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Natural Resource Stewardship and Science

Amphibian Community Monitoring at Kennesaw Mountain National Battlefield Park, 2012

Natural Resource Data Series NPS/SECN/NRDS—2013/548

ON THE COVER
Three-lined Salamander (*Eurycea guttolineata*)
Photograph by: Marylou Moore

Amphibian Community Monitoring at Kennesaw Mountain National Battlefield Park, 2012

Natural Resource Data Series NPS/SECN/NRDS—2013/548

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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 and 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 Kennesaw Mountain National Battlefield Park (KEMO) in 2012.

- 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 3/20/2012 to 6/7/2012. Auditory recordings were collected from 3/20/2012 through 6/7/2012 and visual surveys were conducted from 4/17/2012 through 5/3/2012.

- We detected 20 amphibian species at KEMO during our 2012 monitoring activities. We detected vocalizations from six identifiable anuran species using ARDs. We detected 203 post-metamorphic amphibians in 18 taxa (species or family) and 78 larval stage amphibians in 5 taxa (species or family) during VESs.

- A total of 48 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.

- Slimy salamander (*Plethodon glutinosis*) had the highest frequency of occurrence among amphibians at KEMO in 2012. Cope's gray treefrog (*Hyla chrysoscelis*) had the highest frequency of occurrence among anurans.

- Cope's gray treefrog had the highest relative frequency of detection of vocalizations over the 77-day recording period at KEMO in 2012.

- Spotted or Northern dusky salamander (*Desmognathus conanti* or *fuscus*) and slimy salamander had the highest relative abundance during 2012 VESs.

- Slimy salamander and Cope's gray treefrog were the most widely-distributed amphibians at KEMO in 2012.

- We detected 175 reptiles or reptile signs in 16 taxa (genus or species) during VESs.

- The Southeastern five-lined skink (*Eumeces inexpectatus*) and Southeastern crowned snake (*Tantilla coronata*) were confirmed in the park and added to the reptile park species list.

- No non-native species were found.
- Amphibian communities will next be sampled in 2016.
- 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 and 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 Kennesaw Mountain National Battlefield Park (KEMO).

Study Area

Kennesaw Mountain National Battlefield Park (KEMO), a 2,923-acre (1183 ha) park in the metropolitan Atlanta area, includes the 1,808-foot (551 m) peak of Kennesaw Mountain, Little Kennesaw Mountain, and hundreds of acres of mixed hardwood / pine forests intermixed with a number of grassy fields (Figure 1). Forested areas generally consist of oaks (*Quercus* spp.), hickories (*Carya* spp.), and loblolly pine (*Pinus taeda*). Included are more than 22 miles (35.4) of designated hiking trails that attract hundreds of recreational visitors daily. The Park's location in the metropolitan Atlanta area makes it the second-most visited battlefield in the National Park System, and has earned it a position on the Secretary of Interior's list of 25 most threatened parks.

Largely because of its proximity to Atlanta, major threats to natural resources exist at KEMO. The development of Cobb County and greater metro Atlanta makes the lands within Kennesaw Mountain relatively valuable for localized plant and animal communities. Cobb County has plans to expand roads and highways that traverse the park and pose a potential threat to both cultural and natural resources. Air pollution also poses a major threat to the Park, which is located in a designated ozone nonattainment area. Vegetation in KEMO is considered at high risk of injury from ozone.

Additionally, there are minor threats from encroachment of adjacent landowners, non-native invasive plant species, and industrial air and water pollution. Since 1993, Southern pine beetle (*Dendroctonus frontalis*) infestations have killed thousands of pine trees throughout the park and the resulting increase in fuels laying on the forest floor pose an increased fire risk. The mitigation of encroachments and the removal of non-native plants are ongoing programs.

KEMO has 24 known amphibian species, consisting of 12 species in Anura (frogs and toads) and 12 species in Caudata (e.g. salamanders, newts, amphiumas, sirens) (NPSpecies 2013, Table A-1).

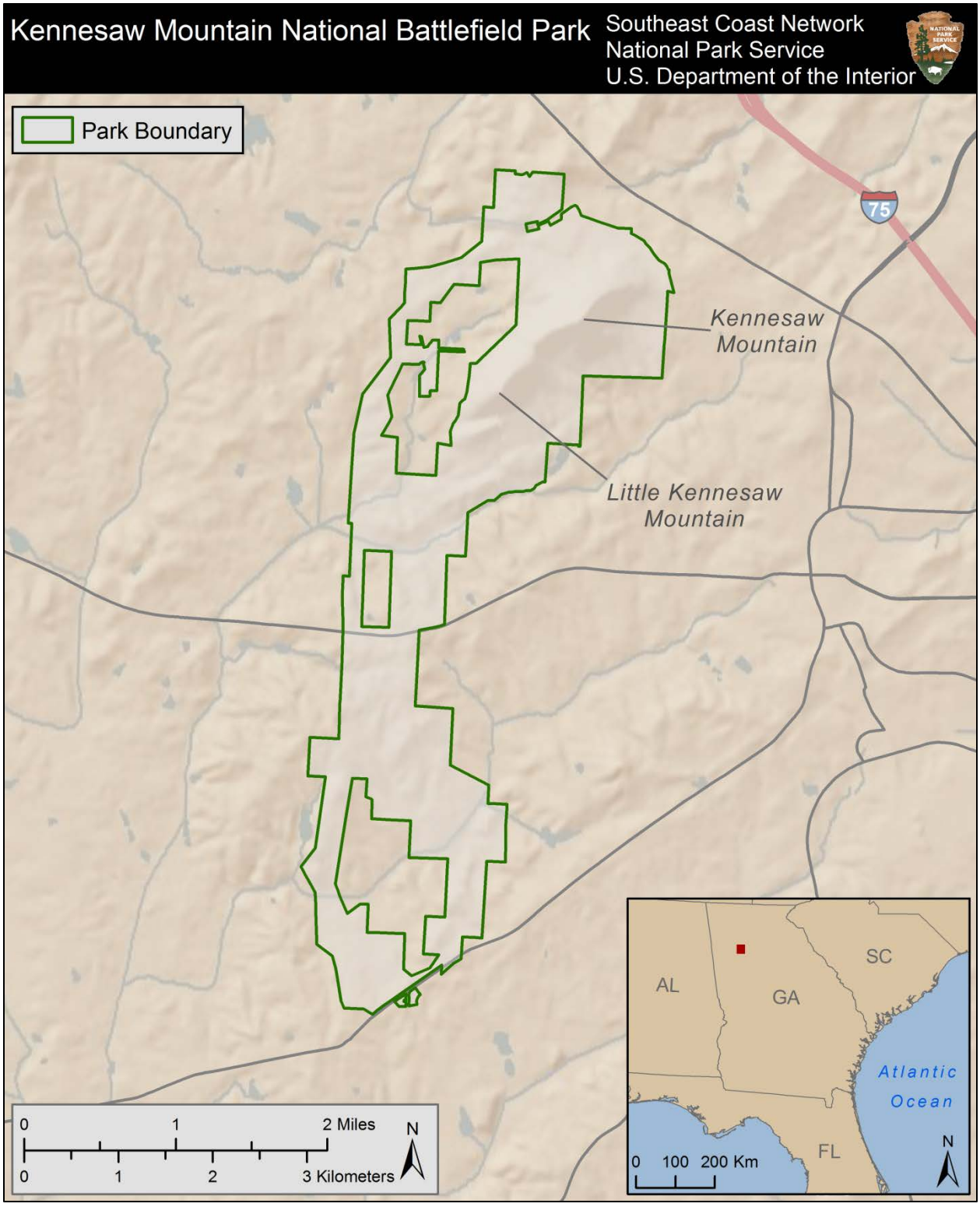


Figure 1. Location of Kennesaw Mountain National Battlefield Park.

Environmental Setting During Sampling Event

Climatologically, the Southeastern U.S. experienced unusually warm average temperatures throughout the winter and spring (January to May, 2012), and near normal or slightly cooler than average summer and fall temperatures (Wright 2013). Total annual precipitation averaged below normal across the southeastern states in 2012, although Florida and Alabama experienced near normal levels. North Carolina and South Carolina had below normal precipitation, while Georgia averaged well below normal annual precipitation (Wright 2013).

Based on data collected from the Atlanta Hartsfield International Airport and the Dallas 7 NE weather stations, mean monthly temperatures were above average at KEMO during much of the SECN amphibian monitoring time frame of March through early June, 2012 (Figure 2) (Wright 2013). March recorded the largest departure from normal temperatures, although the maximum and minimum temperatures were not outside the range of the 30-year average. The average maximum high temperature was 80.1°F, with maximum high temperatures ranging from 74.0°F to 87.1°F. The average minimum temperature was 58.2°F, with minimum lows ranging from 49.6°F to 67.8°F during the sampling period.

Precipitation levels averaged below normal during the 2012 SECN sampling period at KEMO (March through early June), with April showing the largest departure from average precipitation levels (Figure 3). Average precipitation in April was well below the 25th percentile for the 30-year average, as was February, just prior to the commencement of the sampling effort. Total yearly precipitation at KEMO averaged 38.83 inches, which is 12.52 inches below normal (Wright 2013).

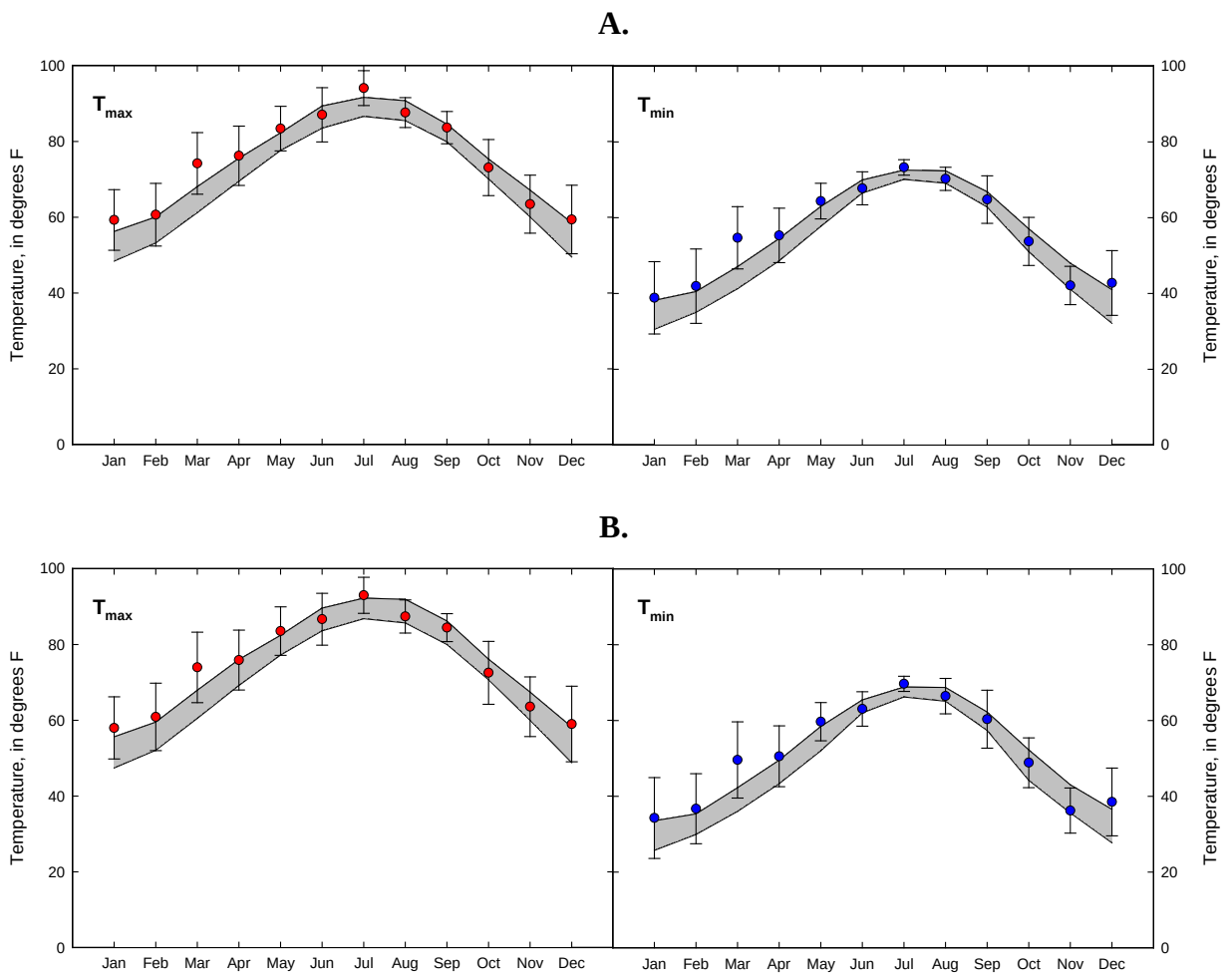
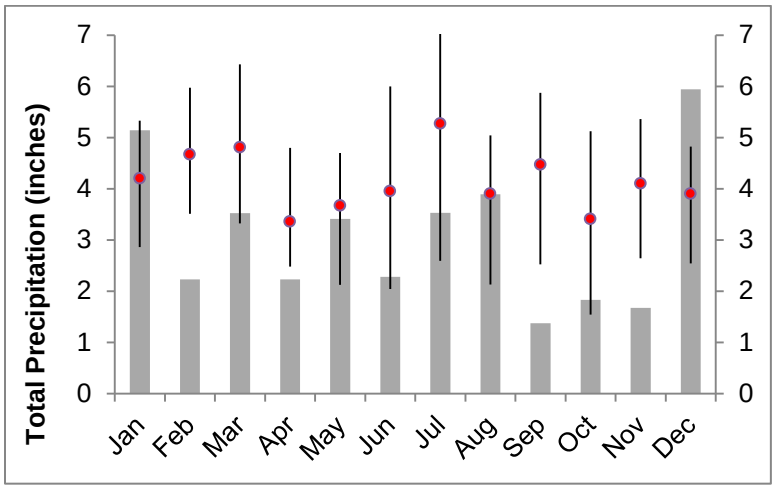


Figure 2. 2012 average monthly temperature and the 30-year (1981 – 2010) average for A. Atlanta Hartsfield International Airport and B Dallas 7 NE weather stations. Units = °F. Points indicate the 2012 average monthly maximum and minimum temperatures. Error bars indicate +/- standard deviation. The dual solid lines bound the standard deviation around the 30-year (1981-2010) mean monthly temperature.

A.



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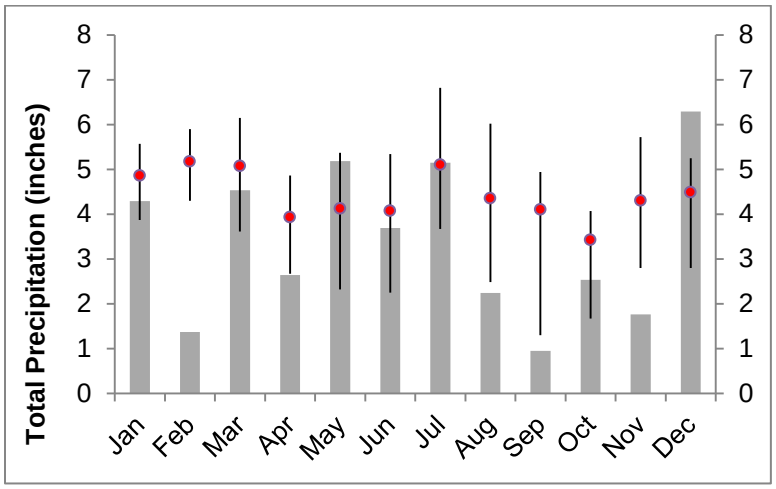

Figure 3. Total monthly precipitation during 2012 and the 30-year (1981 - 2010) monthly averages for A. Atlanta Hartsfield International Airport and B. Dallas 7 NE weather stations. The gray columns represent 2012 total monthly precipitation. The red circles represent the 30-year average; the lines indicate the 25th and 75th percentile of the 30-year normal data for each month.

At the time when visual encounter surveys were conducted (4/17/2012 to 5/3/2012), conditions were very dry with no measureable precipitation observed and soil moisture averaging approximately 1% (Table 1).

Table 1. Environmental Variables during visual encounter surveys conducted at Kennesaw Mountain National Battlefield Park, 2012. 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 (%)	75.78	17.00	
Soil Moisture (%)	1.23	0.60	
Temperature (ºF)	66.61	9.79	
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 2012 are also presented below.

Methods

Sampling Design

To allow for park-wide inference, the KEMO 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 2012, 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).

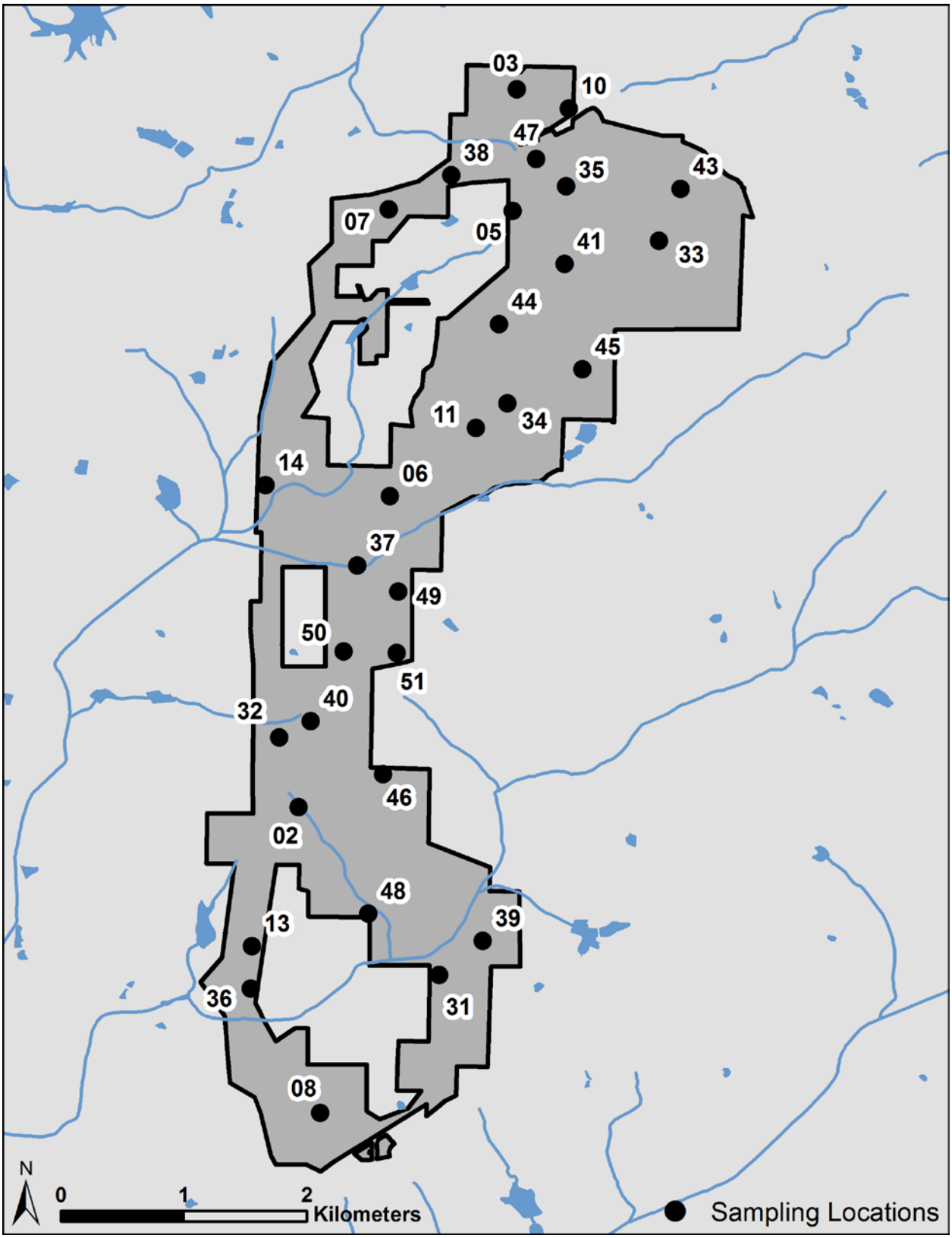

Figure 4. Spatially-balanced random sampling locations at Kennesaw Mountain National Battlefield Park, 2012.

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 18:00 (6:00 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.

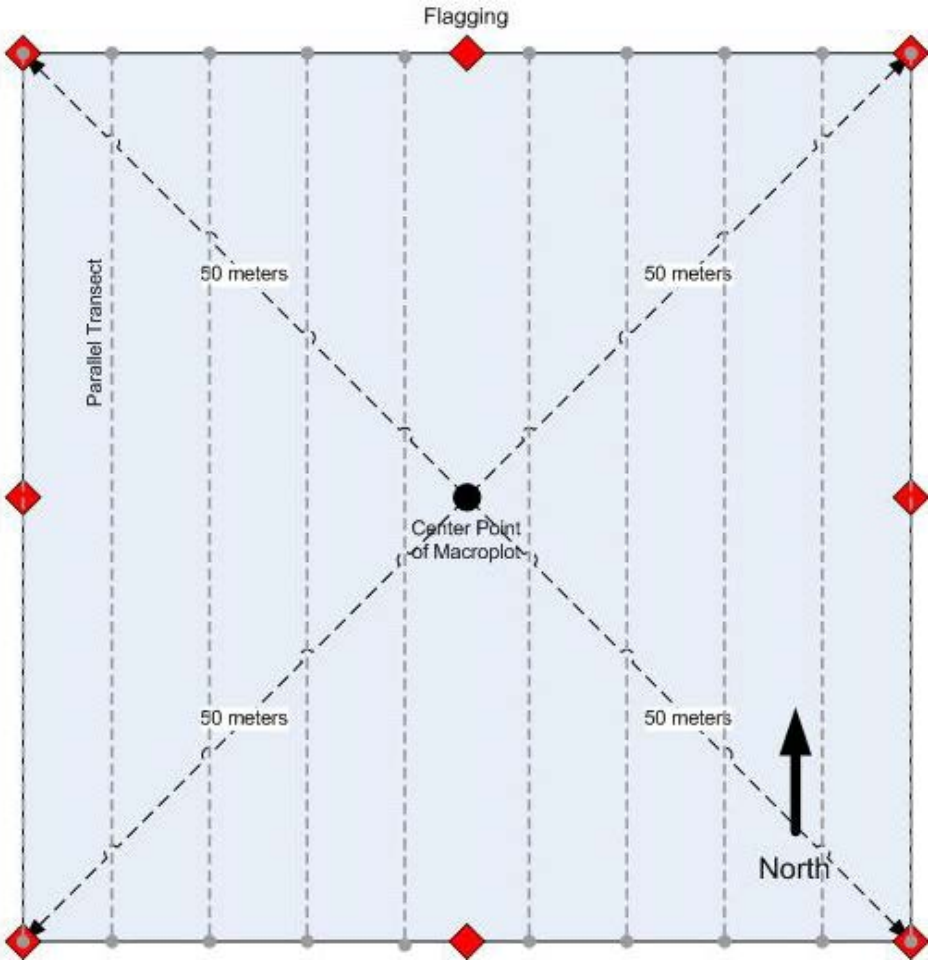

Figure 5. Macroplot (0.5-ha) layout for amphibian community monitoring in Southeast Coast Network parks. Visual encounter surveys (VESs) occur along parallel transects within the macroplot; Automated recording devices (ARDs) are deployed for 77 days at or near the center point of the macroplot.

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 3/20/2012 through 6/7/2012. A total of 22,211.5 minutes was recorded by all of the devices deployed at Kennesaw Mountain National Battlefield Park. The ARD malfunctioned or was damaged in a storm and recorded only partial data at four sampling locations (7, 13, 34 and 36).

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 Kennesaw Mountain National Battlefield Park from 4/17/2012 to 5/3/2012.

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 are, however identified to most refined taxonomic level possible. For example, while the surveyors are approaching a small pool surrounded by dense vegetation they catch brief glimpses of and hear 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 site and the local fauna, a conservative estimation is used and these species are 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

While 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 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, the spotted and Northern dusky salamanders (*Desmognathus conanti* and *fuscus*) have been grouped, and the Northern and Southern cricket frogs (*Acris crepitans* or *gryllus*) have been grouped under *Acris* sp.

During 2012 monitoring activities, we detected 20 amphibian species at KEMO. Using ARDs we detected vocalizing anurans in six species (Table 2). During the VESs, we detected 203 post-metamorphic amphibians in 18 taxa (species or family) and 78 larval stage amphibians in five taxa (species or family) (Table A-3). Two anuran species accounted for over 85% of the vocalizations detected, while five species composed approximately 86% of the VES sample.

Slimy salamander (*Plethodon glutinosis*) detected at half of the sampling locations in Kennesaw Mountain National Battlefield Park, had the highest frequency of occurrence (naïve occupancy) of all amphibians detected during our 2012 surveying period (Table 2). Cope's gray treefrog (*Hyla chrysoscelis*), had the highest frequency of occurrence among anurans, with approximately 37% naïve occupancy at KEMO sampling locations.

Just six anuran species were detected using ARDs at KEMO in 2012. Cope's gray treefrog had the highest relative detection frequency of vocalizations recorded by ARDs over the 77-day sampling period, accounting for approximately 48% of all vocalizations (Figure 6). Spring peeper (*Pseudacris crucifer*) had the second highest relative vocalization detection frequency, composing nearly 38% of the vocalization detections.

Amphibian species diversity was high during visual encounter surveys, particularly among salamanders. Over 84% of the post-metamorphic amphibians detected during 2012 were salamanders representing nine different species. The spotted or Northern dusky salamander (*Desmognathus conanti* or *fuscus*) had the highest relative abundance of amphibian species during the VESs, accounting for one-third of all amphibians counted during sampling activities (Figure 7). The slimy salamander, which composed 32% of the amphibian sample counted during VESs, had the next highest relative abundance at KEMO in 2012, followed by the Southern two-lined salamander with 11%. Cope's gray treefrog had the highest relative abundance among anurans during the VESs at nearly 7%.

Over one-quarter of all amphibian detections during VESs in 2012 were of larval-stage animals (Table A-3). Southern two-lined salamander larvae (*Eurycea cirrigera*) accounted for 51% of larval stage amphibian detections, while 24 % of the larval stage sample was composed of three-

lined salamander larvae (*Eurycea guttolineata*). The spotted or Northern dusky salamander accounted for 17% of the larval stage detections. No non-native amphibian species were detected at KEMO in 2012.

Table 2. Percentage of sampling locations where each amphibian species was detected (i.e., naïve occupancy) by method and across methods at Kennesaw Mountain National Battlefield Park, 2012.

	Detection Method		
Species	**All**	**VES**	**ARD**
Anura			
Cope's Gray Treefrog	36.7	*23.3*	*16.7*
Spring Peeper	10.0	*0.0*	*10.0*
Fowler's Toad	10.0	*6.7*	*3.3*
American Toad	6.7	*0.0*	*6.7*
Green Frog	6.7	*6.7*	*0.0*
Lithobates sp.	6.7	*6.7*	*NA*
Cricket Frog.	3.3	*3.3*	*0.0*
Green Treefrog	3.3	*3.3*	*0.0*
Southeastern (Upland) Chorus Frog	3.3	*0.0*	*3.3*
Bullfrog	3.3	*0.0*	*3.3*
Pickerel Frog	3.3	*3.3*	*0.0*
Southern Leopard Frog	3.3	*3.3*	*0.0*
Anura sp.	3.3	*3.3*	*NA*
Caudata			
Slimy Salamander	50.0	*50.0*	*NA*
Southern Two-lined Salamander	16.7	*16.7*	*NA*
Spotted/Northern Dusky Salamander	13.3	*13.3*	*NA*
Three-lined Salamander	13.3	*13.3*	*NA*
Marbled Salamander	10.0	*10.0*	*NA*
Red Salamander	6.7	*6.7*	*NA*
Spotted Salamander	3.3	*3.3*	*NA*
Seal Salamander	3.3	*3.3*	*NA*
Southern Red-backed Salamander	3.3	*3.3*	*NA*
Plethodontidae sp.	3.3	*3.3*	*NA*
Total Locations Surveyed	**30**	**30**	**30**

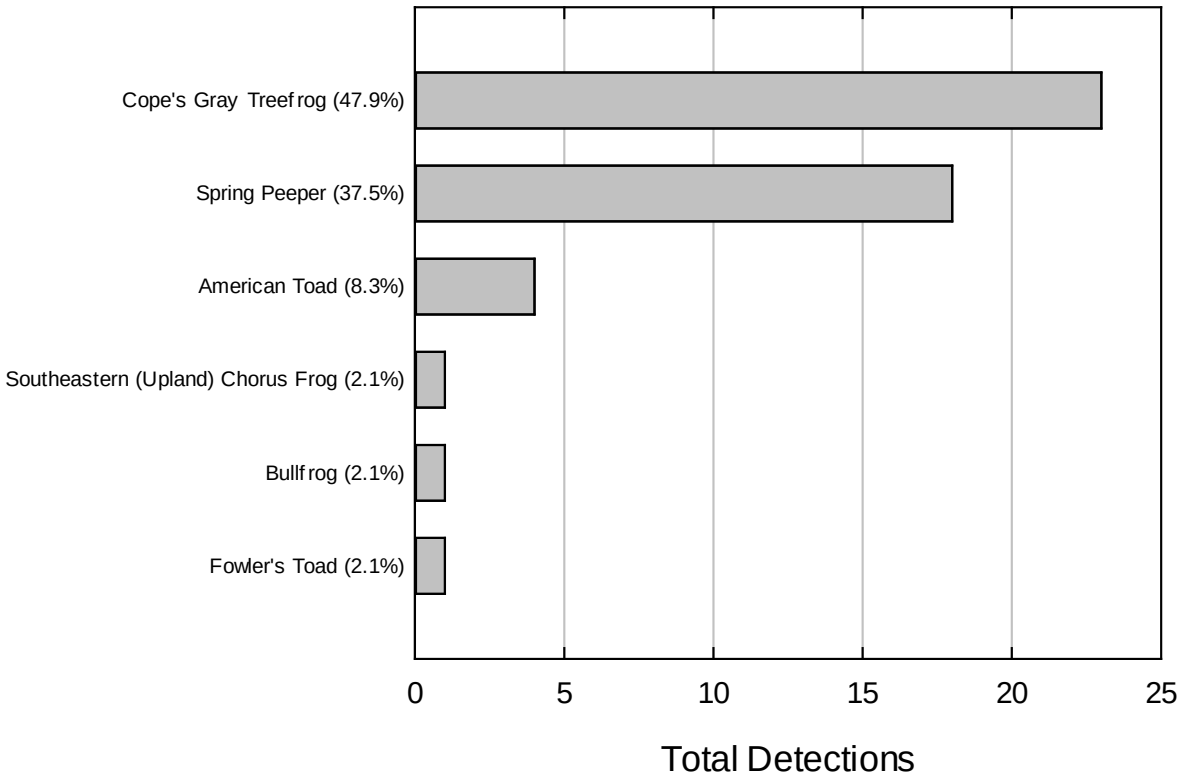

Figure 6. Number of anuran vocalization detections and the percent relative detection frequency (i.e., number of species vocalizations compared to all species' vocalizations) of recorded calls during automated recording device (ARD) deployment (20 March to 7 June 2012) at Kennesaw Mountain National Battlefield Park. Based on n=48 detections.

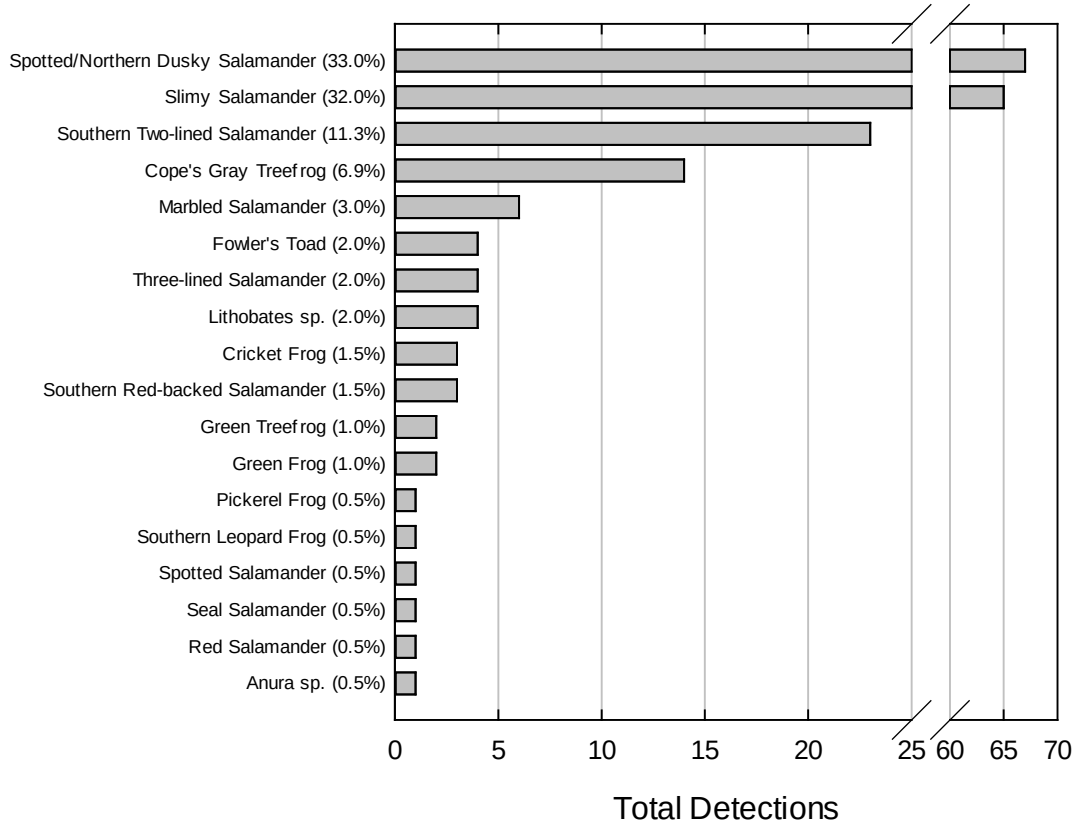

Figure 7. Number of individual amphibians detected and the relative abundance (as a percentage) of each species in the sample of post-metamorphic amphibians detected during visual encounter surveys at Kennesaw Mountain National Battlefield Park, 2012. Based on n=203 detections.

New Species Records

All amphibian species detected during the monitoring event were previously known to occur at Kennesaw Mountain National Battlefield Park.

Amphibian Distribution

The slimy salamander was the most widely distributed amphibian species at KEMO in 2012, and was found at sampling locations throughout the north-south expanse of the park (Table 2, Appendix B). Cope's gray treefrog, also distributed throughout the north-south expanse of the park, although at fewer sampling locations than the slimy salamander, had the widest distribution among anurans. The narrowest distributions were found for the Southern cricket frog, green treefrog (*Hyla cinerea*), Southeastern (upland) chorus frog (*Pseudacris feriarum*), bullfrog, pickerel frog, and Southern leopard frog (*Lithobates catesbeianus*, *L. palustris*, and *L. sphenocephalus*), as well as the spotted, seal, and Southern red-backed salamanders (*Ambystoma maculatum*, *Desmognathus monticola*, and *Plethodon serratus*). Each of these species was detected at only one sampling location at KEMO. Distribution maps for all amphibians that were detected during the monitoring event are presented in Appendix B.

Vocalization Phenology

Of the anurans detected at Kennesaw Mountain National Battlefield Park using ARDs in 2012, two species would be appropriate candidates to determine trends in vocalization start dates, American toad and Cope's gray treefrog. 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 first vocal detection of the Cope's gray treefrog occurred on 4/2/2012 and the American toad was first detected on 5/13/2012. One species is an appropriate candidate for tracking end dates due to the timing of its typical vocalization window in the Southeast, which closes well before our recording schedule concludes. The spring peeper was last detected using ARDs on 5/13/2012 (Figure 8).

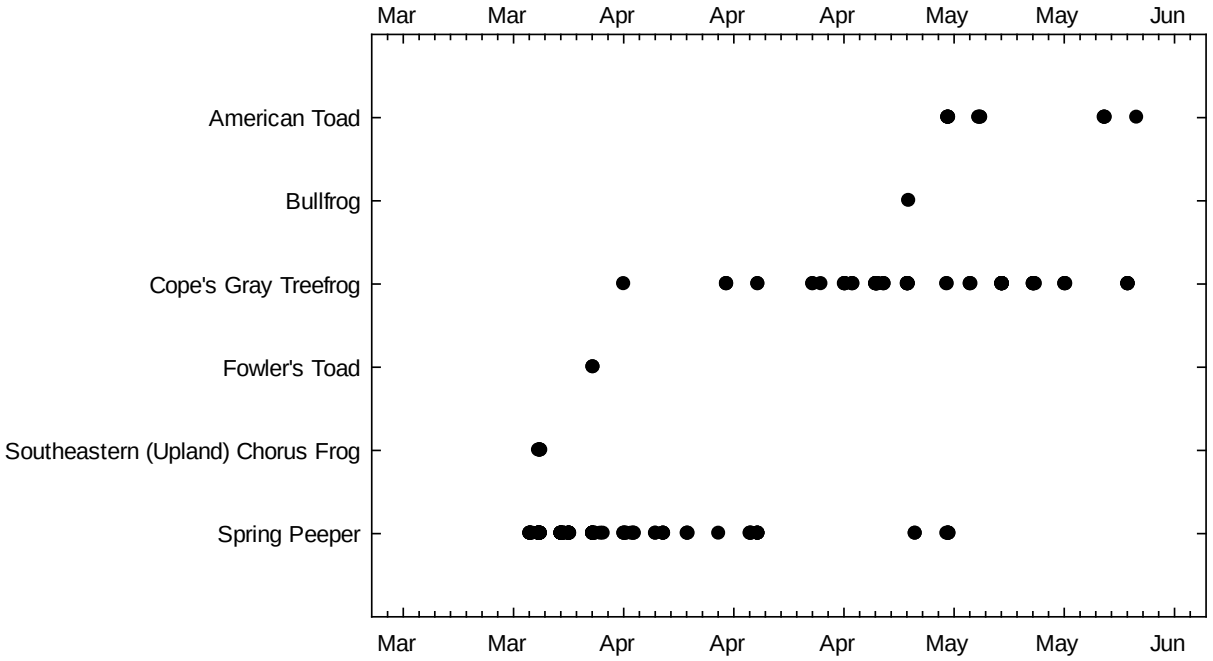

Figure 8. Vocalization phenology for species detected using automated recording devices (ARDs) at Kennesaw Mountain National Battlefield Park, from 20 March to 7 June 2012. Based on n=48 detections.

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Appendix A. Amphibian Species Detection Data

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

Scientific Name	Common Name	NPSpecies	ARD	VES
Anaxyrus americanus	American Toad	X	X	
Anaxyrus fowleri	Fowler's Toad	X	X	X
Acris crepitans/gryllus	Cricket Frog	X		X
Hyla chrysoscelis	Cope's Gray Treefrog	X	X	X
Hyla cinerea	Green Treefrog	X		X
Hyla versicolor	Gray Treefrog	X		
Pseudacris crucifer	Spring Peeper	X	X	
Pseudacris feriarum	Southeastern (Upland) Chorus Frog	X	X	
Lithobates catesbeianus	Bullfrog	X	X	
Lithobates clamitans	Green Frog	X		X
Lithobates palustris	Pickerel Frog	X		X
Lithobates sphenocephalus	Southern Leopard Frog	X		X
Ambystoma maculatum	Spotted Salamander	X		X
Ambystoma opacum	Marbled Salamander	X		X
Desmognathus conanti	Spotted Dusky Salamander	X		X
Desmognathus fuscus	Northern Dusky Salamander	X		X
Desmognathus monticola	Seal Salamander	X		X
Eurycea cirrigera	Southern Two-lined Salamander	X		X
Eurycea guttolineata	Three-lined Salamander	X		X
Gyrinophilus porphyriticus	Spring Salamander	X		
Plethodon glutinosus	Slimy Salamander	X		X
Plethodon serratus	Southern Red-backed Salamander	X		X
Plethodon websteri	Southern Zig-zag Salamander	X		
Pseudotriton ruber	Red Salamander	X		X

Table A-2. Amphibian species or species sign detected at each sampling location at Kennesaw Mountain National Battlefield Park, 2012.

	Sampling Location																												
Species	**2**	**3**	**5**	**6**	**7**	**8**	**10**	**11**	**13**	**14**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**
American Toad									X											X										
Fowler's Toad														X									X	X						
Cricket Frog						X																								
Cope's Gray Treefrog	X		X			X				X							X		X				X		X		X	X		X
Green Treefrog																											X			
Spring Peeper										X						X			X											
Southeastern (Upland) Chorus Frog											X																			
Bullfrog																							X							
Green Frog						X																				X				
Pickerel Frog	X																													
Southern Leopard Frog																	X													
Lithobates sp.	X																										X			
Anura sp.						X																								
Spotted Salamander										X																				
Marbled Salamander										X	X								X											
Spotted or Northern Dusky Salamander	X					X										X											X			
Seal Salamander	X																													
Southern Two-lined Salamander	X					X											X									X	X			
Three-lined Salamander	X					X										X	X													
Slimy Salamander	X	X		X	X	X		X		X	X				X		X		X			X			X		X			X
Southern Red-backed Salamander																						X								
Red Salamander	X					X																								
Plethodontidae sp.						X																								

Table A-3. Total number of larval and post-metamorphic detections of amphibian species during visual encounter surveys at Kennesaw Mountain National Battlefield Park, 2012.

	Species	Number of Post-Metamorphic Detections	Number of Larval Detections	Species Total Detections
Anura	Fowler's Toad	4	0	**4**
	Cricket Frog	3	0	**3**
	Cope's Gray Treefrog	14	0	**14**
	Green Treefrog	2	0	**2**
	Green Frog	2	0	**2**
	Pickerel Frog	1	0	**1**
	Southern Leopard Frog	1	0	**1**
	Lithobates sp.	4	0	**4**
	Anura sp.	1	0	**1**
Caudata	Spotted Salamander	1	0	**1**
	Marbled Salamander	6	0	**6**
	Spotted or Northern Dusky Salamander	67	13	**80**
	Seal Salamander	1	0	**1**
	Southern Two-lined Salamander	23	40	**63**
	Three-lined Salamander	4	19	**23**
	Slimy Salamander	65	0	**65**
	Southern Red-backed Salamander	3	0	**3**
	Red Salamander	1	3	**4**
	Plethodontidae species	0	3	**3**
	Total Detections	**203**	**78**	**281**

Appendix B. Distribution Maps for Amphibian Species Encountered

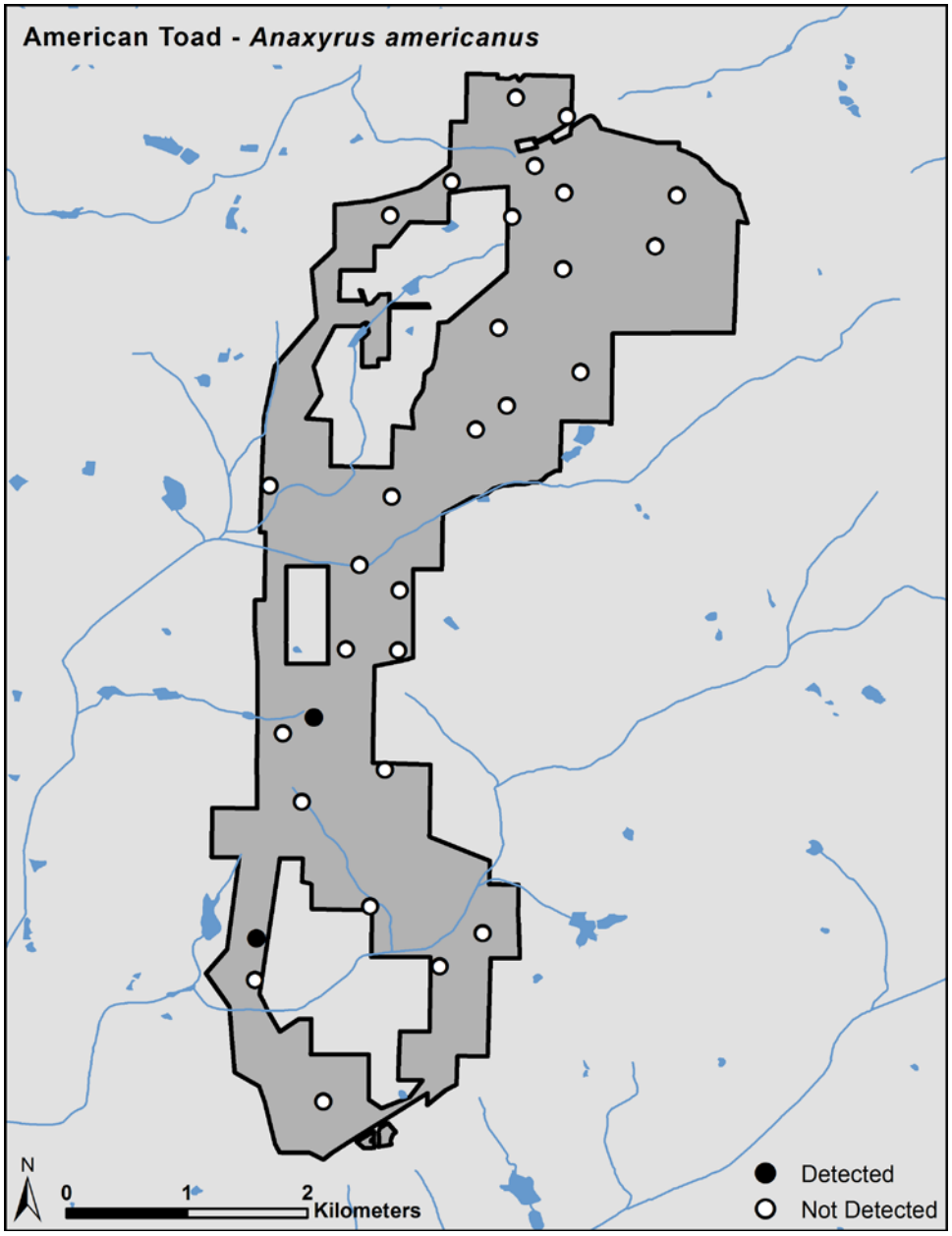

Figure B-1. Sampling locations where American Toad (*Anaxyrus americanus*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

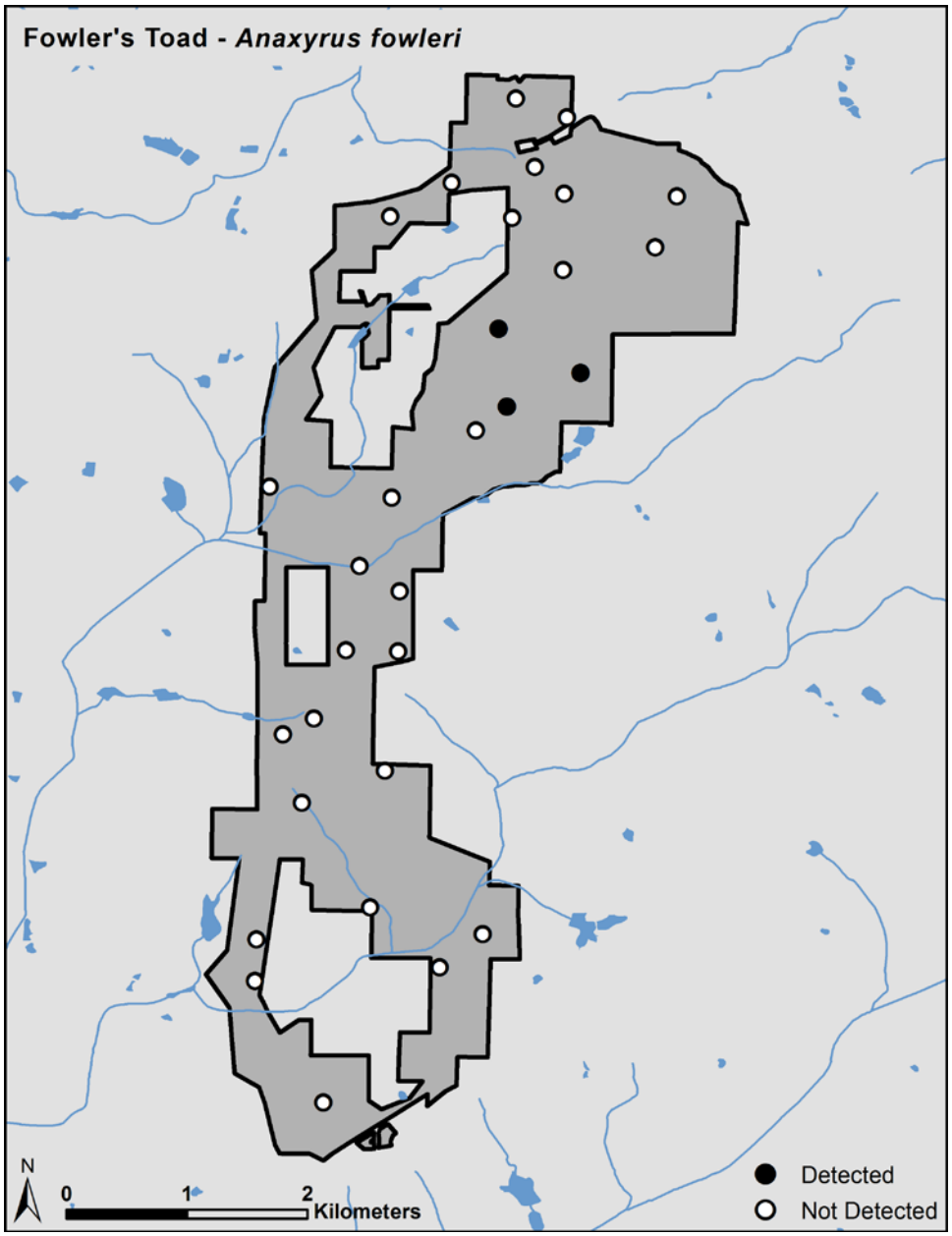

Figure B-2. Sampling locations where Fowler's Toad (*Anaxyrus fowleri*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

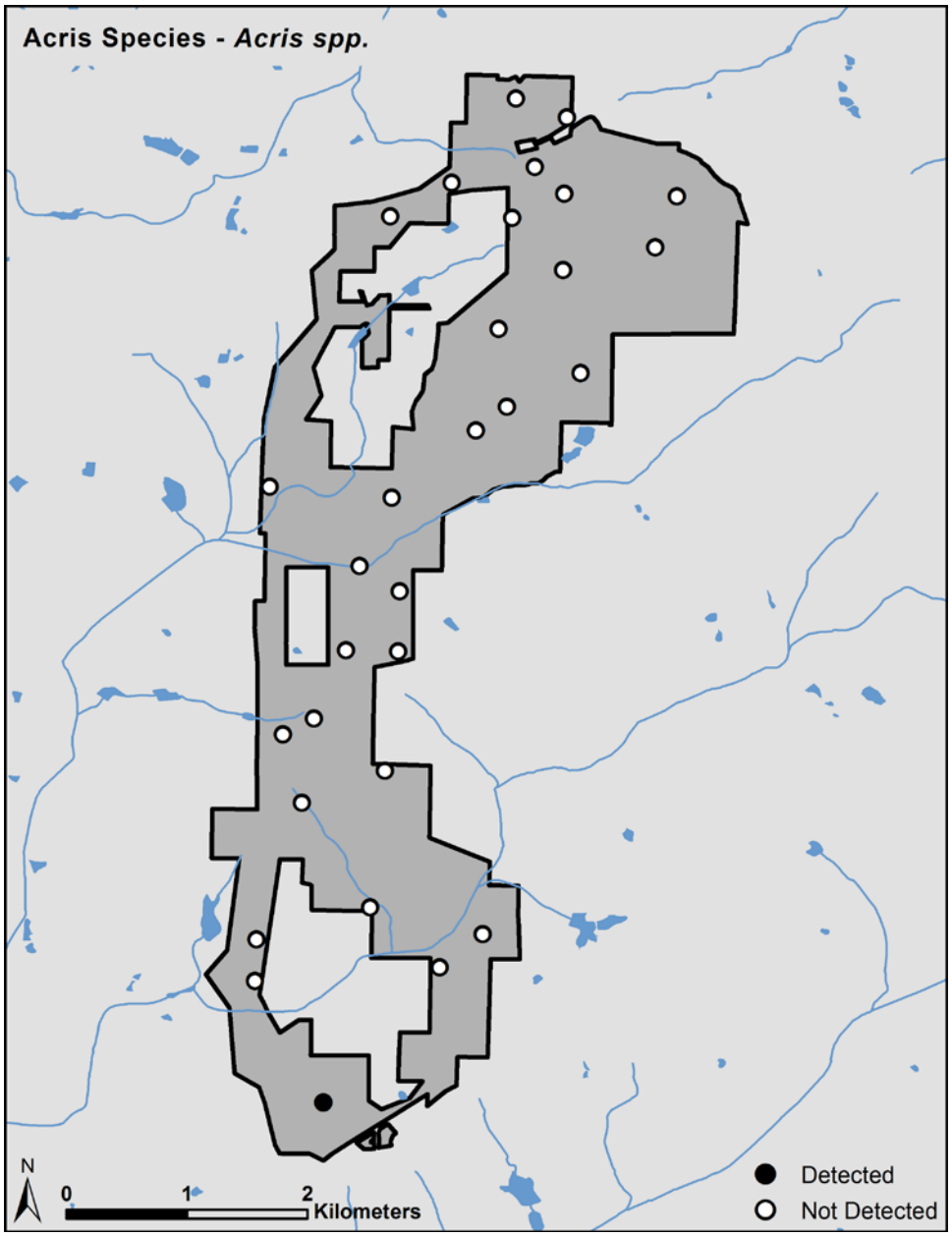

Figure B-3. Sampling location where Cricket Frog (*Acris crepitans* or *gryllus*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

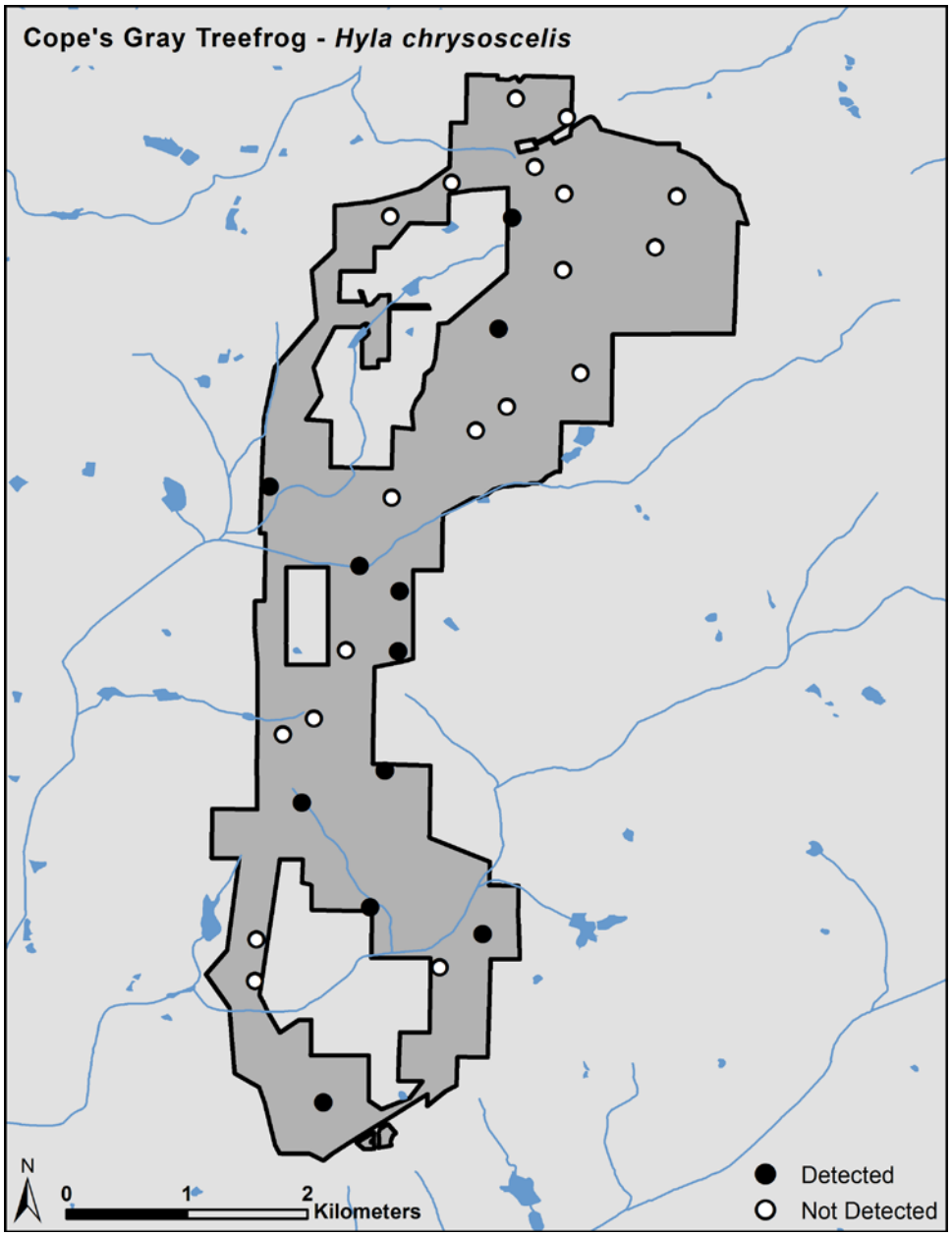

Figure B-4. Sampling locations where Cope's Gray Treefrog (*Hyla chrysoscelis*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

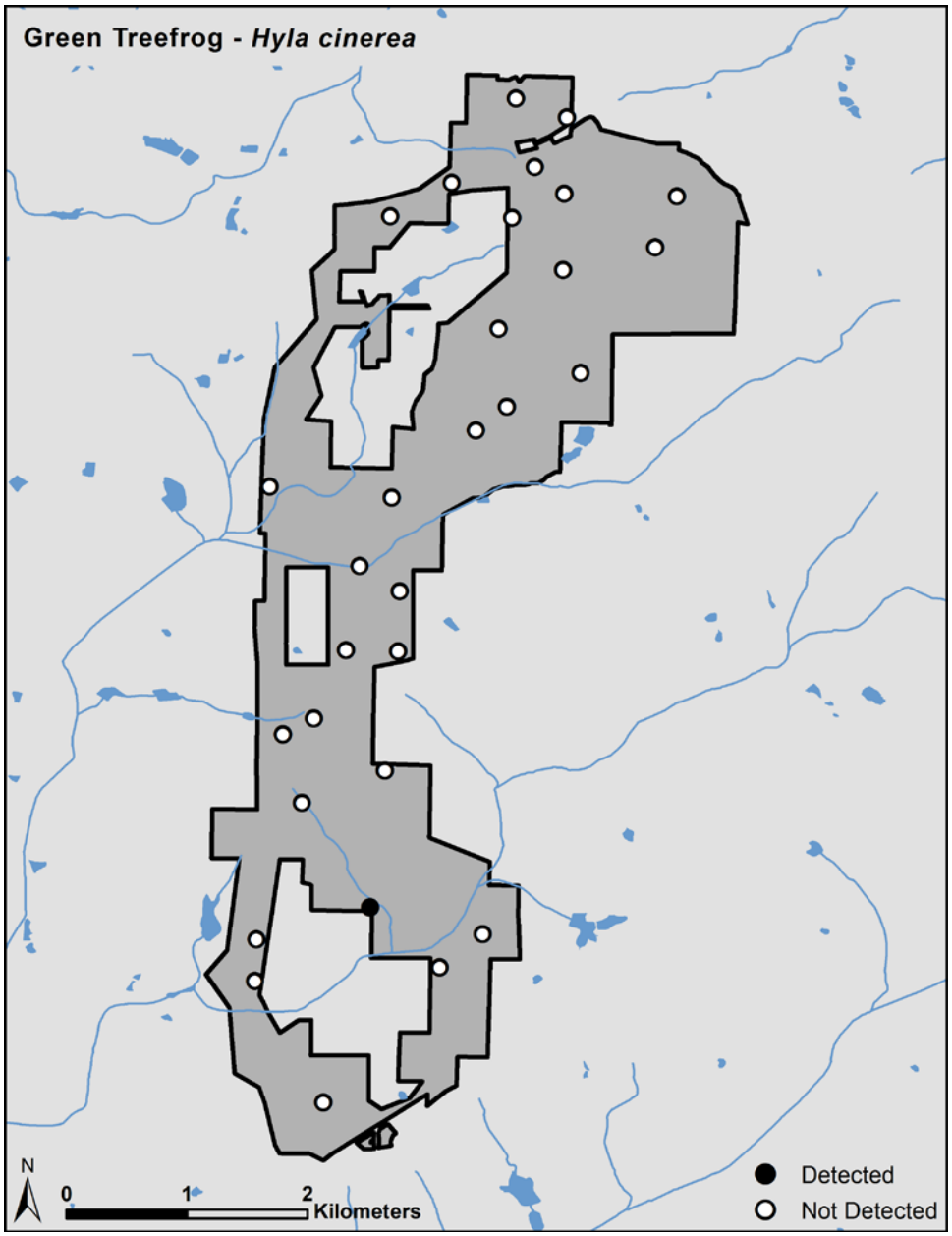

Figure B-5. Sampling location where Green Treefrog (Hyla cinerea) was detected at Kennesaw Mountain National Battlefield Park, 2012.

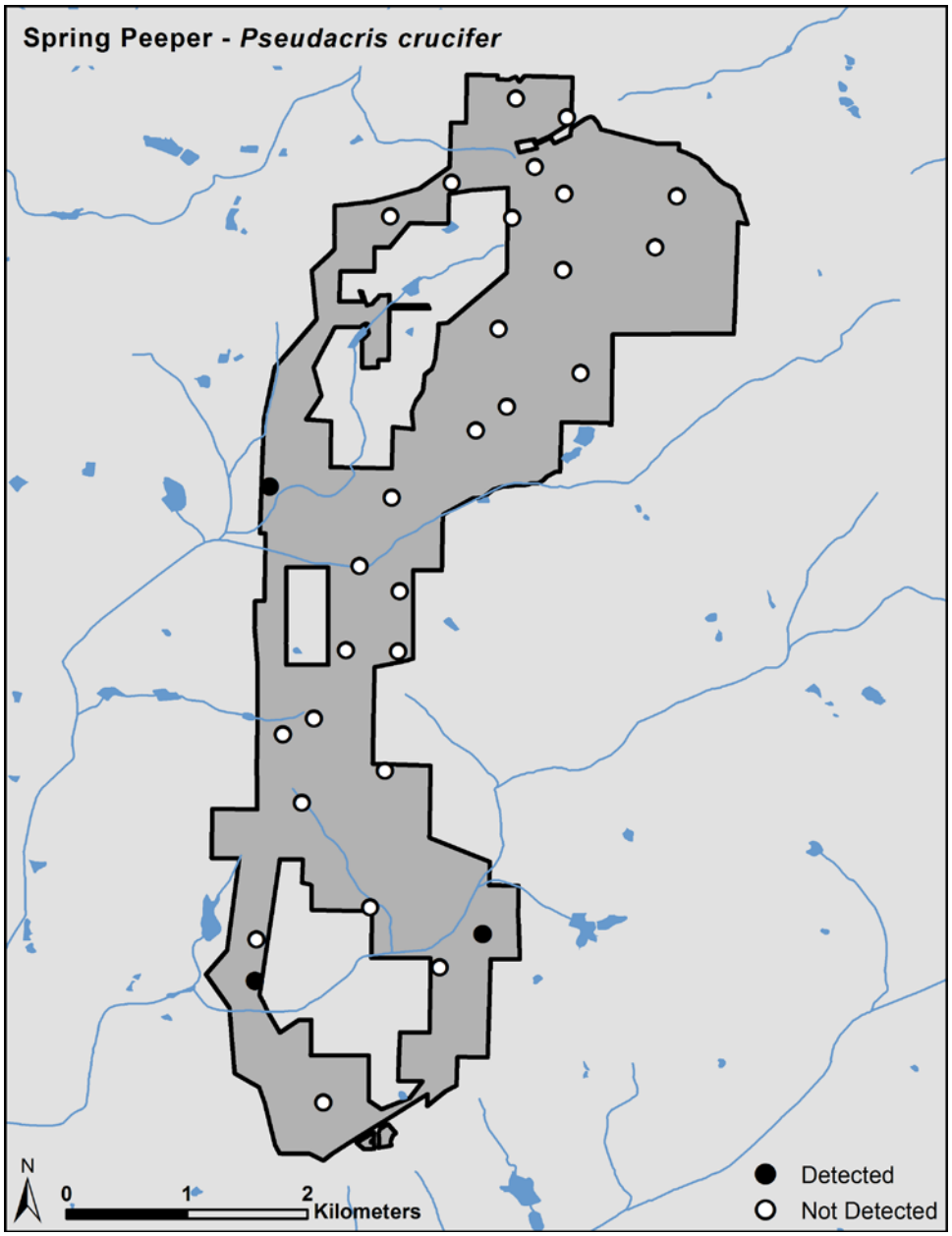

Figure B-6. Sampling locations where Spring Peeper (Pseudacris crucifer) was detected at Kennesaw Mountain National Battlefield Park, 2012.

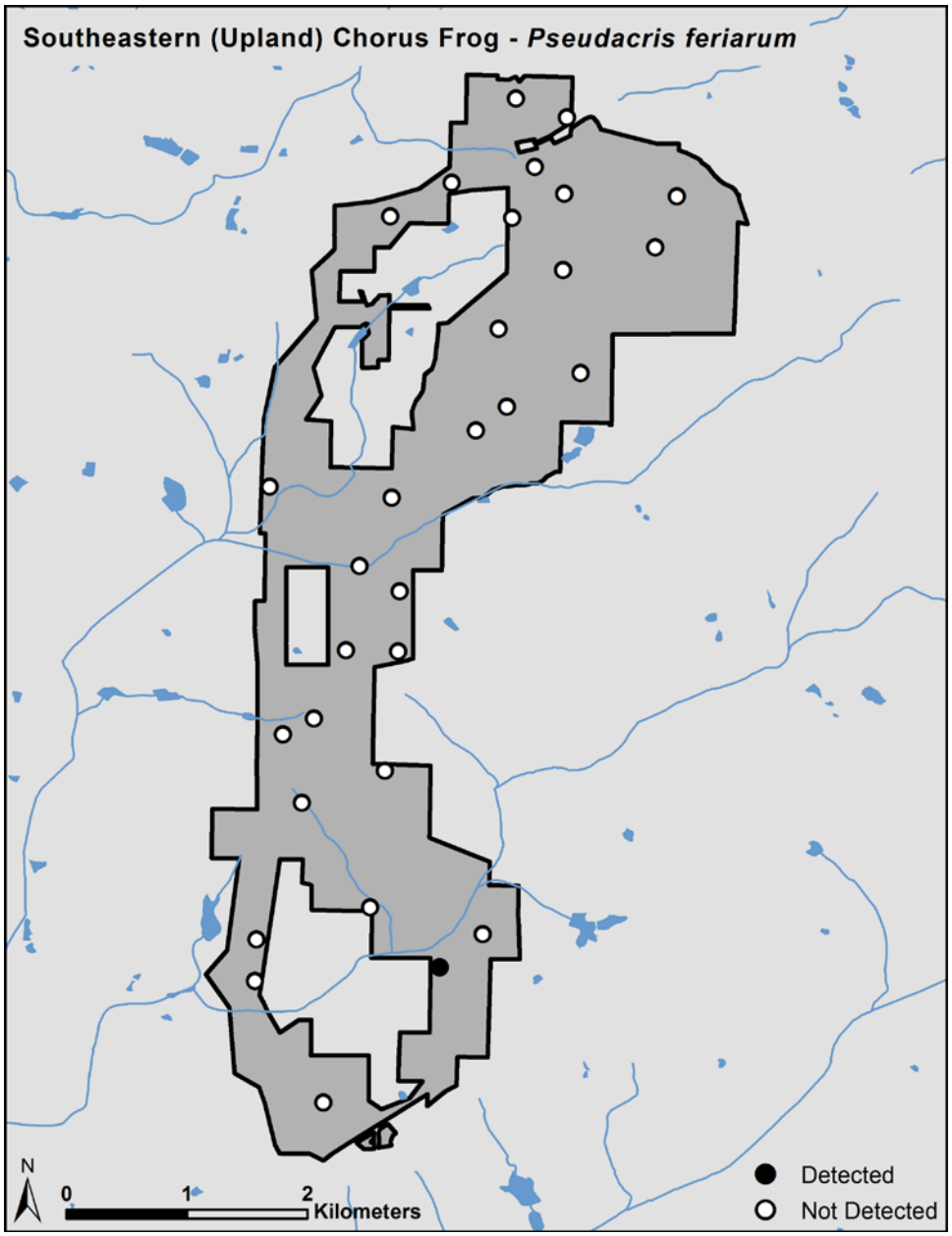

Figure B-7. Sampling location where little Southeastern (Upland) Chorus Frog (*Pseudacris feriarum*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

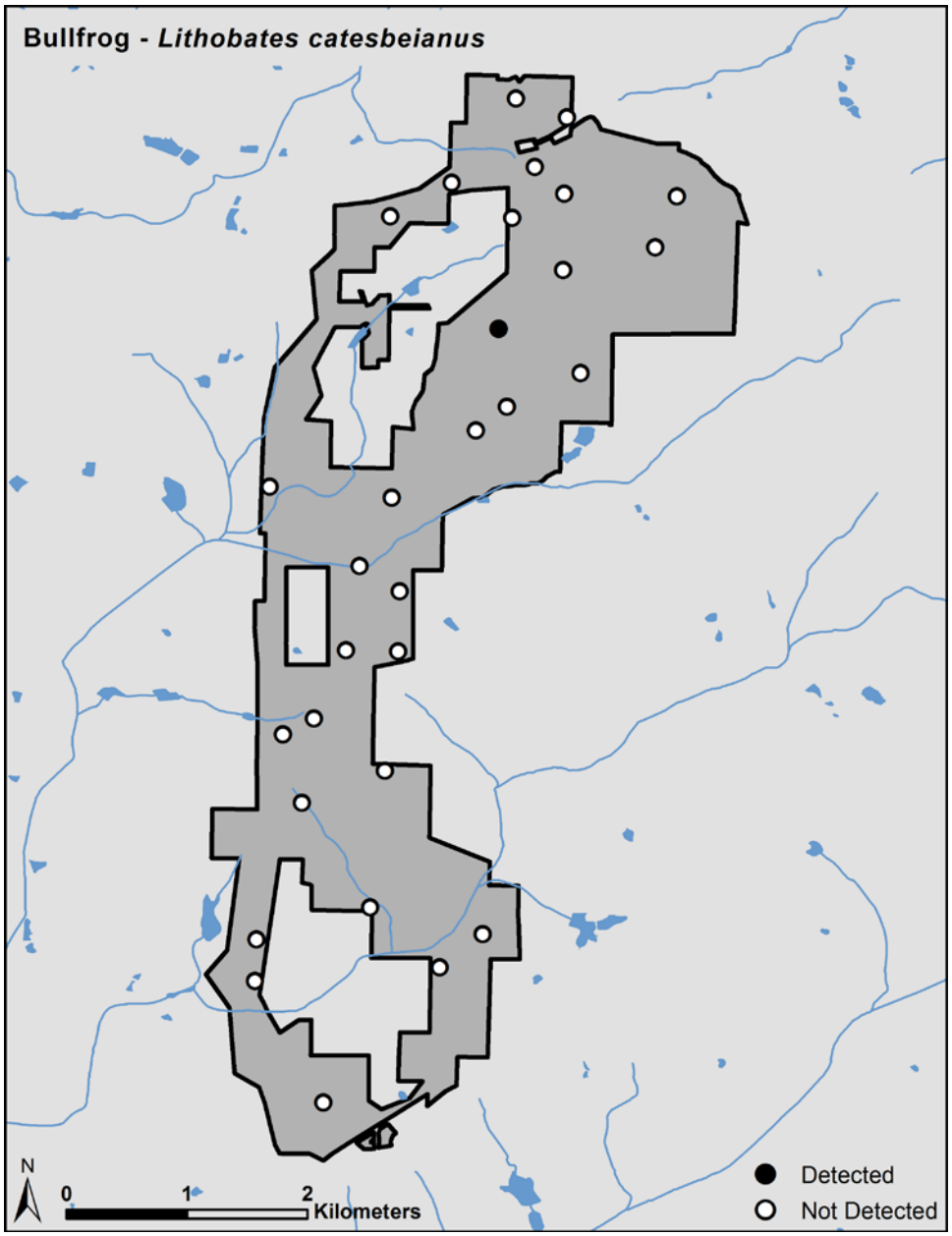

Figure B-8. Sampling location where Bullfrog (*Lithobates catesbeianus*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

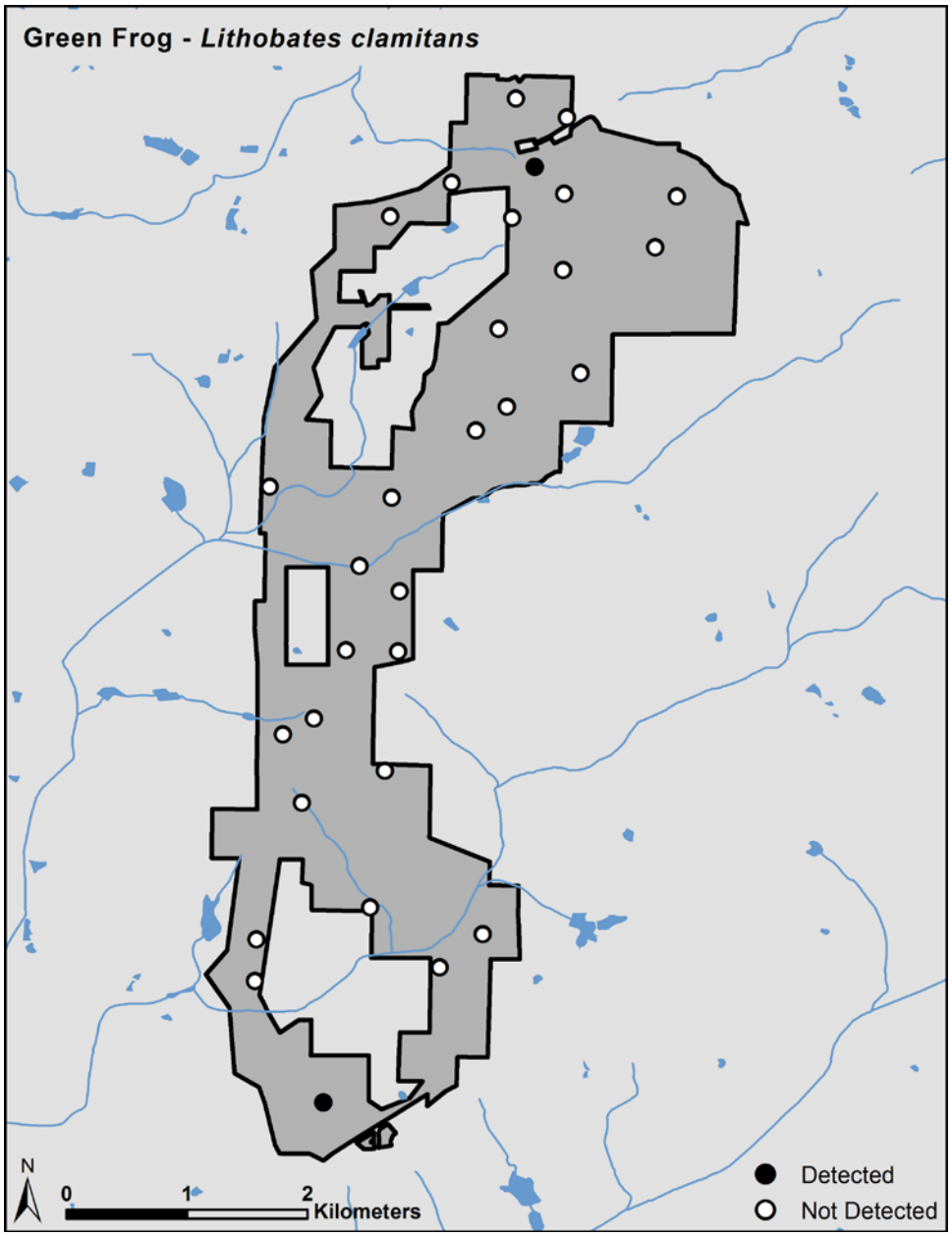

Figure B-9. Sampling locations where Green Frog (*Lithobates clamitans*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

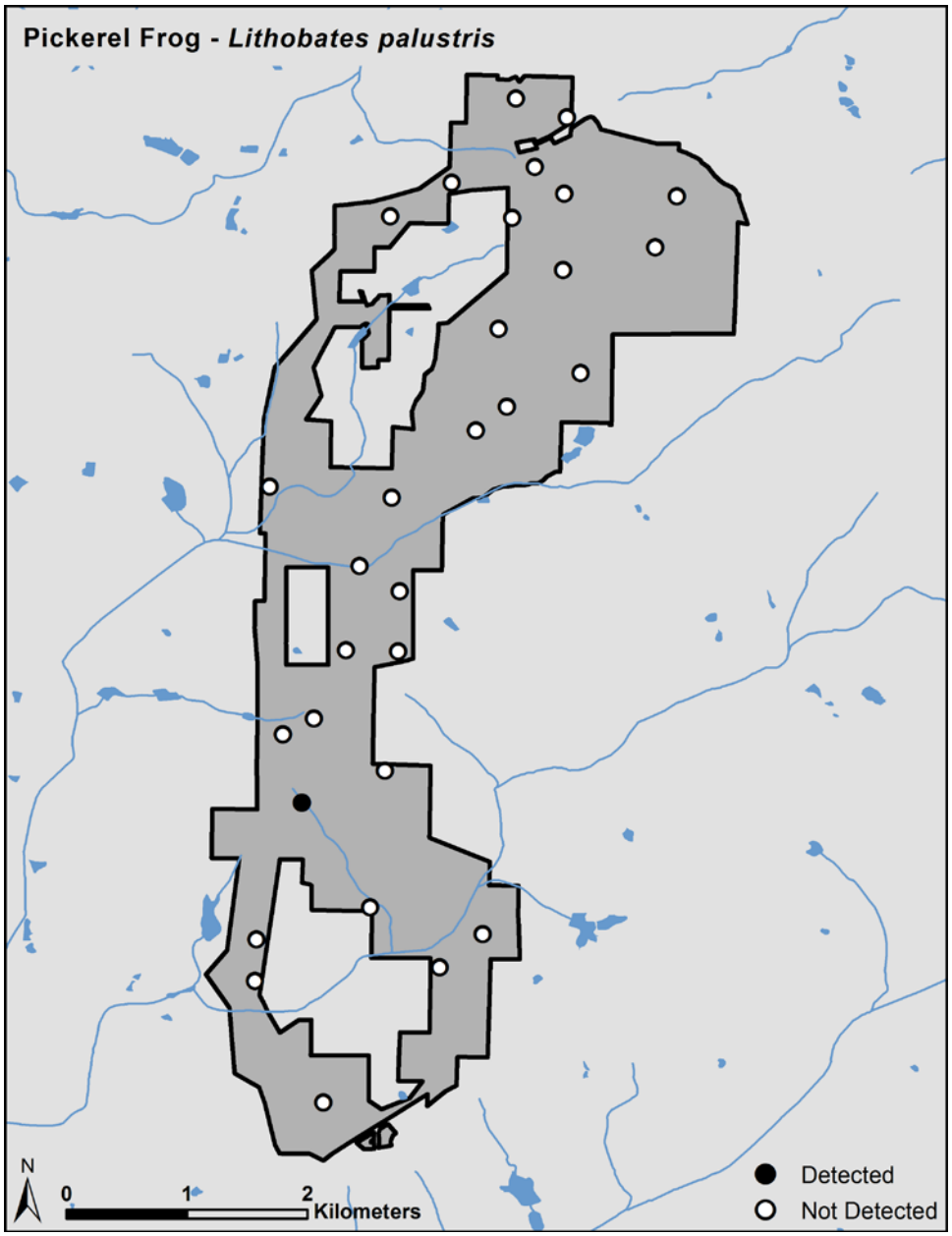

Figure B-10. Sampling location where Pickerel Frog (*Lithobates palustris*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

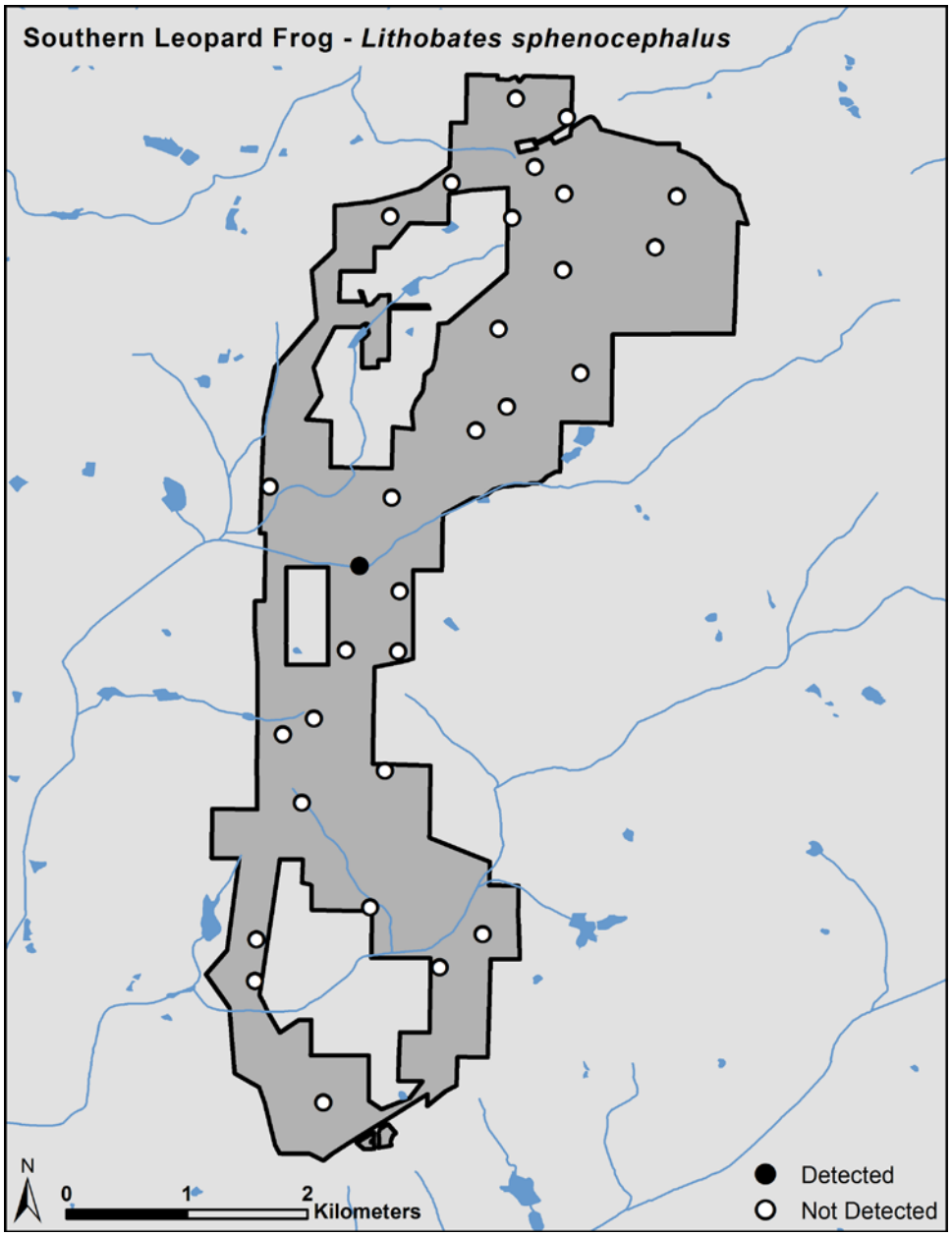

Figure B-11. Sampling location where Southern Leopard Frog (*Lithobates sphenocephalus*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

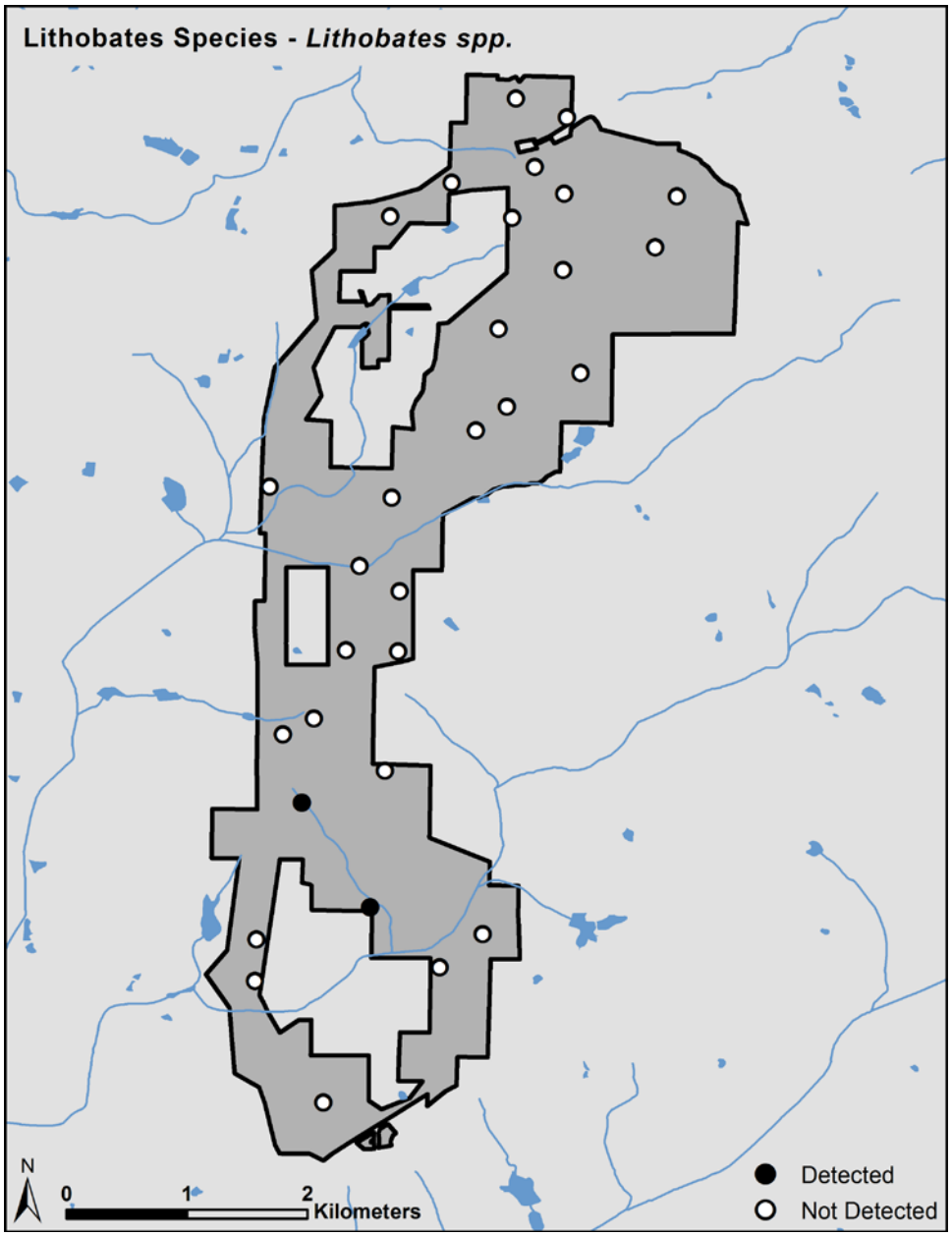

Figure B-12. Sampling locations where a *Lithobates* species (*Lithobates* sp.) was detected at Kennesaw Mountain National Battlefield Park, 2012.

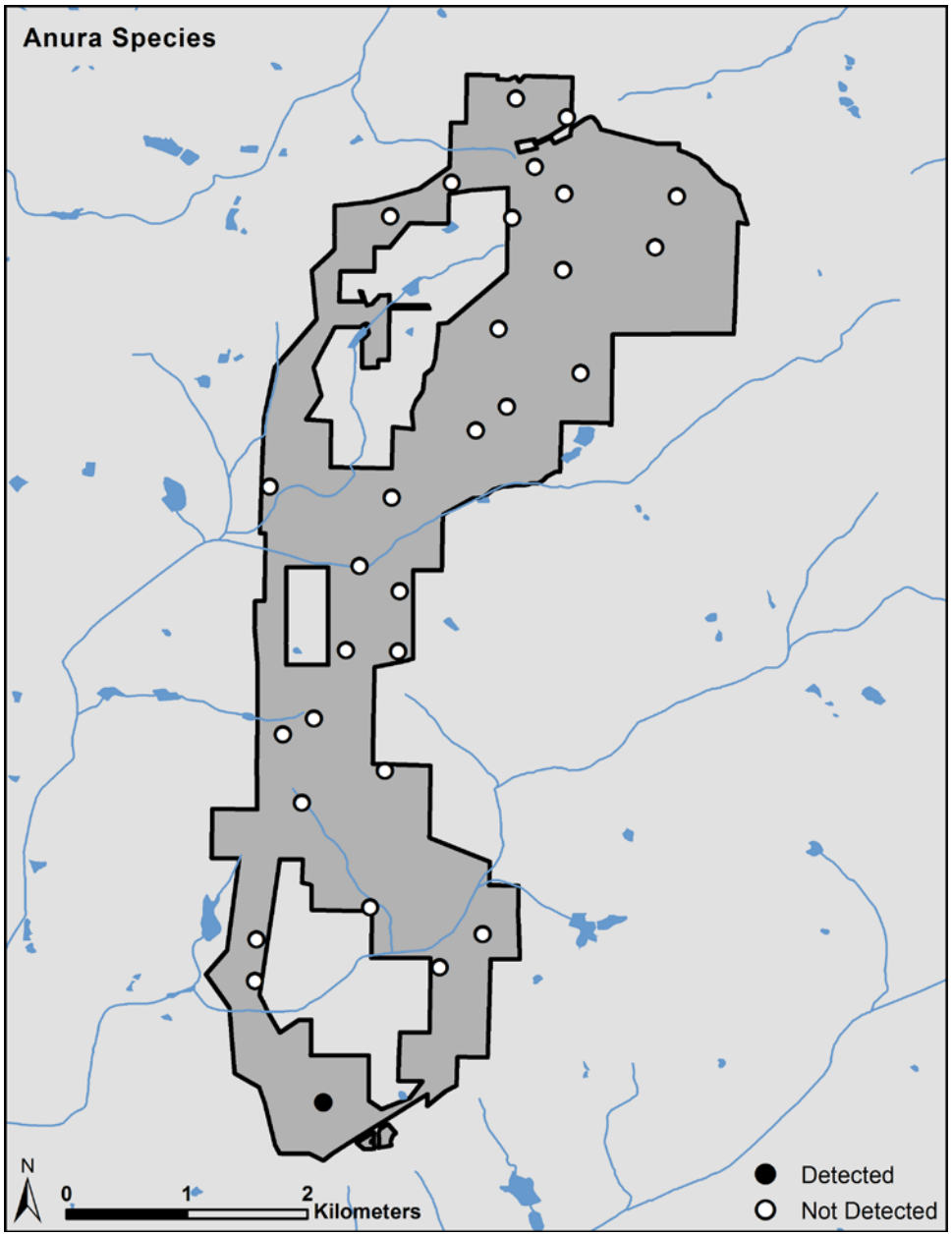

Figure B-13. Sampling location where a Frog species (*Anura* sp.) was detected at Kennesaw Mountain National Battlefield Park, 2012.

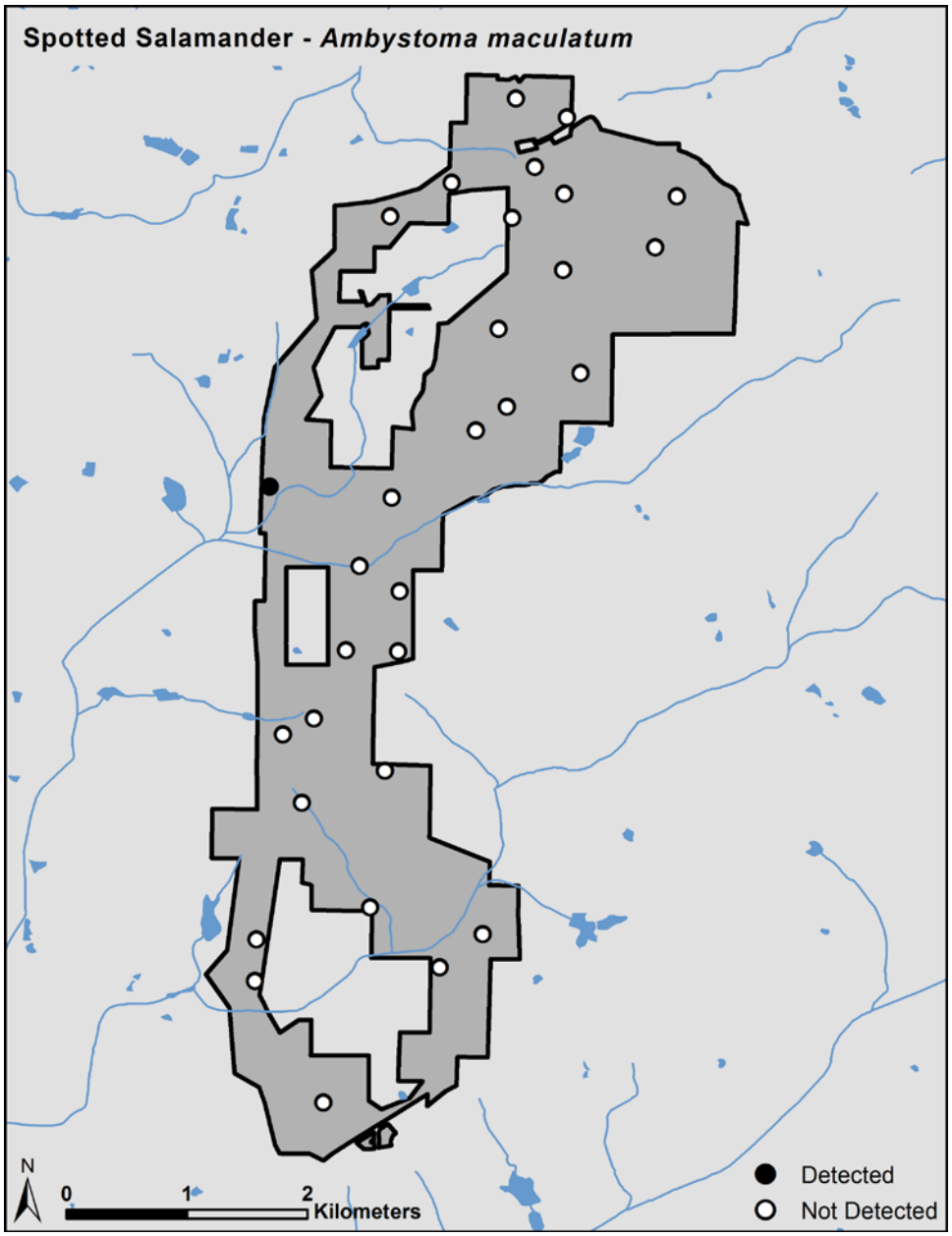

Figure B-14. Sampling location where Spotted Salamander (*Ambystoma maculatum*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

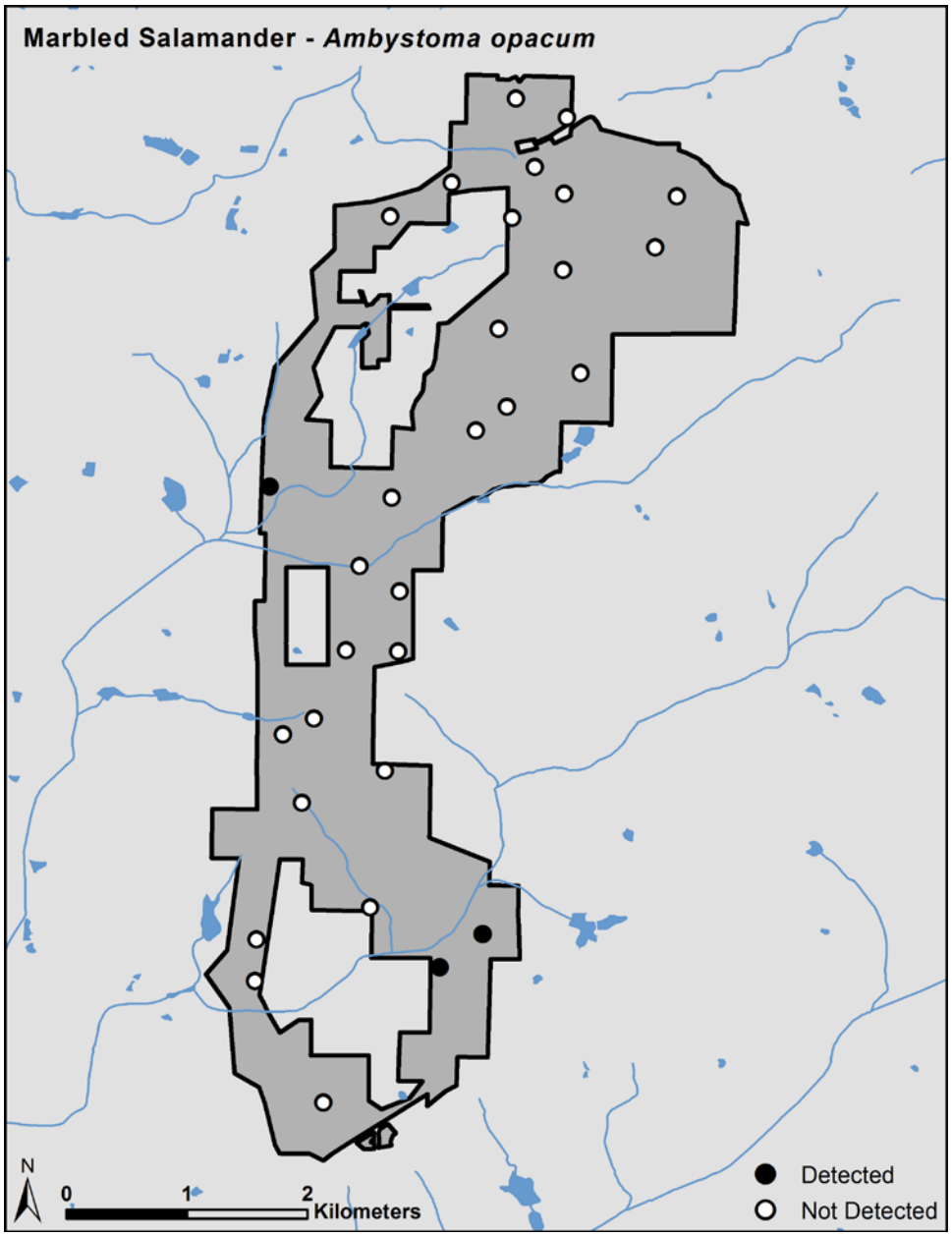

Figure B-15. Sampling locations where Marbled Salamander (*Ambystoma opacum*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

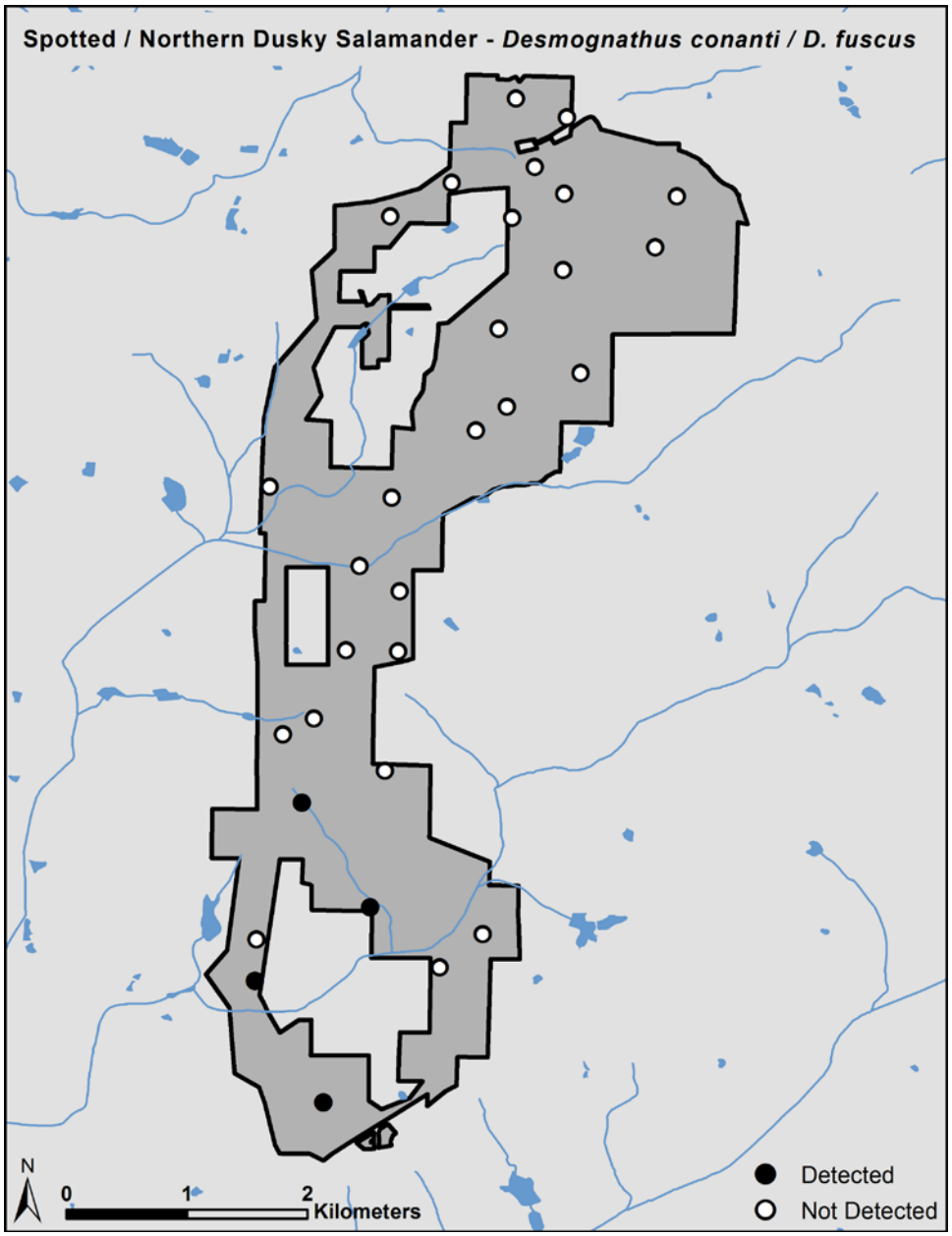

Figure B-16. Sampling locations where Spotted/ Northern Dusky Salamander (*Desmognathus conanti* or *fuscus*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

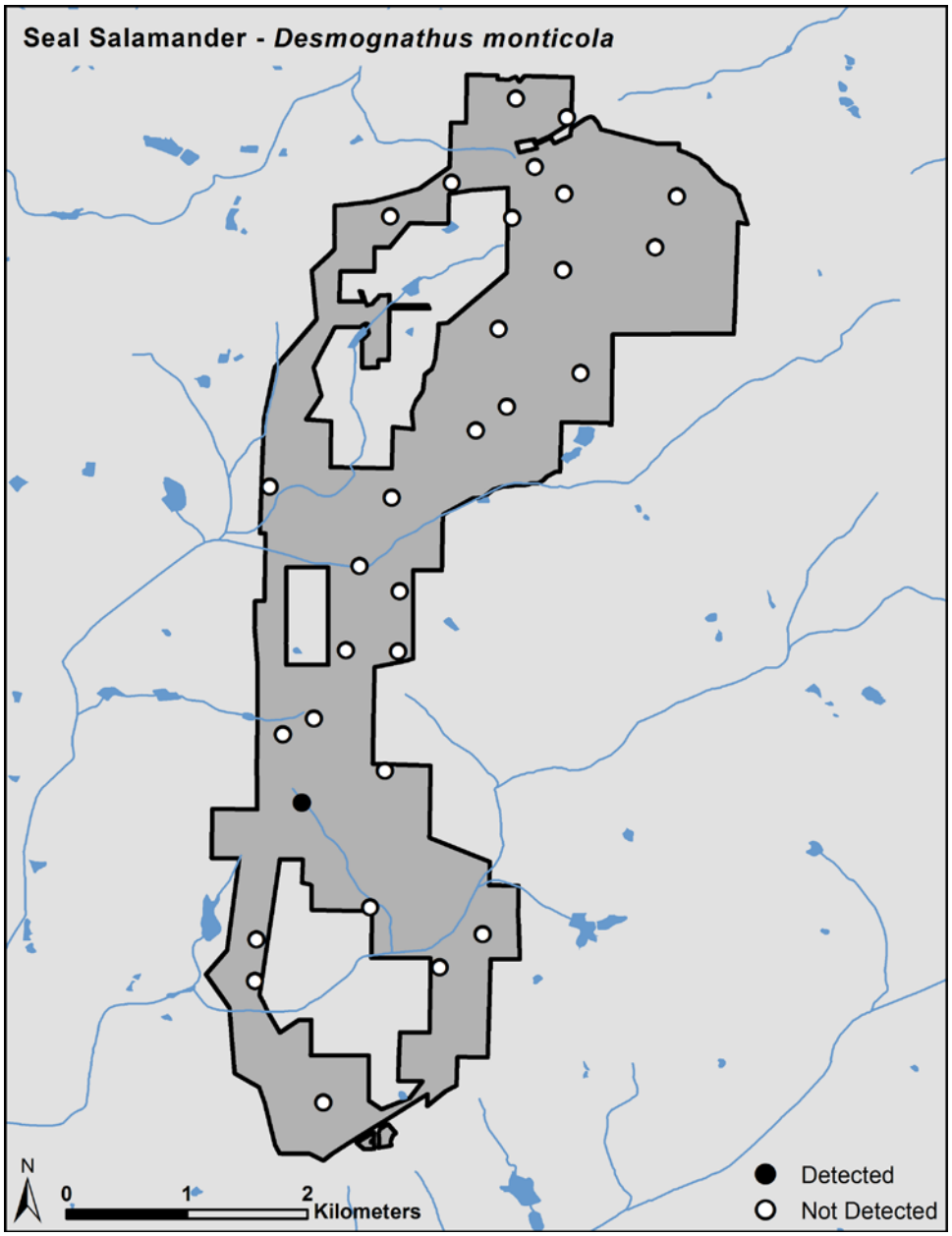

Figure B-17. Sampling location where Seal Salamander (*Desmognathus monticola*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

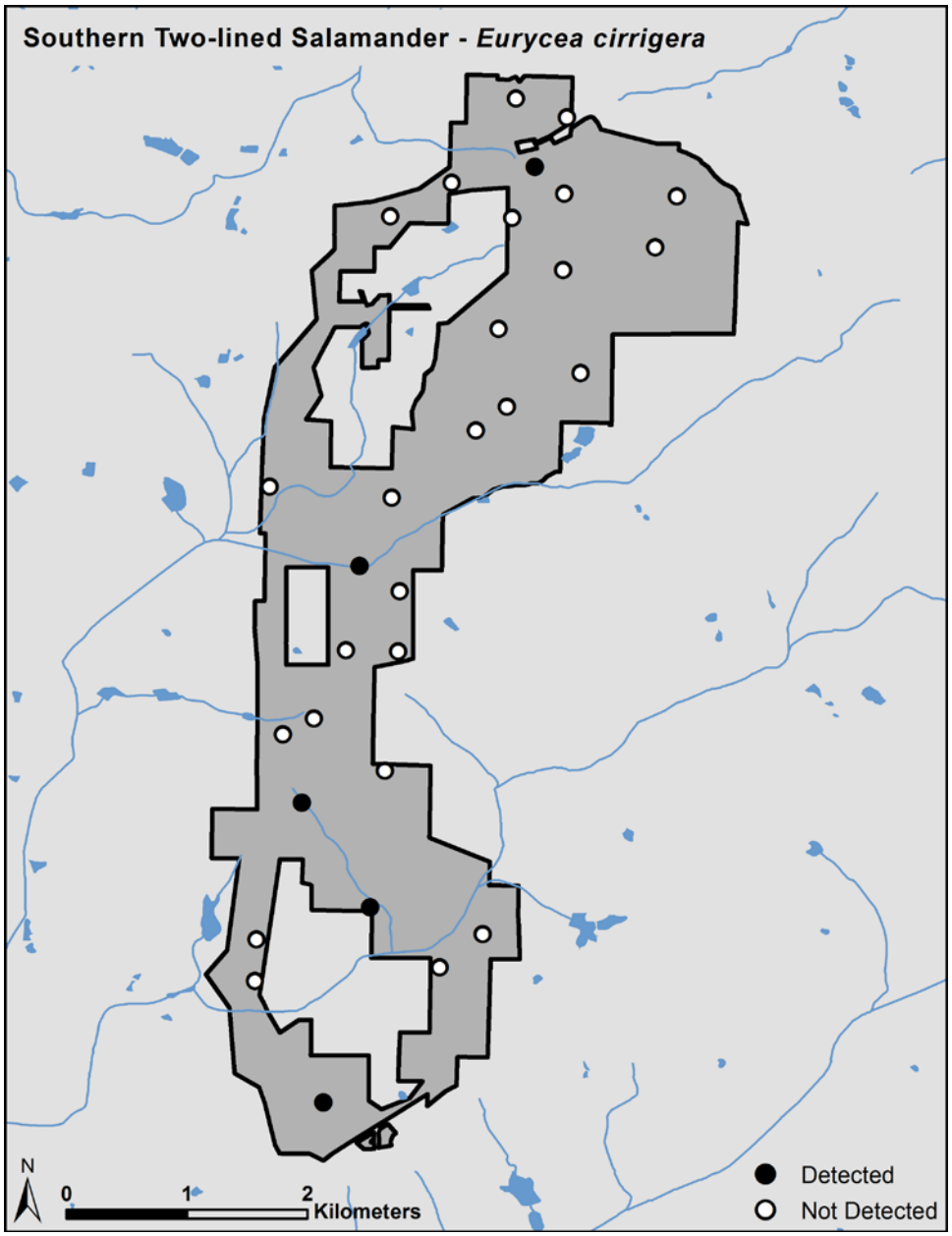

Figure B-18. Sampling locations where Southern Two-lined Salamander (*Eurycea cirrigera*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

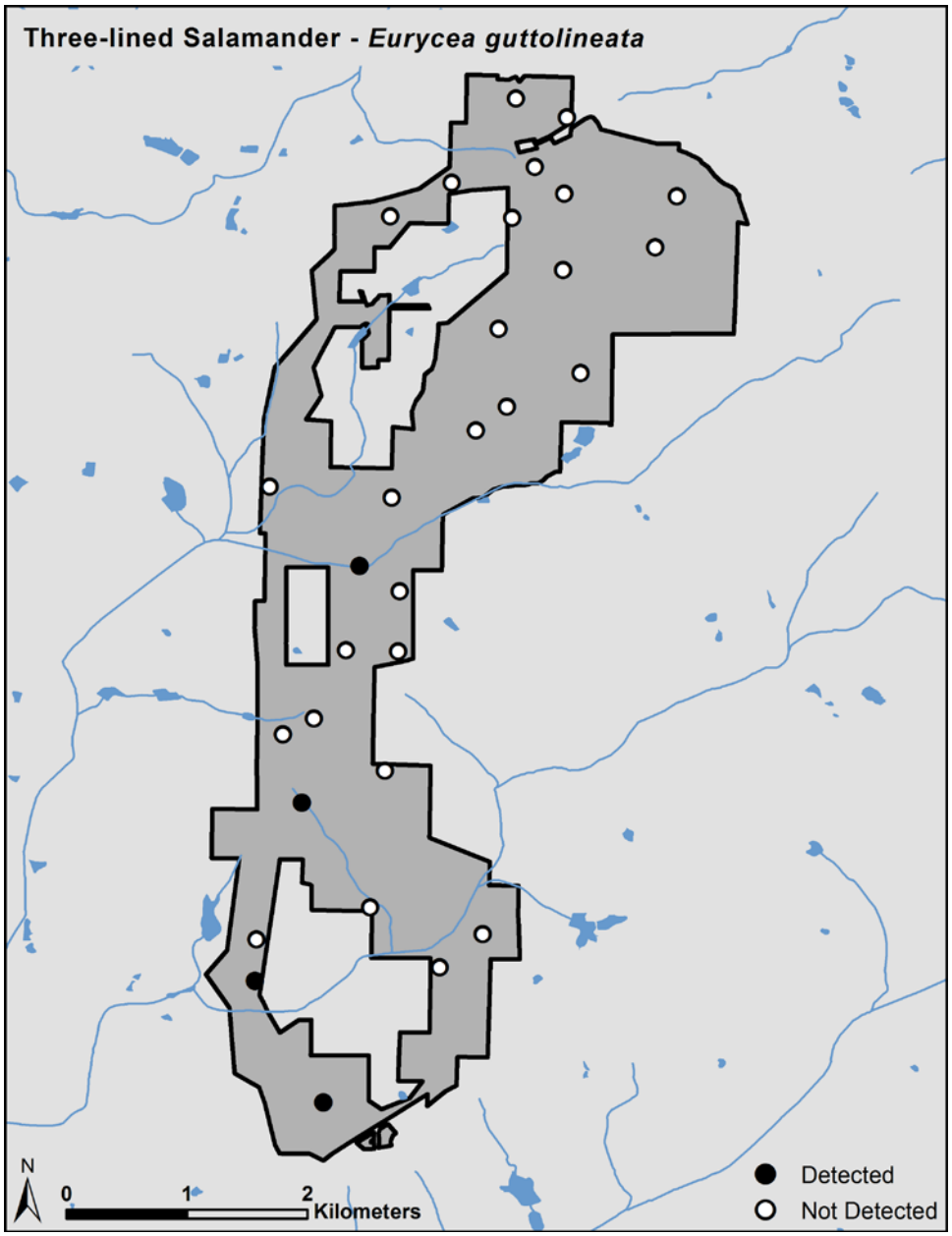

Figure B-19. Sampling locations where Three-lined Salamander (*Eurycea guttolineata*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

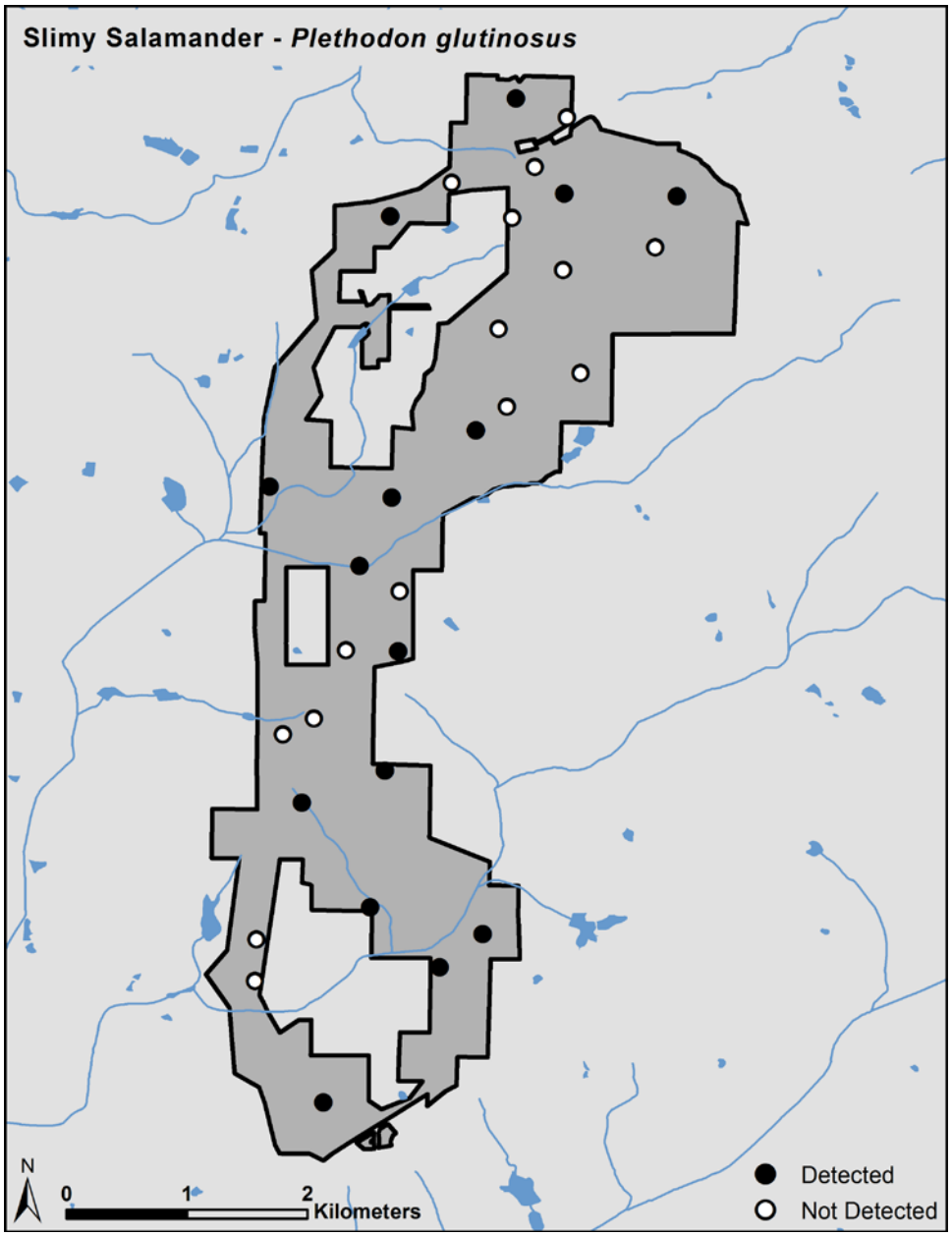

Figure B-20. Sampling locations where Slimy Salamander (*Plethodon glutinosis*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

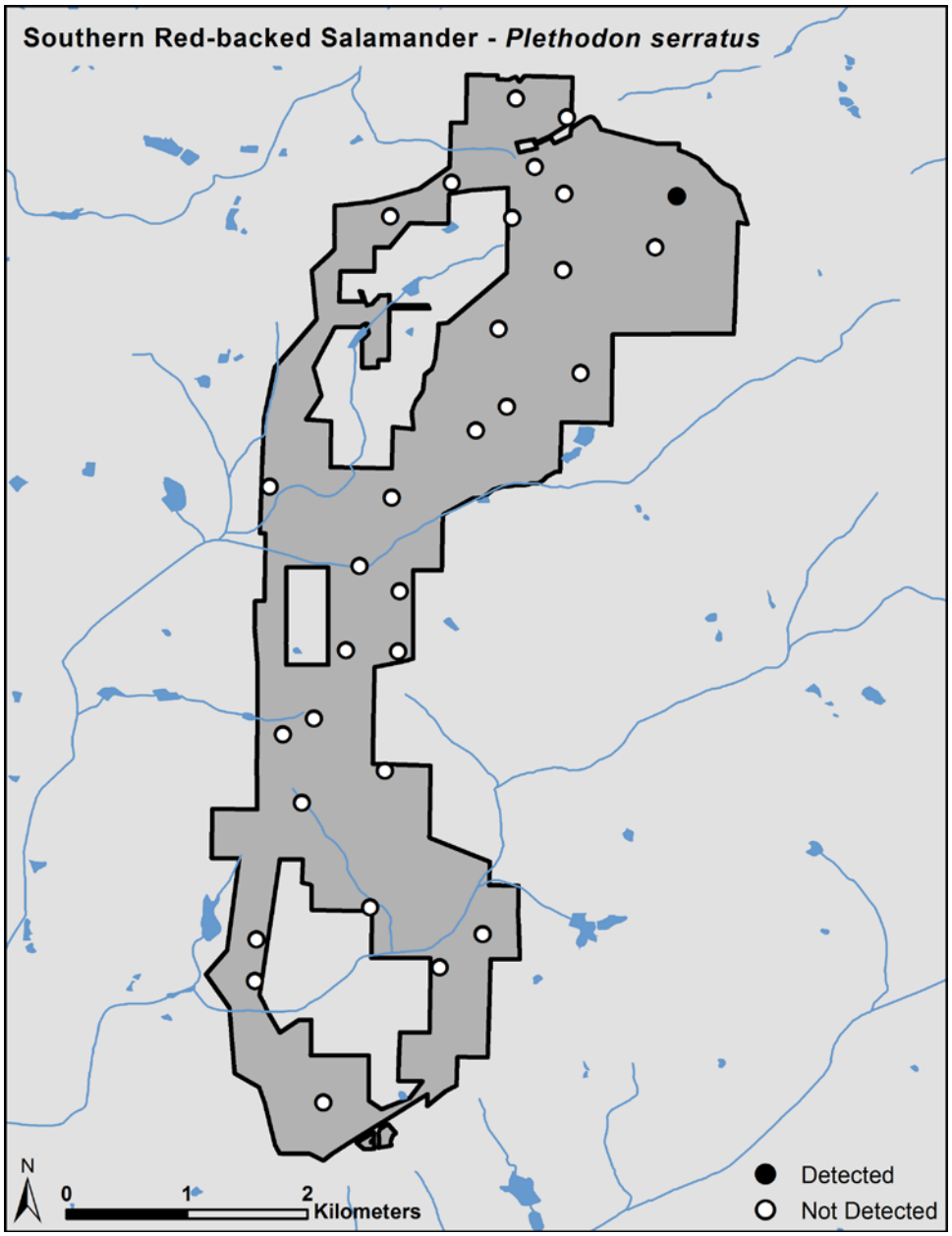

Figure B-21. Sampling location where Southern Red-backed Salamander (*Plethodon serratus*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

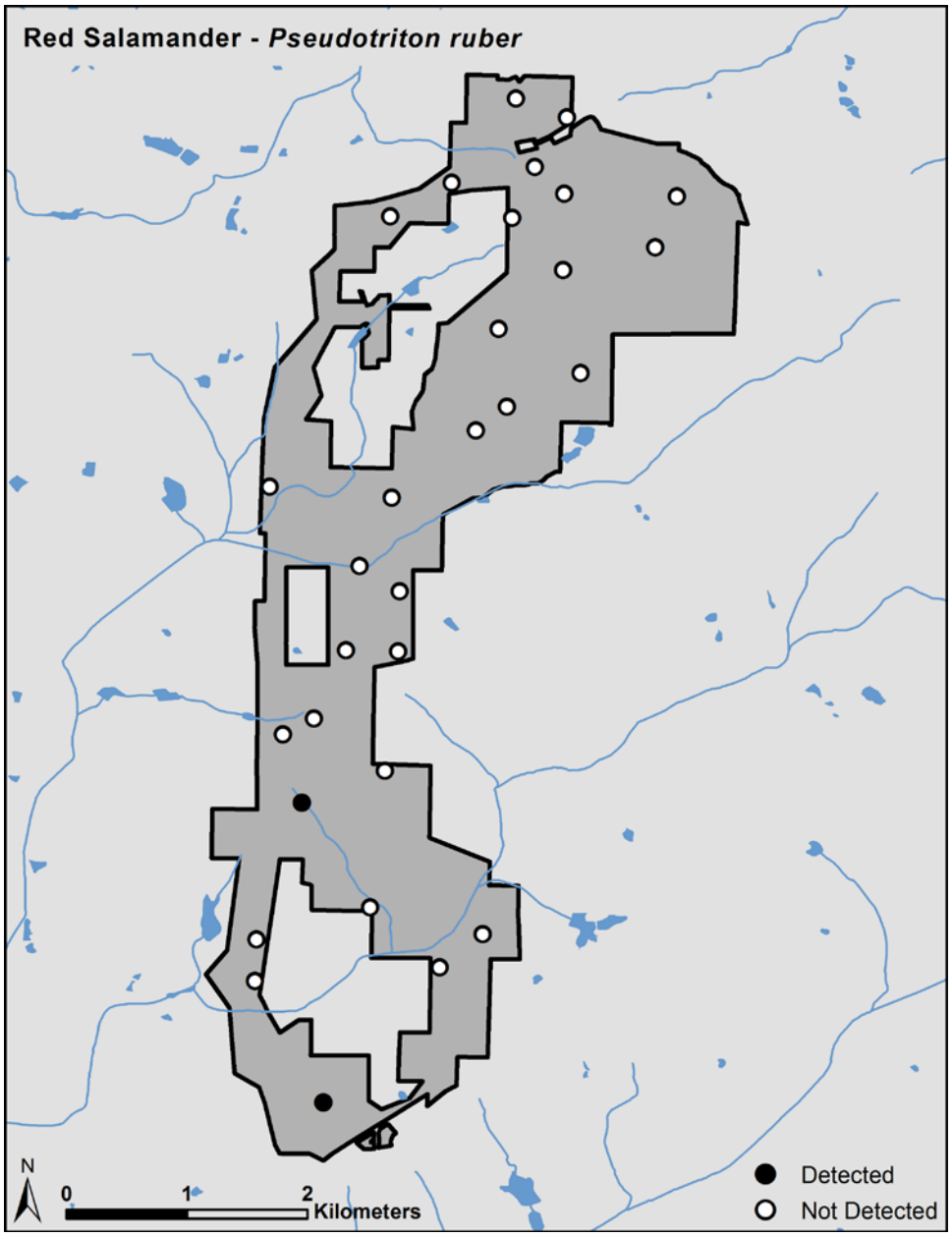

Figure B-22. Sampling locations where Red Salamander (*Pseudotriton ruber*) was detected at Kennesaw Mountain National Battlefield Park, 2012.

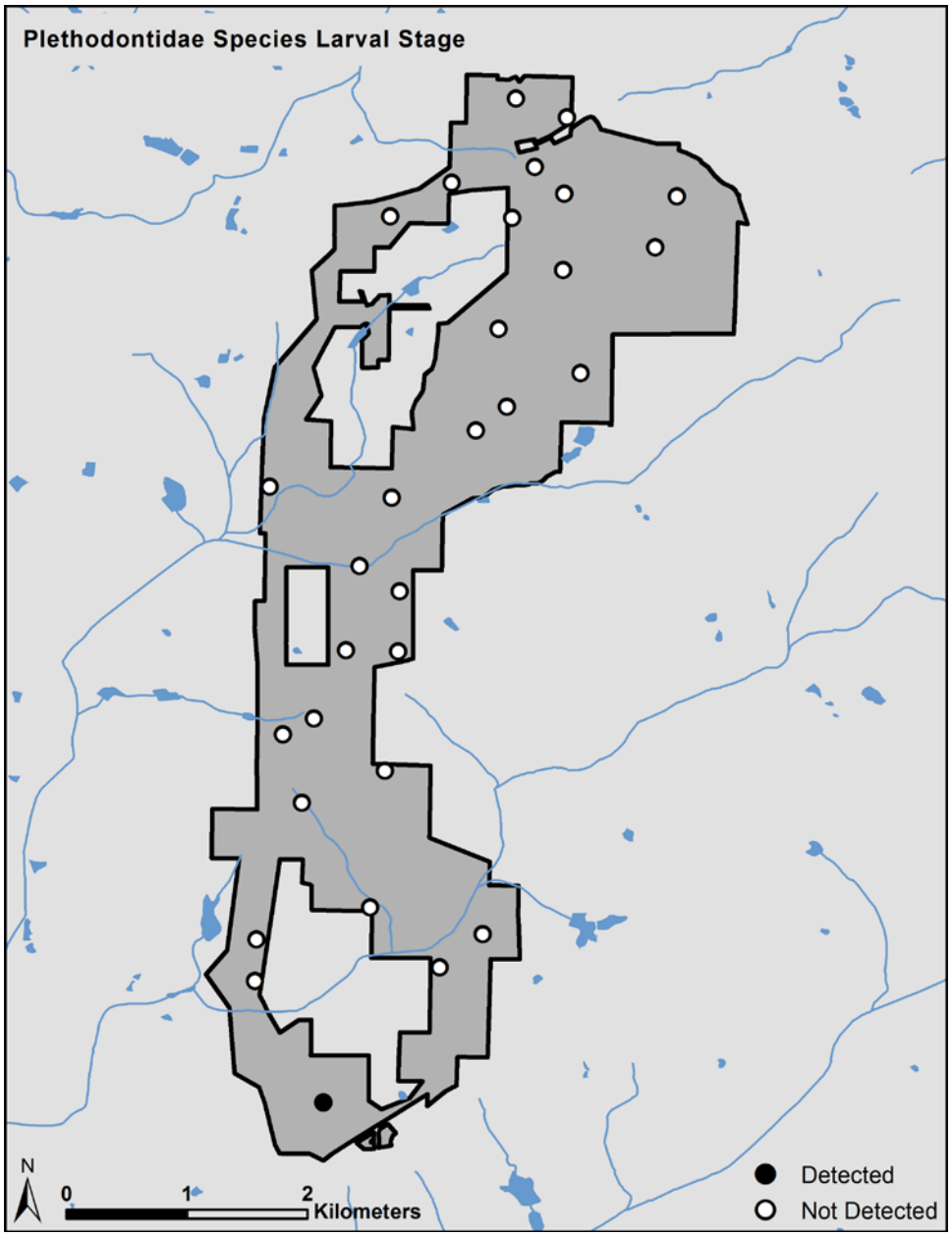

Figure B-23. Sampling location where a larval stage Plethodon Salamander species (*Plethodontidae* sp.) was detected at Kennesaw Mountain National Battlefield Park, 2012.

Appendix C. Reptile Species Detection Data

Kennesaw Mountain National Battlefield Park has 29 known reptile species, consisting of 24 species in *Squamata* (e.g. lizards, snakes, geckos, and skinks), and 5 species in *Testudines* (turtles and tortoises) (Table C-1). As a result of our 2012 monitoring activities, two reptile species were added to the park species list; the Southeastern crowned snake (*Tantilla coronata*) and the Southeastern five-lined skink (*Eumeces inexpectatus*) (Table C-3).

Due to their similar appearance, unless an individual is captured, it is not possible to differentiate between the five-lined skink (*Eumeces fasciatus*) and the Southeastern five-lined skink (*Eumeces inexpectatus*). In cases where capture was not possible, we have combined the detections under the designation five-lined or Southeastern five-lined skink for data analysis in this report.

We detected 175 reptiles or reptile signs from 16 different taxa (genus or species) during visual encounter surveys at KEMO in 2012 (Table C-1, Figure C-1). The worm snake (*Carphophis amoenus*) and had the highest frequency of occurrence among reptile species, and was detected at 67% of the sampling locations (Table C-2). The ground skink (*Scincella lateralis*) was detected at 40% of the sampling locations at KEMO, while the five-lined or Southeastern five-lined skink (*Eumeces fasciatus* / *inexpectatus*) was found at half of the locations. The worm snake had the highest relative abundance, accounting for 29% of all reptile sightings during VESs in 2012. The Eastern Fence Lizard (*Sceloporus undulatus*) accounted for over 16% of the reptiles sighted, and nearly 13% of all reptiles detected were ground skinks (Figure C-1). The black rat snake (*Elaphe obsoleta*), Southeastern crowned snake, and red-bellied snake (*Storeria occipitomaculata*) were the least abundant reptiles during the VESs, with one individual of each species detected at KEMO in 2012.

Table C-1. Reptile species known to occur at Kennesaw Mountain National Battlefield Park based on the Park's certified species list (NPSpecies 2013) and those detected during this sampling effort.

Scientific Name	Common Name	NPSpecies	VES
Ophisaurus attenuatus	Slender Glass Lizard	X	
Carphophis amoenus	Worm Snake	X	X
Coluber constrictor	Black Racer	X	
Diadophis punctatus	Ring-necked Snake	X	X
Elaphe guttata	Corn Snake	X	
Elaphe obsoleta	Black Rat Snake	X	X
Lampropeltis getula	Eastern Kingsnake	X	X
Nerodia erythrogaster	Plain-bellied Water Snake	X	
Nerodia erythrogaster erythrogaster	Red-bellied Water Snake	X	
Nerodia sipedon	Northern Water Snake	X	X
Opheodrys aestivus	Rough Green Snake	X	
Storeria dekayi	Dekay's Brown Snake	X	
Storeria occipitomaculata	Red-bellied Snake	X	X
Tantilla coronata	Southeastern Crowned Snake		X
Thamnophis sirtalis	Garter Snake	X	X
Virginia valeriae	Smooth Earth Snake	X	
Sceloporus undulatus	Eastern Fence Lizard	X	X
Anolis carolinensis	Green Anole	X	X
Eumeces fasciatus	Five-lined Skink	X	X
Eumeces inexpectatus	Southeastern Five-lined Skink		X
Eumeces laticeps	Broad-headed Skink	X	X
Scincella lateralis	Ground Skink	X	X
Aspidoscelis sexlineatus	Six-lined Racerunner	X	
Agkistrodon contortrix	Copperhead	X	
Chelydra serpentina serpentina	Eastern Snapping Turtle	X	
Chrysemys picta	Painted Turtle	X	
Terrapene carolina	Eastern Box Turtle	X	X
Trachemys scripta scripta	Yellow-bellied Slider	X	
Sternotherus odoratus	Common Musk Turtle	X	

Table C-2. Reptilian species or species sign detected at each sampling location at Kennesaw Mountain National Battlefield Park, 2012.

	Sampling Location																												
Species	**2**	**3**	**5**	**6**	**7**	**8**	**10**	**11**	**13**	**14**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**
Worm Snake	X	X	X	X	X	X	X	X	X	X	X	X			X						X	X	X	X	X	X				X
Ring-neck Snake										X	X	X							X			X		X	X		X			X
Black Rat Snake																					X									
Eastern Kingsnake	X									X			X																	
Northern Water Snake						X											X													
Water Snake sp.	X																													
Red-bellied Snake															X															
Southeastern Crowned Snake								X																						
Garter Snake														X									X							
Eastern Fence Lizard									X				X	X							X		X	X			X			
Green Anole	X								X				X	X							X							X	X	
Five-lined Skink											X							X	X											
Southeastern Five-lined Skink																							X							
Southeastern Five-lined or Five-lined Skink	X												X	X									X	X	X			X		
SE Five-lined, Five-lined , or Broad-head Skink	X													X													X			
Broad-head Skink														X							X		X					X		
Ground Skink	X								X	X	X			X		X			X	X				X	X			X	X	
Eastern Box Turtle	X		X										X										X				X			
Eastern Box Turtle shell																											X			

Table C-3. New reptile species detected at Kennesaw Mountain National Battlefield Park in 2012 and recommended NPSpecies classifications.

Scientific Name	Common Name	Abundance	Residency	Nativity	Pest	Management Priority	Exploitation Concerns
Eumeces inexpectatus	Southeastern Five-lined Skink	Unknown	Resident	Native	No	No	No
Tantilla coronata	Southeastern Crowned Snake	Unknown	Resident	Native	No	No	No

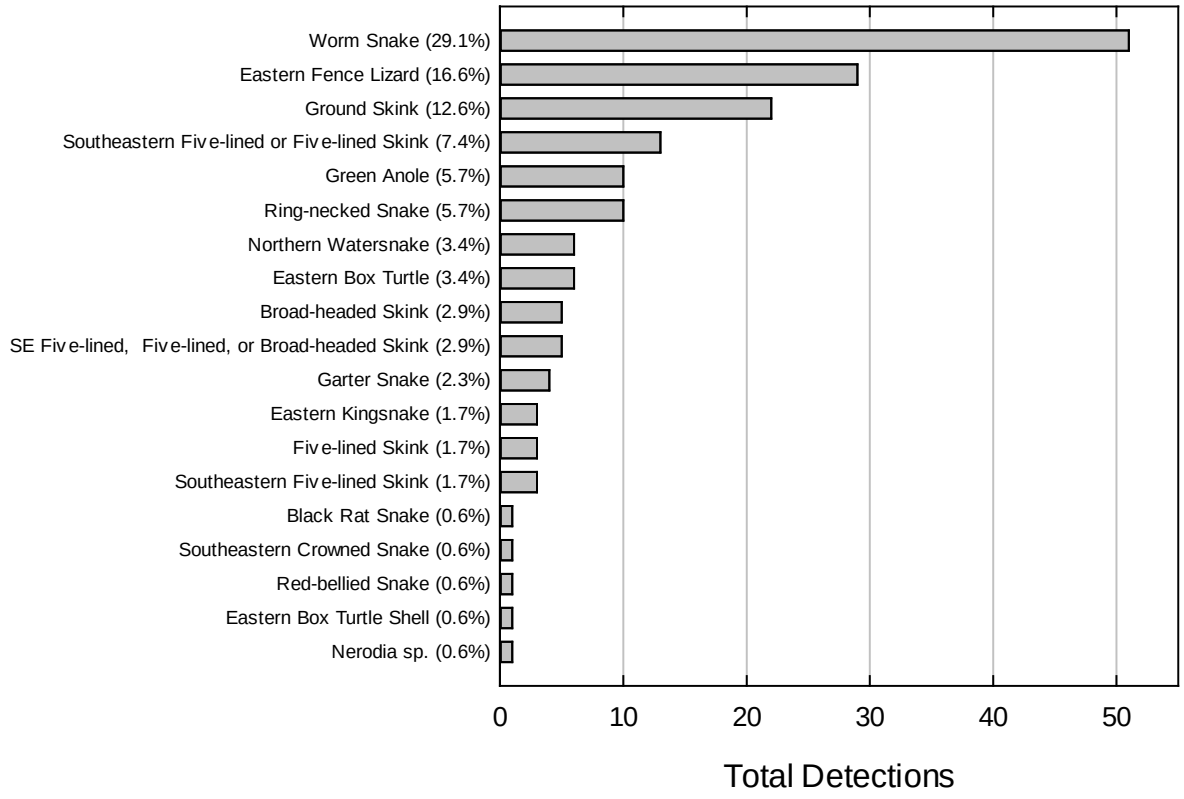

Figure C-1. Number of individual reptiles and reptile signs detected and percent species composition during visual encounter surveys at Kennesaw Mountain National Battlefield Park, 2012. Based on n=175 detections.