The Plight of Bats in North America: Modifying Habitat to Improve Bat Diversity

Senior Project

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Abstract

Worldwide bats play an essential role in the ecosystems they inhabit. The use of pesticides, large scale wind power plants, and habitat degradation has all lead to a decline in native bat populations (Jones et al. 93). As natural roosting locations continue to be destroyed or otherwise disturbed by humans, local bats are left with even fewer quality roosting locations. North American bats are also dealing with the novel disease known as White Known Syndrome, which has caused massive fatalities as well as local extinctions in native bats. This is a fungal pathogen that attacks bats while they are in a torpor state, and ultimately results in the death of the bat host. As bat populations continue to decrease there is potential for major economic impacts to the agricultural industry, many of the insects bats prey on we consider agricultural pests. It is believed that habitat modifications are one solution to bolster locals bat populations. This project aims to identify, as well as implement ways habitat modifications can be used to increase bat diversity at a local level.

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Introduction

Throughout the world bats play an essential role in the ecosystems they inhabit. As human influence has spread, increasing conflict has ensued between bats and humans. The use of pesticides, the construction of large-scale wind power plants, and the degradation of habitat degradation all have led to a decline in native bat populations (Jones et al. 93). This degradation of habitat can be seen most obviously in the loss of bat roosting sites. Traditionally bats have roosted in tree hollows and natural caves (Howell 170). As humans have modified the habitat of North America, bats have adapted to make use of manmade structures such as attics, barns, and abandoned houses (Howell 169-170). As natural roosting locations continue to be destroyed or otherwise disturbed by humans, local bats are left with even fewer quality roosting locations. The issue of habitat loss is one that nearly every species of bat in North America is facing (Tuttle et al. 5).

This loss of habitat also severely impacts bats by limiting hibernation locations. Bats have very specific parameter requirements regarding their hibernation locations, especially in regards to humidity (Boyles 48). The required specificity that many bats place on their hibernation locations makes it extremely difficult for them to find new locations where they can successfully hibernate. Locations with lower than optimal humidity expose the bats to dehydration during the hibernation period, greatly decreasing their odds of a successful hibernation. The need for a very specific microclimate helps to explain why many species of bat consistently return to the same roost locations year after year (Tuttle et al.).

White Nose Syndrome

As of late a new disease is ravaging bat populations across the east coast of the United States. White-nose syndrome (WNS) is a novel fungal pathogen that has resulted in severe damage in bat populations ranging from as far north as Maine and Quebec to as far south as Alabama. In populations of bats infected with this fungal pathogen, a 70 percent mortality rate has been witnessed (Fisher 186). It has been speculated that a lack of quality roosting sites has made bat populations more vulnerable to this novel pathogen. It is also estimated that human interference is one of the leading causes for the spread of this disease. The modification of existing habitat to better suit the needs of local bat populations is one solution to countering this new threat to bat diversity. Currently, at least 14 species of bats are using artificial roosts (Tuttle et al. 5). This fact makes the construction of bat boxes a viable option to increase bat diversity.

To effectively combat this new pathogen we must first understand the nature of the disease and why it has now appeared in local bat populations. White-nose syndrome is a fungal disease that attacks hibernating bats. “WNS has been characterized as a condition of hibernating bats and was named for the visually striking white fungal growth on muzzles, ears, and/or wing membranes of affected bats” (Blehert 227). The prominent symptoms of this disease make it visually distinguishable from other bat diseases. The exact fungus that is responsible for white-nose syndrome is *Pseudogymnoascus destructans*. *Pseudogymnoascus destructans* is a generalist parasite among bat species and is able to infect many different species. Bat are affected by this fungus during hibernation. It is a cold tolerant fungus that does best at temperatures below 20 degrees Celsius, which makes it optimally suited to attack bats during their period of hibernation. It is believed that this fungus causes bat to exit the state of torpor more frequently than normal. This greater activity level during hibernation results in bats suffering from dehydration (Warnecke et al. 7002) and ultimately succumbing to the parasite. Suboptimal hibernation roosts that lack the optimal humidity would farther exacerbate this problem, resulting in even higher mortality. In Europe bats have shown to be far more resistant to the effects of white-nose syndrome, having developed physiological and behavioral responses to it (Warnecke et al. 7001). This adaptation suggests that European bats have evolved alongside of *Pseudogymnoascus destructans*; it is likely that European bat species have been in an evolutionary arms race with *Pseudogymnoascus destructans* for generations. This would explain why North American bat species have been blindsided by this pathogen that causes relatively minimal damage to European bat populations (Warnecke et al. 7002).

One of the greatest threats of invasive fungi is the rate at which they are able to deplete the population of a nonresistant host. The natural limiting factor for parasites such as *G. destructans* is the population density of its host (Fisher 186-188). When population densities decrease, the transmission of parasites stops as host are few and far between. During this time the host population slowly recovers back to the point where the pathogen can again spread through the population. Parasites such as fungi that are highly viral and spread rapidly will kill off the nonresistant host populations, resulting in local extinctions of endemic species (Fisher 188).

Bat Ecology

Bats play an essential role in the ecosystems that they inhabit. They also have the unique distinction of being the only mammal capable of true flight. Many species of bat are insectivores that can assist in the management of insects that are viewed as pests to humans. A single little brown bat is capable of consuming a thousand small insects such as mosquitoes in a single hour; large brown bats frequently consume garden pests such as cucumber beetles, June bugs, cut bugs, and earworm moths (Tuttle et al. 4). The value of bats as natural pest control cannot be underestimated, for a large colony of bats can make a real impact on the populations of local pests. The presence of bats directly reduces the number of herbivorous insects that consume plants as well as indirectly reducing the amount of vegetation consumed by insects (Kalka 7). By facilitating the presence of native bats the need for pesticides in our everyday activities such as gardening can be lessened, in turn lessening our dependence on pesticides which do harm to bats. If all bat species in North America were suddenly to go extinct, it is estimated that more than $3.7 billion dollars of additional damage would be caused by agricultural pests (Boyles et al. 41). This number underlines the essential role bats play not only in the wild but to our own economic wellbeing.

Bats are exceptionally long lived compared to other animals of similar body size. This trait is often attributed to their ability of flight (Conn 437). Due to their ability to avoid danger, it is cost effective to maintain their own cells versus pushing all available resources into a single reproductive event. This reproductive strategy allows a single individual to reproduce over a much longer span of time (Conn 437). This strategy also means that should a large decline in population numbers occur, it will take a very significant amount of time for the population to recover to previous levels (Jones et al. 5). This slow generation time puts bats at extreme risk to a fast-spreading, high-mortality fungal pathogen such as white-nose syndrome.

Bats and Agriculture

It is believed that the long life expectancy of many bats and the sheer mass of prey they consume makes them especially vulnerable to accumulating pesticide toxins from tainted food sources. Due to the long accumulation time of these toxins, bat immune systems may be negatively affected, subjecting them to a greater likelihood disease (Quarles 4). It has been demonstrated that bats are especially vulnerable to pesticides and metabolize them more slowly than other insectivores (Quarles 4). The use of pesticide on agricultural crops also reduces the total amount of forage available for bats, further negatively affecting them (Jones et al. 103). The overall movement to industrial-style agriculture has harmed bats. It is already well established that the clearing of field edges reduces bird diversity, and natural field edges provide essential resources to many bird species during the winter months (Smith et al. 258). The decline of many bird species can be closely tied with modern agricultural intensification (Vickery et al 41). This practice also reduces bats' foraging habitat and the movement corridors they have traditionally taken advantage of (Jones et al. 103). In a study researching red bats, Kenneth J. Mager and Thomas A. Nelson found that their highest rate of capture of red bats occurred along field edges. They attributed this to the large amount of foraging opportunities that occur in this habitat (124).

Bats as Bioindicators

The sensitivity that bats show to subpar environmental conditions make them an optimal species to use as a bionindicator for the health of the ecosystem as a whole. Bats also inhabit a wide range of habitats worldwide, making it easier to directly compare one ecosystem to another. In this case bat can be used as a standard metric to judge the overall health of an ecosystem (Jones et al. 103-104).

The feeding habits of bats also make them optimal for this role. Toxins such as pesticides accumulate as they move up through different trophic levels. In the case of a bat it takes on the toxicity load from all of the thousands of insects it consumes in a single night (Quarles 4). This can be likened to how top oceanic predators such as tuna and swordfish accumulate high levels of the heavy metal mercury by consuming large amounts of smaller fish that have a lesser amount of mercury stored in their own tissues. Much like mercury many pesticides are difficult to metabolize making it difficult for tan affected organism such as a bat to rid themselves of the toxin. It instead accumulates in their tissues.

Modifications to the Environment to Facilitate the Presence of Bats

One possible solution to lessening the negative impacts of human disturbance on bat colonies is the restriction of people entering caves that are used as roost locations (Martin 144-145). Constructing internal gates in caves that are known bat roosts prevents people from entering cave chambers where bats are roosting. This helps to eliminate unnecessary stress caused by humans on significant bat colonies. The construction of these gates has been proven not to discourage the bats from continuing using the location as a roost (Martin 145).

Another such modification of the environment is to alter the individual microclimate that are being used by bat colonies. Such a tactic could prove very effective against white-nose syndrome due to its preferences of cold climates. Artificially raising the temperature of a large hibernation location could prove to be an economical method for endangered bat species that are already restricted to small range. Modifying the humidity of these hibernation locations could also prove valuable in reducing the mortality of bats due to dehydration.

One possible implementation of bat boxes is to use them as a way to open up more quality habitat to local bat populations. There are many habitats that have abundant foraging opportunities but lack accessible roosting sights. One such example of this is the placement of bat boxes in wetlands and flooded agricultural fields (Flaquer 224). Wetlands supply the two most important resources that bats require: prey in the form of insects and abundant sources of drinking water (Flaquer 224). Providing bat populations with more access to rich resources through the use of bat boxes is a means of management that potentially could bolster local populations. This method of management has proven to be successful, boosting some of the highest occupation rates of bat boxes recorded (Flaquer 227).

Bat Species of Interest

One of the most common species of bat throughout the United States is the little brown bat (Dzel et al 392). This species ranges from as far north as Alaska and as far south as Central Mexico. This species is of critical importance in many ecosystems and plays a critical role in the reduction of insects. This is considered a cave dwelling bat as it primarily use caves, tree hollows, and old buildings in which to roost. Unlike tree roosting bats that make large scale migrations to feed and hibernate in different geographic areas, the little brown bat is present in the same geographic area year-round (Rysgaard 245) The widespread nature of this particular species of bat also makes it a good choice for a bioindicator species (Jones et al. 103-104). This species also is very abundant and readily uses artificial roosts, making them an optimal species to target with bat boxes. Although one of the most widespread species of bat in North America, the little brown bat is now facing serious challenges. The introduction of white nose syndrome is blamed for many local populations within this species now facing local extinction (Frick et al 680).

A second species of interest to this project is the large brown bat. Like the little brown bat, this species is also a cave roosting species that is present year-round (Rysgaard 247). Also similar to the little brown bat is the widespread nature of this species. A unique trait of this species is that is has been known to exit torpor periodically during hibernation to rehydrate by drinking water droplets off cave ceilings and walls as well as catching and feeding on insects present within the roost cave (Rysgaard 253). This species is also well known to readily take advantage of artificial roosting boxes when the opportunity presents itself.

Another species of interest to this project is the evening bat (*Nycticeius humeralis*). This species inhabits a range from as far south as Mexico and as far north as Indiana (Watkins 1). Unlike the two species previously discussed, the evening bat is a tree-roosting bat that does not make use of caves and is known to make migrations between feeding and roosting habitats. While exact migration routes have not been documented, the absence of this species from its more northern geographic range points too its being a migratory species (Watkins 1). This species has also been recorded taking advantage of bat boxes. Its relative prevalence in this part of its range and the fact that it will take advantage of manmade roost structures make it a notable species to the scope of this project ("BAT" 1).

Bat Box Project

In light of the threats facing bats in North Carolina, my project includes the construction and placement of a bat box in the hope of providing housing that increases bat populations, in particular the little brown bat and the big brown bat. My bat box uses three-quarter inch spacing between the baffles of the house to optimize the space to accommodate the widest range of bat species. For the construction of this bat box, I chose a three-chamber design, because multiple chambers allow the bats better to thermoregulate. Each chamber as its own microclimate, giving the bats roosting in the box options to move between chambers to get either warmer or cooler depending on the outside temperature. These multiple chambers increase the attractiveness of the bat box as a roosting location and increase its odds of being used. The wooden landing platform as well as the plywood that make up the baffles of the box are roughed up with a wood chisel to make it easier for the bats to grip the wood and maneuver in the box, thus eliminating the chance of slick boards causing any bats to lose their grip and fall out of the box. A horizontal cut is made on the front of the box into the first chamber to allow proper ventilation during the hottest months. Side vents are also present in-between the first and second baffle in order to provide proper ventilation. This is important due to the large number of bats that might use a single roost at one time. A small overhanging piece of wood prevents water from entering into the box through this chamber. Both the inside and outside of the box are painted with a non-toxic black paint, assisting in weatherproofing the box as well as well as making the inside of the box a more attractive roost location by darkening it.

I have mounted my box on a lone standing pine in the middle of a field near a source of drinking water. The location of the box on a solitary tree gives bats more comfort because they more easily can survey their surrounding and detect predators than if the box was attached to a hardwood with many branches and close proximity to other trees. The box is oriented to the west to avoid overheating the box in the summer months. This location is surrounded by flowing irrigation ditches on all sides that provide a constant source of water for the bats living in this box. Moreover, the Lumber River backs up to this property, creating temporary wetlands as the river rises during times of heavy rain. This ecosystem provides ample insects during these times of the year for the bats to forage on.

Conclusion

It can take as much as a year for bats to move into a new roosting location, so it will take time to measure the ultimate success of this project. It is my goal to convince the landowner as well as the property owners of adjacent farms to take other steps in making the surrounding habitat more bat friendly. Simple steps such as not bush-hogging field edges would potentially make the available habitat even more appealing to local bats.

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