eMammal Final Report

Triangle Cemeteries

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Contents

Executive Summary

From August to November 2015, eMammal worked with citizen-scientists to conduct a camera-trap mammal survey of cemeteries in the Raleigh, NC area. Between 17 cemeteries we set 61 cameras distributed randomly within each site. All animals in the captured photographs were identified to species by the volunteers, reviewed by experts to verify the species identification, and uploaded to the eMammal data repository housed at the Smithsonian Institution. In this report we present baseline information regarding the presence, activity and site use for all mammal and ground bird species captured on our cameras and compare these with other nearby sites that eMammal sampled concurrently. We present detection maps for common species as well as measures of species richness and intensity of use of the commonly detected species and make some comparisons between the cemetery sites.

The survey was conducted over a period of three months resulting in a total of 1228 camera nights of survey effort and over 1,437 animal detections. Of the 10 mammal species detected by our cameras, white-tailed deer was the most common followed by eastern gray squirrel, wild turkey, and gray fox. The most rarely detected species were woodchuck and eastern cottontail. We also detected both domestic dogs and domestic cats, but they are not included in the data results. Species richness was highest in Falls Community Cemetery and Mount Hope Cemetery, and lowest in Beechwood Cemetery. Between habitat types, animal activity was highest in rural habitats, and lowest in suburban habitats. White-tailed deer were highly detected among all cemeteries and habitat types, while coyotes and eastern gray squirrels were mainly in rural habitats and red foxes were mainly found in suburban areas.

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1.0 Introduction

1.1 General Background

Most mammals possess large home ranges and are affected by ecological processes that occur on a fairly large scale. Studying the ecology of those species is most relevant at the large, landscape scales, however studies of wildlife on these larger scales are rare. This is because data collection on the larger scales (landscape, regional, national, global) is generally constrained by budget and manpower. Citizen Science represents a new avenue for conducting large-scale biological studies because volunteers provide the manpower and thus larger volumes of data can be collected for less money. While Citizen Science offers some clear advantages to biological data collection, there are also potential challenges. Variation in volunteer skills can lead to variation in sampling efforts and data quality, which can be a major concern for this type of work. Rigorous training and a simple sampling design is key to getting the most out of Citizen Science collected data. Despite the challenges, Citizen Scientist projects are valuable not only because of the important scientific data they collect but also because of their involvement the community in nature and sciences. The success of this approach is most obvious in birds, where a long history of bird monitoring programs such as Christmas Bird Counts or Breeding Bird Surveys have not only provided important long-term data on bird populations (Sauer 2008), but also help build large communities of bird-watchers who care greatly about the preservation of nature. Modern web technology has allowed for a great expansion in this type of work, with the eBird site receiving now over 1.5 million bird records per month (Sullivan et al. 2009). Mammals are more difficult to see, and thus have not been subject to as many citizen science efforts. Motion-sensitive camera traps offer a new opportunity to engage citizens in collecting survey data on mammal communities. The success of our early citizen science work along the Appalachian Trail shows that this activity is fun for participants (90+% return rate from year to year), and also that it can produce rigorous scientific data (Erb et al. 2012). Indeed, the pictures from camera traps are analogous to museum specimens, providing a photographic voucher of a particular species, recorded at a particular place and time.

1.2 Project Sites

We surveyed a total of 61 sites between August and November 2015 (Figure 1). Sites were chosen at random while avoiding high human traffic areas and maintaining a spacing of at least 200m between adjacent cameras. All cameras ran continuously for approximately 3 weeks. Survey effort within the cemeteries totaled 1,228 camera nights.

1.3 Contents of this Report

This report represents the results of the eMammal project to survey mammal intensity of use and activity in cemeteries along an urban-rural gradient around the city of Raleigh, NC. These results include descriptive statistics and maps of animal detections within cemeteries. The data presented here do not incorporate any estimates of detection probability and may not reflect true abundance. Future analyses of these data will involve occupancy modeling which will allow us to address our questions of the effect of consumptive and non-consumptive recreation on wildlife. Occupancy modeling takes into account detection probability, which allows us to control for site-specific differences that might affect how animals are detected by cameras. In this way, we will be able to make inference using data collected over all sites. However, these analyses will take some time and are therefore not included in this report. We will make the results of these analyses available to all agency and volunteer participants in the form of a peer-reviewed publication by the end of 2017.

2.0 Materials and Methods

Field work began in August 2015. Sixty-one cameras were set by eMammal volunteers for 3 weeks between August and November. All volunteers who helped set cameras for the project were trained either in person or online to ensure that all camera protocols were standardized. All pictures were identified and uploaded using eMammal software to be stored in the Smithsonian Data Repository.

2.1 Volunteer recruitment and training

We recruited student volunteers by working with professors at NCSU to integrate eMammal into the classroom. We recruited citizen-science volunteers by advertising on blogs, radio shows and newspaper articles. Most of our citizen-scientists were adults. In total, 60 volunteers participated in this project, contributing a total of 450 volunteer hours. The eMammal team held two in-person trainings for volunteers at NCSU and required that all other volunteers complete an online, video-based training course. Trainings were comprehensive and included how to use a GPS, how to setup and use a camera trap, how to use the eMammal software and how to identify mammal species. Volunteers were provided with all necessary equipment, including the cameras, memory cards, batteries and camera locks.

2.2 Camera surveys

Camera locations were chosen by the eMammal team in as random a fashion as possible. Adjacent cameras were spaced at least 200m apart to maintain sample independence. Sixty-one sites were sampled over the course of the project. All cameras ran for 3 weeks.

Figure 1: A map of all camera sites sampled by the eMammal Project in cemeteries from August-November 2015.

2.3 Animal data collection and verification

To transfer data from the volunteers to eMammal staff, volunteers used a custom software application called "Leopold" to identify animal pictures and upload the data to a cloud storage location. The eMammal team used a web based data review tool to verify and, if necessary, correct volunteer identifications. Past projects have shown that the average volunteer success in species identification is quite high (97.2%) (Forrester et al. *in review*). The Smithsonian Institution has developed a data repository to store all camera trap photos as digital museum "specimens" that will be curated as a publically accessible Smithsonian collection. This repository is accessible to other institutions to store, search, and analyze their own camera trap data.

2.4 Data analysis

The analyses presented in this report focus on raw animal counts and rates. Raw counts and rates are presented in a number of basic, descriptive ways: species richness, community composition, and activity over time of day. Species richness is the number of species present in a community and is the simplest representation of diversity. To measure species richness, we simply count the number of difference species detected in each protected area. Community composition is another representation of diversity and incorporates the relative abundance of species within the community. This is more accurately a measure of the relative activity level of each species at the site. We used the raw animal count data to generate proportional histograms that to illustrate the active time of each species in each protected area by time of day. This information allows us to compare activity patterns between species and look for indications of attraction or avoidance.

3.0 Results

Compared to other open sites (golf courses) eMammal has sampled in North Carolina, the Triangle area cemeteries had similar species richness with 10 species detected. We were able to detect woodchucks at some of the cemeteries, which were not detected at the golf courses. By contrast, striped skunks were detected on golf courses, but not cemeteries.

3.1 Species Richness

Over the entire study, we detected 10 different mammal species. Species richness (diversity) was highest in Falls Community and Mount Hope Cemeteries, with 7 different mammal species detected (Figure 2). Overall, species richness was highest in the exurban cemeteries (8 species) compared to suburban (7 species) and rural cemeteries (7 species). We note that species richness is directly related to the amount of sampling done in an area, since each cemetery was sampled at a low level (Table 1), species richness reported here is most likely not a complete count of all species that use each site.

3.2 Community Composition and Activity

Accounting for the amount of time each camera ran (number of days) provides a more accurate index of animal activity/relative abundance than raw counts. Activity indices combining all sites sampled show that white-tailed deer were the most commonly detected species overall, followed by eastern gray squirrel, wild turkey, and gray fox. The least commonly detected species over all sites sampled were woodchuck and eastern cottontail (Fig 3). To illustrate animal activity, we mapped average detection rate for the most commonly detected species and displayed the results using proportional symbols (Fig 5-7).

3.3 Animal Activity Compared between Habitat Types and Cemeteries

We noted interesting differences in animal activity between different habitat types. As may be expected, rural habitats had the most animal activity, followed by exurban and then suburban habitats. White-tailed deer were highly abundant in the majority of the habitats, while eastern gray squirrel and wild turkey were found mainly in rural habitats. An interesting finding was that the majority of red foxes were found in suburban habitats (Figure 3).

Differences in animal activity were also noted between different cemeteries. Greenlawn, Mount Hope, and Maplewood (Clayton) cemeteries had the highest rates of overall animal activity. In Greenlawn, all of the detections were of white-tailed deer (Figure 4). Carolina Biblical Gardens had the majority of the coyote detections, and Maplewood Cemetery (Durham) had almost all of the red fox detections. Gray fox were detected in about half of the cemeteries, and white-tailed deer were detected in almost all of the cemeteries (Figures 8-15).

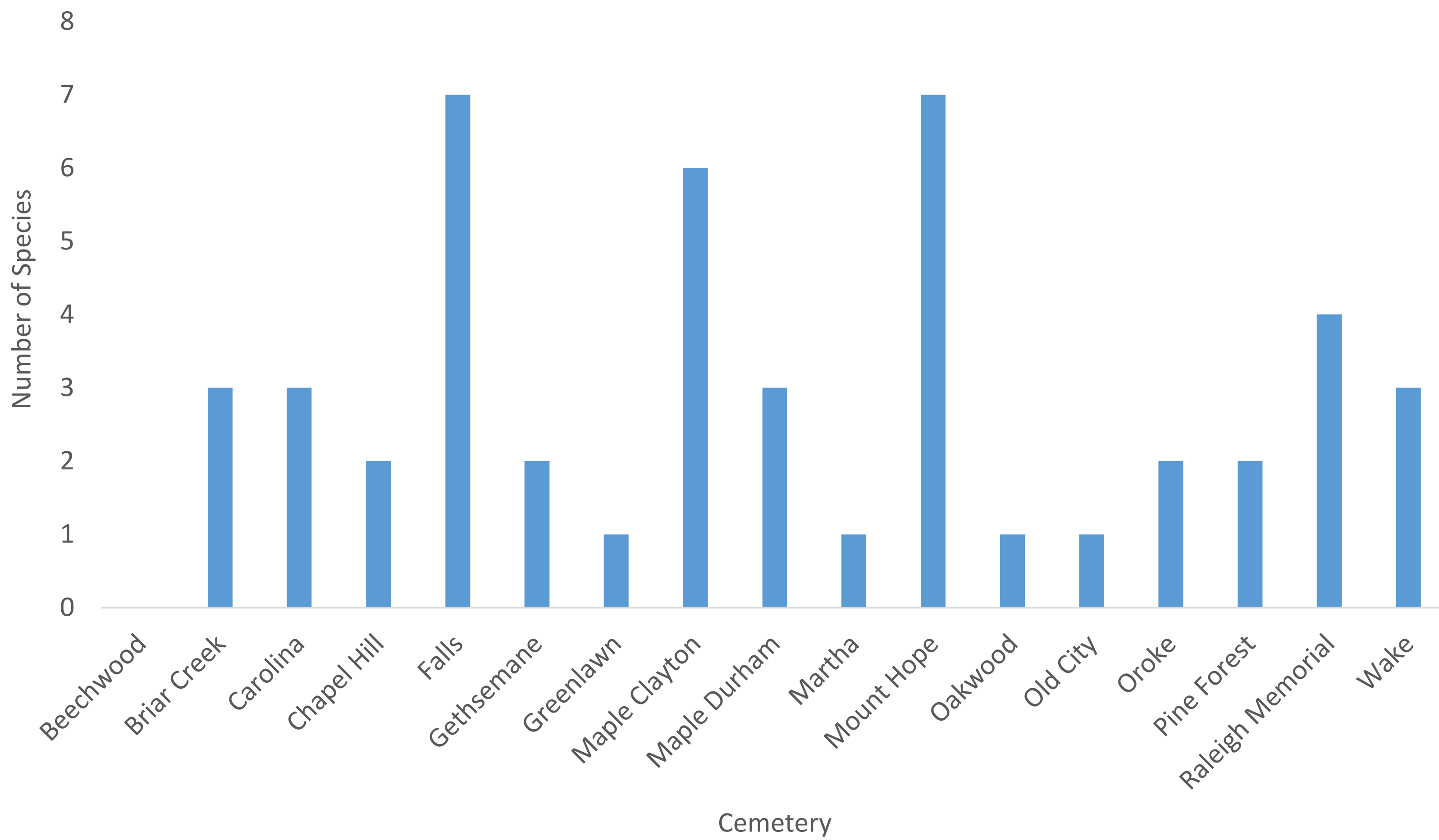


Figure 2: Species richness: the number of mammal species detected within each cemetery site from August-November 2015.

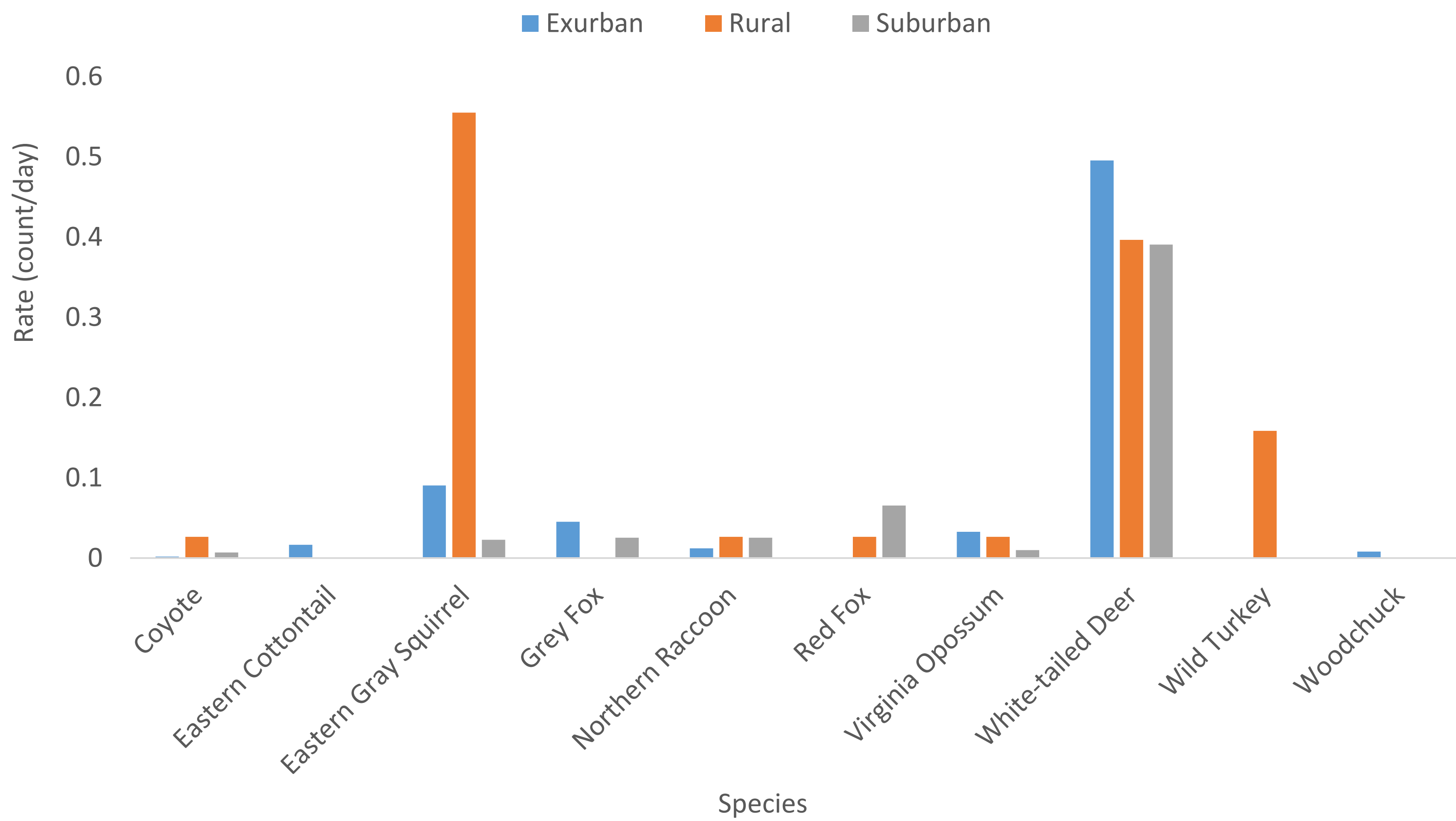


Figure 3: The average count/day for each mammal species between different cemetery habitat types from August to November 2015

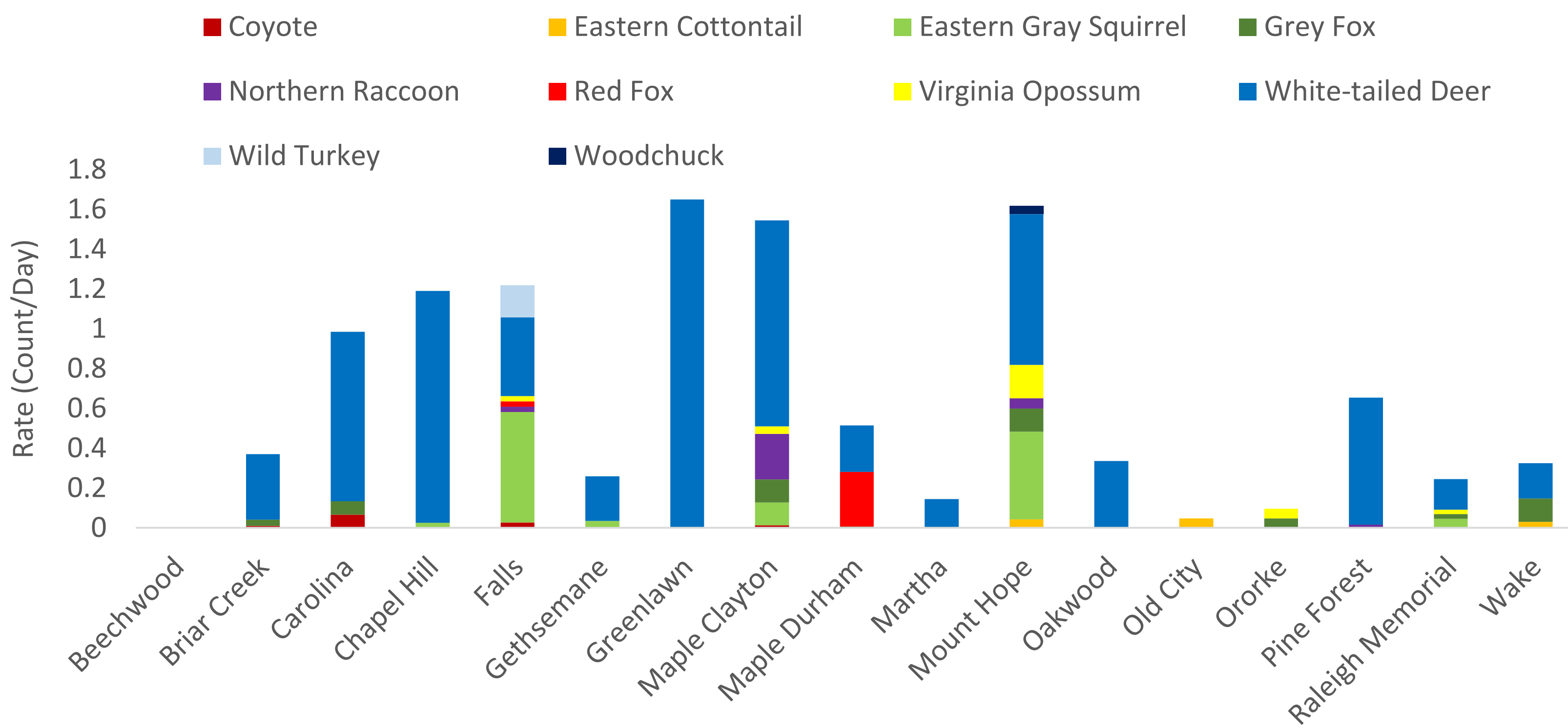
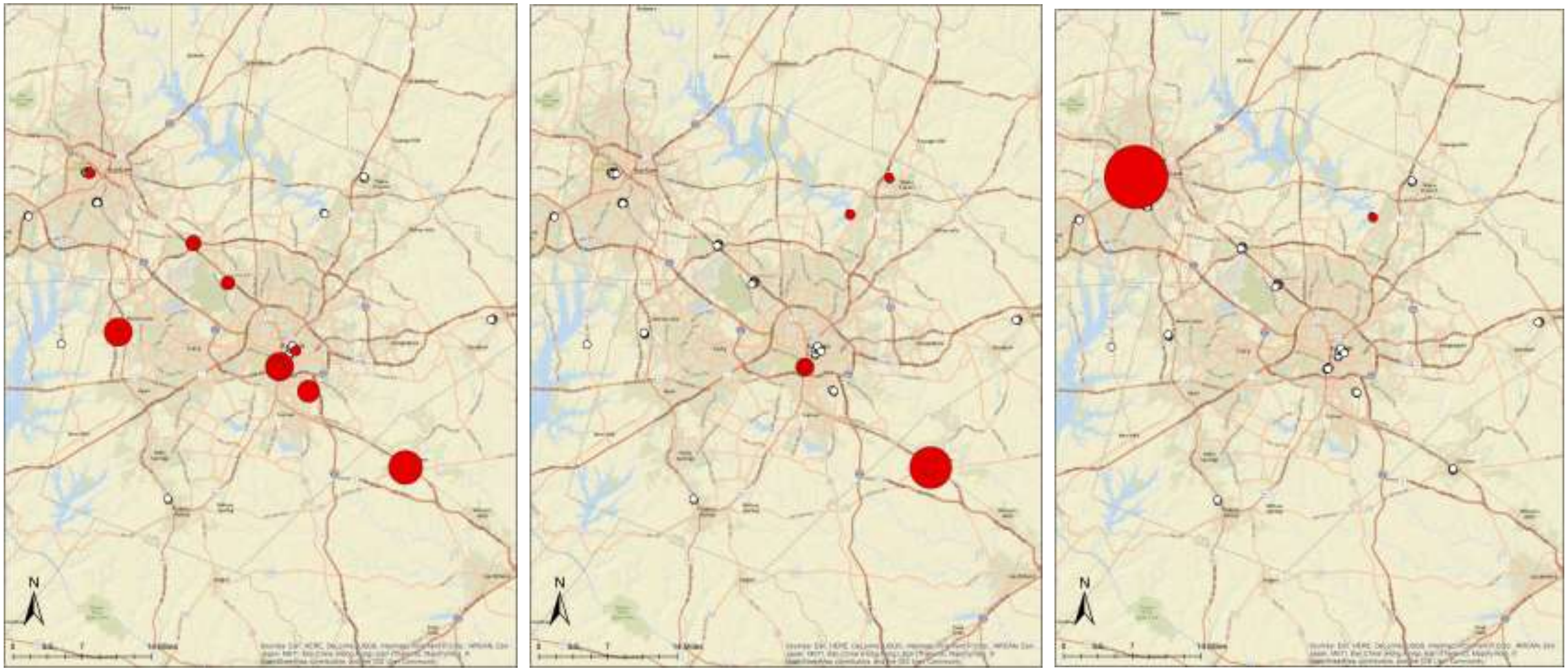


Figure 4: Stacked graph showing the relative abundance calculated as rate (count per day) for all mammal species in cemeteries sampled by eMammal in fall 2015.

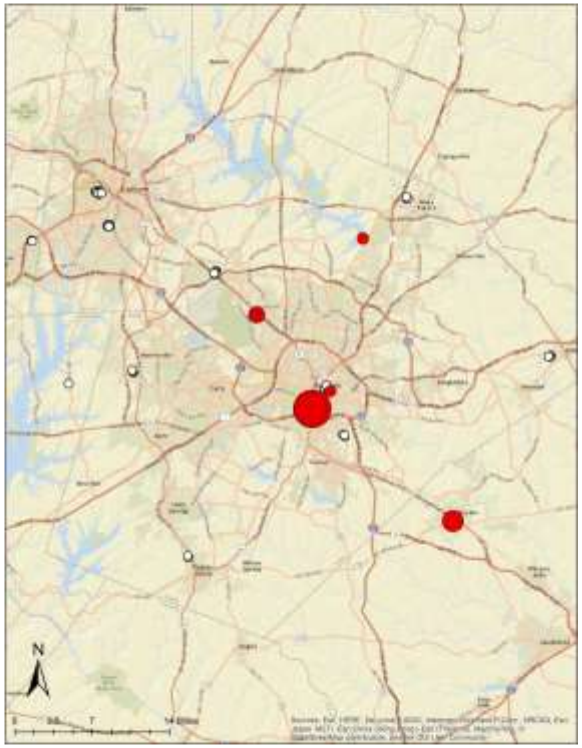
Coyote Eastern Cottontail Eastern Gray Squirrel

Figure 5: Average coyote, eastern cottontail, and eastern gray squirrel detection rate (count/day) at each cemetery camera site fall 2015. The size of the circles is proportional to the average detection rate at that location. White circles denote sites where that species was not detected.

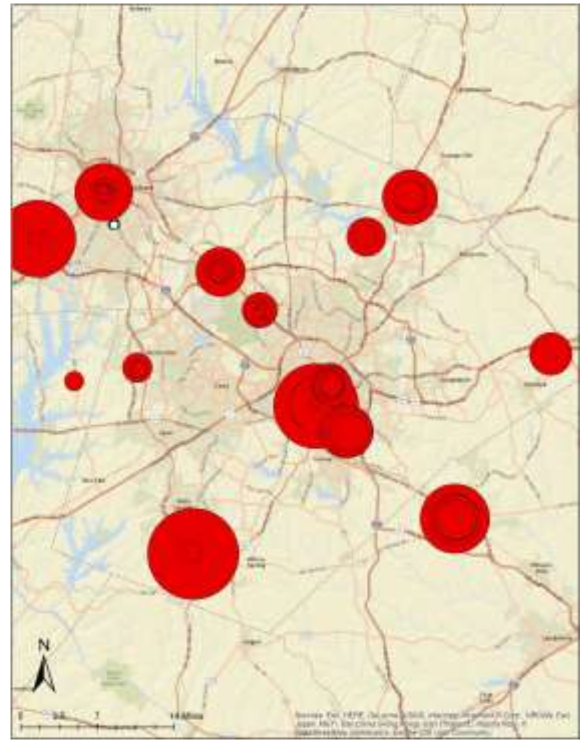


Gray Fox Northern Raccoon Red Fox

Figure 6: Average gray fox, northern raccoon, and red fox detection rate (count/day) at each cemetery camera site fall 2015. The size of the circles is proportional to the average detection rate at that location. White circles denote sites where that species was not detected.



Virginia Opossum



White-tailed Deer

Figure 7: Average Virginia opossum and white-tailed deer detection rate (count/day) at each cemetery camera site fall 2015. The size of the circles is proportional to the average detection rate at that location. White circles denote sites where that species was not detected.

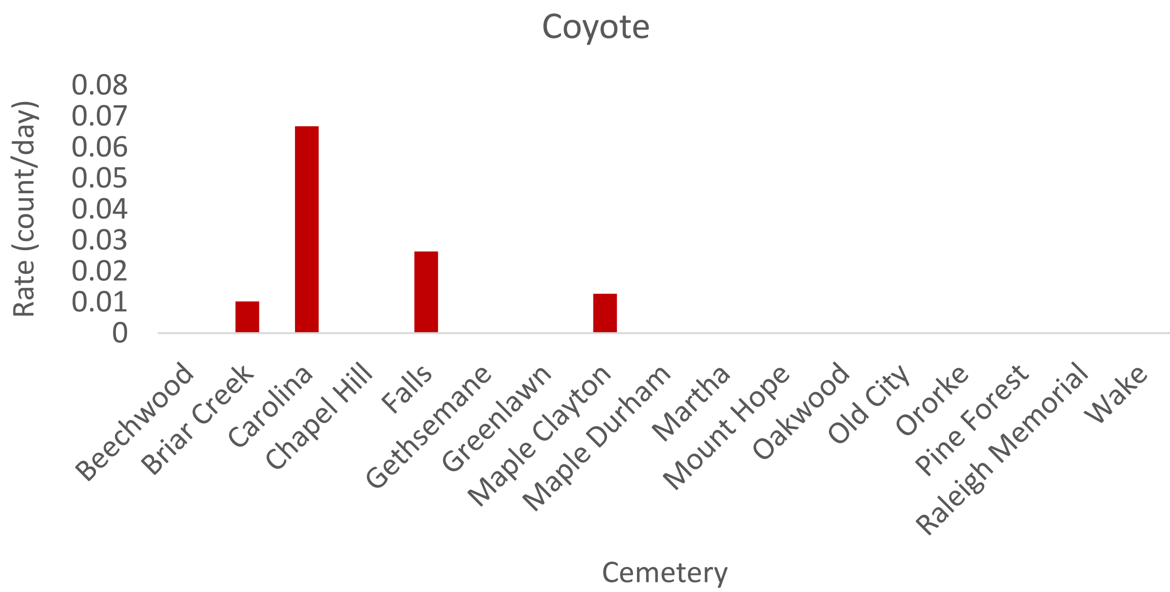


Figure 8: Coyote activity (count/day) compared between cemetery sites in fall 2015.

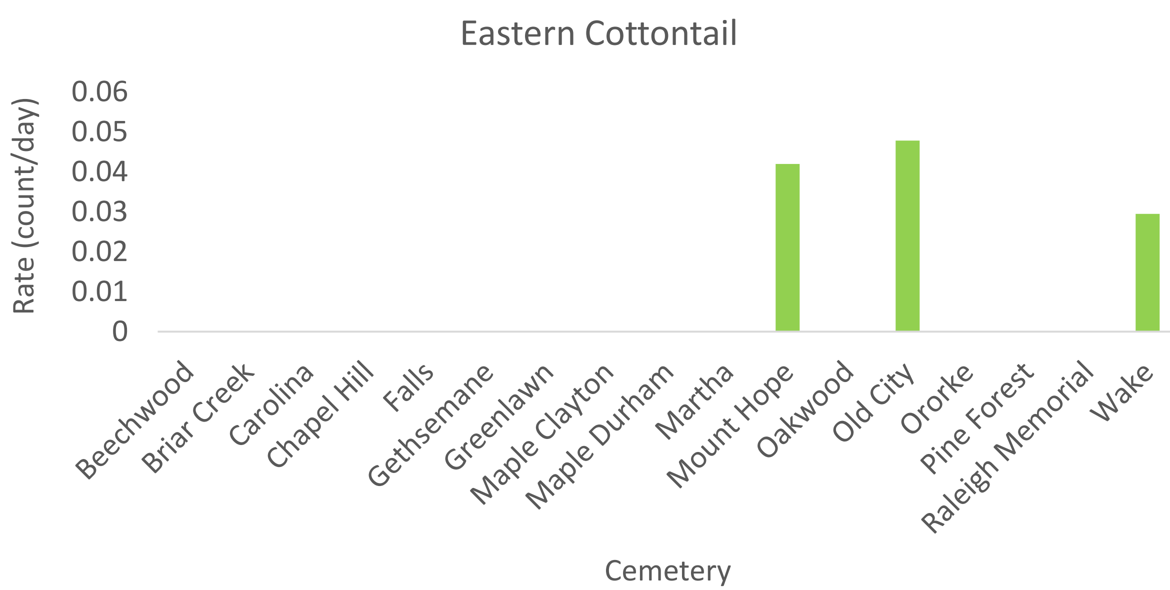


Figure 9: Eastern cottontail activity (count/day) compared between cemetery sites in fall 2015.

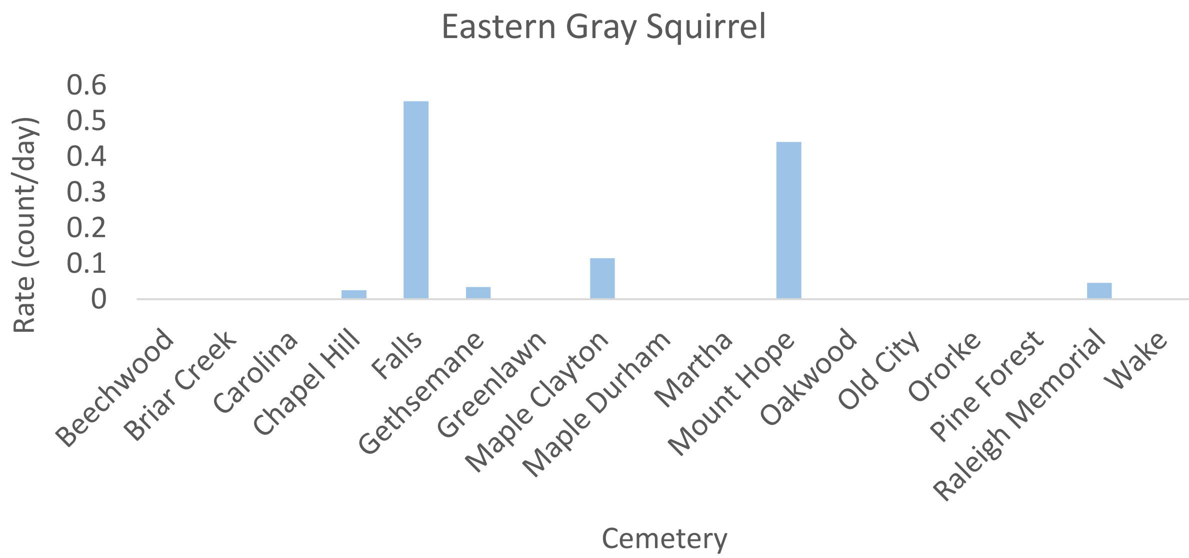


Figure 10: Eastern gray squirrel activity (count/day) compared between cemetery sites in fall 2015.

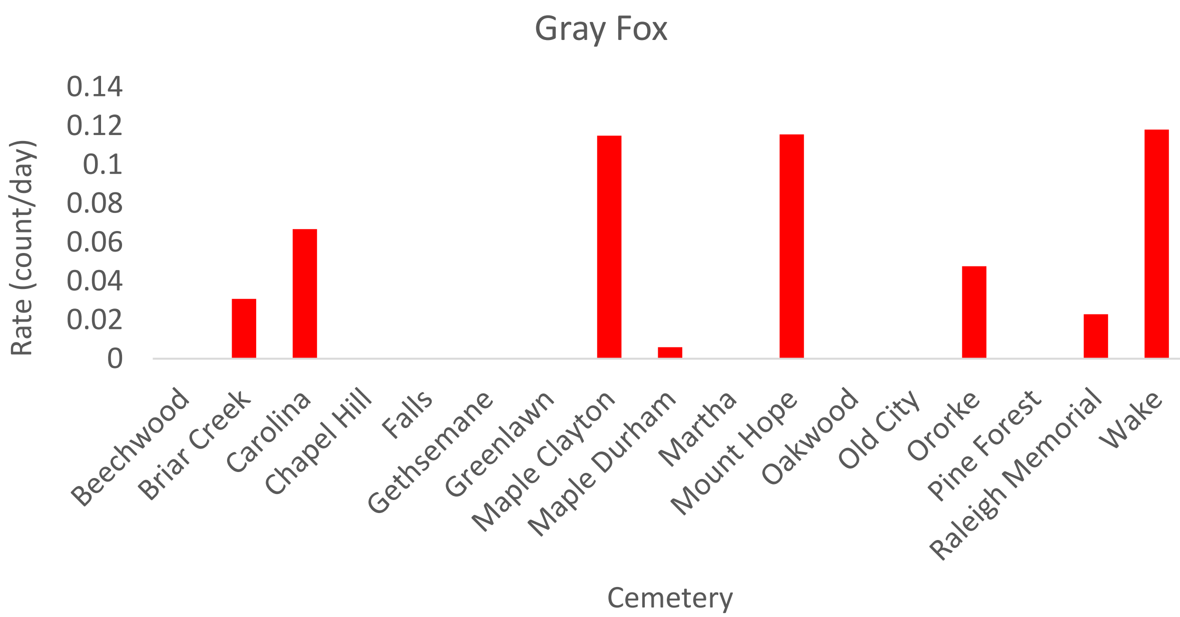


Figure 11: Gray fox activity (count/day) compared between cemetery sites in fall 2015.

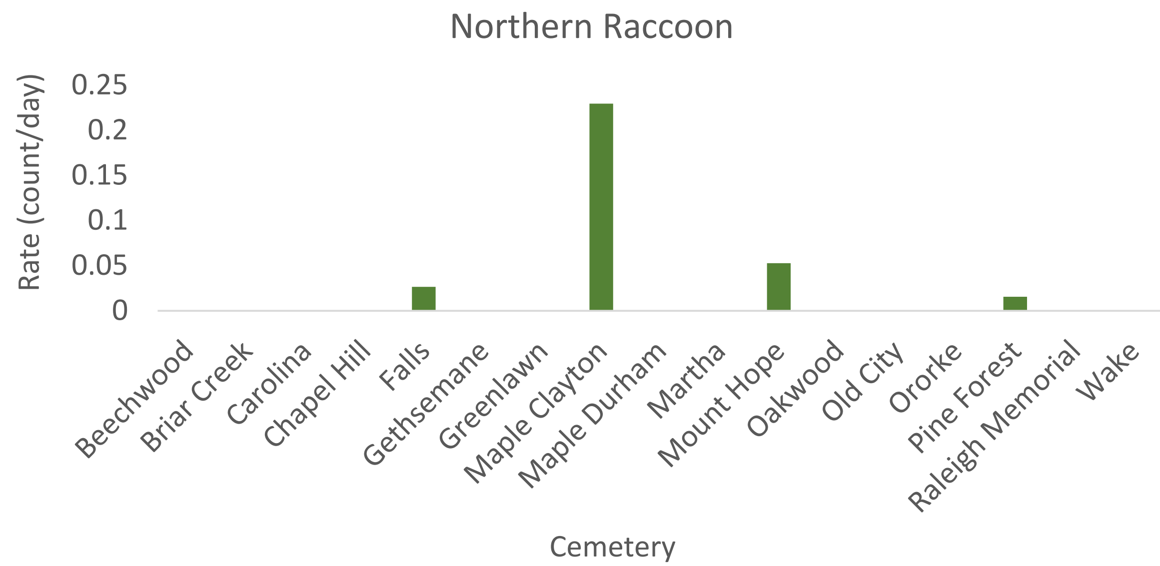


Figure 12: Northern raccoon activity (count/day) compared between cemetery sites in fall 2015.

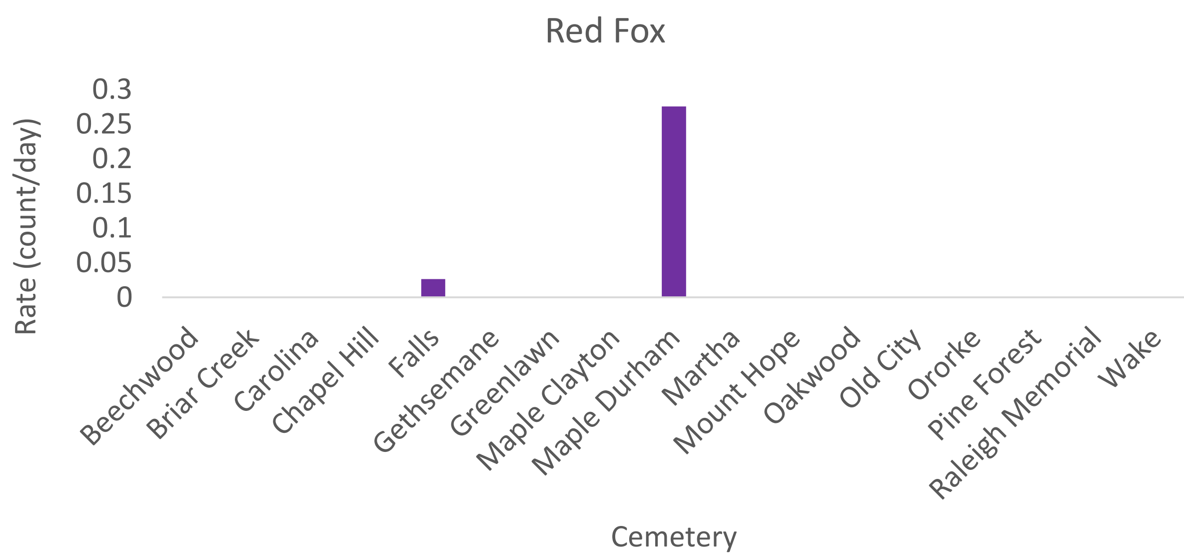


Figure 13: Red fox activity (count/day) compared between cemetery sites in fall 2015.

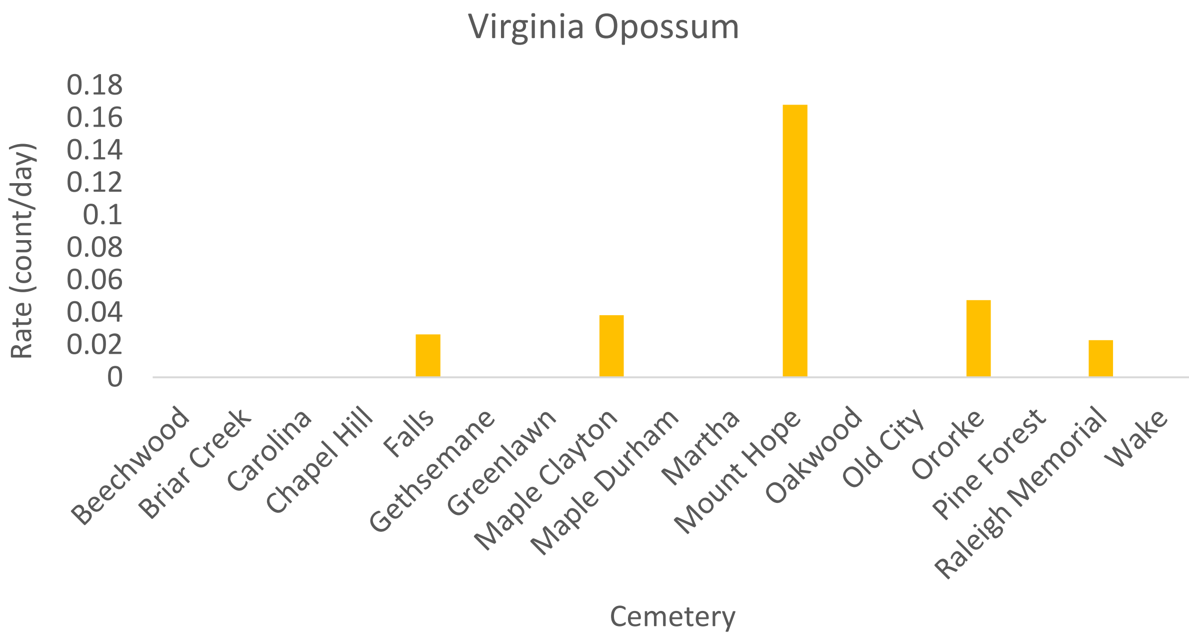


Figure 14: Virginia Opossum activity (count/day) compared between cemetery sites in fall 2015.

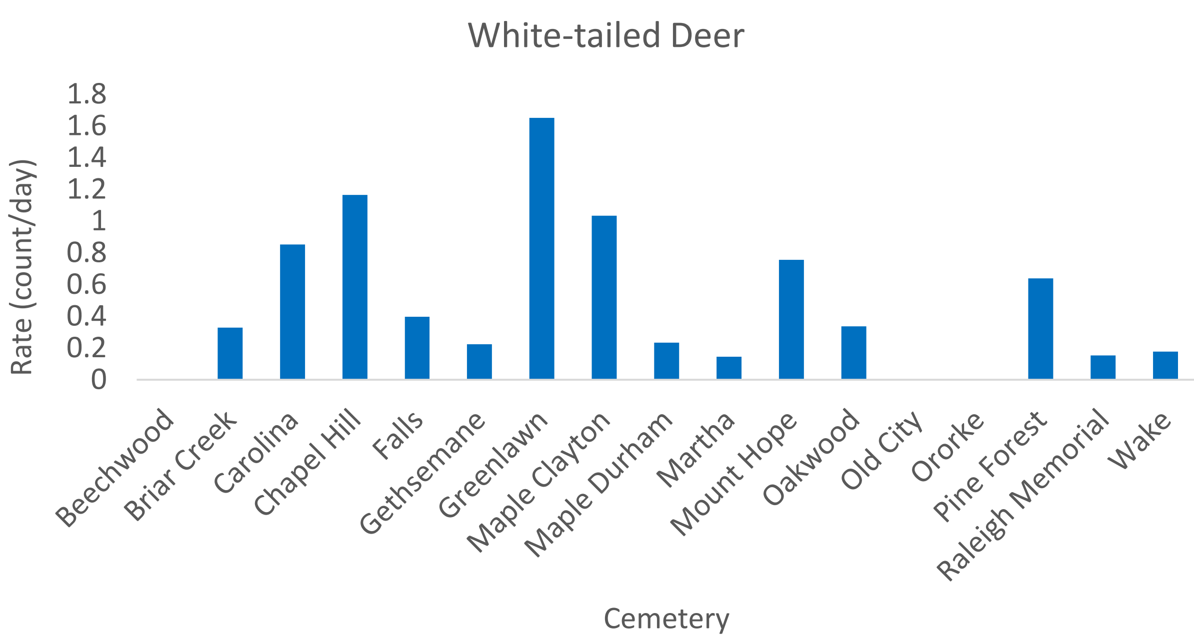


Figure 15: White-tailed deer activity (count/day) compared between cemetery sites in fall 2015.

3.5 Daily Activity Patterns

Animal activity patterns represent the times of day that different species are more commonly detected, and thus likely more active. Figures 16-22 show the activity patterns for the most common species detected within cemeteries from August to November, 2015. As expected, coyote, grey fox, red fox, and northern raccoon were primarily nocturnal over all sites sampled. Eastern gray squirrel and wild turkey were primarily diurnal, and white-tailed deer were detected mostly at night, but also throughout the day with variability.

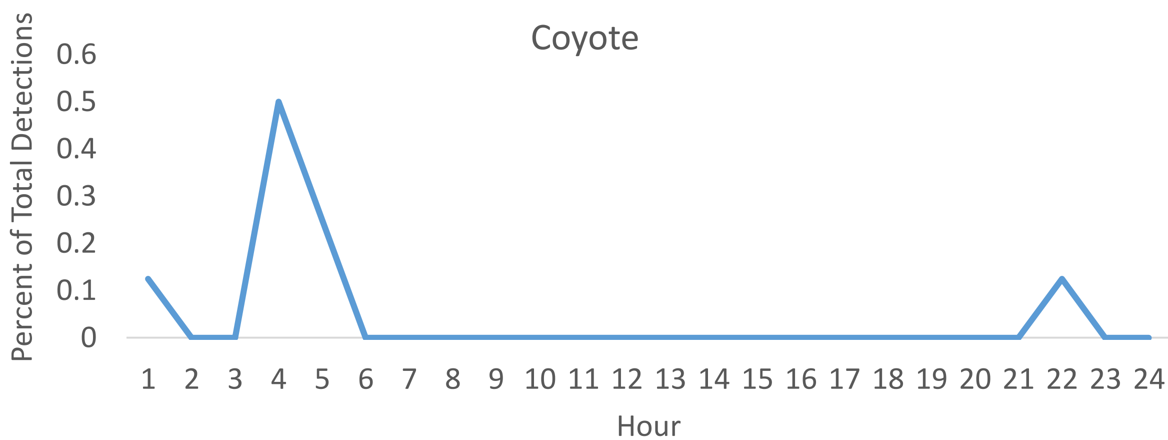


Figure 16: Activity pattern (percent of detections by time of day) for coyote in cemeteries in fall 2015.

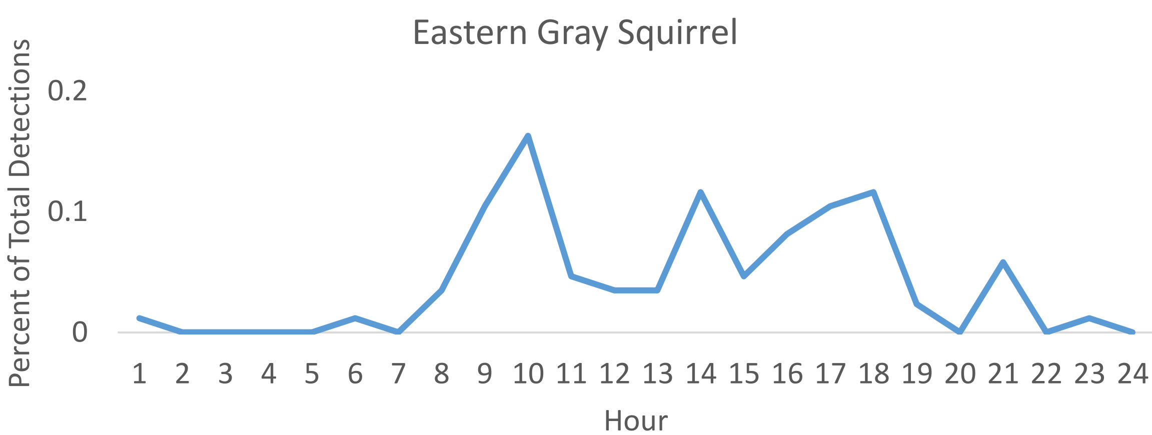


Figure 17: Activity pattern (percent of detections by time of day) for eastern gray squirrel in cemeteries in fall 2015.

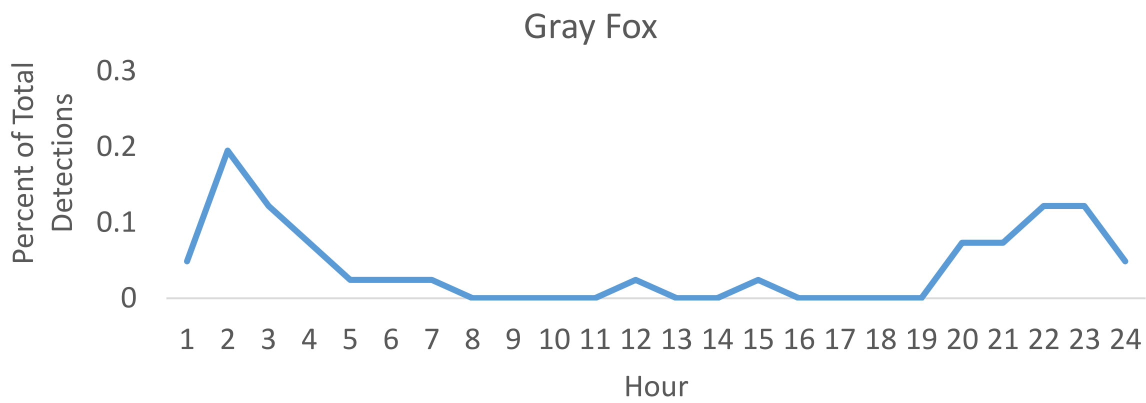


Figure 18: Activity pattern (percent of detections by time of day) for gray fox in cemeteries in fall 2015.

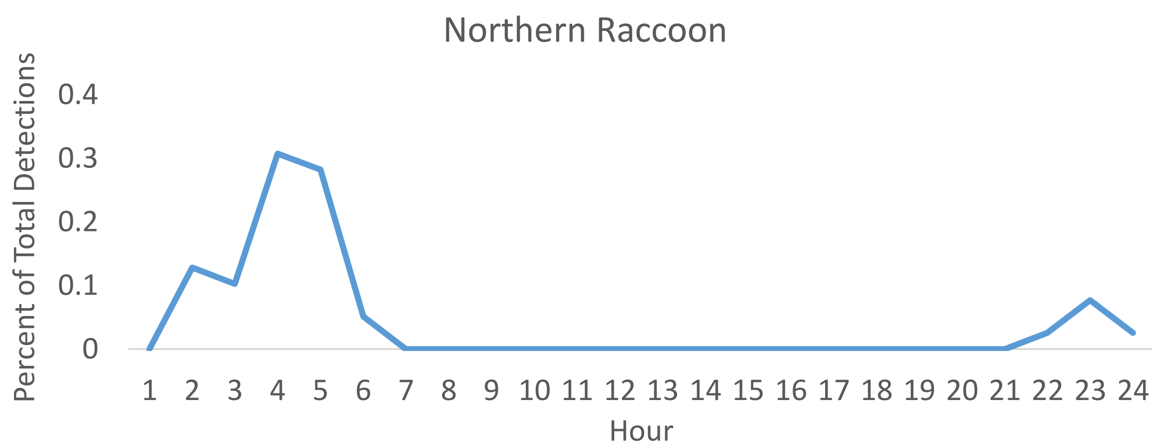


Figure 19: Activity pattern (percent of detections by time of day) for northern raccoon in cemeteries in fall 2015.

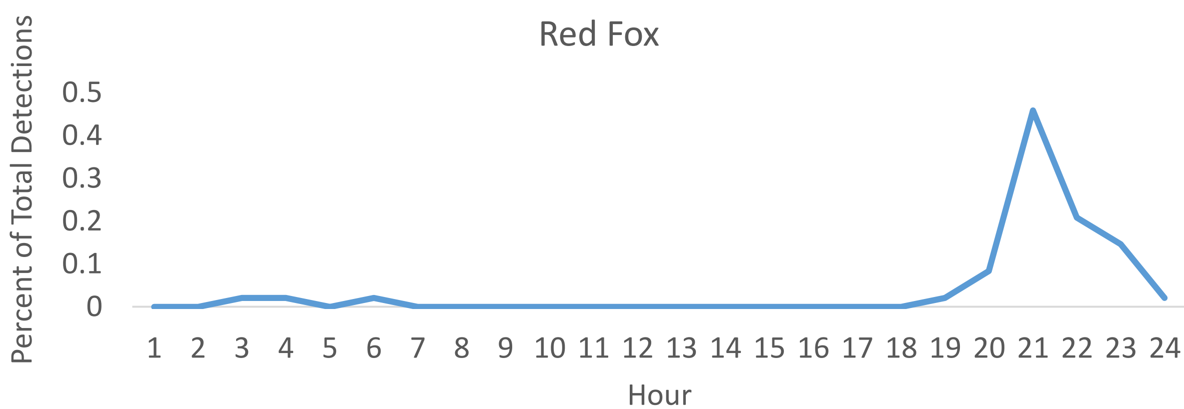


Figure 20: Activity pattern (percent of detections by time of day) for red fox in cemeteries in fall 2015.

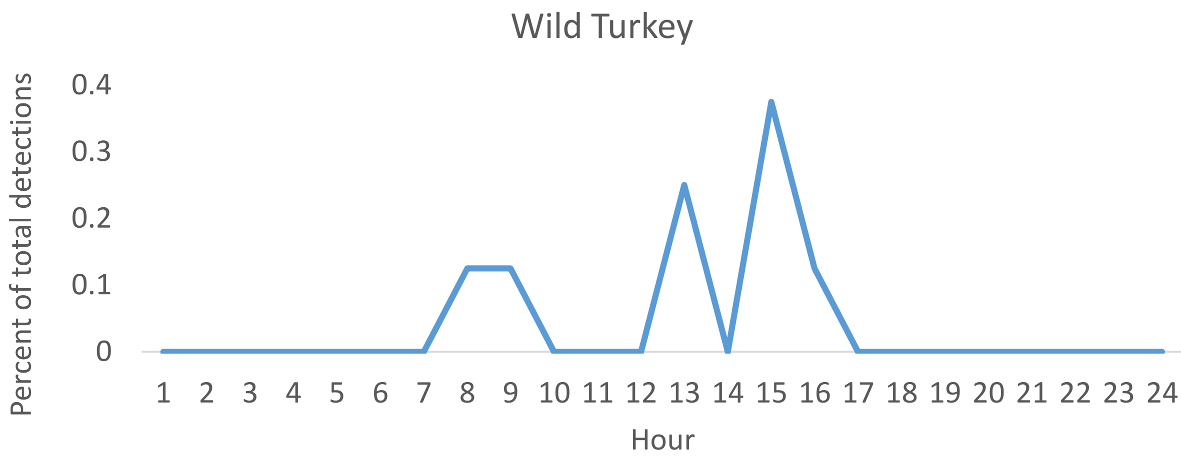


Figure 21: Activity pattern (percent of detections by time of day) for wild turkey in cemeteries in fall 2015.

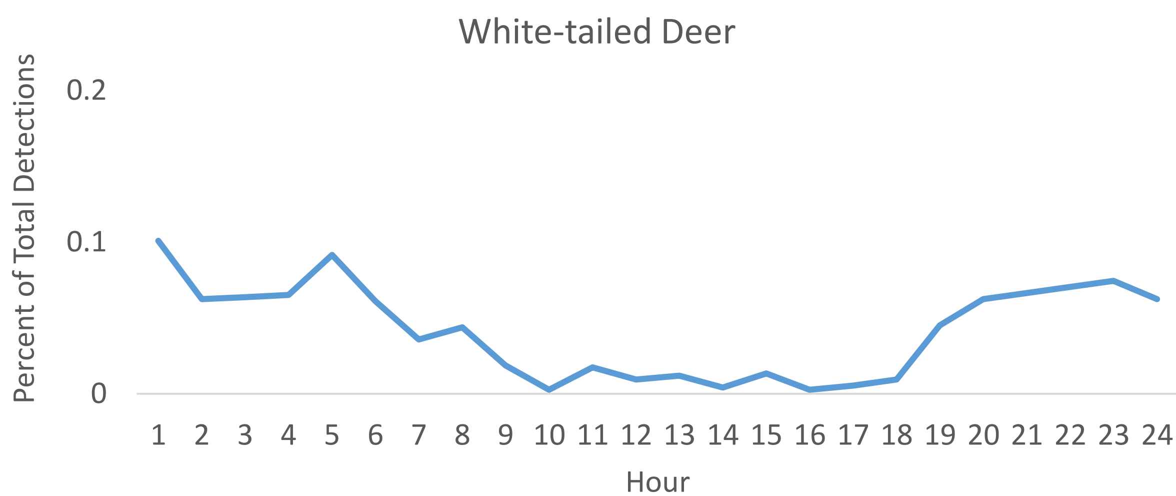


Figure 22: Activity pattern (percent of detections by time of day) for white-tailed deer in cemeteries in fall 2015.

5.0 Discussion

Our cameras were able to document a number of species within cemeteries. When comparing this cemetery dataset to past data eMammal collected at Triangle golf courses, species richness was similar, with some species (woodchuck) detected in cemeteries and not golf courses and vice versa (striped skunk). Overall species richness varied between cemeteries, but was highest in exurban sites, and lowest in rural and suburban sites. Some species were spread out between cemeteries, while others were not. For example, white-tailed deer were the overall most commonly detected and most ubiquitous species, being detected in almost every cemetery. Notably, white-tailed deer were absent from two cemeteries: O'Rorke Catholic Cemetery and Old City Cemetery but these cemeteries were sampled at a very low leve1 (1 and 2 cameras respectively) so deer would have most likely been detected if more cameras had been deployed for a longer period of time. In general, we note that sampling effort in each individual cemetery was low and thus is not representative of all species that may use that cemetery, it is simply a representation of the wildlife activity during that small window of time at the locations where the cameras were placed.

In addition to white-tailed deer, both gray fox and gray squirrel were fairly ubiquitous, being detected in over 1/3 of all cemeteries sampled, although both species had much lower detection rates than white-tailed deer. Gray fox were most commonly detected in exurban sites and gray squirrels were most common in rural sites. All other species were less ubiquitous, being detected at less than 1/3 of cemeteries. Of these, half were most common in rural cemeteries and half were most common in exurban cemeteries. Red fox was the only species to show a higher detection rate at suburban cemeteries, but they were only detected in two different cemeteries. Gray foxes are typically more common in suburban areas in North Carolina than red foxes, so this result was somewhat interesting and could suggest open areas like cemeteries provide good alternative habitat for red foxes in suburban areas, however more research would need to be done to establish this. Additionally, the one rural cemetery we sampled had a relatively high species richness which could represent (perhaps not surprisingly) better habitat for most species in rural areas. We are planning to add more rural open sites to this dataset for analysis of this trend in the future.

Table 1: A list of 17 Cemeteries used in the research with the number of camera traps used at each site.

Cemetery	Number of Cameras	Development Zone	Address:
Beechwood Cemetery	5	Suburban	3300 Fayetteville Road, Durham, NC
Brier Creek Memorial Gardens	5	Exurban	7600 Acc Blvd, Raleigh, NC
Carolina Biblical Gardens	3	Suburban	3401 Creech Road, Raleigh, NC
Chapel Hill Memorial Cemetery	2	Suburban	1721 Legion Road, Chapel Hill, NC
Falls Community Cemetery	2	Rural	12173 Falls of Neuse Road, Wake Forest, NC
Gethsemane Memorial Gardens	3	Exurban	809 W Gannon Ave, Zebulon, NC
Greenlawn Memorial Garden	2	Exurban	1621 Broad Street, Fuquay Varina, NC
Maplewood Cemetery Clayton	4	Suburban	10707 N Carolina 42, Clayton, NC
Maplewood Cemetery Durham	6	Suburban	Duke University Rd, Durham, NC
Martha's Chapel Christian Church	1	Exurban	2811 Marthas Chapel Rd, Apex, NC
Mount Hope Cemetery	3	Exurban	1120 Fayetteville St., Raleigh, NC
Oakwood Cemetery	6	Suburban	701 Oakwood Ave, Raleigh, NC
Old City Cemetery	2	Exurban	17 S. East St., Raleigh, NC
O'Rorke Catholic Cemetery	1	Suburban	1101 Pender St., Raleigh, NC
Pine Forest Memorial Gardens	3	Exurban	770 Stadium Dr., Wake Forest, NC
Raleigh Memorial Park	3	Suburban	7209 Glenwood Avenue, Raleigh, NC
Wake Memorial Park	3	Exurban	101 Gathering Park, Cary, NC

6.0 References

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