



Summary of Vocal Anuran Monitoring at Kennesaw Mountain National Battlefield Park, 2009

Natural Resource Report NPS/SECN/NRDS—2011/154



ON THE COVER

Pseudacris crucifer (spring peeper)

Photograph by SECN staff.

Summary of Vocal Anuran Monitoring at Kennesaw Mountain National Battlefield Park, 2009

Natural Resource Data Series NPS/SECN/NRDS—2011/154

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data were collected and analyzed using established methods based on peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

This report summarizes data collected with partial implementation and test application of the Draft SECN Amphibian Community Monitoring Protocol (Byrne et al., *in preparation*) at Kennesaw Mountain National Battlefield Park in 2009.

1. Data were collected at 30 spatially-balanced random locations at the Park.
2. Sampling activities occurred at the Park from 4/24/2009 to 5/4/2009.
3. The monitoring activity summarized herein was part of the protocol refinement process and consisted solely of ARD monitoring for vocal anurans (i.e., frogs and toads that vocalize).
4. We detected six vocal anurans, including five of the 11 known vocal anuran species and one additional species not previously on the species list (green treefrog).
5. No non-native amphibians were detected.
6. Observed amphibian-species richness was six.
7. Spring peeper was the most widely distributed species.
8. Full protocol implementation will be implemented again at the Park in 2011.
9. The full dataset, and associated metadata, can be acquired from the data store at <http://science.nature.nps.gov/nrdata/>

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, Petranks 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 under the Automated Recording Device Standard Operating Procedure (SOP #4) of the draft SECN Amphibian Community Monitoring Protocol (Byrne et al., *in preparation*).

Objective

- Determine trends in amphibian-species occupancy, distribution, diversity, and community composition in SECN parks.

Methods

Study Area

Kennesaw Mountain National Battlefield Park (KEMO) is located in Cobb County in the suburbs of Atlanta, GA (Figure 1). The Park's goal is to interpret a major Civil War battle during the Atlanta campaign where more than 67,000 soldiers lost their lives. The 2,923-acre Park consists of the 1,808-foot peak of Kennesaw Mountain, Little Kennesaw Mountain, hundreds of acres of mixed hardwood/pine forests, open grassy fields, and more than 16 miles of hiking trails. Vegetation communities at the Park consist primarily of mixed-hardwood and pine forests. The most common tree species at the Park include oaks (e.g., *Quercus alba*, *Q. falcata*, *Q. stellata*), hickories (*Carya alba*, *C. glabra*), and loblolly pine (*Pinus taeda*), and the open grassy areas are a diverse assemblage of native and non-native grass and forb species (Zomlefer et al. 2010).

According to the 2006 Census, Cobb County is the fourth most populous county in Georgia and has been the second-most densely populated county in Georgia since 1990. The Park's location in the metropolitan Atlanta area, consequently, 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. As with many urban parks, KEMO is exposed to a variety of stressors, including non-native/invasive species, air pollution, and water pollution. Despite its high use and prominent wildland-urban interface, KEMO provides a very unique and remnant example of the area prior to development, and is a highly prized educational, historical, and recreation site by the people in the area.

KEMO has 12 known vocal anurans (i.e., frogs and toads that vocalize), including one species (green treefrog [*Hyla cinerea*]) added to the species list as a result of the monitoring results presented herein (Appendix A).

Sampling Design

A detailed explanation of the sampling design and site selection can be found in the SECN Draft Amphibian Monitoring Protocol (Byrne et al., *in preparation*) and sample site selection SOP (Byrne 2009). In summary, to allow for park-wide inference, the Park's administrative boundary was used as the sampling frame. The sampling frame was divided into a systematic 0.5-ha grid; the center point of each grid cell served as the potential sampling site. A spatially-balanced sample was drawn from this grid using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald et al. 2007). Alternate points were used when selection criteria (i.e., including safety and access issues) were not met. A sample size of 30 was chosen after

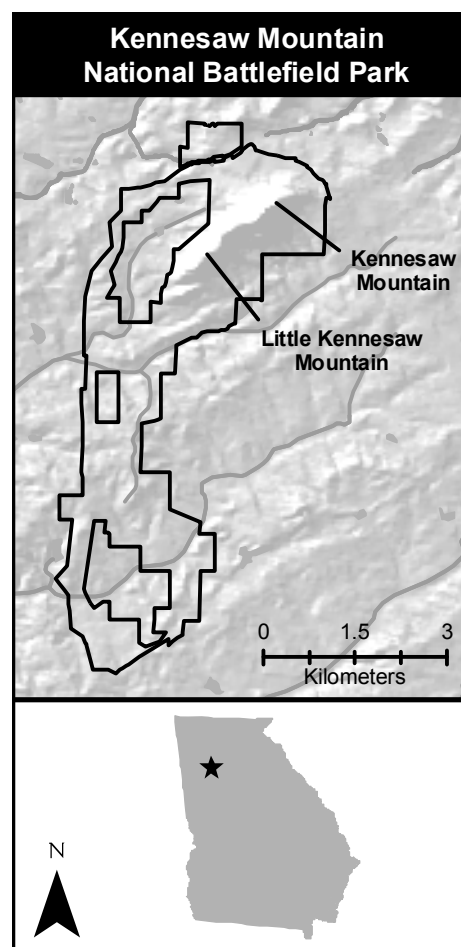


Figure 1. Location of Kennesaw National Battlefield Park.

consideration of the Park's size, hypothesized variability, and logistical issues regarding travel time and conducting monitoring activities in five to six park units per year. Sampling locations are presented in Figure 2.

Sampling Methodology

This monitoring effort was part of protocol refinement and only one methodology was implemented, automated-recording devices (ARD). The devices were programmed to record one minute every ten minutes from dusk to dawn once every two days, and were deployed for ten days. ARDs only detect species that vocalize (e.g., vocal anurans) and the resultant binary dataset provides detection and non-detection information (i.e., no relative abundance information). This sampling technique is described in detail in Byrne (2007).

The ARDs were deployed from 4/24/2009 to 5/4/2009. Two of the devices malfunctioned resulting in a total of 8,960 minutes recorded by the devices at the Park.

Data Analysis

Because this is the first year of this protocol's implementation at the Park, only the status of the elements presented in the aforementioned monitoring objective are presented; except occupancy. Further, because only one method was implemented (i.e., ARDs), the results of this summary apply only to the vocal anuran component of the amphibian community. The data in this report are summarized and presented in three general categories: diversity, composition, and distribution. Sampling locations are presented in Figure 2, labeled locations are presented in Appendix B, and species detected at each location are presented in Appendix C.

Despite a well-trained and dedicated 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. Two factors are the most common challenges, animal-escape behavior and variability in identifying characteristics within some genera. 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. Although the majority of these species could most likely be indentified to the genus or family level (i.e., Unknown *Rana* 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". Examples of very similar characteristics within genera where their known ranges overlap are *Acris gryllus* / *A. crepitans* and some *Desmognathus* species. While reliable identification can be obtained for most of the species through physical characteristics or range discrimination, pooling to genus or group ensures consistency and does not adversely affect our knowledge of the site as these species are very likely to play a very similar role in the ecosystem.

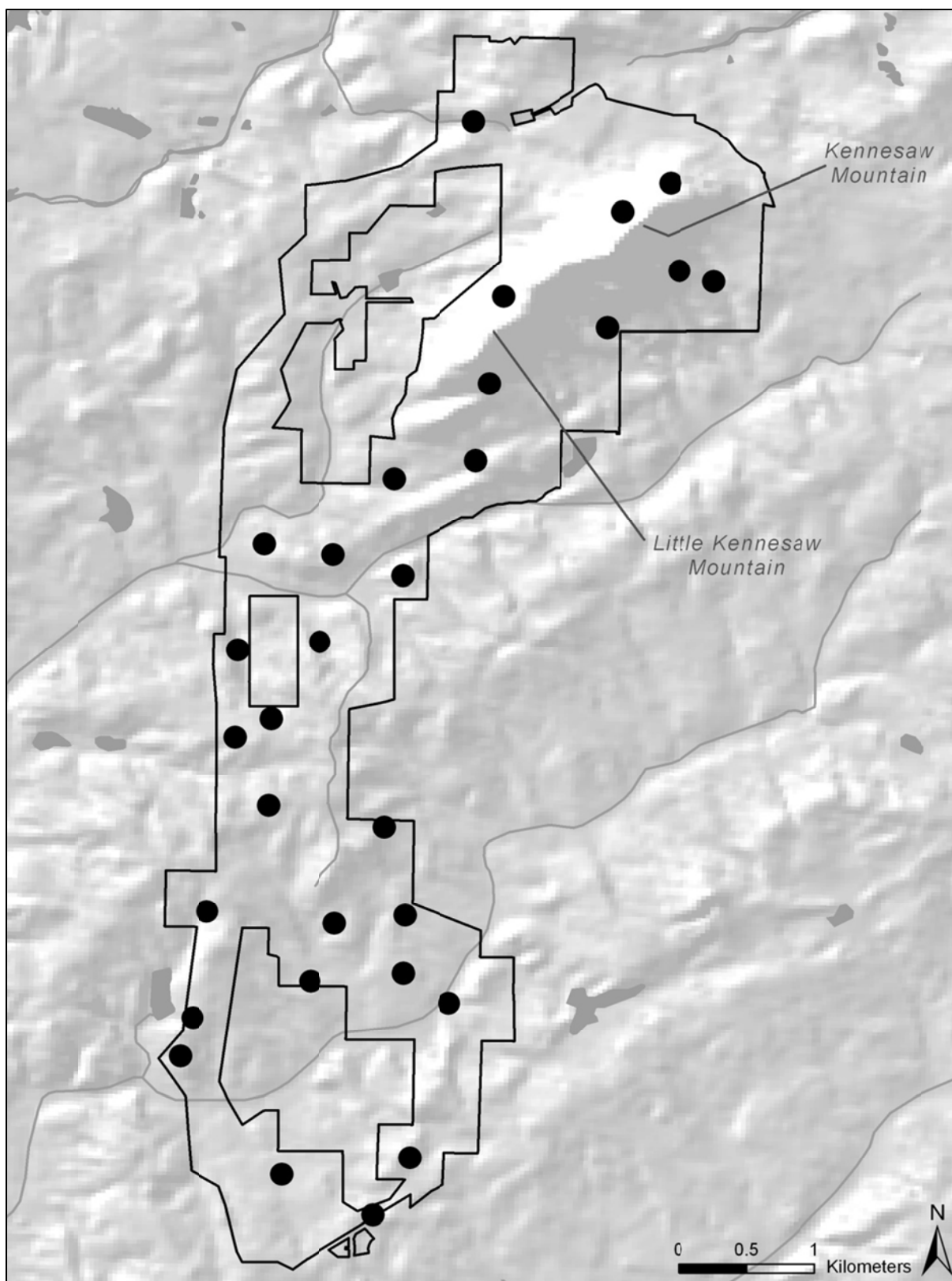


Figure 2. Spatially-balanced random sampling locations at KEMO, 2009.

Diversity

Diversity is defined as “the variety and abundance of species in a defined unit of study” (Magurran 2004, p. 8). Diversity is a community property that is related to trophic structure, productivity, stability, (McIntosh 1967, McNaughton 1977), immigration / emigration (Colwell and Lees 2000), and ecological condition (i.e., ecological integrity as defined by Karr and Chu [1995]). Species diversity consists of two components: the number of species (species richness) and the relative abundance of those species (species evenness / dominance) within a defined community (Margalef 1958, Lloyd and Ghelardi 1964, Pielou 1966). Species diversity is often communicated in the form of diversity indices. The term community refers to the assemblage of species populations that occur together in space and time (Begon et al. 1986), and we consider the park as a whole community as per the conceptual ecological models presented in our monitoring plan (see Chapter 2 in DeVivo et al. 2008).

Because diversity indices respond differently to various mechanisms that influence community change, several indices must be used to adequately characterize diversity in SECN parks (Haedrick 1975, Boyle et al. 1984). After careful appraisal of advantages and disadvantages of the many diversity indices, a suite of alpha diversity indices were selected to summarize these data (Table 1), where alpha diversity is the diversity of species within a defined area, community, or ecosystem (Whittaker 1972). The detection / non-detection (i.e., incidence) data resultant of the ARD technique alone does not facilitate the calculation of several abundance-based species diversity, evenness, and dominance indices (e.g., Fisher's α [1943], Gini [1912], Berger-Parker [1970]) typically presented in annual data summaries for amphibian community monitoring; however, several incidence-based species richness indices are calculated (Table 1).

Species-diversity estimates are based only on amphibian observations identified to the species level. Non-native amphibians, if detected, were not included in diversity estimates.

Composition

Measures of community composition are often good indicators of abiotic variability, disturbance, or other stressors. Frequency of occurrence estimates are calculated for all species detected. Counts were also pooled across non-native species to generate frequency of occurrence estimates for all non-natives.

Distribution

The distribution of species on park lands is integral to informed management. Further, changes in species distributions over time provides useful information regarding possible unseen influences that alter wildlife-habitat use and may be indicative of other issues. This section presents maps of all sampling locations where each amphibian was detected.

Table 1. Diversity indices used (incidence-based), corresponding symbol, community attribute the index reflects, the range of index values, and notes on each index.

Index	Symbol	Community Attribute	Index Citation	Notes
Native Spp. Richness	S_{obs}	Richness	n/a	Value is a positive integer that indicates the number of native species in the sample. Intuitive. Good discriminant ability if sampling effort is comparable; sensitive to sample size, the occurrence of rare species, or those with low detectability; does not account for relative abundances.
Chao 2	Chao2	Richness	Chao (1984) Chao (1987)	Values indicate an estimate of total species richness (including species not present in the sample); incidence-based estimate; works well with dataset containing several infrequent observations.
Incidence-based Coverage	ICE	Richness	Lee and Chao (1994) Chazdon et al. (1998)	Values indicate an estimate of total species richness (including species not present in the sample); incidence-based estimate.
Jackknife 1	Jack1	Richness	Burnham and Overton (1978) Burnham and Overton (1979) Heltshe and Forrester (1983)	Values indicate an estimate of total species richness (including species not present in the sample); incidence-based estimate; The higher the value the higher the species richness. This procedure requires no assumptions regarding the data distribution.
Jackknife 2	Jack2	Richness	Smith and van Belle (1984)	Values indicate an estimate of species richness; incidence-based estimate.
Bootstrap	Boot	Richness	Smith and van Belle (1984)	Values indicate an estimate of species richness; incidence-based estimate.

Results

Diversity

Diversity indices calculated for these data were selected to reflect community composition (i.e., number of species) (Table 2). Confidence intervals for each of the diversity indices were estimated with a bootstrap procedure. A brief explanation of interpreting the value is presented in Table 2.

The species accumulation curve generated from the data asymptotes at a value greater than the sample size of 28 (i.e., more than the total number of samples collected), therefore the results of the ARD data alone are inadequate in characterizing amphibian diversity at the Park. This was expected and adequately characterizing the amphibian community was not the primary goal of this effort; rather, the primary goal was to test the ARD technique and refine this component of the amphibian-community monitoring protocol (Byrne et al., *in preparation*).

Observed species richness (i.e., S_{obs}) is 6 (95% CI: 3.52, 8.47). The Jack1, Jack2, and Boot species richness estimates and confidence intervals are relatively consistent with one another (i.e., 7–10; Table 2). Further, these estimates perform comparatively well given the characteristics of the dataset and are likely better estimates of true species richness than the Chao2 or ICE indices because of the uncertainty associated with these estimates (as indicated by the high confidence intervals)

Because this partial implementation of the SECN amphibian-community monitoring protocol was the first for monitoring effort for this vital sign, these values will serve as an information base when baseline values of the amphibian community as a whole are generated as a result of planned 2011 monitoring efforts.

Table 2. Amphibian alpha-diversity estimates at KEMO, 2009.

Index	Symbol	Value	Lower 95% CI	Upper 95% CI	Value Interpretation
Native Spp. Richness	S_{obs}	6.00	3.52	8.47	Number of native species detected
Chao 2	Chao2	6.96	6.08	16.36	Estimated true species richness (high CI)
Incidence-based Coverage	ICE	9.75	1.89	17.61	Estimated true species richness (high CI)
Jackknife 1	Jack1	8.89	5.75	12.03	Estimated true species richness
Jackknife 2	Jack2	9.89	7.19	12.59	Estimated true species richness
Bootstrap	Boot	7.34	6.60	8.08	Estimated true species richness

Composition

We detected 6 amphibian species. Spring peeper (*Pseudacris crucifer*) was detected at more sampling locations than any other species (Figure 3). Frequency of occurrence provides insight into the abundance of detected species across the park and whether a species is commonly or uncommonly encountered; however, this is strongly influenced by a species' detectability as more-easily detected species may be more frequently encountered (and vice versa). Spring peeper was also the most frequently encountered species, followed by Cope's gray treefrog (*Hyla chrysoscelis*) and green frog (*Rana clamitans*) (Table 3). No non-native species were detected.

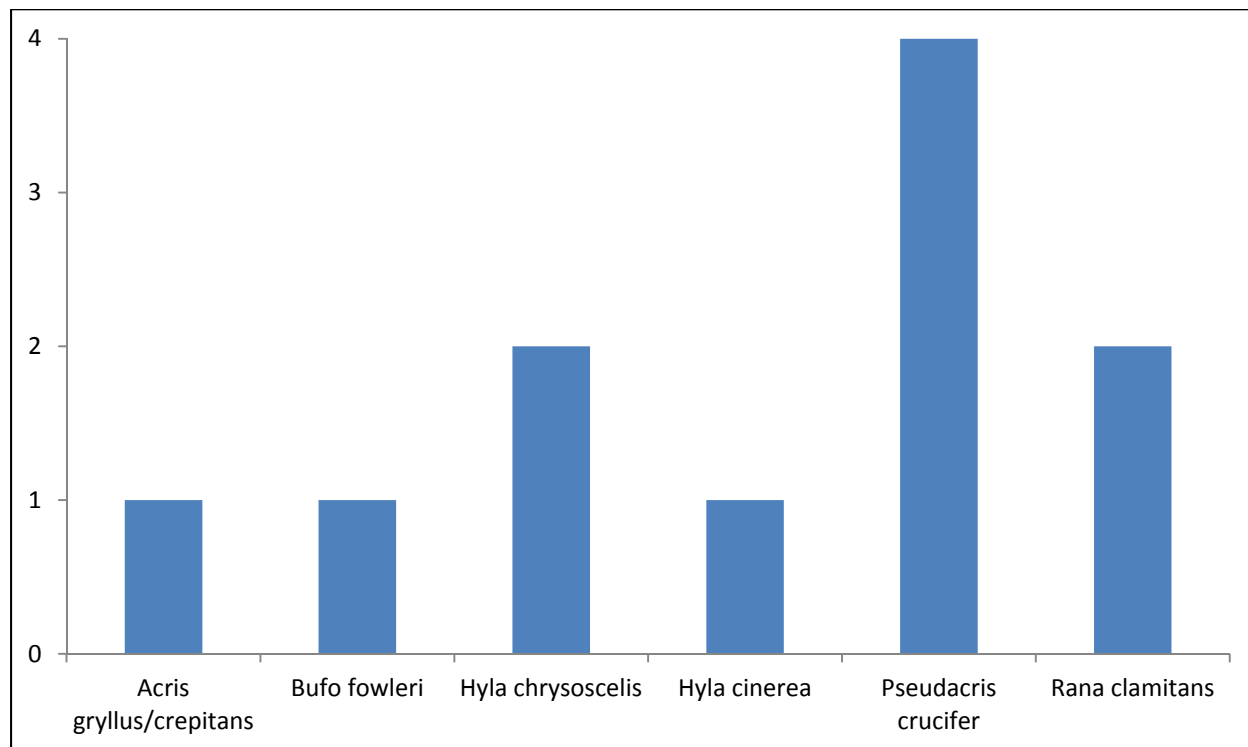


Figure 3. Number of vocal anuran detections, KEMO, 2009.

Table 3. Frequency of occurrence of amphibians at KEMO, 2009.

Scientific Name	Common Name	Frequency of Occurrence
<i>Pseudacris crucifer</i>	Spring peeper	0.14
<i>Hyla chrysoscelis</i>	Cope's gray treefrog	0.07
<i>Rana clamitans</i>	Green frog	0.07
<i>Acris crepitans/gryllus</i>	Cricket frog	0.04
<i>Bufo fowleri</i>	Fowler's toad	0.04
<i>Hyla cinerea</i>	Green treefrog	0.04

Distribution

Spring peeper was the most widely distributed species at the Park (Figure 8). All other species were detected at only one or two sampling locations. More species were detected (i.e., 3) at sampling locations 23 and 24 (Figure B-1, Table C-1) than other locations. Green treefrog was also detected at the Park (Figure 7). This occurrence represents an addition to the KEMO species list as well as a range extension for the green treefrog. These species are known to hitch rides on vehicles. Figures 4–9 illustrate the locations where each species was detected.

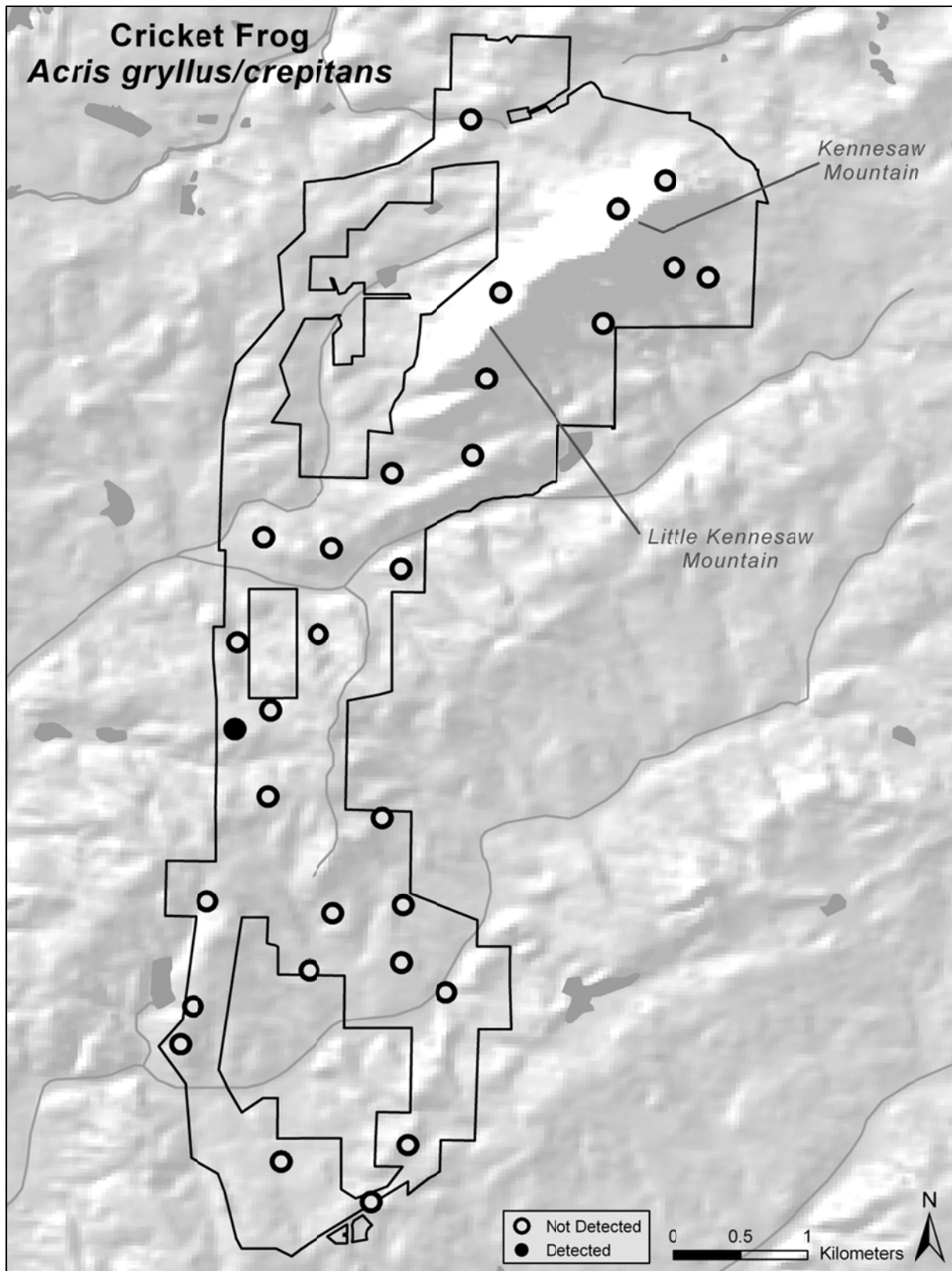


Figure 4. Sampling locations where cricket frog (*Acris gryllus / crepitans*) was detected at KEMO, 2009. ● = detected, ○ = not detected.

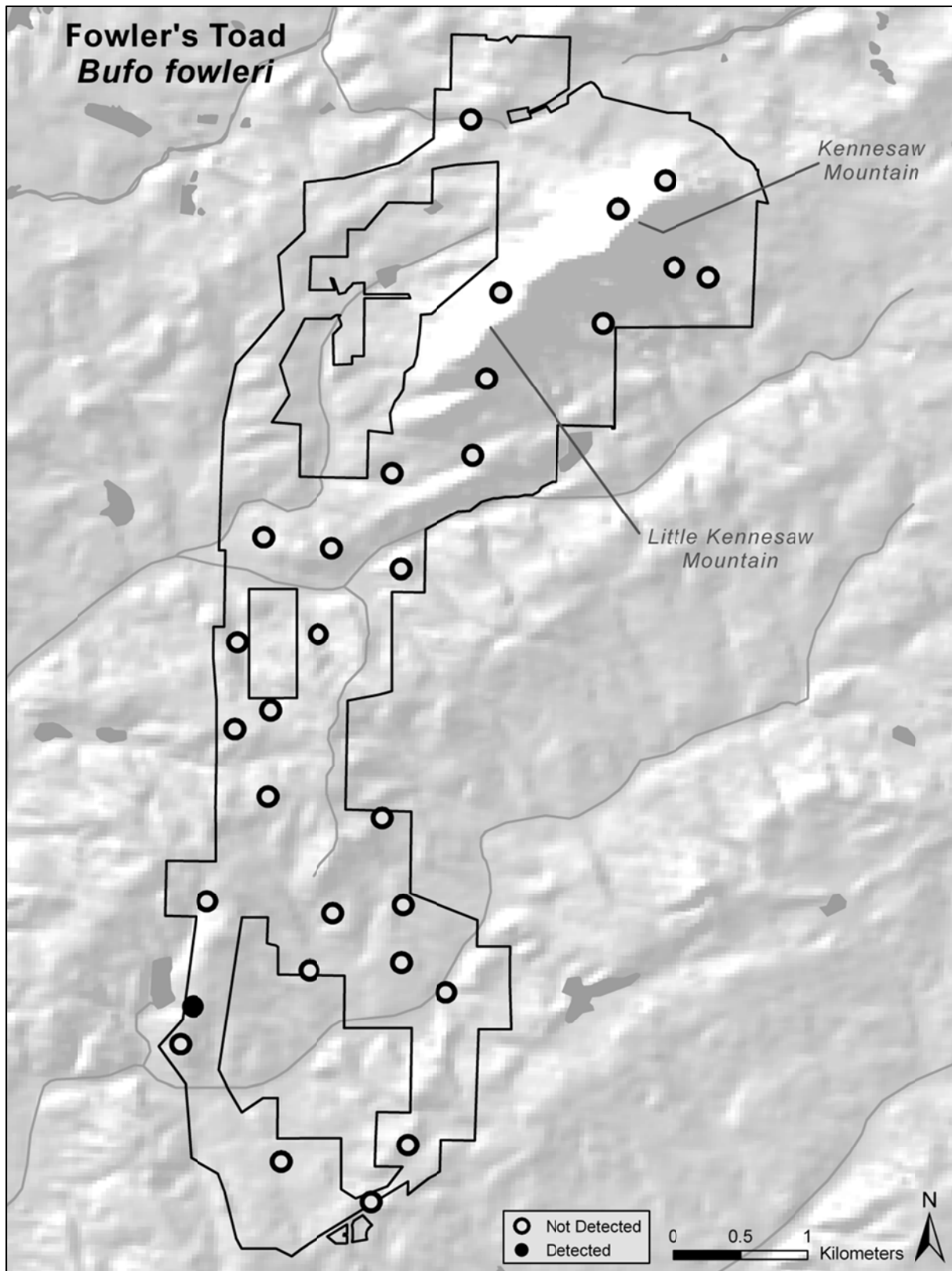


Figure 5. Sampling locations where Fowler's toad (*Bufo fowleri*) was detected at KEMO, 2009.
● = detected, ○ = not detected.

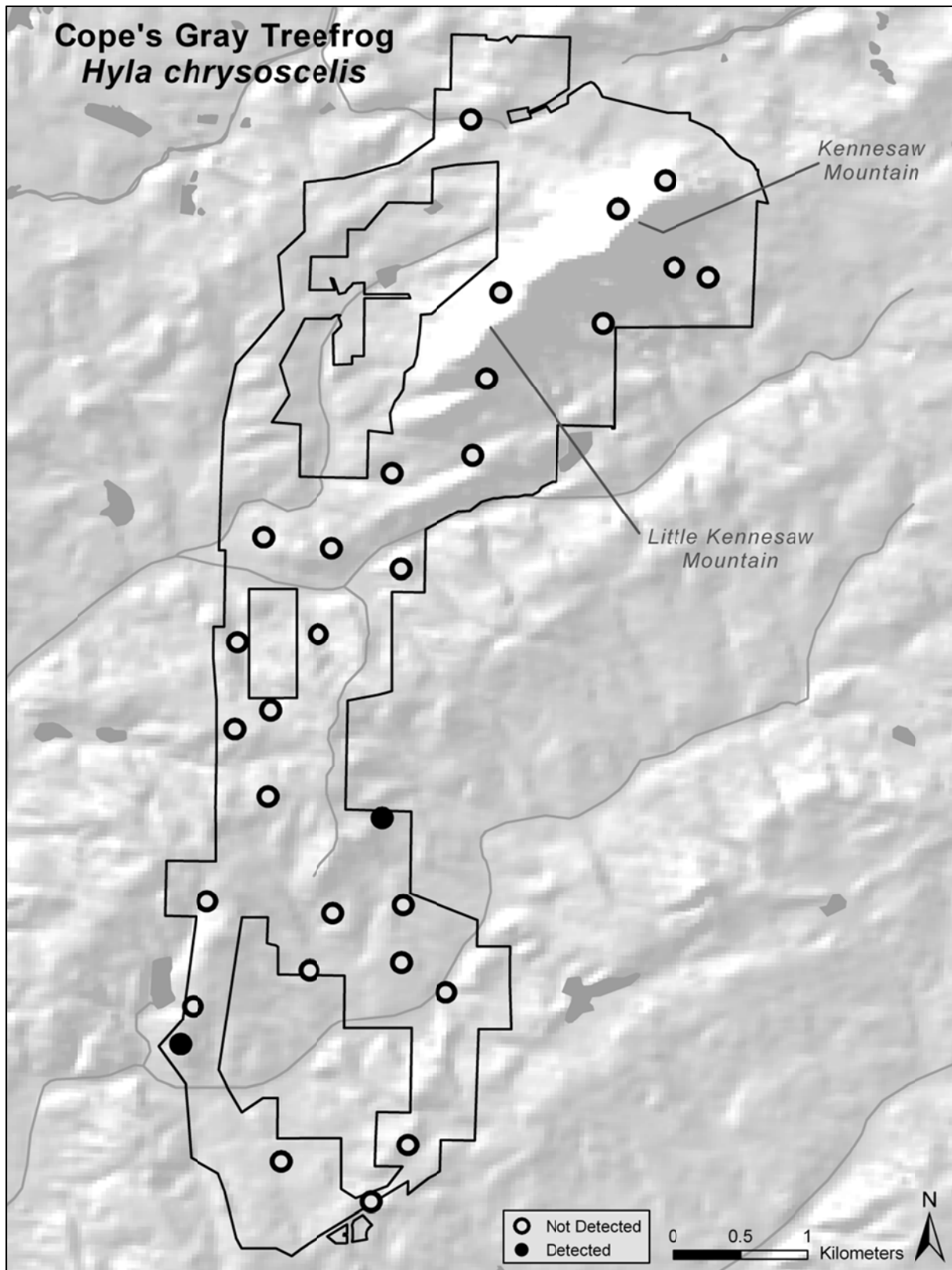


Figure 6. Sampling locations where Cope's gray treefrog (*Hyla chrysoscelis*) was detected at KEMO, 2009. ● = detected, ○ = not detected.

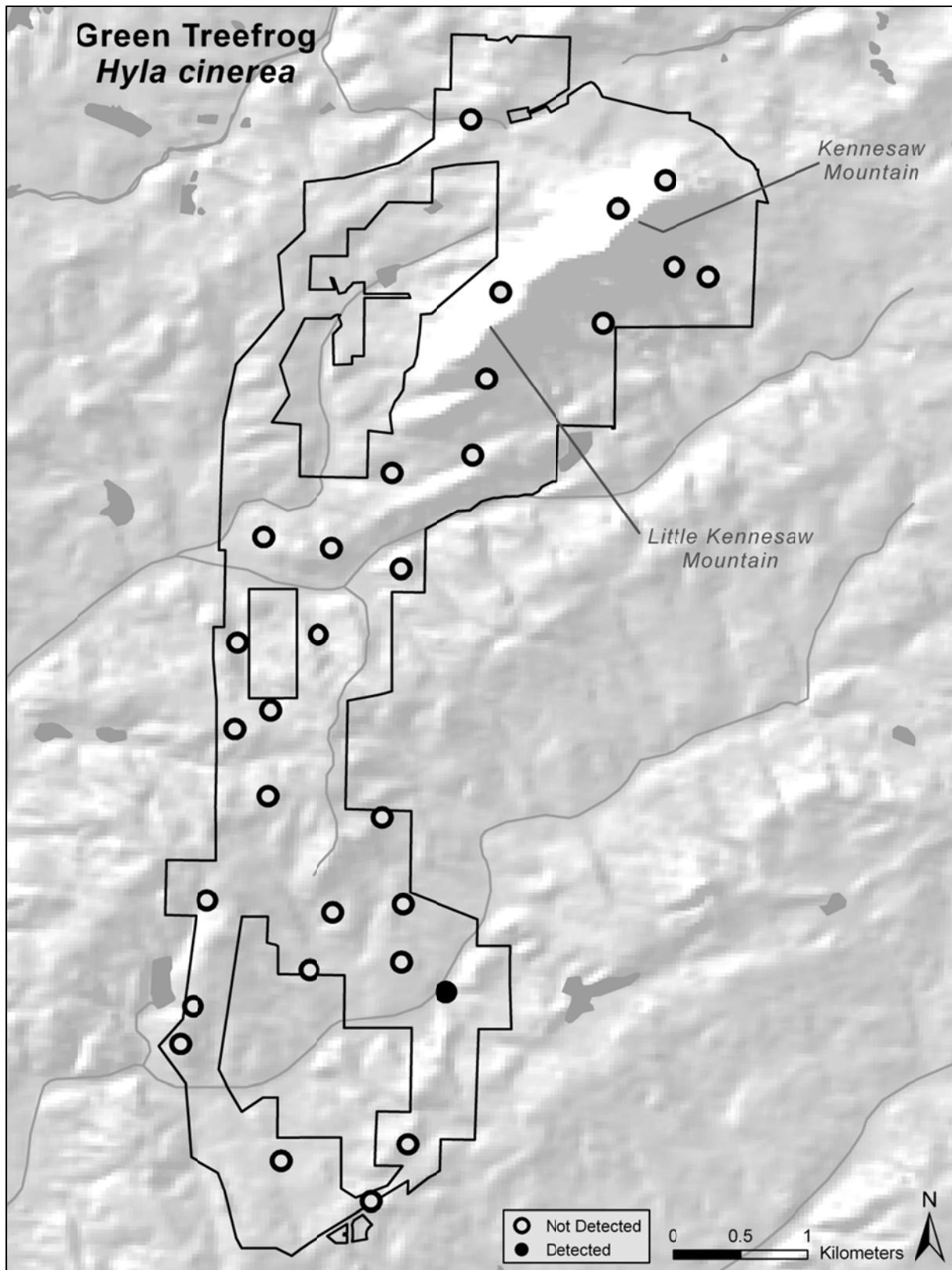


Figure 7. Sampling locations where green treefrog (*Hyla cinerea*) was detected at KEMO, 2009.
● = detected, ○ = not detected.

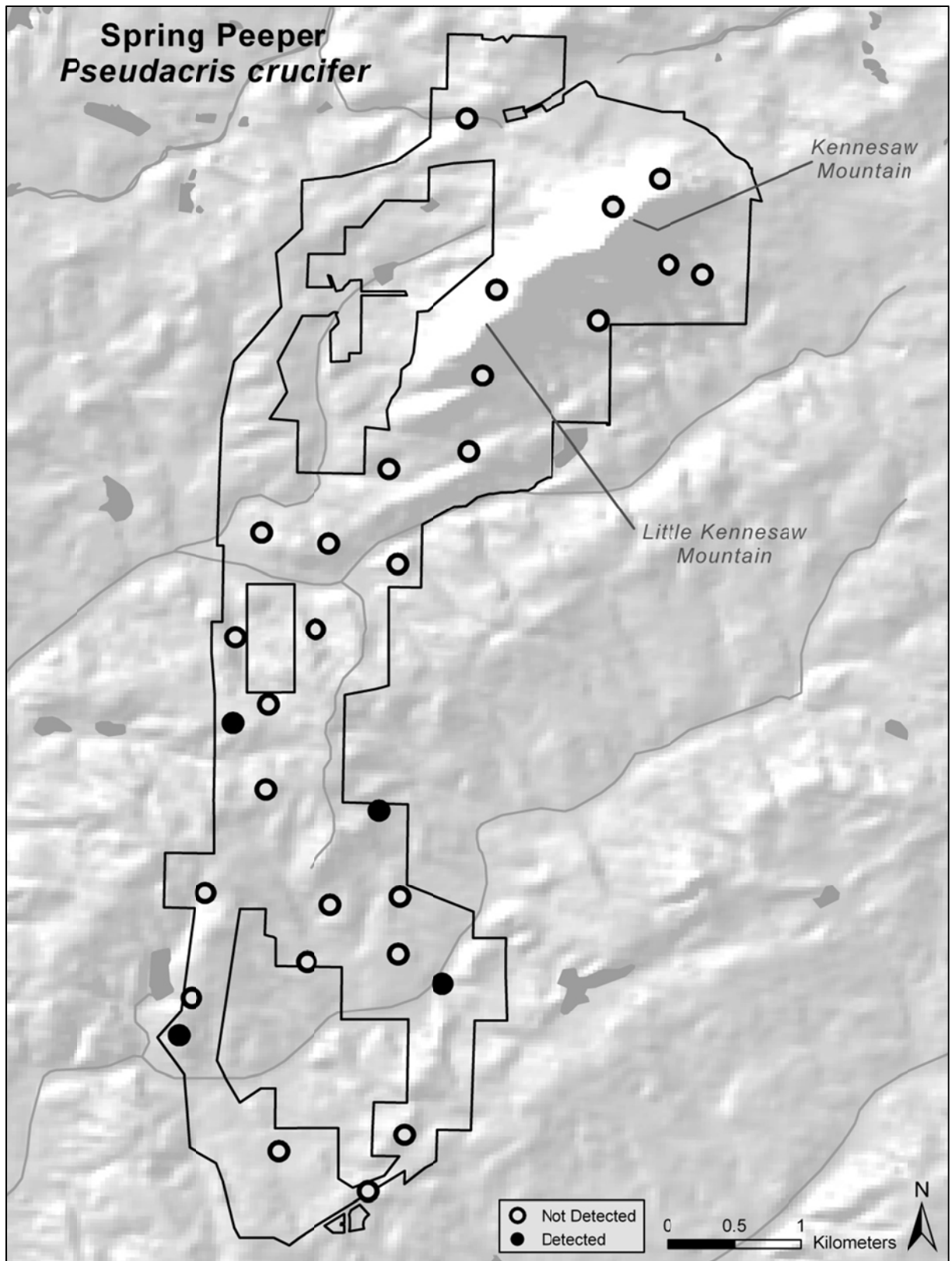


Figure 8. Sampling locations where spring peeper (*Pseudacris crucifer*) was detected at KEMO, 2009.
● = detected, ○ = not detected.

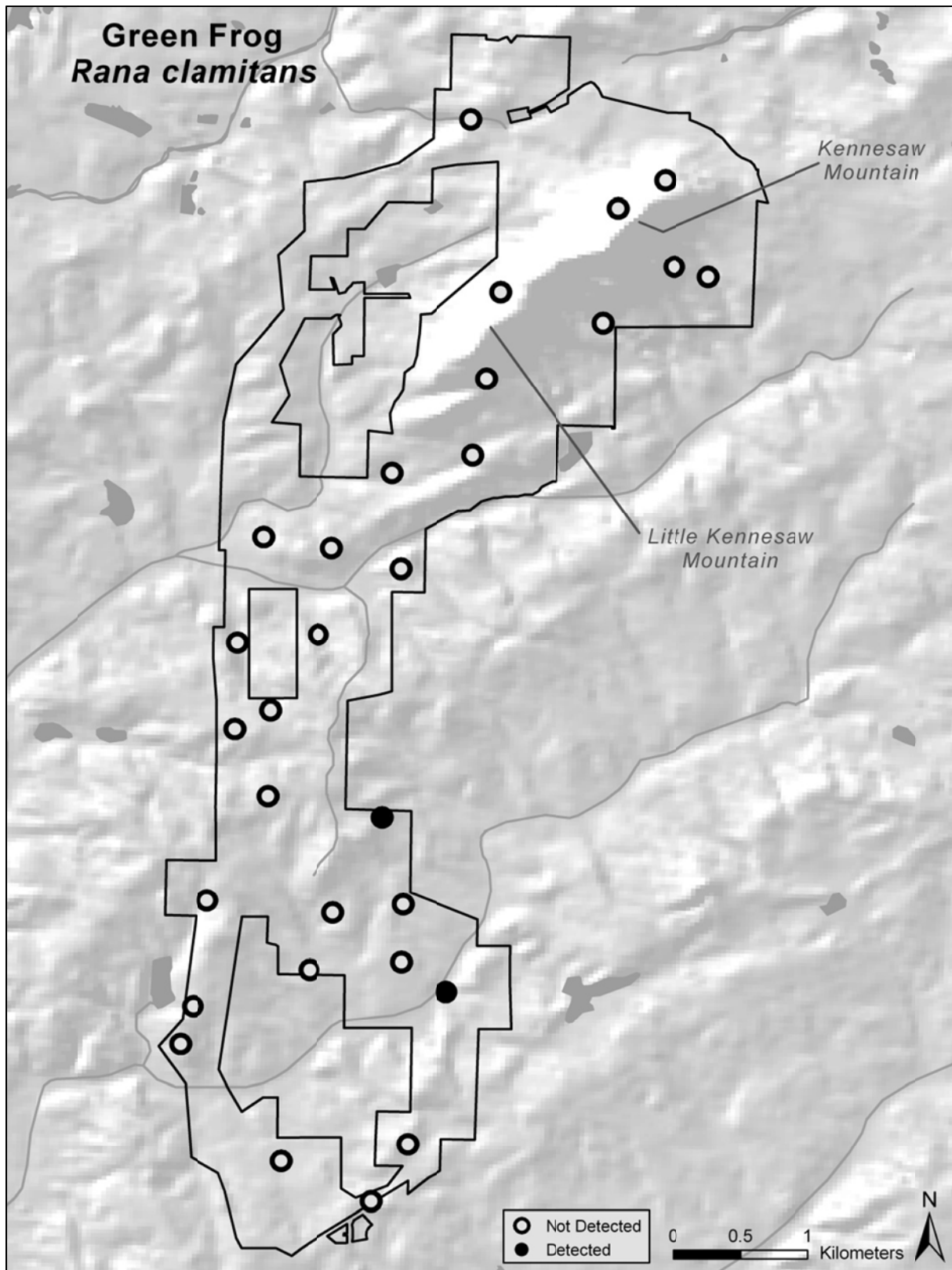


Figure 9. Sampling locations where green frog (*Rana clamitans*) was detected at KEMO, 2009.
● = detected, ○ = not detected.

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Appendix A. Vocal anurans known to occur at KEMO.

Table A-1. Vocal anurans known to occur at KEMO based upon records in NPSpecies (2011) or from monitoring efforts presented herein.

Order	Family	Scientific Name	Common Name	NPSpecies	ARD
Anura	Bufonidae	<i>Bufo americanus</i>	American Toad	X	
Anura	Bufonidae	<i>Bufo fowleri</i>	Fowler's Toad	X	X
Anura	Hylidae	<i>Acris crepitans</i>	Northern Cricket Frog	X	X
Anura	Hylidae	<i>Hyla chrysoscelis</i>	Cope's Gray Treefrog	X	X
Anura	Hylidae	<i>Hyla cinerea</i>	Green Treefrog		X
Anura	Hylidae	<i>Hyla versicolor</i>	Gray Treefrog	X	
Anura	Hylidae	<i>Pseudacris crucifer</i>	Spring Peeper	X	X
Anura	Hylidae	<i>Pseudacris feriarum</i>	Southeastern Chorus Frog	X	
Anura	Ranidae	<i>Rana catesbeiana</i>	Bullfrog	X	
Anura	Ranidae	<i>Rana clamitans</i>	Green Frog	X	X
Anura	Ranidae	<i>Rana palustris</i>	Pickereel Frog	X	
Anura	Ranidae	<i>Rana sphenoccephala</i>	Southern Leopard Frog	X	

Appendix B. Map of sampling locations with point labels.

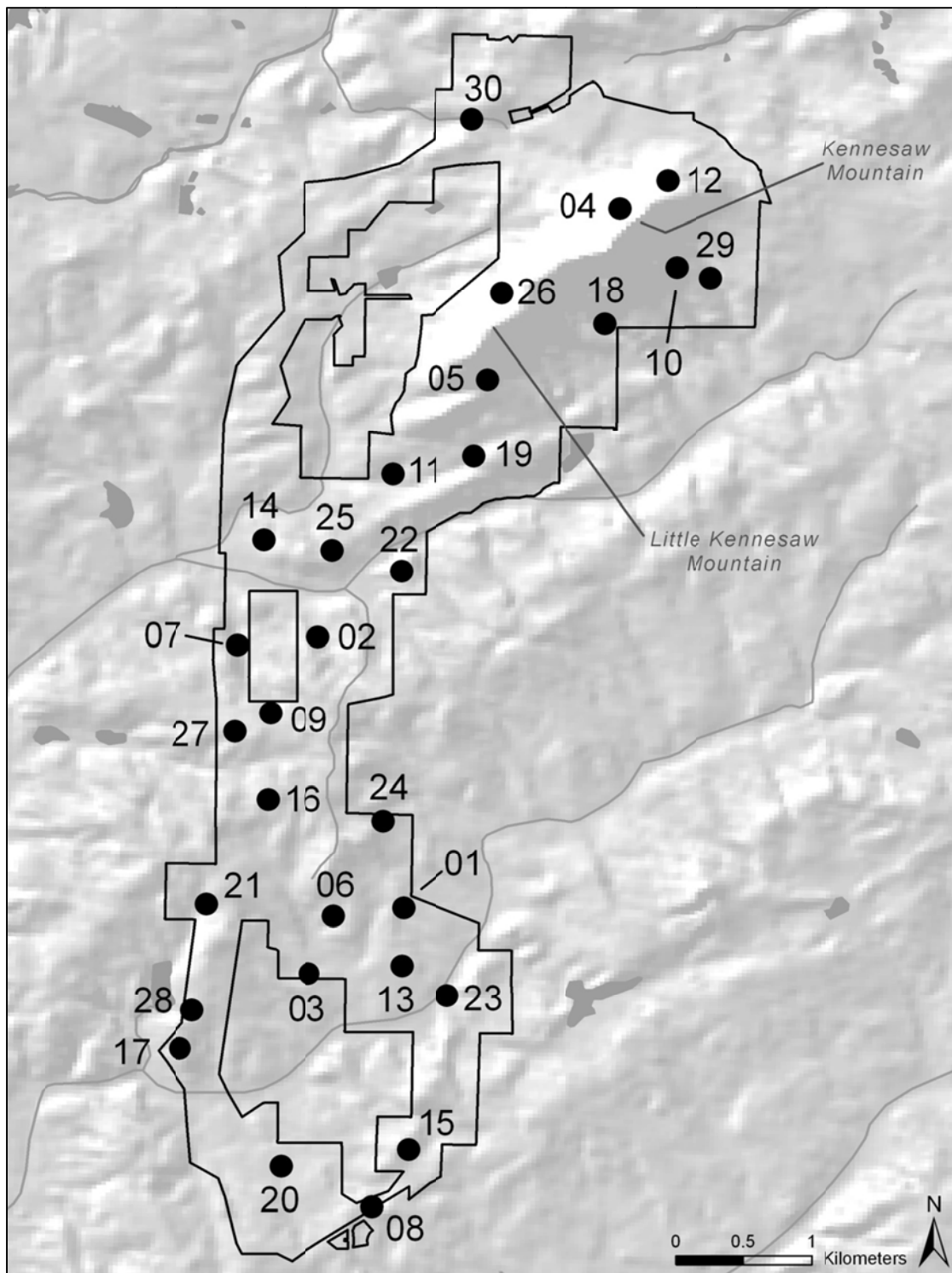


Figure B-1. Spatially-balanced random sampling locations at KEMO with labels, 2009.

Appendix C. Species detections by sampling location.

Table C-1. Species detected at each sampling location at KEMO, 2009. Refer to Appendix B for labeled sampling-locations. Shaded cells indicate ARD malfunction.

Scientific Name	Sampling Location																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
<i>Acris crepitans/gryllus</i>																											X			
<i>Bufo fowleri</i>																													X	
<i>Hyla chrysoscelis</i>																	X							X						
<i>Hyla cinerea</i>																							X							
<i>Pseudacris crucifer</i>																	X						X	X			X			
<i>Rana clamitans</i>																							X	X						