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Article *in* Southeastern Naturalist · June 2016

DOI: 10.1656/058.015.0204

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Source: Southeastern Naturalist, 15(2):235-242.
Published By: Eagle Hill Institute
DOI: http://dx.doi.org/10.1656/058.015.0204
URL: http://www.bioone.org/doi/full/10.1656/058.015.0204

Use of a Multi-tactic Approach to Locate an Endangered Florida Bonneted Bat Roost

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Abstract - Effective strategies for bat conservation require knowledge of species-specific roost ecology. Thus, conservation planning is difficult for species with poorly understood roost use, such as the federally endangered *Eumops floridanus* (Florida Bonneted Bat). Prior to this study, only 1 active natural roost had been documented throughout the Florida Bonneted Bat's geographic range. Search efforts to locate new roosts using several techniques have been unsuccessful. Here we present a simple methodology that we successfully implemented to locate a second Florida Bonneted Bat natural roost. Using acoustics, cavity searches, and emergence observations, we documented a colony of Florida Bonneted Bats roosting in a *Pinus elliottii* (Slash Pine) snag in Florida Panther National Wildlife Refuge in Collier County, FL. Our discovery highlights the importance of snags, and provides additional details to state and federal agencies tasked with species recovery.

Introduction

Eumops floridanus (Allen) (Florida Bonneted Bat, Molossidae), endemic to the southern half of Florida, was recently listed as federally endangered due to threats facing its small, isolated populations (USFWS 2013). Unusual among temperate bat species, Florida Bonneted Bats are large (30–60 g) and roost in small groups (Belwood 1992; H.K. Ober et al., in review). Habitat loss, degradation, and modification caused by land development, agriculture, and climate change are expected to further threaten the Florida Bonneted Bat and limit the availability of their natural roost sites and foraging habitats (USFWS 2013).

Very little is known about roost selection by Florida Bonneted Bats (USFWS 2013). Incidental observations from the 20th century indicated that these bats roosted in cavities associated with natural and artificial structures including *Roystonea* spp. (royal palms), rock outcroppings, Spanish-style barrel roof-tiles, bat houses, and buildings (Belwood 1992, Gore et al. 2015, Jennings 1958. Timm and Genoways 2004). However, since 1979 only 1 natural roost containing a Florida Bonneted Bat colony has been documented. This roost was discovered in 2013 at Avon Park Air Force Range, Avon Park, FL, in a cavity excavated in a *Pinus palustris* (Mill) (Longleaf Pine) by *Picoides borealis* (Vieillot) (Red-cockaded Woodpeckers, RCW) (Angell and Thompson, in press). The entrance to the cavity was slightly enlarged, likely by another woodpecker species. The 1979 roost was also in a Longleaf Pine cavity originally excavated by RCWs and later enlarged by a *Dryocopus pileatus* L. (Pileated Woodpecker) (Belwood 1981).

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Manuscript Editor: Andrew Edelman

Development of roost-protection guidelines is considered one of the highest conservation priorities for Florida Bonneted Bats (FWC 2013, USFWS 2013), but without identification and description of additional roosts, there is little data upon which to base management actions. Documentation of roost sites could improve understanding of roost selection, help prioritize restoration measures, and may prevent roost destruction. Discovery of additional roost sites could also provide opportunities to learn about the species' roost fidelity, seasonal roost use, sex composition of colonies (through capture efforts), and responses to environmental or management perturbations.

The technique typically used to locate new roosts for tree-roosting bats in the temperate zone is radio-tagging and tracking individuals to their roosts (Amelon et al. 2009). However, the use of radiotelemetry for Florida Bonneted Bats is challenging because (1) high-flying molossids (Norberg and Rayner 1987) are difficult to capture away from known roost sites, and (2) a federal permit and extensive biological expertise are required to handle this endangered species. Based on the 2 accounts of Florida Bonneted Bats using enlarged RCW cavities, recent search efforts have taken 2 approaches to locate new roosts. The first approach is to inspect RCW cavities using pole-mounted camera systems (P. Halupa, USFWS, Vero Beach FL, pers. comm.). This search method requires substantial effort for a low likelihood of success, given the rarity of the species. The second approach employs dogs to identify the scent of the bats' guano (USFWS 2013). This method is costly, time-consuming, and has not resulted in the discovery of any Florida Bonneted Bat roosts. In this note, we document the targeted approach we used to search for Florida Bonneted Bat roosts on the Florida Panther National Wildlife Refuge (FPNWR), an area ~70 km from the nearest known artificial roost and 150 km from the only known natural roost site.

Field-site Description

The FPNWR was established in Collier County, FL in 1989 to protect habitat for the federally endangered *Puma concolor coryi* (Bangs) (Florida Panther) (USFWS 2000). This 10,688-ha refuge contains a mixture of *Pinus elliottii* (Engelm.) (Slash Pine) forests, hardwood-swamp forest, cypress-strand forest, marl prairies, hardwood hammocks, and scattered cypress domes. The FPNWR is bordered on the east by Big Cypress National Preserve (separated by State Road 29) and on the south by Fakahatchee Strand Preserve State Park (separated by I-75). During the rainy season (May–October), up to 90% of the FPNWR can be inundated with water, >1 m in depth (M. Danaher, FPNWR, Immokalee, FL, pers. comm.). Prior to establishment as a refuge, the property was used for hunting, cattle grazing, farming, and logging, including logging of virgin cypress (USFWS 2000). Prior to our study, Florida Bonneted Bats were detected in several locations in FPNWR using acoustic surveys, suggesting that this area may be important for the species (USFWS 2013).

Methods

We searched for roosts using a combination of acoustic surveys, cavity scouting, and emergence observations. As part of a larger study we were conducting to investigate the effects of fire on Florida Bonneted Bats in southwest Florida, we deployed Song Meter SM3BAT (Wildlife Acoustics, Maynard, MA) ultrasonic detectors in 28 randomly selected locations within pine and prairie communities in FPNWR. We set detectors to record for 2 nights at each location during June 2015. We created spectrograms of the bat echolocation calls recorded with these detectors and used Kaleidoscope Pro (3.1.4B, Wildlife Acoustics) and manual validation to identify the calls to species based on their unique characteristics. One ultrasonic detector recorded a high number of Florida Bonneted Bat calls (mean = 57 call files/night). It also detected calls early in the evening (<40 min after sunset) and social calls (mean = 20/night; Fig. 1). We had observed similar levels of activity and social calls around bat houses known to serve as day roosts for the species in the Fred C. Babcock–Cecil M. Webb Wildlife Management Area (BWWMA), located ~95 km to the northwest. Additionally, the times we detected early Florida Bonneted Bat calls in FPNWR corresponded closely to emergence times from the BWWMA bat houses. Therefore, we speculated we were in the vicinity of an active roost.

We targeted the area of high activity in FPNWR by stationing 3–5 observers 200 m from the ultrasonic detector at randomly selected compass bearings (1–360º) from sunset to 45 min post-sunset. Florida Bonneted Bats produce the lowest-frequency echolocation calls of any bat species in Florida (10–25 kHz, Marks and Marks 2006), which fall within the audible range of some humans. We trained observers to identify these audible echolocation calls or, if they were unable to hear in this frequency range, to identify calls using a handheld ultrasonic detector (Echo Meter EM3+ [Wildlife Acoustics], D240x [Pettersson Elektronik AB]). When an observer detected a Florida Bonneted Bat, they documented the time, coordinates of location, and trajectory of flight. Using portable-document format (PDF) maps (2.7.0, Avenza Systems, Inc., Toronto, ON, Canada), we plotted these data on a georeferenced map of the FPNWR and defined a 100-m-radius focal area from where the bats appeared

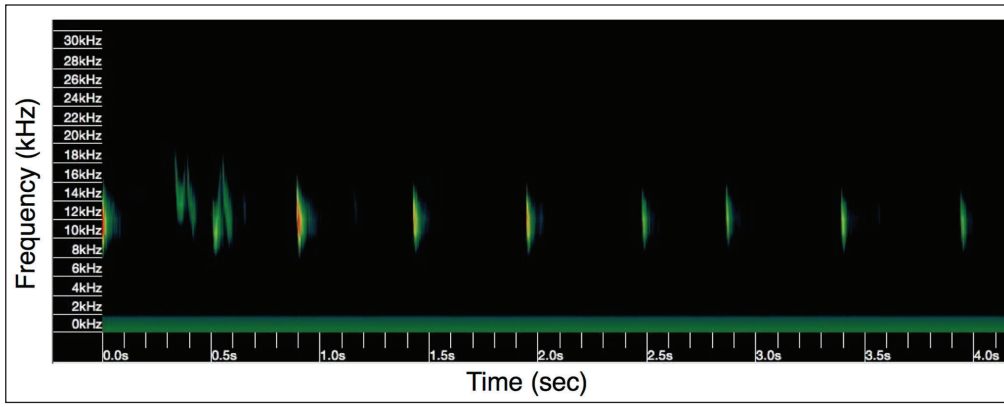

Figure 1. Spectrogram of a *Eumops floridanus* (Florida Bonneted Bat) call sequence visualized with Kaleidoscope Viewer (Wildlife Acoustics). Social calls begin at 0.3 s and end at 0.6 s.

to originate soon after the presumed time of emergence. In daylight, we searched the focal area with binoculars for trees or snags with cavities or loose bark that we estimated were large enough for Florida Bonneted Bats (diameter of opening ≥ 2.5 cm). At sunset, we conducted emergence observations by stationing observers at potential roost sites to watch for emerging bats. Over 5 nights, we narrowed our focal area each night, based on Florida Bonneted Bat acoustic detections, until we located a roost.

When we found a roost site that contained bats, we verified that they were Florida Bonneted Bats by identifying their echolocation calls during emergence and through a roost inspection using a TreeTop Peeper camera (Elevated Video Inspection System, Sandpiper Technologies, Inc., Manteca, CA; Fig. 2a). We characterized the roost structure and the surrounding vegetation within a 15-m-radius

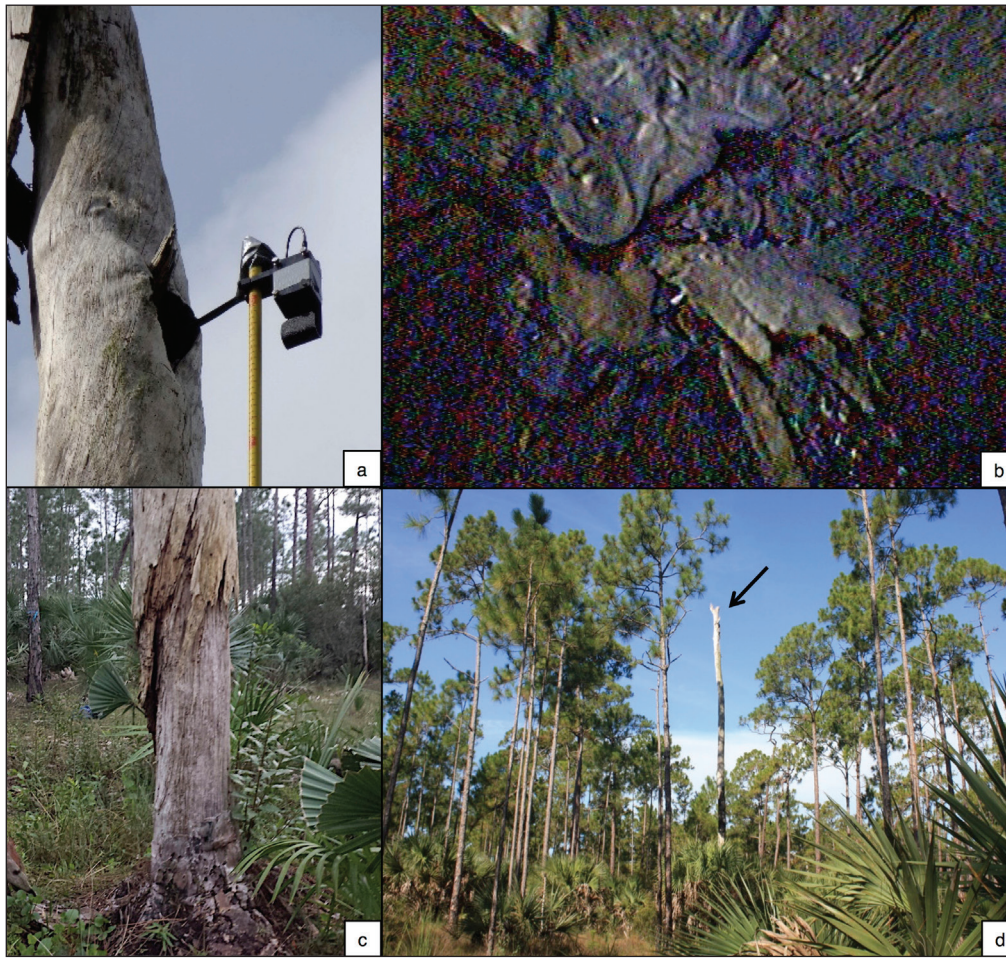

Figure 2. Photographs of a *Eumops floridanus* (Florida Bonneted Bat) roost discovered in a *Pinus elliottii* (Slash Pine) snag on Florida Panther National Wildlife Refuge, Collier County, FL: (a) TreeTop Peeper camera used by Florida Fish and Wildlife Conservation Commission personnel to inspect the Florida Bonneted Bat roost cavity (photo © Leah Miller, Friends of the Florida Panther Refuge, Naples, FL), (b) Florida Bonneted Bats roosting in the cavity, (c) decayed base of the snag, and (d) roost snag in surrounding hydric Slash Pine flatwood habitat.

plot; for the roost tree and all trees ≥3 m tall, we identified species and measured diameter at breast height (DBH) and height using a DBH tape and clinometer. We identified shrubs <3 m tall to species, and estimated average height and percent shrub cover by species. We estimated percent canopy cover with a densiometer at the base of the roost tree and at a point 10 m from it in each cardinal direction.

Results

We discovered a Florida Bonneted Bat roost in a cavity 11.1 m above the ground in a Slash Pine snag (Fig. 2b). Characteristics of the roost are reported in Table 1. We observed 4 bats with the TreeTop Peeper camera (Fig. 2a); however, the cavity extended above the observed bats for an unknown height. On 2 consecutive nights (7 and 8 July 2015) at 20:44 (21 min after sunset), 12 Florida Bonneted Bats emerged from the roost. The continuation of bat vocalizations after the emergence indicated that additional adults or pups remained inside the roost. The cavity entrance faced 175º south, and appeared to have formed from a decayed branch wound. The base of the snag was in a moderate state of decay (Fig. 2c) and light was visible through a crack in the back wall of the cavity. The snag was located in an area of predominantly hydric Slash Pine flatwoods (Table 1, Fig. 2d). The midstory of the roost plot consisted of dense *Sabal palmetto* (Walter) (Cabbage Palm) (~40% cover, ~2 m tall) and *Serenoa repens* (Bartram) (Saw Palmetto) (~15% cover, ~1.5 m tall). *Morella cerifera* L. (Wax Myrtle), *Myrsine floridana* A. DC. (Myrsine), *Taxodium distichum* var.

Table 1. Characteristics of a *Eumops floridanus* (Florida Bonneted Bat) roost cavity, roost snag, and surrounding vegetation in Florida Panther National Wildlife Refuge. Measurements are reported for trees within a 15-m-radius plot of the roost tree (mean ± SE). DBH = diameter at breast height.

Feature	Measurement
Roost cavity	
Height	11.1 m
Entrance	14 cm x 9 cm
Interior width	~12 cm
Roost snag	
Height	12.6 m
DBH	27.4 cm
Canopy (trees ≥ 3m tall)	
Mean canopy cover	45%
Min. distance from roost	5.2 m
Slash pine	
Density	311 stems ha^{-1}
Mean height	16.0 ± 1.1 m
Mean DBH	19.3 ± 1.7 cm
Cabbage Palm	
Density	255 stems ha^{-1}
Mean height	3.3 ± 0.1 m
Mean DBH	34.4 ± 1.7 cm

imbricarium (Bongn.) (Pond Cypress), and *Persea borbonia* L. (Red Bay) were each present at ~10% cover. *Cladium jamaicense* (Crantz) (Saw-grass), *Aristida stricta* (Michx.) (Wiregrass), *Muhlenbergia capillaris* (Lam.) Trin. (Muhly Grass), and other graminoids covered the remaining area in the plot. Two small cypress–mixed hardwood hammocks were located ~100 m southwest and 30 m southeast from the roost. The management unit (172.2 ha) where we discovered the roost has been burned every 3–5 years since the FPNWR was established in 1989, and the most recent silvicultural activities at the site included herbicide treatment in 2015 and mechanical removal of Cabbage Palm in 2010 and 2011 (M. Danaher, FPNWR, Immokalee, FL, pers. comm.).

Discussion

Our discovery of a new Florida Bonneted Bat roost represents the second natural roost identified for this species since 1979. This record also fills an important geographic gap between known roost sites in Miami–Dade and Charlotte counties. Roosts act as a critical, yet limiting, resource to bats for protection, social interactions, and reproduction (Kunz 1982). Thus, this new roost contributes to our very limited knowledge of roost use and to development of recovery plans for Florida Bonneted Bats (FWC 2013). Our finding that 12 bats emerged from the snag falls within the range of individuals observed in natural roosts—22 bats in Avon Park (Angell and Thompson, in press) and 8 bats in Punta Gorda (Belwood 1981). In Avon Park, 16 bats emerged from the roost and 6 more were counted inside the roost via investigation with a peeper camera (Angell and Thompson, in press). In our study, there were likely more individuals remaining in the roost after emergence of the bats we counted. Ober et al. (in review) provide evidence that Florida Bonneted Bats form harems, and suggest that colony sizes may remain small so that males can successfully defend them; thus, availability of suitable roosts may directly affect population growth.

The characteristics we report (roost type, tree species, tree size, state of decay, cavity size, cavity orientation, and surrounding habitat) are all factors known to influence roost selection of cavity-roosting bats (Barclay and Kurta 2007). The roost we discovered differs in several important aspects from those previously documented. In contrast to the other 2 natural roosts in RCW cavities within live Longleaf Pine trees, this roost was in a cavity formed by a decaying dead Slash Pine branch. This finding highlights the importance of managing to retain snags throughout the species' range. Also, the cavity was higher (11.1 m) than the other 2 roosts (7.1 m and 4.6 m). Poles of either 10.7 m (35 ft) or 15.2 m (50 ft) are typically used with peeper cameras to inspect RCW cavities (H. Nardi, FWC, Naples FL, pers. comm.). Our results indicate that searches for natural Florida Bonneted Bat roosts should not be limited to RCW cavities, and poles capable of reaching cavities > 10.7 m (35 ft) from the ground are necessary. Peeper cameras could be used to supplement emergence observations in searches of potential roost cavities in focal areas. However, we do not recommend relying solely on these cameras to confirm the presence of Florida Bonneted Bats due to the potential for roosts to be too high for peeper cameras to reach, too small for peeper cameras to fit, or shaped in such a way that bats may roost out of view of the camera.

The method that we have described has clear advantages over other roost-searching techniques for this species due to its targeted approach, low cost, and need for limited equipment and biological expertise. This method can be used to home in on roost sites once Florida Bonneted Bats have been consistently detected in an area early in the evening. Molossids fly at high altitudes (Norberg and Rayner 1987); thus, mist netting away from known roost sites is not an effective way to sample Florida Bonneted Bat activity. In contrast, their audible and easily identifiable echolocation calls present a unique opportunity to identify hot spots of activity close to emergence time and to locate flight paths, which can be traced back to roost structures. In this study, we used both ultrasonic equipment and human observers. Depending on available resources, this method could also be effectively conducted solely by human observers trained to recognize Florida Bonneted Bat echolocation calls and distributed across an area where the species is known to consistently occur.

Acknowledgments

We extend special thanks to Ben Nottingham, Kevin Godsea, Mark Danaher, Sarah Steele Cabrera, Leah Miller, and the staff from Florida Panther National Wildlife Refuge for collaborating closely with us on this effort. We also thank the Florida Fish and Wildlife Conservation Commission (Dan Mitchell, Ross Scott, Hana Nardi, and Ryan Deibler) for donating an ATV and providing camera equipment and personnel to observe the roost cavity. Naples Zoo, Friends of Panther Refuge, and Big Cypress National Preserve purchased and lent us ultrasonic equipment for the duration of the project. Many other staff and volunteers from Fred C. Babcock–Cecil M. Webb Wildlife Management Area, Fakahatchee Strand Preserve State Park, and Big Cypress National Preserve contributed local knowledge, equipment, and assistance in phases leading to the discovery of the roost. Finally, we are grateful to the fantastic University of Florida technicians on the project: Kirk Silas, Megan Wallrichs, Tara Rambo, Amy Hammesfahr, and Rebecca Sensor. This research was funded by a grant from the Joint Fire Science Program.

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