



Summary of Vocal Anuran Monitoring at Ocmulgee National Monument, 2009

Natural Resource Report NPS/SECN/NRDS—2011/157



ON THE COVER

Gastrophysone carolinensis (Eastern narrow-mouthed toad)

Photograph by SECN staff.

Summary of Vocal Anuran Monitoring at Ocmulgee National Monument, 2009

Natural Resource Data Series NPS/SECN/NRDS—2011/157

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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 Ocmulgee National Monument in 2009.

1. Data were collected at 20 spatially-balanced random locations at the Park.
2. Sampling activities occurred at the Park from 5/5/2009 to 5/15/2009.
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 11 of the 16 vocal anurans known to occur at the Park.
5. No non-native amphibians were detected.
6. Bird-voiced treefrog was the most widely distributed species.
7. Full protocol implementation will be implemented at the Park in 2011.
8. 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

Ocmulgee National Monument (OCMU) is located in central Georgia in the city of Macon (Figure 1). The Monument occurs in the transition zone (i.e., “Fall Line”) between the Piedmont and the Atlantic Coastal Plain. The goal of the Monument is to preserve and interpret approximately 12,000 years of rich and varied human inhabitation of the site; including over 1,000 years of occupation by the Mississippian mound-building culture.

The 284-ha (702 ac) Monument is bordered to the west by the Ocmulgee River. Although several small streams feed into the Ocmulgee River upstream from the Monument, the main flow of the river is regulated outflow from the man-made reservoir of Lake Jackson. Despite a regulated flow, periodic flooding events occur in the floodplain mimicking natural and historic patterns. The Monument primarily consists of a large floodplain, herbaceous wetlands, and adjacent uplands. The floodplain vegetation community is composed of several canopy species, including green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), hackberry (*Celtis* spp.), and red maple (*Acer rubrum*), while the uplands are characterized by canopy species such as loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*), and oaks (*Quercus* spp.). Smartweed (*Polygonum* spp.) and maidencane (*Panicum hemitomon*) often occur in the herbaceous wetlands.

As with many urban parks, the Monument has a prominent wildland-urban interface. Interstate 16 occurs on the western edge and a major railroad traverses the Monument. Because the Monument is adjacent to the Ocmulgee River, however, it serves as a critical corridor for a variety of wildlife species facilitating movement to other protected lands north and south of the Monument.

OCMU has 16 known vocal anurans (i.e., frogs and toads that vocalize; Table A-1).

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

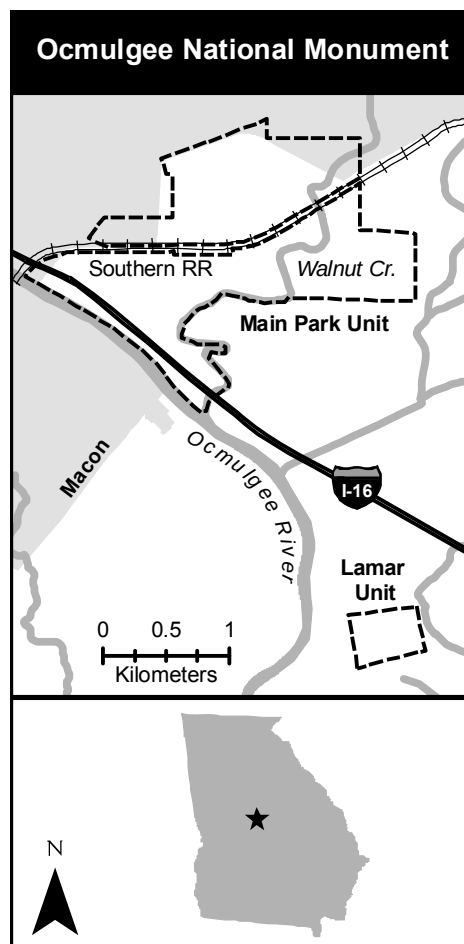


Figure 1. Location of Ocmulgee National Monument.

(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 20 was chosen after 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 5/5/2009 to 5/15/2009. Two of the devices malfunctioned resulting in a total of 5,760 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.

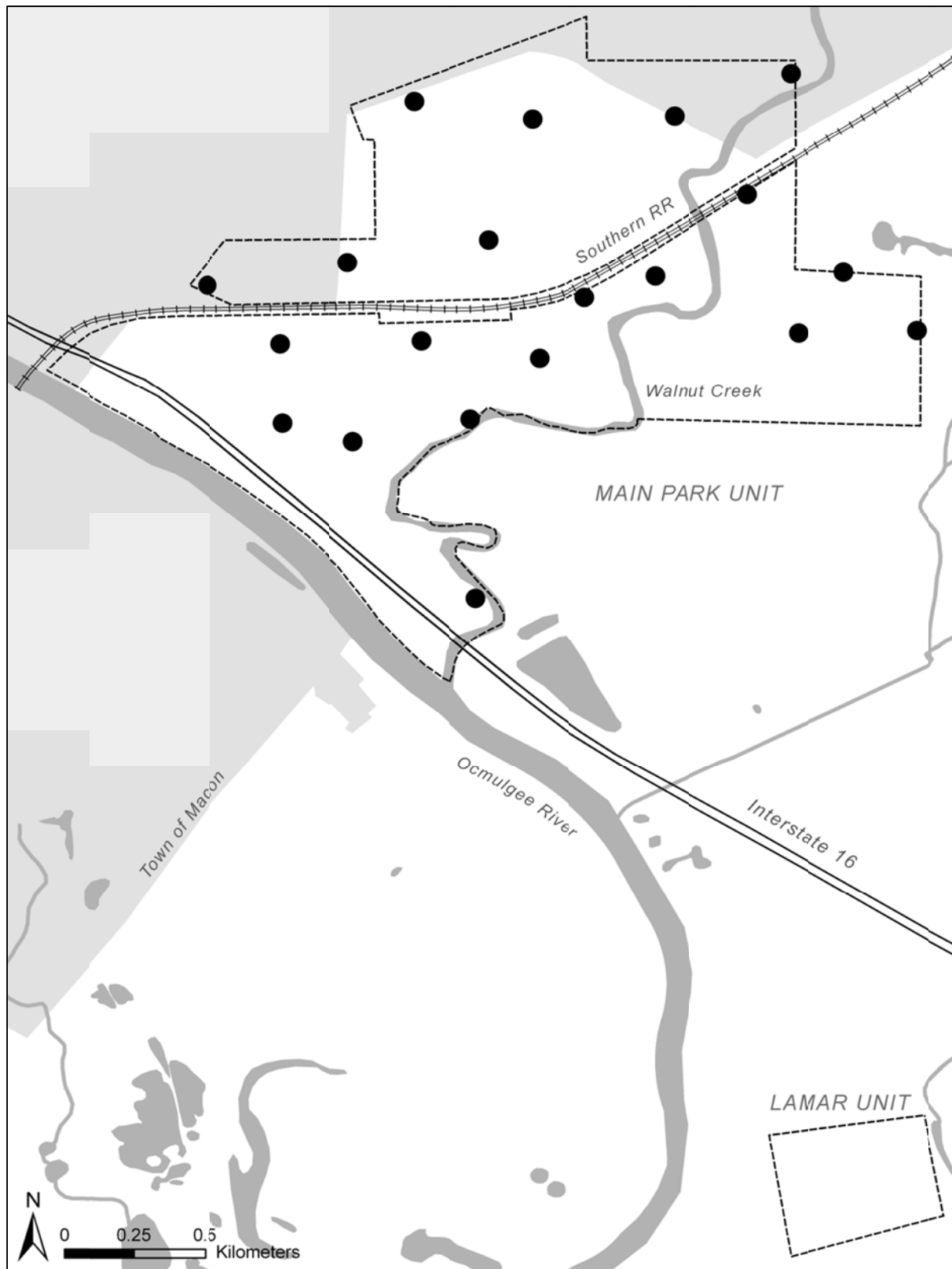


Figure 2. Spatially-balanced random sampling locations at OCMU, 2009.

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. For all species detected, a naïve estimate of occupancy is calculated as the proportion of sites where the species was detected at least once and unadjusted for probability of detection. All non-native species detections were pooled to calculate the proportion of sites where at least one non-native species was detected. Future data analyses will include estimates of occupancy adjusted for probability of detection (MacKenzie et al. 2002) and taking into account environmental covariates known to influence the probability of detection of amphibians (e.g., rainfall and temperature).

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 approximately 18, the number of actual samples collected (two of the 20 devices malfunctioned). Therefore, the ARD results are suggestive in adequately characterizing vocal-anuran community diversity at the Monument. This was not expected and we consider this finding very promising given the goal of this monitoring effort was to test only the ARD component of the SECN amphibian-community monitoring protocol (Byrne et al., *in preparation*).

Observed species richness (i.e., S_{obs}) is 11 (95% CI: 9.68, 12.31). All indices are consistent with one another and appear to perform well given the dataset (i.e., low uncertainty indicated by small 95% confidence intervals). Estimates of true vocal anuran species richness range from the observed value of 11 to just under 13 (Table 2).

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 OCMU, 2009.

Index	Symbol	Value	Lower 95% CI	Upper 95% CI	Value Interpretation
Native Spp. Richness	S_{obs}	11.00	9.68	12.31	Number of native species detected.
Chao 2	Chao2	11.18	11.00	14.91	Estimated true species richness.
Incidence-based Coverage	ICE	12.49	10.65	14.33	Estimated true species richness.
Jackknife 1	Jack1	12.88	10.35	15.41	Estimated true species richness.
Jackknife 2	Jack2	11.32	8.18	14.46	Estimated true species richness.
Bootstrap	Boot	12.19	11.13	13.25	Estimated true species richness.

Composition

We detected eleven amphibian species. Bird-voiced treefrog (*Hyla avivoca*) was detected at more sampling locations than any other species, followed by green treefrog (*Hyla cinerea*), cricket frog (*Acris gryllus/crepitans*), green frog (*Rana clamitans*), and Southern toad (*Bufo terrestris*) (Figure 3). Squirrel treefrog (*Hyla squirella*) and Eastern narrow-mouthed toad (*Gastrophryne carolinensis*) were only detected at one sampling location. Occupancy provides insight into the distribution of species across the park and whether a species is commonly or uncommonly encountered; however, this is strongly influenced by a species' detectability (which will be accounted for in future analyses) as more-easily detected species may be more frequently encountered (and vice versa). Bird-voiced treefrog was also the most frequently encountered species, again followed by green treefrog, cricket frog, and green frog (Table 3). No non-native species were detected.

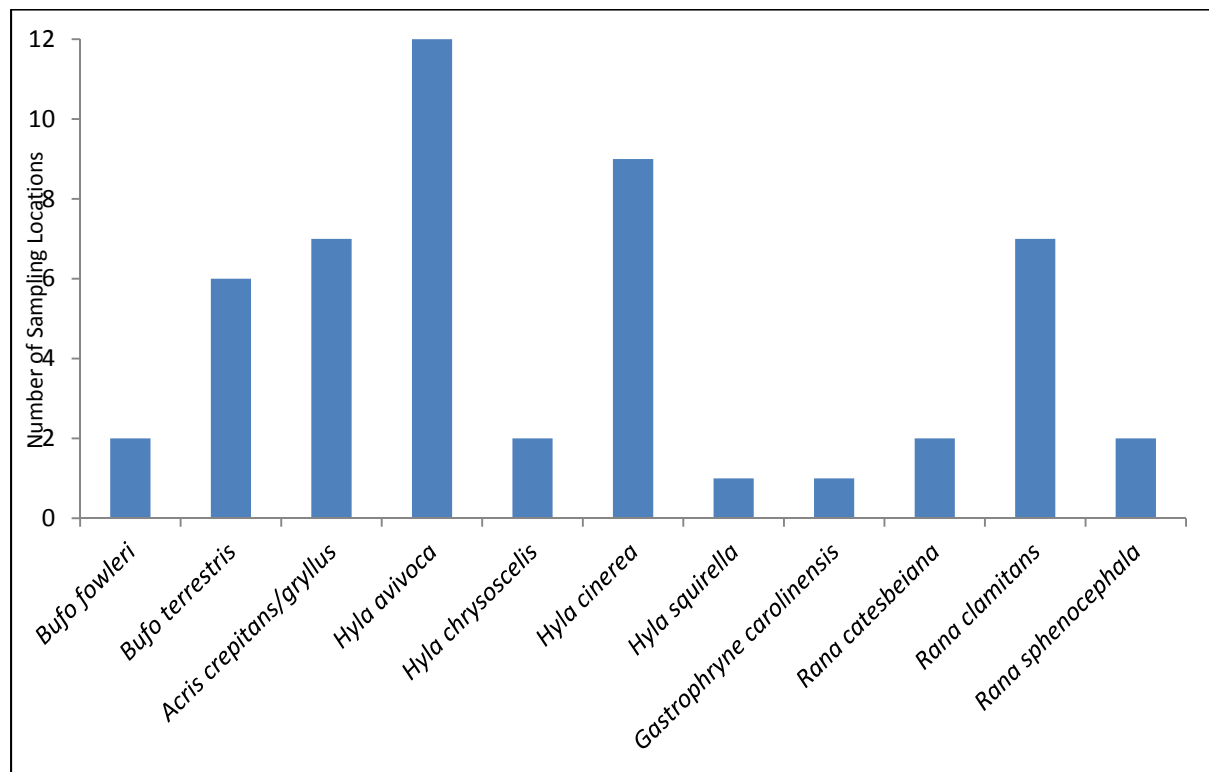


Figure 3. Number of sampling locations where each species was detected at OCMU, 2009.

Table 3. Naïve occupancy estimates (proportion of sites where the species was detected) for amphibians at OCMU, 2009.

Scientific Name	Common Name	Frequency of Occurrence
<i>Hyla avivoca</i>	Bird-voiced treefrog	0.67
<i>Hyla cinerea</i>	Green treefrog	0.50
<i>Acris crepitans/gryllus</i>	Cricket frog	0.39
<i>Rana clamitans</i>	Green frog	0.39
<i>Bufo terrestris</i>	Southern toad	0.33
<i>Bufo fowleri</i>	Fowler's toad	0.11
<i>Hyla chrysoscelis</i>	Cope's gray treefrog	0.11
<i>Rana catesbeiana</i>	Bullfrog	0.11
<i>Rana sphenocephala</i>	Southern leopard frog	0.11
<i>Hyla squirella</i>	Squirrel treefrog	0.06
<i>Gastrophryne carolinensis</i>	Eastern narrow-mouthed toad	0.06

Distribution

Bird-voiced treefrog was the most widely distributed species at the Park (Figure 5). Southern toad, cricket frog, green treefrog, and green frog were detected at more than five locations (Figures 6, 7, 8, 9) while squirrel and Eastern narrow-mouthed toad were only detected at one location (Figures 10, 11). The most species were detected at sampling locations 13 (n=8) and 20 (n=7) (Figure B-1, Table C-1).

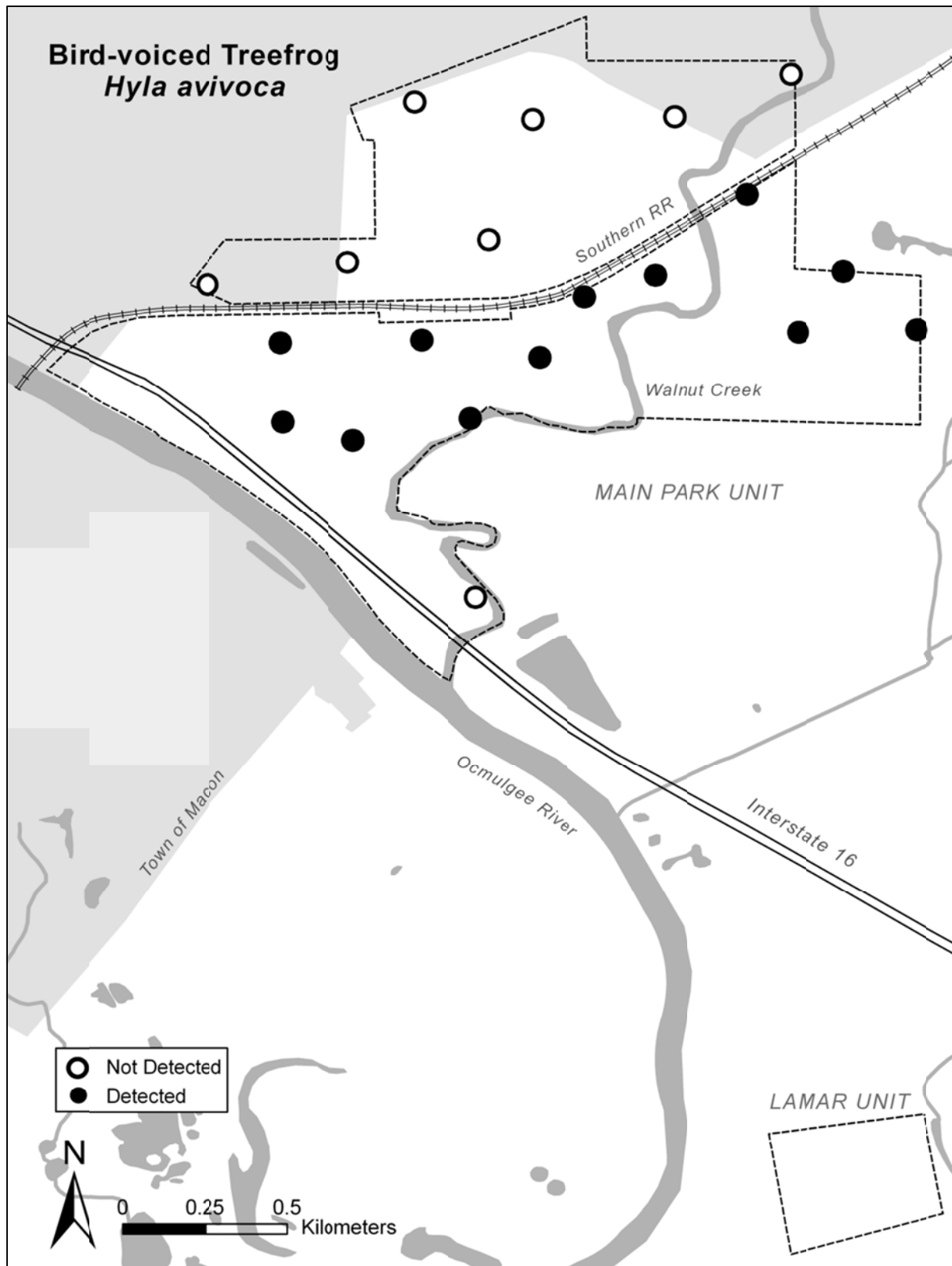


Figure 5. Sampling locations where bird-voiced treefrog (*Hyla avivoca*) was detected at OCMU, 2009. ● = detected, ○ = not detected.

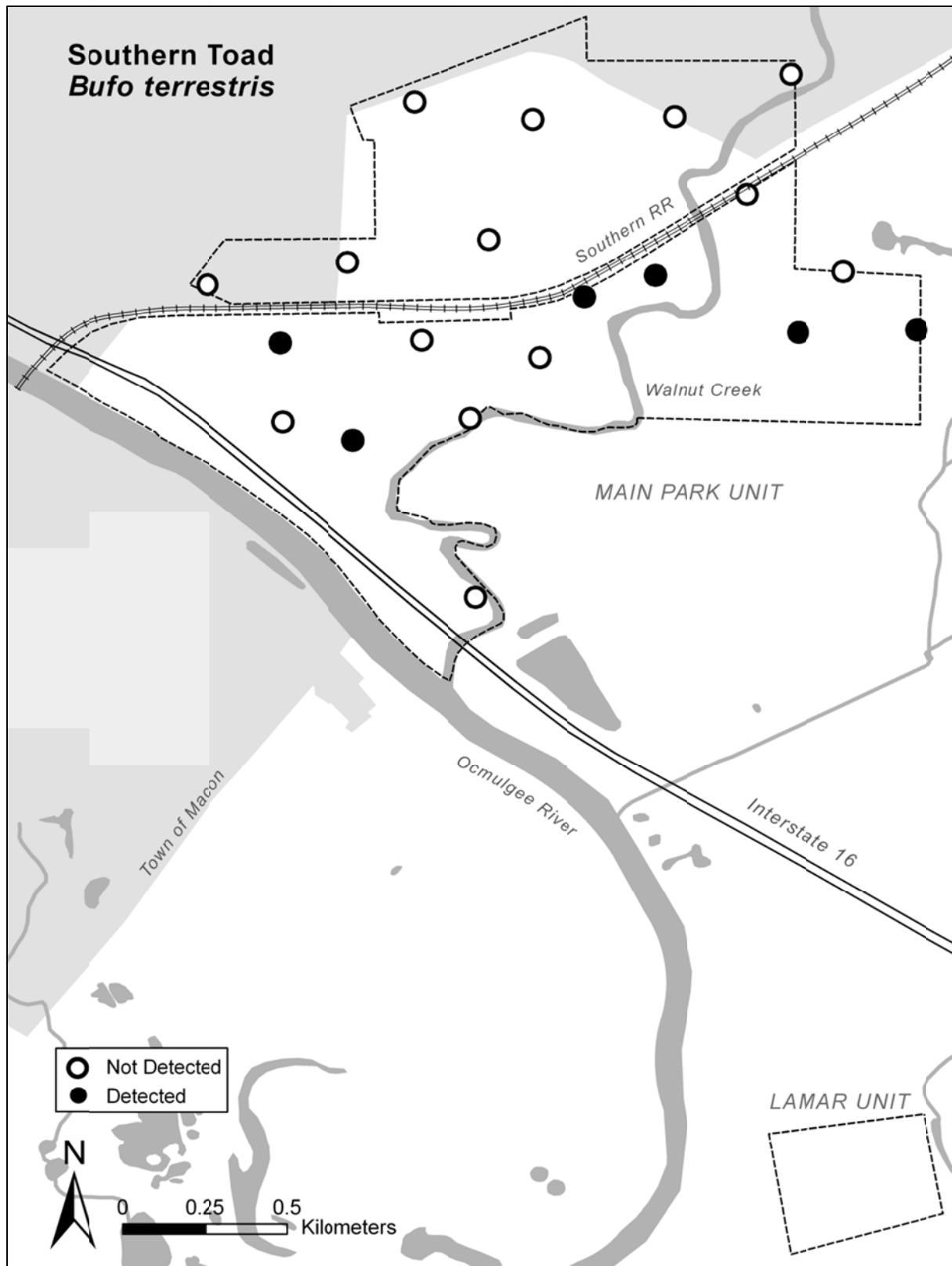


Figure 6. Sampling locations where Southern toad (*Bufo terrestris*) was detected at OCMU, 2009.
● = detected, ○ = not detected.

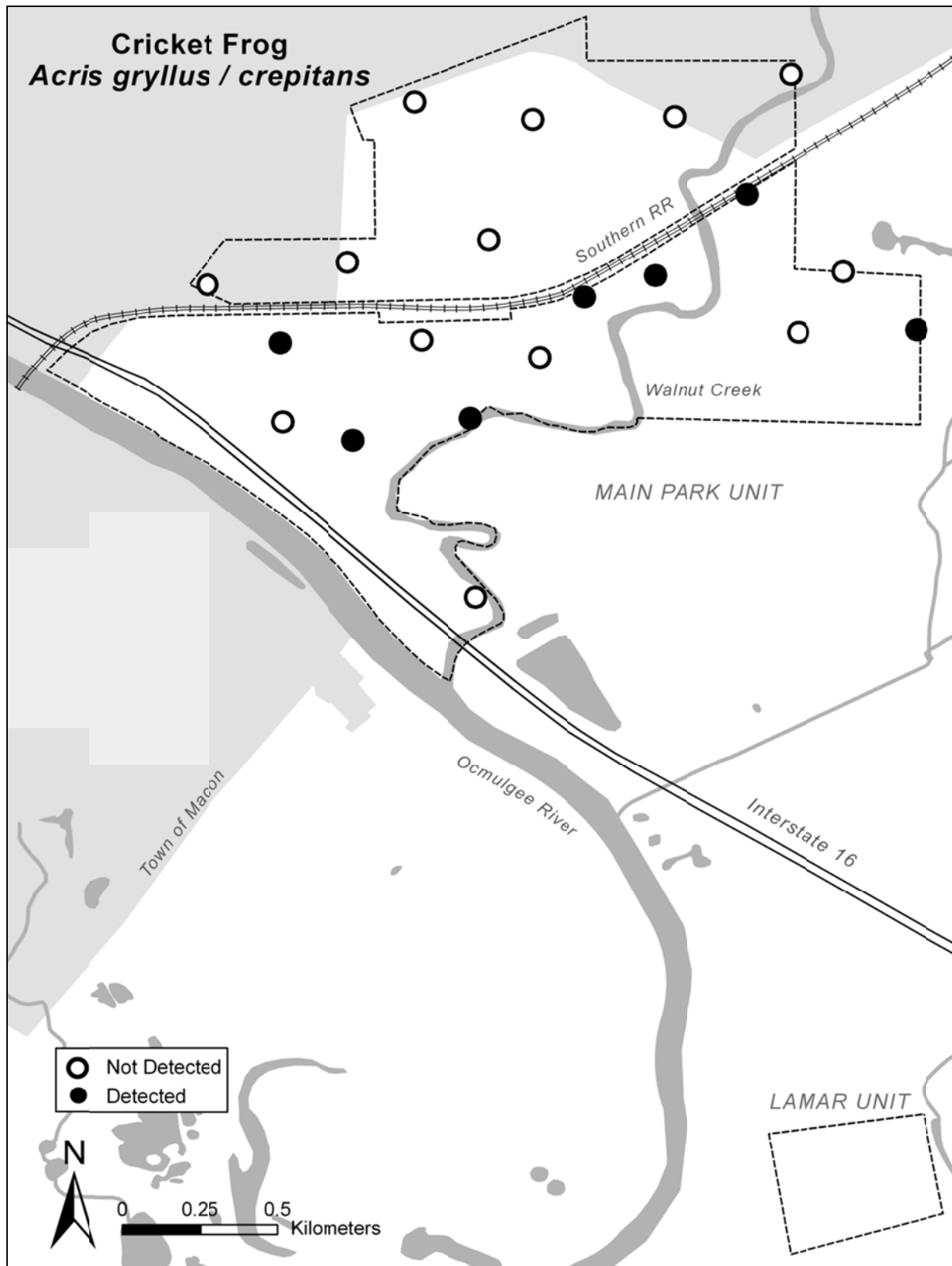


Figure 7. Sampling locations where cricket frog (*Acris gryllus / crepitans*) was detected at OCMU, 2009. ● = detected, ○ = not detected.

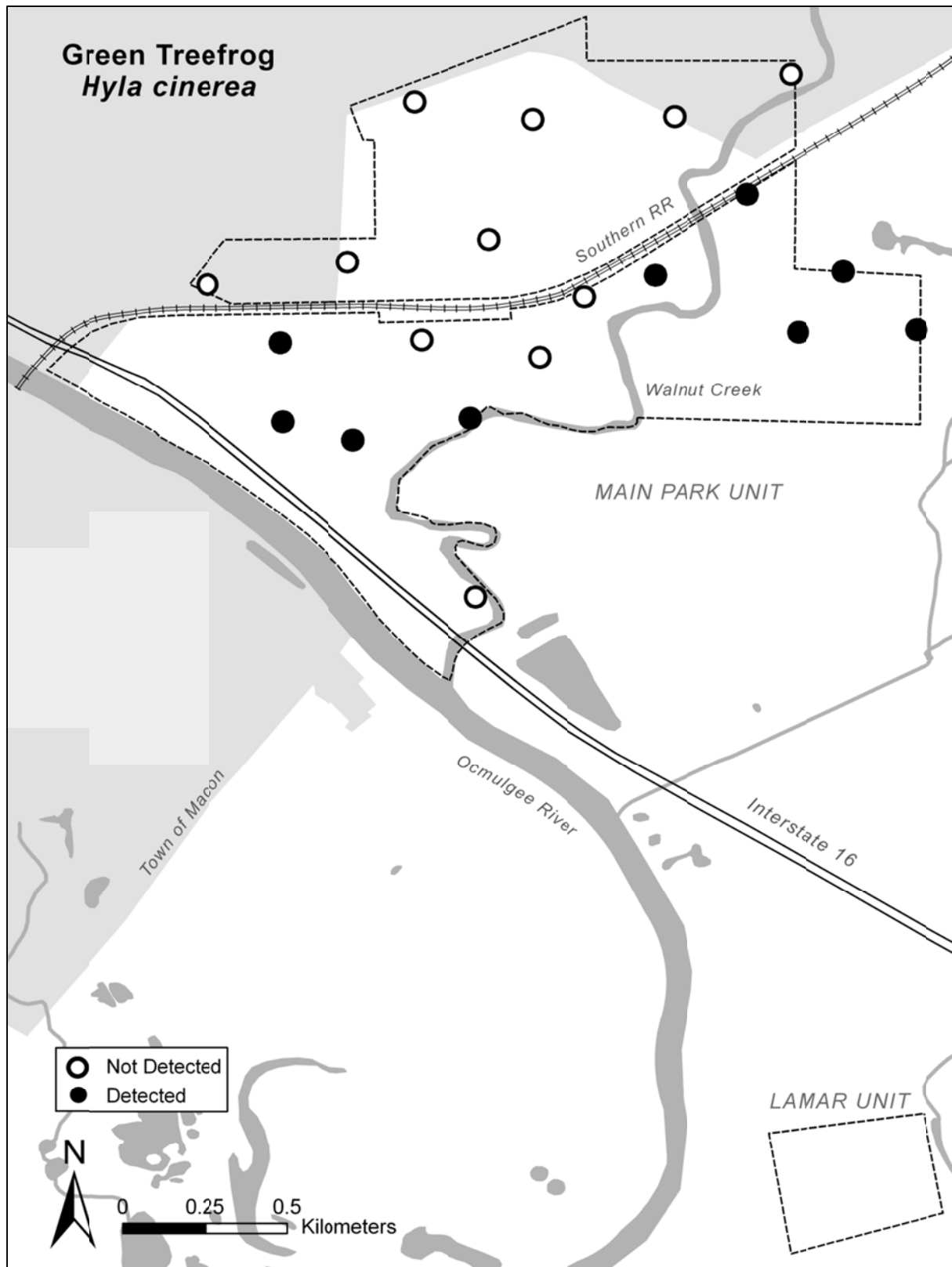


Figure 8. Sampling locations where green treefrog (*Hyla cinerea*) was detected at OCMU, 2009.
● = detected, ○ = not detected.

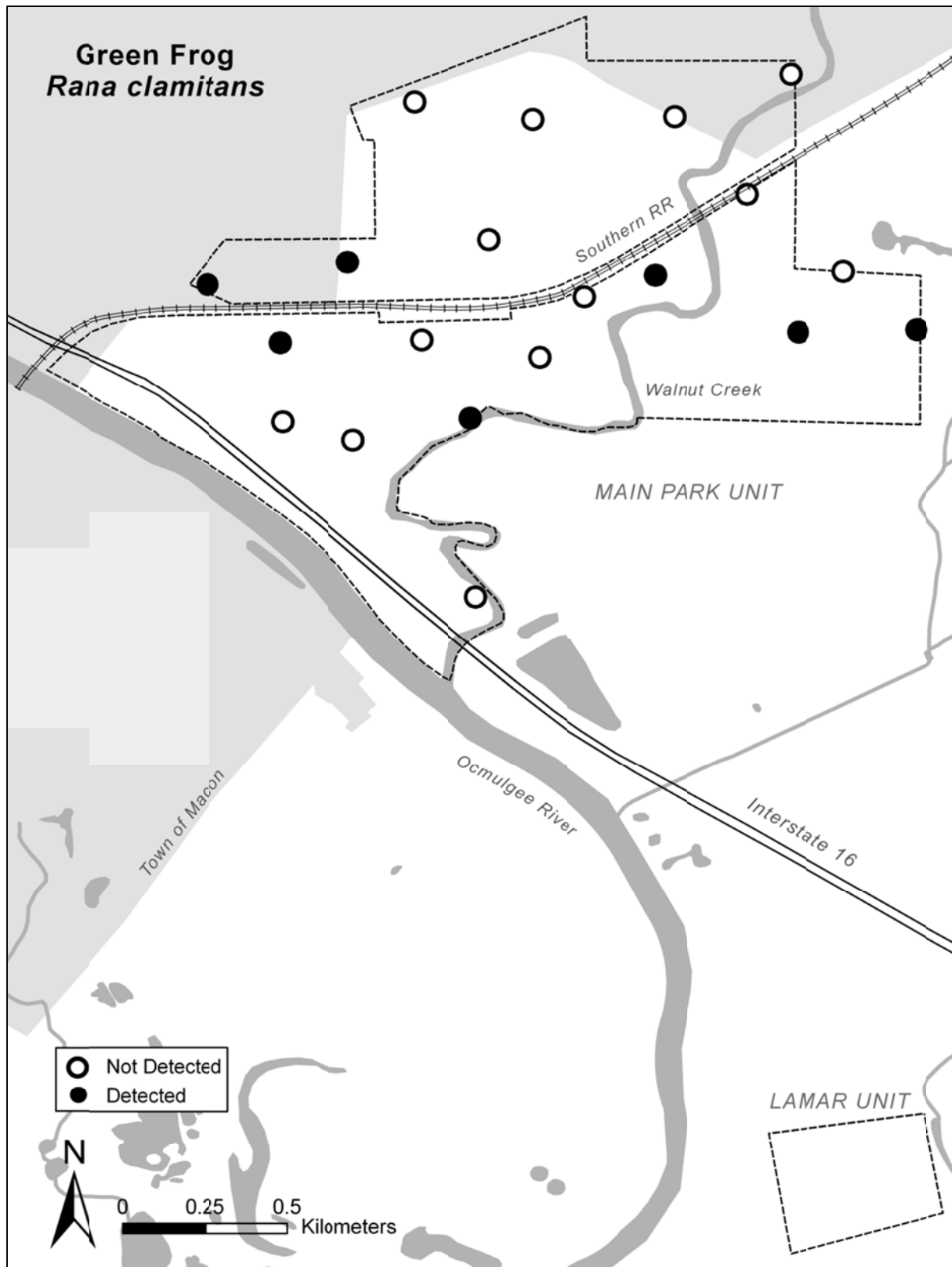


Figure 9. Sampling locations where green frog (*Rana clamitans*) was detected at OCMU, 2009. detected, ○ = not detected.

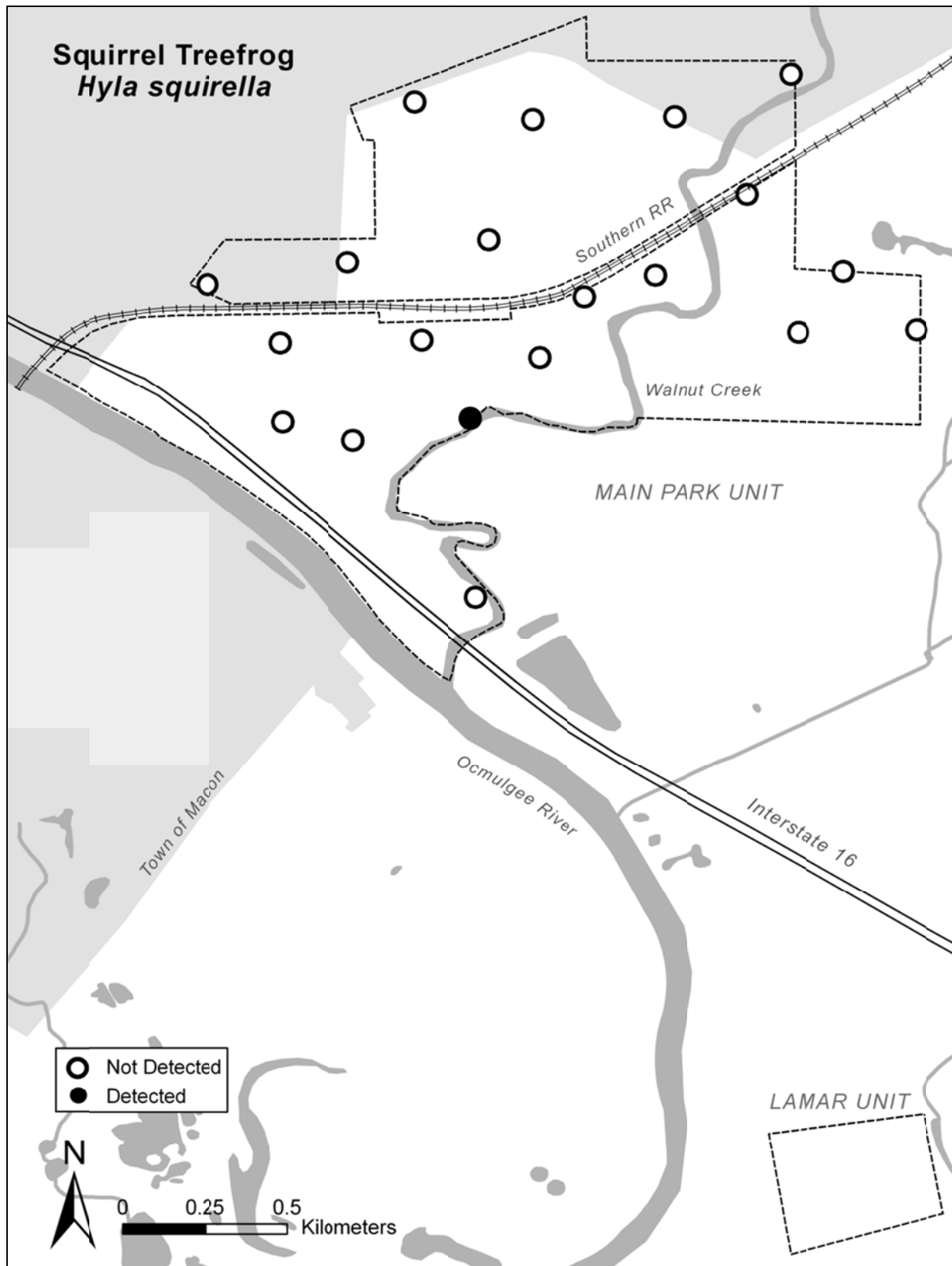


Figure 10. Sampling locations where squirrel treefrog (*Hyla squirella*) was detected at OCMU, 2009.
● = detected, ○ = not detected.

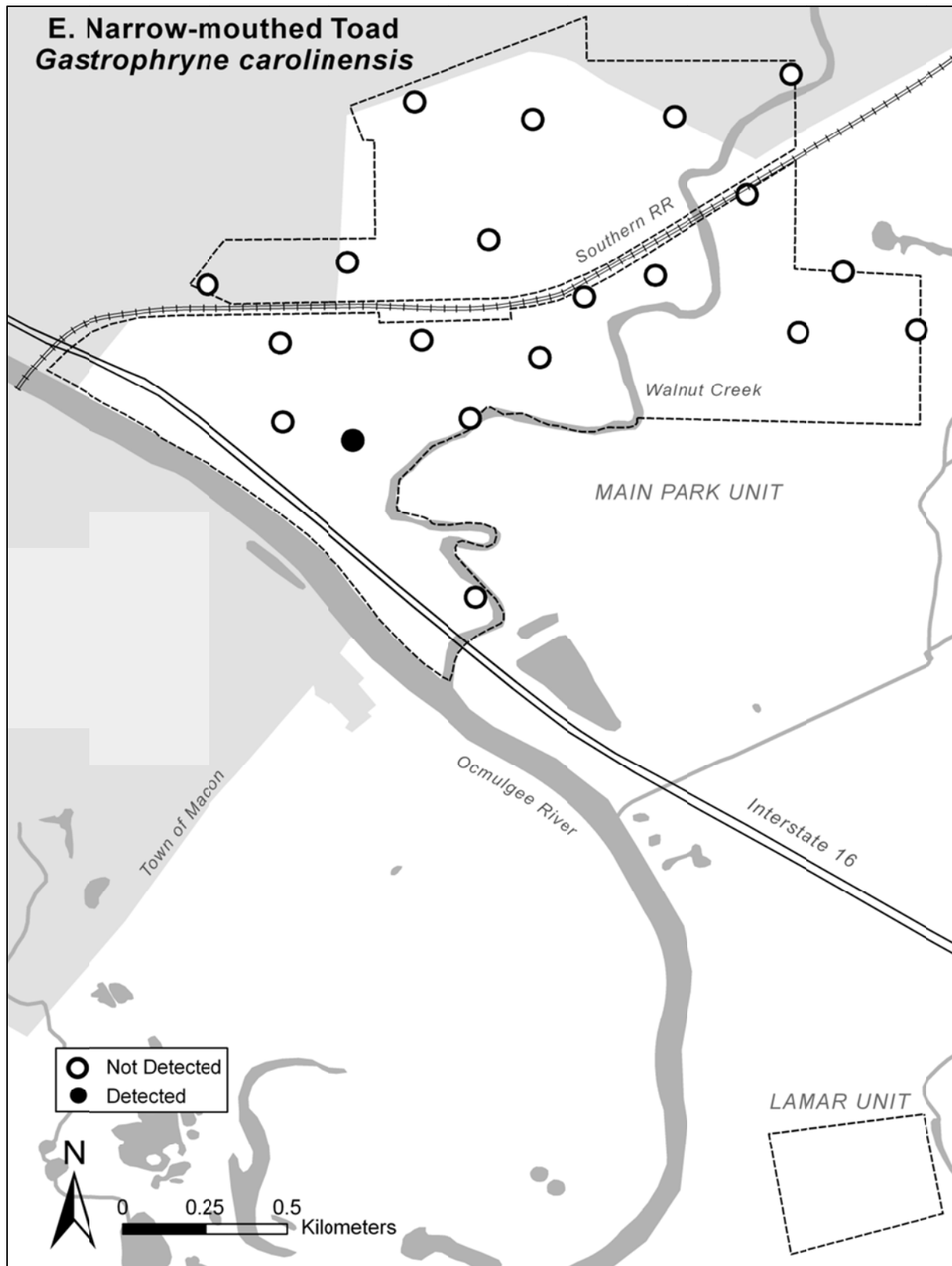


Figure 11. Sampling locations where Eastern narrow-mouthed toad (*Gastrophryne carolinensis*) was detected at OCMU, 2009. ● = detected, ○ = not detected.

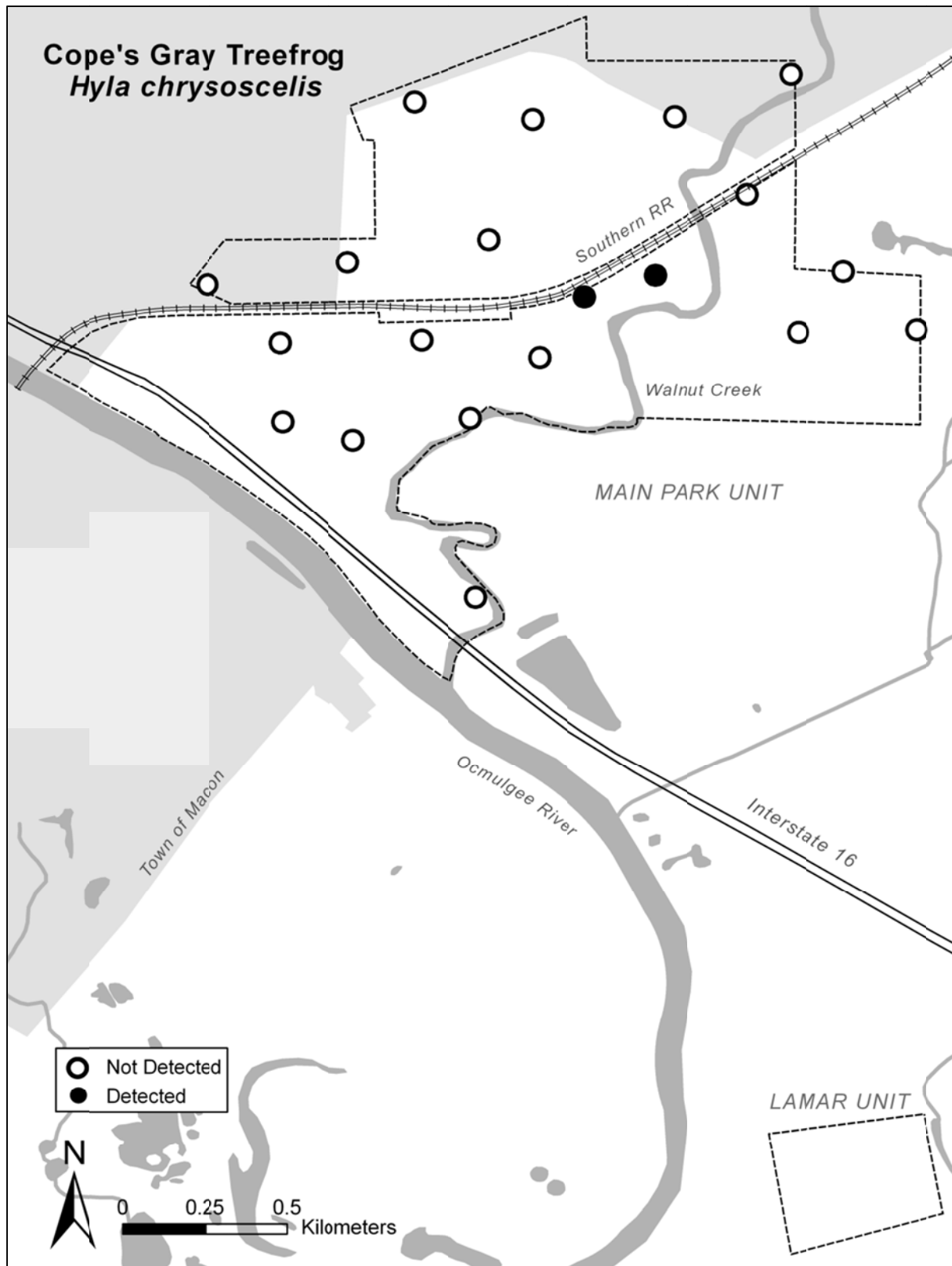


Figure 12. Sampling locations where Cope's gray treefrog (*Hyla chrysoscelis*) was detected at OCMU, 2009. ● = detected, ○ = not detected.

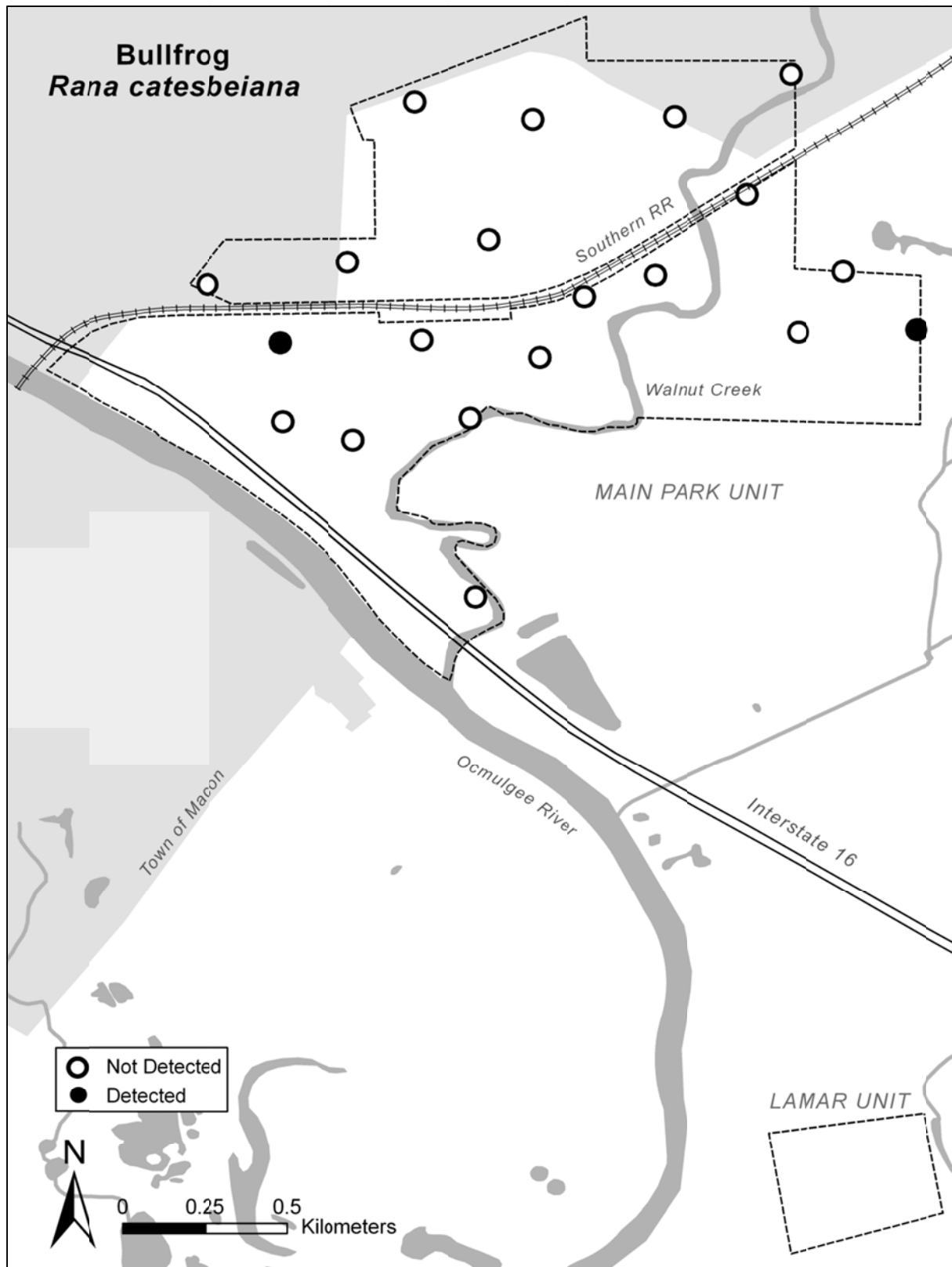


Figure 13. Sampling locations where bullfrog (*Rana catesbeiana*) was detected at OCMU, 2009.
● = detected, ○ = not detected.

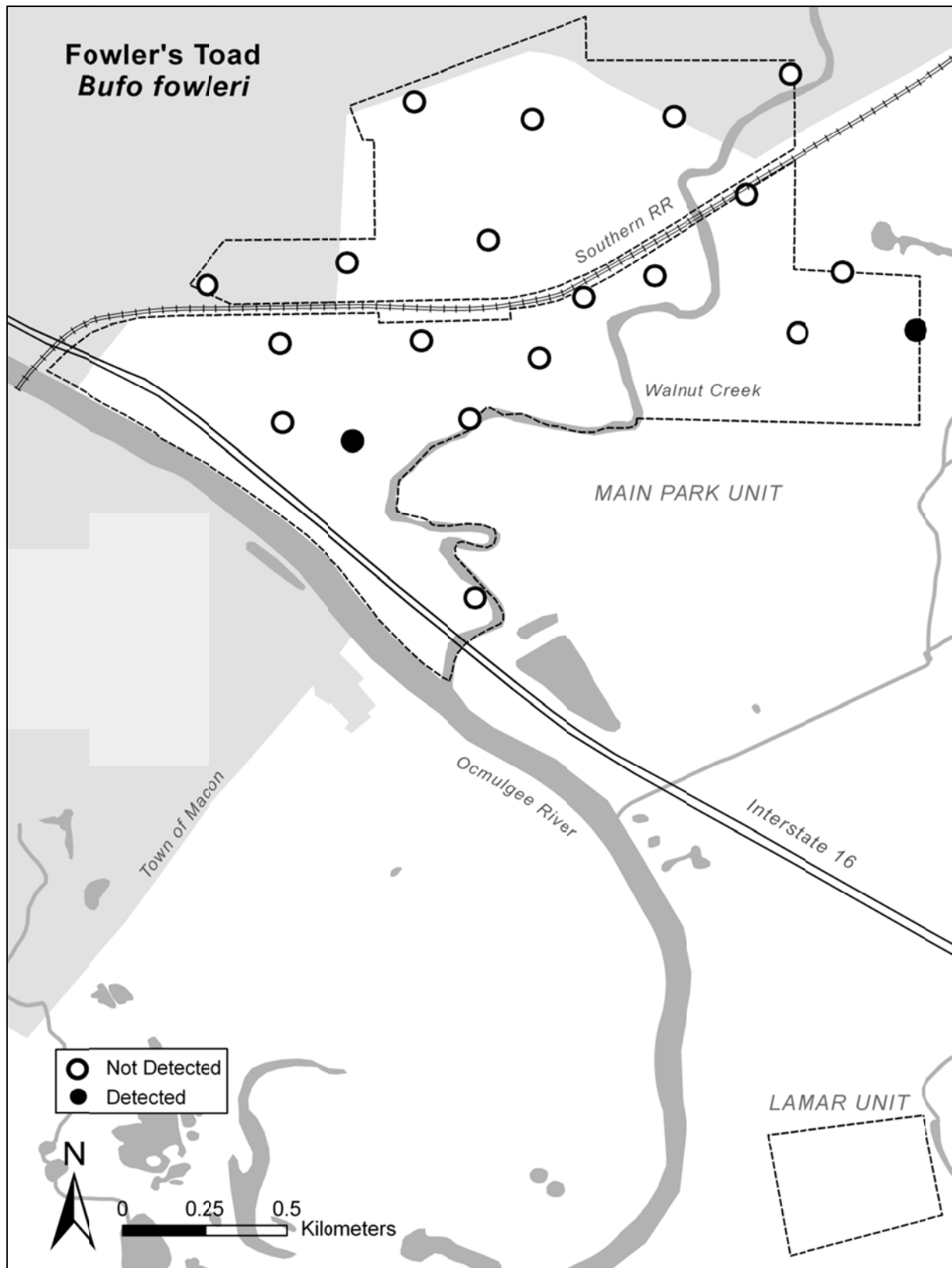


Figure 14. Sampling locations where Fowler's toad (*Bufo fowleri*) was detected at OCMU, 2009.
● = detected, ○ = not detected.

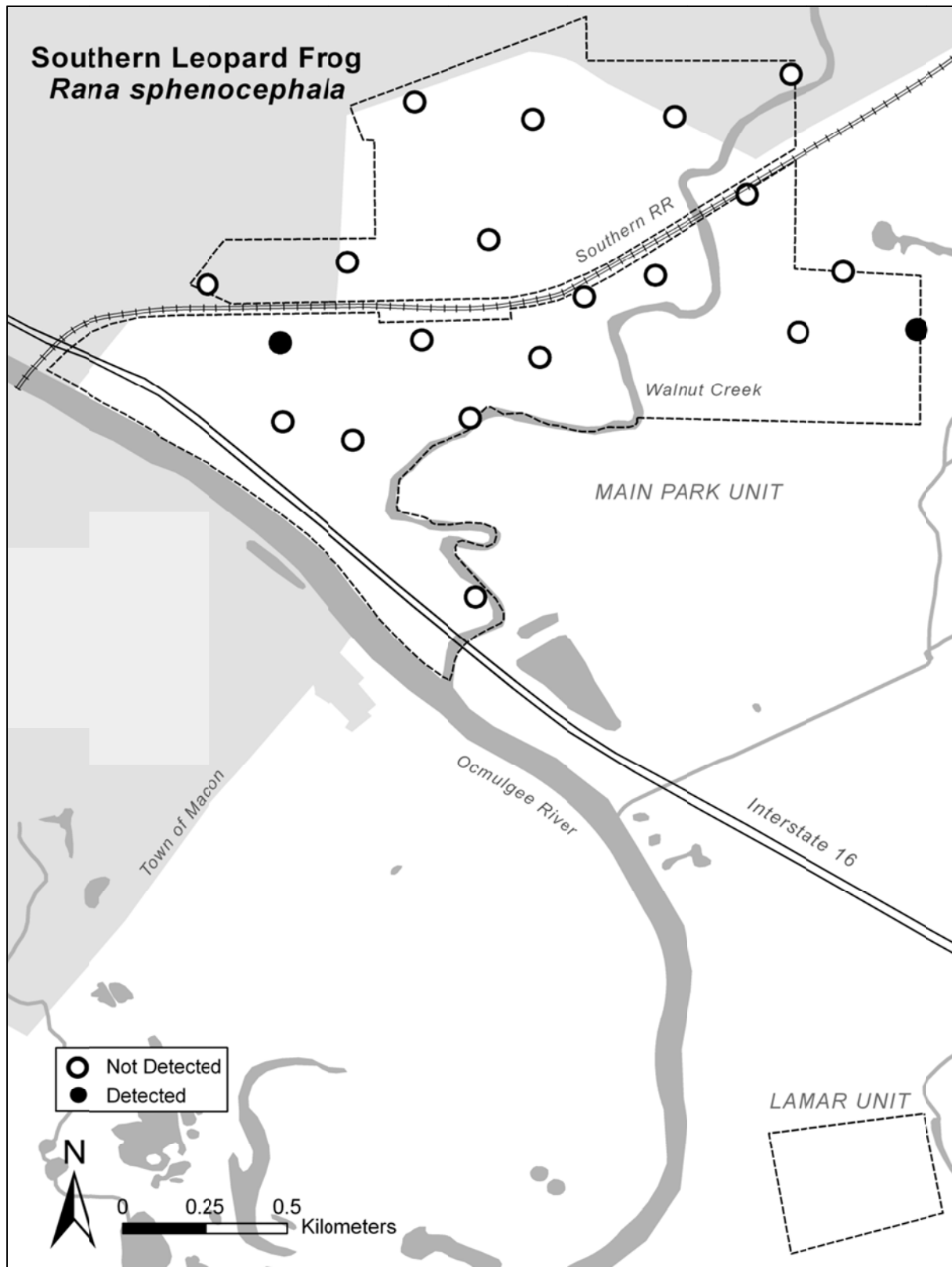


Figure 15. Sampling locations where Southern leopard frog (*Rana sphenoccephala*) was detected at OCMU, 2009. ● = detected, ○ = not detected.

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Appendix A. Vocal anurans known to occur at OCMU.

Table A-1. Vocal anurans known to occur at OCMU based upon records in NPSpecies (2011).

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	Bufonidae	<i>Bufo terrestris</i>	Southern toad	X	X
Anura	Hylidae	<i>Acris crepitans/ gryllus</i>	Northern / Southern cricket frog	X	X
Anura	Hylidae	<i>Hyla avivoca</i>	Bird-voiced treefrog	X	X
Anura	Hylidae	<i>Hyla chrysoscelis</i>	Cope's gray treefrog	X	X
Anura	Hylidae	<i>Hyla cinerea</i>	Green treefrog	X	X
Anura	Hylidae	<i>Hyla squirella</i>	Squirrel treefrog	X	X
Anura	Hylidae	<i>Pseudacris crucifer</i>	Spring peeper	X	
Anura	Hylidae	<i>Pseudacris nigrita</i>	Southern chorus frog	X	
Anura	Hylidae	<i>Pseudacris ornata</i>	Ornate chorus frog	X	
Anura	Microhylidae	<i>Gastrophryne carolinensis</i>	Eastern narrow-mouthed toad	X	X
Anura	Ranidae	<i>Rana catesbeiana</i>	Bullfrog	X	X
Anura	Ranidae	<i>Rana clamitans</i>	Green frog	X	X
Anura	Ranidae	<i>Rana sphenoccephala</i>	Southern leopard frog	X	X

Appendix B. Map of sampling locations with point labels.

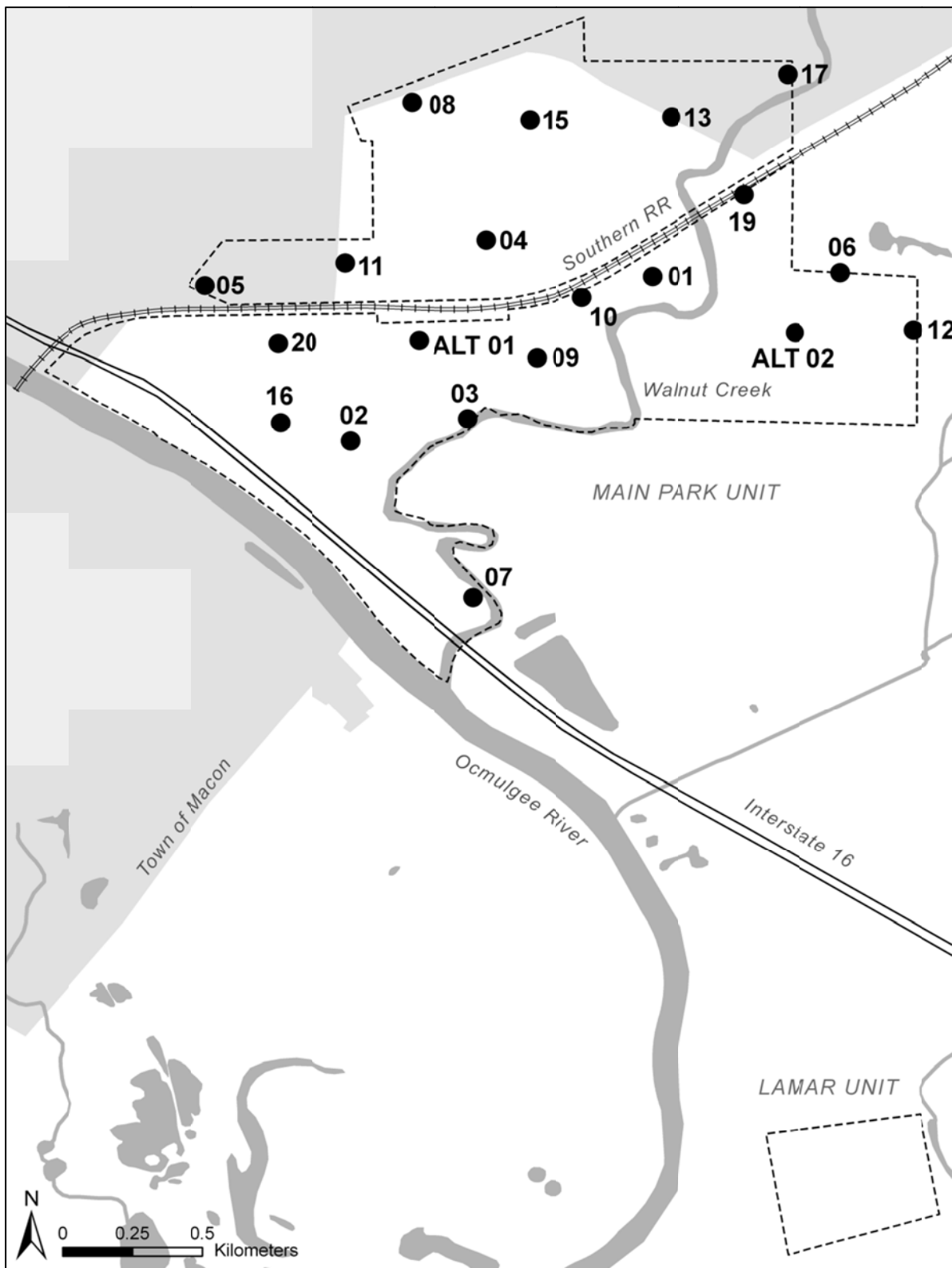


Figure B-1. Spatially-balanced random sampling locations at OCMU with labels, 2009.

Appendix C. Species detections by sampling location.

Table C-1. Species detected at each sampling location at OCMU, 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	15	16	17	19	20	A1	A2
<i>Acris crepitans/gryllus</i>	X	X	X							X			X				X	X		
<i>Bufo fowleri</i>		X											X							
<i>Bufo terrestris</i>	X	X								X			X					X		X
<i>Gastrophryne carolinensis</i>		X																		
<i>Hyla avivoca</i>	X	X	X			X			X	X			X		X		X	X	X	X
<i>Hyla chrysoscelis</i>	X									X										
<i>Hyla cinerea</i>	X	X	X			X							X		X		X	X		X
<i>Hyla squirella</i>			X																	
<i>Rana catesbeiana</i>													X					X		
<i>Rana clamitans</i>	X		X		X						X		X					X		X
<i>Rana sphenoccephala</i>													X					X		