A Study to Promote Bat Occupancy at the University of Central Florida Bat Houses

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Introduction

In 2008, the International Union for the Conservation of Nature (IUCN) completed a five-year census of the world's recognized mammal species with the final result being 5,488 recognized species (IUCN Red List of Threatened Species, 2008). Of these, 1,240, roughly 20%, are bats. The only true flying mammal, bats belong to the order *Chiroptera*, or "hand wing" in Latin, owing to their wings' homologous structure with the human hand (Hunter, 2007).

The state of Florida is home to thirteen recorded species of bat. Of these, some are seasonal residents and fewer yet are common in Central Florida. These include the evening bat (*Nycticeius humeralis*), the northern yellow bat (*Lasiurus intermedius*), the Seminole bat (*Lasiurus seminolus*), and the Brazilian free-tailed bat (*Tadarida brasiliensis*) (Florida Bat Conservancy, 2011). All bats in Florida are insectivores and can help maintain low populations of insect pests like mosquitoes with their ability to consume 3,000 insects per night per bat (Florida Bat Conservancy, 2011). This, in turn, can reduce insect-carried diseases and subsequently, health costs.

Meanwhile, the University of Central Florida's main campus in Orlando is an epicenter for the range of the aforementioned common central Florida bats. Covering 1,415 acres, of which more than 500 are conserved natural lands, this urban university is a prime candidate for artificial bat housing (UCF Landscape and Natural Resources, 2011). Currently, about eight bat houses span the campus, concentrated primarily within the natural areas. The map at right shows the locations of the various bat houses, as well as a culvert where many bats are currently residing.

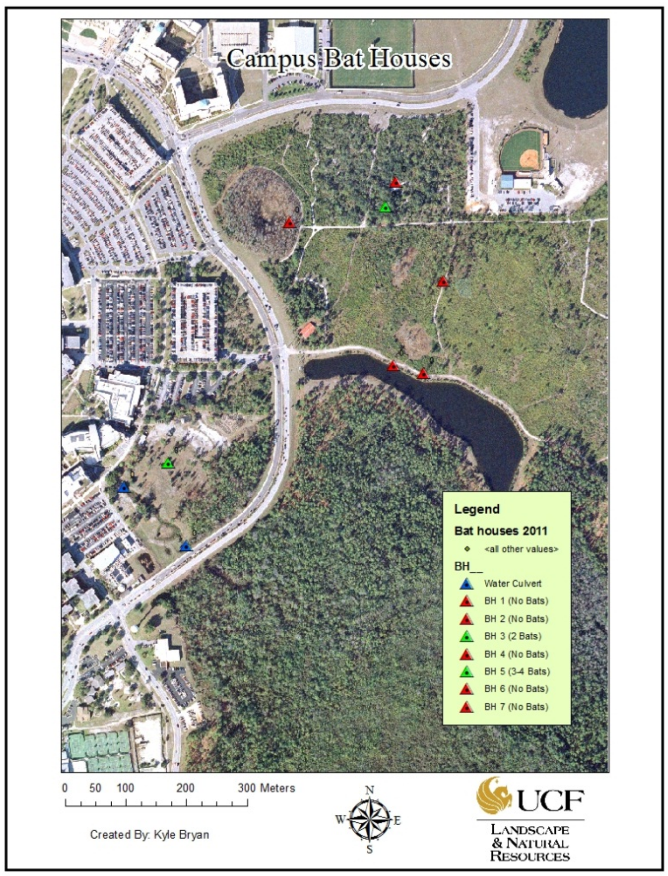

Figure 1: Map of bat house locations on the UCF campus

Although they have been present for a few years, the dwellings have failed to attract any substantial number of resident bats. According to Dr. Klowden, Professor of Ecology at the University of Central Florida, it may often take years for bats to discover the houses and establish colonies (Klowden, 2011).

Figure 2: Hollow trees, such as these, provide ideal roosts for Florida bats

Bat houses are designed to mimic the native bats' natural habitats. In central Florida, this includes long-dead trees (**snags**), dead palm fronds, Spanish moss, buildings, and the rare Florida cave. These provide safe, dry homes that are easy to grip and offer refuge from daylight, given that bats are nocturnal. Populations can range from a few bats to a few thousand on average. Of the two primary categories of bat house, back-yard and communal or condominium, the focus of this project is the former.

To gain a proper perspective as to the driving reasons for this venture one must be familiar with the **triple-bottom line**. Coined by author John Elkington in his 1998 book *Cannibals with Forks: the Triple Bottom Line of 21st Century Business*, this central concept encompasses the **three pillars of sustainability**: economics, environmentalism, and all social aspects (Brown et al, 2006). It is also commonly referred to as "people, profit, planet" for convenient alliteration.

This project aims to fulfill the three pillars of the triple-bottom line. One environmental benefit is proving additional habitat to the bats, which combats human-caused habitat destruction. From a social aspect, maintaining a healthy bat population in bat houses will keep the numbers of insects such as mosquitoes (a **vector species** which transmit dangerous diseases to humans) in check so they do not overpopulate. From an economic and social standpoint, this could potentially reduce local health care costs via slowing insect-mediated disease transmission.

As bats control insects, we can also reduce our dependence on toxic pesticides to eliminate pests. These pesticides leech into our environment and have unintentional and far-reaching side effects (Pimentel, 1971). Additionally, these structures provide alternative and appealing housing for bats that might otherwise establish themselves in a person's home (Florida Bat Conservancy, 2011). Though getting bats out of our houses is a social benefit, there are economic benefits to this. If bats are no longer roosting in our attics, we will not have to spend money on extermination, trying to get them out. Bats are an interesting and entertaining organism to observe in the wild and these houses help preserve a group of animals that are quickly disappearing.

Social	Economic	Environmental
Limiting vector species helps prevent infectious diseases spread by various insects	Limiting vector species can reduce health care costs	Providing living space for bats offsets human-caused habitat destruction
Providing alternate housing for bats prevents them from installing themselves in housing or other buildings, becoming a nuisance	Keeping bats out of houses eliminates the cost of damages incurred from unwelcome bats as well as the cost of having to remove the bats from houses.	Increasing bat habitat reduces the amount of pesticides needed to combat insects.

Table 1: Benefits of bat houses

The goal of this project was to attract and maintain permanent bat populations on the campus of the University of Central Florida (UCF). The remainder of this paper will address the methods followed and results obtained from our research on bat houses, as well as barriers we encountered while conducting our studies.

Methods

The methodology throughout this project was driven by the overall goal which the group sought to accomplish. This was to determine why the local bat population was failing to inhabit the current roosts and subsequently remedy the problem.

To do this, the driving course of action was to determine what environmental and constructional parameters the current bat houses fell within and to alter them individually and in combination to ultimately find the ideal and successful conditions. In terms of organization, the variables deemed most crucial for monitoring were placement in relation to sun, temperature, percent humidity, wind, tree cover, food availability, height above ground of house, tree versus poll mounted, human and animal activity level, and overall construction of the roosts (Marks and Marks, 2006).

Our first study addressed direction in relation to the sun. As suggested by the Wisconsin Department of Natural Resources (Wisconsin Department of Natural Resources, 2011), bats tend to inhabit houses that face a southern or southeasterly direction as these houses will get the most amount of midday sun. Thus, we used a compass to determine the direction that each house was facing. Direction also clearly affected the temperature (i.e. facing sun versus shade et cetera). To this end, we monitored temperature using the Kestrel meter as we experimented with placement in relation to the sun.

Figure 3: A Kestrel 3000 meter, courtesy of kestrelmeters.com

In addition to direction and temperature, we also tested whether humidity affects the likelihood of bat activity. As the houses were already mounted in areas of different humidity we tracked humidity near some lake and swamp ecosystems, which will have higher humidity, and others in field ecosystems such as the oak hammock pinewood flats which should have comparatively low humidity (Florida Fish and Wildlife Commission*)*. Again, a Kestrel 3000 Wind Meter was used, which has an associated rate of error of +/- 0.30 meters/second in terms of wind speed, +/- 3% from 5 to 95% for relative humidity, and +/- 0.10 ºF or ºC. Given the low error rates, small and durable build, and quick means of gathering data, the Kestrel was an ideal tool of choice (Western Safety Products).

Tree cover may also have a role in optimal bat house location. To quantify canopy cover, a densitometer was used to estimate a percentage of tree cover directly above the roosts.

Another consideration for location of bat houses is food availability. As Florida bats prey mostly on insects, that is what was primarily noted. Unfortunately, there was not sufficient time to capture insects and quantify the density of local prey populations. Because of this, insect abundance was estimated per site.

Heights of each house were measured to compare to later, experimental heights. To do this the group used measuring tape and an extension ladder. While doing this, the construction of the houses was also recorded. Using this data, the group built two additional bat houses, a single-chambered and a multi-chambered, or “nursery”, house and erected the single-chambered house at twelve feet as suggested by previously noted readings, rather than the eighteen feet observed with the already existing roosts. In fact, the single-chambered house was used to replace a badly damaged roost in the oak hammock that was lacking most of its roof.

The bat houses on campus are of a single chamber design, which are projected to work but are not the most desirable living conditions for the bats. According to the Florida Bat Conservancy, the species of bat most likely to move into our bat houses is the Evening Bat (*Nycticeius humeralis*). These bats usually roost in snags or caves, but when interacting with the urban environment they will move in to manmade structures that provide tight crevices for them to huddle in.

Figure 4: The bat house at the oak hammock, with destroyed roof

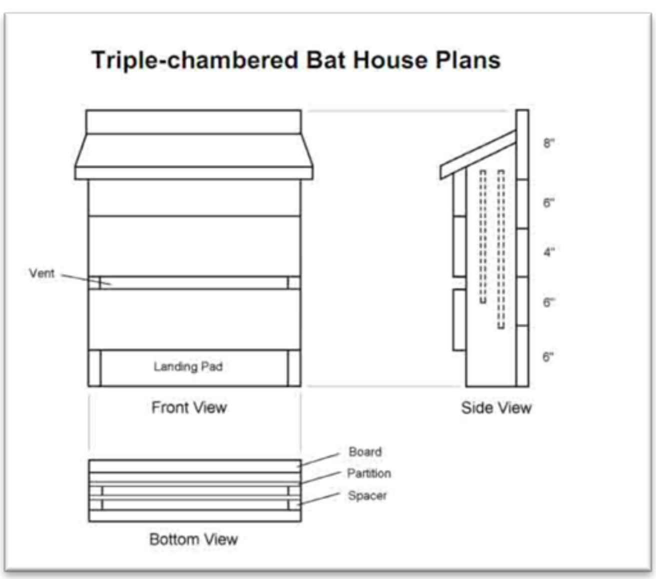

Figure 5: Plans for a multi-chambered bat house, courtesy of Florida Bat Conservancy

We built a **multi-chambered** bat house because it would promote ideal living conditions for the bats. This several-room house mimicked their natural habitat helping their ability to regulate their body temperature. The Wisconsin Department of Natural Resources states that the most successful bat houses have the dimensions of 24 inches tall by at least 14 inches wide, with an open bottom to reduce the buildup of guano and parasites (Wisconsin Department of Natural Resources, 2011). Another necessary improvement to the current bat house model was to supply the bat house with a **landing pad**, a rough, approximately four inch piece of wood that hangs down from the bottom of the bat house to allow them to land and then make their way up into their roosting chamber.

Human activity was noted as well along the trails adjacent to the houses but was ultimately determined to be fairly constant and thus a null variable.

Finally, the places where bats are currently known to be living as reported by eye-witnesses and confirmed by our group were observed heavily. The surrounding conditions were measured as per the other roosts. The goal of this was to replicate the conditions of successful bat habitats to incentivize the local population to inhabit the new and old roosts. Unfortunately, due to time restrictions (as the process of the artificial roost relocation and bats actually taking up residence takes a great deal of time), this portion has yet to be completed.

To minimize error, the group members were tasked with the same duties throughout the project. This ensured consistent use of tools such as the Kestrel and minimized variability in more subjective areas such as insect population estimation. Much of the data was still difficult to draw conclusions from due to time constraints.

Variable	Method of Testing
Placement in relation to the sun	Compare cardinal direction versus success (as measured by number of bats
Temperature	Measure temperature of houses using the Kestrel Meter
Humidity	Measure humidity using Kestrel Meter
Tree cover	Measure using densitometer
Food availability	Estimate insect population in various locations
Height	Compare twelve food (new house) and eighteen foot (existing house) success rate
Backing structure	Tree versus pole mounted success rate
Construction	Make a model bat house based on designs found which claim to optimize occupancy. Test this design against the designs currently being used.
Wind	Measure wind at house entrances
Level of human activity	Compare traffic rate between houses

Table 2: Methods of testing variables

Outcomes and Results

Thoroughly examining the houses that were made for the bats, we were able to conclude that some houses were in fact being inhabited. However, the populations in these houses were low, ranging from two to four bats in each house.

Approximately three years ago, there was a bat infestation at the UCF campus. At that time, the bats were relocated to the different bat houses, so it is curious that these bats are not occupying the houses. Laura Finn, the bat expert from Flight by Night Inc., stated that one possible reason the bat numbers are fluctuating is because of the time and season though more likely, they have found a suitable environment and their numbers are still relatively low, so there is no need for them to relocate into the bat houses.

Figure 6: The inside of the culvert where the bats are currently living

By taking emergence counts of the bats, we have seen a small population at the UCF campus, inhabiting two culverts in the arboretum area. As the culverts provide storm water drainage for the UCF campus, there is a lot of standing water which attracts mosquitoes. A heavy infestation of these bugs seems to be a key aspect to attracting bats.

We found that both houses which had bats had a large number of mosquitoes nearby. There was no other constant difference between those two houses and the others which remained uninhabited.

Another recommendation made by Laura Finn is to build a large house that mimics human construction. She suggests that the bats are attracted to buildings because the insulation provides them with extra warmth, which is especially critical during winter months. A large bat house could be built, such as the bat barn found at the University of Florida, but a new design could be used which incorporates insulation into the walls and some of the crevices.

We also discovered that wasps tend to build nests in the bat houses. Each of the houses contained either an active or abandoned wasps' nest. The bats have likely stayed away from those houses with active nests and may not have returned to colonize the houses that the wasps have abandoned.

Bat Habitat	Direction	Wind Max	Wind Average	Tree Cover	Temperature (in ºF)	Humidity
Creol Pond	NW/SE	4.9	1.25	0%	78.55	62.75%
Red Trail	S	6	1.1	95%	82.1	68.3%
Oak Hammock	S/SW	1.2	0.7	95%	79.23	67.03%
Oak Hammock (pole)	NW/SE	2.13	0.73	0%	82.96	64.86%
Arboretum		0	0	25%	81	71.7%
Cypress Dome		3.2	0.7		86.2	62.2%
Culvert		1.1	0.8		79.7	79.8%

Table 3: Average conditions of the different bat habitats on the UCF campus

Changes

Due to the time constraint of this project many changes have occurred since our initial proposal. The first and biggest change was that we were unable to move the bat houses around to test different variables that the bats may have preferred. Though we originally intended to move the existing bat houses to various locations, we discovered the results we would have obtained might not have been accurate, as it can take up to three years before bats will decide to inhabit the houses.

Another obstacle that prevented us from moving the houses easily was the way the houses were mounted onto the trees and poles. They were so firmly nailed on that it was nearly impossible to remove them without taking them apart piece by piece. Rather than moving the houses around we took several readings and studied the number of bats we were able to see in the areas so that we could hypothesize on the ideal locations to put any future bat houses. While doing the project, we discovered that the current locations of the bat houses were different enough that we were able to test all of the variables with some degree of success.

Barriers Encountered and Solutions

Several barriers came up as we worked on our group project. Mostly, there were issues with scheduling, both with ourselves and with our facilitator, Kyle Bryan. Some supplies were needed that we did not anticipate, and at times, the weather was uncooperative.

Though we encountered these barriers, our group worked hard to overcome them. When there were scheduling conflicts, we chose times were most of our group could meet and assigned other tasks to those team members who were not able to attend the group session. On the days that Kyle was unable to help us with our field work, we took readings so as to ensure continuity in our measurements. We also did emergence counts to estimate the number of bats living in the culverts. Days of poor weather were rescheduled to ensure that data was not skewed, especially when taking humidity readings. As soon as we knew we needed materials that were not currently available to us, we spoke with Kyle to get said materials, such as an extension ladder and new poles for the houses.

The greatest barrier we encountered was lack of time to fully measure all variables and come to solid conclusions. Because of these time constraints, we could not measure seasonal variations or progress over time. The results we found are tentative but still need more research. Given more time to research and conduct field studies, we are confident that a good conclusion on ideal conditions for bat habitation can be reached.

Suggestions for Project Improvement

We suggest taking a census of the bats prior to attempting to relocate them to the bat houses. As referred to earlier in this paper, the bats are currently roosting in two culverts which are providing ideal habitats for them. If the bat population is still relatively low and the culverts have not reached **carrying capacity (**the maximum number of bats that are able to live in that area), there will be little reason for the bats to explore new areas to inhabit. In order to have an accurate idea of why the bats have not relocated into the bat houses, we need to understand how suitable their current habitat is and whether there is a need for relocation.

Also, there need be more facilitators for this project. Though Kyle was very helpful and accommodating, sometimes scheduling issues beyond his control brought our work to a standstill. Since our facilitator was an essential component of our field work, his absence was very detrimental to our project. Having a second contact who could step in when Kyle was unable to meet with us (such as when he had to attend a conference) would have been very useful in allowing us to continue with our work.

Finally, the biggest suggestion is to allow more time for this project. We understand that this class is only one semester long, and as such, we are limited to the number of months that can be dedicated to field work. However, in order to find out what maximizes bat occupancy in manmade bat houses, we must allow the bats to naturally populate the houses, which can take several years. To this end, we suggest expanding this project over several semesters, with each team building on the work of the last. In this way, we can ensure that the information is representative of seasonal variations and other natural patterns which may only express themselves over time.

We expect that with sufficient time, we will be able to encourage the bats at the UCF campus to take up residence in the bat houses. We suggest clearing the current houses of active wasps' nests and taking periodic census to make sure the wasps do not re-establish residence. In addition, locating these houses near areas with high mosquito activity will boost the likelihood bats will reside in them. Expanding this research over a longer period of time will allow us to have a more precise understanding of the factors affecting the bat population on campus and how to increase the suitability of the bat houses.

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