (Grant et al. 2016; Grant et al. 2020; Luedtke et al. 2023). 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; Grant et al. 2020).

The southern region of the United States hosts the highest amphibian species richness in North America. The region contains at least 45 species of anurans (i.e., frogs, toads, and treefrogs), which represent 41% of the anuran species richness of North America, north of Mexico (Dorcas and Gibbons 2008; SSAR 2017). Within the 15 park units monitored by the National Park Service’s (NPS) Southeast Coast Inventory and Monitoring Network (SECN), at least 32 species of anurans have been documented to occur (NPS 2025).



Southern toad (*Anaxyrus terrestris*), one of several species detected during monitoring in 2014. NPS / Kristen Maxfield (NPgallery).

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 assemblages, 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 can inform assessments of ecosystem integrity and sustainability (Halstead et al. 2022). Given the noteworthy species richness 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.

Overview (continued)

Objectives

This report summarizes data collected at Ocmulgee Mounds National Historical Park under the SECN Anuran Monitoring Protocol (Byrne et al. 2013). The data address the following protocol objectives:

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

Significant Results

This report summarizes data collected in 2014 at Ocmulgee Mounds National Historical Park during implementation of the Southeast Coast Network's Anuran Monitoring Protocol (Byrne et al. 2013).

- Automated recording devices (ARDs) captured anuran (i.e., frog, toad, and treefrog) vocalizations between March 12 and June 6 at 22 spatially-balanced random sampling locations.
- We extracted 10,755 potential audio signals from 11,988 minutes of audio recordings. We manually reviewed a systematically selected subset of 3,594 (33.4%) of the extracted signals and classified to species any identifiable anuran vocalizations found within that subset.
- Anurans were observed at all 22 sampled locations.
- We identified 14 native species of anurans, each of which was previously documented at the park. No non-indigenous anurans were detected.
- The most frequently detected species was southern toad (*Anaxyrus terrestris*), which occurred at 63.6% of sampled locations. Spring peeper (*Pseudacris crucifer*) and bird-voiced treefrog (*Dryophytes avivoca*) were also frequently encountered and were detected at 45.5% and 40.9% of sampled sites, respectively.
- The next sampling of anuran communities was in 2017.

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

- [Data summary brief](https://irma.nps.gov/DataStore/Reference/Profile/2311241) (https://irma.nps.gov/DataStore/Reference/Profile/2311241)
- [Species distribution maps](https://irma.nps.gov/DataStore/Reference/Profile/2311272) (https://irma.nps.gov/DataStore/Reference/Profile/2311272)
- [Full dataset and metadata](https://irma.nps.gov/DataStore/Reference/Profile/2307457) (https://irma.nps.gov/DataStore/Reference/Profile/2307457)



Spring peeper (*Pseudacris crucifer*), one of several species detected during monitoring in 2014. NPS / GULN (NPGallery)

Study Area

Ocmulgee Mounds National Historical Park (NHP) lies in central Georgia, along the Fall Line, a biogeophysical transition zone between the Piedmont and Southeastern Plains ecoregions. Parts of the park lie within the city limits of Macon, Georgia, and the Ocmulgee River borders the park on the southern edge. A greenway corridor along the river connects the park with natural areas to the south.

Landforms at the park consist primarily of a sizeable floodplain and associated herbaceous wetlands and adjacent uplands. A large, maintained utility right-of-way and railroad track crosses the park in the northeast. The natural resources of the park have been heavily impacted by human influence. Notably, I-16 essentially disconnects the river from its floodplain and alters the natural hydrologic patterns of the area. Threats to biological resources at the park are primarily anthropogenic in origin, and include non-native species, air and water pollution, development, and other issues arising from the park's proximity to Macon.

Ocmulgee Mounds National Historical Park had 18 previously documented anuran species when sampling occurred in 2014 (Table 1; NPS 2025).

Table 1. Anurans known to occur within Ocmulgee Mounds National Historical Park based upon records in NPSpecies (NPS 2025) and those detected during our 2014 sampling. Documented species indicated with “X”.

Order	Family	Species	Authority	Common Name	NPSpecies (2025)	SECN Monitoring (2014)
Anura	Bufonidae	<i>Anaxyrus americanus</i>	Holbrook 1836	American toad	X	X
		<i>Anaxyrus fowleri</i>	Hinckley 1882	Fowler's toad	X	X
		<i>Anaxyrus terrestris</i>	Bonnaterre 1789	Southern toad	X	X
	Hylidae	<i>Acris</i> spp. ¹	Duméril and Bibron 1841	Cricket frog spp. ¹	X ¹	X ¹
		<i>Acris crepitans</i>	Baird 1854	Northern cricket frog ¹	X ¹	–
		<i>Acris gryllus</i>	LeConte 1825	Southern cricket frog ¹	X ¹	–
		<i>Dryophytes avivoca</i>	Viosca 1928	Bird-voiced treefrog	X	X
		<i>Dryophytes chrysoscelis</i>	Cope 1880	Cope's gray treefrog	X	X
		<i>Dryophytes cinereus</i>	Schneider 1799	Green treefrog	X	X
		<i>Dryophytes squirellus</i>	Daudin 1800	Squirrel treefrog	X	X
		<i>Pseudacris crucifer</i>	Wied-Neuwied 1838	Spring peeper	X	X
		<i>Pseudacris feriarum</i>	Baird 1854	Upland chorus frog	X	X
		<i>Pseudacris nigrita</i>	LeConte 1825	Southern chorus frog	X	–
		<i>Pseudacris ornata</i>	Holbrook 1836	Ornate chorus frog	X	–
	Microhylidae	<i>Gastrophryne carolinensis</i>	Holbrook 1835	E. narrow-mouthed toad	X	X
	Ranidae	<i>Lithobates catesbeianus</i>	Shaw 1802	American bullfrog	X	X
		<i>Lithobates clamitans</i>	Latreille 1801	Green 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 *Acris crepitans* and *A. gryllus* cannot be distinguished reliably by ARD recordings. We lumped all *Acris* spp. vocalizations at the genus level.

Methods

Sampling Design

The Southeast Coast Network established a randomly-selected, spatially-balanced set of sample locations ($n = 22$) 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 2014 sampling only. More comprehensive details regarding study design, data collection, and data analyses can be found in the SECN Anuran Monitoring Protocol (Byrne et al. 2013).

Data Collection

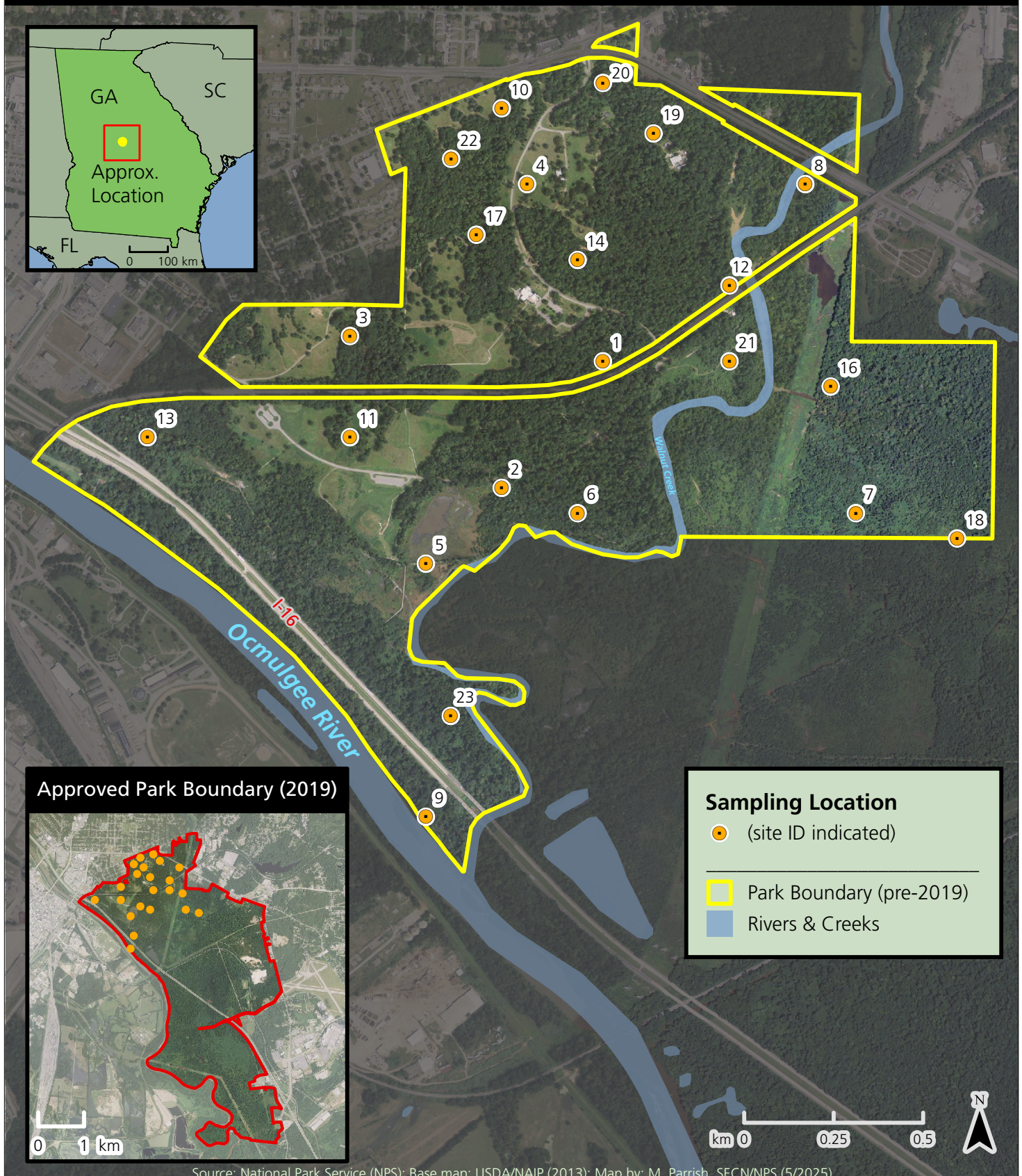
In 2014, we deployed automated recording devices (ARDs) at 22 permanent sampling locations (Figure 1) between March 12 and June 06. We programmed each ARD to record audio on every fourth night, in 30-second intervals every 10 minutes from 20:00 to 04:50. Exact duration of deployment varied slightly, but ranged between 20 and 22 nights for each ARD. Together, our ARDs captured 11,988 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 2025) 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.



Audio Sampling Locations



Source: National Park Service (NPS); Base map: USDA/NAIP (2013); Map by: M. Parrish, SECN/NPS (5/2025).

Figure 1. Permanent audio sampling locations ($n = 22$) within Ocmulgee Mounds National Historical Park. Sampling location ID numbers are indicated at each point. NPS / SECN.

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 tends to produce clusters that are 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 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 Wildlife Biologist.

Taxonomic Standards

Our use of taxonomic nomenclature followed the Integrated Taxonomic Information System (ITIS 2025). The National Park Service maintains the online database NPSpecies (NPS 2025), 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 anurans. Our results were derived from a semi-automated evaluation of 11,988 minutes of audio from 23,976 recordings captured across 22 sample locations. We extracted 10,755 potential signals from the audio recordings, of which we manually classified 3,594 (33.4% of signals). We included in analyses only detections of anurans that were identified to the species level, with the exception of cricket frogs (*Acris* spp.), which were lumped at the genus level due to similarities between two species likely to occur in the park’s geographic region. 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.



Cope's gray treefrog (*Dryophytes chrysoscelis*), one of several species detected during monitoring in 2014. NPS / NPGallery

Field methods for sampling species richness (e.g., point-counts or audio sampling) produce incomplete counts, due to imperfect detection of cryptic species that may be present but difficult to record during surveys. Observed species richness, therefore, is expected to be an underestimate of true species richness, though it offers utility as a richness index. 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*); however, these approaches perform poorly 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 ones 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 further sampling, we plan to examine park data for trends in species composition and spatial distribution with the goal of providing insight into possible drivers (e.g., habitat condition or hydrological processes) of those ecological outcomes.

Results

Species Richness

Observed species richness for native anurans at Ocmulgee Mounds National Historical Park in 2014 was 14 (Table 1). Because detections of two potential species of cricket frogs were lumped at the genus level, that value may be undercounted by one. We did not detect any non-indigenous anuran species. Mean $\pm$ SD observed species richness of native anurans per sample location was 3.59 ± 2.56 (range: 0–9; Table 2; Figure 2). Anurans were detected at 20 of 22 sample locations (none were detected at sites 13 and 14; Figures 1 and 2).

Table 2. Species detections (indicated with “X”) and observed native species richness at each sampling location within Ocmulgee Mounds National Historical Park in 2014. Refer to Figure 1 for labeled sampling locations.

Common Name	01	02	03	04	05	06	07	08	09	10	11	12	13	14	16	17	18	19	20	21	22	23
American toad	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–
Fowler's toad	–	–	–	–	–	X	–	X	X	–	–	X	–	–	X	–	–	–	–	X	–	–
Southern toad	X	X	–	–	X	X	–	X	X	–	X	X	–	–	X	–	X	–	X	X	X	X
Cricket frog spp. ¹	–	X	–	–	X	–	–	X	–	–	–	X	–	–	X	–	X	–	–	–	–	–
Bird-voiced treefrog	–	X	–	–	X	X	X	X	–	–	–	X	–	–	X	–	X	–	–	X	–	–
Cope's gray treefrog	X	–	–	–	–	–	X	–	–	X	X	–	–	–	X	–	X	–	X	X	–	–
Green treefrog	–	X	–	–	X	X	–	X	X	–	–	–	–	–	X	–	–	–	–	–	–	–
Squirrel treefrog	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spring peeper	–	X	X	–	X	X	X	X	X	–	X	–	–	–	–	–	X	–	–	X	–	–
Upland chorus frog	X	–	–	X	–	–	–	–	–	X	–	–	–	–	–	X	–	X	–	–	–	X
Eastern narrow-mouthed toad	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
American bullfrog	–	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Green frog	–	–	–	–	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Southern leopard frog	–	X	–	–	X	X	X	–	X	–	X	–	–	–	–	–	X	–	–	–	–	–
Observed Species Richness	4	7	1	1	9	6	4	7	5	2	4	4	0	0	6	1	6	1	2	5	2	2

¹ *Acris crepitans* and *A. gryllus* cannot be distinguished reliably by ARD recordings. We lumped all *Acris* spp. vocalizations at the genus level.



Species Richness at Sampling Locations

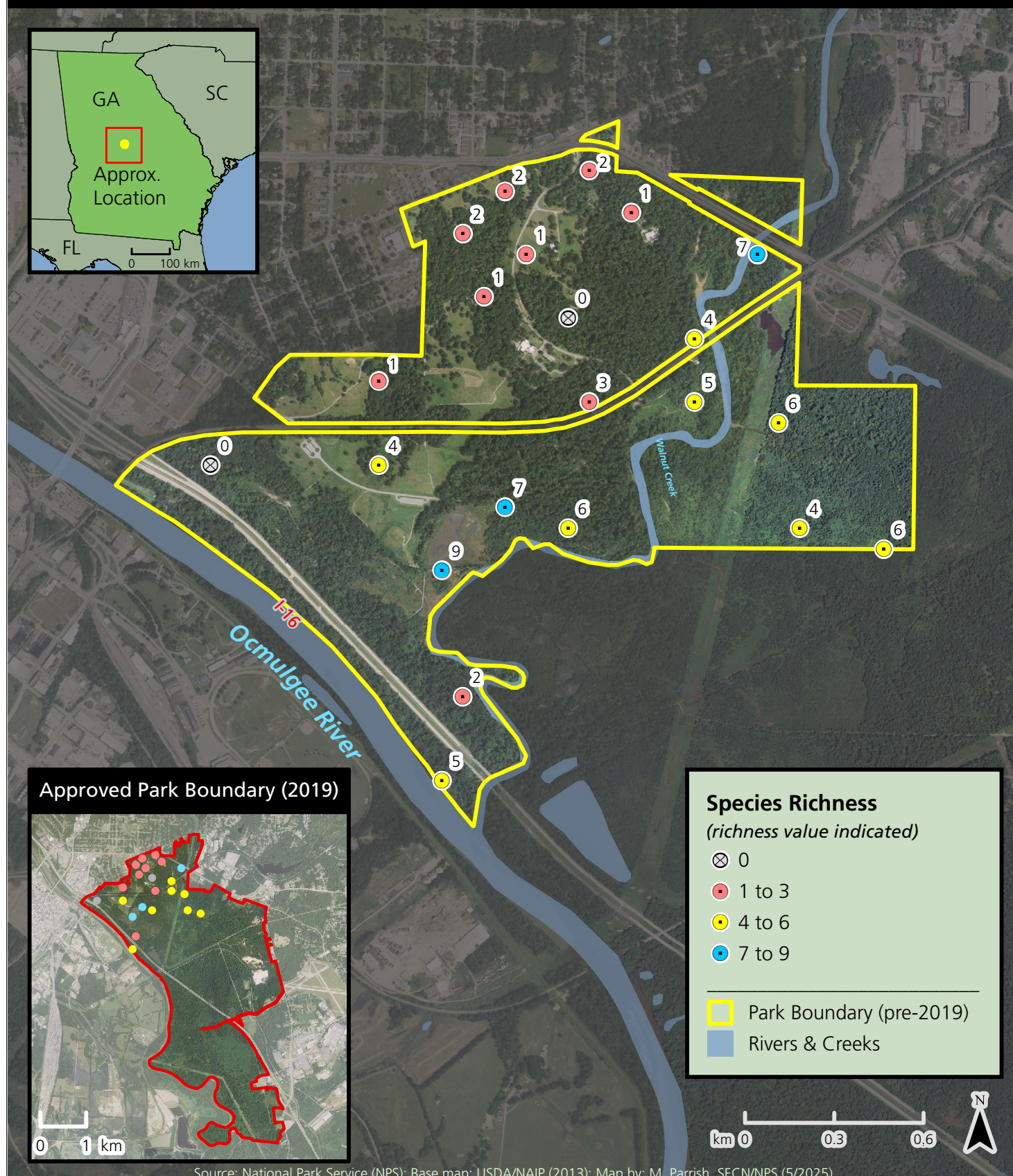


Figure 2. Vocal anuran species richness at sampling locations within Ocmulgee Mounds National Historical Park, based on audio recording detections in 2014. NPS / SECN.

Results (continued)

Occupancy and Spatial Distribution

Naïve occupancy was greatest for southern toad (*Anaxyrus terrestris*), which occurred at 63.6% of sampled locations (Table 3). Spring peeper (*Pseudacris crucifer*) and bird-voiced treefrog (*Dryophytes avivoca*) were also relatively commonly detected and occurred at 45.5% and 40.9% of sampled sites, respectively (Table 3). American bullfrog (*Lithobates catesbeianus*), green frog (*L. clamitans*), American toad (*A. americanus*), squirrel treefrog (*D. squirellus*), and eastern narrow-mouthed toad (*Gastrophryne carolinensis*) were detected at only one sample location each (Table 3).

Table 3. Naïve occupancy estimates (i.e., proportion of permanent sampling locations where a species was detected) for vocal anurans within Ocmulgee Mounds National Historical Park in 2014, ranked by descending proportion of locations occupied.

Common Name	Scientific Name	Naïve Occupancy ¹
Southern toad	<i>Anaxyrus terrestris</i>	63.6%
Spring peeper	<i>Pseudacris crucifer</i>	45.5%
Bird-voiced treefrog	<i>Dryophytes avivoca</i>	40.9%
Cope's gray treefrog	<i>Dryophytes chrysoscelis</i>	36.4%
Southern leopard frog	<i>Lithobates sphenoccephalus</i>	31.8%
Fowler's toad	<i>Anaxyrus fowleri</i>	27.3%
Cricket frog spp. ²	<i>Acris</i> spp.	27.3%
Green treefrog	<i>Dryophytes cinereus</i>	27.3%
Upland chorus frog	<i>Pseudacris feriarum</i>	27.3%
American bullfrog	<i>Lithobates catesbeianus</i>	9.1%
Green Frog	<i>Lithobates clamitans</i>	9.1%
American toad	<i>Anaxyrus americanus</i>	4.5%
Squirrel treefrog	<i>Dryophytes squirellus</i>	4.5%
E. narrow-mouthed toad	<i>Gastrophryne carolinensis</i>	4.5%

¹Percent of sampling locations (n = 22) where species was observed.
²*Acris crepitans* and *A. gryllus* cannot be distinguished reliably by ARD recordings. We lumped all *Acris* spp. vocalizations at the genus level.

All 14 anuran species we detected in 2014 were previously documented at Ocmulgee Mounds National Historical Park (NPS 2025, Table 1).

We did not observe southern chorus frog (*P. nigrata*) or ornate chorus frog (*P. ornata*) which were previously documented at Ocmulgee Mounds National Historical Park. Both species are known only from single reports of auditory observations (Tuberville et al. 2005; NPS 2025), which we consider weak evidence of occurrence. We did not detect eastern spadefoot (*Scaphiopus holbrookii*; NPS 2025). Eastern spadefoot occurs in Bond Swamp National Wildlife Refuge (e.g., Hatch 2023), approximately 4.5 miles (7.25 kilometers) south of Ocmulgee Mounds NHP and the species could be reasonably expected within the park; however, we are unaware of voucher records for eastern spadefoot within the park.

Distribution Maps
Distribution maps indicating the sampling location(s) where species detections occurred are available on the NPS Integrated Resource Management Application portal at [Species Distribution Maps](https://irma.nps.gov/DataStore/Reference/Profile/2311272) (<https://irma.nps.gov/DataStore/Reference/Profile/2311272>).

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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>)

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

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