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Anuran Community Monitoring at Fort Frederica National Monument

2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2015/980



On the cover:
Little Grass Frog (*Pseudacris ocularis*)
Photograph by: Piper Bazemore

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Contents

Page

Tables iv

Figures iv

Executive Summary v

Introduction 1

- Overview 1
- Monitoring Objectives 2
- Study Area 2

Methods 4

- Sampling Design 4
- Taxonomic Standards 4
- Data Collection 4
- Automated Recording Devices 4
- Data Analysis 5
  - Composition 5
  - Distribution 5
  - Phenology 5

Results 6

- Composition 6
- New Species Records 6
- Distribution 8
- Phenology 8

Literature Cited 9

Appendix A—Anuran Species Detection Data 10

Appendix B—Distribution Maps for Anuran Species Encountered 11

Tables

Page

Table 1. Percentage of sampling locations where each anuran species was detected (i.e., naïve occupancy) by automated recording devices (ARDs) at Fort Frederica National Monument, 2014. 7

Table 2. New anuran species detected at For Frederica National Monument and recommended NPSpecies classifications. 7

Table A-1. Anuran species known to occur at Fort Frederica National Monument based on the park's certified species list (NPSpecies 2015) and those detected during this sampling effort. 10

Table A-2. Anuran species detected at each sampling location at Fort Frederica National Monument, 2014. 10

Figures

Page

Figure 1. Location of Fort Frederica National Monument 2

Figure 2. Spatially-balanced random sampling locations at Fort Frederica National Monument, 2014. 3

Figure 3. Number of anuran vocalization detections and the percent relative detection frequency (i.e., number of species vocalizations compared to all species' vocalizations) of recorded calls during automated recording device (ARD) deployment at Fort Frederica National Monument. 7

Figure 4. Vocalization phenology for species detected using automated recording devices (ARDs) at Fort Frederica National Monument, from 11 March to 28 May 2014. 8

Figure B-1. Sampling location where southern toad (*Anaxyrus terrestris*) was detected at Fort Frederica National Monument, 2014. 12

Figure B-2. Sampling location where southern cricket frog (*Acris gryllus*) was detected at Fort Frederica National Monument, 2014. 13

Figure B-3. Sampling locations where green treefrog (*Hyla cinerea*) were detected at Fort Frederica National Monument, 2014. 14

Figure B-4. Sampling locations where pine woods treefrog (*Hyla femoralis*) were detected at Fort Frederica National Monument, 2014. 15

Figure B-5. Sampling locations where squirrel treefrog (*Hyla squirella*) were detected at Fort Frederica National Monument, 2014. 16

Figure B-6. Sampling locations where spring peeper (*Pseudacris crucifer*) were detected at Fort Frederica National Monument, 2014. 17

Figure B-7. Sampling locations where little grass frog (*Pseudacris ocularis*) were detected at Fort Frederica National Monument, 2014. 18

Figure B-8. Sampling locations where greenhouse frog (*Eleutherodactylus planirostris*) were detected at Fort Frederica National Monument, 2014. 19

Figure B-9. Sampling locations where southern leopard frog (*Lithobates sphenocephalus*) were detected at Fort Frederica National Monument, 2014. 20

Figure B-10. Sampling locations where eastern spadefoot toad (*Scaphiopus holbrookii*) were detected at Fort Frederica National Monument, 2014. 21

Executive Summary

The southern United States hosts one of the most diverse amphibian communities in the world and supports the highest density of amphibian species in North America (Echternacht and Harris 1993). The South contains 63 species of frogs and toads, 11 of which are endemic; this accounts for almost 40% of the total number of anuran species in the United States (Dorcas and Gibbons 2008, Echternacht and Harris 1993). The park units in the National Park Service's (NPS) Southeast Coast Network (SECN) are home to 35 known anuran species (frogs and toads). Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern United States, anuran communities are a priority for SECN monitoring efforts. This report summarizes anuran community vital signs monitoring data collected at Fort Frederica National Monument (FOFR) in 2014.

- Automated recording devices (ARDs) were used to collect recordings from 3/11/2014 through 5/28/2014 at 11 spatially balanced random locations.
- Vocalizations from nine native anuran species and one non-native species were identified.
- A total of 87 vocal detections were made using the ARD recordings. Each detection represents an identifiable observation of a species or species group during one night of monitoring at a sampling location.
- The greenhouse frog (*Eleutherodactylus planirostris*) was the most frequently detected anuran at FOFR in 2014. The green treefrog (*Hyla cinerea*) and the squirrel treefrog (*Hyla squirella*) had the second highest naïve occupancy rates at the park.
- The greenhouse frog had the highest relative frequency of detection of vocalizations over the 77-day recording period in 2014; the green treefrog had the second highest frequency of detection.
- Green treefrog, squirrel treefrog, and greenhouse frog were the most widely distributed anuran species, each having been found throughout the park.
- Four anurans were added to the FOFR species list as the result of our 2014 monitoring efforts; green treefrog, pine woods treefrog (*Hyla femoralis*), spring peeper (*Pseudacris crucifer*), and little grass frog (*Pseudacris ocularis*).
- One non-native species, the greenhouse frog, was detected.
- Anuran communities at Fort Frederica National Monument will next be sampled in 2017.
- The full dataset and associated metadata can be acquired from the NPS Integrated Resource Management Applications (IRMA) portal at http://irma.nps.gov.

Introduction

Overview

Amphibian populations have declined in North America and many other areas around the world. Several factors have contributed to these population declines and localized extinctions. Among these factors are disease and anthropogenic stressors, such as habitat loss and degradation, non-native predators, acid precipitation, altered hydrology and hydroperiod, ultraviolet radiation, and chemical contaminants (Collins and Storfer 2003). Although diseases and parasites naturally occur in amphibian populations, their effects can be exacerbated when combined with other anthropogenic stressors.

Amphibians have complex life cycles in which the immature phase often consists of an aquatic larval stage, followed by a post-metamorphic adult terrestrial stage. Slight alterations in the aquatic or terrestrial communities upon which amphibians depend can substantially impact the survival, reproduction, and persistence of a species. Given their habitat requirements, anatomy, and physiology, amphibians are considered good indicators of ecological condition.

The southern United States hosts one of the most diverse amphibian communities in the world and supports the highest density of amphibian species in North America (Echternacht and Harris 1993). The South is home to 63 species of frogs and toads, 11 of which are endemic; this accounts for almost 40% of the total number of anuran species in the Unites States (Dorcas and Gibbons 2008, Echternacht and Harris 1993). Units in the National Park Service's (NPS) Southeast Coast Network (SECN) have 35 known anuran species (frogs and toads). Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern United States, anuran communities are a priority for SECN monitoring efforts.

The National Park Service Omnibus Management Act of 1998, and other reinforcing policies and regulations, require park managers "to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources" (Title II, Sec. 204). The anuran community monitoring data summarized herein is a tool to assist park managers in fulfilling this mandate.

This report summarizes data collected as a part of the Southeast Coast Network Vital Signs Monitoring Program's efforts to assess the status and trends of anuran communities at Fort Frederica National Monument (FOFR).

Study Area

Fort Frederica National Monument (FOFR) is located on St. Simon's Island in southeast Georgia (Figure 1). The monument is divided by the Frederica River, one of the primary salt marsh rivers in the Brunswick area, with 99 acres of marsh lands at the Frederica site on the west side of the river and approximately 137 acres of uplands adjoining the east side of the river. The separate Bloody Marsh site consists of eight acres, of which approximately five acres are tidal marsh.

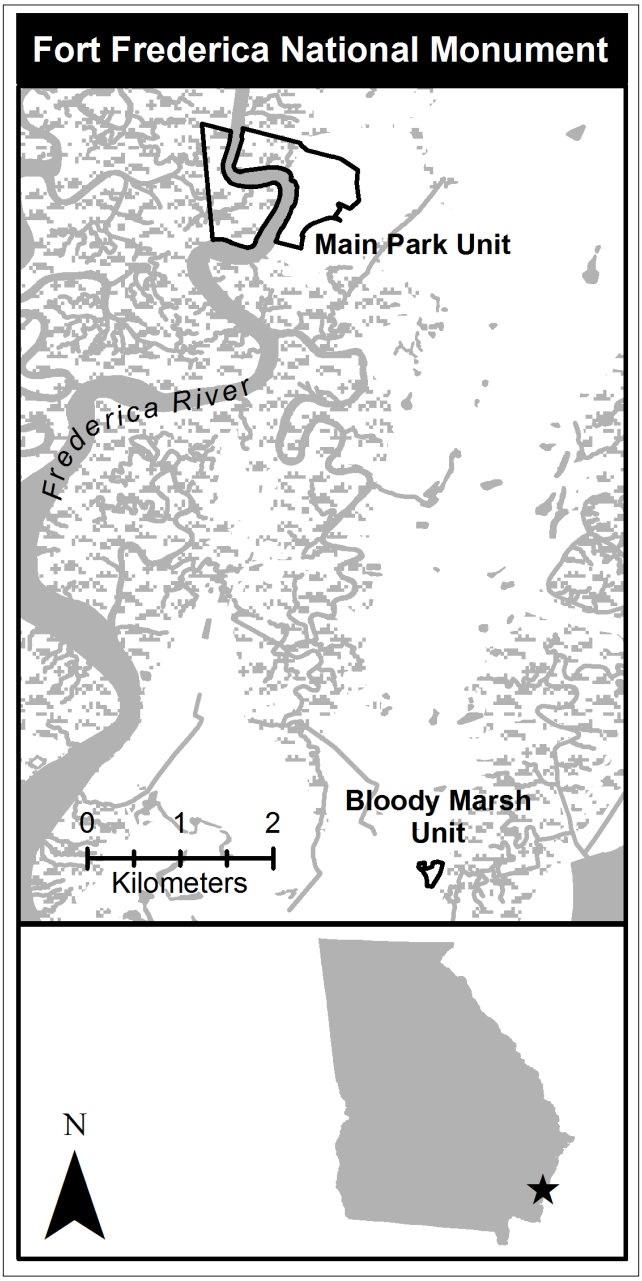


Figure 1. Location of Fort Frederica National Monument

The salt marsh is dominated by cordgrass (*Spartina* spp.), and the uplands are a mix of coastal maritime hammock dominated by Virginia live oak (*Quercus virginiana*) and a small component of slash pine (*Pinus elliottii*).

Fort Frederica has 12 known anuran species (frogs and toads), four of which were added to the park species list as a result of the SECN's 2014 monitoring effort (NPSpecies 2015; Appendix A).

Monitoring Objectives

Analysis of monitoring data is based on detections of vocal anurans using automated recording devices. A detection consists of one or more observations of a species or species group during one night of monitoring at a sampling location. The Southeast Coast Network has four monitoring objectives related to anuran communities based on post-metamorphic anuran vocalization data collected from March to mid-June in non-saline wetland and upland vegetation communities in all SECN park units (Byrne et al. 2013):

- Determine the status and trends in species richness and diversity of anuran communities. Species richness and diversity estimates are based on the total number of species detected (native and non-native).
- Determine the status and trends in occupancy by anuran species. Occupancy estimates provide insight into the likelihood of encountering a specific species in a given area. The rarity, diversity, and distribution of a species or group and associated relative comparisons provide insight into the composition of the sample.
- Determine the status and trends in frequency of detection of vocal anurans. Frequency of detection is the number of nights a species or species group is observed during the sampling event at each sampling location.
- Determine trends in the vocalization phenology of select anurans with high detectability. Vocal anuran calling patterns of species with high detectability (i.e., an unbiased detectability estimate generated from the occupancy-modeling process) will be analyzed to determine the status and trends in the first and last dates on which species are detected.

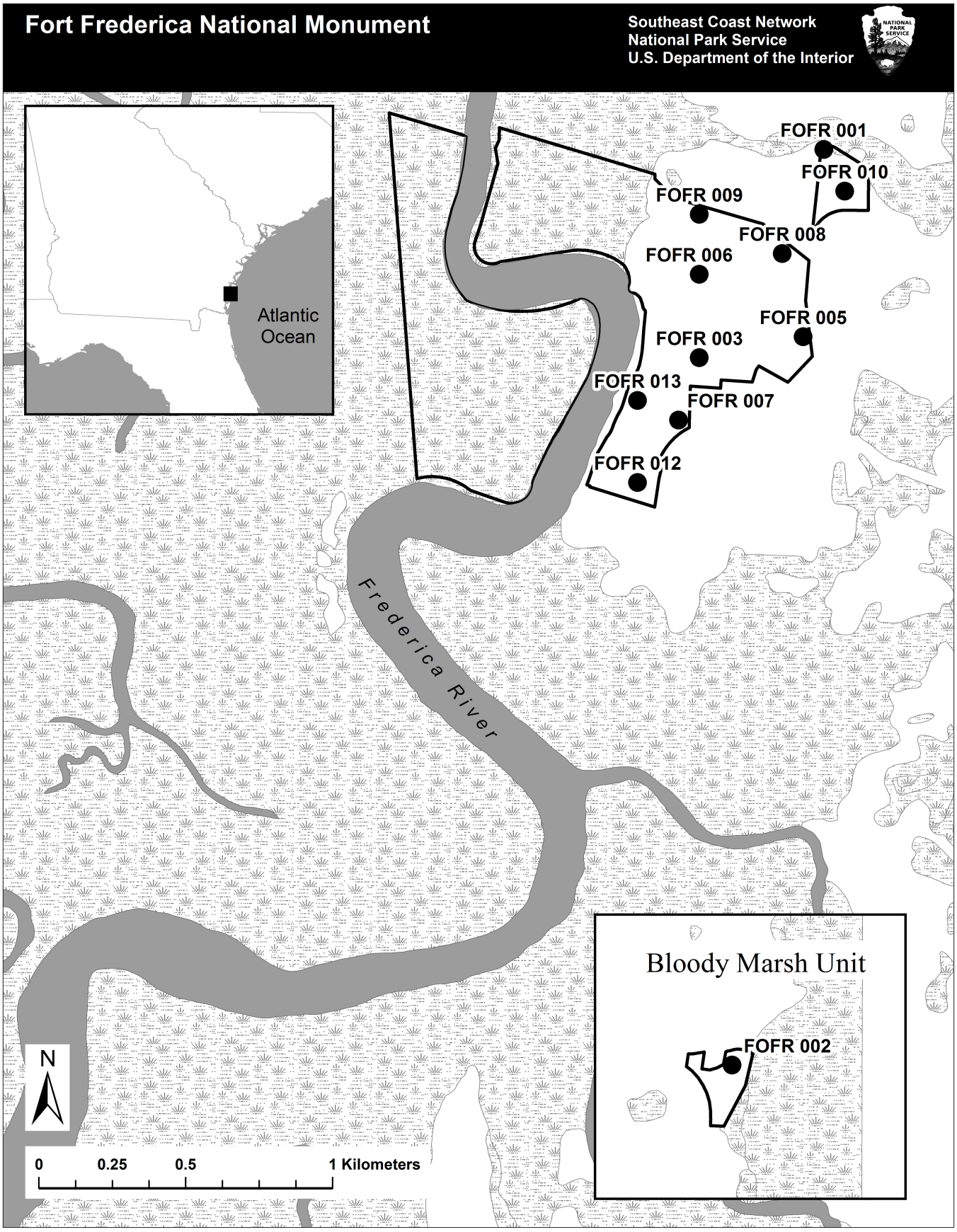


Figure 2. Spatially balanced random sampling locations at Fort Frederica National Monument, 2014.

Methods

Sampling Design

The sampling design and sampling-location selection is detailed in Appendix B of the SECN Vocal Anuran Community Monitoring Protocol (Byrne et al. 2013) and in the sampling-location selection Standard Operating Procedure #1.1.1 (Byrne 2012). In summary, the park's administrative boundary was used as the sampling frame to allow for park-wide inference. The sampling frame was divided into a systematic 0.5-hectare grid; the center point of each grid cell served as the potential sampling location. A spatially balanced sample was drawn from this grid using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald et al. 2007). Alternate points were used when specified selection criteria (e.g., safety issues, accessibility) were not met. In 2014, anuran communities were sampled at 11 locations that met the selection criteria (Figure 2).

Taxonomic Standards

Taxonomy and nomenclature follow standards set forth in the Integrated Taxonomic Information System (ITIS; http://www.itis.gov/). The National Park Service uses the online application NPSpecies (https://irma.nps.gov/npspecies) to document "our knowledge about the occurrence and status of species on National Park Service lands," including maintenance of species lists for NPS properties. The taxonomy and nomenclature in NPSpecies is periodically updated with the most current ITIS catalog. As noted on the ITIS webpage, the system intends not to "serve as a forum for cutting-edge taxonomic classifications," but rather to use "classifications that have gained broad acceptance in the taxonomic literature and by professionals who work with the taxa."

All vocalizations are identified to the finest (i.e., lowest) resolution possible in the taxonomic hierarchy. Only vocalizations identified to the species level are used in the analyses presented herein.

Data Collection

A passive sampling technique was used to collect recordings in the field. Recordings were then manually evaluated using Song Scope software (Wildlife Acoustics Inc.) and data were extracted to be used in the anuran community monitoring data analysis. Anuran monitoring locations are co-located with the SECN landbird community and vegetation community monitoring locations.

Automated Recording Devices

Automated recording devices (ARDs) are often used to characterize soundscapes. Recently, this technology has been applied to wildlife species monitoring efforts. The use of ARDs is advantageous in SECN parks because of (a) the high number of vocal anurans (i.e., vocalizing frogs and toads) in SECN parks, (b) the assumed broad distribution of many of these species across park lands, (c) the crepuscular and nocturnal calling behavior that predominates among the vocal anurans in SECN park units (Mohr and Dorcas 1999, Bridges and Dorcas 2000, Todd et al. 2003), (d) the safety issues for personnel conducting night-time calling surveys, and (e) the adherence of detection/non-detection data from ARDs to the monitoring objectives. Further, the devices produce recordings which serve as a permanent data product that can be further analyzed as technology improves. The recordings can also be analyzed by other researchers, analyzed for other taxa, or used to quantify the soundscape.

To address some of the known influences related to imperfect detection (MacKenzie et al. 2002, MacKenzie et al. 2006), automated recording devices were deployed for 77 days to ensure detection of species present at the park as well as to assess changes in calling phenology. After the deployment period, the devices were retrieved and audio files were analyzed by SECN staff to determine the date, time, and species of all vocal anurans that were detected.

As is the case with all data collected by ARDs, the information derived is based on species' detectability. The occupancy estimates and phenology trends are based on methodology and data collection that does not account for environmental cues that initiate calling behavior (e.g., rainfall, humidity, and temperature). Additionally, while every effort is made to ensure that the recording timeframe is sufficient to encompass most vocalizing anurans, the recordings are only a portion of the time during which anurans are active. Based upon pilot monitoring efforts in the SECN from 2009 through 2012 and vocalization-phenology information in the region (Dorcas and Gibbons 2008), we determined the most appropriate timeframe for deploying the ARDs in SECN park units to be March through June.

ARDs were deployed at or near the center point of each selected 0.5-hectare grid cell (i.e., the sampling location). The devices were programmed to record every four days from 18:00 (6:00 pm) to 06:50 (6:50 am) for 30 seconds every 10 minutes. This recording schedule continued for

11 weeks (i.e., 77 days) and provided 20 distinct sampling events. ARDs were deployed at Fort Frederica National Monument from 3/11/2014 through 5/28/2014. A total of 7,449 minutes were recorded by all of the devices deployed. The ARD malfunctioned or was damaged by weather events and recorded only partial data at two sampling locations (003 and 005). The ARD at sampling locations 003 and 005 recorded for five and six sampling events, respectively.

Species occurrences were derived from the recordings by applying various algorithms in a software environment (i.e., Song Scope), and through a manual-evaluation process implemented to maintain quality assurance and quality control standards. These processes are detailed in SOPs 1.4.2 and 1.4.21 of the SECN Vocal Anuran Community Monitoring Protocol (Byrne et al 2013).

Data Analysis

This protocol collects detection / non-detection data. In contrast to detections made from visual survey methods in which individuals can be seen, differentiated, and counted, detections from automated recording devices cannot be reliably associated with more than one individual. In general, one individual will vocalize multiple times during the survey period and is likely detected multiple times. Individual anurans vocalizing in a chorus also cannot be reliably differentiated by voice alone. Consequently, data-summary techniques do not equate one vocalization with one individual and are conducted accordingly.

Composition

Measures of community composition are often good indicators of abiotic variability, disturbance, or other stressors. Summaries related to composition include the total number of species detected (i.e., species richness), naïve occupancy, and relative detection frequency. Species richness is simply the number of native species detected.

Naïve occupancy is the percentage of the sampling locations where a species was detected at least once, without adjusting for probability of detection (i.e., detectability). Naïve occupancy is also referred to as frequency of occurrence. Naïve occupancy provides insight into the distribution of a species across the park and whether the species can be considered common or uncommon. Species with high values occur at more locations than those with low values.

Relative detection frequency uses detection history as an index to communicate the frequency at which each species is detected relative to all other species in the sample. This estimate conveys information about the detectability of a species or, more specifically, a characteristic that makes a species detectable (e.g., vocalization behavior). Species with high relative-detection frequency values are detected more frequently than species with low values. To minimize the bias inherent in this summary from the influences of detectability, vocalization behavior, sound properties, and various aspects of the automated analysis process, the estimate of relative detection frequency is derived by pooling across the detection histories and sampling locations for each species.

Distribution

Understanding changes in the distribution of amphibian species is integral to informed management of species and their requisite habitats. Changes in species distributions over time provide useful information at both the local and landscape scale regarding how species respond to large-scale influences such as changing land use, climate, hydrology, or habitat availability and condition. Shifting species distributions alter species interactions and the food-web structure, thereby producing cascading effects on ecosystem processes (Montoya and Raffaelli 2010). Distribution maps for all anuran species encountered are presented in Appendix B.

Phenology

Phenology, the periodic life-cycle events of plants and animals as they are influenced by changes in the seasons, is an increasingly useful tool in monitoring climate change and its potential effects on amphibian populations (Blaustein et al. 2001, Gibbs and Breisch 2001, Corn 2005, Parmesan 2007, Blaustein et al. 2010, Todd et al. 2014). The timing of anuran territorial and mating vocalizations can provide insight into the initiation of the breeding season for these animals, and tracking these dates may prove to be a robust method for monitoring climate change, as it presents in the southeastern United States. The Southeast Coast Network reports the earliest and latest vocalization dates of select anuran species based on their known annual vocalization pattern and the recording window of our methodology. Species should be detected during three or more park-wide sampling events during the survey year to be considered for reporting in phenology. Vocalization start dates are reported for species that typically begin to vocalize well after the start of our recording schedule in SECN parks, while species known to cease vocalizing well before our recording schedule concludes are appropriate candidates for tracking vocalization end dates (Dorcas and Gibbons, 2008). Periodic synthesis reports, which will be published after multiple rounds of sampling, will summarize phenological history of anuran species detected across the Southeast Coast Network for which appropriate candidates for trend analysis are available.

Results

Composition

We detected five of the seven native anuran species known to be present at Fort Frederica in 2014. We also detected four additional native species to be added to the park species list (Table 1). One non-native anuran, the greenhouse frog (*Eleutherodactylus planirostris*), was detected.

Overall, species diversity was low for our suite of sampling locations at Fort Frederica, with only three species having occupancy rates over 20%. The non-native greenhouse frog, detected at approximately 54% of the sampling locations in Fort Frederica National Monument, had the highest naïve occupancy rate of all anurans detected during our 2014 surveying period. Green treefrog (*Hyla cinerea*) and squirrel treefrog (*Hyla squirella*) tied as the second most frequently encountered anurans, both having been detected at 5 of the 11 sampling locations throughout Fort Frederica. The southern cricket frog (*Acris gryllus*) and the southern toad (*Anaxyrus terrestris*) were the least frequently occurring anurans at Fort Frederica, each detected vocalizing at only one sampling location in 2014 (Table 1).

Despite the low overall species diversity at Fort Frederica National Monument in 2014, several sampling locations at the park were found to have relatively high species richness, compared to the median of two species detected per site. Sampling location FOFR 001 had the highest anuran species richness, with seven species detected vocalizing during our survey effort. FOFR 006 was found to have five species present, while four species were detected each at sampling locations FOFR 002 and FOFR 009 (Table A-2).

The greenhouse frog also had the highest relative detection frequency of vocalizations recorded by ARDs over the 77-day period. This species accounted for approximately 30% of the total vocal detections at the park in 2014, and was detected during 26 discrete sampling events park-wide over the 77-day sampling period (Figure 3). The green treefrog, detected during 24 park-wide sampling events, and the squirrel treefrog, found vocalizing during 17 sampling events, also had high relative detection frequency rates. These three anurans dominated the vocal detection sample at Fort Frederica, accounting for 77% of all detections. The southern cricket frog, detected on only one sampling event and at one sampling location had the lowest relative detection frequency.

We detected one non-native anuran species at Fort Frederica National Monument in 2014. The frequency of occurrence of non-native anurans (the greenhouse frog) at FOFR is 54.5% (Table 1, Table A-2).

New Species Records

We detected four additional anuran species, not currently on the FOFR anuran species list, during our 2014 monitoring efforts (Table 2). Anurans added to the Fort Frederica park species list as a result of our 2014 monitoring efforts were green treefrog, pine woods treefrog (*Hyla femoralis*), spring peeper (*Pseudacris crucifer*) and little grass frog (*Pseudacris ocularis*).

Because each new species was detected at two or more of the park sampling locations in 2014, it seems likely that all four species were present in 2009, although our sampling methodology at the time failed to detect them. This apparent detection failure can likely be attributed to the greatly reduced recording window of only 10 days dictated by our 2009 methodology, as opposed to the 77-day recording time frame of our current methodology. A shorter recording window would not have reflected the variety of responses from anuran species to changes in temperature and moisture levels, which are induced by a wide array of weather events. Additionally, the ARDs were deployed only in mid-season, from 18–28 May 2009. Recordings from this limited date range would not capture anurans which vocalize almost exclusively during the earliest part of the breeding season, such as the spring peeper.

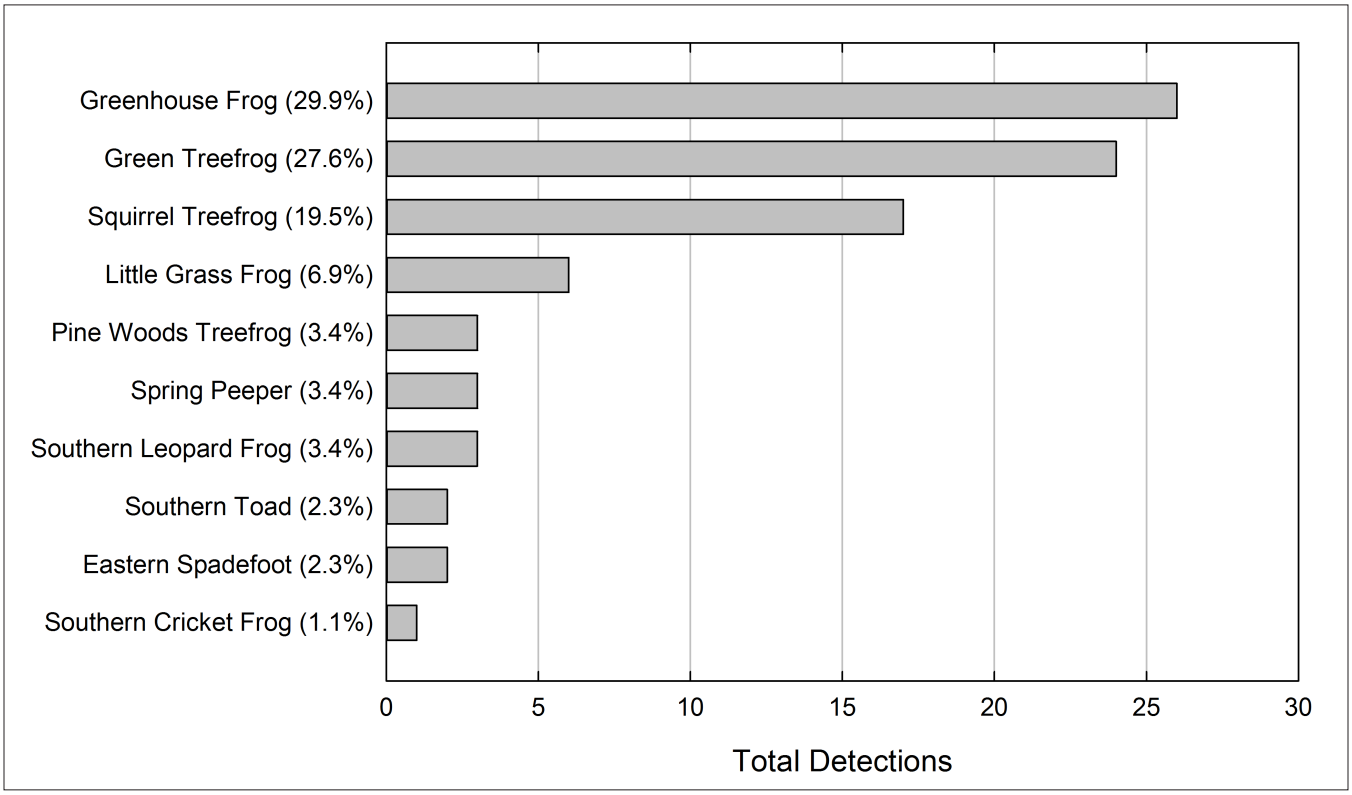


Figure 3. Number of anuran vocalization detections and the percent relative detection frequency (i.e., number of species vocalizations compared to all species' vocalizations) of recorded calls during automated recording device (ARD) deployment (11 March to 28 May 2014) at Fort Frederica National Monument. Based on n=87 detections.

Table 1. Percentage of sampling locations where each anuran species was detected (i.e., naïve occupancy) by automated recording devices (ARDs) at Fort Frederica National Monument, 2014.

Anuran Species	Naïve Occupancy
Greenhouse Frog	54.5
Green Treefrog	45.5
Squirrel Treefrog	45.5
Pine Woods Treefrog	18.2
Spring Peeper	18.2
Little Grass Frog	18.2
Southern Leopard Frog	18.2
Eastern Spadefoot Toad	18.2
Southern Cricket Frog	9.1
Southern Toad	9.1
Total Locations Surveyed	11

Table 2. New anuran species detected at For Frederica National Monument and recommended NPSpecies classifications.

Scientific Name	Common Name	Abundance	Residency	Nativity	Pest	Management Priority	Exploitation Concerns
Hyla cinerea	Green Treefrog	Unknown	Resident	Native	No	No	No
Hyla femoralis	Pine Woods Treefrog	Unknown	Resident	Native	No	No	No
Pseudacris crucifer	Spring Peeper	Unknown	Resident	Native	No	No	No
Pseudacris ocularis	Little Grass Frog	Unknown	Resident	Native	No	No	No

Distribution

The green treefrog, squirrel treefrog, and greenhouse frog were the most widely distributed anuran species at Fort Frederica National Monument in 2014, and each was found at sampling locations throughout the main unit of the park, as well as in the detached Bloody Marsh unit (Figures B-3, B-5, and B-8, Appendix B). The narrowest distributions were found for the southern toad and the southern cricket frog. Both of these species were detected at only one sampling location at Fort Frederica. Distribution maps for all anurans detected during the monitoring event are presented in Appendix B.

Phenology

Four species detected in 2014 would be appropriate candidates to determine trends in vocalization start dates. The first vocal detection of the greenhouse frog occurred on 3/27/2014 and the squirrel treefrog was first detected on 3/28/2014. The green treefrog was not detected until 4/21/2014, and the pine woods treefrog was first detected vocalizing on 4/28/2014. One species is an appropriate candidate for tracking end dates. The spring peeper was last detected vocalizing on 3/20/2014 (Figure 4).

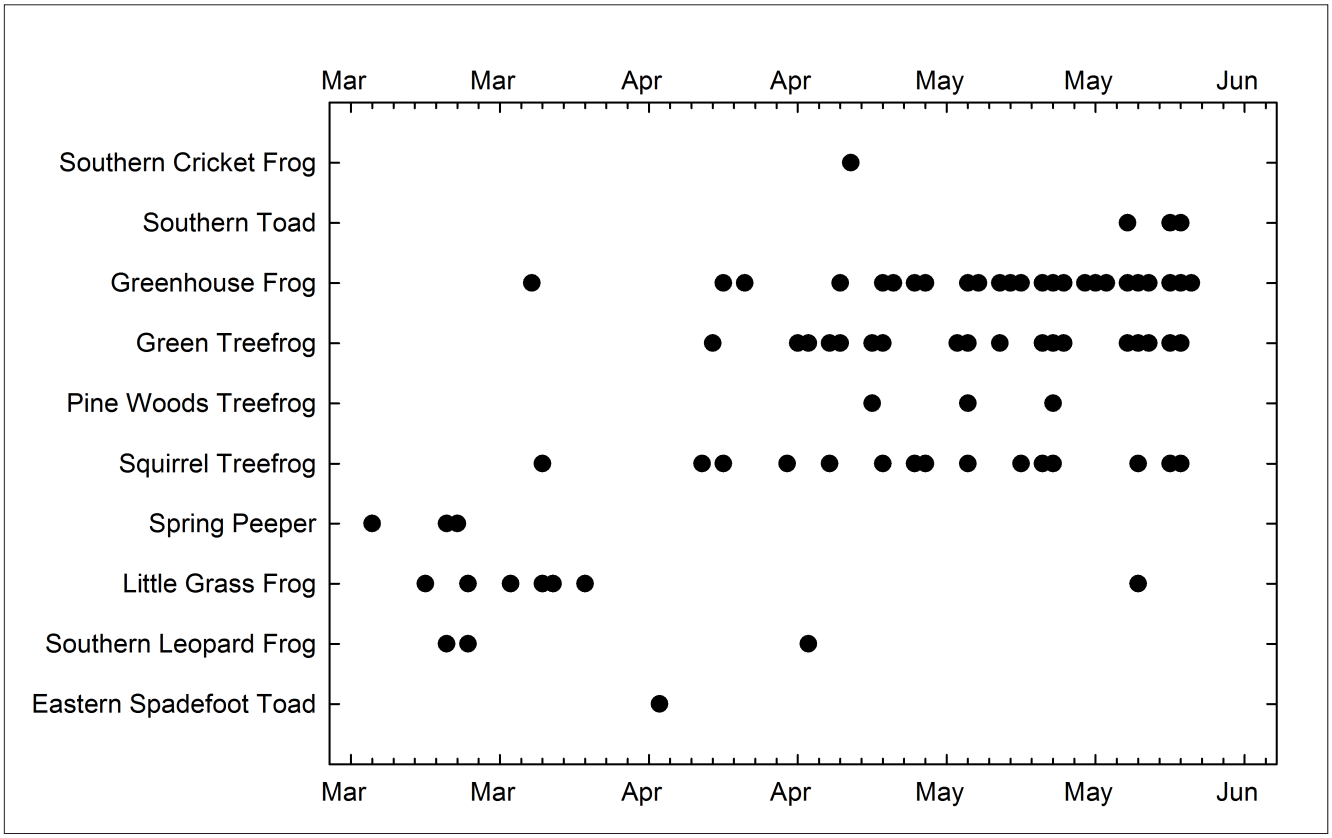


Figure 4. Vocalization phenology for species detected using automated recording devices (ARDs) at Fort Frederica National Monument, from 11 March to 28 May 2014. Based on n=87 detections.

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Appendix A—Anuran Species Detection Data

Table A-1. Anuran species known to occur at Fort Frederica National Monument based on the monument's certified species list (NPSpecies 2015) and those detected during this sampling effort.

Scientific Name	Common Name	NPSpecies	ARD
Anaxyrus terrestris	Southern Toad	X	X
Acris gryllus	Southern Cricket Frog	X	X
Hyla cinerea	Green Treefrog		X
Hyla femoralis	Pine Woods Treefrog		X
Hyla gratiosa	Barking Treefrog	X	
Hyla squirella	Squirrel Treefrog	X	X
Pseudacris crucifer	Spring Peeper		X
Pseudacris ocularis	Little Grass Frog		X
Eleutherodactylus planirostris	Greenhouse Frog	X	X
Gastrophryne carolinensis	Eastern Narrowmouth Toad	X	
Lithobates sphenocephalus	Southern Leopard Frog	X	X
Scaphiopus holbrookii	Eastern Spadefoot Toad	X	X

Table A-2. Anuran species detected at each sampling location at Fort Frederica National Monument, 2014.

Species	1	2	3	5	6	7	8	9	10	12	13
Southern Toad					X						
Southern Cricket Frog	X										
Green Treefrog	X	X				X		X		X	
Pine Woods Treefrog	X				X						
Squirrel Treefrog	X	X			X	X		X			
Spring Peeper				X				X			
Little Grass Frog	X	X									
Greenhouse Frog	X	X	X		X		X	X			
Eastern Spadefoot Toad					X		X				
Southern Leopard Frog	X			X							

Appendix B—Distribution Maps for Anuran Species Encountered

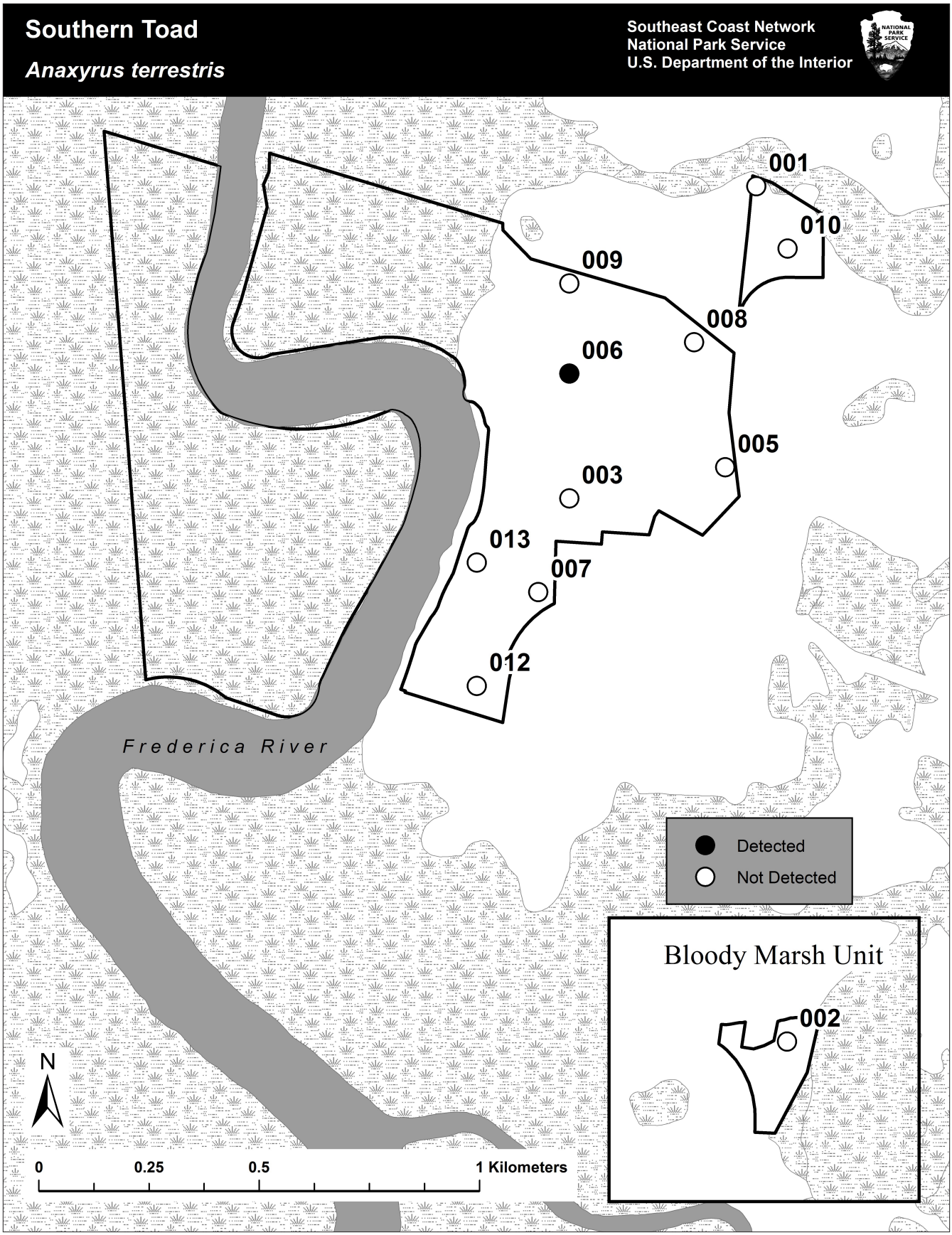


Figure B-1. Sampling location where southern toad (*Anaxyrus terrestris*) was detected at Fort Frederica National Monument, 2014.

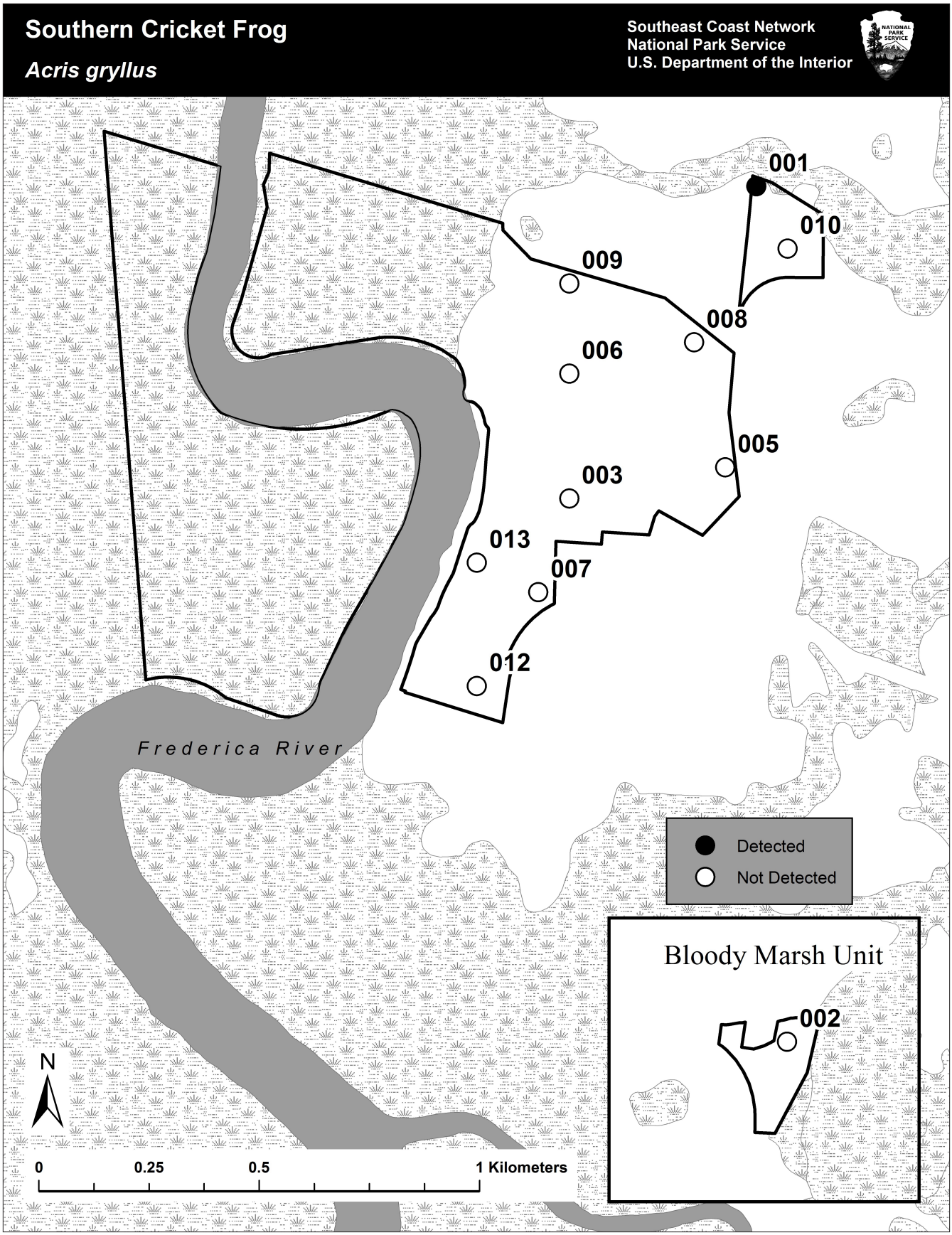


Figure B-2. Sampling location where southern cricket frog (*Acris gryllus*) was detected at Fort Frederica National Monument, 2014.

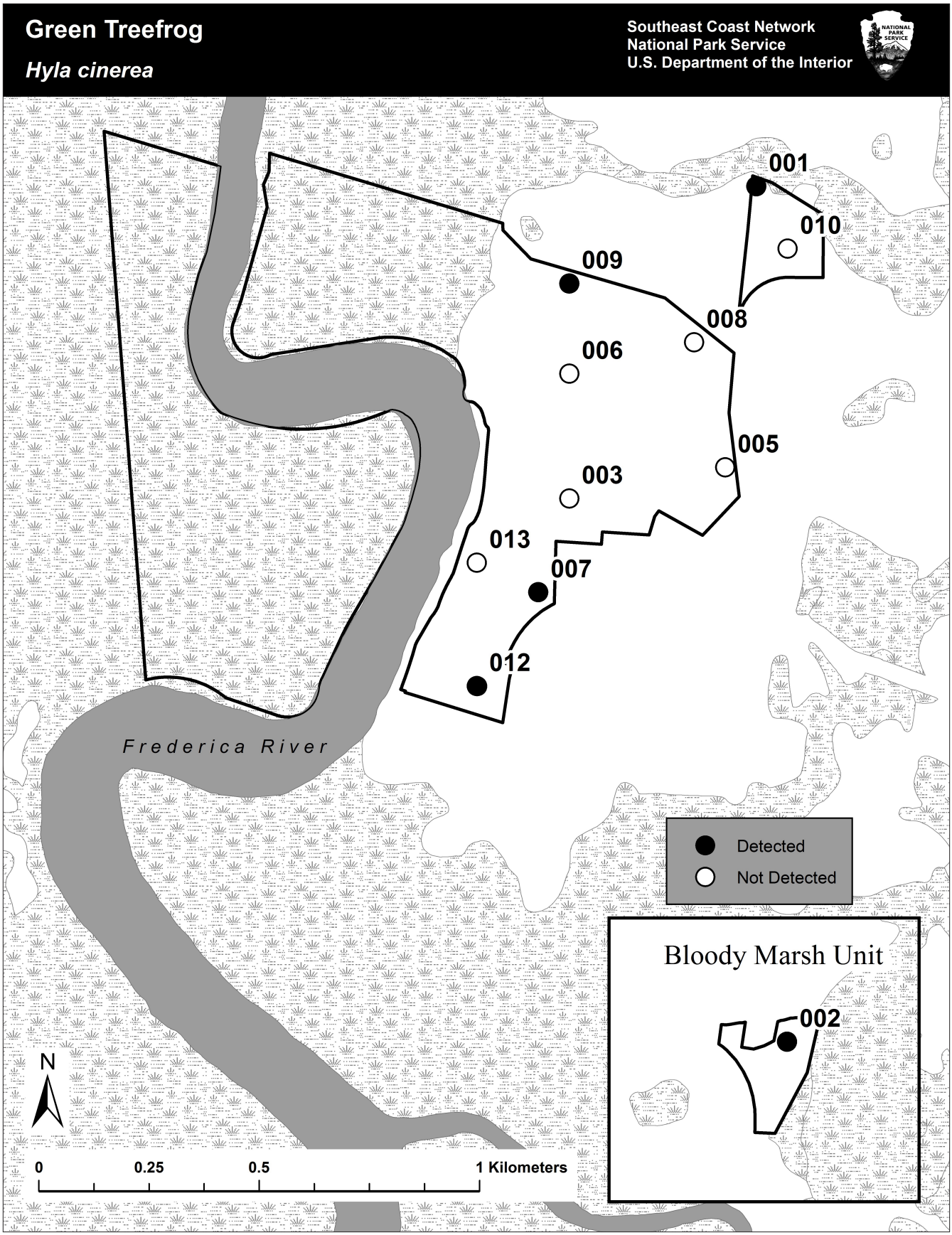


Figure B-3. Sampling locations where green treefrog (*Hyla cinerea*) was detected at Fort Frederica National Monument, 2014.

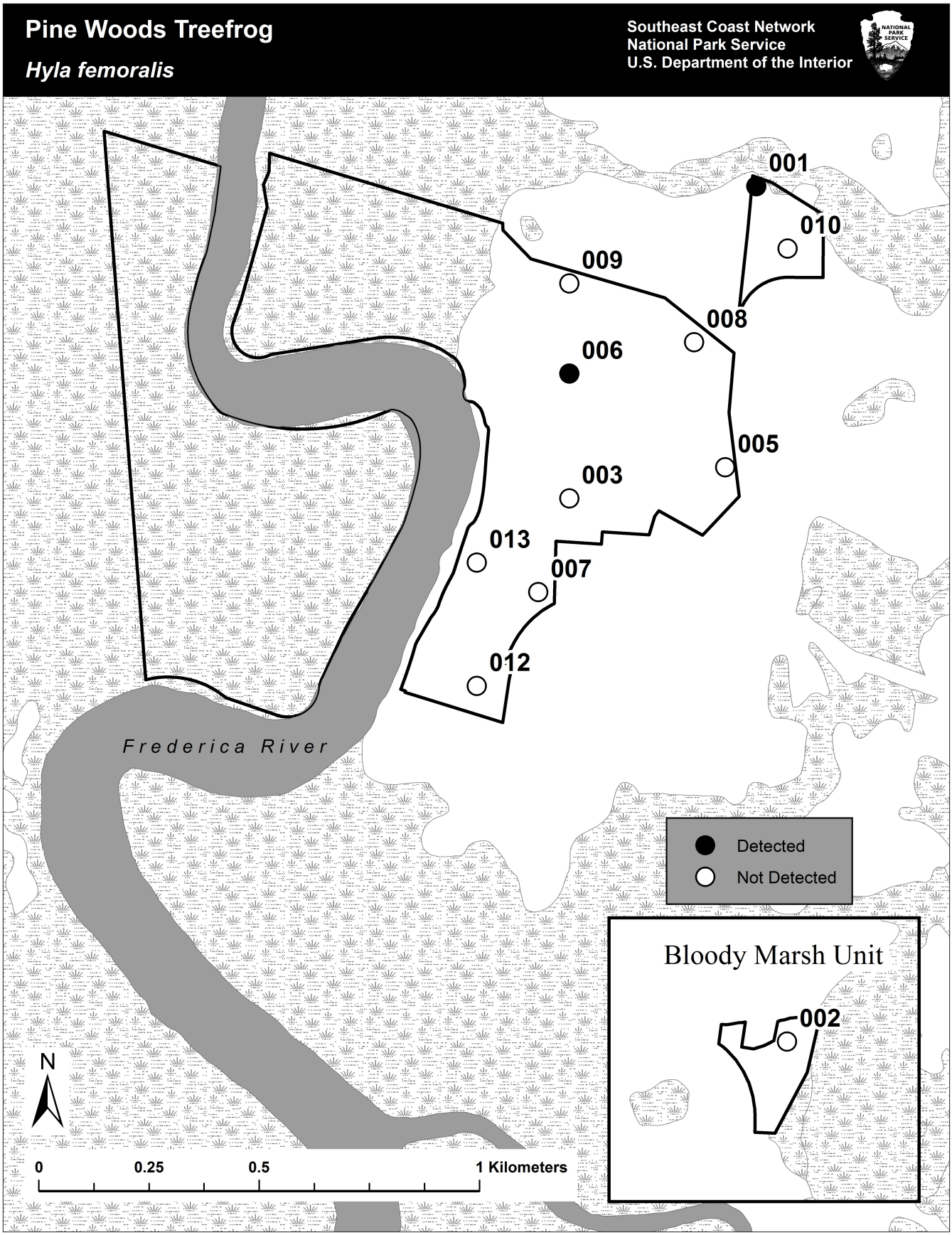


Figure B-4. Sampling locations where pine woods treefrog (*Hyla femoralis*) was detected at Fort Frederica National Monument, 2014.

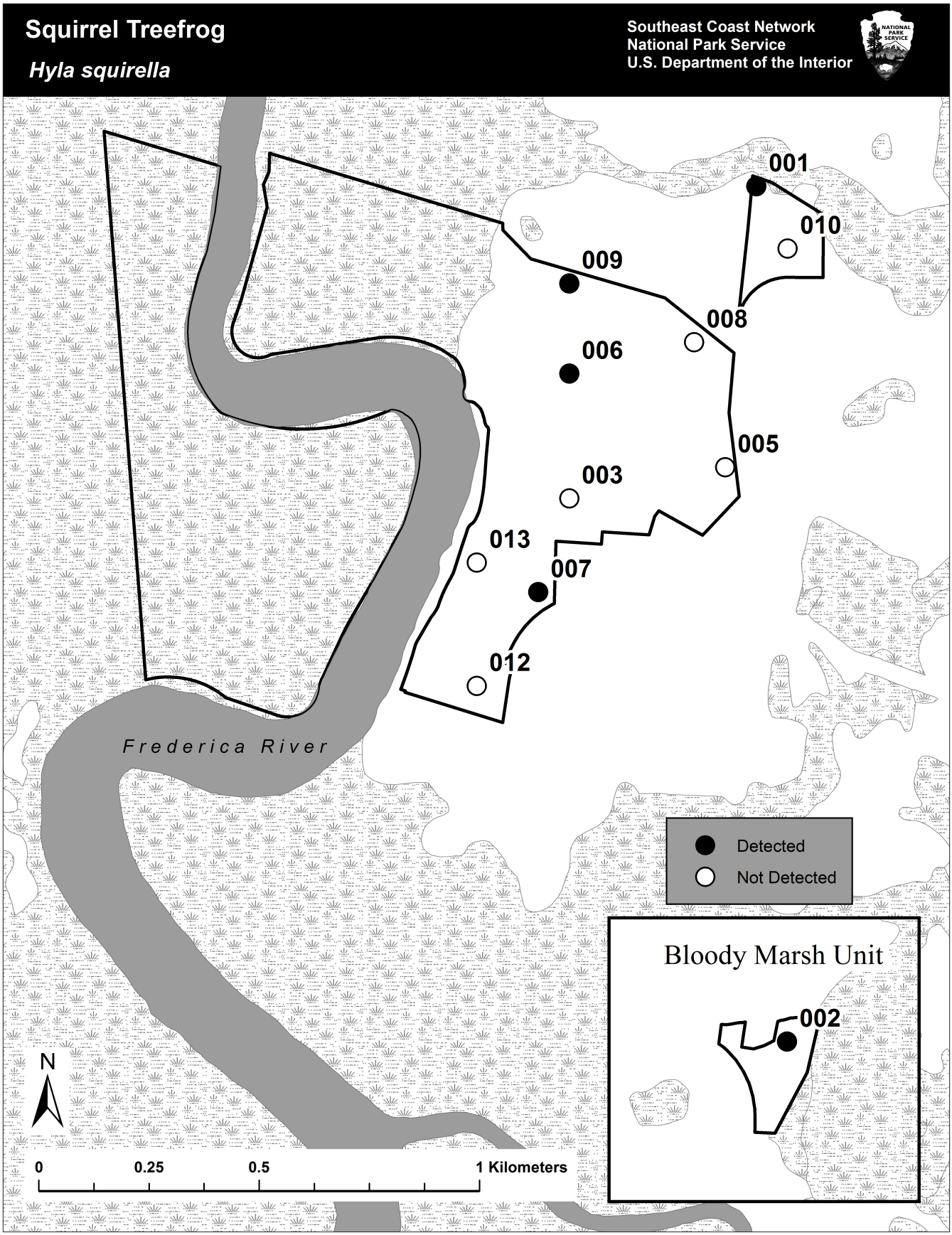


Figure B-5. Sampling locations where squirrel treefrog (*Hyla squirella*) was detected at Fort Frederica National Monument, 2014.

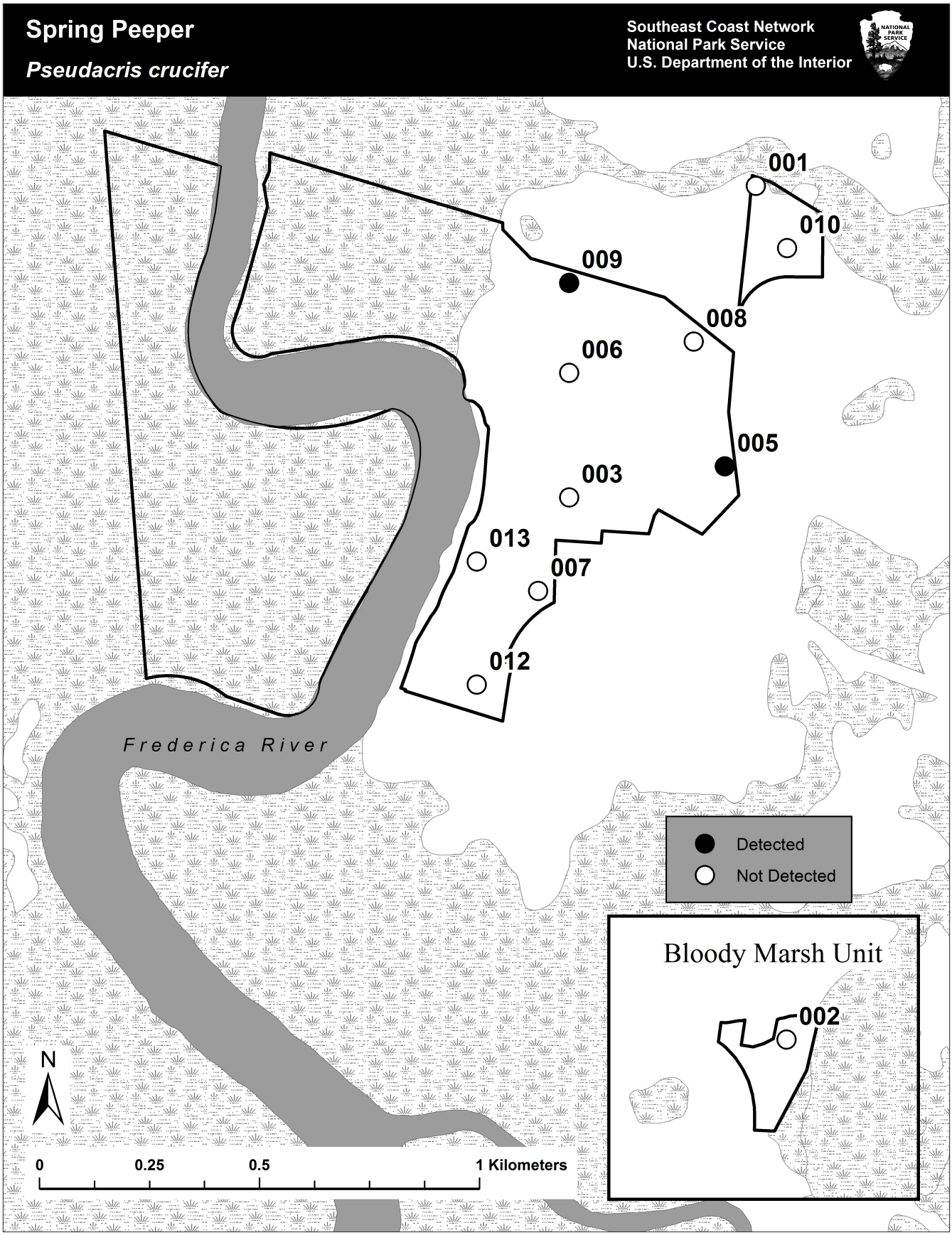


Figure B-6. Sampling locations where spring peeper (*Pseudacris crucifer*) was detected at Fort Frederica National Monument, 2014.

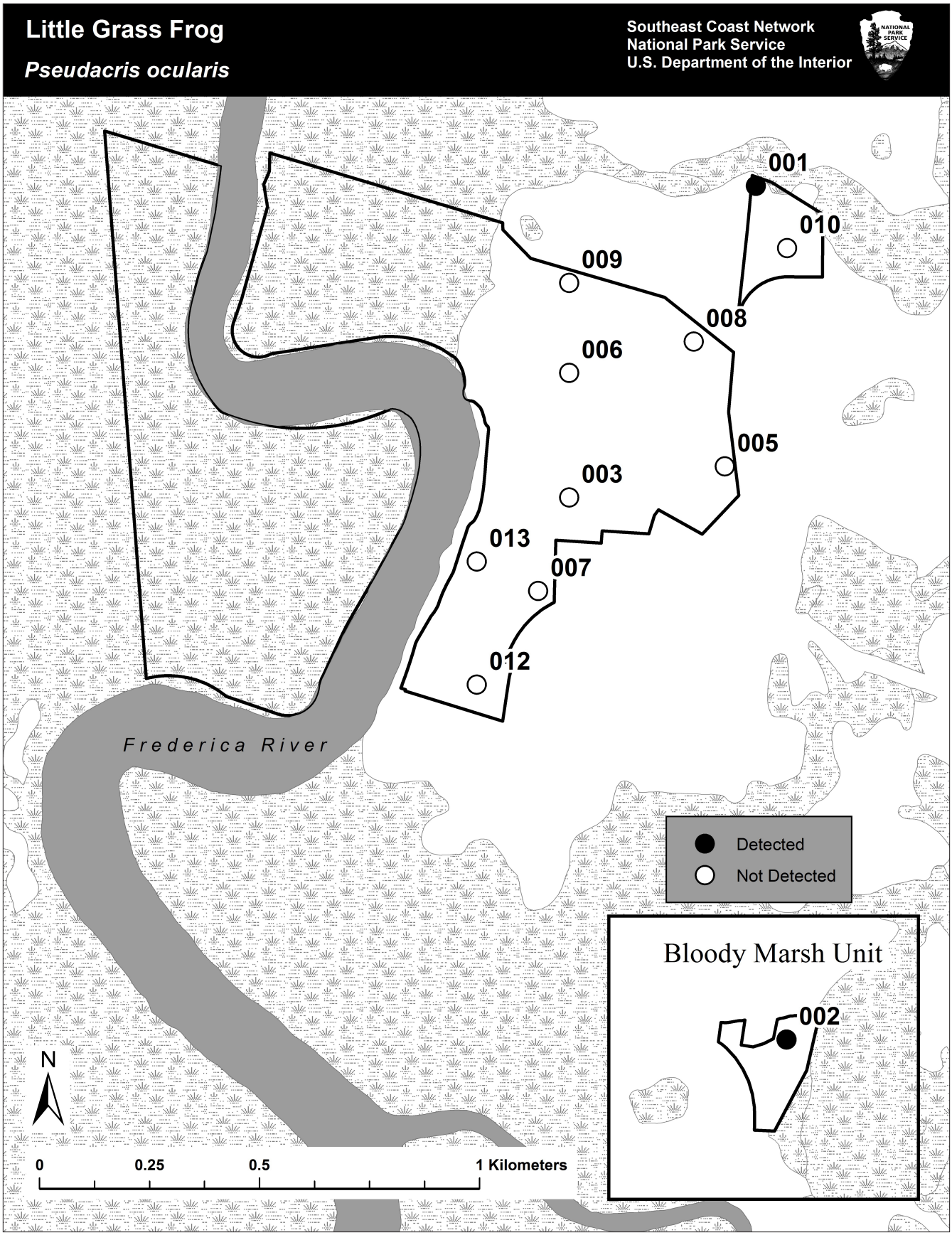


Figure B-7. Sampling locations where little grass frog (*Pseudacris ocularis*) was detected at Fort Frederica National Monument, 2014.

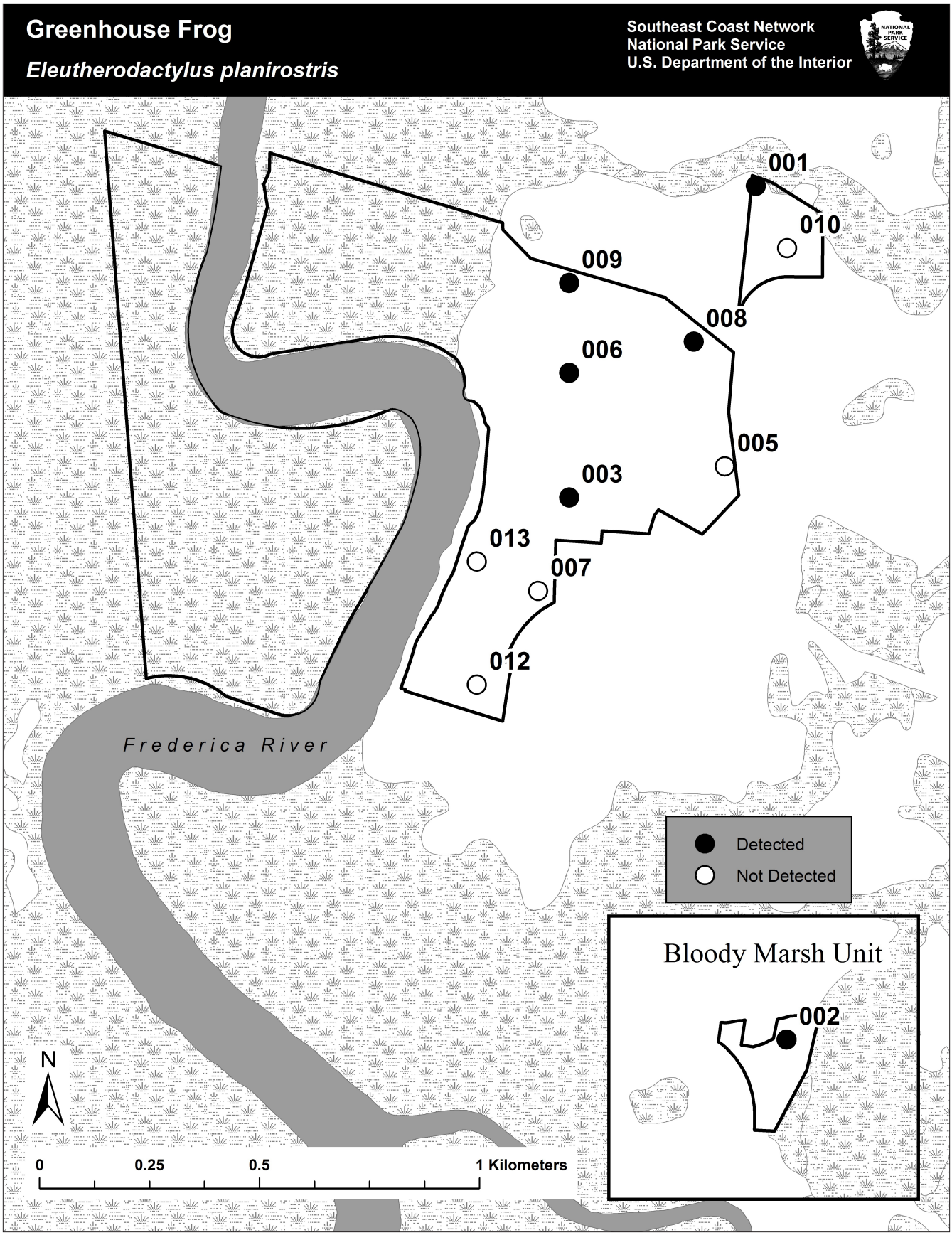


Figure B-8. Sampling locations where greenhouse frog (*Eleutherodactylus planirostris*) was detected at Fort Frederica National Monument, 2014.

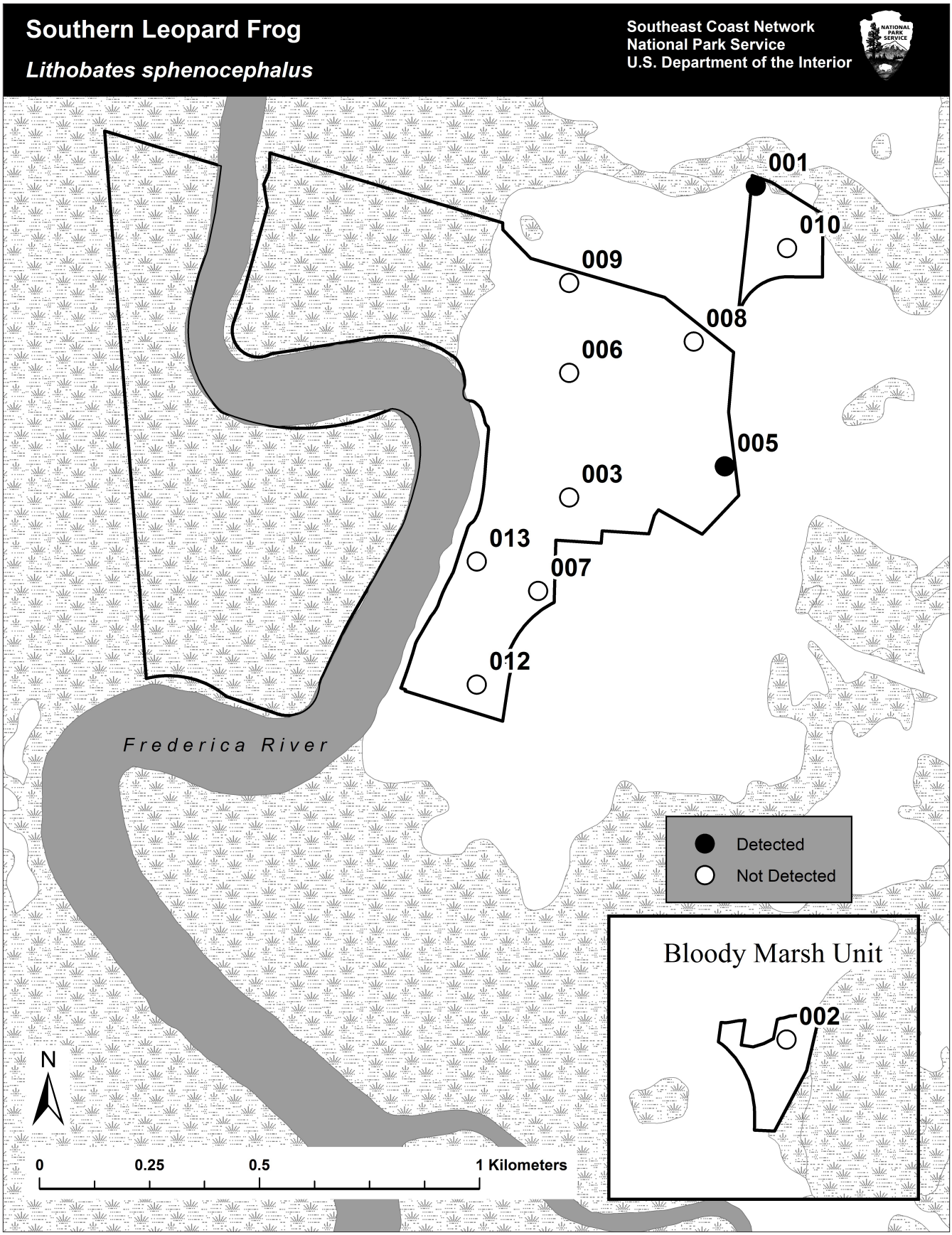


Figure B-9. Sampling locations where southern leopard frog (*Lithobates sphenocephalus*) was detected at Fort Frederica National Monument, 2014.

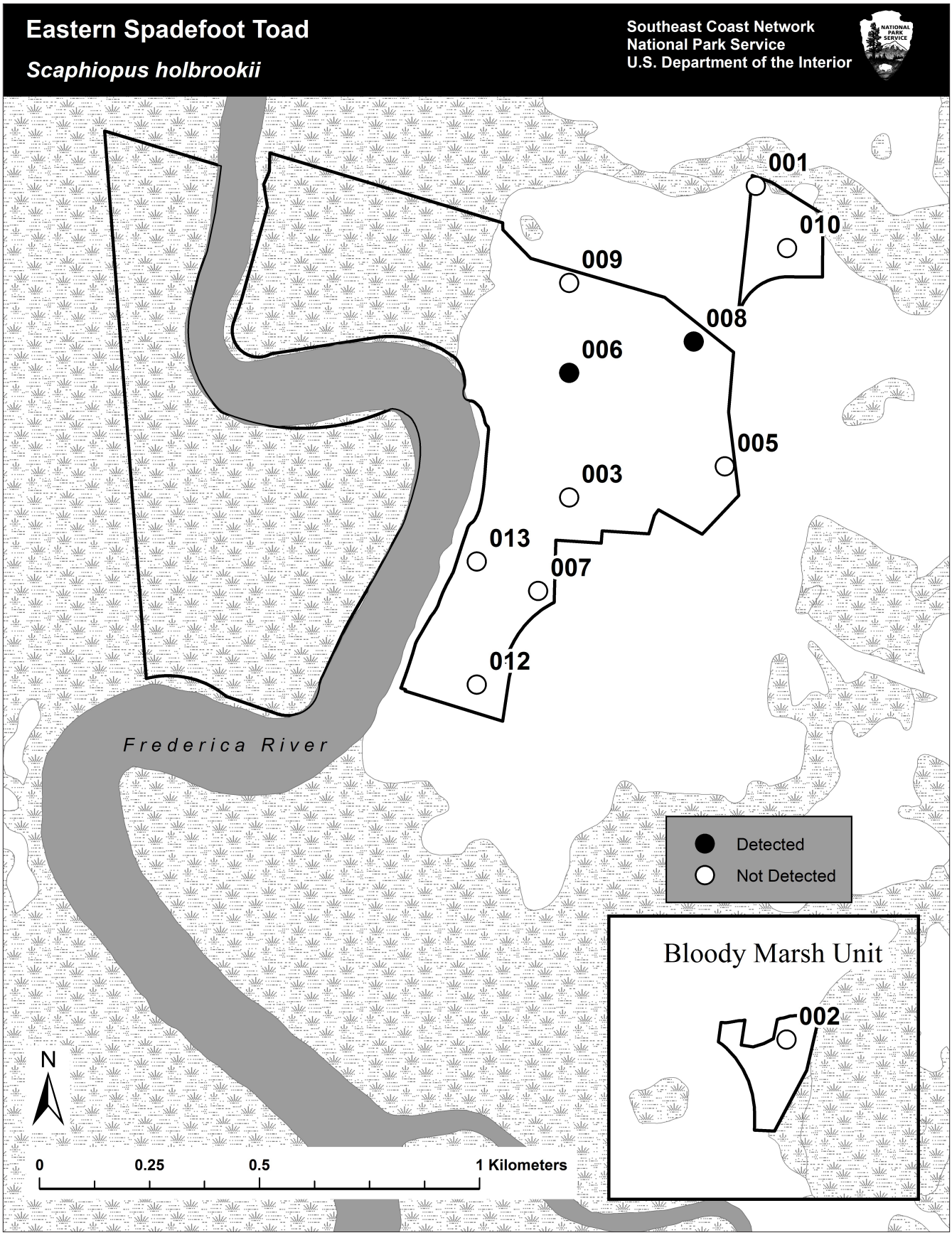


Figure B-10. Sampling locations where eastern spadefoot toad (*Scaphiopus holbrookii*) was detected at Fort Frederica National Monument, 2014.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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