Bat Species and Distribution in a Gulf Coast System at Fort DeSoto Park, Florida

Jennifer Beltran

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Bat Species and Distribution in a Gulf Coast System at Fort DeSoto Park, Florida

by

Jennifer Beltran

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
Department of Environmental Science and Policy
College of Arts and Sciences
University of South Florida St. Petersburg

Major Professor: Deby Cassill, Ph.D.
Christopher Meindl, Ph.D.

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Abstract

Determining the spatial distribution and species of bats in coastal habitats is a crucial step toward integrating bat conservation with local, state and national land management practices. Short-term acoustical monitoring with the Anabat SD2 detector was conducted at Fort DeSoto Park in Pinellas County, Florida from June 2010 to May 2011; excluding January, February, November, and December. Foraging activity by four species of bats was recorded. Echolocation calls by the Brazilian free-tailed (*Tadarida brasiliensis*), evening (*Nycticeius humeralis*) and the northern yellow (*Lasiurus intermedius*) were common; the Seminole (*Lasiurus seminolus*) was recorded only twice. Temporarily, foraging activity was highest during the summer months of June, July, and August and during 30 to 120 minutes after sunset. Spatially, foraging activity was highest where the insects were—in habitats with permanent freshwater, pine flatwoods, cabbage palms or mangroves. Foraging activity was lowest over sand dunes and open beaches. Serendipitously, bats were recorded drinking from a permanent freshwater pond with little aquatic plant clutter; later in the study, after tall, aquatic grasses were introduced and filled the pond, bats were no longer observed drinking—a potentially important finding for bat conservation at Fort DeSoto Park. In summary, bats were opportunistic foragers, foraging during the times and locations of the highest insect population.
Chapter 1: Introduction

Bats, which make up one-fifth of the world’s mammalian species (Simmons, 2005), are distributed among a wide range of habitats on every continent except Antarctica (Orr, 1971; Fenton, 1997). Temperature and humidity affect the activity of insects, which in turn, affects the foraging activity of bats (Taylor, 1963; Rydell et al., 1996). During cool weather, when insect activity is low, bat foraging activity is low (Kunz, 1982; Hayes, 1997). To maximize foraging effort, insectivorous bats forage extensively at dusk and dawn during peak insect activity (Rydell et al., 1996).

Insectivorous bats are opportunistic generalists (Whitaker, 2004), feeding on available insects including Lepidoptera (moths), Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Hymenoptera (wasps, bees, and ants), Odonata (dragonflies and damselflies), Orthoptera (grasshoppers), Isoptera (termites), and Ephemeroptera (mayflies) (Fenton, 1974; Hill and Smith, 1984). Thus, bats are an important bio-control of night-flying insects (Kunz, 1974; Lee and McCracken, 2005).

While foraging, insectivorous bats use echolocation to maneuver through their environment and to detect and capture prey in flight or by gleaning, depending on the species (Griffin et al., 1960; Fenton, 1974). Bat echolocation calls have a signature range of pitch (measured in kHz), amplitude and frequency that is species-specific (Fenton and Bell, 1981; O’Farrell et al., 1999). Recent advances in technology are capable of recording and translating species-specific echolocation calls while bats are in flight. In-
flight recording devices are a major advance for determining species presence compared to the traditional, but invasive and time consuming, method of physically capturing bats with mist nets (O’Farrell et al., 1999; White and Gehert, 2001).

Thirteen species of bats are permanent residents of Florida although an additional seven species have been occasionally documented (Marks and Marks, 2006). Five species of bats have been documented in Pinellas County, Florida: the Brazilian free-tailed bat, *Tadarida brasiliensis*; the evening bat, *Nycticeius humeralis*; the northern yellow bat, *Lasiurus intermedius*; the Seminole bat, *Lasiurus seminolus*; and the tri-color bat, *Perimyotis subflavus*. Of these, the Brazilian free-tailed bat, the evening bat and the northern yellow bat are common in the Pinellas County area of Tampa Bay (The Florida Bat Conservancy, unpublished data over a 20-year period).

The Brazilian free-tailed bat is a colonial bat that is widely distributed throughout North, South, and Central America (Wilkins, 1989). These bats are high and fast flyers with low clutter maneuverability (Norberg and Rayner, 1987) that limits them to foraging in open spaces (Nowak, 1994). Although their natural roosts are tree cavities, Brazilian free-tailed bats have adapted to roost primarily in manmade structures such as attics, bridges, and bat houses (Wilkins, 1989). Brazilian free-tailed bats emerge early to forage, averaging around 15 minutes after sunset (Reichard et al., 2009) and can fly as far as 50 km or more to reach their foraging grounds (Griffin, 1971).

The evening bat is a colonial bat found in the southeastern United States (Watkins, 1972). Evening bats are slower in flight and have more clutter maneuverability than the Brazilian free-tailed bat (Norberg and Rayner, 1987). The evening bat uses a number of different roosts that include Spanish moss (*Tillandsia usneoides*), bark, tree
cavities, and manmade structures (Jennings, 1958; Menzel et al., 1999). Generally, the evening bat forages in open natural habitats such as tree edges and fields (Geluso et al., 2008).

The northern yellow bat is a solitary mammal distributed throughout the coastal southeastern United States and forages over open areas (Webster et al., 1980). The roosting habitat of this bat is dead palm fronds and Spanish moss (*T. usneoides*) (Webster et al., 1980; Nowalk, 1994).

The Seminole bat is solitary and distributed throughout the southeastern United States (Wilkins, 1987). Seminole bats are often found in forested areas and roost in Spanish moss (*T. usneoides*) and in the foliage of pine trees in wooded areas (Nowalk, 1994; Menzel et al. 1998; Perry and Thill, 2007).

Finally, the tri-colored bat, which can be both colonial or solitary, is distributed throughout the eastern United States, ranging as far north as Canada (Fujita and Kunz, 1984). Tri-colored bats forage over water and along treelines (Davis and Mumford, 1962); and roost in foliage, caves, crevices, and manmade structures (Barbour and Davis, 1969).

During foraging, bats fly down and briefly dip their mouths into water to drink water from rivers, lakes and ponds (Fenton, 1992; Seidman and Zabel, 2001). Bats prefer drinking from calm water bodies and avoid surfaces with waves or ripples (Fenton and Bell, 1979; Rydell et al. 1999). The open water surface area that bats need varies with their size and maneuverability. Bats with high maneuverability only need a few inches of water while larger, faster fliers with lower maneuverability require larger bodies of water from which to drink (Fenton, 1992).
Studies of bat ecology along coastal systems are uncommon. Kellner and Harestad (2005) characterized the diets of bats found foraging in coastal forests of British Columbia. Species were identified via mist net capture methods. Feces samples were taken from captured bats to identify insect species consumed. Johnson and Gates (2007) used mist net surveys and acoustical monitoring to determine the distribution of bat species in a coastal system in Maryland.

The objective of this study was to determine the species and to describe their temporal and spatial foraging distribution at Fort DeSoto Park, in Pinellas County, Florida; a 1,136-acre coastal park. Documenting the species and activity distribution of bats in this coastal habitat is an essential first step for acquiring baseline information (Kalko et al., 1996; Johnson and Gates, 2007) to guide biologists, policymakers, and park managers as they consider incorporating bat conservation into local, state and national environmental management plans.
Chapter 2: Methods and Materials

Study Site: Fort DeSoto Park is a coastal ecosystem that occupies the southern-most point in Pinellas County, Florida. The park has over seven miles of waterfront, including three miles of beach. Fort DeSoto Park consists of five barrier islands: Madelaine Key, St. Jean Key, St. Christopher Key, Bonne Fortune Key, and the main island of Mullet Key. Together these islands total 1,136 acres. Habitats on Fort DeSoto include pine flatwoods, mangroves, and beach. Dominant tree species include slash pine (*Pinus elliottii*), saw palmetto (*Serenoa repens*), cabbage palm (*Sabal palmetto*), Australian pine (*Casuarina equisetifolia*), and red (*Rhizophora mangle*) and black mangrove (*Avicennia germinans*).
Nine areas of Fort DeSoto Park were selected for surveying bat activity (Fig. 1). Eight of the sites are located on the main island of Mullet Key. The ninth site is located on St. Jean Key. The survey sites were selected by accessibility and habitat homogeneity. Two of these sites contained a permanent freshwater source.

Figure 1: Fort DeSoto Park survey site names and locations. Sites were delineated based on habitat homogeneity with the site. For example, the Arrowhead site was dominated by pine flatwoods.

North Beach is open beach with sand dunes and a tidal inlet surrounded by mangroves. This site also includes a paved parking lot lined with Australian pine and cabbage palms. A permanent freshwater pond is located near North Beach, approximately 370 feet east of the parking lot. Land near the freshwater pond has cabbage palms and snags. The permanent pond, 95 feet long and 35 feet wide, is man-made. Until June 2010,
the pond had few visible aquatic plants (Fig. 2). By March 2011, aquatic plants had been introduced, obstructing most of the surface area (Fig. 3). An unoccupied bat house installed on a freestanding pole is located approximately 285 feet northeast from the freshwater pond in a sandy area surrounded by mangroves.

Figure 2: Freshwater pond at the North Beach survey location site in June 2010. Photograph by Jennifer Beltran.
The Arrowhead site includes pine flatwoods, with mangroves lining the waterfront. The pine flatwoods contain pines, cabbage palms, Spanish moss, and snags. At the time of the study, eight unoccupied bat houses were located approximately ten feet above the ground, attached to the sides of slash pines. The Open site includes open beach and sand dunes. A few cabbage palms are scattered along the sand dunes on the gulf side. Cabbage palms, mangroves, and snags line the roadway on the bay side. The Fort site includes the historic fort, a parking lot, and fishing pier. Several boardwalks lead out to the open beach. Light posts line the parking lot and the pier. A freshwater well is located at this site. Cabbage palms line both sides of the roadway and the parking lots.
Authorities built an artesian well during construction of the fort in the late 1800s. Although the well is now covered, water trickles out into a small basin and is accessible to insects, birds and other animals (Fig. 4). Cabbage palms stand near the well.

Figure 4: Artesian well with basin at the Fort survey location site. Photograph by Jennifer Beltran.
The Kayak Rental site includes mangroves near the water’s edge and pine flatwoods a bit further inland. The pine flatwoods contain pines, snags, Spanish moss, and cabbage palms. The Headquarters site contains an office building, parking lots, flagpole with spotlights. Beach dunes are located behind the headquarters building. Cabbage palms and Australian pines are scattered around the perimeter of the parking lot. The Bayway site is located on the Pinellas Bayway roadway near the entrance to the park’s campground. Australian pine, mangroves, and cabbage palms line both sides of the two-lane roadway. The East Beach site includes open beach with sand dunes and a parking lot lined with Australian pine. Cabbage palms are scattered throughout the parking lot. Mangroves line the bay side of the roadway. The Eastern Point site is located at the round-a-bout on the east side of the park. Mangroves line both sides of the roadway.

*Acoustical Monitoring:* The frequencies of bat echolocation calls are measured in kHz units. Because most echolocation calls are inaudible to humans, bat detectors are required to translate calls into the audible range (Brigham et al., 2004). An echolocation sequence is defined as a series of vocal calls produced by an individual bat as it passes within range of a detector (Broders, 2003). The Anabat SD2 detector (Titley Scientific, New South Wales, Australia) used in this study is a broadband (20-200 kHz) detector that can detect a range of foraging calls from numerous bat species. To translate bat echolocation calls into an audible range for humans, the detector divides the frequency of the incoming echolocation sequence by a preset division ratio; set at 16 in this study (Fig. 5). Echolocation calls were saved on a compact flash drive in the field and later uploaded.
onto computer software for analysis using Analook software (Titley Scientific, New South Wales, Australia). The Analook software produces a frequency-time graph of each echolocation call. Species were identified by examining the characteristics of each echolocation sequence for signature characteristics, such as its shape, kHz range and frequency (Fig. 6 and 7).

Figure 5: Anabat SD2 detector. Photograph by Jennifer Beltran.
Figure 6: Evening bat (*N. humeralis*) echolocation sequence via Analook software.
The Anabat detector has limitations. First, the detector cannot differentiate individual bats. It is impossible to determine if twenty echolocation sequences recorded by the same species were emitted by one individual or multiple individuals. Second, the Anabat is less sensitive to distant echolocation calls. This is partly due to the fact that all ultrasonic sounds are made audible, potentially obstructing the bats’ echolocation calls (Brigham et al., 2004). Third, detection of echolocation sequences depends on the range and direction in which the detector is set (Weller and Zabel, 2002). The Anabat detector microphone picks up echolocation sequences that are approximately 100 feet in distance and within a 90° cone in width.

Echolocation call monitoring is an effective, non-invasive method for inventorying bat species and activity in specific habitats of interest (Fenton and Bell,
1981; Brigham et al., 2004). Moreover, monitoring bats with detectors allows for sampling larger areas than capture methods and can detect rare and uncommon species or those that are difficult to capture (O’Farrell and Gannon, 1999). In summary, no method used to identify bats will yield a complete picture of bat activity. Because the objective of this study was to determine species and foraging activity over time and habitat types, acoustical survey methods were chosen.

Study Surveys: Eighteen acoustical surveys were conducted over a period of eight months from June 2010 to May 2011 (March=1, April=3, May=3, June=2, July=3, August=2, September=2, October=2), at Fort DeSoto Park using the Anabat SD2 detector. November, December, January, and February were excluded; because of cooler temperatures, activity for both insects and bats is significantly reduced (Taylor, 1963; Kunz, 1982). Evenings with moderate to heavy precipitation were avoided.

Each acoustic survey began at sunset and ended three hours later. During the first hour, echolocation calls were recorded at a stationary site; during the second and third hours, echolocation calls were recorded while roving around within the same site and occasionally within an adjacent site. During roving, accessible areas including bike paths, tree lines, nature trails, and beach dunes were traversed. A three-hour survey method with stationary and roving periods was chosen to capture high foraging activity at dusk and after.

Data Analysis: Echolocation calls were analyzed to determine species type. Descriptive statistics were used to determine the temporal distribution of echolocation calls by month and by time after sunset, as well as the spatial distribution of echolocation
calls by habitat type. Graphs were completed using Microsoft Excel. Maps were compiled using ArcGIS. The survey sites and months were not randomly selected, nor were sites nested within months (e.g. every site surveyed each month). Thus, comparative tests were not conducted and generalizations can not be made beyond the Fort DeSoto Park site. Nevertheless, this survey succeeded in determining which bat species forage within this coastal park and indicated their relative temporal and spatial distribution during the designated survey period.
Chapter 3: Results

*Bat Species:* From June 2010 through May 2011 a total of 1,332 echolocation sequences were recorded; four species of bats were identified at Fort DeSoto Park (Fig 8). The evening bat accounted for the majority of echolocation sequences (66%, 884). The northern yellow bat, the Brazilian free-tailed bat and the Seminole bat accounted for most of the remaining echolocation sequences (18%, 234; 11%, 143; 0.02%, 2 respectively). Five percent (69/1,332) of the echolocation sequences were undetermined.

![Bat Species and Activity Documented at Fort DeSoto Park, 2010-2011](image)

Figure 8: Frequency of bat activity by species documented at Fort DeSoto Park from June 2010 through May 2011.

*Temporal Distribution after Sunset:* Eighty-four percent (1,119/1,332) of the total echolocation sequences recorded at Fort DeSoto Park were between 31 and 120 minutes.
after sunset. Sixty percent (794/1,332) of the sequences recorded were during the roving (61-180 minutes after sunset) period of the surveys. The remaining 40% (538/1,332) were recorded during the stationary (1-60 minutes after sunset) period (Fig. 9).

Figure 9: Bat activity documented at Fort DeSoto Park based on minutes after sunset. Bats normally emerge 15-20 minutes after sunset; the first stationary bar (1-30 minutes after sunset) is skewed by timing of emergence.

*Method (stationary versus roving):* All four of the bat species documented at Fort DeSoto Park (Brazilian free-tailed, evening, northern yellow, and Seminole) were detected within an hour (1-60 minutes after sunset) of sunset (Fig. 10). Evening bats accounted for 58% (307/538) of the total stationary sequences recorded. The northern yellow bat, the Brazilian free-tailed bat and the Seminole bat accounted for most of the remaining echolocation sequences (31%, 234/538; 6%, 33/538; 0.40%, 2 respectively). Five percent (29/538) of the echolocation sequences were undetermined.
Three out of the four species (Brazilian free-tailed, evening, and northern yellow) were documented during the roving (61-180 minutes after sunset) survey period (Fig. 10). Evening bats accounted for 73% (577/794) of the total roving sequences recorded. The northern yellow and the Brazilian free-tailed bat accounted for most of the remaining echolocation sequences (14%, 110/794 and 8%, 67/794 respectively). Five percent (40/794) of the echolocation sequences were undetermined.

Figure 10: Frequency of bats by species documented at Fort DeSoto Park during stationary and roving survey periods.
Figure 11: Spatial distribution of bat foraging activity during stationary and roving methods. Red dots display bat foraging activity stationary survey sites (1-60 min. after sunset). Several stationary sites were surveyed more than once. Blue dots display bat foraging activity during roving methods (61-180 minutes after sunset). Activity points represent coordinates of recorded bat activity, not individuals. Thus, each point represents multiple echolocation sequences from one or more individuals.

Spatial Distribution: Sixty-six percent (885/1,332) of the echolocation sequences recorded at Fort DeSoto Park were over coastal habitat which included pine flatwoods, cabbage palms, mangroves, parking lots, and Australian pines; the remaining 34% (447) of the echolocation sequences were recorded within 100 feet of water despite the fact that only two of the nine (< 1% of park landmass) survey sites has permanent freshwater.

Sixty-four percent (567/885) of the echolocation sequences documented over land were during the second hour of the survey period (roving; between 61-120 minutes after sunset). The remaining 36% (318/887) were during the first (stationary; 1-30 minutes
after sunset) and third (roving; 121-180 minutes after sunset) hour of the survey period (Fig. 12). Sixty-eight percent (306/447) of the echolocation sequences documented near permanent freshwater occurred during the first hour (stationary; 1-30 minutes after sunset) of the survey period; the remaining 32% (141/447) occurred final two hours (roving; 61-180 minutes after sunset) of the survey period (Fig. 12).

![Bat Activity Documented Over Land and Permanent Freshwater](image)

Figure 12: A comparison of echolocation sequences documented over land and near permanent freshwater by minutes after sunset.

During the survey in June 28th, 2010, the permanent freshwater pond near North Beach had few visible aquatic plants. Bats were recorded foraging near the pond and observed swooping down to drink. By March 17th, 2011 aquatic plants had been introduced. Although bats were recorded foraging no bats were observed to be drinking. Plants protruding from the water’s surface discourages bats from drinking (Fig. 3).
May 28th, 2011, a limited number of bats were observed and recorded foraging over and near the pond but none were observed drinking (13).

Figure 13: Echolocation sequences documented within 100 feet of the freshwater pond at the North Beach site. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.

At the Fort site, bats were observed and recorded foraging within 100 feet of the artesian well basin, but they were not observed to be drinking. Observations and recordings at the artesian well revealed significantly more echolocation calls on August 30th, 2010 than on May 27th, 2011 (Fig. 14).
Figure 14: Echolocation sequences documented over the artesian well basin at the Fort site. One hundred sixty-four northern yellow bat echolocation sequences were documented foraging over the well on August 30th while only one northern yellow bat sequence was documented on May 27th. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.

Four bat species were recorded foraging over land at Fort DeSoto Park (Fig. 15). The evening bat accounted for 77% (678/885) of the total echolocation sequences recorded over land. The Brazilian free-tailed, northern yellow, and the Seminole bat accounted for most of the remaining echolocation sequences (14%, 121/885; 4%, 36/885; 0.10%, 1 respectively). Five percent (49/885) of the echolocation sequences were undetermined.

Four species of bats were recorded within 100 feet of the permanent freshwater sites (Fig. 15). The evening bat accounted for 47% (206/447) of the total echolocation sequences recorded near permanent freshwater. The northern yellow, Brazilian free-tailed, and the Seminole bat accounted for most of the remaining echolocation sequences.
Four percent (20/447) of the echolocation sequences were undetermined.

Figure 15: Proportion of bat activity by species documented foraging over land and near permanent freshwater. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.

The North Beach site accounted for 26% (341/1,332) of the total echolocation sequences (Fig. 16). Sixty-one percent of these sequences (208/341) were recorded over the freshwater pond. A few bats were observed and recorded foraging over the parking lot, Australian pines and sand dunes. No bats were seen or recorded foraging on the open beach. The Fort site accounted for 18% (239/1,332) of the total echolocation sequences (Fig 16). Ninety-seven percent (231/239) of these sequences were documented over the freshwater artesian well basin. No recordings of echolocation sequences were documented at the historic Fort, parking lot, sand dunes, or open beach. The Arrowhead
site accounted for 15% (205/1,332) of the total echolocation sequences (Fig. 16). Bats were observed and recorded foraging throughout the pine flatwoods and mangroves. The Eastern Point site accounted for 14% (181/1,332) of the total echolocation sequences (Fig. 16). Bats were observed and recorded flying in over the mangroves from outside the park as well as foraging over the mangroves. The East Beach site accounted for 9% (125/1,332) of the total echolocation sequences (Fig. 16). The majority of sequences at this site were documented foraging over the parking lot and around the Australian pines. A few bats were observed and recorded foraging over the sand dunes, but no bats were seen or recorded foraging on the open beach. The Headquarters site accounted for 7% (92/1,332) of the total echolocation sequences recorded (Fig. 16). Spotlights shining on the flagpole attracted a large number of insects, which in turn, attracted foraging bats. No other sites had spotlights. The Bayway site accounted for 5% (65/1,332) of the total echolocation sequences (Fig. 16). Few bats were observed foraging over the roadway and adjacent mangroves. The Open site accounted for 5% (65/1,332) of the total echolocation sequences recorded (Fig. 16). Few bats were recorded foraging over the sand dunes. No bats were recorded over open beach. The Kayak Rental site accounted for 1% (12/1,332) of the total echolocation sequences (Fig. 16). At this site, few bats were recorded foraging over the pine flatwoods and mangroves.
Figure 16: Frequency of bat activity by site location. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.

Figure 17: Cumulative frequency of bat activity by site recorded at Fort DeSoto Park. This map includes both stationary (1-30 minutes after sunset) and roving (61-180 minutes after sunset). Activity points represent coordinates of recorded bat activity, not individuals.
The majority of Brazilian free-tailed bat activity was documented in habitats that included mangroves, cabbage palms, and permanent freshwater. They were also observed and recorded foraging over the parking lots. The Eastern Point, Bayway, Fort, North Beach, and the Headquarters sites accounted 75% (108/143) of Brazilian free-tailed bats documented at Fort DeSoto Park (Fig. 18 and 21). The Kayak Trail, East Beach, Arrowhead, and Open sites accounted for the remaining 25% (35/143) sequences recorded.

Figure 18: Frequency of the Brazilian free-tailed bat by site location. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.

The majority of evening bat activity was documented in habitats that included pine flatwoods, mangroves, cabbage palms, and permanent freshwater. They were also
observed and recorded foraging over the parking lots. The North Beach, Arrowhead, and Eastern Point sites accounted for 65% (578/884) of the total evening bat activity documented at Fort DeSoto Park (Fig. 19 and 21). The East Beach, Headquarters, Open, Fort, Bayway, and Kayak Trail sites accounted for the remaining 35% (306/884) sequences recorded.

The majority of northern yellow bat activity was documented in habitats that include pine flatwoods, cabbage palms, and permanent freshwater. The Fort site accounted for 70% (165/233) of the total northern yellow bat activity documented at Fort DeSoto Park (Fig. 20 and 21). The North Beach, Eastern Point, Arrowhead, Headquarters, Kayak Trail, Open, Bayway, and East Beach sites accounted for the remaining 30% (68/233) sequences recorded.
Figure 20: Frequency of the northern yellow bat by survey site location. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.
Figure 21: Bat activity documented per species per site at Fort DeSoto Park. (a) Brazilian free tail bat. (b) Seminole bat. (c) Evening bat. (d) Northern yellow bat. Map includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data. Each point represents multiple echolocation sequences from one or more individuals.

*Temporal Distribution by Month:* Fifty-three percent (708/1,332) of the total echolocation sequences recorded at Fort DeSoto Park were documented in the summer months of June, July, and August (Fig. 22). The remaining 47% (624/1,332) sequences were recorded during the months of March, April, May, September, and October.
Figure 22: Frequency of bat activity by month. Although three surveys were conducted in May, the low frequency is unexplained. January, February, November, and December were not surveyed. Graph includes both stationary (1-60 minutes after sunset) and roving (61-180 minutes after sunset) data.
Chapter 4: Discussion

In this study four species of bats were documented foraging at Fort DeSoto Park: the evening, northern yellow, Brazilian free-tailed, and the Seminole bat. The Seminole bat, was detected only twice; once at the permanent freshwater pond at North beach and once at the Headquarters site. Although a fifth species, the tri-colored bat, has been documented inland in Pinellas County by the Florida Bat Conservancy, it was not found in this survey at Fort DeSoto Park.

Evening bats, accounting for the majority of bat species activity, are the most opportunistic species documented at the park. Because they are known to roost in both natural and manmade structures (Jennings, 1958; Menzel et al., 1999), it is possible that they are roosting within park boundaries or in close proximity. Northern yellow and Seminole bats are roost-site specific, requiring habitats that include dead palm fronds and Spanish moss (Nowalk, 1994). Urban sprawl causes a decline of habitat-specific species (Fenton, 1997, Gehrt and Chelsvig, 2004).

Even though they are common in Pinellas County (The Florida Bat Conservancy, unpublished data over a 20-year period), Brazilian free-tailed bats accounted for only 11% of bat species activity recorded. This species has adapted to urban sprawl, roosting primarily in manmade structures (Wilkins, 1989); thus, they may be foraging over more urban areas close to their roosting spots. Brazilian free-tailed bats can fly at high altitudes
The presence of bats at any given location varies depending on a number of environmental factors such as time of day, temperature, humidity and abundance of insects (Taylor, 1963; Rydell et al., 1996). Even though foraging activity in our study varied considerably, a few patterns emerged. Total foraging activity was highest during the second hour (61-120 minutes after sunset) of the surveys which corresponds to peak insect activity (Rydell et al., 1996). Foraging activity was highest in habitats that included pine flatwoods, cabbage palms, mangroves, and permanent freshwater. The freshwater pond, located in North Beach, is in close proximity to Arrowhead. In all likelihood, foraging was high at these two sites because of high insect biomass attracted to water (Fukui, et al., 2006). The Fort followed as the second most significant site of bat activity, probably because of a small basin associated with its artesian well. Bat foraging was lowest over sand dunes and the open beaches. These findings concur with those of Johnson and Gates (2007) who documented six species of bats at Assateague Island National Seashore in Maryland. Their survey, conducted over five habitat types using the Anabat detector and mist nets, found that bat activity was highest in forested areas, freshwater bodies, and bayside wetlands.

Thirty-four percent of the total echolocation sequences were recorded near permanent freshwater sources despite the fact that it accounts for less than 1% of the park’s total landmass. Bat activity was highest over permanent freshwater during the stationary (1-30 minutes after sunset) period of the surveys; suggesting that bats search for freshwater sources to drink and to forage immediately after they emerge for the night.
Perhaps the most important finding, was the affect that introduced aquatic plants had on the ability of bats to drink from a permanent freshwater pond. This study at Fort DeSoto Park revealed that, despite the limited availability of freshwater, bats did forage along the coast. Because bats prefer calm water bodies free of clutter, disrupting the surface of the park’s only permanent freshwater pond with aquatic plants interfered with the bats’ ability to drink (Fenton and Bell, 1979; Rydell et al. 1999).

Although the artesian well basin at the Fort site accounted for 70% of northern yellow bat sequences, it is important to note that 165 sequences were documented on August 30th, 2010; with only one northern yellow bat sequence recorded on May 27th, 2011. One possible explanation for the difference is that northern yellow bats are a solitary tree-dwelling species that change roost sites more often than colonial bats (Lewis, 1995). Additionally, it is possible that differential insect activity based on month or season was a factor (Fig. 26).

This study raises several questions. If bats no longer drink from the freshwater pond near North Beach, where are they drinking? Several miles from the entrance to Fort DeSoto Park is the town of Terra Verde with four artificial freshwater ponds approximately two miles from the North Beach and Arrowhead sites and approximately three miles from the Fort site. Monitoring these ponds might clarify if bats use them during foraging forays into and out of Fort DeSoto Park.

What was the cause of the decrease in echolocation calls in the spring of 2011? If breeding and pregnancy were factors in May, bats might have abandoned the long flight to Fort DeSoto Park for other more accessible foraging sites with better access to freshwater.
Where do the bats roost? Determining roost sites of bats is difficult. Radiotelemetry, an invasive method of tracking individuals, is the most effective method for determining bat roosting locations (Fenton, 2003). A more extensive study examining the timestamps recorded on the Anabat detector could help determine if they are roosting within the park’s boundaries.

Descriptive studies using bat detectors yield important preliminary information on the species and distribution of bat activity in different habitats (Kalko et al., 1996; Johnson and Gates, 2007). Once this baseline information is acquired, effective land management and conservation policies for this important mammal can be implemented. For example, potential land management policies for bat conservation at Fort DeSoto Park should include open, permanent freshwater sources in areas of high foraging activity, such as the North Beach and Arrowhead sites. Roosting can also be encouraged by avoiding the trimming of dead fronds from cabbage palms and leaving Spanish moss in the tree branches. At the time of the study, eight unoccupied bat houses were located approximately ten feet above the ground, attached to the sides of slash pines. Studies suggest that bat houses on the sides of trees discourages bats from roosting due to limited maneuverability around clutter. It is suggested that the bat houses be installed on a free-standing pole at least ten feet from the treeline (Tuttle et al., 2005).

In conclusion, this study supports the fact that bats are important agents for insect pest control and that a source of freshwater is essential to maintain their presence in coastal regions.
List of References


