Acoustic Survey of *Eumops floridanus* in Three Miami-Dade County Parks within the Richmond Tract Miami, Florida

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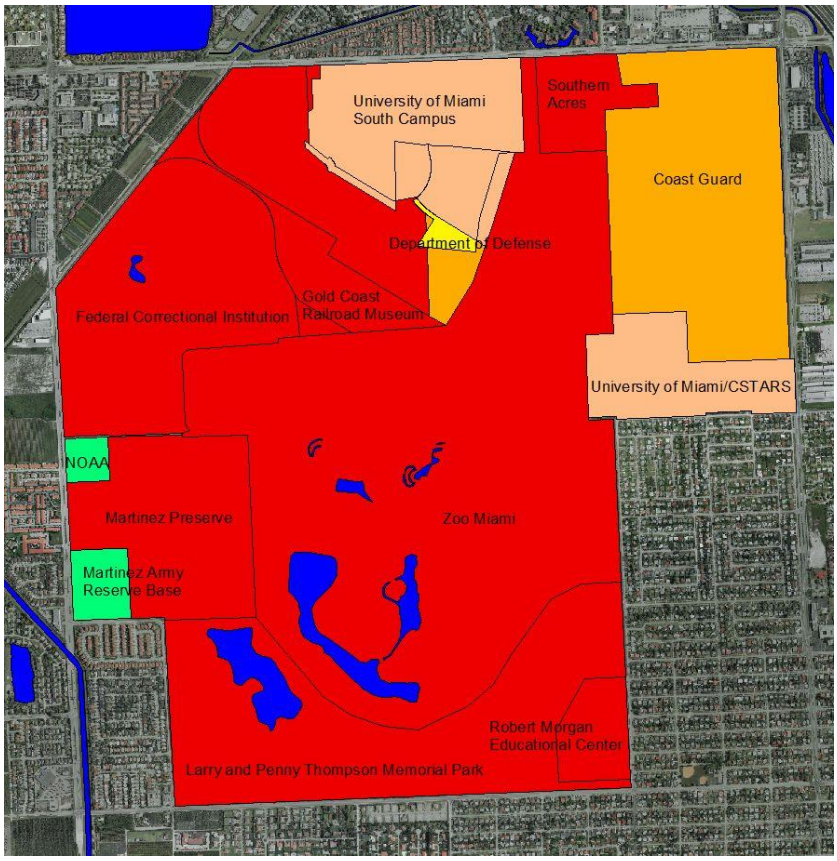
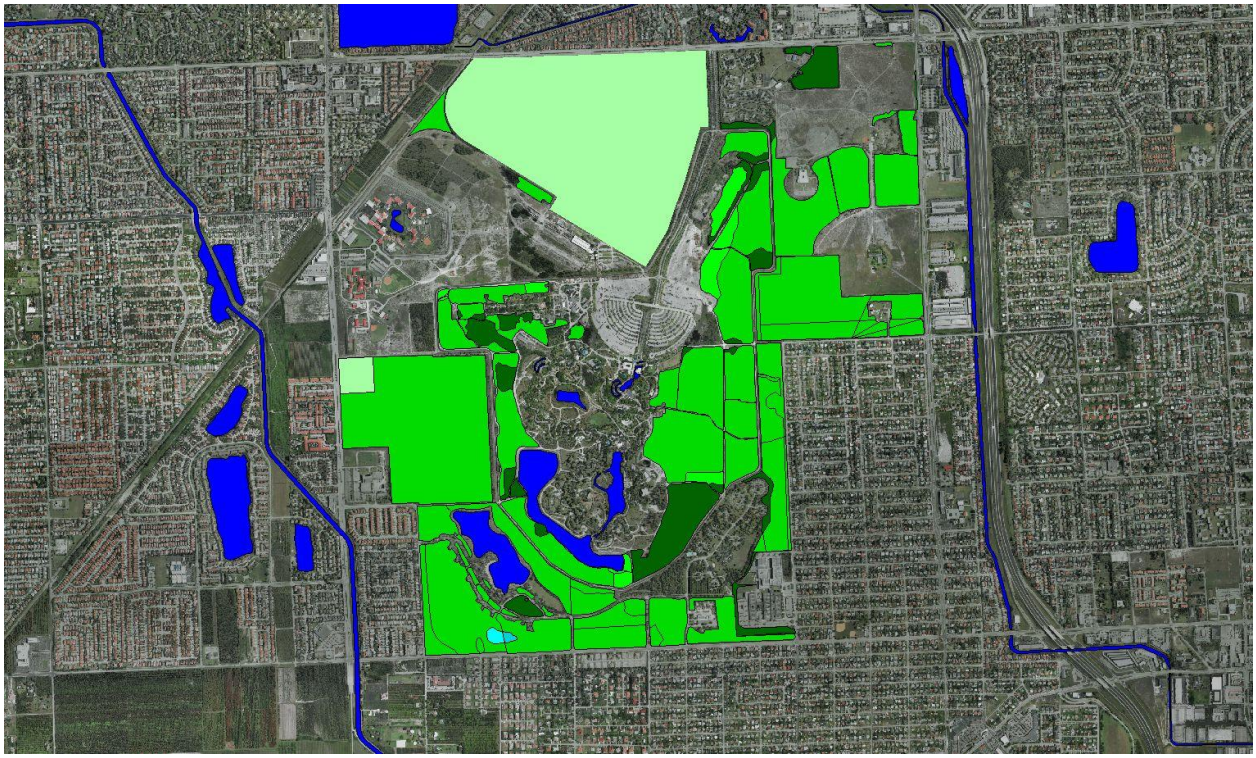
History and Description of Study Location:

The Richmond Tract, in Miami-Dade County, is the site of the former Richmond Naval Air Station and is bordered by SW 152nd street to the north, SW 117th Avenue to the east, SW 137th to the west and SW 184th Street to the south. Found within its borders at the time of this study are three Miami-Dade County Parks (Zoo Miami, Larry and Penny Thompson Memorial Park (L&P), and the Martinez Pineland Preserve), the University of Miami's South Campus and Richmond Campus/Center for Southeastern Tropical Advanced Remote Sensing (CSTARS), a National Oceanic and Atmospheric Administration (NOAA) monitoring station, the Martinez US Army Reserve Center, Southern Acres private housing, a Federal Correctional Institution, a Department of Defense facility, the Gold Coast Railroad Museum, a US Coast Guard facility and the Robert Morgan Educational Center (Map 1).



Map 1: Property ownership within the Richmond Tract. Ownership by various entities has been color coded.

The Richmond Tract contains the largest and most biodiverse fragment of critically endangered pine rockland outside of the Everglades National Park. The remaining pine rockland habitat is contained within the Miami-Dade County, US Coast Guard, and University of Miami properties (Map 2). It contains an assemblage of federal, state and locally endangered and threatened species for which a large number are endemic and a couple are found no place else but the Richmond Tract.



Map 2: Natural communities within the Richmond Tract. Bright green represents delineated pine rockland. Dark green represents undeveloped, disturbed, and predominantly non-native vegetation. Light green represents areas that contain pine rockland but no GIS delineated data was available. Dark blue represents large artificial bodies of water. Light blue represents a large solution hole at L&P and the only remaining natural feature containing some water for most of the year. No natural community GIS data was available for the University of Miami's South Campus, the NOAA property or the Department of Defense facility.

For this study, the three Miami-Dade County parks were chosen largely due to ease of property access, containing the majority of land area of the Richmond Tract, containing the majority of the pine rockland habitat, and a historical *Eumops floridanus* (Eufl) carcass being found at one of the parks.

Zoo Miami consists of 740 acres in total in which 340 acres are developed as a zoological park and botanical gardens. There are 246 acres of pine rockland forming the eastern, southern and western borders of the property. The remaining acreage consist mostly of three large borrow pit lakes created around 1980 when the zoo was constructed, eucalyptus and mango groves, and the zoo's main guest parking lot that is part of a former mooring pad for dirigibles when the property acted as a naval base.

Larry and Penny Thompson Memorial Park is 270 acres in total and borders both Zoo Miami and the Martinez Preserve at their southern borders. It contains 200 acres of pine rockland, and the remaining

70 acres consist of a large borrow pit lake, a mango grove, a recreational vehicle campground and a small number of facility operation support buildings.

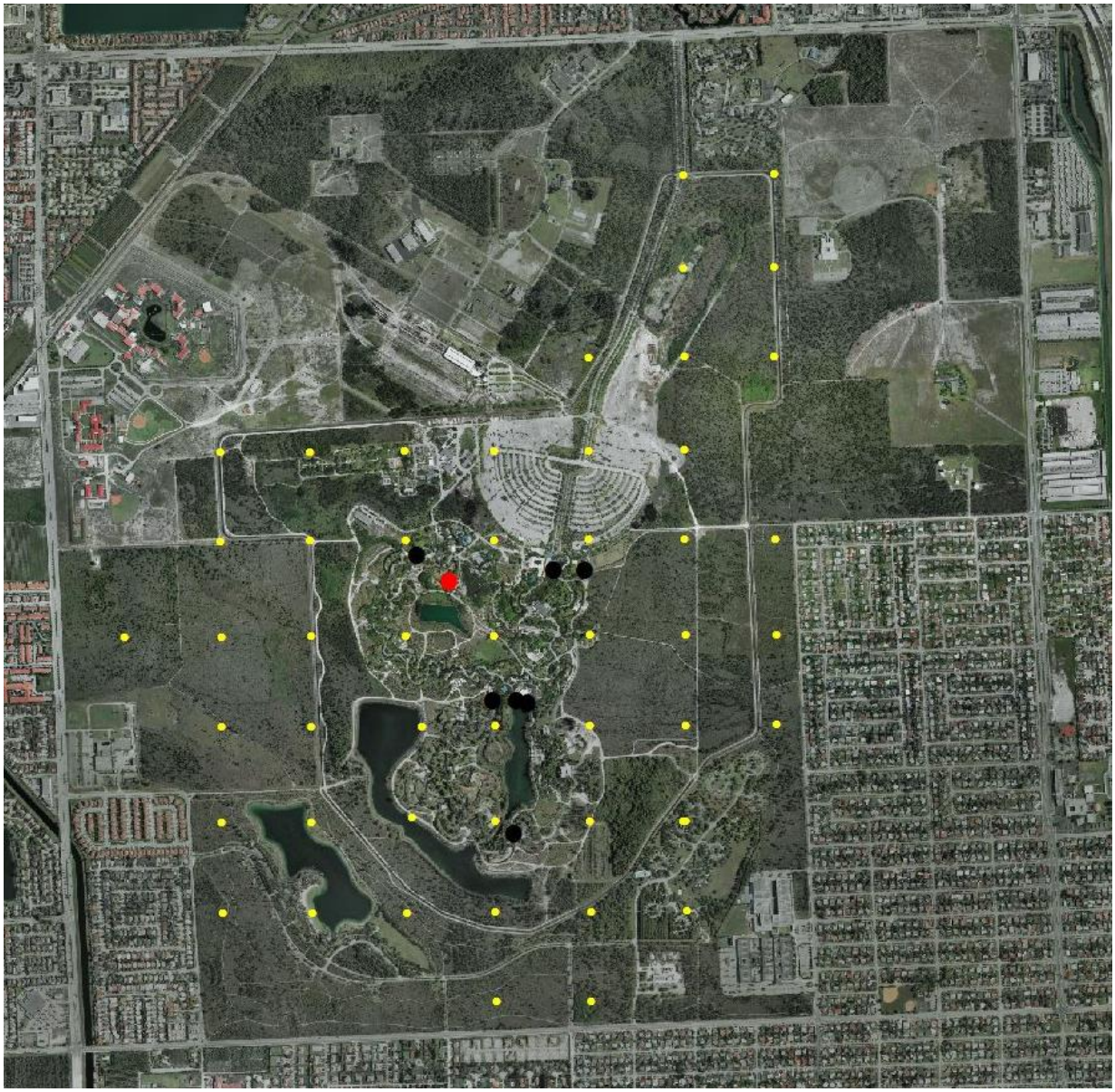
The Martinez Pineland Preserve lies on the western border of Zoo Miami. It has 110 acres of pine rockland and 28 acres of a remnant slough with no facilities or public access.

In 2004, a deceased Eufl was hosed off a high ledge in the Asian elephant barn at Zoo Miami while staff was performing maintenance cleaning of the structure (Picture 1). It was taken by a zookeeper to the senior veterinarian at the time, Dr. Christine Miller, who sent off information for further identification and species confirmation.

Picture 1: Eufl carcass found in 2004 in the Asian Elephant barn at Zoo Miami

On September 19th, 2011 George and Cyndi Marks, from the Florida Bat Conservancy, were accompanied by Zoo Miami staff to conduct acoustic monitoring on zoo grounds with a concentration between the area between the historic roost site at Asian elephant barn and one of the nearby lakes (Picture 2). The monitoring period was approximately 2 hours post sunset. No bats were witnessed emerging from the elephant barn. A single constant frequency vocalization in the appropriate frequency range for Eufl was detected.

Known mixed species roost sites contained in single and multi-chamber bat houses and structures on zoo grounds are shown in Map 3. Only *Tadarida brasiliensis* (Tabr) and *Nycticeius humeralis* (Nyhu) have been documented at these roosts. A historic Tabr roost was documented through photos at the giraffe barn near the large southern lake of Zoo Miami but the population has since been displaced for many years by a breeding pair of *Tyto alba*.



Map 3: The red dot indicates the location of the Asian elephant barn. Black dots indicate the locations of known mixed species roosts of Tabr and Nyhu. Yellow dots represent each acoustic monitoring location from this study.

In late January 2012, Zoo Miami's Conservation and Research Department applied for and received a Flexible Funds grant through the United States Fish and Wildlife Service's South Florida Ecological Services Office to obtain ultrasonic frequency acoustic monitoring equipment and interpretive software in an effort to monitor the study area for Eufl presence and possible discovery of roost locations.

Materials and Methodology:

A grid with points 1000ft apart was projected over the three aforementioned Miami-Dade County parks to determine GPS coordinates that would become each of the acoustic sampling sites. To cover almost all of the area, 50 sites were chosen (Map 3). These sites were then randomly chosen to create an equipment deployment schedule. All 50 sites were sampled before repeating any of the same sites. Each site was sampled three times within a one year period for a total of 150 sampling nights. The first sampling for the study began on October 1st, 2012 and the last sampling was September 27th, 2013. Each acoustic sampling site was set to begin 30-60 minutes before sunset and continue 30-60 minutes past dawn to ensure that the entire night was recorded.

The passive recording equipment utilized was a single SM2BAT+ with a 10 meter SM2 microphone cable and SMX-US Weatherproof Ultrasonic Microphone (Wildlife Acoustics, Inc. 3 Clock Tower Place, Suite 210 Maynard, MA 01754-2549 USA; www.wildlifeacoustics.com). The sample rate was set to 192 kHz mono and set to record WAV files with no compression. The high pass filter was set to fs/16 and the low pass filter was off. No gain was utilized. The event trigger level was set to +12 db SNR and 0.5 seconds. The omnidirectional microphone was attached to the top of a collapsible fiberglass Jackite 17' Platinum Kite Pole (Jackite, Inc. 2868 West Landing Road, Virginia Beach, VA 23456 USA; www.jackite.com). The pole was passed through a screw clamp in a CST/berger 67-4250X prism pole tripod (CST/berger 255 West Fleming Street Watseka, IL 60970 USA; www.cstberger.us) with the legs extended to provide stability to the pole in adverse conditions and minimize any impact to the substrate (Picture 2). The manufacturer suggests the range of the microphone implemented, and the probable cone of detection, is a radius of 30-100m.

The resulting WAV files were then processed through the SonoBat Batch Scrubber 5.1.vi with the settings to include signals from 5-20 kHz and "medium" to accept all but poor quality calls and some noise and tonal content. Five, out of the total one hundred fifty, nights resulted in no quality calls after being passed through this utility software.

The resulting WAV files were then ran through the SonoBat SM2 Batch Attributer software to assign each previous night's coordinate on the grid to the metadata of each individual file.

SonoBat 3.1.1 rev. 5139 US west proto.vi software (SonoBat 315 Park Avenue Arcata, CA 95521; www.sonobat.com) was used on the resultant WAV files for qualitative call identification. Any suspected Eufl files were also listened to using the raw audio playback and time-expansion to confirm it as a bat vocalization. Any constant frequency call sequences where the body of the call was above 18 kHz were rejected as possible Eufl to avoid any confusion with Tabr low frequency calls.

Qualitative call identification was not performed for non-Eumops species. To quantify and allow distribution comparison between non-Eumops and Eumops within GIS software, all non-Eumops species call sequences were assigned a value of 1 for every 100 call sequences recorded on each acoustic sampling night. Call sequence counts of 50 and above were rounded up to 100 for a value of 1 and 49 and below down to a value of 0.

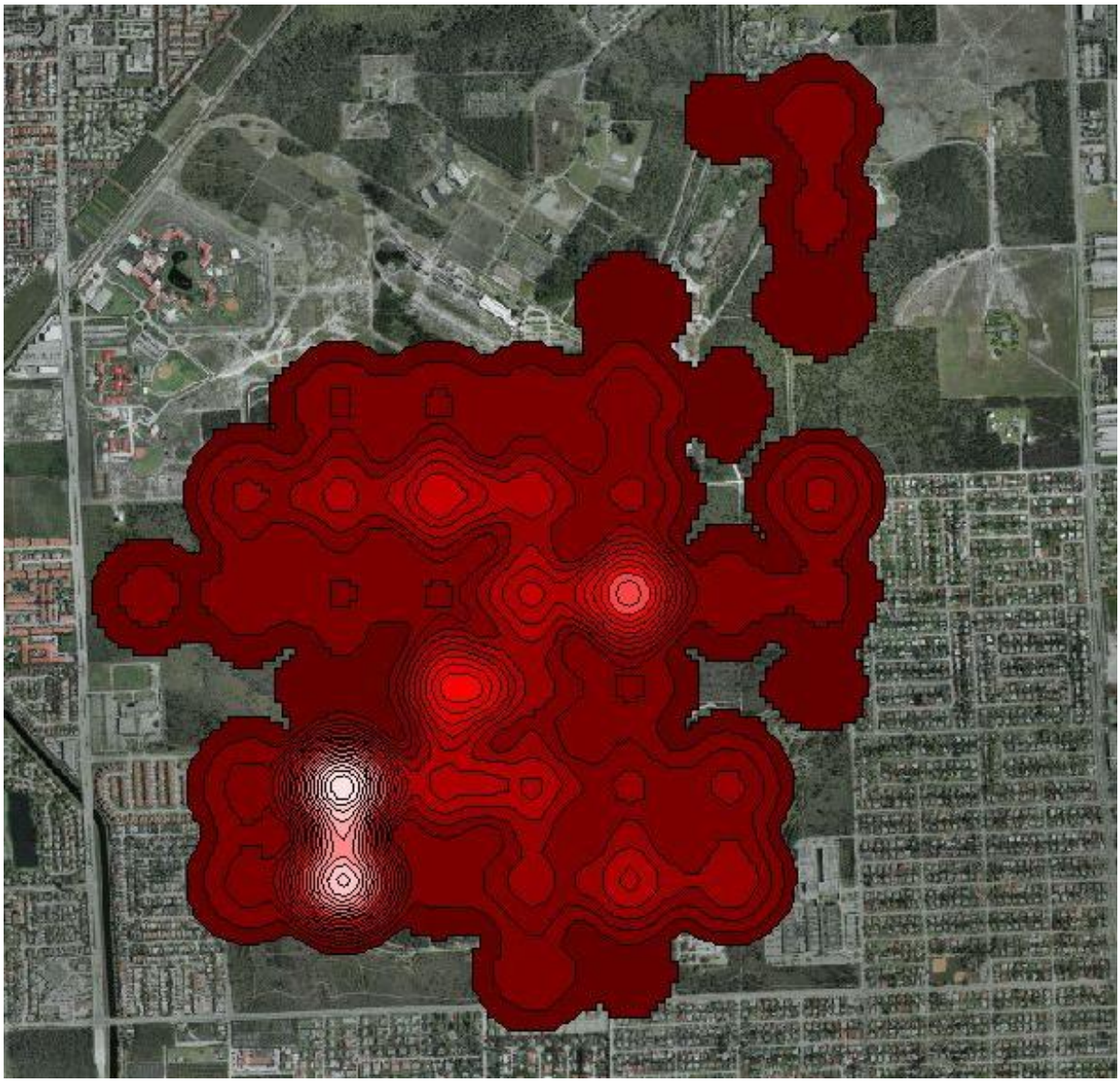
Each Eufl call sequence that did not occur within 2 seconds of another was counted as a single pass. Each pass had the GPS coordinate of the associated acoustic sampling site entered into ArcView GIS 3.2a (ESRI 380 New York Street Redlands, CA 92373; www.esri.com) for further analysis. The Animal Movement 2.1 beta test extension was used to create fixed kernel home range distributions with a smoothing factor of 125.

Picture 2: Deployed microphone, collapsible fiberglass pole and tripod.

Results:

There were 47,030 WAV files generated that passed through the SonoBat Batch Scrubber software. Of these, 1,163 were confirmed as Eufl through qualitative call identification. This roughly accounts for a 2.5% detection probability of Eufl within the acoustic sampling sites.

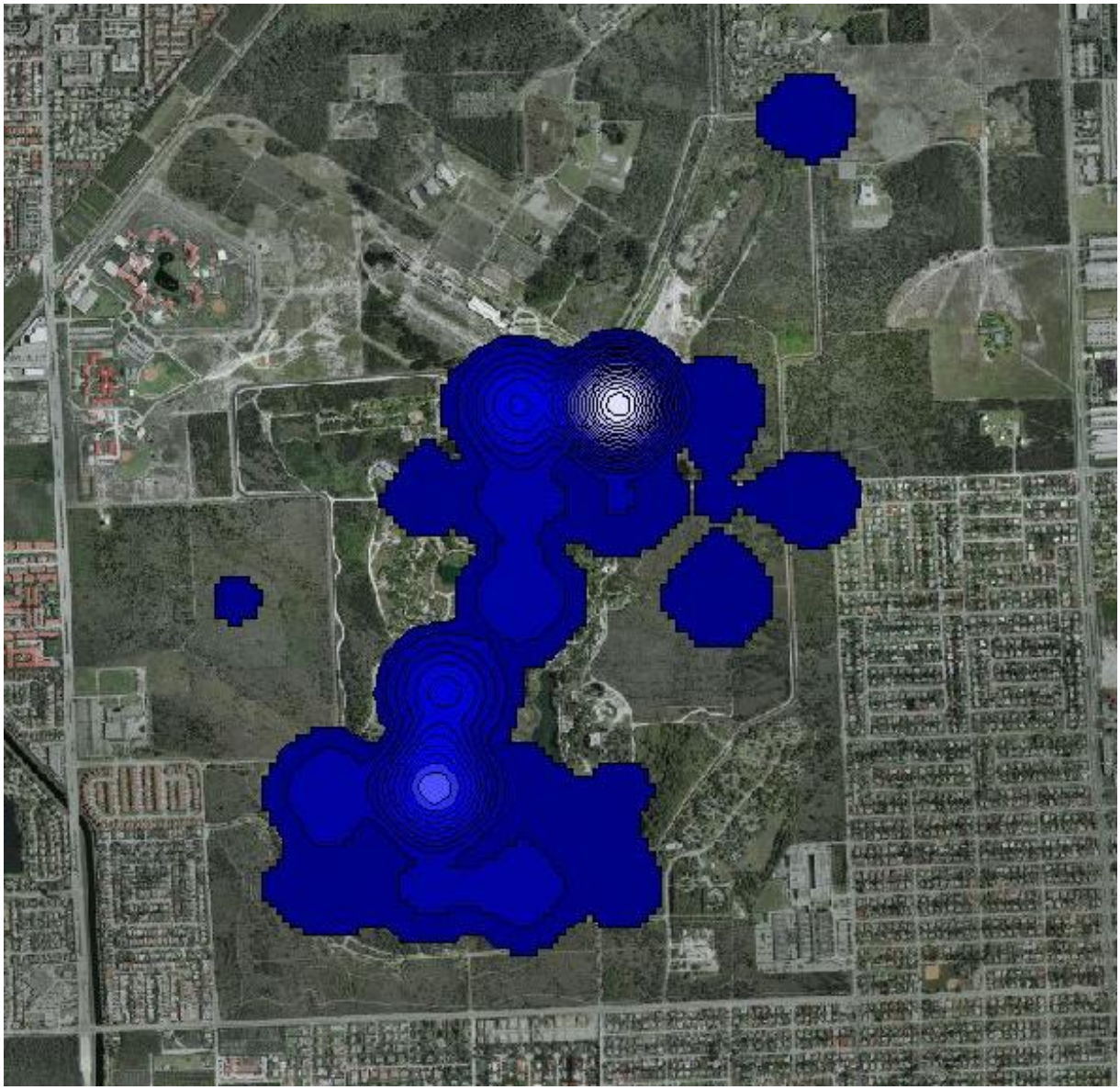
Utilizing ArcView software, projecting the fixed kernel home range distributions of non-*Eumops* species with probability classification in 5% intervals, a broad distribution can be seen with higher probability around the artificial water bodies and lower distribution in pine rockland within the study site. This is represented through graduated color (Map 4) and gridline dot gradients (Map 5).



Map 4: Non-*Eumops* fixed kernel distribution with 5% probability intervals. Highest probability is displayed in white with graduated color to lowest probability, dark red.

Map 5: Non-*Eumops* fixed kernel distribution with gridline dot density probability. The higher the dot density field in an area indicates a higher detection probability.

The same distribution maps were generated for Eufl and represented in Map 6 & 7 respectively.

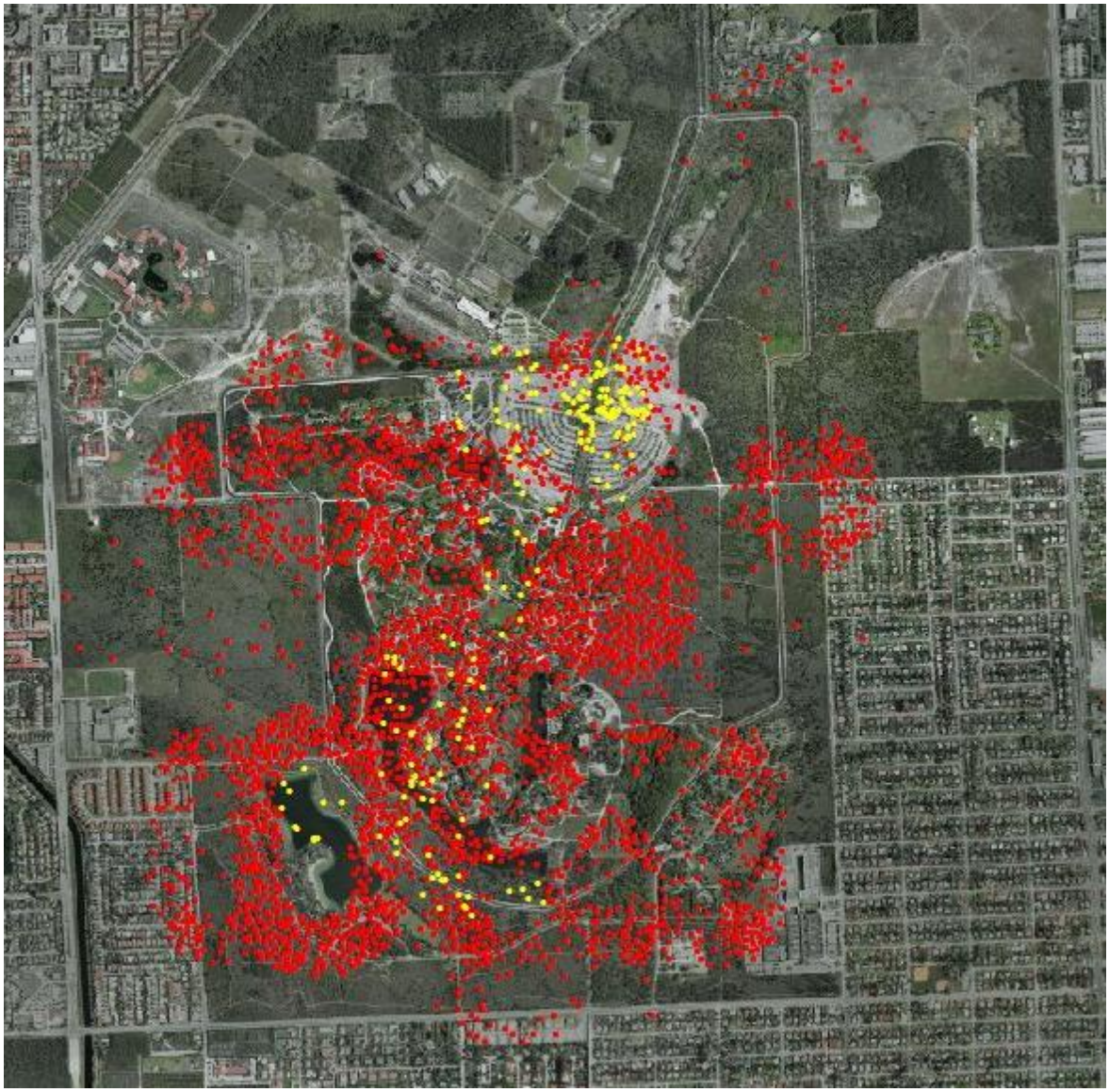


Map 6: Eufl fixed kernel distribution with 5% probability intervals. Highest probability is displayed in white with graduated color to lowest probability, dark blue.

Map 7: Eufl fixed kernel distribution with gridline dot density probability

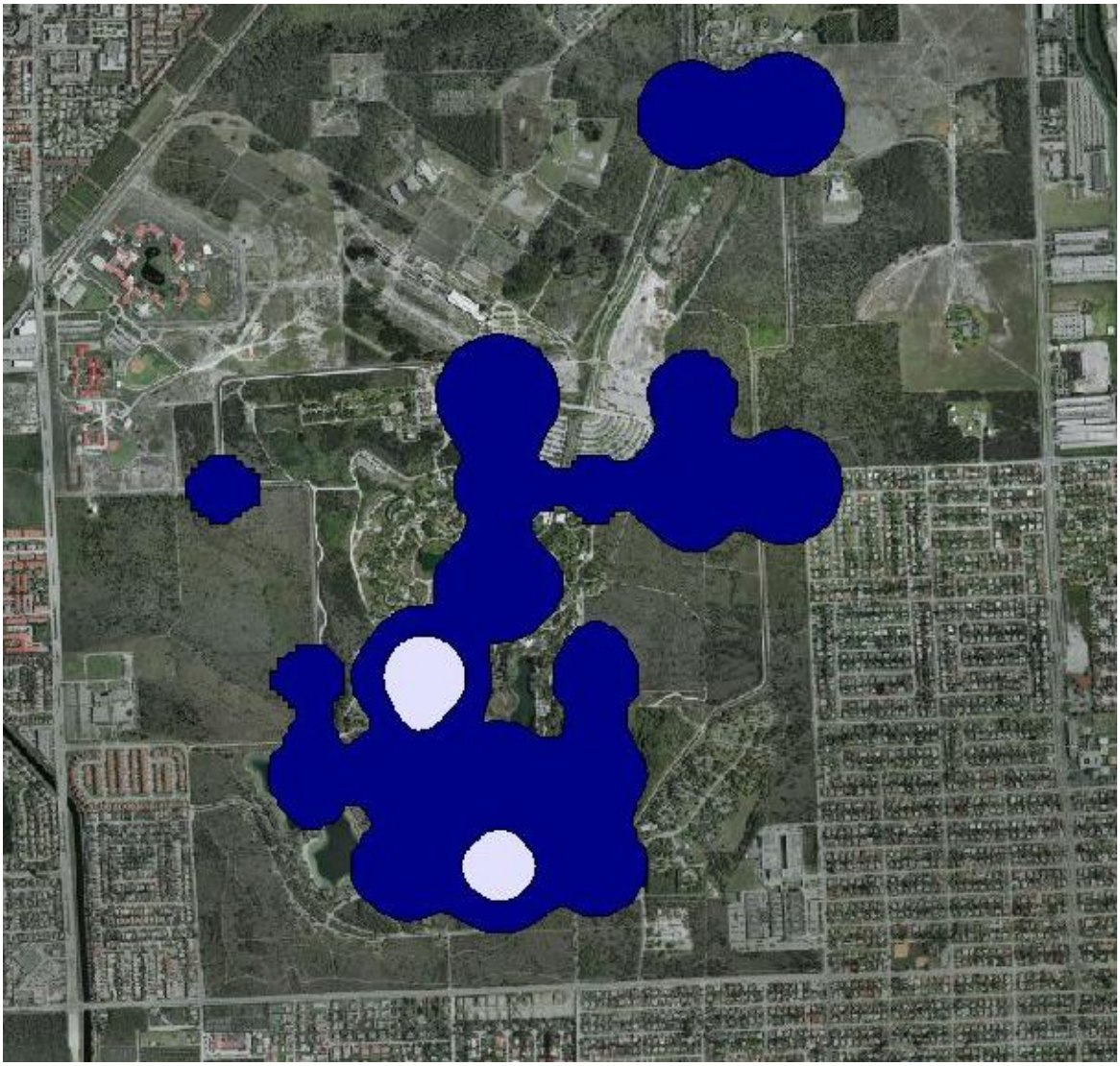
A much narrower distribution pattern for Eufl was found with associations with Zoo Miami's main parking lot, the large artificial lake at the southern end of the zoo's property, the areas between the two sites and, to a lesser extent, the lake at L&P.

The projection of the fixed kernel distribution gridline dot density probability of both total Eufl and non-*Eumops* together shows shared usage of all bat species of the large lake at the southern end of Zoo Miami. There is also a noticeable distinction in increased usage of Eufl of the zoo's parking lot when compared to other non-*Eumops* (Map 8).



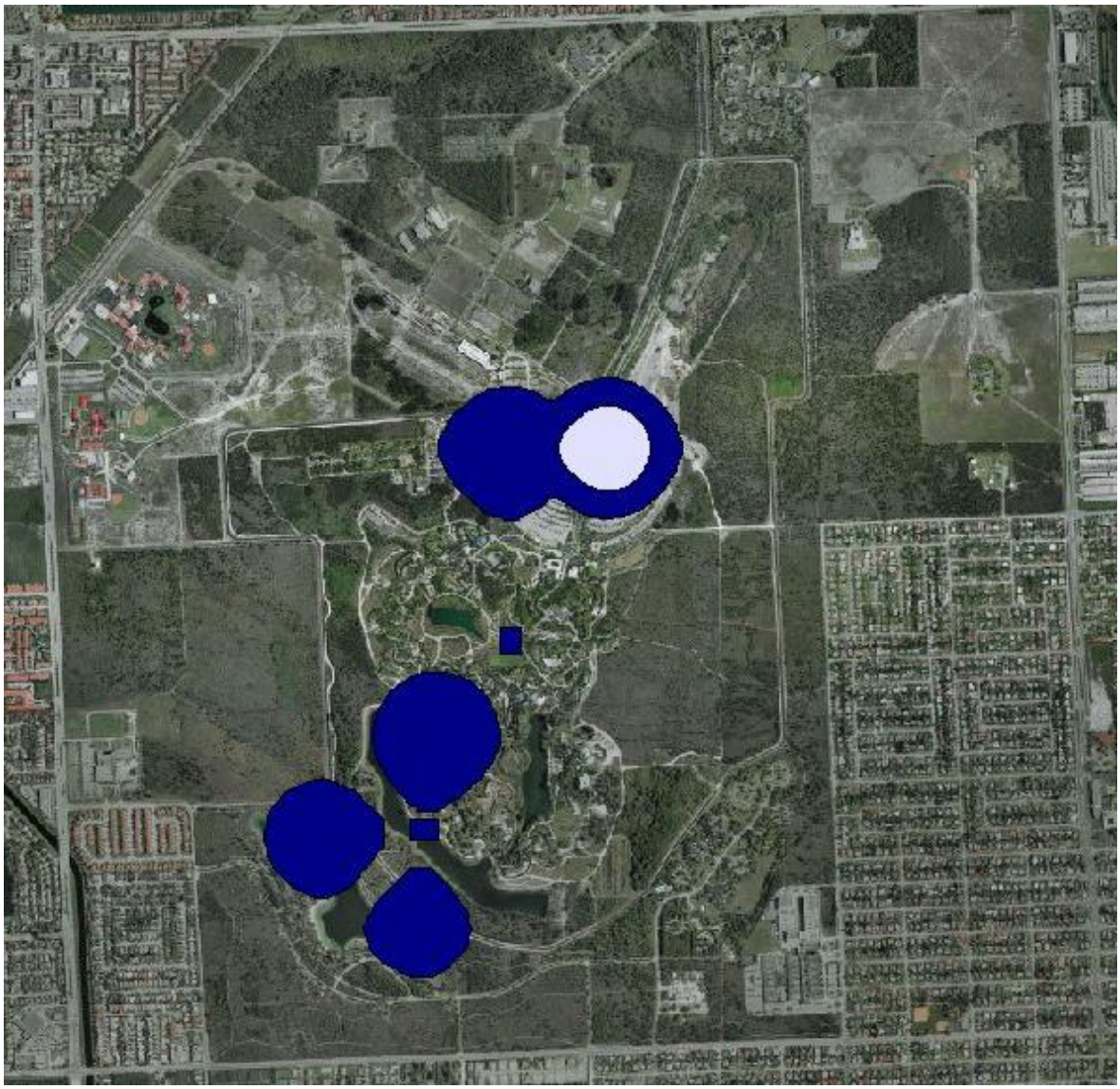
Map 8: Combined non-*Eumops* (red dots) and Eufl (yellow dots) fixed kernel distribution with gridline dot density probability

The study was divided into three complete acoustic sampling periods, as described below. When each of the sampling periods for Eufl is mapped separately, a variation in distribution can be observed over the study site through time. The first period, October 1st, 2012 through December 21st, 2012 (representing the first part of the dry season in South Florida) is displayed in Maps 9 and 10. The second period, January 3rd, 2013 through March 31st, 2013 (the second half of the dry season) is represented in Maps 11 and 12. The third period, April 2nd, 2013 through September 27th, 2013 (the rainy season in South Florida) is displayed in Maps 13 and 14.



Map 9: Eufl fixed kernel distribution with graduated color at 50% probability in white and 51-95% in blue for the time period of October 1st, 2012 through December 21st, 2012.

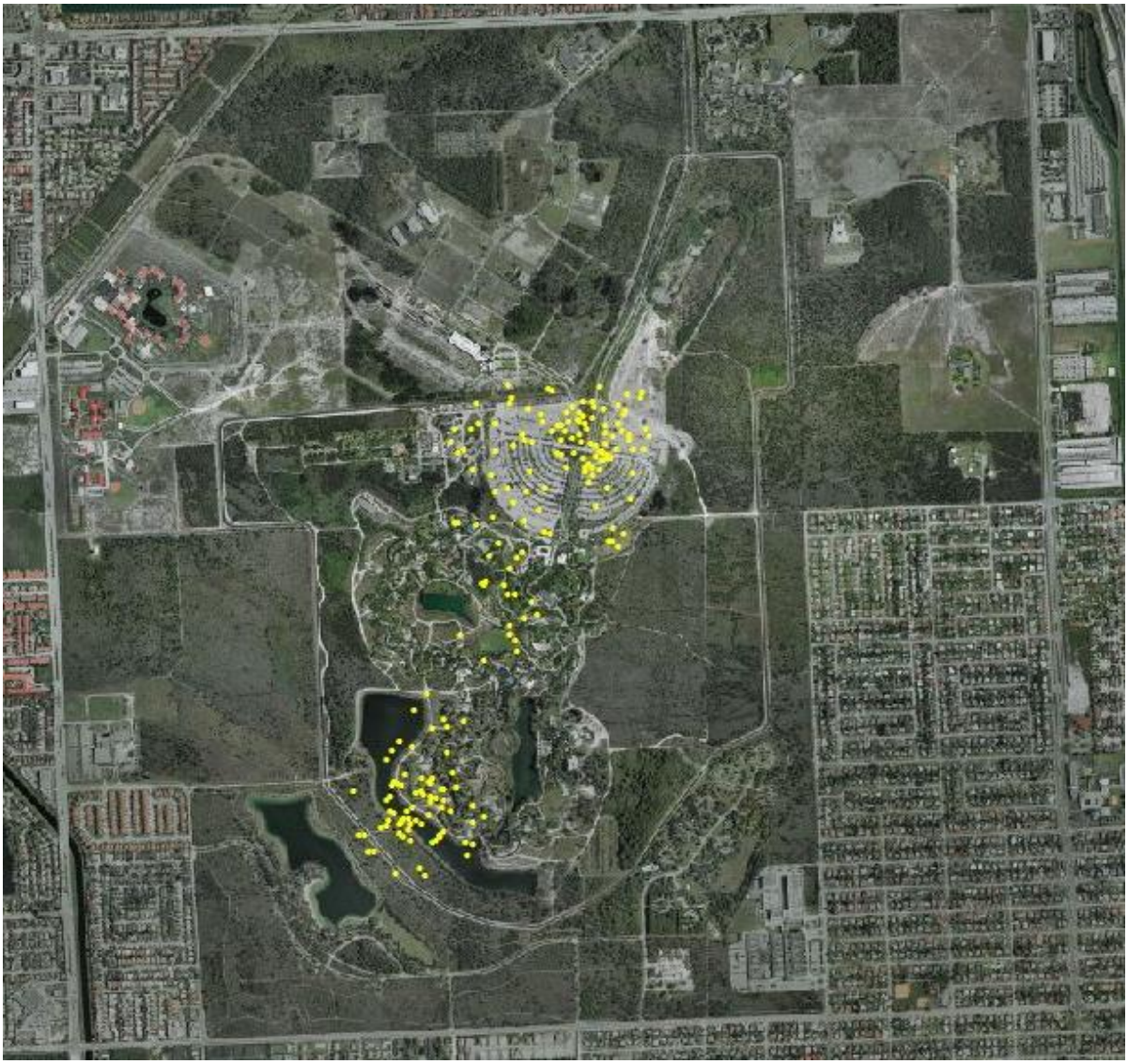
Map 10: Eufl fixed kernel distribution with gridline dot density probability for the time period of October 1st, 2012 through December 21st, 2012.



Map 11: Eufl fixed kernel distribution with graduated color at 50% probability in white and 51-95% in blue for the time period of January 3rd, 2013 through March 31st, 2013.

Map 12: Eufl fixed kernel distribution with gridline dot density probability for the time period of January 3rd, 2013 through March 31st, 2013.

Map 13: Eufl fixed kernel distribution with graduated color at 50% probability in white and 51-95% in blue for the time period of April 2nd, 2013 through September 27th, 2013.



Map 14: Eufl fixed kernel distribution with gridline dot density probability for the time period of April 2nd, 2013 through September 27th, 2013.

A shift from primary distribution of Eufl around the southern lake at Zoo Miami in the first period to primarily the parking lot in the second period can be seen demonstrated in the Maps 9 and 11. Maps 13 and 14 show a more even distribution among the two sites throughout the third period (rainy season).

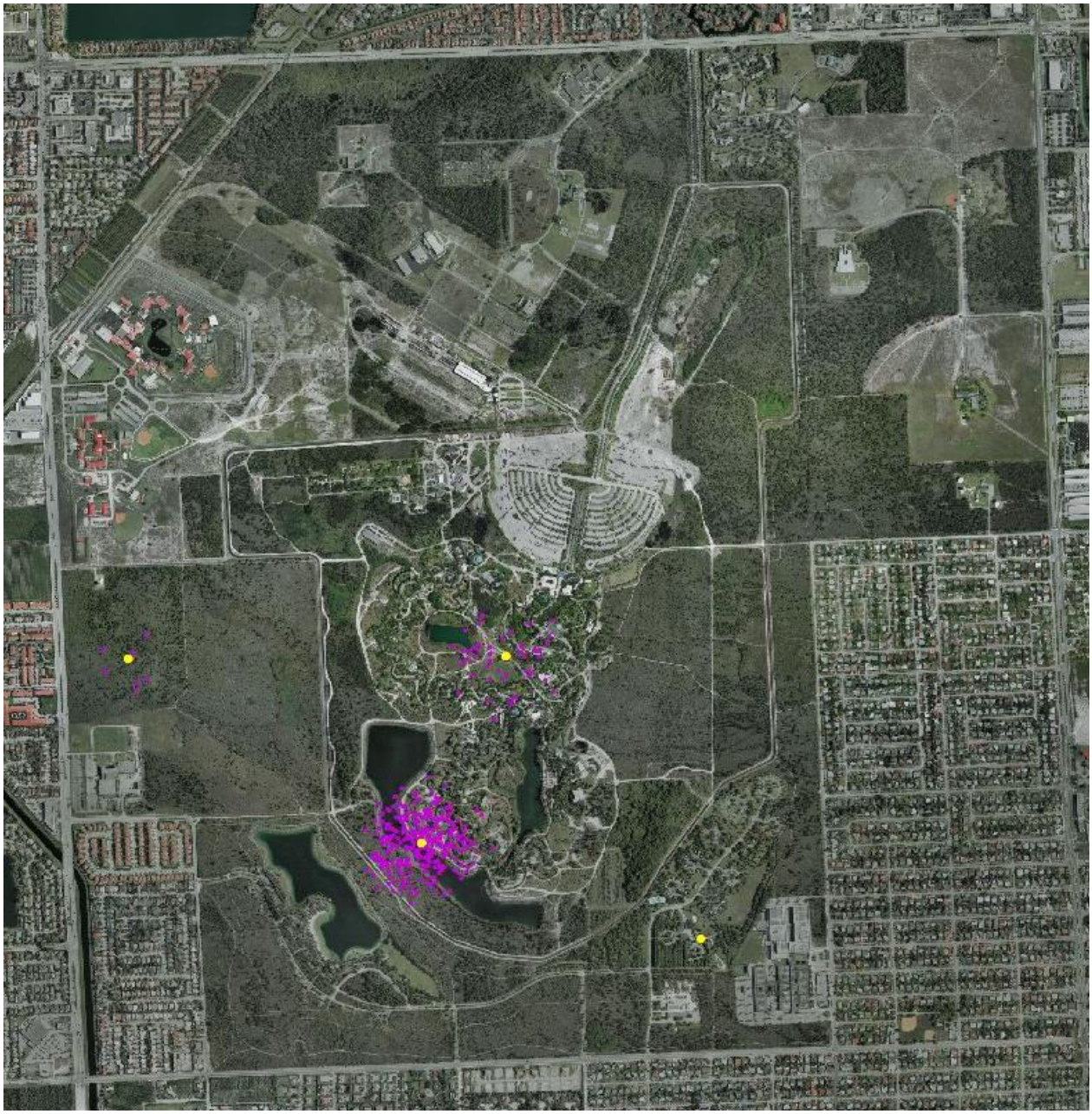
Total Eufl calls detected within 30 minutes of sunset are demonstrated in Map 15 to show early emergence locations, presumably from a roosting location, within or near the study site. Eufl calls detected between 30-45 minutes from sunset are demonstrated in Map 16.

Map 15: Eufl fixed kernel distribution with gridline dot density probability for calls occurring between sunset and 30 minutes post-sunset. Red dots represent acoustic survey sites.

Map 16: Eufl fixed kernel distribution with gridline dot density probability for calls occurring between 30-45 minutes post-sunset. Red dots represent acoustic survey sites.

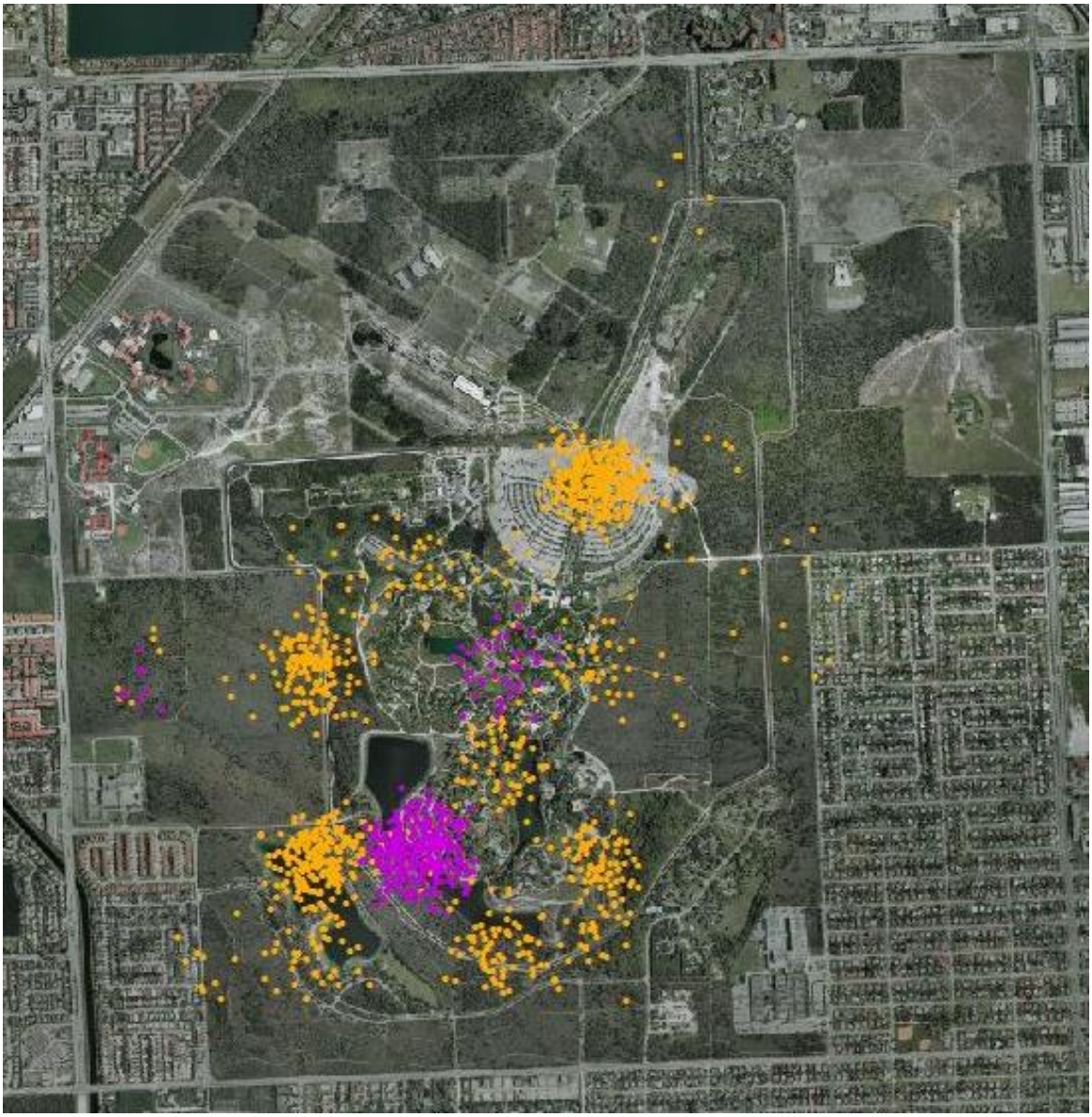
Calls detected between sunset and within 30 minutes post sunset are concentrated mostly outside areas of the highest total call probability areas (Map 15). Between 30-45 minutes post sunset, the distribution pattern has changed to have a large focus in the zoo's parking lot and many points outside the total call probability areas. There is no directionality to the data to determine the vector trends for these areas seen in Map 16.

Calls detected within one hour of sunrise are represented in Map 17.



Map 17: Eufl fixed kernel distribution with gridline dot density probability for calls occurring within one hour of sunrise. Yellow dots represent acoustic survey sites.

Map 18 projects the combined fixed kernel distributions of late detections and early detections throughout the study period.



Map 18: Eufl fixed kernel distribution with gridline dot density probability for calls occurring between sunset and 45 minutes post sunset (yellow) and within one hour of sunrise (purple).

Discussion:

Quantitative and qualitative call identification was not performed on the vast majority of non-*Eumops* bat species calls recorded within the study site. But, relative abundance was noted through the qualitative call identification for Eufl. Tabr and Nyhu were the most abundant, followed by *Lasiurus* sp., and rarely *Pipistrellus subflavus* and *Eptesicus fuscus*.

The areas of highest probability obtained through the fixed kernel distribution maps appear to show suitable or preferred foraging locations for Eufl due to high frequency of detected calls and prolonged periods of time that Eufl were present at each sampling site location. Feeding buzzes for Eufl were also

recorded in these areas. Eufl utilizes the large parking lot at Zoo Miami, the southernmost lake on zoo property, and, to a lesser extent, the lake at Larry and Penny Thompson Memorial Park. Non-*Eumops* species at the study location have a much wider distribution than Eufl and appear to heavily utilize all of the artificial water features within the study site. None of the species appear to display heavy foraging activity within the borders of the pine rockland. There is a noticeable preference of Eufl and lack of non-*Eumops* foraging activity in the large parking lot. Eufl appears to not prefer to forage at the smaller lakes or field areas on the developed grounds at the study site which non-*Eumops* species utilize heavily.

Common features of the preferred foraging areas for Eufl at this study location are large wide open spaces with little obstruction present and very little to no artificial lighting. These features appear to be consistent with one of the only other known foraging locations for Eufl, the Granada Golf Course see in Map 19(2001 Granada Boulevard, Coral Gables, FL 33134). The largest and southern most lake at Zoo Miami has a slightly curving total linear length of approximately 3000ft. Its largest width at the northern third is approximately 670ft and the width of the southern two thirds varies between 150-260ft. The parking lot at Zoo Miami is approximately 2000ft at its greatest east to west dimension and approximately 2500ft in its greatest north to south dimension. The greatest, slightly curving, linear length of the Granada Golf Course is approximately 5100ft, has minimal artificial lighting and no intact natural areas adjacent to it. The approximate total width of the course is 510ft with the unobstructed flyways varying in width from 125-210ft. The less preferred lake for foraging at L&P is approximately 1500ft at its greatest length, has no artificial lighting, intact pine rockland adjacent to it, and varies in width from approximately 330-600ft. The entrance drive to the zoo at the north end of the survey has an unobstructed linear length of approximately 4725ft, a width of 36ft, no artificial lighting along the majority of its length, intact pine rockland in close proximity, and did not have Eufl foraging activity recorded within it. The next largest lake within the study area that had no Eufl foraging activity recorded around it is approximately 1075ft in length, approximately 245ft in width at its widest point, no artificial lighting, and no intact natural areas directly adjacent to it.

Map 19: Ariel view of Granada Golf Course in Coral Gables, FL.

Given that *Eumops* wing structure is conducive to high-speed and prolonged flight (Findley et al. 1972 as cited in Best et al. 1997, p. 3) and the preferred foraging locations share lengthy unobstructed areas, the results indicate that areas greater than 1500 linear feet and a width of at least 125-150ft of unobstructed flight would have a higher probability of Eufl foraging activity. This landscape arrangement would also improve foraging efficiency for a species with these anatomical characteristics and expend less energy than in areas where frequent or tight turns would be required. Identifying candidate areas that share these characteristics may improve survey site selection for Eufl.

These landscape characteristics would also need to be paired with suitable or preferred insect prey being present at the same locations. Since the necessary or preferred insect prey species for Eufl is still poorly described, it could be difficult to include this factor in predicting foraging locations at this time. Since there were some shifts in seasonal foraging activity shown in this study, pairing nocturnal flying insect surveys at the known foraging locations when Eumops are present may provide more information for predicting important habitat criteria. Foraging locations identified in this study all had intact pine rockland bordering the areas and could be serving as the source for suitable or preferred prey. The fact that other species of bats did not prefer to forage in the zoo's parking lot may also provide important information on suitable or preferred insect prey species through comparative insect surveys. If roost sites could be located within or adjacent to the study area, guano analysis paired with the insect surveys would also provide significant information about the prey species and their life cycle requirements. Given that there are no natural areas present around the Granada Golf Course, it may be found that Eufl

is very adaptable in its prey species utilization but the seasonal change and site selection seen in this study adds support to the hypothesis that it has prey and habitat preferences.

The lack of a significant amount of artificial lighting at the known foraging locations is another factor that has a potential but unknown influence on site selection at this time. Performing further surveys at both illuminated and non-illuminated locations with the same physical landscape characteristics may provide more information on the influence of this factor.

Accessible freshwater would be another factor in site selection. Given the foraging site selection characteristics seen in this study and the anatomical characteristics of the species, it would be logical to conclude that these preferred freshwater sites would also have to be fairly lengthy, linear, and unobstructed bodies to allow ease of drinking on the wing.

On February 24th, 2013, specially trained Eufl guano detection dogs, which were contracted by USFWS, were brought into the study area to aid in possible roost site detection. No candidate locations resulted from the visit based on the current early detection data at the time. The early emergence and late detection locations that have resulted from this completed study provide additional candidate locations that require further exploration for roosts. There are no large snags in these early detection areas that are sizable enough or have cavities that appear that they could support a Eufl colony due to most being destroyed in hurricanes occurring in recent history. There are concrete structures at Zoo Miami for housing parts of the animal collection and wooden structures at both Zoo Miami and Larry and Penny Thompson Memorial Parkwhich contain gaps in the roof and overhang construction in these early detection areas that could possibly support Eufl roosting.

Calls detected within the pine rockland areas at the east and west margins of the study site can be seen most clearly on Maps 10, 16 and 17. These Eufl calls were recorded repeatedly in these locations but were usually limited to just a single constant frequency call or short sequence in low abundance on any given night of the survey. These areas do not represent significant foraging areas for Eufl. It is believed that these represent nightly flight paths over these locations. Since a single acoustic monitoring device with no directionality information was utilized in this study, it cannot be determined from this study if these are Eufl entering or leaving the study area. The use of multiple acoustic recording units with synchronized times or active recording in these areas may answer these pending questions.

On Maps 6, 9, 10, and 16 a sampling site location at the very northern extent of the survey repeatedly detected the presence of Eufl but is disjunctive to the rest of the recordings. It is unclear if this represents a separate colony or if the detections are connected through properties not included in this study.

Conclusions:

Eumops floridanus occupies the properties of the Richmond Tract. Important foraging locations for Eufl are the large parking lot at Zoo Miami, the southernmost lake on Zoo Miami property and to a lesser extent, the lake present at L&P. Eufl appear to prefer large unobstructed areas in which to forage with lengths greater than 1500 ft and widths at least 125-150ft. Other factors such as artificial lighting, prey

species present, and roost and accessible freshwater proximity to these foraging locations still require further study. There is a seasonal shift demonstrated in foraging location preference. Pine rockland does not directly appear to be an important foraging location for Eufl but its adjacent proximity to preferred foraging locations, the prey life cycle, and prey species Eufl prefers needs further study in relation to this specific habitat. Eufl overlaps foraging locations for some other species of bats but also utilizes areas not preferred by other bat species found in the study site. Early emergence of Eufl was detected which supports roosting within or adjacent to the acoustic study site. Movement of Eufl into or out of the Richmond tract properties is occurring at the eastern and western edges over pine rockland. A region at the northernmost extent of the acoustic study site has disjunctive activity to the rest of the properties included in this study. Further long term acoustic studies within the Richmond Tract are required to fully characterize important foraging locations throughout the seasons and identify further early emergence sites that may indicate possible roost locations.

It is suggested that long term acoustic surveys of the US Coast Guard Facility, the University of Miami CSTARS, the Federal Correctional Institution, the University of Miami South Campus, the Department of Defense, and Three Lakes housing development (located north of the Richmond Tract across SW 152nd Street) that possess large, unobstructed areas similar to utilized areas identified at this study site are performed. The length of subsequent studies should take into account the seasonal shift of foraging locations seen in this acoustic survey.

References:

BEST, T. L., W. M. KISER, AND J. C. RAINEY. 1997. Eumops glaucinus. Mammalian Species 551:1–6.