



Amphibian Community Monitoring at Chattahoochee River National Recreation Area, 2011

Natural Resource Data Series NPS/SECN/NRDS—2013/522



ON THE COVER

Top left: Southeastern (Upland) Chorus Frog (*Pseudacris feriarum*)
Photograph by: Briana Smrekar

Amphibian Community Monitoring at Chattahoochee River National Recreation Area, 2011

Natural Resource Data Series NPS/SECN/NRDS—2013/522

Briana D. Smrekar, Michael W. Byrne, Marylou N. Moore, Aaron T. Pressnell

National Park Service
Southeast Coast Inventory and Monitoring Network
Cumberland Island National Seashore
Saint Marys, Georgia 31558

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Executive Summary

The southeastern U.S. is host to one of the most diverse amphibian communities in the world. With an estimated 140 amphibian species, more than half of which are salamanders, the Southeast accounts for about half of the total number of amphibians in the U.S (Echternacht & Harris 1993, Petranka 1998). The Southeast Coast Network (SECN) has 61 known amphibian species; 26 in Caudata (salamanders, newts, amphiumas, sirens), and 35 in Anura (frogs and toads; Appendix A). Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern U.S., amphibian communities are a priority for SECN monitoring efforts. This report summarizes amphibian community vital signs monitoring data collected at Chattahoochee River National Recreation Area (CHAT) in 2011.

- Data were collected at 30 spatially-balanced random locations using two techniques: automated recording devices (ARDs) and visual encounter surveys (VESs).
- Sampling activities occurred at the park from 3/16/2011 to 6/23/2011. Auditory recordings were collected from 3/16/2011 to 6/2/2011 and visual surveys were conducted from 6/7/2011 through 6/23/2011.
- A total of 230 vocal detections were made using the ARD recordings, where each detection represents an identifiable observation of a species or species group during one night of monitoring at a sampling location.
- We detected 21 amphibian species. We detected 237 post-metamorphic amphibians in 22 taxa (species or order) and 18 larval stage amphibians in five taxa during visual encounter surveys. We detected anuran calls in 11 identifiable species using automated recording devices.
- We detected 78 reptiles or reptile signs in 15 identifiable taxa.
- Cope's gray treefrog (*Hyla chrysoscelis*) and American toad (*Anaxyrus americanus*) had the highest frequency of occurrence at CHAT, and American toad had the highest relative abundance of amphibians during VESs in 2011.
- Among caudates, slimy salamander (*Plethodon glutinosus*) had the highest frequency of occurrence, while the southern two-lined salamander (*Eurycea cirrigera*) had the highest relative abundance during VESs in 2011.
- Spring peeper (*Pseudacris crucifer*) and Cope's gray treefrog had the highest relative detection frequency of vocalizations during the 77-day ARD recording period.
- Cope's gray treefrog, American toad, and spring peeper were the most widely distributed amphibians during 2011, found at sampling locations along the entire north-south expanse of the park. Ground skink (*Scincella lateralis*) and worm snake (*Carphophis amoenus*) were the most broadly distributed reptiles.

- The green treefrog (*Hyla cinerea*) and the spotted dusky salamander (*Desmognathus conanti*) were added to the species list at Chattahoochee River.
- No non-native species were found.
- Amphibian communities will next be sampled in 2015.
- 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 exhibited declines in North America and many other areas around the world. Several factors are attributable to 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, the effects of these influences can be exacerbated when combined with other anthropogenic stressors.

Amphibians have complex life cycles, where 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 are dependent can have substantial impacts on the survival, reproduction, and persistence of a species. Given their habitat requirements, anatomy, and physiology, amphibians are considered good indicators of ecological condition.

The southeastern U.S. is host to one of the most diverse amphibian communities in the world. With an estimated 140 amphibian species, more than half of which are salamanders, the Southeast accounts for about half of the total number of amphibians in the U.S (Echternacht & Harris 1993, Petranka 1998). The Southeast Coast Network (SECN) has 61 known amphibian species; 26 in Caudata (salamanders, newts, amphiumas, sirens), and 35 in Anura (frogs and toads; Appendix A).

Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern U.S., amphibian 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 amphibian 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 amphibian communities at Chattahoochee River National Recreation Area (CHAT).

Study Area

Located in north-central Georgia, CHAT extends for 48 miles (77 km) along the Chattahoochee River corridor between the city of Atlanta and Lake Lanier to the north (Figure 1). The upstream terminus of the park is Buford Dam, which is operated by the Army Corps of Engineers, and generates electricity and provides water to the greater Atlanta metropolitan region. The operation of the dam dramatically alters river flows and water temperatures within the park. The Park’s entire length runs along the Brevard Fault Zone, which forms the Chattahoochee River channel, one of the oldest river channels in the United States. The Brevard Fault is a major 320+

mile long geological feature that, in part, delineates the Appalachian Mountains and the Piedmont Plateau physiographic provinces.

The National Park Service owns 9,886 ac (4,000 ha) of land along the river. The park has one of the most prominent wildland-urban interfaces of all SECN parks, resulting in property-encroachment issues, non-native plants and animals, pesticide use, contaminated runoff (e.g., sewage, nutrients), and several other management challenges. According to the 2010 United States Census, the five counties in which the park occurs have been some of the fastest growing and most densely populated in Georgia since 1990.

Despite these challenges, the park hosts a diverse array of flora and fauna, ecological communities, topography, and other attributes that make this park a unique and highly prized resource by its users. The vegetation communities vary with topography and proximity to the river. Uplands include mixed-hardwood communities dominated by oaks (*Quercus* sp.), tuliptree (*Liriodendron tulipifera*), and American beech (*Fagus grandiflora*), and pine forests containing loblolly pine (*Pinus taeda*) and shortleaf pine (*P. echinata*). Lowlands include floodplains and riparian areas with canopy species such as water birch (*Betula nigra*), mesic oaks (e.g., *Quercus nigra*, *Q. laurifolia*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), and hackberry (*Celtis laevigata*).

CHAT has 26 known amphibian species, including two species added to the species list because of this monitoring effort (NPSpecies 2012; Appendix A). There are 14 species of Anurans (frogs and toads) and 12 species of Caudates (salamanders, newts, amphiumas, and sirens).

Chattahoochee River National Recreation Area

Southeast Coast Network
National Park Service
U.S. Department of the Interior

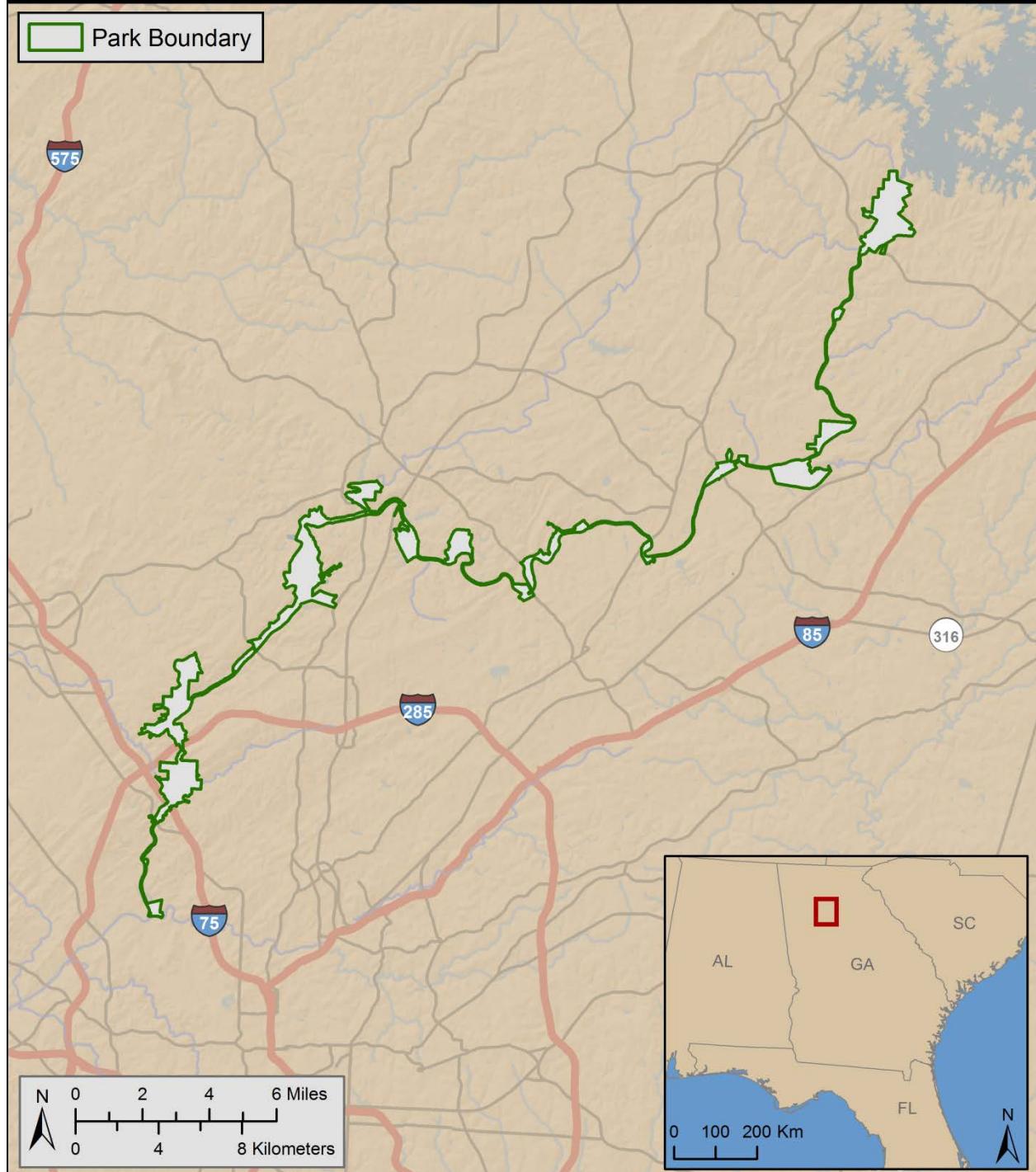


Figure 1. Location of Chattahoochee River National Recreation Area.

Environmental Setting During Sampling Event

Climatologically, the southeastern U.S. experienced warmer than normal average temperatures throughout much of 2011, which was preceded by a winter season (December 2010-February 2011) with temperatures below normal or much below normal. Precipitation was well below average during much of the year, with conditions in the southeastern states rated as abnormally dry or in drought status (Wright 2012).

Based on data collected from the Atlanta Hartsfield International Airport, Dallas 7 NE, and Gainesville, Georgia weather stations, mean monthly temperatures were above average during much of the SECN amphibian monitoring time frame of March through June, 2011 (Figure 2). Temperatures ranged from 41.4 to 92.2°F during the sampling period, with June recording the highest departures from average temperature (Wright 2012). Precipitation during the same period was at normal levels during the first part of the SECN sampling period, but below average from April through June. Total annual precipitation averaged 8.2 inches below normal for the greater Atlanta area (Figure 3).

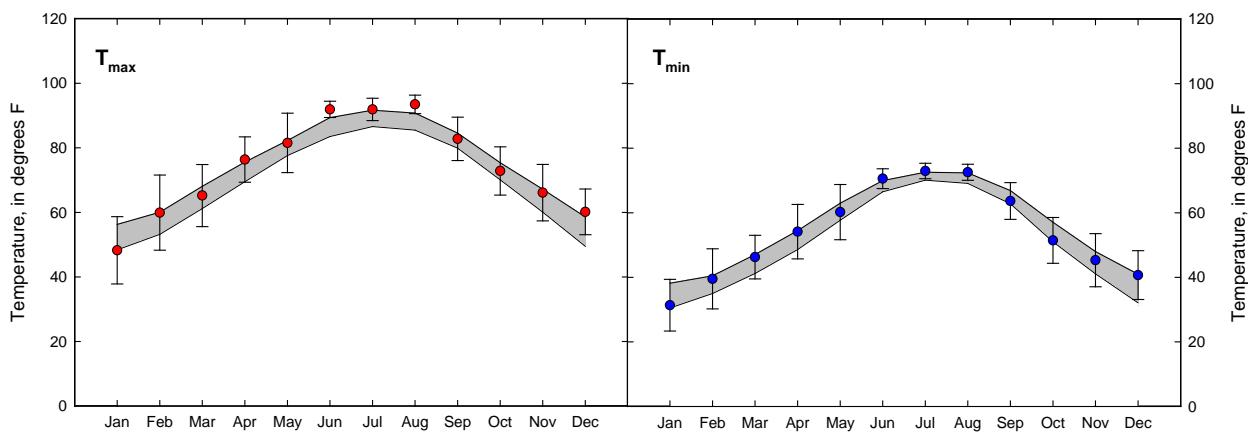
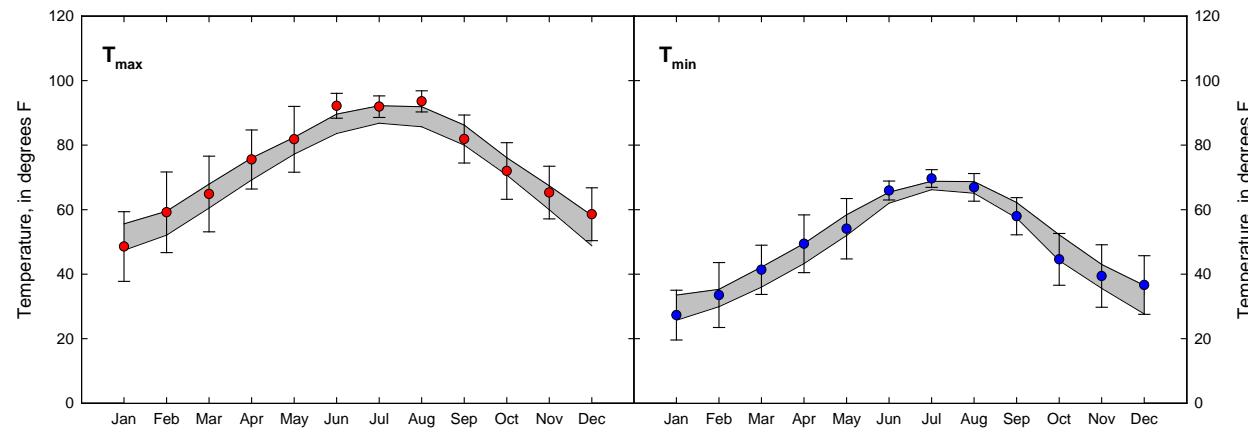
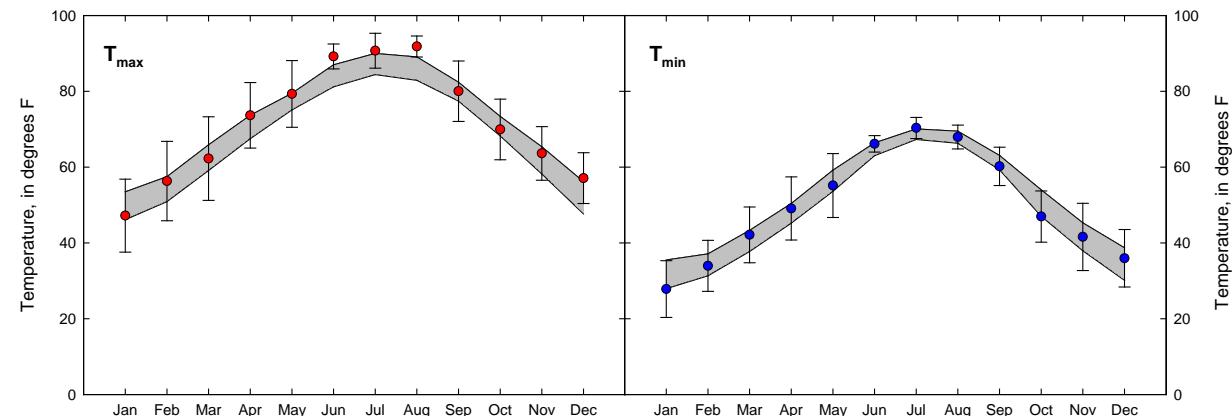
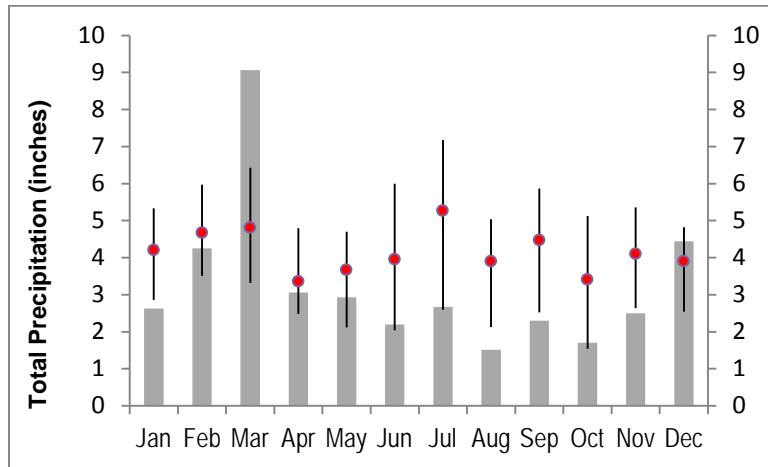
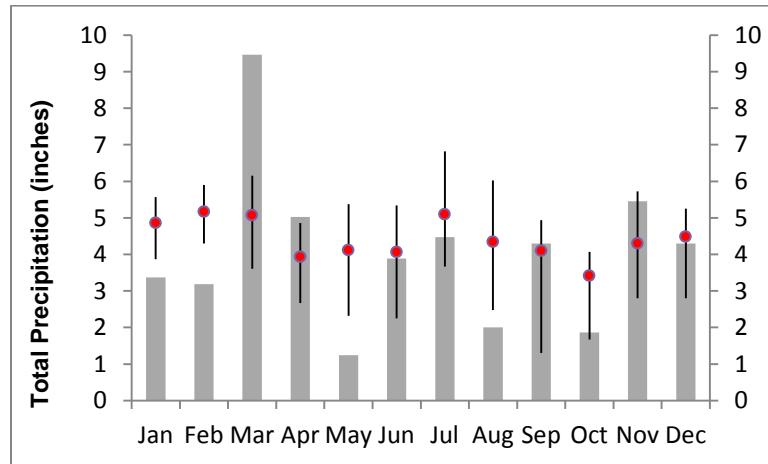
A.**B.****C.**

Figure 2. 2011 average monthly temperature and the 30-year (1981 – 2010) average for A. Atlanta Hartsfield International Airport, B. Dallas 7 NE and C. Gainesville stations. Units = °F. Points indicate the 2011 average monthly maximum and minimum temperatures. Error bars indicate +/- standard deviation. The dual solid lines bound the standard deviation around the 30-year (1981-2010) mean monthly temperature.

A.



B.



C.

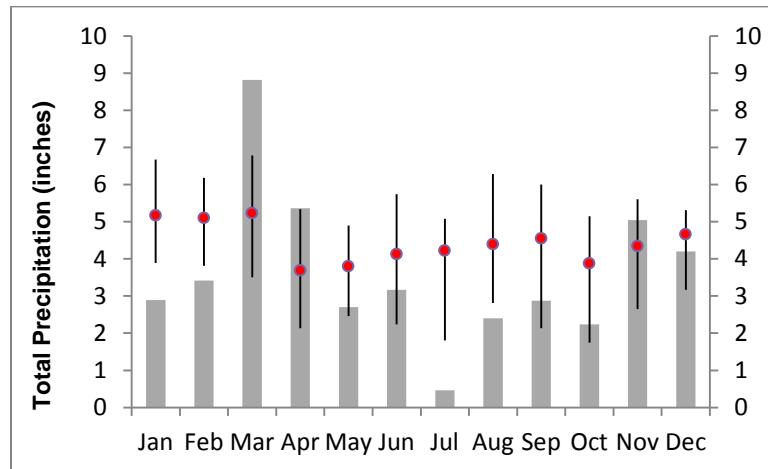


Figure 3. Total monthly precipitation during 2011 and the 30-year (1981 - 2010) monthly averages for A. Atlanta Hartsfield International Airport, B. Dallas 7 NE and C. Gainesville stations. The gray columns represent 2011 total monthly precipitation. The red circles represent the 30-year average; the lines indicate the 25th and 75th percentile of the 30-year normal data for each month.

At the time when visual encounter surveys were conducted (6/7/2011 to 6/23/2011), conditions were relatively dry with negligible precipitation observed and soil moisture averaged approximately 1% (Table 1).

Table 1. Environmental Variables during visual encounter surveys conducted at Chattahoochee River National Recreation Area, 2011. Averages for Noise, Precipitation, and Wind Speed are calculated as the mode of parameter codes (see footnote for code definitions).

Parameter	Average	Standard Deviation	Notes
Noise	1.00	N/A	Slight effects to sampling with barely noticeable reductions to hearing
Precipitation	0.00	N/A	No Precipitation
Relative Humidity (%)	78.65	15.50	
Soil Moisture (%)	1.08	1.29	
Temperature (°F)	76.26	6.90	
Wind Speed	0.00	N/A	<1 mph

¹ Noise codes are determined in the field as follows: 0 – No appreciable effect, no background noise; 1 – Slightly affecting sampling, barely reduces hearing; 2 – Moderately affecting sampling, noticeable reduction of hearing; 3 – Seriously affecting sampling, noticeable reduction of hearing; 4 – Profoundly affecting sampling, greatly reduced hearing.

² Precipitation codes are determined in the field as follows: 0 – None; 1 – Mist or fog; 2 – Light drizzle; 3 – Light rain; 4 – Heavy rain; 5 – Sleet; 6 – Snow.

³ Wind speed codes are determined in the field as follows: 0 – Calm (< 1mph), smoke rises vertically; 1 – Light air (1-3 mph), smoke drifts, weather vane inactive; 2 – Light breeze (4-7 mph), leaves rustle, can feel wind on face; 3 – Gentle breeze (8-12 mph), leaves and twigs move around, small flags extend; 4 – Moderate breeze (13-18 mph), moves thin branches, raises loose papers; 5 – Fresh breeze (19-24 mph), small trees begin to sway; 6 – Strong breeze (>24 mph), large branches moving, wind whistling.

Monitoring Objectives

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

- Determine the status and trends in species richness and diversity of amphibian communities. Species richness and diversity estimates are based on the total number of species detected (i.e., native and non-native).
- Determine the status and trends in occupancy by amphibian species. Occupancy estimates provide insight into the likelihood of encountering a specific species, rarity, diversity, and distribution of a species or group, and 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 estimated 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.

Additional amphibian and reptile data based on visual encounter methods that were being tested as a part of protocol development in FY 2011 are also presented below.

Methods

Sampling Design

To allow for park-wide inference, the CHAT administrative boundary was used as the sampling frame, within which a spatially-balanced sample was drawn using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald et al. 2007). Alternate points were used when selection criteria (i.e., including safety and access issues) were not met. In 2011, Amphibian Communities were sampled at 30 locations that met the selection criteria (i.e., safety and access considerations) as described in Byrne et al. (2013 *in review*) (Figure 4).

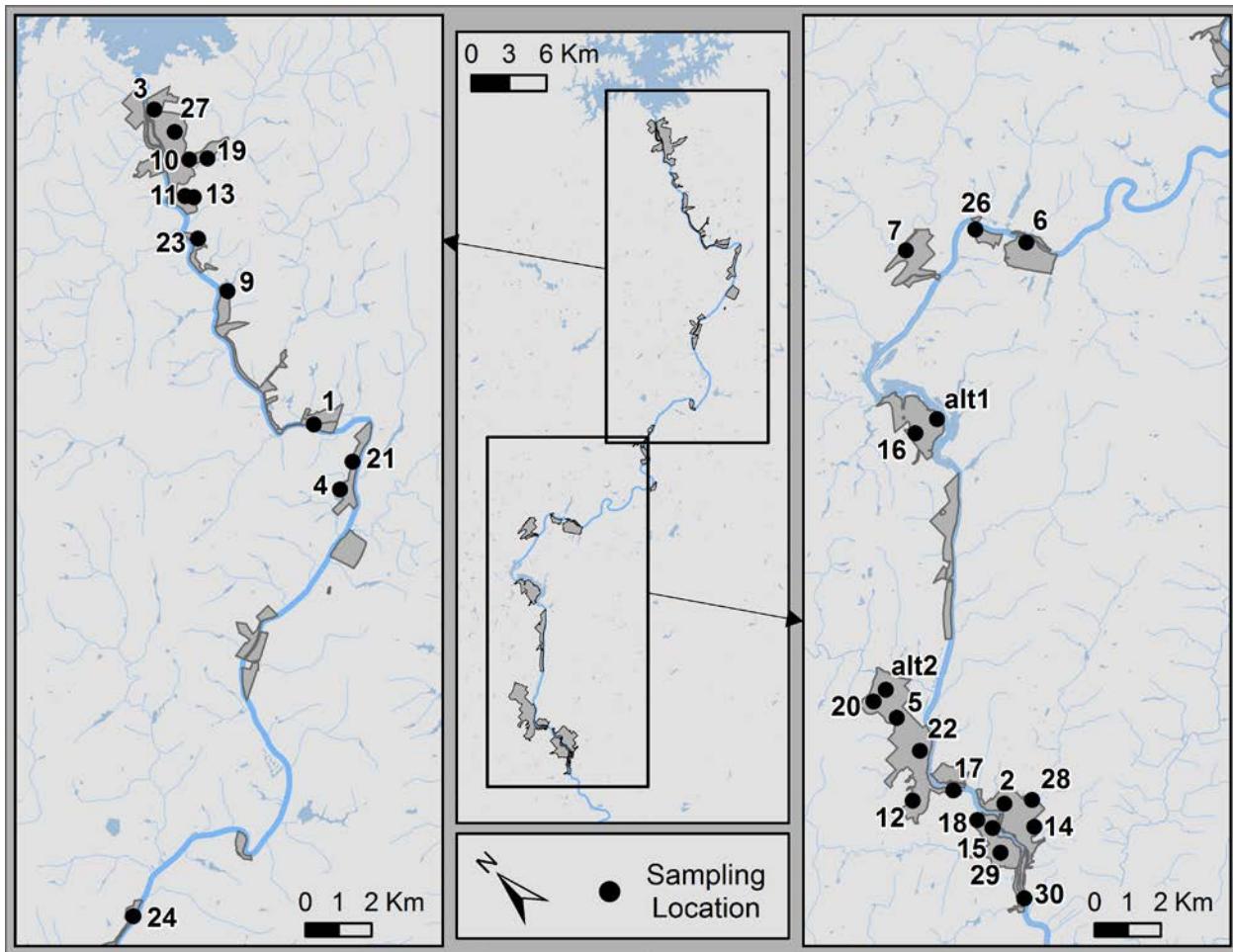


Figure 4. Spatially-balanced random sampling locations at Chattahoochee River National Recreation Area, 2011.

Sampling Methodology

Three sampling techniques were used as part of SECN amphibian monitoring, including a combination of active and passive sampling techniques. The active techniques were a time- and area-constrained medium-intensity visual encounter survey (VES) that was conducted systematically through the 0.5-ha macroplot, and the dip-net techniques incorporated in sampling locations with aquatic communities. All species or species sign detected by sight or sound were recorded as part of the VESs. The passive technique was an automated-recording device (ARD)

programmed to record every four days from 20:00 (8:00 pm) to 06:50 am for 30 seconds of every 10 minutes. Use of multiple techniques, as a “toolbox” approach (Olson et al. 1997), is generally agreed to be the most effective means to monitor amphibian communities (Hutchens and DePerno 2009). The sampling techniques were co-located, with the ARDs deployed at the center point of each 0.5-ha macroplot where VES sampling occurred (Figure 5). All three techniques adequately detect any species that occurs in the 0.5-ha macroplot.

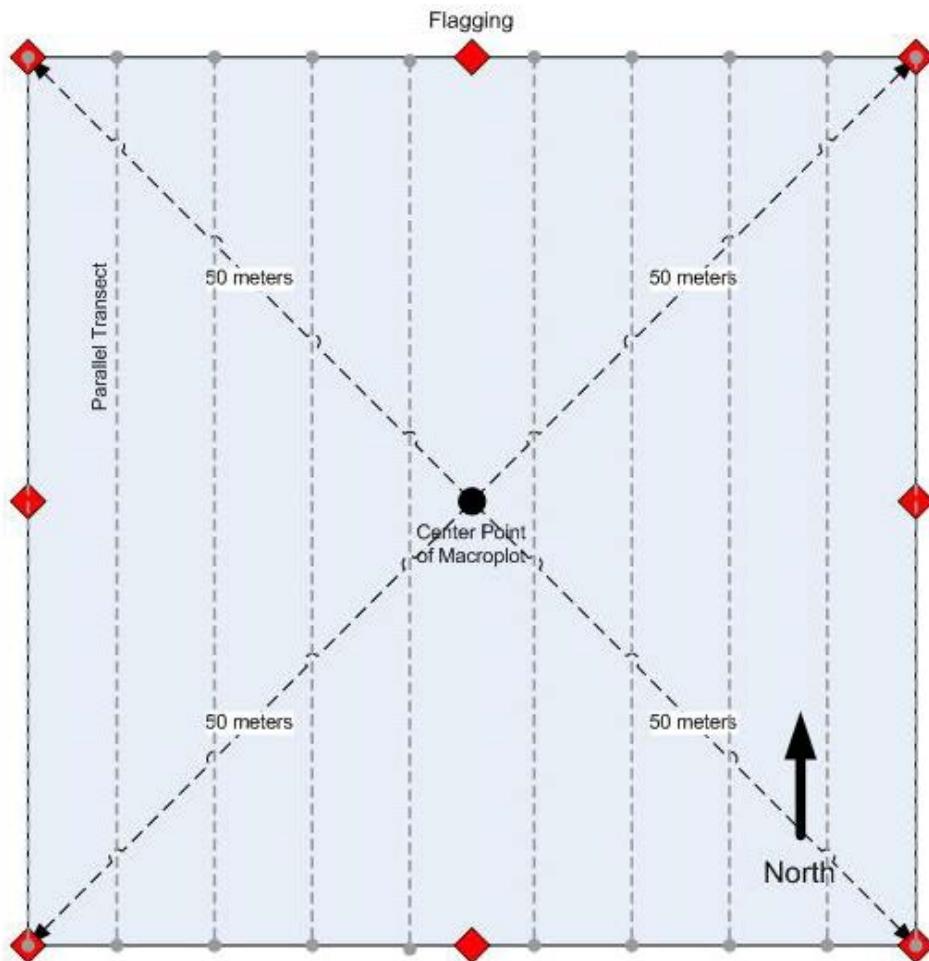


Figure 5. Macroplot (0.5-ha) layout for amphibian community monitoring in Southeast Coast Network parks. Visual encounter surveys (VESs) occur along parallel transects within the macroplot; Automated recording devices (ARDs) are deployed for 77 days at roughly the center point of the macroplot.

Automated Recording Devices

Automated recording devices are often used to characterize soundscapes. Recently this technology has been applied to monitoring wildlife species. 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 (i.e., 35), (b) many of these species are assumed to be broadly distributed across park lands, (c) crepuscular and nocturnal calling behavior predominates the vocal anurans in SECN parks (Mohr and Dorcas 1999, Bridges and Dorcas 2000, Todd et al. 2003), (d) night-time calling surveys are a concern given the safety issues for personnel conducting the surveys, and (e) the resultant detection/non-detection data of ARDs adheres to the monitoring objective.

Further, the devices produce a permanent data product (i.e., recordings) that can be further analyzed as technology improves, analyzed by other researchers, analyzed for other taxa, or to quantify the soundscape.

To address some of the known influences related to imperfect detection (MacKenzie et al. 2002, MacKenzie et al. 2006), devices were deployed for a duration of 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 with 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 our recording timeframe is sufficient to encompass most vocalizing anurans, the recordings are only a portion of the time during which anurans are active. To adequately characterize the anuran community, we determined the most appropriate timeframe for deploying the ARDs in SECN parks to be March through June based on vocalization-phenology information (Dorcas and Gibbons 2008) and data from 2009-2012 recordings in National Park units across the SECN. The most appropriate anuran candidate species' vocalization dates are published in this report.

ARDs were deployed from 3/16/2011 to 6/2/2011. A total of 18,711 minutes was recorded by all of the devices deployed at Chattahoochee River National Recreation Area. The ARD malfunctioned or was damaged in a storm and recorded only partial data at three sampling locations (02, 11, and 12).

Visual Encounter Surveys

The VES consisted of a medium-intensity time-constrained survey, the duration of which is determined at the sampling location based on vegetation density prior to initiation of the survey. All potential cover objects (e.g., leaf litter, under logs/rocks, other potential cover items) within the plot were searched and all species detected were identified and recorded (including reptiles). Cover objects were returned to their original position to reduce habitat impacts from monitoring activities. Animals were captured only to facilitate accurate identification. If streams or wetlands were encountered within the macroplot, dip-nets and hand-capture techniques were used to detect and identify aquatic amphibians or larvae.

Visual Encounter Surveys were conducted at Chattahoochee River National Recreation Area from 6/7/2011 to 6/23/2011.

Taxonomic Standards

Despite a well-trained field crew, complete identification of all individuals encountered was not always possible due to the quick and evasive nature of many species. Species were, however identified to the most refined taxonomic level possible. For example, while the surveyors were approaching a small pool surrounded by dense vegetation they caught a brief glimpse of and heard several frogs dive into the pool prior to completing a full visual inspection of the individuals necessary for identification. While the majority of these species could most likely be identified to the genus or family level (i.e., Unknown *Lithobates* or *Ranidae* in this instance)

based upon knowledge of the location and the local fauna, a conservative estimation was used and these species were identified to Order as “Unknown anuran”.

Data Analysis

This protocol collects detection / non-detection data, which, although somewhat inaccurately, is also often referred to as presence / absence data. In contrast to detections made from visual survey methods where individuals can be seen, differentiated, and counted, detections from our other surveying method, 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 to be detected multiple times. 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, relative abundance, 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. Naïve occupancy is also referred to as frequency of occurrence. Relative abundance is the number of individuals of a particular species expressed as a percentage of the total number of amphibians in the sample. The sample size is the total number of amphibians counted at all sampling locations in the park. Relative detection frequency uses the detection history as an index of abundance to communicate the composition of each species detected relative to all other species detected in the sample. 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 relating to how species respond to large-scale influences such as changing land use, climate, hydrology, or habitat availability and condition. Shifting species distributions can produce cascading effects through altered species interactions and alterations within the food-web structure, thereby affecting ecosystem processes (Montoya and Raffaelli 2010). Distribution maps for all amphibian 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. 2011). 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 SECN 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. Periodic synthesis reports, which will be published after multiple rounds of sampling, will summarize phenological history of amphibian species detected across the SECN for which appropriate candidates for trend analysis are available.

Results

Community Composition

Although the primary purpose of this SECN monitoring effort was to detect amphibians, due to their common habitat use reptiles were also encountered during VESs. It is important to note that VESs and ARDs are not considered effective tools to survey for many reptile species, nor was the intent of VES implementation to target reptiles. Although not the target of the SECN's amphibian sampling protocol, we have included a reptile species detection data summary in Appendix C.

Note that due to interbreeding, and/or a similar appearance or vocalization, it was not always possible to differentiate between several groups of amphibians. In these cases, the two similar species were grouped together for data analysis, and it is likely that they serve the same ecological niche. For this report, spotted and northern dusky salamanders (*Desmognathus conanti* or *fuscus*) have been grouped together. Northern and southern cricket frogs (*Acris crepitans* or *gryllus*) have been grouped under *Acris* sp., while southern two-lined (*Eurycea cirrigera*) and three-lined salamander (*Eurycea guttolineata*) larvae have been combined under *Eurycea* sp.

We detected 21 amphibian species at CHAT in 2011. During the VESs, we detected 237 post-metamorphic amphibians in 22 identifiable taxa (species or order) and 18 larval stage amphibians in five taxa. Using ARDs we detected vocalizing anurans in 11 species (Table 2). Seven amphibian species composed approximately 70% of the VES sample and three anuran species accounted for over 80% of the vocalizations detected.

Cope's gray treefrog (*Hyla chrysoscelis*) and the American toad (*Anaxyrus americanus*), each detected at around half of the sampling locations in Chattahoochee River National Recreation Area, had the highest frequency of occurrence (naïve occupancy) of all amphibians detected during our 2011 surveying period (Table 2). The slimy salamander (*Plethodon glutinosus*) had the highest frequency of occurrence among caudates, detected at slightly over 23% of the sampling locations. Pickerel frog (*Lithobates palustris*) and cricket frog (*Acris* sp.) had the lowest frequency of occurrence of all anuran species, while the marbled (*Ambystoma opacum*), seal (*Desmognathus monticola*), and three-lined salamanders were the least frequently occurring caudates (Table 2).

The American toad had both the highest relative abundance of all amphibian species during the VESs, and the highest relative abundance among anurans, accounting for 22% of all amphibians and nearly 35% of all anurans counted during 2011 sampling activities (Figure 6). The southern two-lined salamander had the highest relative abundance among caudates counted during the VESs. The green frog (*Lithobates clamitans*) and eastern narrow-mouthed toad (*Gastrophryne carolinensis*) had the lowest relative abundance among anurans during VESs, while the marbled and three-lined salamanders, as well as larva of the seal and southern two-lined salamanders had the lowest counts among caudates. Notably, while the spotted/northern dusky salamander and the southern two-lined salamander had relatively low naïve occupancy rates (Table 2), they had the highest relative abundances among caudates during the VESs (Figure 6). Together, these two species accounted for 63% of the total salamander count during 2011, and over half of the spotted dusky salamander individuals were in the larval stage.

Spring peeper (*Pseudacris crucifer*) and Cope's gray treefrog had the highest relative detection frequencies of vocalizations recorded by ARDs over the 77-day sampling period, and together accounted for approximately 69% of all vocalizations (Figure 7). Green frog, eastern narrow-mouthed toad, and cricket frog had the lowest relative frequency of detection rates with just one vocalization detection each. Despite having a park-wide naïve occupancy rate of almost 47%, the American toad had a low relative detection frequency of vocalizations at just 6% of all vocalizations detected during 2011. No non-native amphibian species were detected.

Table 2. Percentage of sampling locations where each amphibian species was detected (i.e., naïve occupancy) by method and across methods at Chattahoochee National Recreation Area, 2011. NA indicates that the method does not apply to this species.

Common Name	Detection Method		
	All	VES	ARD
Anura			
Cope's Gray Treefrog	53.3	33.3	40.0
American Toad	46.7	16.7	33.3
Southeastern (Upland) Chorus Frog	33.3	16.7	23.3
Spring Peeper	30.0	3.3	30.0
Green Treefrog	20.0	13.3	13.3
Fowler's Toad	16.7	10.0	6.7
Southern Leopard Frog	10.0	10.0	3.3
Eastern Narrow-mouthed Toad	6.7	3.3	3.3
Green Frog	6.7	3.3	3.3
Pickerel Frog	3.3	3.3	3.3
Cricket Frog	3.3	0.0	3.3
<i>Ranidae</i> sp.	3.3	3.3	NA
Caudata			
Slimy Salamander	23.3	23.3	NA
Spotted/Northern Dusky Salamander	13.3	13.3	NA
Spotted Salamander	10.0	10.0	NA
Eastern Newt	6.7	6.7	NA
Red Salamander	6.7	6.7	NA
Southern Two-lined Salamander	6.7	6.7	NA
Marbled Salamander	3.3	3.3	NA
Seal Salamander	3.3	3.3	NA
Three-lined Salamander	3.3	3.3	NA
Desmognathus sp.	3.3	3.3	NA
<i>Eurycea</i> sp.	3.3	3.3	NA
<i>Caudata</i> sp.	3.3	3.3	NA
Total Locations Surveyed	30	30	30

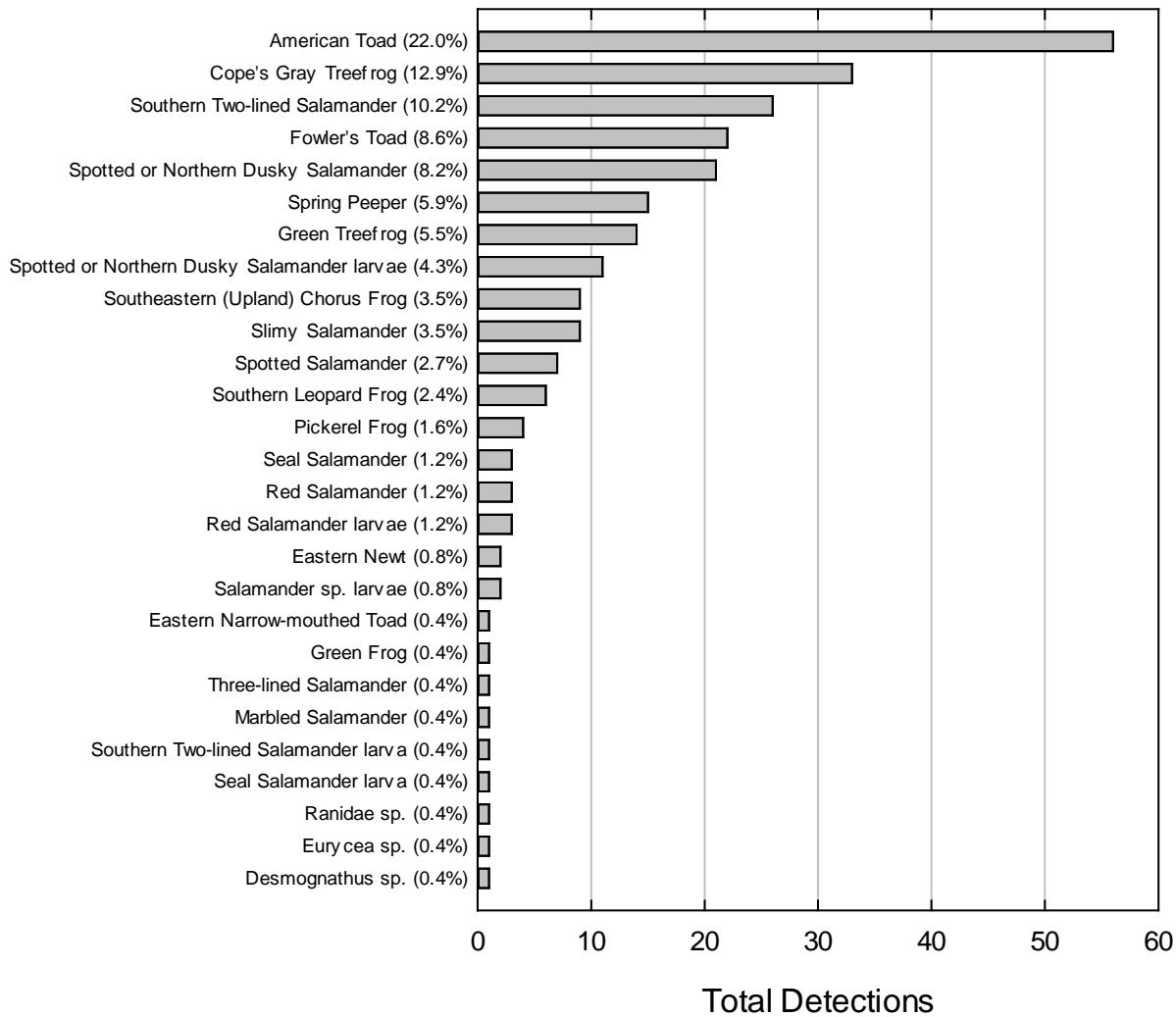


Figure 6. Number of amphibian individuals detected and the relative abundance (as a percentage) of each species in the sample of all amphibian individuals found during visual encounter surveys at Chattahoochee River National Recreation Area, 2011. Based on n=255 detections.

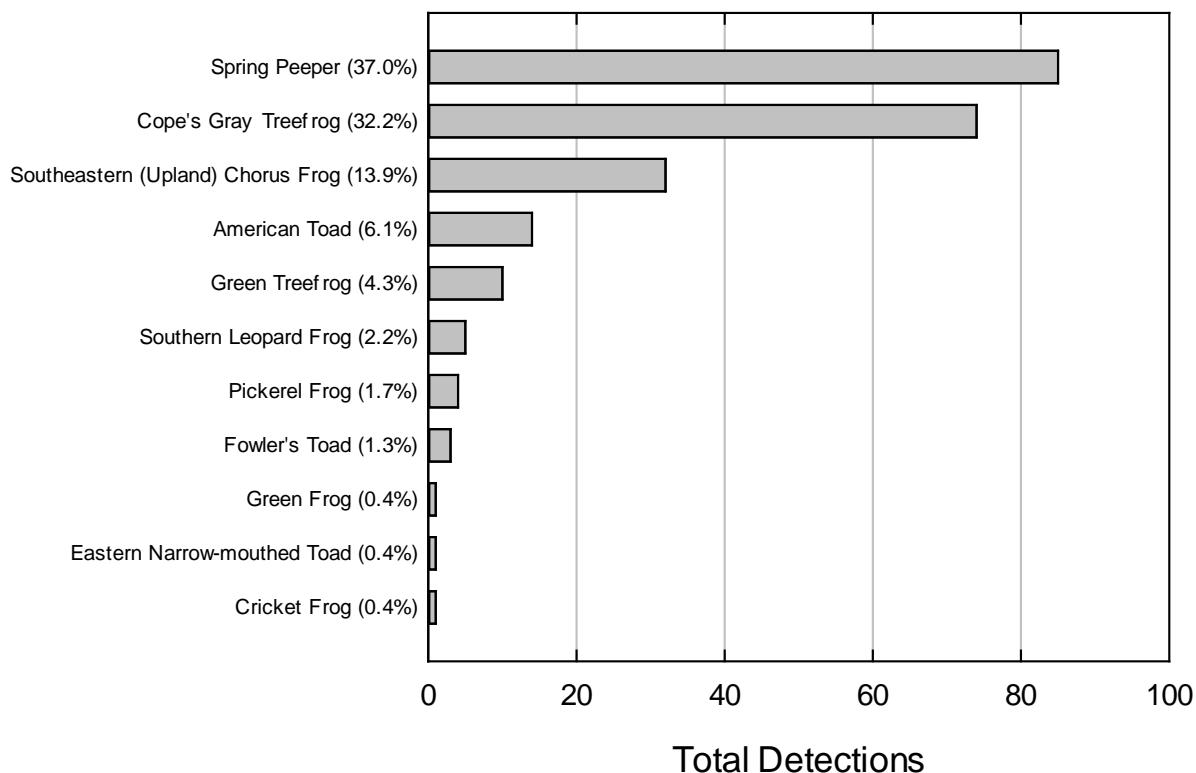


Figure 7. Number of anuran vocalization detections and the percent relative detection frequency (i.e., number of species vocalizations compared to all species' vocalizations) of recorded calls during automated recording device (ARD) deployment (16 March to 2 June 2011) at Chattahoochee River National Recreation Area. Based on n= 230 detections.

New Species Records

Two amphibian species not previously known to occur at CHAT were detected during the monitoring event, green treefrog (*Hyla cinerea*) and spotted dusky salamander (Table 3). While the spotted dusky salamander typically has a more southern range than the northern dusky salamander, their ranges overlap in northern Georgia and the two species may interbreed (Mitchell and Gibbons 2010). Therefore we have combined the two species for data analysis purposes.

Table 3. New amphibian species detected at Chattahoochee River National Recreation Area and recommended NPSpecies classifications.

Scientific Name	Common Name	Abundance	Residency	Nativity	Pest	Management Priority	Exploitation Concerns
<i>Desmognathus conanti</i>	Spotted Dusky Salamander	Unknown	Resident	Native	No	No	No
<i>Hyla cinerea</i>	Green Treefrog	Unknown	Resident	Native	No	No	No

Amphibian Distribution

Cope's gray treefrog and American toad were the most widely distributed anuran species at the Recreation Area and were detected throughout the park, from the most northern unit of the park to the most southern (Table 2 and Appendix B). Slimy salamander was the most broadly distributed salamander species, found in units all along the north-south expanse of the park. The pickerel frog and cricket frog, as well as the spotted (*Ambystoma maculatum*) and seal salamanders were found only in the northern sections of the park, from Jones Bridge and to the north. The marbled and three-lined salamanders were located only in the southern half of the park, units south of Holcomb Bridge. Distribution maps for all amphibians that were detected during the monitoring event are presented in Appendix B.

Vocalization Phenology

Of the anurans detected using ARDs at Chattahoochee River in 2011, three species would be appropriate candidates to determine trends in vocalization start dates; green treefrog, eastern narrow-mouthed toad, and Fowler's toad. These species were considered appropriate candidates because they typically begin to vocalize well after the start of our recording schedule in the SECN parks (Dorcas and Gibbons 2008). The Fowler's toad (*Anaxyrus fowleri*) was first detected on 4/21/2011, while the green treefrog initiated calling on 5/10/2011. The earliest vocal detection of the eastern narrow-mouthed toad was on 6/2/2011. Two species, American toad and pickerel frog, were appropriate candidates for tracking end dates due to the timing of their typical vocalization windows in the Southeast, which close well before our recording schedule concludes. The American toad was last detected using ARDs on 4/18/2011, and the end date for pickerel frog calls was 4/7/2011 at our sampling locations at CHAT (Figure 8).

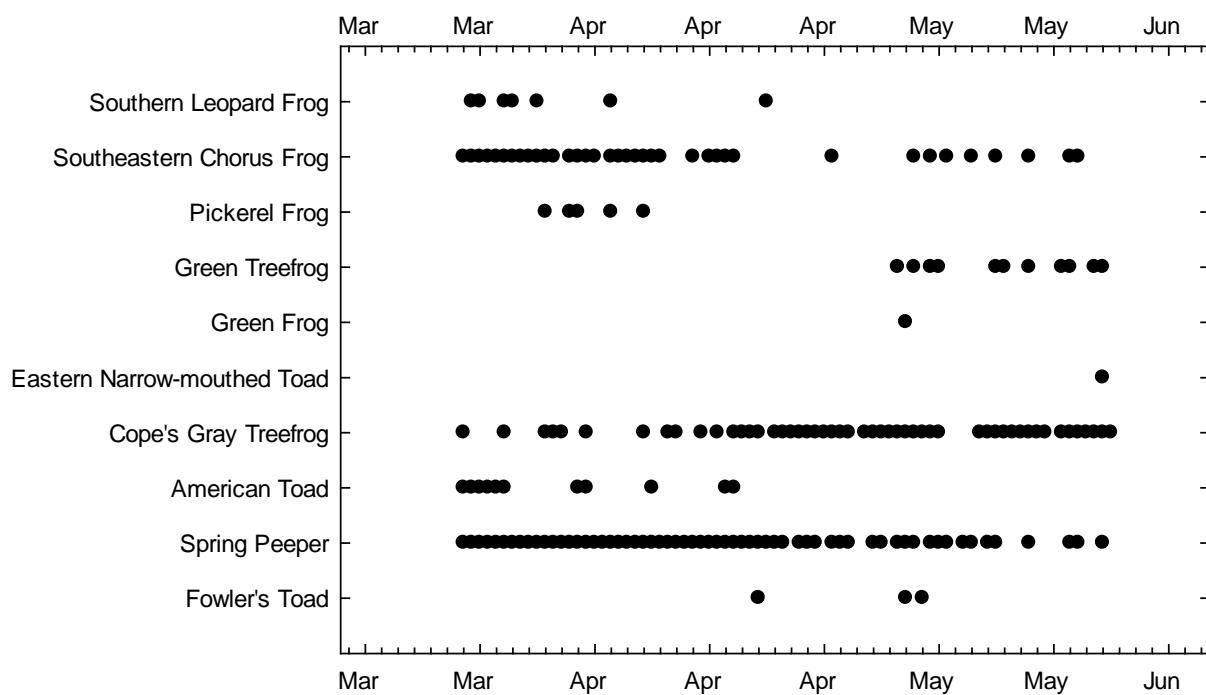


Figure 8. Vocalization phenology for species detected with automated recording devices (ARDs) at Chattahoochee River National Recreation Area, from 16 March to 2 June 2011. Based on n=230 detections.

Literature Cited

- Blaustein, A. R., L. K. Beldon, D. H. Olson, D. M. Green, T. L. Root, and J. M. Kiesecker. 2001. Amphibian breeding and climate change. *Conservation Biology* 15:1804-1809.
- Blaustein, A. R., S. C. Walls, B. A. Bancroft, J. L. Lawler, C. L. Searle, and S. S. Gervasi. 2010. Direct and indirect effects of climate change on amphibian populations. *Diversity* 2:281-313.
- Bridges, A. S., and M. E. Dorcas. 2000. Temporal variation in anuran calling behavior: implications for surveys and monitoring programs. *Copeia* 2:587-592.
- Byrne, M. W., J. C. DeVivo, B. D. Smrekar, L. M. Elston, C. J. Wright, and E. Thompson. *In review*. Protocol for monitoring vocal anuran communities in Southeast Coast Network parks. Natural Resource Report NPS/SECN/NRR-2013-XXX. National Park Service, Fort Collins, Colorado.
- Collins, J. P., and A. Storfer. 2003. Global amphibian declines: Sorting the hypotheses. *Diversity and Distributions* 9:89–98.
- Corn, P. S. 2005. Climate change and amphibians. *Animal Biodiversity and Conservation*. 28:59-67.
- Dorcas, M., and W. Gibbons. 2008. Frogs and Toads of the Southeast. University of Georgia Press, Athens.
- Echternacht, A. C., and L. D. Harris. 1993. The fauna and wildlife of the southeastern United States. Pages 81-116 in W.H. Martin, S.G. Boyce, and A.C. Echternacht, eds., *Biodiversity of the Southeastern United States: Lowland terrestrial communities*. John Wiley and Sons, New York, New York, USA.
- Gibbs, J. P., and A. R. Breisch. 2001. Climate warming and calling phenology of frogs near Ithaca, New York, 1900-1999. *Conservation Biology* 15:1175-1178.
- Hutchens, S. J., and C. S. DePerno. 2009. Efficacy of sampling techniques for determining species richness estimates of reptiles and amphibians. *Wildlife Biology* 15:113-122.
- MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy when detection probabilities are less than one. *Ecology* 83: 2248-2255.
- MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. A. Bailey, and J. E. Hines. 2006. Occupancy modeling and estimation. Elsevier, San Diego, California, USA.
- Mitchell, J., and W. Gibbons. 2010. Salamanders of the Southeast. University of Georgia Press, Athens.
- Montoya, J. M., and D. Raffaelli. 2010. Climate change, biotic interactions and ecosystem services. *Philosophical Transactions of the Royal Society B* 365:2013-2018.

Mohr, J. R., and M. E. Dorcas. 1999. A comparison of anuran calling patterns at two Carolina bays in South Carolina. *Journal of the Elisha Mitchell Scientific Society* 115:63-70.

NPSpecies - The National Park Service Biodiversity Database. Secure online version.
<https://science1.nature.nps.gov/npspecies/web/main/start> (Park list: accessed 1/13/2012).

Olson, D. H., W. P. Leonard, and R. B. Bury (eds.). 1997. Sampling amphibians in lentic habitats (Northwest Fauna 4). Society for Northwestern Vertebrate Biology, Olympia, WA, USA. 134pp.

Parmesan, C. 2007. Influences of species, latitudes, and methodologies on estimates of phonological response to global warming. *Global Change Biology* 13:1860-1872.

Petraska, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC, USA.

Theobald, D. M., D. L. Stevens, D. White, N. S. Urquhart, A. R. Olsen, and J. B. Norman. 2007. Using GIS to generate spatially balanced random survey designs for natural resource applications. *Environmental Management* 40:134-146.

Todd, M. J., R. R. Cocklin, and M. E. Dorcas. 2003. Temporal and spatial variation in anuran calling activity in the western Piedmont of North Carolina. *Journal of the North Carolina Academy of Science*. 119:103-110.

Todd, B. D., D. E. Scott, J. H. K. Pechmann, and J. W. Gibbons. 2011. Climate change correlates with rapid delays and advancements in reproductive timing in an amphibian community. *Proceedings of the Royal Society B* 278:2191-2197.

Wright, C. J. 2012. Summary of weather and climate monitoring in Southeast Coast Network parks, 2011. Natural Resource Data Series NPS/SECN/NRDS—2012/365. National Park Service, Fort Collins, Colorado.

U.S. Census Bureau. 2010. State & county QuickFacts: Georgia. <http://quickfacts.census.gov> (Accessed July 10, 2013).

Appendix A. Amphibian Species Detection Data

Table A-1. Amphibian species known to occur at Chattahoochee River National Recreation Area based on the Park's certified species list (NPSpecies 2013) and those detected during this sampling effort.

Scientific Name	Common Name	NPSpecies	ARD	VES
<i>Anaxyrus americanus</i>	American Toad	X	X	X
<i>Anaxyrus fowleri</i>	Fowler's Toad	X	X	X
<i>Acris</i> sp.	Cricket Frog	X	X	
<i>Hyla chrysoscelis</i>	Cope's Gray Treefrog	X	X	X
<i>Hyla cinerea</i>	Green Treefrog		X	X
<i>Pseudacris crucifer</i>	Spring Peeper	X	X	X
<i>Pseudacris feriarum</i>	Southeastern (Upland) Chorus Frog	X	X	X
<i>Gastrophryne carolinensis</i>	Eastern Narrow-mouthed Toad	X	X	X
<i>Lithobates catesbeianus</i>	Bullfrog	X		
<i>Lithobates clamitans</i>	Green Frog	X	X	X
<i>Lithobates palustris</i>	Pickerel Frog	X	X	X
<i>Lithobates sphenocephalus</i>	Southern Leopard Frog	X	X	X
<i>Scaphiopus holbrookii</i>	Eastern Spadefoot Toad	X		
<i>Ambystoma maculatum</i>	Spotted Salamander	X		X
<i>Ambystoma opacum</i>	Marbled Salamander	X		X
<i>Desmognathus conanti</i>	Spotted Dusky Salamander			X
<i>Desmognathus fuscus</i>	Northern Dusky Salamander	X		X
<i>Desmognathus monticola</i>	Seal Salamander	X		X
<i>Eurycea cirrigera</i>	Southern Two-lined Salamander	X		X
<i>Eurycea guttolineata</i>	Three-lined Salamander	X		X
<i>Gyrinophilus porphyriticus</i>	Spring Salamander	X		
<i>Plethodon glutinosus</i>	Slimy Salamander	X		X
<i>Plethodon serratus</i>	Southern Red-backed Salamander	X		
<i>Pseudotriton ruber</i>	Red Salamander	X		X
<i>Notophthalmus viridescens</i>	Eastern Newt	X		X

Table A-2. Amphibian species or species sign detected at each sampling location at Chattahoochee River National Recreation Area, 2011.

Common Name	Sampling Location																												
	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	30	alt1
American Toad	X		X										X					X	X	X	X	X	X		X	X	X		
Fowler's Toad				X			X											X							X	X			
Cricket Frog				X																									
Cope's Gray Treefrog	X			X	X			X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X			
Green Treefrog	X				X					X							X				X						X		
Spring Peeper	X			X				X	X			X	X	X					X	X	X	X		X	X		X		
Southeastern (Upland) Chorus Frog		X	X	X				X	X			X	X							X	X	X							
Eastern Narrow- mouthed Toad				X																	X								
Pickerel Frog				X																									
Southern Leopard Frog			X					X		X																			
Green Frog				X	X																								
Ranidae sp.		X																											
Spotted Salamander			X				X													X									
Marbled Salamander																					X								
Spotted / Northern Dusky Salamander		X		X							X															X			
Seal Salamander		X																											
Desmognathus sp.		X																											
Southern Two-lined Salamander		X									X																		
Three-lined Salamander											X																		
Eurycea sp.				X																									
Slimy Salamander		X	X						X				X				X			X			X			X			
Red Salamander		X		X																									
Eastern Newt												X								X									
Caudata sp.																											X		

Table A-3. Amphibian species or species sign detected during Visual Encounter Surveys at Chattahoochee River National Recreation Area, 2011.

Common Name	Number of Visual Encounters	Number of Audio Encounters	Total Taxa (Species, Genus, Family, or Order) Detections
American Toad	56	0	56
Cope's Gray Treefrog	1	32	33
Spotted/Northern Dusky Salamander	32	NA	32
Southern Two-lined Salamander	27	NA	27
Fowler's Toad	22	0	22
Spring Peeper	15	0	15
Green Treefrog	1	13	14
Slimy Salamander	9	NA	9
Southeastern (Upland) Chorus Frog	9	0	9
Spotted Salamander	7	NA	7
Southern Leopard Frog	6	0	6
Red Salamander	6	NA	6
Pickerel Frog	4	0	4
Seal Salamander	4	NA	4
Eastern Newt	2	NA	2
<i>Caudata</i> species	2	NA	2
Green Frog	1	0	1
<i>Ranidae</i> species	1	0	1
Marbled Salamander	1	NA	1
<i>Desmognathus</i> species	1	NA	1
Eastern Narrow-mouthed Toad	1	0	1
<i>Eurycea</i> species	1	NA	1
Three-lined Salamander	1	NA	1
Total Detections	210	45	255

Appendix B. Distribution Maps for Amphibian Species Encountered

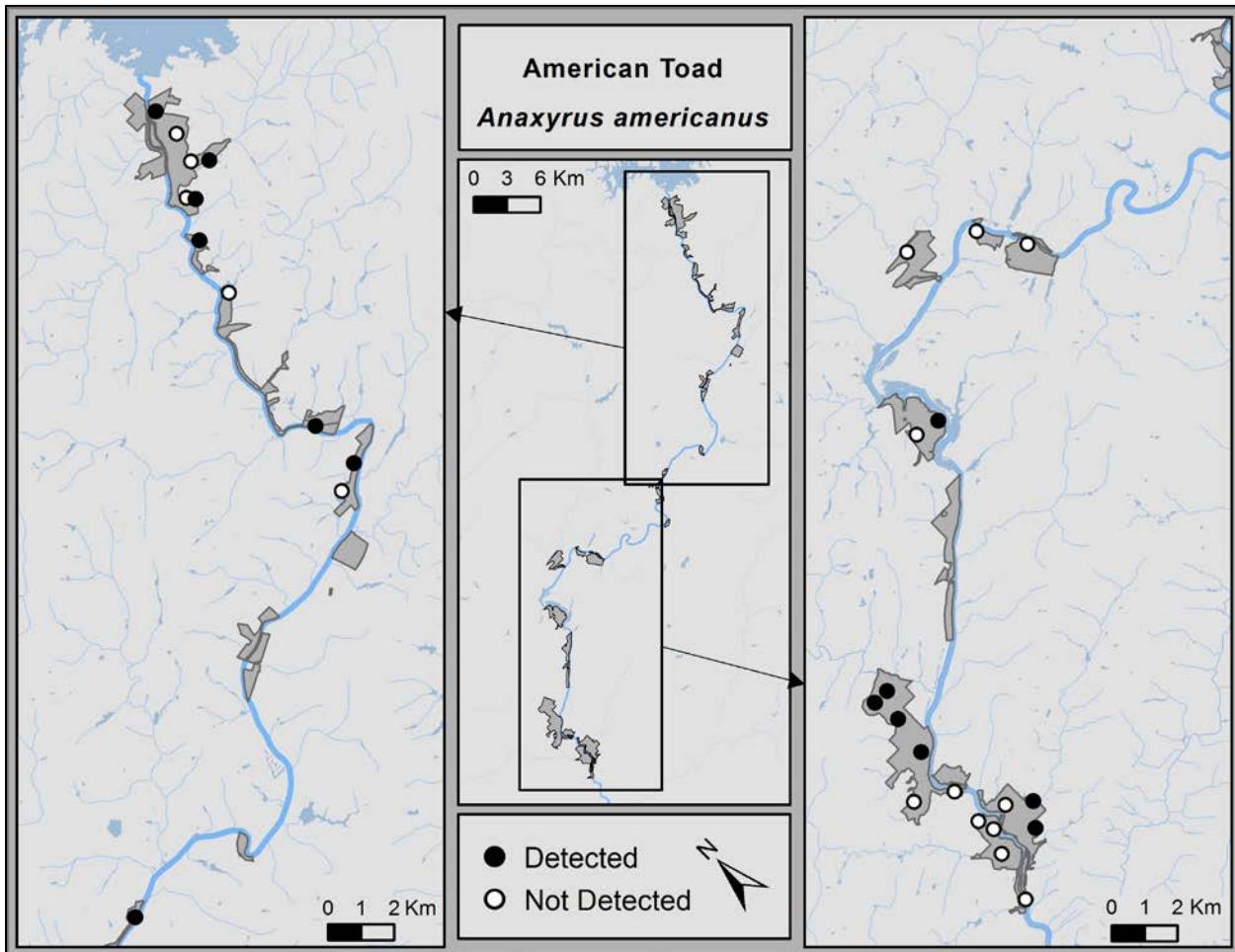


Figure B-1. Sampling locations where American toad (*Anaxyrus americanus*) was detected at Chattahoochee River National Recreation Area, 2011.

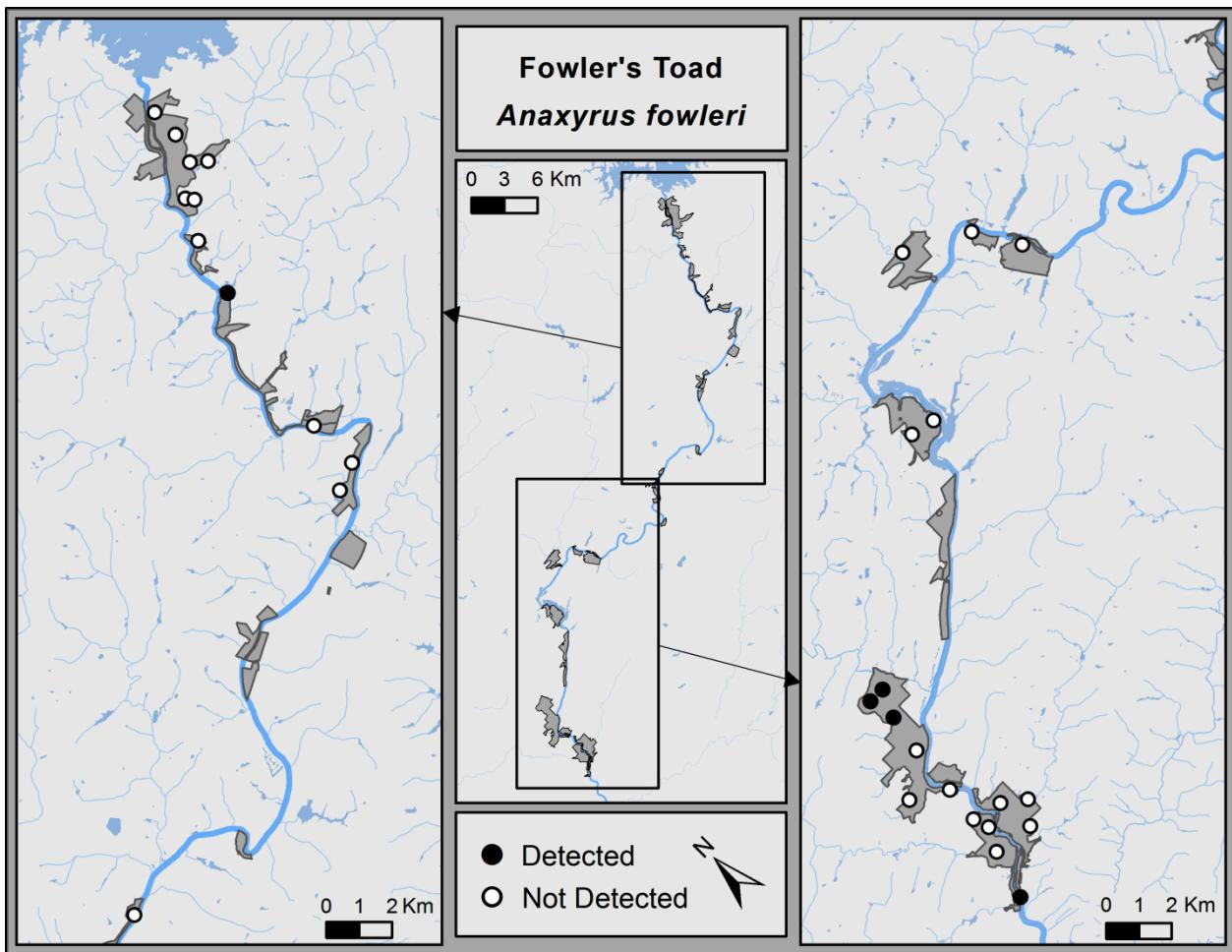


Figure B-2. Sampling locations where Fowler's toad (*Anaxyrus fowleri*) was detected at Chattahoochee River National Recreation Area, 2011.

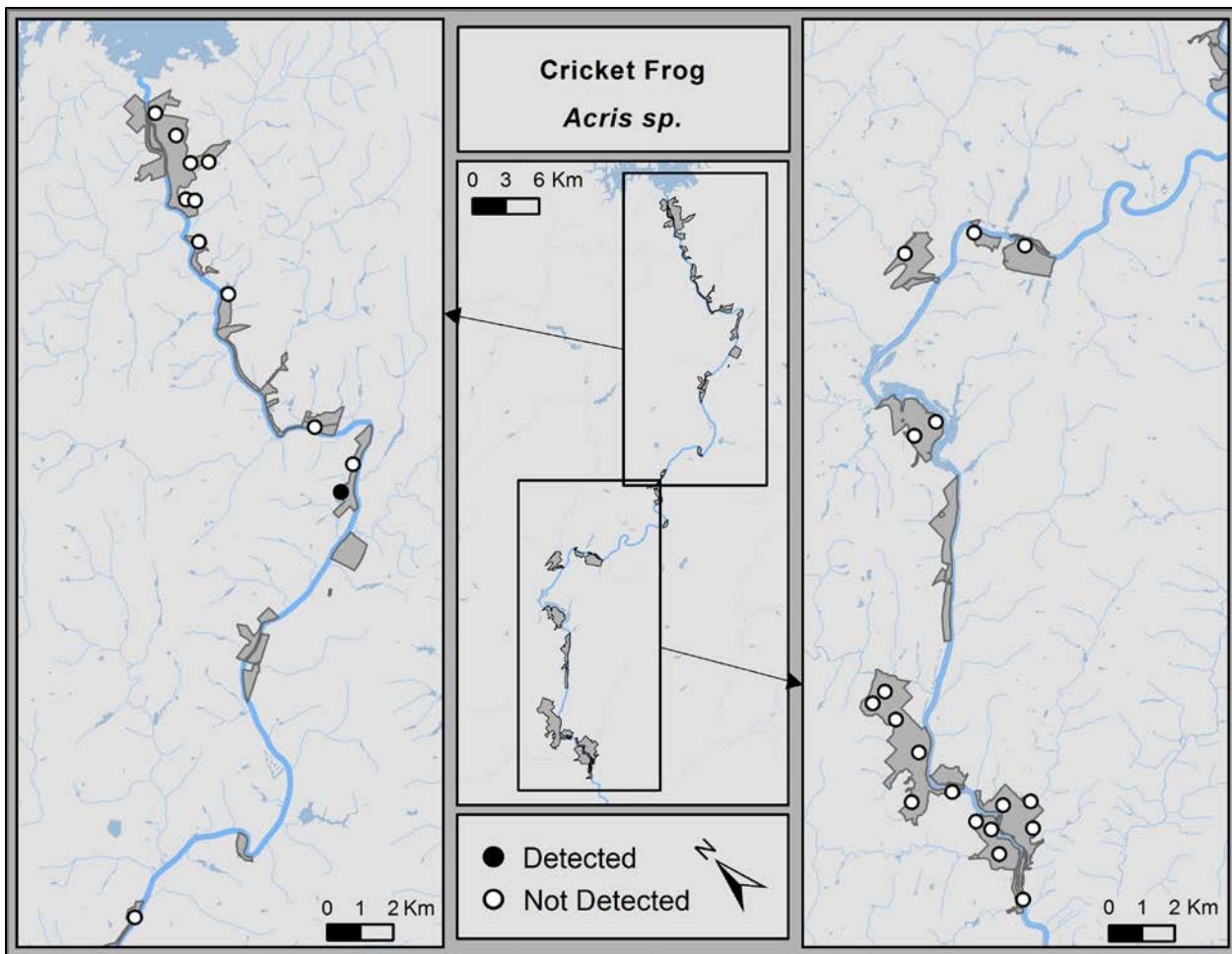


Figure B-3. Sampling locations where cricket frog (*Acris* sp.) was detected at Chattahoochee River National Recreation Area, 2011.

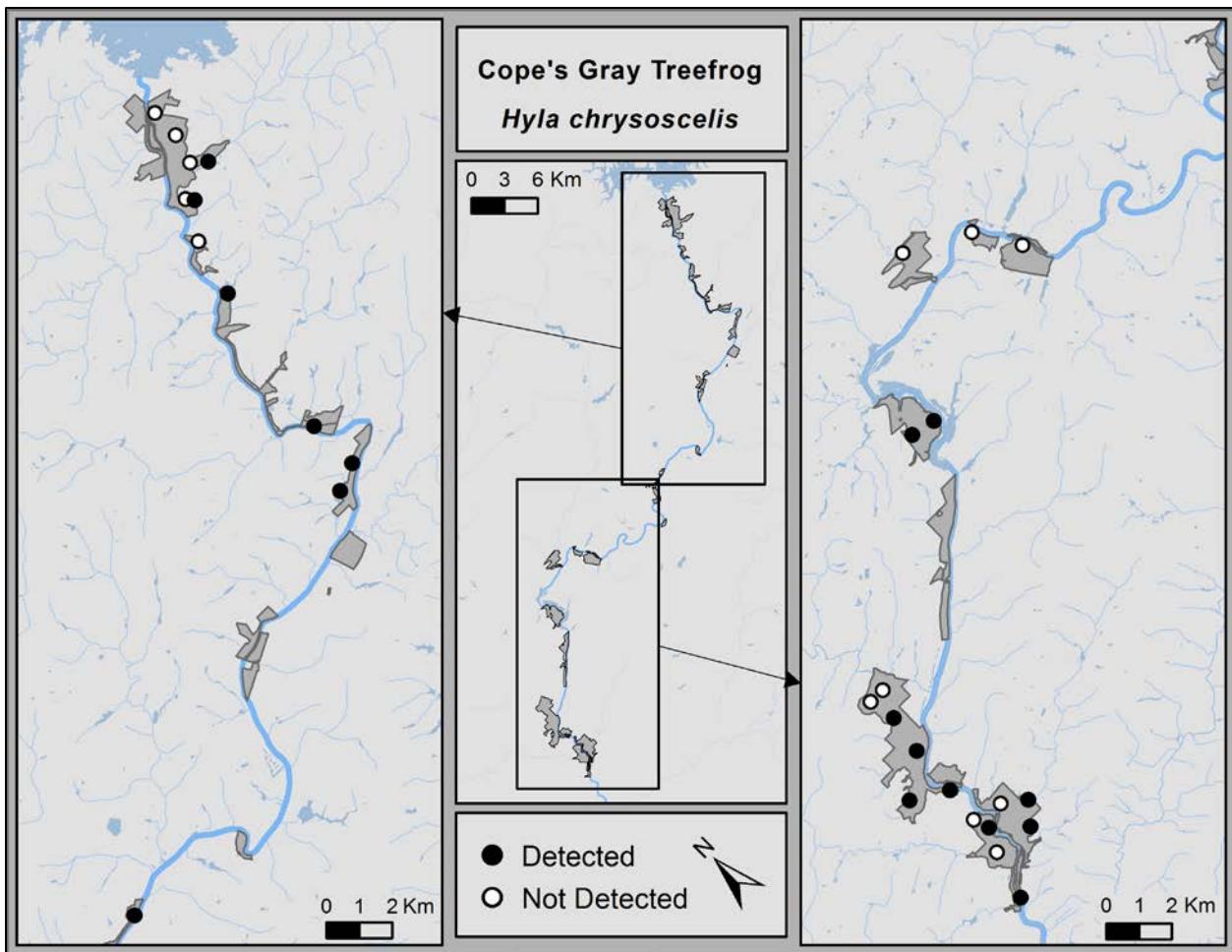


Figure B-4. Sampling locations where Cope's gray treefrog (*Hyla chrysoscelis*) was detected at Chattahoochee River National Recreation Area, 2011.

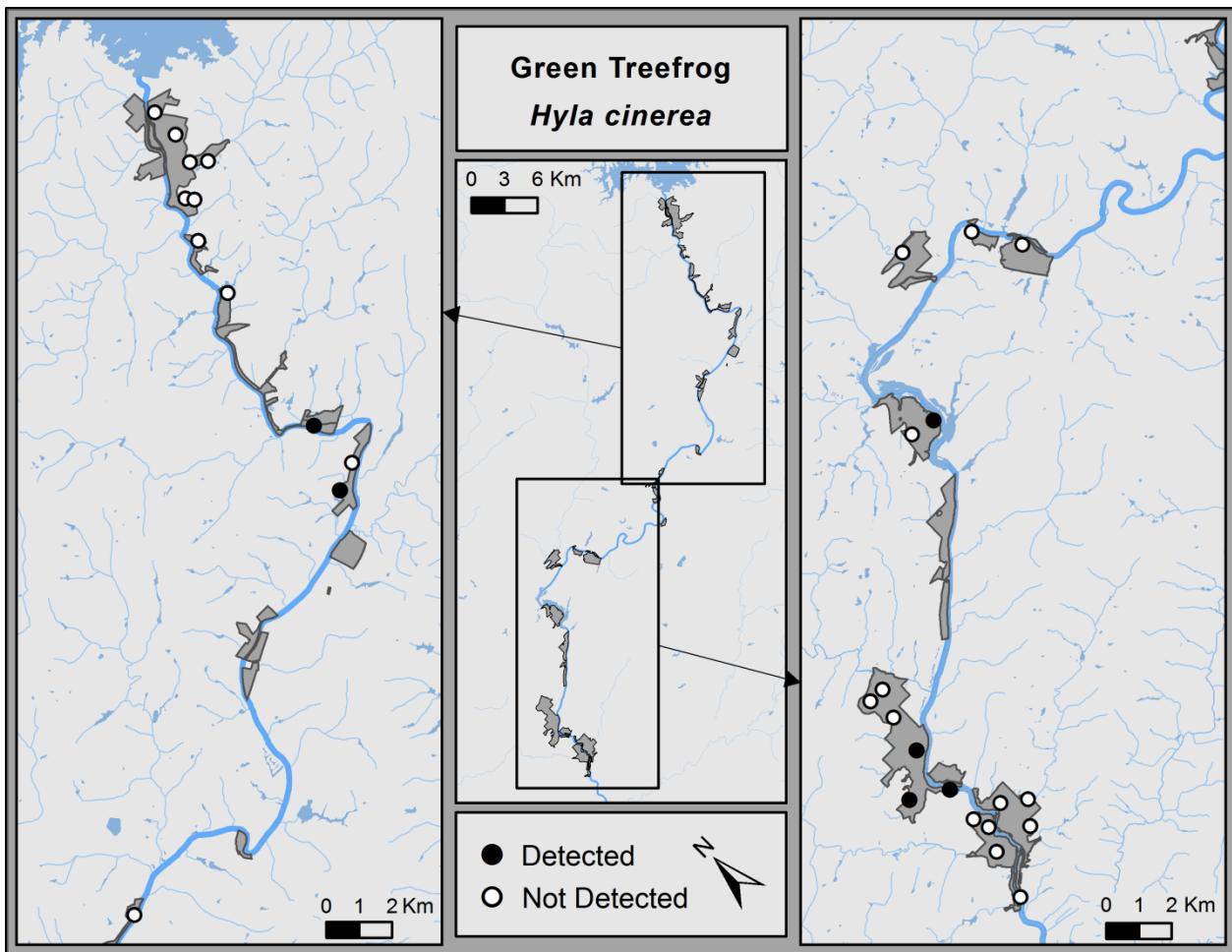


Figure B-5. Sampling locations where green treefrog (*Hyla cinerea*) was detected at Chattahoochee River National Recreation Area, 2011.

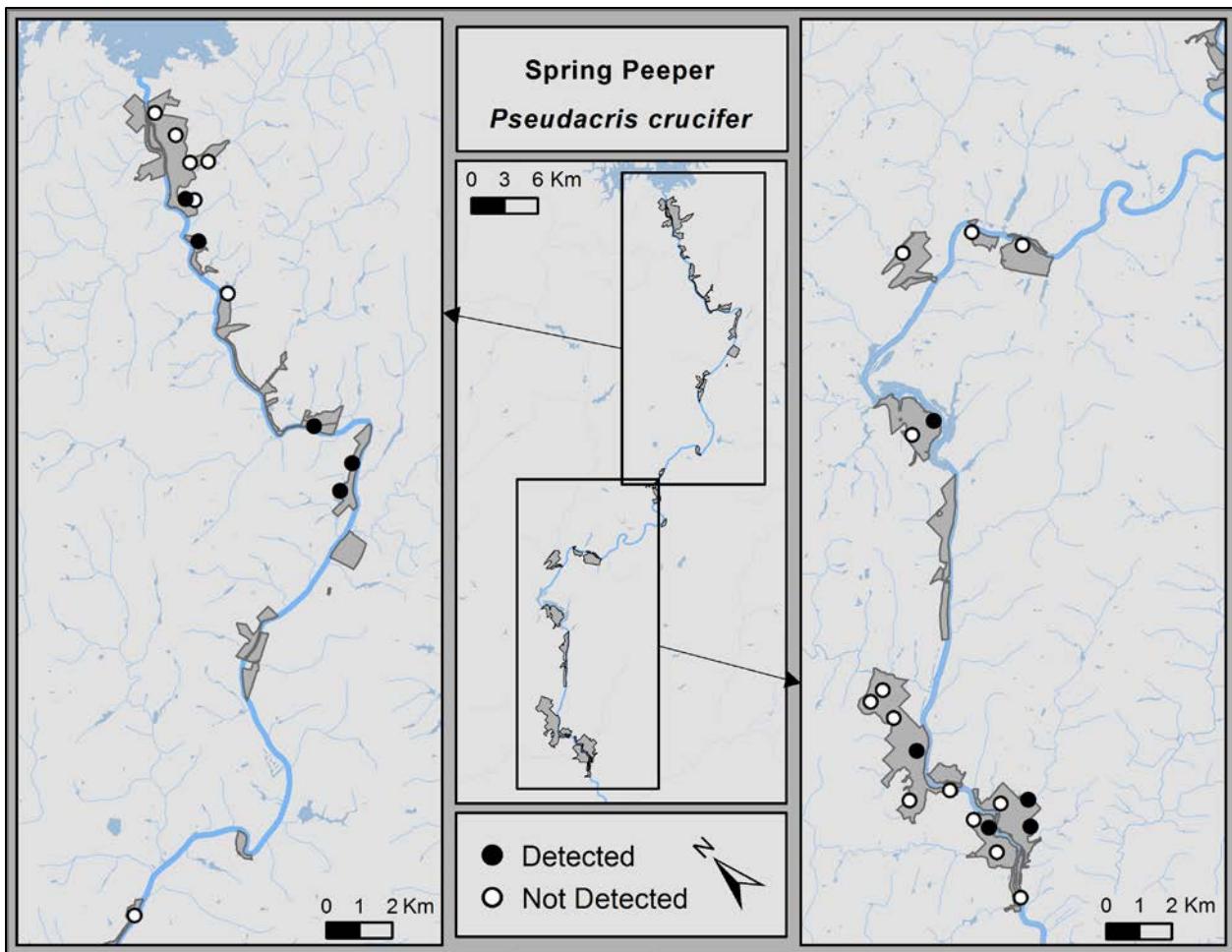


Figure B-6. Sampling locations where spring peeper (*Pseudacris crucifer*) was detected at Chattahoochee River National Recreation Area, 2011.

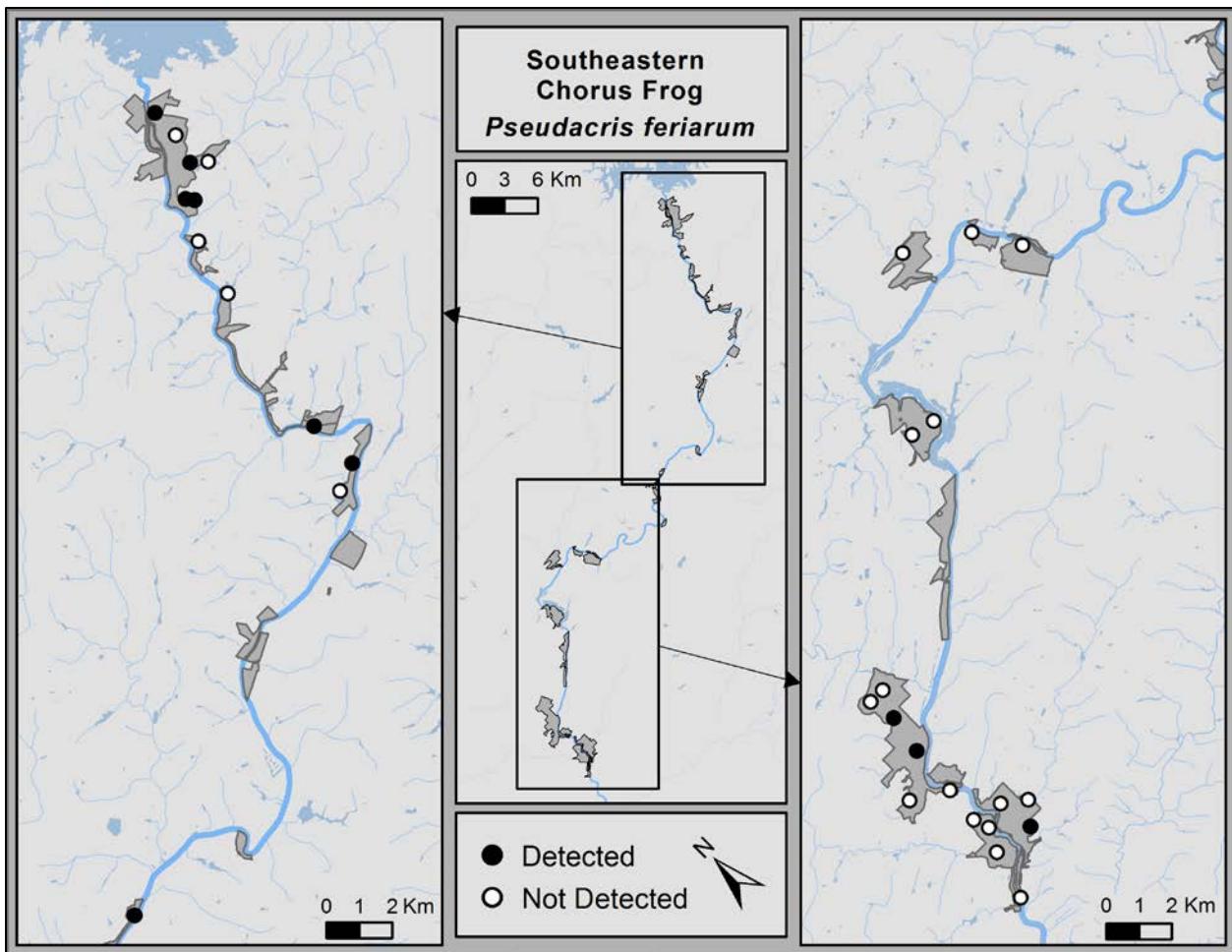


Figure B-7. Sampling locations where southeastern (upland) chorus frog (*Pseudacris feriarum*) was detected at Chattahoochee River National Recreation Area, 2011.

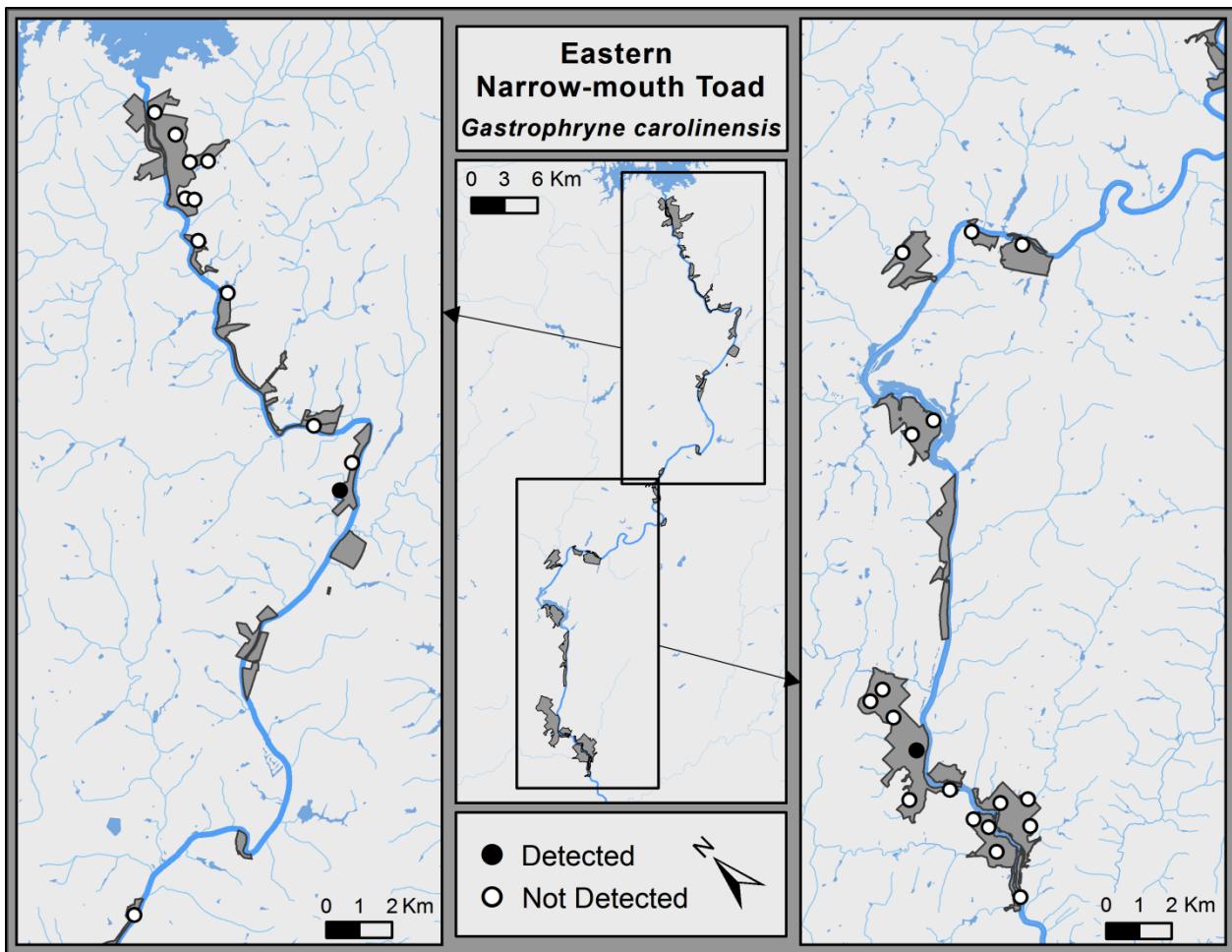


Figure B-8. Sampling locations where eastern narrow-mouthed toad (*Gastrophryne carolinensis*) was detected at Chattahoochee River National Recreation Area, 2011.

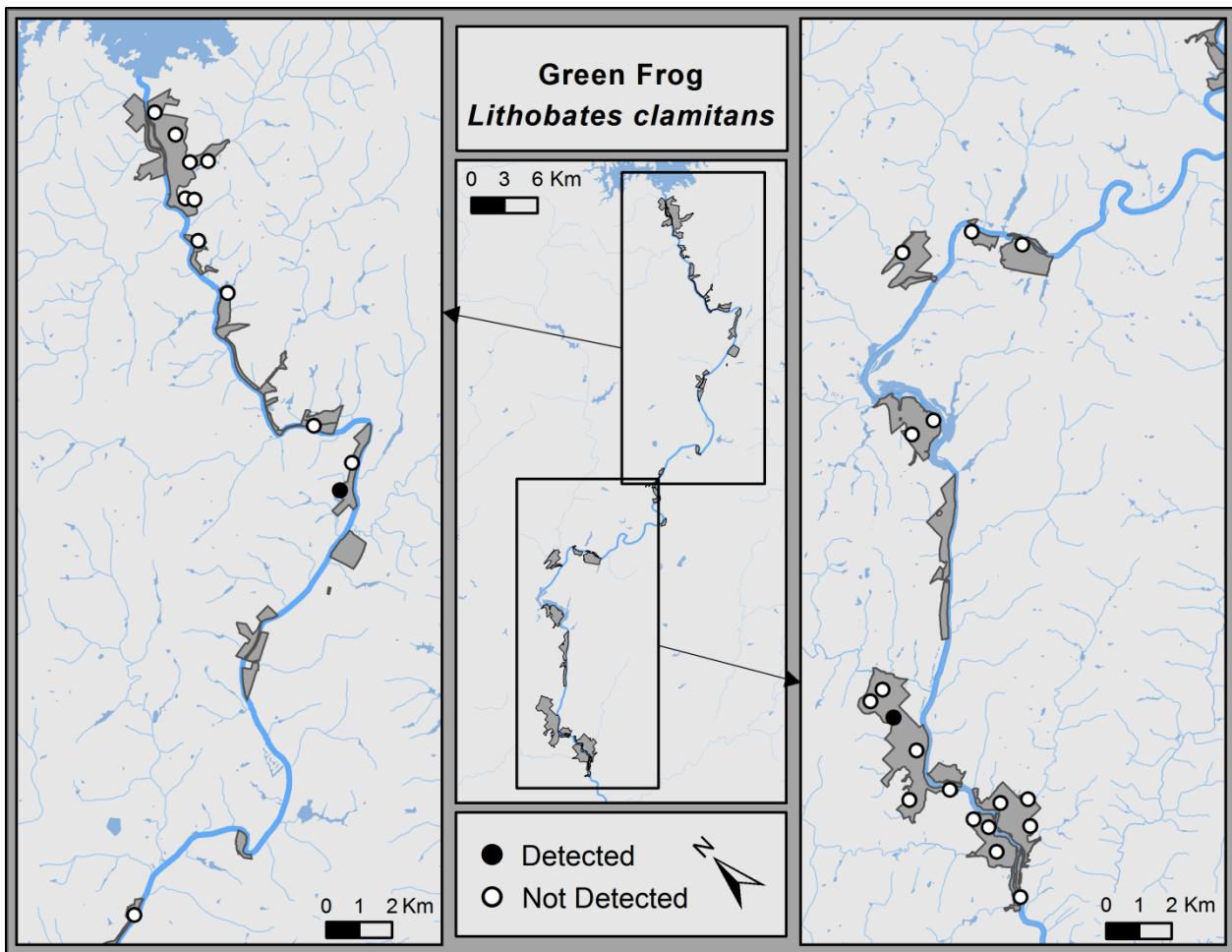


Figure B-9. Sampling locations where green frog (*Lithobates clamitans*) was detected at Chattahoochee River National Recreation Area, 2011.

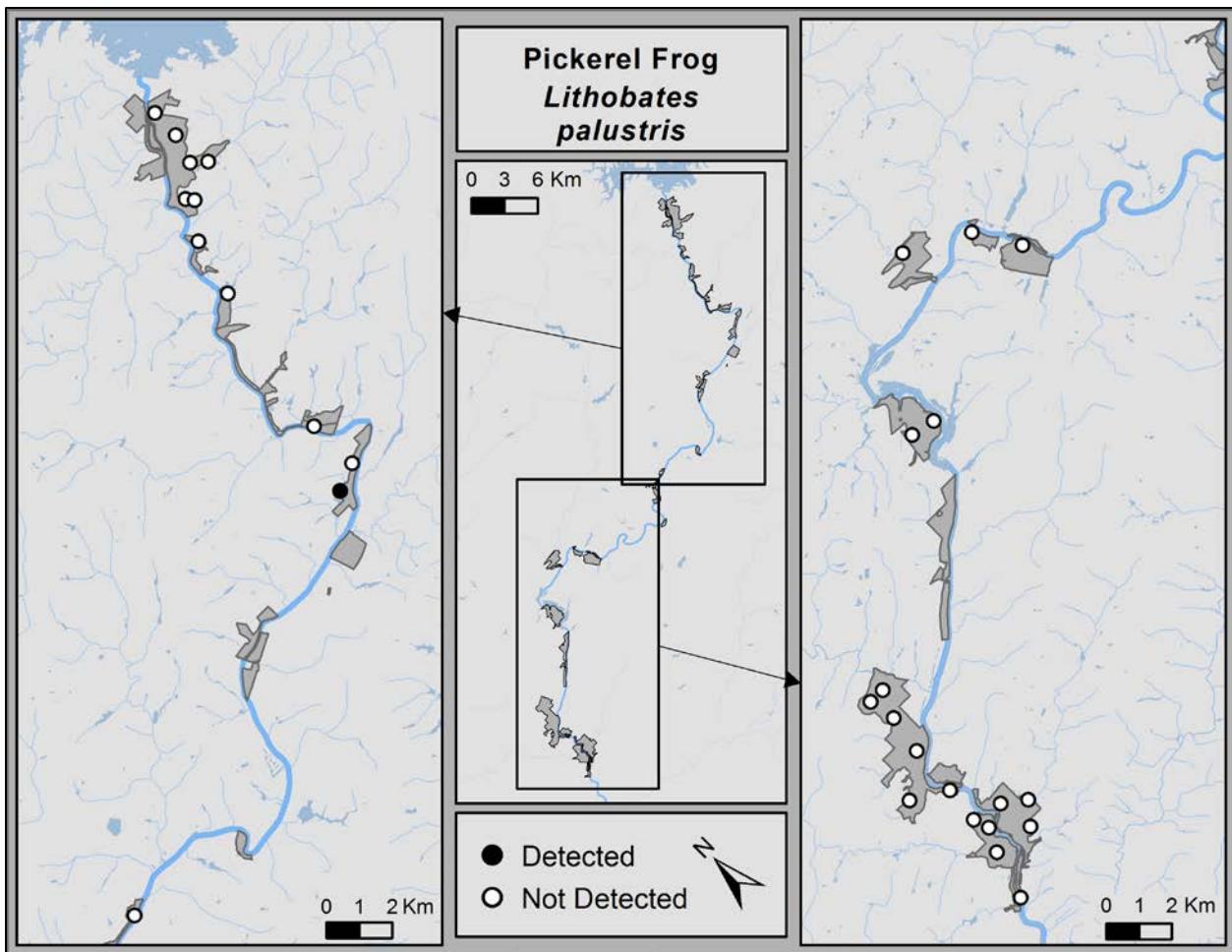


Figure B-10. Sampling locations where pickerel frog (*Lithobates palustris*) was detected at Chattahoochee River National Recreation Area, 2011.

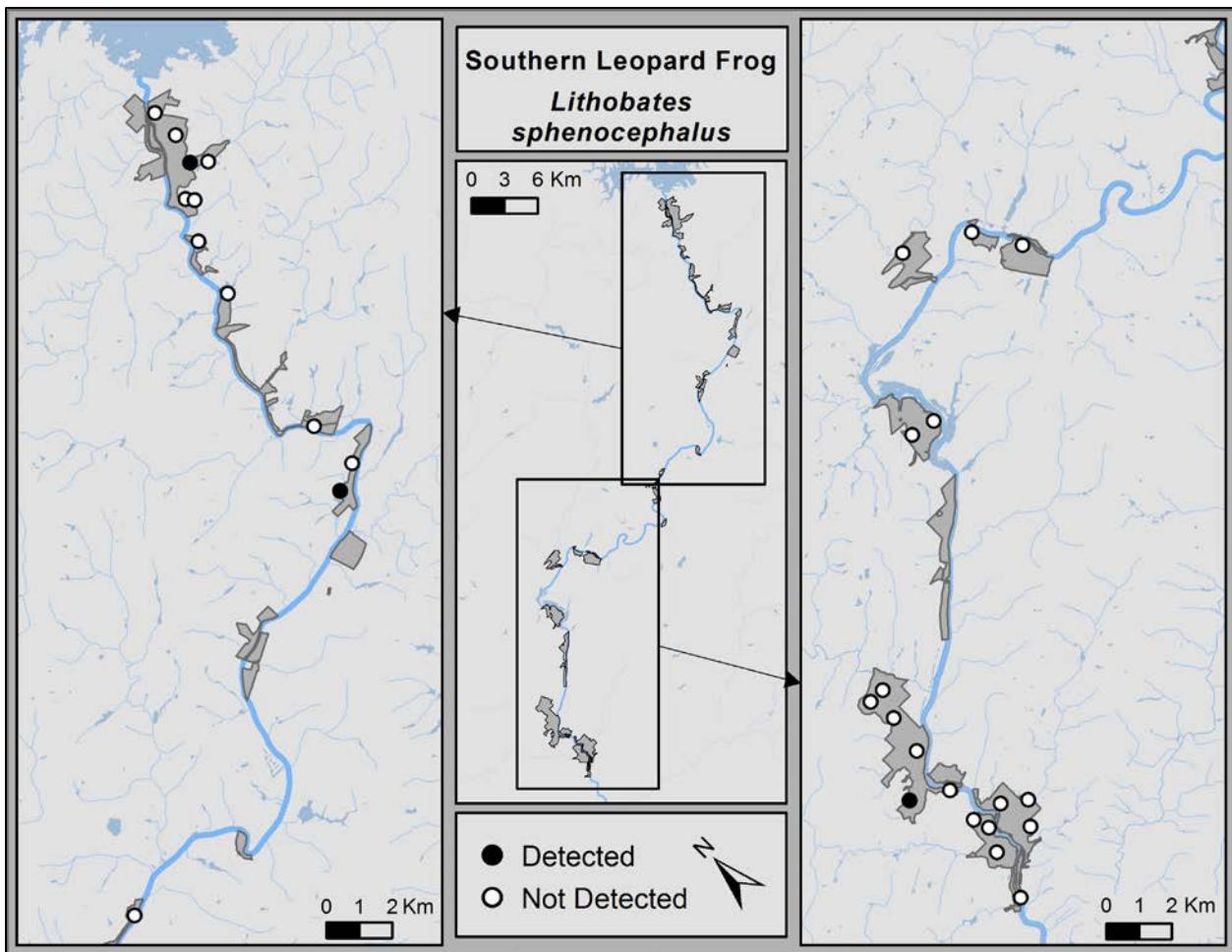


Figure B-11. Sampling locations where southern leopard frog (*Lithobates sphenocephalus*) was detected at Chattahoochee River National Recreation Area, 2011.

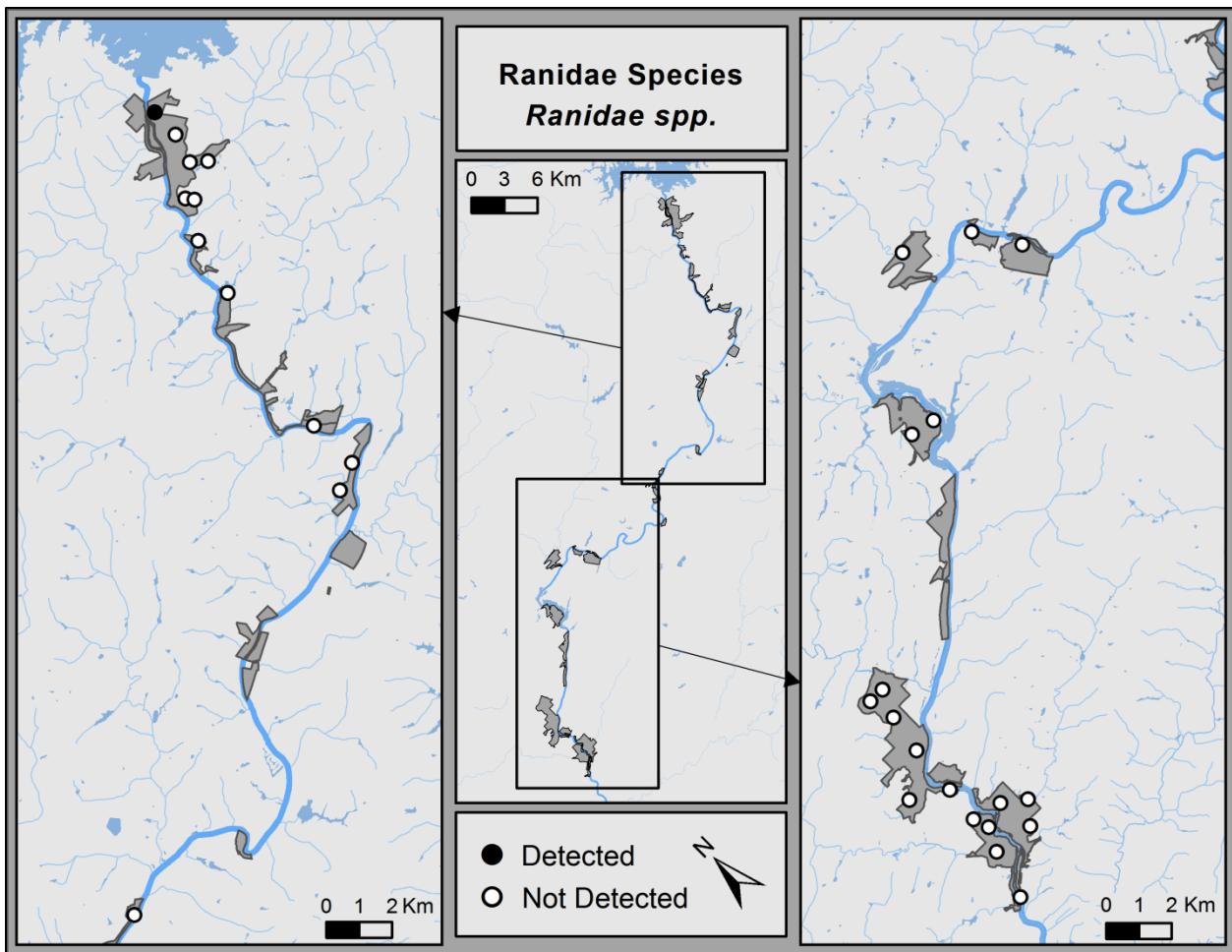


Figure B-12. Sampling locations where unknown Ranidae species was detected at Chattahoochee River National Recreation Area, 2011.

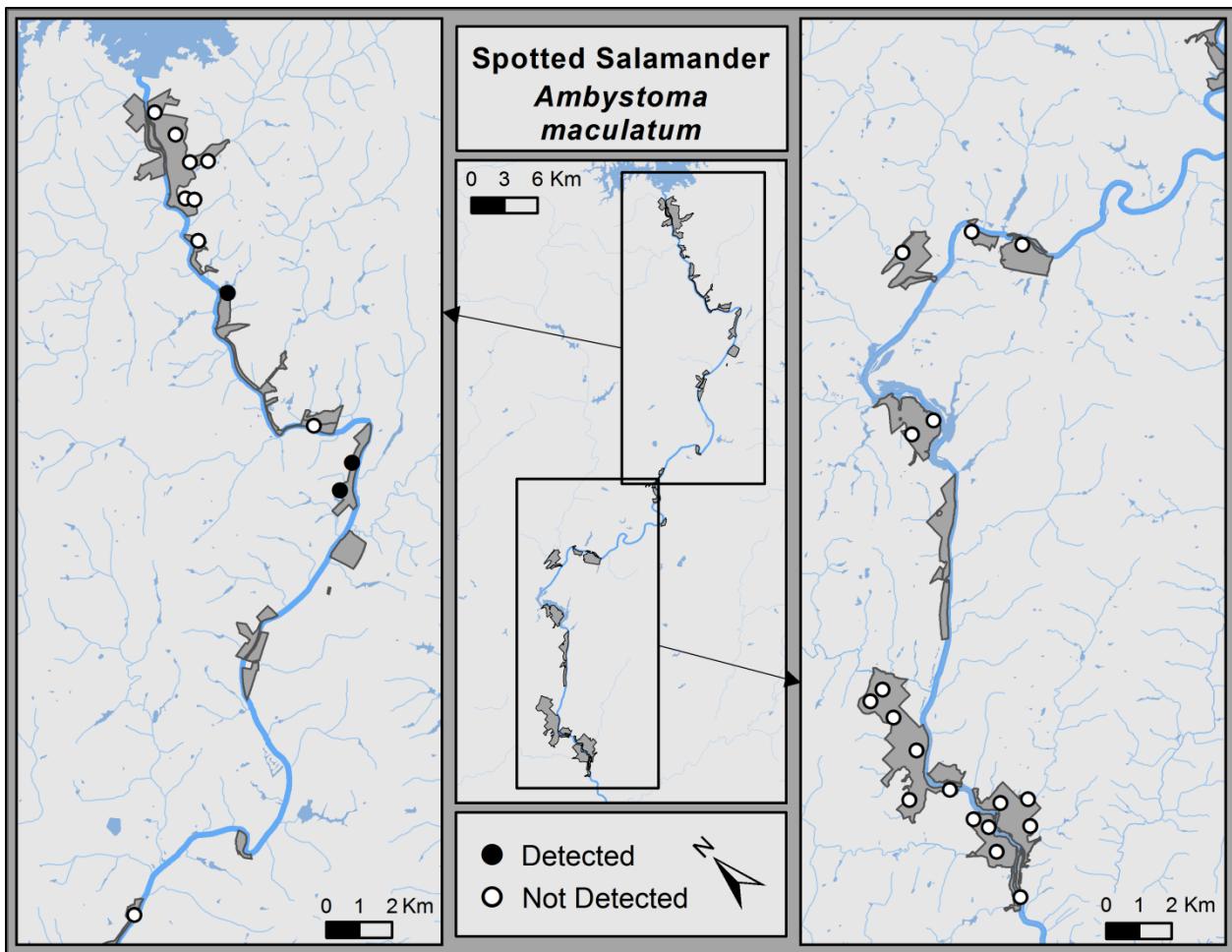


Figure B-13. Sampling locations where spotted salamander (*Ambystoma maculatum*) was detected at Chattahoochee River National Recreation Area, 2011.

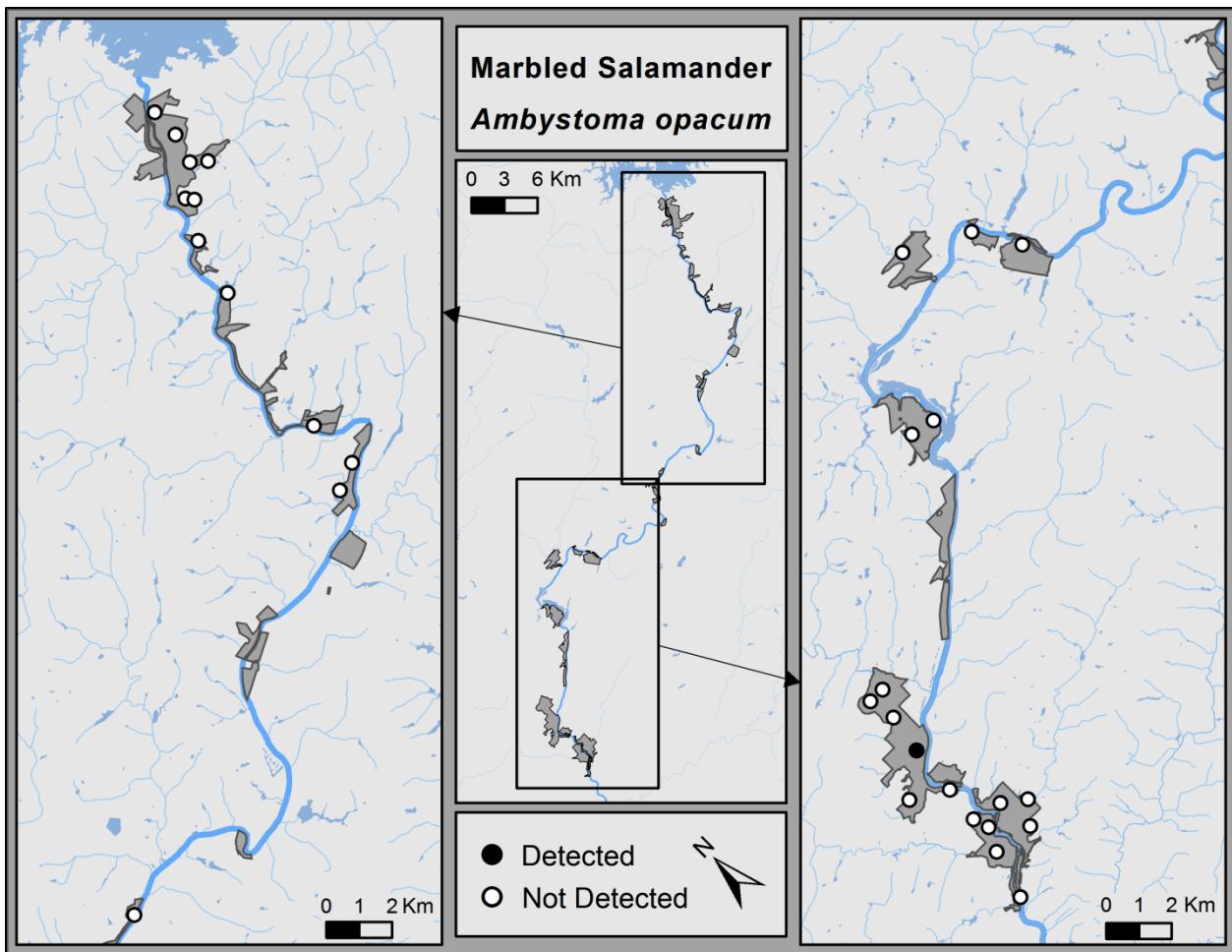


Figure B-14. Sampling locations where marbled salamander (*Ambystoma opacum*) was detected at Chattahoochee River National Recreation Area, 2011.

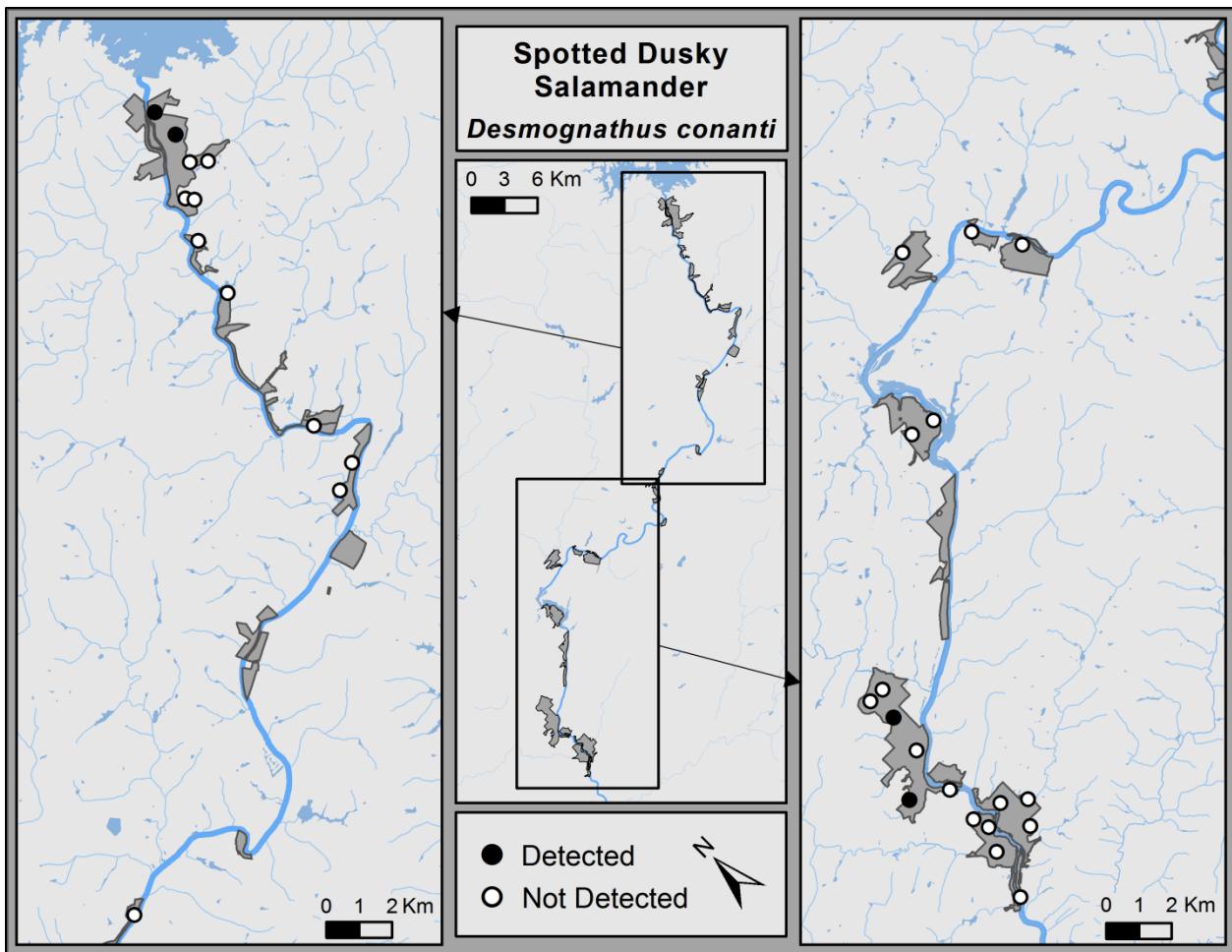


Figure B-15. Sampling locations where spotted dusky salamander (*Desmognathus conanti*) was detected at Chattahoochee River National Recreation Area, 2011.

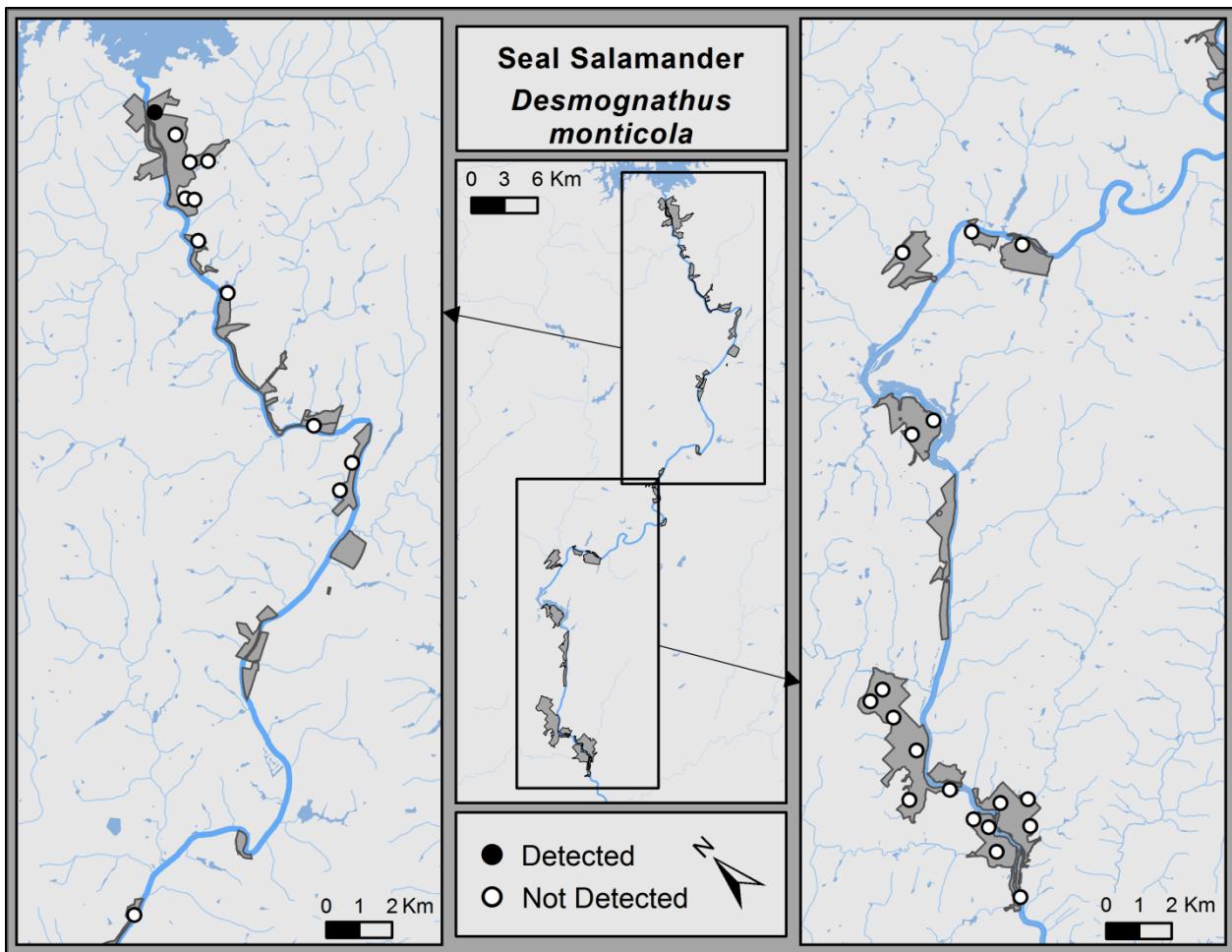


Figure B-16. Sampling locations where seal salamander (*Desmognathus monticola*) was detected at Chattahoochee River National Recreation Area, 2011.

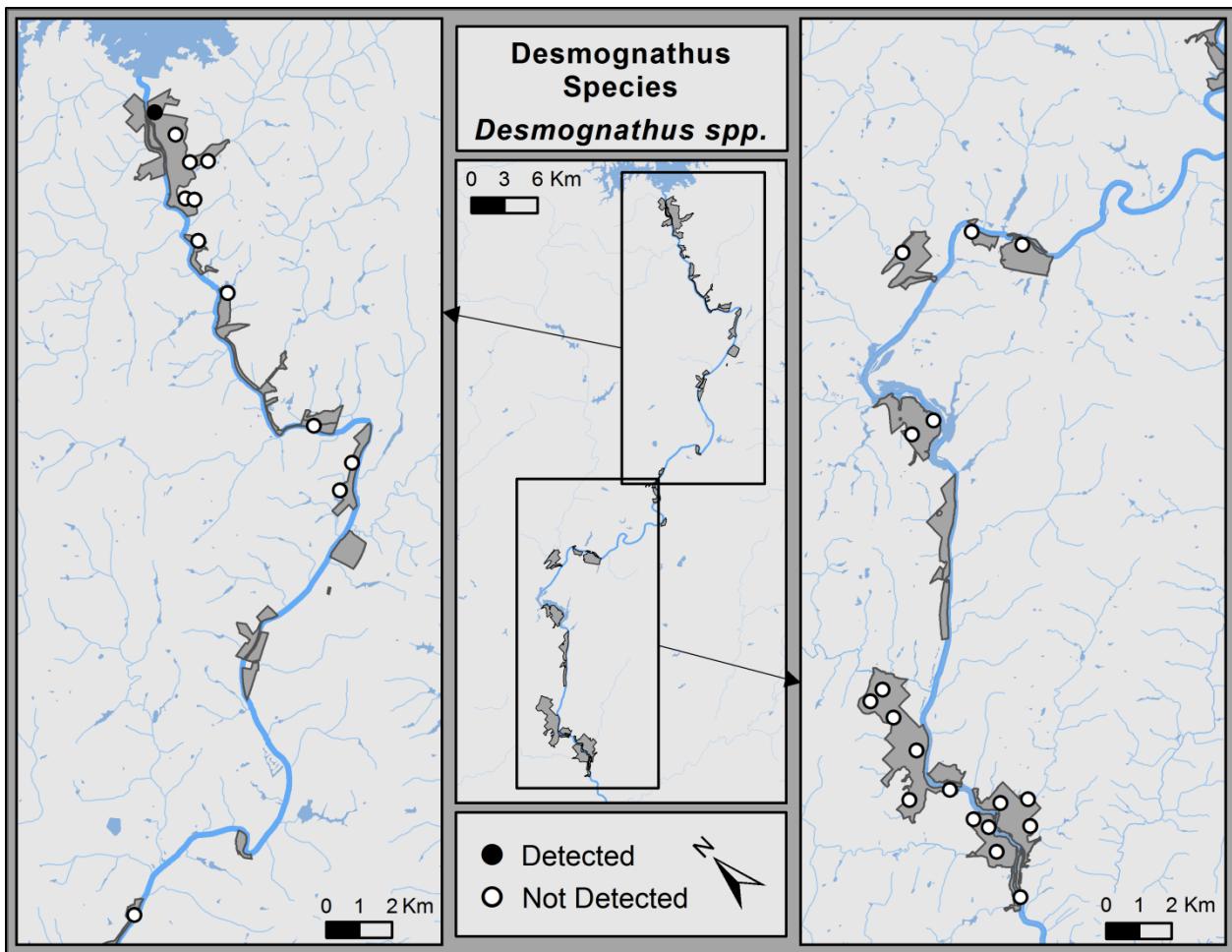


Figure B-17. Sampling locations where *Desmognathus* salamander (*Desmognathus* sp.) was detected at Chattahoochee River National Recreation Area, 2011.

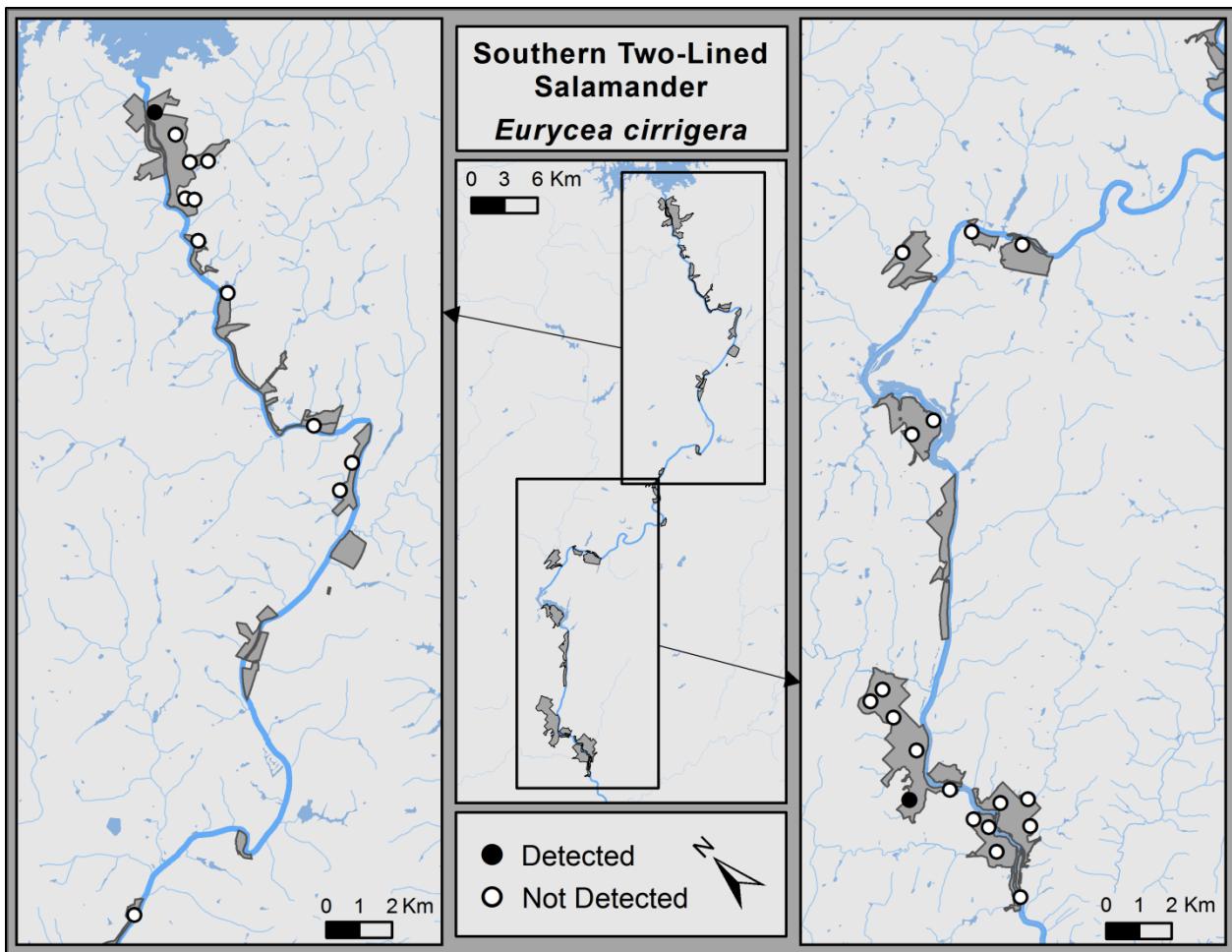


Figure B-18. Sampling locations where southern two-lined salamander (*Eurycea cirrigera*) was detected at Chattahoochee River National Recreation Area, 2011.

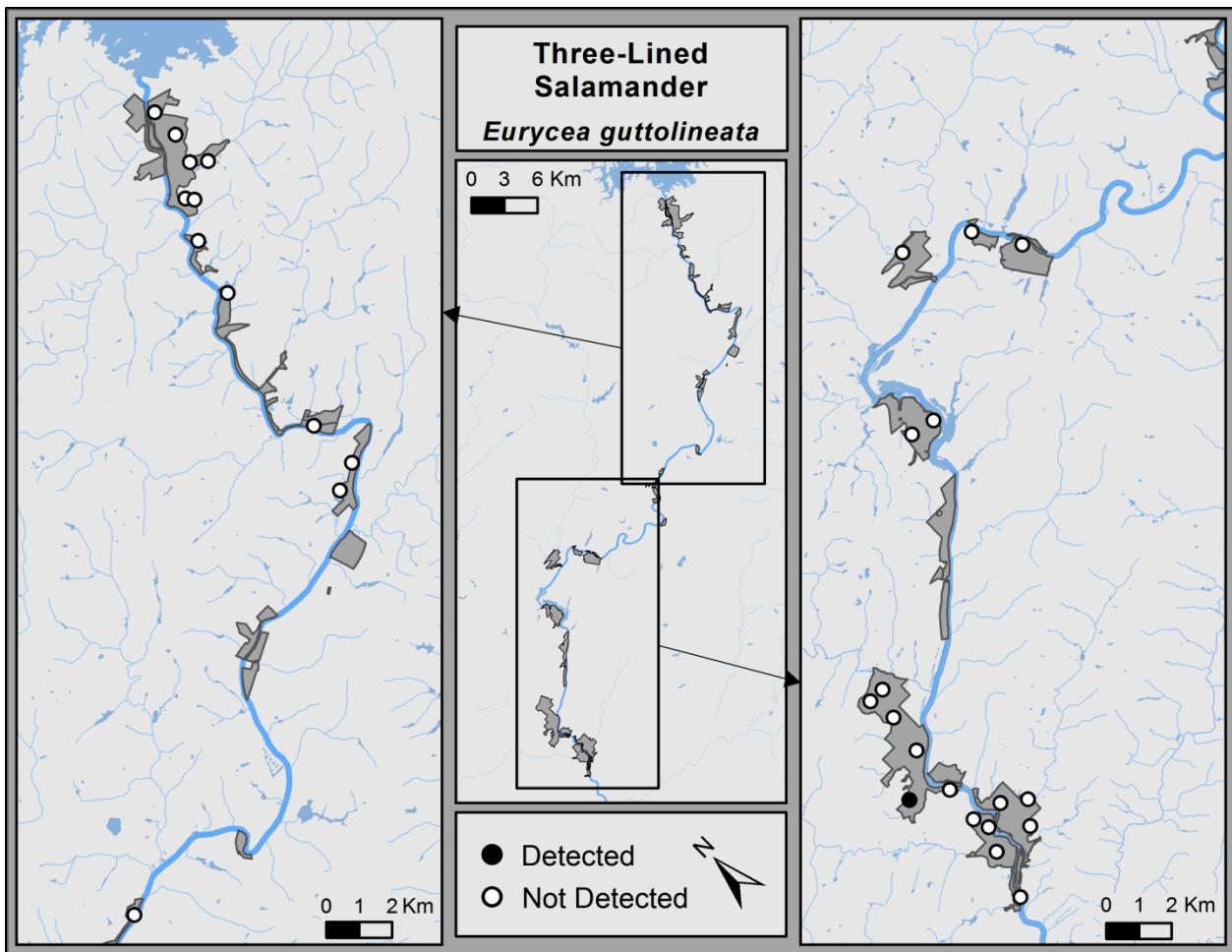


Figure B-19. Sampling locations where three-lined salamander (*Eurycea guttolineata*) was detected at Chattahoochee River National Recreation Area, 2011.

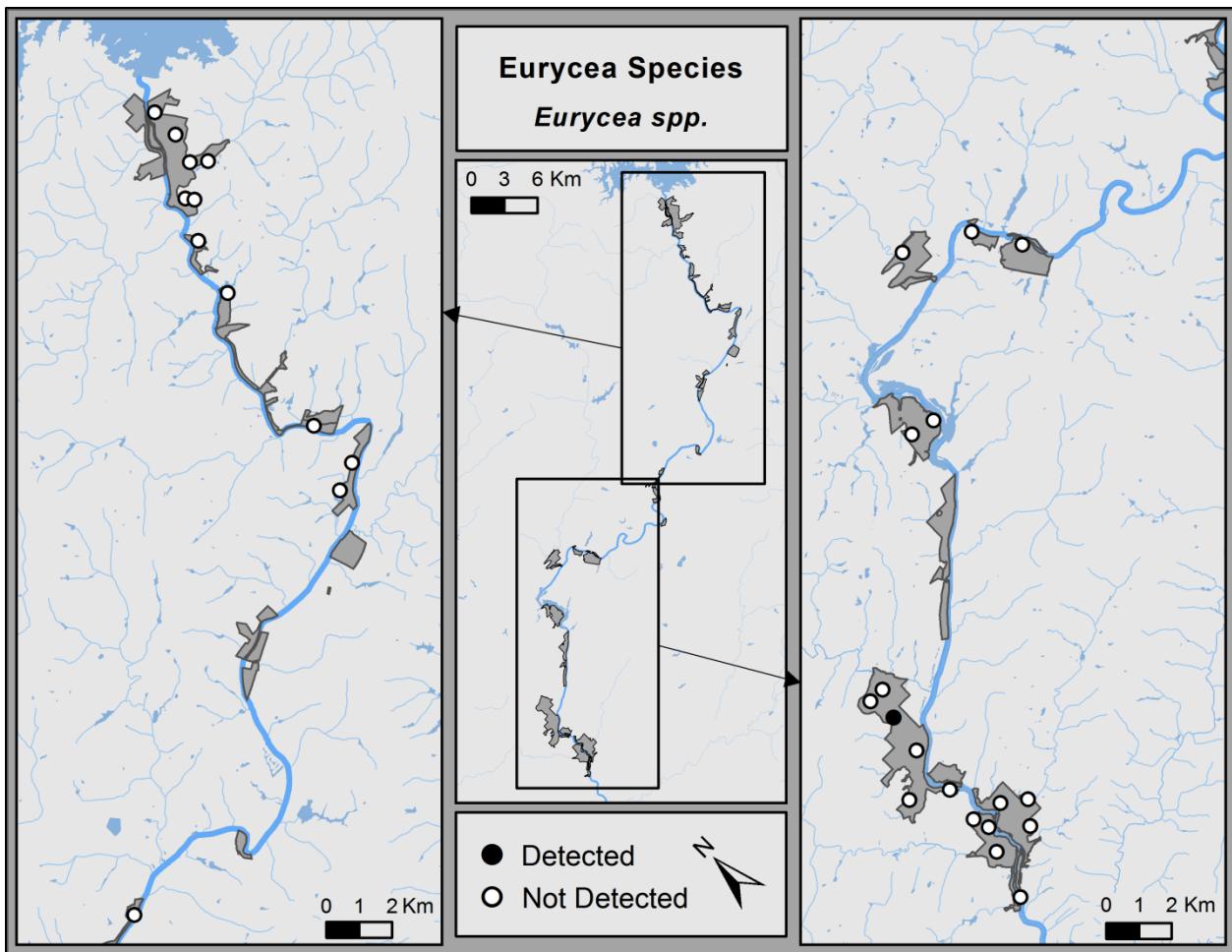


Figure B-20. Sampling locations where southern two-lined or three-lined salamander (*Eurycea* sp.) was detected at Chattahoochee River National Recreation Area, 2011.

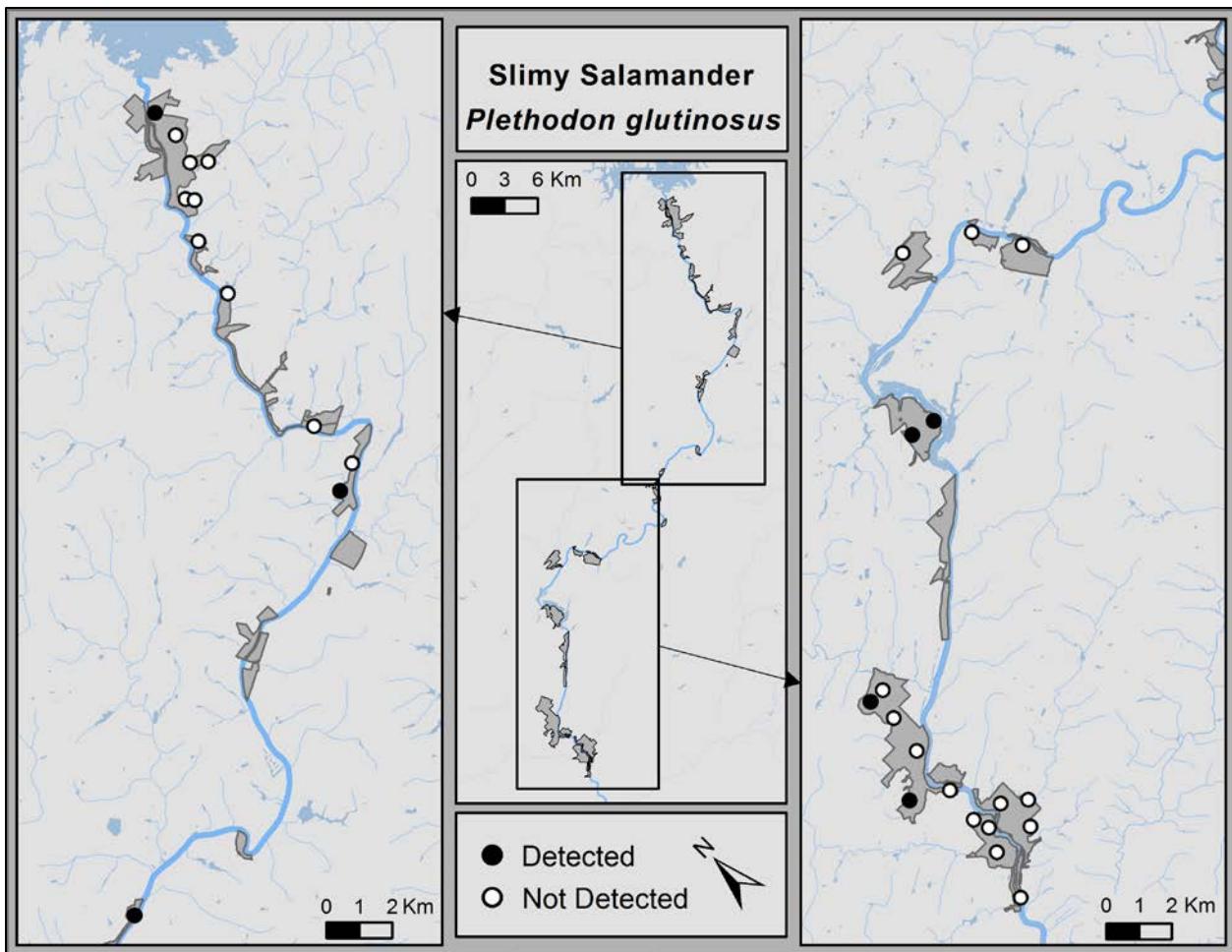


Figure B-21. Sampling locations where slimy salamander (*Plethodon glutinosus*) was detected at Chattahoochee River National Recreation Area, 2011.

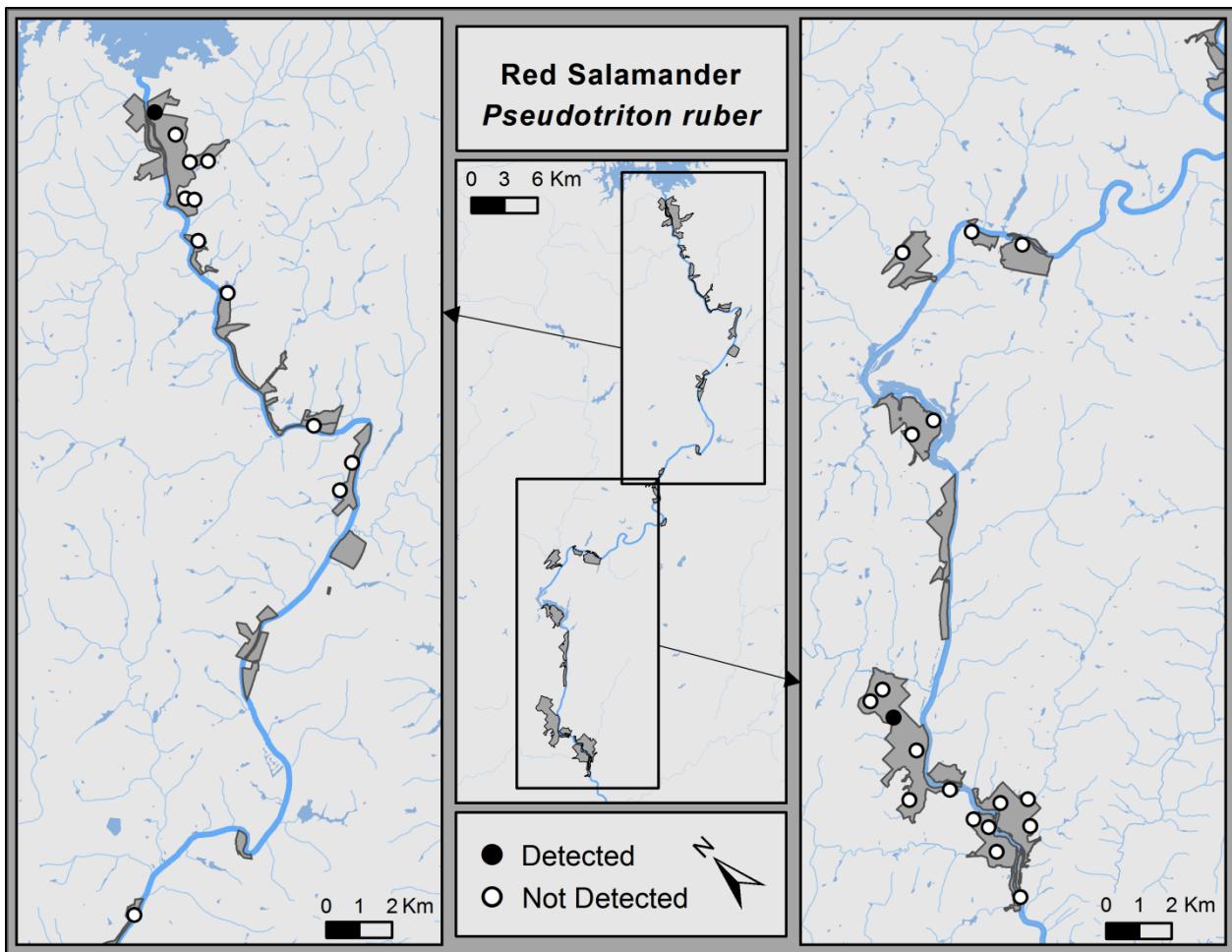


Figure B-22. Sampling locations where red salamander (*Pseudotriton ruber*) was detected at Chattahoochee River National Recreation Area, 2011.

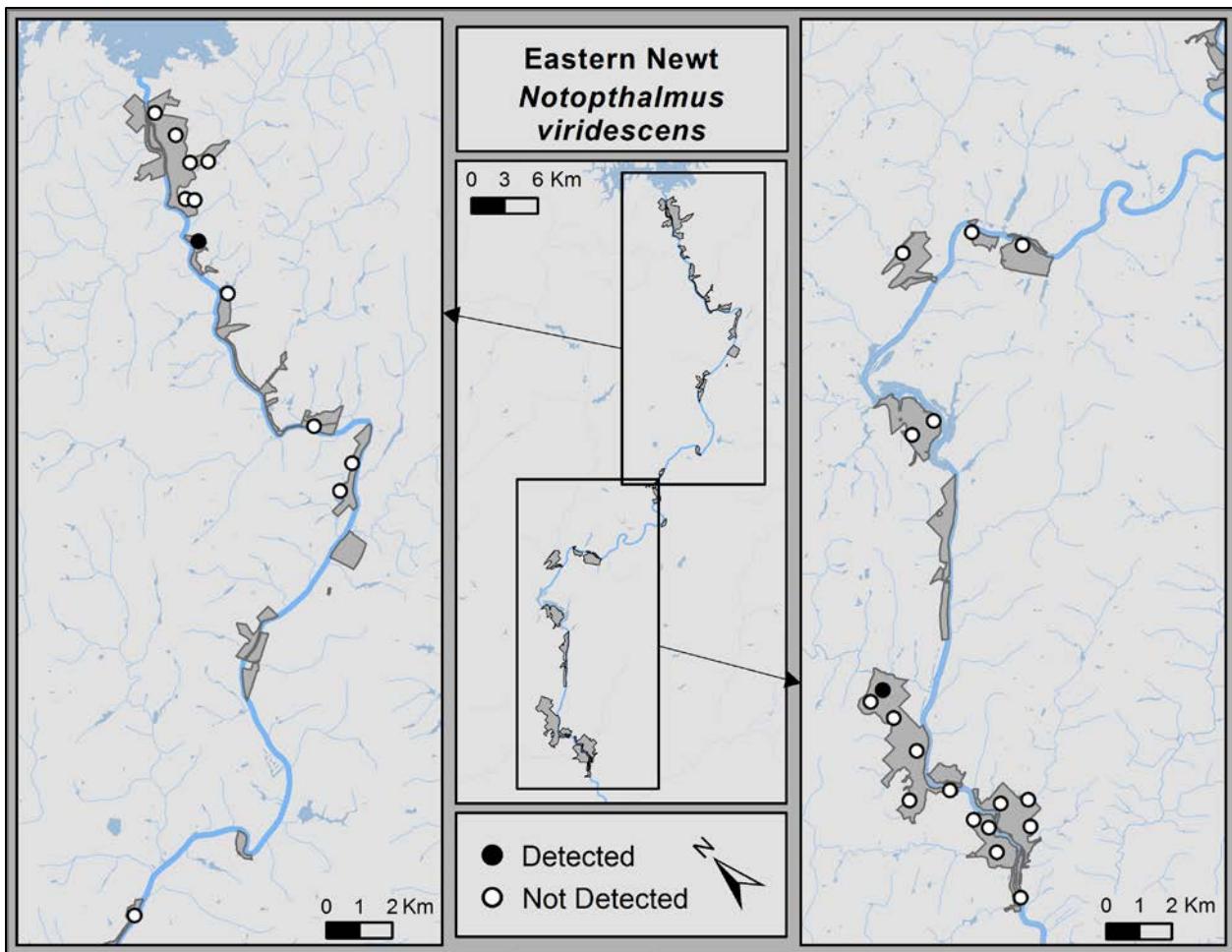


Figure B-23. Sampling locations where eastern newt (*Notophthalmus viridescens*) was detected at Chattahoochee River National Recreation Area, 2011.

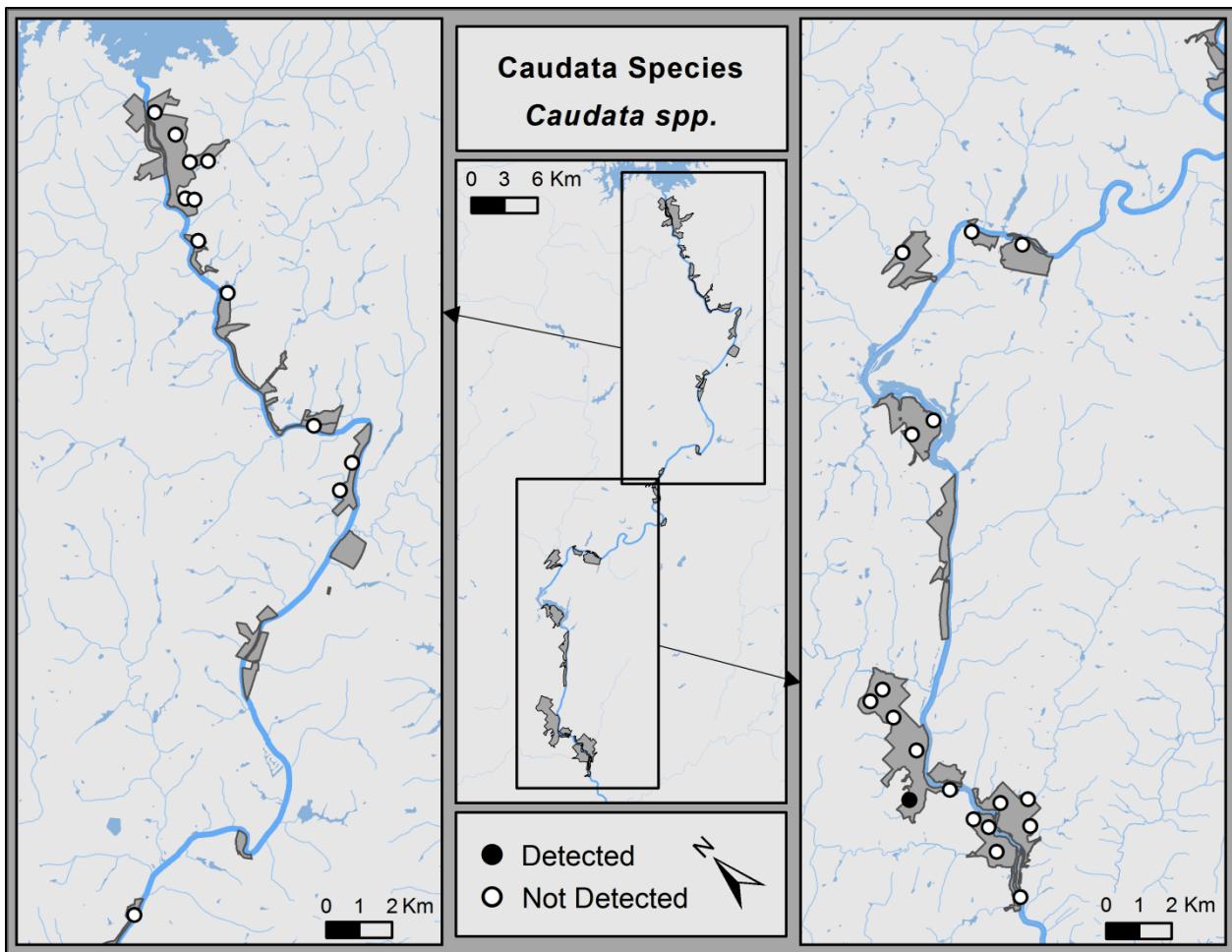


Figure B-24. Sampling locations where a salamander species (*Caudata sp.*) was detected at Chattahoochee River National Recreation Area, 2011.

Appendix C. Reptile Species Detection Data

Chattahoochee River National Recreation Area has 39 known reptile species, consisting of 30 species in *Squamata* (e.g. lizards, snakes, geckos, and skinks), and 9 species in *Testudines* (turtles and tortoises) (Table C-1).

We detected 78 reptiles or reptile signs from 15 different taxa during 2011 sampling activities (Figure C-1, Table C-1). Due to the difficulty in differentiating between two very similar species, the five-lined skink and the Southeastern five-lined skink (*Eumeces inexpectatus* or *fasciatus*) were grouped together for this analysis. The ground skink (*Scincella lateralis*) was the most frequently detected reptile species, accounting for 24% of all reptile sightings, and was found at 27% of sampling locations. The worm snake (*Carphophis amoenus*) accounted for 14% of the total reptile detections and was also found at 27% of the sampling locations. The Eastern box turtle (*Terrapene Carolina*), accounting for 13% of total detections was located at 23% of the sampling locations (Figure C-1). The red-bellied snake (*Storeria occipitomaculata*), black racer (*Coluber constrictor*), broad-headed skink (*Eumeces laticeps*), Eastern fence lizard (*Sceloporus undulatus*), and an Eastern mud or musk turtle (*Kinosternon subrubrum* or *Sternotherus* sp.) were the least frequently detected reptiles / reptile signs, found only at one sampling location each (Table C-2). No non-native reptile species were detected.

Table C-1. Reptile species known to occur at Chattahoochee River National Recreation area based on the Park's certified species list (NPSpecies 2011) and those detected during this sampling effort.

Scientific Name	Common Name	NPSpecies	VES
<i>Ophisaurus attenuatus</i>	Slender Glass Lizard	X	
<i>Ophisaurus ventralis</i>	Eastern Glass Lizard	X	
<i>Carphophis amoenus</i>	Worm Snake	X	X
<i>Cemophora coccinea</i>	Scarlet Snake	X	
<i>Coluber constrictor</i>	Black Racer	X	X
<i>Diadophis punctatus</i>	Ring-necked Snake	X	X
<i>Elaphe guttata</i>	Corn Snake, Red Rat Snake	X	
<i>Elaphe obsoleta</i>	Black Rat Snake	X	X
<i>Heterodon platirhinos</i>	Eastern Hognose Snake	X	
<i>Lampropeltis calligaster</i>	Mole Kingsnake	X	
<i>Lampropeltis getula</i>	Common Kingsnake	X	
<i>Lampropeltis triangulum</i>	Milk Snake	X	
<i>Nerodia erythrogaster</i>	Plain-bellied Water Snake	X	
<i>Nerodia sipedon</i>	Northern Water Snake	X	
<i>Opheodrys aestivus</i>	Rough Green Snake	X	
<i>Regina septemvittata</i>	Queen Snake	X	
<i>Storeria dekayi</i>	Dekay's Brown Snake	X	X
<i>Storeria occipitomaculata</i>	Red-bellied Snake	X	X
<i>Tantilla coronata</i>	Southeastern Crowned Snake	X	
<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	X	
<i>Thamnophis sirtalis</i>	Garter Snake	X	X
<i>Virginia valeriae</i>	Smooth Earth Snake	X	

Table C-1. Continued.

<i>Sceloporus undulatus</i>	Eastern Fence Lizard	X	X
<i>Anolis carolinensis</i>	Green Anole	X	X
<i>Eumeces fasciatus</i>	Five-lined Skink	X	X
<i>Eumeces inexpectatus</i>	Southeastern Five-lined Skink	X	X
<i>Eumeces laticeps</i>	Broad-headed Skink	X	X
<i>Scincella lateralis</i>	Ground Skink	X	X
<i>Aspidoscelis sexlineatus</i>	Six-lined Racerunner	X	
<i>Agkistrodon contortrix</i>	Copperhead	X	
<i>Chelydra serpentina serpentina</i>	Eastern Snapping Turtle	X	
<i>Chrysemys picta</i>	Painted Turtle	X	
<i>Pseudemys concinna</i>	River Cooter	X	
<i>Terrapene carolina</i>	Eastern Box Turtle	X	X
<i>Trachemys scripta scripta</i>	Yellow-bellied Slider	X	
<i>Kinosternon subrubrum</i>	Eastern mud turtle	X	X
<i>Sternotherus minor</i>	Loggerhead Musk Turtle	X	X
<i>Sternotherus odoratus</i>	Common Musk Turtle	X	X
<i>Apalone spinifera aspera</i>	Gulf Coast Spiny Softshell Turtle	X	

Table C-2. Reptilian species or species sign detected at each sampling location at Chattahoochee River National Recreation Area, 2011.

Common Name	Sampling Location																													
	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	30	alt1	alt2
Worm Snake		X		X				X	X	X							X				X			X		X				
Black Racer																											X			
Ring-necked Snake		X																X	X					X		X				
Black Rat Snake																X		X												
Rat Snake skin														X																
Dekay's Brown Snake														X	X															
Red-bellied Snake														X																
Garter Snake			X											X							X									
Snake species eggs																												X		
Eastern Fence Lizard					X																									
Green Anole																			X					X		X				
Five-lined or Southeastern Five-lined Skink	X																													
Five-lined or Southeastern Five-lined Skink eggs	X													X																
Broad-headed Skink			X																											
Ground Skink	X					X						X	X	X	X									X	X		X	X		
Eastern Box Turtle		X									X		X	X							X	X	X	X						
Eastern Box Turtle shell											X				X															
Mud or Musk Turtle																													X	
Common or Loggerhead Musk Turtle shell												X																		

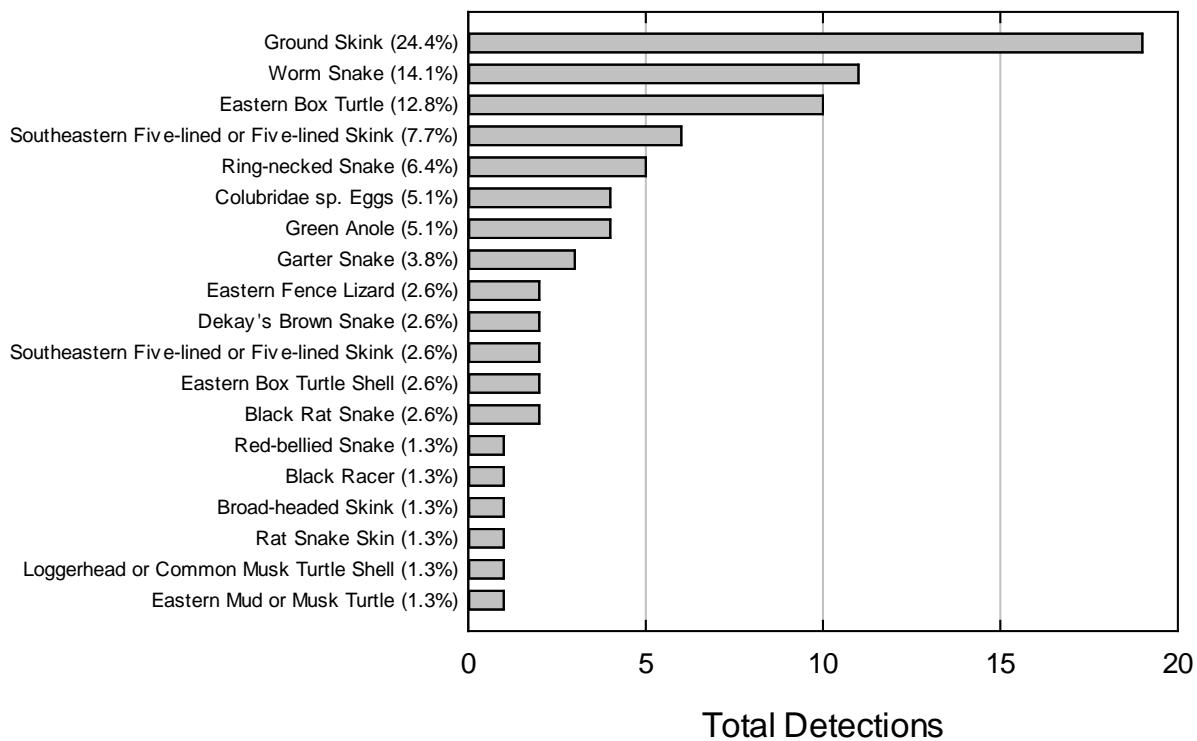


Figure C-1. Number of individual reptiles and reptile signs detected and percent species composition during visual encounter surveys at Chattahoochee River National Recreation Area, 2011. Based on n=78 detections.