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Learning to Love Bats

Bethany J. Lawson

The University of Southern Mississippi

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by

Bethany Joy Lawson

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Approved by:

Mark M. Miller, Ph.D., Thesis Adviser
Professor of Geography

Jake Schaefer, Ph.D., Director
School of Biological, Environmental, and Earth Sciences

Ellen Weinauer, Ph.D., Dean
Honors College

Abstract

Throughout history, bats have often become entangled in various myths and legends that have negatively influenced human perceptions of bats. Media outlets often sensationalize the relationship of bats to novel diseases, which also creates negative perceptions of bats in the human imagination. Bats are beneficial to our ecosystems and provide pollination services, seed dispersal, and insect control. However, bats are currently facing a variety of life-threatening issues, such as habitat destruction, fatalities at wind energy sites, climate change, and most notably, white-nose syndrome – a disease that has killed millions of North American bats in the past decade. With bats under this dire amount of stress, it is imperative that humans learn to appreciate this order of mammals and engage in more conservation-related behaviors. In several sites across the US, people can visit cave openings and national parks to engage in bat-related ecotourism. This thesis examines public education at bat-ecotourism sites and its impact on bat conservation. There is little published research available on bat-related education at ecotourism sites to date, and this thesis investigates the best practices in this growing field. Data were gathered through personal interviews with educators at bat-ecotourism sites and through personal observations of these sites. This research identifies models of how bat-ecotourism sites are aiding bat conservation and how educators at bat-ecotourism sites dispel myths about bats, educate the public of their importance, and encourage conservation-related behaviors towards bats.

Key words: geography, bat, bat ecotourism, bat conservation, conservation education, conservation

Dedication

To my sister Evelyn,

Thank you for being so supportive of my research and for accompanying me to countless batty locations, bat festivals, and bat meetings. Our road trips are forever engraved in my memories. It will always be you, me, and the three B's – bears, bats, and Buc-ee's.

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List of Abbreviations

ABC	American Bird Conservancy
BCI	Bat Conservation International
CDC	Centers for Disease Control and Prevention
NPS	National Park Service
Pd	*Pseudogymnoascus destructans*
USM	the University of Southern Mississippi
WNS	White-nose syndrome

Chapter 1: Introduction

It is human nature to protect things that are of value and importance, but quite often people are ignorant concerning how their daily lives impact the environment around them. In recent decades, conservation education has become an important tool in informing the public of their influence on the environment and how to conserve natural resources in their communities. The International Zoo Educators Association defines conservation education as "the process of influencing people's attitudes, emotions, knowledge, and behaviors about wildlife and wild places" (International Zoo Educators Association). This process is often carried out in educational institutions, zoos and aquariums, and through community projects and organizations.

Conservation education, a form of education focused on educating the public about the natural world and its importance, is becoming increasingly important as the world becomes more heavily populated with people. With growing urbanization and human presence in the natural world, it is essential that the public learn to value the other creatures of the planet and recognize the essential roles they play as a part of our global ecosystem. However, humans are known to hold certain biases towards different species, whether it is based on their aggressiveness or even their relative attractiveness. Animals such as sharks, wolves, coyotes, skunks, and rats are examples of such species that tend to be stigmatized (George et al. 2016). Unfortunately, bats also tend to be negatively perceived by humans, and at times, these negative perceptions have influenced their conservation across the globe.

The research problem

Bats, which belong to the order Chiroptera in class Mammalia, have historically been portrayed as disease-carrying, blood-thirsty animals. However, these portrayals are exaggerated, considering only three of the world's 1,000+ bat species drink blood as a part of their diet (Hoffmaster, Vonk, and Mies 2016). In a study observing human perceptions of historically stigmatized species from 1978 to 2014, researchers found that human perceptions of bats had evolved into a more positive perception (George et al. 2016). However, this is unlikely to remain the case for long. Merlin Tuttle, a pioneer in the field of bat biology and bat conservation, fears that bats are becoming the scapegoat for the spread of many different global illnesses (Tuttle 2017). Regardless of whether or not scientific evidence is present for the association, bats are often blamed as being the cause and the carriers of multiple diseases (Tuttle 2017). After years of conservation efforts, bats are steadily becoming more at risk for anthropogenic harm due to these accusations. In order to combat the misinformation presented in the media, conservation education related to bats needs to become a priority.

Conservation education about bats is becoming increasingly important in North America, considering the rapid increase in bat fatalities in recent years. Bats are currently faced with a variety of major threats, including white-nose syndrome (Bat Conservation International White-nose Syndrome), increasing wind energy fatalities (Arnett et al. 2008), and the looming threat of climate change, which carries with it an unknown future regarding the livelihood of bats (Sherwin, Montgomery, and Lundy 2013). Increasing urbanization is encouraging bats to seek shelter in human structures, which leaves them vulnerable to anthropogenic harm if humans take action to remove the bats from their

roosts (Fagan, Wilcox, and Wilcox 2018). These factors pose a great threat to the livelihood of not only the bats, but also to the structure of the global ecosystem. Bats play many ecological roles such as seed dispersal, pollination, and pest control (Kunz et al. 2011). Distributing this information and encouraging the public to participate in bat-related conservation activities, such as building bat houses and planting bat gardens, is essential in order to change human attitudes towards bats, mitigate unnecessary harm towards this taxon, and encourage the public to adopt a more positive perception of wildlife. (As a note, taxon refers to a specific taxonomic group of animals. Bat researchers often refer to bats as a taxon, and in this paper, taxon will refer to the order of mammals comprising bats.) Conservation education initiatives are an important starting point for initiating this process, and preliminary studies on bat-related conservation education strategies offer encouraging results regarding their effectiveness at distributing this information.

The research question

My research question is, "Can public education, including bat-related tourism, assist in bat conservation efforts?" I hypothesize that public education assists bat conservation efforts by educating people on the environmental importance of bats and alleviating negative, historical biases towards the taxon which currently hinder their conservation. Many bat fatalities result from anthropogenic influences, such as wind energy and climate change, and it is essential that people know and understand their impact on the global ecosystem and support research to mitigate these harms.

While reading literature pertaining to bats, education, and ecotourism, I identified several specific questions to answer during my research process:

- Can education directly impact the conservation of bat species by teaching people how to avoid spreading *Pseudogymnoascus destructans*, the fungus which causes white-nose syndrome, on their visits to bat-roosting sites?
- Can conservation education influence people to be less of a disturbance to unmonitored bat roosts?
- Can education encourage people to take direct action in preserving bat species through conservation behaviors, such as bat house building?
- Will people who understand the threats bats are facing encourage their local governments to monitor bat populations and mortalities in natural roosts and at wind energy sites and voice their opinions to those who might want to destroy urban bat roosts?
- Are bat-related tourism sites effective places to distribute educational materials to the public, since these areas involve a stronger, more interactive experience with the taxon?

Purpose of the research

The ultimate goal of my thesis is to contribute more knowledge to the field of bat conservation. I believe that my research will provide educators with a comprehensive overview of what other organizations are doing to benefit bat conservation efforts. Specifically, my research will provide educators with an overview of the best practices regarding bat-related conservation education currently being conducted by professionals

at bat ecotourism sites. By researching organizations conducting bat conservation, their methods, and the effect of the various programs, I hope to illuminate which methods of bat conservation are effective or ineffective in influencing human perceptions of bats and ultimately their behaviors towards bats. By doing so, conservation organizations will have a better framework on which to model their conservation education strategies.

Throughout the course of my research, I spoke with professionals in the National Park Service, and I also spoke with someone who has worked as an intern for Bat Conservation International. By identifying the best practices in bat education conducted by these world-renowned organizations, I am hoping that other National Parks, ecotourism sites, and smaller conservation groups at the state or local level can benefit. For example, the Mississippi Bat Working Group, a group that conducts bat research and bat-related educational outreach in Mississippi, could benefit from learning about the educational strategies other educators are using across the southern United States. New, emerging bat conservation groups could also benefit, as well as teachers in classrooms who wish to teach their students about bats.

Methodology

My research is structured into two main parts. The first part of my project is a review of current literature pertaining to threats to bats, conservation/environmental education, bat conservation, ecotourism, bat-related ecotourism, bird-related ecotourism, and human perceptions of bats. I based this review on published articles from academic journals and information obtained from renowned bat conservation groups. I also looked at sources for a popular audience such as social media and websites, where information

about bats is frequently disseminated to the public. Lastly, I reviewed social media sites to observe how information about bats is being distributed to the public through media format.

The second part of my project is comprised of fieldwork based on a qualitative research approach. Data were collected through qualitative interviews with professionals working with bat-related conservation education at ecotourism sites, as well as through personal observations of the landscapes near ecotourism sites. During my interviews, I used a well-established research framework known as Grounded Theory, where the information obtained from each interview guided the questions of the subsequent interview (Charmaz 2014). The interviews were coded, and various themes were extracted from the data. I also observed the conservation education strategies at ecotourism sites by watching the educational programs and speaking to the educators about their goals and activities within their educational programs.

Study sites were selected based on my personal accessibility to the sites and the sites' roles in conservation education or bat-related ecotourism. Bracken Cave Preserve in San Antonio, Texas, the Congress Avenue Bridge in Austin, Texas, the Camden Street Bridge in San Antonio, Texas, and Old Tunnel State Park in Fredericksburg, Texas, were selected because they can be defined as bat-related ecotourism sites. Each destination has a large population of bats, which is usually the main factor drawing tourists to these areas. Bracken Cave Preserve, owned and managed by Bat Conservation International, is the world's largest bat colony and is the residence of more than 15 million Brazilian free-tailed bats (BCI Bracken Cave). Visits to the cave are reserved for members of Bat Conservation International, and the public is only occasionally invited to the site. The

Congress Avenue Bridge in Austin, Texas, is the largest urban bat colony in the world, and the public has full access to visit the 1.5 million Brazilian free-tailed bats at the bridge (BCI Congress Avenue Bridge). Camden Street Bridge in San Antonio, Texas, is a popular bat-viewing destination along the Riverwalk, where visitors can witness a bat emergence of about 50,000 bats (Texas Parks & Wildlife, Camden Street Bridge). Old Tunnel State Park in Fredericksburg, Texas, is one of 12 different bat-watching sites promoted by Texas Parks & Wildlife, and it is home to around three million bats (Texas Parks & Wildlife, Old Tunnel). It is important to note that most bat-watching events take place during the summer months, since the dominant species present in these areas, the Brazilian free-tailed bat, is a migratory species.

I also selected Carlsbad Caverns National Park in New Mexico, Mammoth Cave National Park in Kentucky, and Great Smoky Mountains National Park in Tennessee as study sites. According to the National Park Service's website, "The National Park Service is dedicated to conserving unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations" (National Park Service, Our mission, role, and purpose). Since education is a part of the National Park Service's mission, I wanted to observe how the National Park Service disseminates information about bats in parks that have a significant population of bats, and also because the public is usually aware of the presence of bats at these sites.

I also attended the Austin Bat Fest and the New Orleans Audubon Nature Institute's Bat Appreciation Day as part of this research. The New Orleans Audubon's Bat Appreciation Day took place during Bat Week, which is at the same time as Halloween of each year. Finally, I attended two annual meetings of the Mississippi Bat

Working Group and I visited the Hattiesburg Zoo, which provided a good case example of a small community site.

Overview of findings

Through my research at these study sites, I identified several significant themes about bat-related ecotourism and conservation education by speaking with professionals in these areas and observing educational programs. Overall, I learned that education is an important aspect of bat ecotourism. First, educators at bat-related ecotourism sites have a three-tiered approach to their programs, focusing on debunking bat myths, educating the public on bat biology and their environmental importance, and promoting human safety with bats. Second, bat ecotourism sites seek to promote bat conservation by encouraging conservation-related behaviors, such as bat house building, and by minimizing bat disturbance at ecotourism sites by restricting noise and light pollution. Ecotourism sites are also working to minimize the spread of white-nose syndrome, a deadly bat disease through various sanitizing policies and cave closures. Third, I identified various activities that educators find effective regarding bat education, such as games and bat hikes. Lastly, I found that organizations on social media sites are promoting bat conservation by advertising Bat Week activities and festivals, encouraging communities to establish Bat Week, and by distributing educational materials and videos of bats to the public to diminish the impact of their historical stigmatization.

Chapter 2: Literature Review

Throughout the world, there are over 1,300 bat species, comprising almost a quarter of all known mammal species and making up the second largest group of mammals (BCI Bats are Important). Bats can range in size from the small bumblebee bat, weighing less than a penny, to flying foxes, which can have wing-spans over five feet long (BCI Bats are Important). Bat diets can consist of insects, fruit, fish, and even blood, although only three of the world's bat species actually consume blood (McCracken 1993). Regardless, people often negatively perceive bats due to centuries of mythology associating them with dark characters such as vampires and witches. In the United States and Canada, there are over 40 different bat species. Common North American species include the hoary bat, little brown bat, big brown bat, and Brazilian free-tailed bat. These bats provide numerous economic and ecological services; however, many species are threatened by disease and human activities.

Perceptions of Bats Throughout Time

Throughout history, bats have often become entangled in various myths and legends which have influenced how people perceive them. In Western cultures, most of the mythology portrays bats in a negative light. Remnants of this mythology are still found in modern popular culture, such as in movies with vampires and witches accompanied by bats, and vampires portrayed with bat wings. Early scientists frequently wrote negatively about bats, often as a result of a lack of understanding their nocturnal nature (Allen 2004). From the time of Medieval Europe onward, bats and their

characteristics have been used in artwork and popular culture to represent darkness, best represented by the portrayal of a demon with bat wings in *Dante's Inferno* (Cooke 2018). Bats were often associated with witchcraft because of the bat's ability to fly at night, and people believed witches collected bats for their potions (Cooke 2018). This idea is evident in Shakespeare's *MacBeth*, when witches chant about their potion, which includes "wool of bat" (Cooke 2018). After Bram Stoker's *Dracula* was published in 1897, bats became connected to vampire mythology as well (Cooke 2018). In addition to the widespread connection of bats to witchcraft and vampirism, there are many regional myths about bats. In Germany, people believed for a long time that bats would eat hanging meats in storehouses, and in France, there was a prominent myth that a bat in a woman's hair signified disaster or death (Allen 2004).

While some of these various mythologies continue to persist in the human imagination today, a lot of the negative perceptions surrounding bats in modern times is their association with novel diseases, such as Ebola, SARS, and various coronaviruses (Tuttle 2017). In addition, bats have often been heavily linked to rabies in the media, especially species such as the gray myotis, the tricolored bat (formerly known as the eastern pipistrelle), and the North American silver-haired bat (Fenton 2003; Tuttle 2015). According to the Centers for Disease Control and Prevention, bats are the source of infection for around 70% of the human rabies cases reported in the US, but there are only 1-2 cases of rabies infections on average per year (CDC). The number of human rabies deaths associated with bats is rather low, considering only 28 people between the years 1980 and 2000 died from strains of rabies associated with bats (Fenton 2003). The association of bats to rabies has created many conservation problems for bats throughout

the past few decades. During Tuttle's study of gray myotis, he often encountered caves that had been burned by humans to kill bat populations out of fear of rabies (Tuttle 2015). According to Merlin Tuttle, bats are often the scapegoat for emerging diseases, even if there is no concrete evidence for the association (Tuttle 2017). This scapegoating ultimately hinders global bat conservation and creates fear in the minds of the people, often leading to bat exterminations and roost site destruction (Tuttle 2017). Although bats are often associated with these negative factors, bats provide humans with many ecological and economic services that benefit our world.

Role of Bats in Ecosystems and Economies

Bats play many ecological roles throughout the world, including pollination, seed dispersal, and natural pest control. Bats responsible for pollination and seed dispersal are more common in the tropics, where many fruit bats and nectar-feeding bats live (Kunz et al. 2011). In North America, bats such as the lesser long-nosed bat and the Mexican long-nosed bat are renowned for their pollination of *A. tequilana*, the agave plant associated with tequila manufacturing (Kunz et al. 2011). In addition, bats are important to the pollination and seed dispersal of a variety of other plants and fruits such as bananas, mangos, and durians (Kunz et al. 2011). Bat guano is mined for fertilizer, which is beneficial to farms and communities worldwide (Kunz et al. 2011). Bats also provide economic benefits through the tourism industry, which will be discussed later in the literature review.

Bats are also highly beneficial to the American agricultural industry, especially with regard to pest control. Of the world's 1,300+ bat species, over two-thirds are

insectivorous (Kunz et al. 2011). In Texas, the Brazilian free-tailed bat, an insectivorous bat, consumes agricultural pests such as the corn earworm moth, which can cause substantial crop damages (Cleveland et al. 2006; Kunz et al. 2011). Pregnant Brazilian free-tailed bats are capable of consuming their entire body weight in insects per night, and this natural pest control is vital to industries such as the cotton industry in Texas (Cleveland et al. 2006). It is estimated that these bats save the agricultural industry in Texas around $740,000 a year in pesticides (BCI Bats are Important; Boyles et al. 2011; Cleveland et al. 2006). This diet can also be beneficial to humans and the earth, since fewer pesticides are introduced to the environment. One study estimated that a single colony of 150 big brown bats can consume over one million insects per year (Boyles et al. 2011). In the United States alone, bats are estimated to be worth $3.7 billion to the agricultural industry (BCI Bats Are Important; Boyles et al. 2011). However, in a study completed in 2011, researchers estimated 660 to 1320 metric tons of insects are no longer being consumed in areas affected by white-nose syndrome – a deadly bat disease (Boyles et al. 2011).

Illustration 1: Brazilian free-tailed bats provide many ecological and economic services to the Southwestern US, and they form many of the large bat colonies associated with bat ecotourism sites (Photo by Merlin Tuttle's Bat Conservation.)

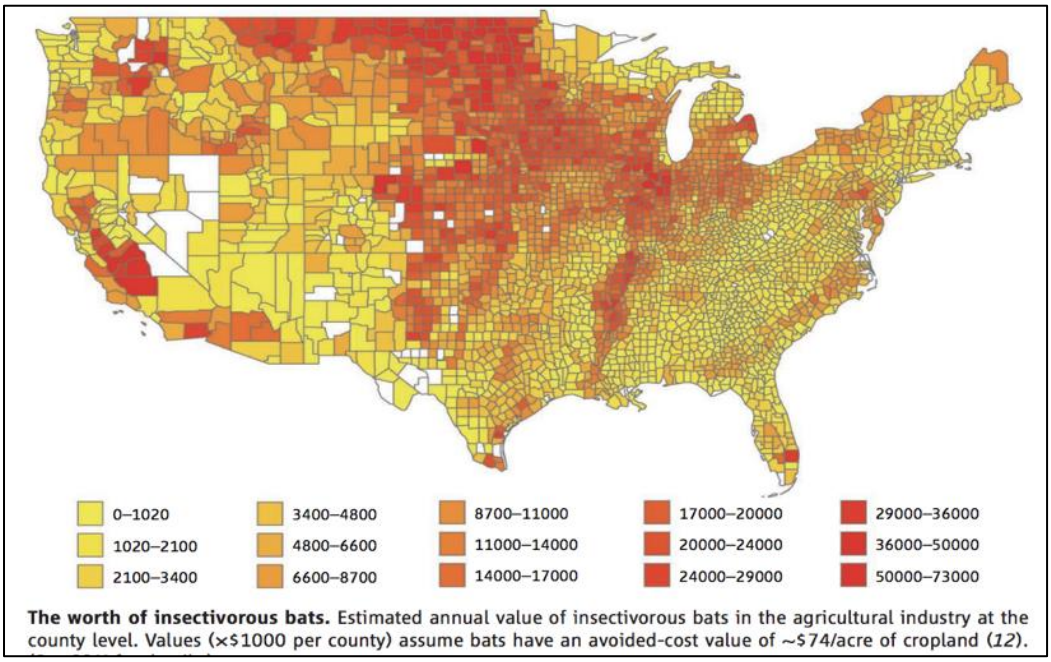


Illustration 2: This is a map showing the economic value of insectivorous bats in the United States (Boyles et al. 2011).

Modern threats to bats: white-nose syndrome

In North America, bat populations are decreasing rapidly due to a number of threats. One of these threats, a disease known as white-nose syndrome, has caused millions of bat fatalities in North America and is now known as "one of the most devastating wildlife epidemics in recorded history" (Frick, Puechmaille, and Willis 2016). White-nose syndrome (abbreviated as WNS), a disease caused by the fungus *Pseudogymnoascus destructans* (*Pd*), causes skin infections in bats during hibernation, causing them to wake during the winter months. Physical distress and a lack of food during the winter months causes many bats infected with WNS to die (Frick, Puechmaille, and Willis 2016). Since the arrival of WNS to North America in 2006, an estimated six million bats have perished (BCI Initiatives). White-nose syndrome is gradually spreading from the eastern coast of North America to the west, and as many as 33 US states and seven Canadian provinces have documented WNS in their bat populations. An additional three states have discovered Pd but no WNS (BCI White-nose syndrome). Of the 12 species affected so far by WNS, two are federally endangered – the gray bat and the Indiana bat – and the northern long-eared bat was recently listed as threatened due to WNS (BCI White-nose syndrome). WNS has caused many bat populations across North America to disappear, and the northern long-eared bat has disappeared from 69 percent of its hibernation spots (Frick et al. 2015). A study on the case of the Indiana bat demonstrates the capability WNS has to significantly reduce/destroy vulnerable bat populations (Thogmartin et al. 2013).

White-nose syndrome is an important factor to consider when studying conservation education related to bats because scientists believe it is likely that the

transmission of white-nose syndrome can be carried out by human activity. It is probable that WNS was brought to North America by a person who had previously visited caves in Europe, since no bats are known to participate in trans-Atlantic migrations (Frick, Puechmaille, and Willis 2016). Globalization has often led to the introduction of non-native diseases and pests to other places, such as the case with the destructive Chinese chestnut blight, and white-nose syndrome is likely another harmful byproduct of human activity. It is important visitors to cave and bat ecotourism sites understand how WNS can be transmitted in order to prevent spreading WNS to unreached bat populations. Organizations such as the National Park Service can also protect caves and mine shafts in their parks to keep visitors from transmitting the fungus and disturbing endangered bat populations during this critical time. The Great Smoky Mountain National Park has taken these measures to protect their vulnerable bat populations by erecting cave gates and closing caves to the public (National Park Service Great Smoky Mountains).

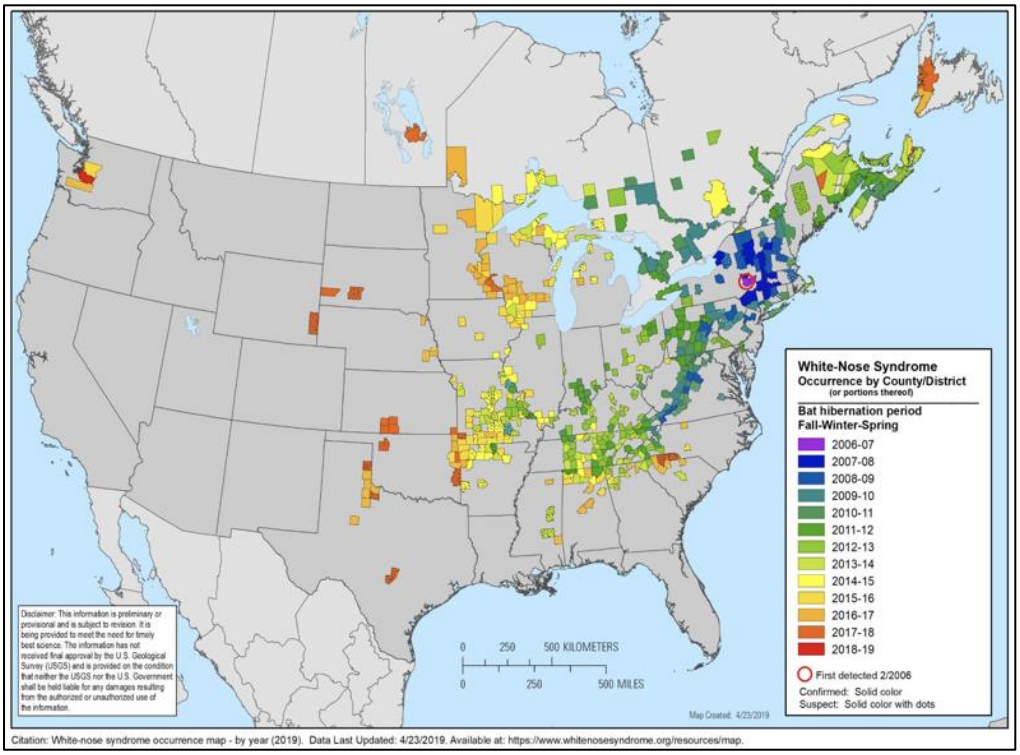


Illustration 3: This map exhibits the spread of white-nose syndrome in North America, as of March 2020 (BCI White-nose Syndrome).

Modern threats to bats: wind energy

White-nose syndrome is not the only factor devastating bat populations in North America. Wind energy is also one of the leading causes of bat fatalities in the United States and worldwide. Bat fatalities related to wind turbines are alarming even when compared to white-nose syndrome. While bats can build immunity to white-nose syndrome over time, wind turbines pose a longstanding threat to bat populations (Boyles et al. 2011). Many bats fatally collide with wind turbines or wander close enough to experience the effects of barotrauma (Arnett and Baerwald 2013). Barotrauma, which causes internal injuries and hemorrhaging, is caused by the pressure changes bats experience as they fly close to a wind turbine (Arnett and Baerwald 2013). The majority of dead bats near wind energy facilities show signs of barotrauma, although many bats

die a distance away from wind energy facilities due to hemorrhaging in the ears leading to issues with echolocation. In this regard, it is possible that many wind energy fatalities are unaccounted for (Arnett and Baerwald 2013).

Wind energy facilities have been expanding rapidly in the United States, with a goal of 20 percent of electrical energy to be supplied by wind turbines by 2030 (Hutchins, Parr, and Schroeder 2016). Greener energy is important given the critical status of human-driven climate change; however, wind energy is having an unprecedented negative effect on wildlife – especially on bats and birds. According to Bat Conservation International, between 2000 and 2011, 650,000 to 1.3 million bats died as a result of wind-energy facilities in the US and Canada, with 24 different species affected (BCI wind energy). This includes both hibernating and migratory bats, which makes wind energy one of the most significant threats to bats (BCI wind energy). Overall, migratory bats are affected the most, with the most fatalities at wind facilities occurring in late summer/early fall during times of migration (Arnett et al. 2008). It is difficult to estimate the number of bird fatalities at wind energy facilities, but various studies suggest as many as 239,000-573,000 bird fatalities annually, with numbers expected to rise above one million by 2030 as wind energy facilities expand across the United States (Hutchins, Parr, and Schroeder 2016).

Illustration 4: The hoary bat species (pictured above) accounts for many of the fatalities at wind energy sites (BCI wind energy). (Photo by Merlin Tuttle's Bat Conservation.)

Modern threats to bats: urbanization

As humans continue to spread across the landscape, wildlife is increasingly losing critical habitat due to human activity. It is common now for bats to seek shelter in older buildings, attics, and homes. Humans are more frequently coming into contact with an animal that many of them fear or consider to be a pest, and many professionals are researching how to help bats adapt to urban environments and mitigate the fears that people have about bats.

One study done by Fagan, Wilcox, and Wilcox studied human perceptions of bats roosting in historical buildings in Cades Cove, Great Smoky Mountains National Park (2018). The researchers conducted surveys at three sites throughout Cades Cove in order to assess the public's attitude toward bat management strategies in the park. The researchers found that after visitors were given information about white-nose syndrome

and the ecological importance of bats, they were more likely to support seasonal building closures to protect bats in the park. Seventy-six percent of park visitors surveyed supported partial building closures during the summer. Only eight percent of visitors were opposed to such closures. Additionally, 63 percent of the people surveyed were interested in having more educational materials at bat sites throughout Cades Cove. This study found that attitudes towards bats and an understanding of the threats this taxon faces are important in influencing public attitudes towards wildlife management strategies related to bats (Fagan, Wilcox, and Wilcox 2018).

One bat species critically affected by human urbanization is the Florida bonneted bat. This species, one of the most endangered in the United States, occupies a small portion of land in southeastern Florida. Rapid urbanization in this area throughout the past several decades has destroyed a significant amount of critical habitat for this bat species. As a result, the Florida bonneted bat has adapted to living in urban environments, where their roosts are often disturbed or destroyed either intentionally or unintentionally. Researchers Melquisedec Gamba-Rios and Frank Ridgley are currently working on an extensive project to help the Florida bonneted bat by developing outreach programs for construction, roofing, and pest control companies, and they will be studying how urban habitat and urban pollutants affect this bat species (*Bats Magazine* 2019). With the help of Bat Conservation International, Florida Power & Lights, and U.S. Fish and Wildlife, Gamba-Rios and Ridgley have already created successful artificial bat roosts in Miami for the Florida bonneted-bat (*Bats Magazine* 2019).

Modern threats to bats: climate change

Although the effect of climate change on each bat species is unknown, scientists can make conjectures on how a particular species might react to a changing environment based on the way climate change will affect a species' biogeographical range. Sherwin, Montgomery, and Lundy (2013) identified several risk factors associated with climate change for bats, including water-stress, the effect of temperature on hibernation health, severe weather events, and habitat loss.

In *Planning* magazine, Barth (2019) uses the term "cascading hazards" to describe the events accompanying natural hazards created by global climate change. It is possible that the disappearance of bats from certain geographical ranges could cause many cascading hazards in the world. For example, Sherwin, Montgomery, and Lundy (2013) discuss how range alterations could cause many ecological and economic problems. Bats are the primary pollinators in many different parts of the world, as well as one of the most significant forms of natural pest control. A shift in geographical range could cause many problems for communities that rely on bats for these purposes.

Although it is too early to see how climate change will affect each bat species, there is evidence emerging of its disastrous effects on certain populations. In 2018, almost one-third of the flying foxes in Australia perished during a two-day record heat wave. Over 23,000 flying foxes and 10,000 black flying foxes died during this event (Mao 2019). Scientists in the area are alarmed, as these record heat waves are expected to continue into the future with a changing global climate (Mao 2019).

Modern human perspectives on bats

As mentioned above, myths about bats have been prominent in the human imagination for centuries (Allen 2004; Cooke 2018). Researchers have conducted surveys at various locations to assess public attitudes towards bats today. By replicating a study conducted in 1978 regarding attitudes towards various animal species, George et al. (2016) found that in the United States, attitudes towards bats have improved significantly from 1978 to 2014. The researchers speculate that the newfound positive attitudes towards historically stigmatized species in the study could be related to two factors. First, increased exposure and attention given to these animals in the media could be creating more knowledge towards the stigmatized species. Second, the researchers speculate that an emerging "mutualistic" attitude between humans and wildlife could foster more positive attitudes (George et al. 2016).

A study conducted in the United States titled "Geography student knowledge of bats and Austin bat colonies" surveyed geography students at Texas State University-San Marcos (Taylor and Butler 2007). The researchers' goal was to assess the students' general knowledge of bats and the specific knowledge of the bat species at the Congress Avenue Bridge, which is in close proximity to the university. The general knowledge of bats that the students exhibited was high, but the authors noted that students were less knowledgeable about the specific bat species at Congress Avenue Bridge in Austin, Texas. The survey results also indicated that some students believed traditional myths about bats, such as the perpetual myth that bats are blind. The authors discuss how knowledge and positive attitudes toward urban wildlife are essential for the conservation of urban species, and the authors believe there is a need for more educational initiatives at

sites such as the Congress Avenue Bridge in order to improve visitors' understanding of urban bat colonies. They recommend distributing information pertaining to the economic and ecological benefits of bats. The researchers also acknowledge that they were surveying a population of college students, and results might be different with a more diverse sample group (Taylor and Butler 2007).

Bird-related ecotourism

Bat tourism is a fairly new field of ecotourism. However, by studying long-standing fields of ecotourism, such as bird-watching/bird-related ecotourism, we can gather evidence of the effectiveness of ecotourism as a conservation strategy. Birds throughout the world are facing many of the same problems as bats; they are experiencing mortality related to urbanization, wind energy development, and climate change (American Bird Conservancy Threats). In order to protect birds and their habitats, the American Bird Conservancy has started a project called Conservation Birding. This project gives tourists an expansive list of places to go birding, where their monetary contributions directly contribute to the habitat management and preservation of multiple bird species. The American Bird Conservancy, in conjunction with other bird conservation organizations, owns over 92 different bird conservation sites, and bird-watching tourists are one of the most significant financial contributors to the management of these areas (American Bird Conservancy Conservation Birding).

Researcher Sheri Glowinski examines whether or not ecotourism based on bird-watching could provide local economic development (Glowinski 2008). Glowinski looks at several case studies which overall indicate that bird-watching has varying degrees of

economic benefits, depending on the location of the bird-watching venue. The author gives suggestions on how to increase economic development in these areas. She also suggests diversifying development due to common bird migratory practices. Glowinski also mentions some potential negative impacts of bird-watching ecotourism, such as disturbance of the birds due to human presence (Glowinski 2008). However, these threats can be mitigated by proper planning and management of the areas.

Bat-related ecotourism

A study evaluating the economic value of tourism of Mexican free-tailed bat viewings determined that recreational bat viewing has significant monetary value (Bagstad and Wiederholt 2013). The authors of this study gathered visitation data from 17 popular bat-viewing sites across the southwestern US and calculated consumer surplus values. They determined that in this area, an estimated 242,000 tourists view bats annually and contribute 6.5 million dollars in consumer surplus (Bagstad and Wiederholt 2013). Bat-viewing sites in Texas are advertised to the public through their Texas Parks & Wildlife website, and they include 12 different bat viewing sites (Texas Parks & Wildlife, Bat-Watching Sites). Florida is also becoming a popular destination for bat-watching, with nine different bat viewing sites (Donahue 2019). Bat-related ecotourism has significant economic value, and since many people visit these areas each year, these sites can also be used as an effective means of distributing conservation education related to bats while also providing economic benefits to communities.

A study conducted by Pennisi, Holland, and Stein (2004) explains the success of ecotourism on altering the attitudes people have of other stigmatized species, such as

wolves and alligators. The researchers view non-consumptive wildlife-oriented recreation as a means of alleviating negative historical biases towards bats and fostering an attitude of conservation in the visitors to bat ecotourism sites. However, they stress that tourism areas must be carefully monitored to ensure the animals are not disturbed or harmed (Pennisi, Holland, and Stein 2004). The study discusses the rising popularity of bat-watching and lists popular bat-viewing areas as well (Pennisi, Holland, and Stein 2004).

Chapter 3: Methods

As a student, I have always been interested in studying conservation. A graduate student in the University of Southern Mississippi's geography department, Nadine Armstrong, introduced me to the concept of bat-related tourism at the Congress Avenue Bridge in Austin, Texas, during my sophomore year at USM. After discussing this unique industry with Armstrong, I began researching bats and bat-related ecotourism extensively by reading published academic journal articles, books, and online web pages created by bat conservation groups. I identified my research topic and my research questions after reading the journal article titled "Public attitudes toward the presence and management of bats roosting in buildings in Great Smoky Mountains National Park Southeastern United States" (Fagan, Wilcox, and Wilcox 2018). In this article, the researchers mentioned that more research needed to be conducted regarding bat education at different parks (Fagan, Wilcox, and Wilcox 2018). Although my study was not structured in the same manner as Fagan, Wilcox, and Wilcox, I wanted to identify what various bat-education strategies educators were utilizing at ecotourism sites across the country.

The methodology for my research consists of qualitative research methods. For my research, I visited areas involved in bat ecotourism and areas that conduct educational outreach programs pertaining to bats. I chose my study sites based on personal accessibility, as well as by identifying popular bat ecotourism sites based on internet searches. I visited three national parks, including Great Smoky Mountains National Park in Tennessee, Mammoth Cave National Park in Kentucky, and Carlsbad Caverns National Park in New Mexico. In Texas, I visited four bat ecotourism locations, including

Bracken Cave in San Antonio, Old Tunnel State Park in Fredericksburg, the Camden Street Bridge in San Antonio, and the Congress Avenue Bridge in Austin. Locally, I visited the Hattiesburg Zoo in Hattiesburg, Mississippi. Lastly, I attended two bat festivals, including the Bat Fest in Austin, Texas, and the Bat Appreciation Day at the Audubon Nature Center in New Orleans, Louisiana. I conducted personal interviews with professionals working in these areas, and I attended their public education programs. I also attended two of the Mississippi Bat Working Group's annual meetings during the course of my research in order to interact with professionals conducting bat research and discuss my personal research.

The approval for this research was granted by the University of Southern Mississippi's Institutional Review Board (IRB) on June 19, 2019. Funding for travel was provided by the University of Southern Mississippi's Honors College, as well as the Drapeau Center for Undergraduate Research. I contacted each location I planned to visit to arrange interviews with ecotourism personnel, and I reached out to a bat specialist to interview through Bat Conservation International. I created the interview questions based on the topics and problems I had identified during my literature review process. In total, I interviewed five professionals during my research. Each interview participant signed a standard informed consent form, and I provided each participant with a copy of this form.

During my research process, I was not only trying to obtain answers to my preliminary questions based on my study of bat-related literature, but I was also seeking to gather as much information about bat education and ecotourism as possible. To date, there is little information about education at bat-ecotourism sites. Rather than comparing my observations to a predefined theory, I collected information through observations and

open-ended interviews to create my own theories about bat-related ecotourism based on my observations. In doing so, I conducted my research using principles of Grounded Theory (Charmaz 2014). After each interview, I compared my findings with my previous interviews and used the new information I had learned to guide my interview questions in the subsequent interview. I recorded each interview, and after all of the interviews were completed, I transcribed the audio tapes of the interviews. Then, I began the interpretive process by coding the interviews based on various themes I found emerging in the data. I decided this methodology was best for my research, since I would be visiting places that were very different from one another, yet I wanted to extract broad commonalities amongst the study sites.

In addition to conducting interviews, I also focused on observing the landscapes of the different ecotourism sites I visited. Throughout my geography studies, I have learned that studying landscape elements is important to gaining information about a place (Cosgrove 1989). As a result, I paid attention to signs portraying information about bats, as well as any bat symbolism present at the ecotourism sites, especially in urban areas such as Austin and San Antonio. As a part of my research, I decided to take pictures of distinctive bat-related landscape elements.

Each interview took place at the ecotourism site where the educator was working, and the interview lengths varied. Interviews were at minimum thirty minutes long. I recorded the interviews using the iPhone's voice memo application and transcribed and coded them at a later date, using the methodology described above and using Charmaz's *Constructing Grounded Theory* as a guide (Charmaz 2014). I also wrote field notes about my observations of the study sites and my observations during the educational programs.

Lastly, I followed bat organizations on social media to observe the content being disseminated and processed via social media platforms.

The Study Sites

Brazilian free-tailed bat viewing in the Southwest

In the Southwestern United States, Brazilian-free tailed bats form some of the largest bat colonies in the world. The Brazilian free-tailed bat, also known as the Mexican free-tailed bat, is a migratory species. These bats migrate from Mexico to the Southwestern US in the spring to reproduce, and they stay until August, when their offspring have become independent. These bats form incredibly enormous colonies, and people travel to bat-ecotourism locations to witness anywhere from thousands to millions of bats emerge from these sites at dusk. Bat-watching has become popular in this region of the country, and several popular viewing sites have emerged. The following entries give further details into the specific sites I visited as a part of my research.

Illustration 5: Pictured is a map from the zoo in San Antonio, Texas, showcasing the various bat-watching sites in the state. (Photo by the author.)

Bracken Cave, San Antonio, TX. Bracken Cave is one of the most spectacular bat-viewing sites in the world. Bracken Cave is the largest known bat maternity colony in the world, which means that female Brazilian free-tailed bats go to this cave each year to give birth to their offspring. This site boasts a population of over 15 million bats during the summer months (BCI Bracken Cave). It is located in a semi-rural area outside of downtown San Antonio, and the property is managed and protected by Bat Conservation International (BCI Bracken Cave). In order to visit the site, one must be a member of BCI or a guest of a member, and members are allowed only one visit per season. A volunteer at the site told me that they do allow non-members to watch a bat emergence one night per season, but they do limit the number of visitors. Visitors to the site can choose either to watch the bats emerge from the cave at night or watch the bats return to the cave early in the morning. The cave opening is located in a deep depression in the ground, and visitors can watch the bats from wooden benches located at the top of a hill. Behind the viewing area, signs welcome visitors and provide more information on the cave and the bats for those who wish to read about it. BCI volunteers accompany guests to the cave, and they answer questions related to bats and make sure that people do not disturb the bats. The manager of Bracken Cave connected me with a woman who is a bat biologist, professor, and former BCI intern, and I interviewed her as a part of my project.

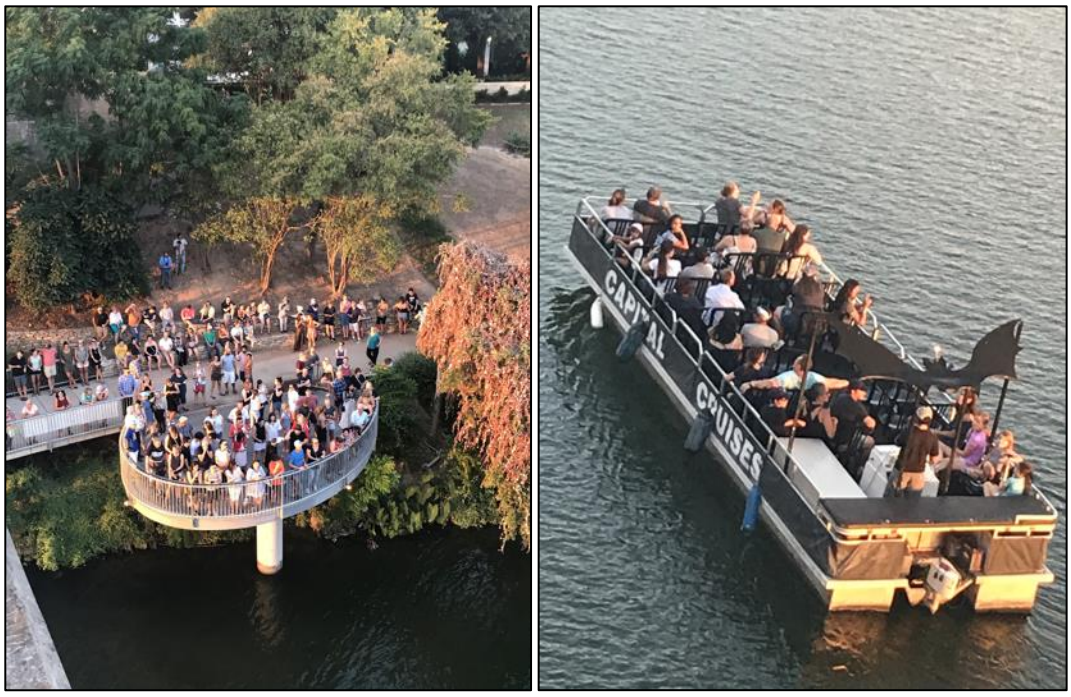
Illustration 6: Bracken Cave, San Antonio, is one of the most popular bat ecotourism sites in Texas, and it is the largest bat maternity colony in the world. (Photo by the author.)

Illustration 7: Artwork at the San Antonio Zoo advertises for Bracken Cave. Artwork by Momo and Pompa. (Photo by the author.)

Camden Street Bridge, San Antonio, TX. The Camden Street Bridge is located in San Antonio, Texas, and the bridge passes over a section of the San Antonio Riverwalk. Unlike Bracken Cave, this bat-viewing area is in a popular urban area, and it is open to the public. An estimated 50,000 Brazilian free-tailed bats live in the crevices of this bridge during the summer months (Texas Parks & Wildlife, Camden Street Bridge), and it has become a relatively popular area for visitors, both for the bats and the artistic elements located at this section of the Riverwalk. Large luminescent fish sculptures hang from the bridge, and there is a seating area near the bridge that has been designed to look like a cave. There are also signs along the river that display educational materials about the bat species. Each year, a festival called "Bat Loco" is held at this location.

Illustration 8: The "Bat Cave" on the Riverwalk near the Camden Street bat emergence site exemplifies how bat-related elements are scattered throughout the city. (Photo by the author.)

Congress Avenue Bridge, Austin, TX. The Congress Avenue Bridge in downtown Austin, Texas, is one of the most popular bat-viewing sites in the Southwest. It is considered to be the world's largest urban bat colony, and around 1.5 million Brazilian free-tailed bats emerge from this bridge each night during the summer season (BCI Congress Avenue Bridge). According to Bat Conservation International, over 100,000 people visit this site each year, bringing in over 10 million dollars in tourism each year (BCI Congress Avenue Bridge). People gather to watch the bats emerge either along the top of the bridge or below the bridge, where viewing platforms have been constructed for this purpose. At the viewing areas below the bridge, there are signs that have more information about the bats and the history of the bridge. At one end of the bridge, there is a large, black bat statue that rotates slowly in the wind. In the river below, bat-watchers kayak or ride on miniature cruise ships decorated with bats to get a better view of the emergence from the water. Many landscape features at this site represent the popularity of the bats in the city. One of my interviewees informed me that volunteers with a different bat organization called Austin Bat Refuge distribute educational materials to visitors of the bridge during the weekends. This bridge is also where the annual Austin Bat Fest is held, which I attended for my research.



Illustrations 9 & 10: Visitors can watch the bat emergence at the Congress Avenue Bridge in Austin, Texas, from either the top of the bridge or from designated viewing areas, as pictured above. (Photos by the author.)

Illustration 11: A large bat statue is located at the end of the Congress Avenue Bridge, signifying to visitors the location of the bat emergence. (Photo by the author.)

Old Tunnel State Park, Fredericksburg, TX. Old Tunnel State Park is located in a rural area in Fredericksburg, Texas. The park gets its name from an abandoned railroad tunnel located near the park's entrance, and during the summer months, this tunnel becomes the home to an estimated 3 million bats (Texas Parks & Wildlife, Old Tunnel). The park attracts railroad hobbyists and people wanting to utilize the recreational hiking trails, but it is especially popular as a bat-ecotourism site. Visitors can view the bat emergences from a deck above the railroad tunnel entrance for free, or visitors can pay to view the bat emergence from a lower viewing deck near the entrance of the tunnel. Texas Parks and Wildlife hosts educational talks prior to the bat emergence, and also has educational displays near the upper viewing deck for those who wish to read more about the bats and the park. At this site, I interviewed the Texas Parks and Wildlife employee who delivered the educational program on the evening when I visited.

Illustration 12: Old Tunnel State Park is home to an abandoned railroad tunnel, which now houses over three million bats. (Photo by the author.)

Illustration 13: The bats at Old Tunnel State Park emerge from the tunnel in a thick cloud. (Photo by the author.)

Carlsbad Caverns National Park, NM. Carlsbad Caverns National Park is famous for its beautiful cave system, but bats have also become a popular attraction for visitors in the summer months when the National Park Service hosts the Bat Flight Program at the outdoor amphitheater located at the natural entrance to the cave system. Each night, a crowd will gather in the amphitheater about a half hour before the expected emergence time to hear a park ranger give an educational talk about bats. The number of bats emerging from the cave varies, but visitors can often see up to half a million bats at this location. In addition to the Bat Flight Program, there are also additional bat-related educational materials indoors at the visitor center. At this site, I interviewed a park ranger known around Carlsbad Caverns as the "bat ranger," who is also the caretaker of a Brazilian free-tailed bat named Anna. Due to injury, Anna is unable to survive in the

wild, and this park ranger is working to have Anna established as the Carlsbad Caverns education bat.

Illustration 14: Visitors to Carlsbad Caverns National Park gather at the Bat Amphitheater each night during the summer season to witness the bat emergence and attend an educational talk. (Photo by the author.)

Bat ecotourism and education in the Southeast

Although the Southeastern United States does not have as many large bat emergences common with bat ecotourism destinations in the Southwest, many locations still engage in bat-related conservation education and bat ecotourism. Many bat festivals take place in the eastern United States, and entities such as the National Park Service and various state departments incorporate bat-related conservation education in their parks. White-nose syndrome was first recorded in the United States on the eastern coast, and many bat populations in this region have suffered drastic population declines (BCI White-nose Syndrome). With this in mind, I decided to include a few locations in the

Southeast in my study in order to examine how educational materials are being distributed in areas where bat populations could be more sensitive to tourists.

Great Smoky Mountains National Park, TN. Great Smoky Mountains National Park is the most popular national park in America (National Park Service Great Smoky Mountains), and after reading Fagan, Wilcox, and Wilcox's study about bats roosting in historic structures in Cades Cove (2018), I decided to include it in my study. At Great Smoky Mountains National Park, I attended two junior ranger programs about bats in Cades Cove. One program was about mammals in the park, and the other program was strictly about bats and owls. At this site, I interviewed the park ranger conducting these educational programs about the bat-related educational programs and activities in the park. We also discussed measures being taken to protect bats in the park with the emergence of white-nose syndrome. I also purchased a pamphlet published by the park about bats in the visitor center.

Mammoth Cave National Park, KY. Mammoth Cave National Park is known for its extensive cave system, as well as for the bats that live inside and outside the cave system. Bats are a popular symbol for the park, and many visitors expect to see them or hear about them when visiting the caves. The park has many signs in the visitor center detailing information about bats, and visitors can purchase books about bats in the gift shops. The park also conducts many environmental education programs in the park and in surrounding schools. At this site, I interviewed a park ranger who works in the educational outreach program, and she showed me many different games and activities the park uses to educate young children about bats. She also gave me details on how

Mammoth Cave National Park is dealing with white-nose syndrome in the park and how they are working to contain its spread.

Audubon Nature Institute, New Orleans, LA. I visited the New Orleans Audubon Nature Institute during their annual festival called Bat Appreciation Day. This festival was held during Bat Week on October 26, 2019. At the festival, there were activities such as arts and crafts for children, and all visitors could engage with activities in the gardens or utilize walking trails at the nature center. The highlight of the day was a lecture on bats by a local bat biologist in the planetarium. When I attended the festival in 2018, there was also a night hike, where visitors could walk on the trails and listen to bats with echometers provided by the bat biologist.

The Mississippi Bat Working Group. During the course of my research, I attended two annual meetings of the Mississippi Bat Working Group. This annual meeting, where both bat professionals and bat enthusiasts are invited to attend, is a place for people to share their bat research and discuss bat conservation in the state. This group also conducts educational outreach initiatives at local festivals and events. During the annual meeting in 2020, three bat researchers spoke of their "mist-net demonstration" event, in which they show audiences how to erect a mist-net to catch bats for research purposes. The group also invites citizens to assist in actual mist-netting events, but they only allow people who have had rabies shots to handle the bats. The Mississippi Bat Working Group is an excellent example of a small, local group partaking in bat-related educational outreach programs.

Chapter 4: Results and Recommendations

Throughout my research process, I gathered material about educational programs at ecotourism sites involved with bats. Educational programs primarily focus on debunking bat myths, educating audiences about bat biology, and informing audiences about the benefits bats provide to local and global environments and economies. Ecotourism sites promote bat conservation by encouraging positive attitudes and behaviors towards bats, as well as encouraging activities that are beneficial to bats, such as bat-house building. Monitoring bat-ecotourism sites also help provide protection to fragile bat populations, and employees at these sites keep people at a safe distance, creating an interactive, educational wildlife-viewing experience. Several bat-ecotourism sites also outsource their educational outreach programs to local communities through school programs, bat festivals, and social media outlets. I also found that bat-ecotourism sites can promote bat conservation by raising money for educational outreach and research.

What kinds of bat-related educational materials are ecotourism sites distributing?

Dispel the myths. While certain bat ecotourism sites are distributing species-specific materials relevant to their geographic area to their audiences, most ecotourism sites address certain keystone elements in their educational programs. “Dispelling the myths” was the most consistent theme amongst the ecotourism destinations that I visited. In order to educate the public on the truth about bats and their many benefits to an economy or ecosystem, educators must first dispel any myths about bats already pervasive in the

minds of their audience. One park ranger explained his perspective on how media has influenced human perceptions of bats throughout time:

> My goal is to try to dispel a lot of the myths around bats that the news media and TV, movies, and things like that has instilled in us over years and years about vampires and how they [bats] are bad and they fly in your hair.

This ranger emphasized how media have given bats a bad reputation throughout time by giving bats associations to dark creatures and instilling prominent myths in the public imagination. Beyond mythology, the ranger also commented later in the interview that the media often sensationalizes rabies reports related to bats, which leads to negative attitudes towards them. After visiting all of my study sites, I observed this sentiment among visitors to bat-related ecotourism sites. I often heard people in the audience express nervousness about the bat emergences. At Old Tunnel State Park, before the educational program began, I heard one lady comment on how she was nervous about a bat flying into her hair. I also heard a similar comment on the Congress Avenue Bridge, where I was also approached by an entrepreneur trying to sell me a poncho to protect me from rabies, just in case a bat attacked me on the bridge; he claimed a woman on the opposite side of the bridge had already been attacked that evening. Myths are not only prominent in the public imagination, but there also seems to be a market for it.

At Great Smoky Mountains National Park, dispelling the myths is a large part of the educational goals of the junior ranger program. When I asked the park ranger about his goals with the bat-related junior ranger programs, he commented:

> For the junior ranger programs, I try to keep it moving quick and not go into great detail and keep them on simple little facts like “Bats are not blind,” “Bats don’t fly into your hair,” “Bats are not mean,” “Bats are not cruel,” “Bats eat a lot of insects.” So they’re good. I keep coming back to try to emphasize how good they are for humans.

For this ranger, his goal is to not only address and correct prominent myths, but he also strives to foster an appreciation for bats and their important ecological roles in the minds of the visitors, which is another dominant theme in the education programs that will be discussed later. When I asked this ranger about how his audience generally perceives bats, I found it interesting that the ranger said that he believes younger people have a more positive attitude towards bats. He elaborated on this subject of negative attitudes towards bats, saying:

> I think the word is starting to get out, especially with young [people]. Now, a little while ago I talked to some lady that absolutely couldn't stand them [bats]. She thought they were creepy. But yeah, I think especially maybe with older people; I don't think it's so much with younger people. Because they [older people] have been conditioned by TV, movies, and the news media that bats are bad. You know, we've grown up seeing vampire movies and things like that.

This ranger believes that the older audience is more conditioned to view bats in a negative light as a result of years of negative media exposure to bats. A different interviewee also believed that for the most part, the younger generation has more positive attitudes towards bats. The education volunteer at Old Tunnel expressed this sentiment, saying:

> There's kids that are maybe in the fifth or sixth grade or in middle school, but they're… equipped with knowledge and inquisitive capabilities that would rival high school or college age kids. And they ask some really significant, meaningful, profound questions. And that's always… a big moment when you see a young person that's already very interested in bats.

This educational volunteer at Old Tunnel has observed that the younger generation is more open to positive, curious attitudes towards bats. This difference in attitudes observed by the park rangers between the younger and older visitors could be the result of less media exposure as one ranger hypothesized, but it could also be the result of more educational outreach programs related to bats. The educational outreach

ranger at Mammoth Cave informed me that their educational programs reached approximately 57,000 students last year, and the education volunteer at Old Tunnel estimated that 80-100 people visit Old Tunnel each night to see the bat emergences during the summer. These visitors are exposed to more educational outreach programs related to bats, in which the truth of their behaviors is exposed. The ranger at Great Smoky Mountains National Park commented:

> Once you are educated about them [bats], once you learn about them, some of those fears, the objects of those fears, turn out to be helpful for man.

This point brings me to the next section of the educational programs I observed. After the programs addressed common bat-myths and misconceptions of the taxon, they often led into a discussion about bat biology, their roles in the ecosystem, and how they are beneficial to humankind and the global environment.

Discuss bat biology. During my observations of the educational programs, I noted that discussing bat biology encompassed a large portion of the programs. After dispelling the myths that lead people to dislike bats, the educational programs would lead into discussing the truth about bats, which encompasses basic bat biology. Many of the educators at the different programs would try to get people excited about bats by discussing how fascinating and unique bats are to Class Mammalia. In addition, educators would emphasize how important bats are to nature and the economy. By teaching the audiences about the interesting characteristics of bats, educators seek to dispel myths and foster an appreciation for bats.

For the most part, the geographic location of the program influenced which particular bat species each program covered. In the Southwest, I found that the programs

mainly focused on the Brazilian free-tailed bat, and in the Southeast, I found that the programs would focus on species more relevant to those areas, such as the hoary bat, the Indiana bat, or the little brown bat. However, most programs discussed the same biological characteristics of bats in general.

One of the most unique characteristics about bats is their ability to fly, a characteristic exclusive to bats in the group of animals known as mammals. During my observations, I noticed that this characteristic was discussed frequently at multiple ecotourism sites. During the junior ranger program at Great Smoky Mountains National Park, the ranger wore a pair of costume bat wings, which is used to attract attention in addition to being used as an educational prop. The ranger explained to the audience how the bats have fingers, but their fingers are covered by a membrane, creating the wings that give bats the ability to fly. This fact was mentioned in several of the programs, and audiences always seemed intrigued by this information. Programs also discussed echolocation, and some programs even created games, which will be discussed later, to teach children the basics of echolocation. I also found that in many programs, educators drew attention to the mammal-like characteristics of bats.

At Carlsbad Caverns National Park and the New Orleans Audubon Nature Institute, the educators discussed the technicalities of bat-birth. The programs discussed how certain species of bats give birth upside-down to a pup, which is usually one-third of the mother's body weight. They discussed how bats could identify their pup out of millions of other bat pups solely based on sound and smell, and how certain bat species can fly with their pups holding onto them. The educators mentioned that they like to

discuss this topic, since it usually gets the attention of mothers in the audience. As one can see, bat education can appeal to adults as well.

All of the educational programs emphasized the importance of bats to seed dispersal, pollination, and pest control, but ecotourism sites in the Southwestern US emphasized these factors even further by discussing the importance of regional bat populations to certain industries. At Carlsbad Caverns National Park, the educator at the Bat Flight Program emphasized the importance of bats to the cotton, corn, and tequila industries of North America by engaging in a "Thank a Bat" segment in the educational program. The ranger would ask questions such as, "Are you wearing a shirt made of cotton?, Do you like margaritas?, Have you eaten corn recently? If so, thank a bat."

Old Tunnel State Park also emphasized the importance of bats to various industries, especially the importance of the Brazilian free-tailed bat in the state. When I asked the educator at Old Tunnel State Park about how Texas Parks & Wildlife is promoting bats at different ecotourism sites across the state, the educator replied:

> Where [Parks & Wildlife] has control over property that are bat roosts, there's more efforts to interact with the public and promote the good things that bats do for the environment and the economy… One of the primary mission objectives of that property is to protect and promote awareness of bats.

As this educator mentioned, discussing the environmental and economic importance of bats to the state of Texas is an important part of the educational programs. Instead of just debunking bat myths, they are trying to convey to the public that the bats are important to the everyday lives of Texans. In doing so, they are working to replace the negative attitudes towards bats with an attitude of appreciation.

Emphasize safety. The goals of the educational programs I visited were, collectively, to dispel myths, change attitudes about bats and discuss bat biology, educate the public on their importance to the ecosystem and economy, and overall, foster an appreciation for the taxon. However, the educators also emphasized that keeping your distance from the bats are essential to the safety of both the bats and the human audience. In this regard, one of the key final key aspects of the educational programs was to emphasize safety. Rangers emphasized that unless you are a bat biologist who has proper vaccinations to handle bats, no one should handle bats they find in the wild. This is largely because, as the rangers at Great Smoky Mountain National Park and Mammoth Cave National Park told me, if humans encounter a bat in the wild, there is a large chance the bat could be sick, whether it be from rabies or white-nose syndrome. Although the ranger at Great Smoky Mountains National Park expressed resentment towards the media's tendency to sensationalize rabies reports and bats in the media, he also expressed strong concern about keeping visitors safe:

> I try to emphasize to kids that you never want to touch one. I think that's very, very important… But we tell people if, the park tells you, if you come into contact with a bat at all, even if he touches you, you should go be evaluated for the [rabies] vaccination.

During my observation of this ranger's program, a visitor told a story about how he discovered a bat on his leg during a fishing trip. The ranger used this man's story as an example to the crowd of safety regarding bats. The ranger told the crowd that a bat active during the daytime, such as during this man's fishing trip, is expressing erratic behavior. The ranger explained the proper course of action would have been to seek medical care and be evaluated for the rabies vaccination. Mammoth Cave National Park takes visitor safety very seriously as well. Before any visitors enter the cave, the rangers are required

to read a white, laminated card detailing safety instructions for the cave tours. On this card, there are safety instructions telling visitors that they might see a bat acting erratically in the cave due to white-nose syndrome, but it is important not to handle them.

Carlsbad Caverns National Park also heavily emphasizes education and safety in this regard. In the guidelines for the Bat Flight Program given to park rangers, it details how rangers working the Bat Flight Program should tell the audience about how it is uncommon for rabies to be transmitted from bats to humans (an average of only two cases per year in the US), but it also heavily emphasizes that the most important piece of information to convey to visitors is to never handle a bat. In this way, both bats and humans are protected from unnecessary disturbances or illnesses.

Illustration 15: Educators always emphasize to their audiences that they should never touch a bat. This sign is from Mammoth Cave National Park. (Photo by the author.)

How are ecotourism sites promoting bat conservation?

Promote positive attitudes and behaviors. As mentioned in the literature review, throughout recent history, humans have often exhibited negative attitudes and behaviors towards bats. Merlin Tuttle's personal experience has led him into caves where he has found evidence of deliberate bat killings by humans (Tuttle 2015). Human fear has often led to practices that have hindered bat conservation in the past. Promoting positive attitudes and behaviors at bat ecotourism sites hopefully decreases the likelihood of these detrimental behaviors, while promoting positive behaviors.

Several of the sites I visited promoted bat-house building as a part of their educational programs. Bat-house building might appear insignificant, but it is actually vital to species such as the Florida-bonneted bat and the species affected by WNS on the east coast (Bats 2019). At the Great Smoky Mountains National Park, the ranger I spoke with includes a bat house display in his educational program. After the program, the ranger encourages the audience to view the bat house, and the ranger gives the audience material on how to build a bat house near their own homes. In doing so, the ranger is not only promoting positive attitudes, but also encouraging conservation behaviors in the visitors to the park. Other bat ecotourism sites also promote bat-house building in their programs. At the Hattiesburg Zoo in Mississippi, bat houses are displayed in several areas of the property.

Illustration 16: A sign at Old Tunnel State Park communicates that "Everyone plays a role in Bat Protection." The sign debunks bat myths and encourages visitors to take part in citizen science, such as bat house building. (Photo by the author.)

Protect fragile bat sites. Of the several bat ecotourism/education sites I visited, there was a large distinction between the bat-viewing policies at the urban sites versus the rural sites. Bats living in the urban spaces, such as the Congress Avenue Bridge or the Camden Street Bridge, have grown accustomed to noise and light pollution, and there are little to no guidelines surrounding this bat-watching experience. However, bats living in rural places such as Carlsbad Caverns, Great Smoky Mountains National Park, Mammoth Cave National Park, Bracken Cave, and Old Tunnel State Park require protection from factors that might disturb bats and cause them to abandon their roosts. As a result, many rural ecotourism sites have policies in place to protect bats from human disturbance, although their policies vary on restrictions from place to place.

Bats at rural ecotourism sites are vulnerable to disturbances caused by humans. At Carlsbad Caverns National Park, I spoke to a ranger who discussed with me the importance of minimizing human disturbances during the Bat Flight program. The ranger

provided me with details about how artificial light and sound can influence the behaviors of the bats, causing them to fly away from the artificial lights or sounds or stop their emergence completely. As a result, Carlsbad Caverns National Park requires all visitors to turn off all electronic devices and put them away during the Bat Flight Program. They also ask all visitors to be quiet during the program, in order to minimize disturbances. There are also additional policies, such as no smoking, and a request to take children to the top of the amphitheater if they are loud during the program. In order to follow these guidelines, the educational aspect of the program takes place before the bat emergence. Visitors are asked to arrive 30 minutes prior to the average bat emergence time, during which a ranger will give a brief educational talk and answer questions about bats from the audience. As soon as the first bat emerges from the cave, the ranger will stop the educational program while the audience watches the bats emerge from the cave.

Old Tunnel State Park and Bracken Cave have similar policies to Carlsbad Caverns, but they were more lenient on the technology policies. Visitors are allowed to take pictures and videos, but flash and loud sounds are prohibited. This way, visitors can record their experiences, while also minimizing disturbances for the bats. Although they allow technology, the educators encourage visitors to put away their electronic devices in order to really experience the bat emergence. These policies put in place by Carlsbad Caverns, Old Tunnel, and Bracken Cave make the bat-watching experience better for both humans and the bats. The bats are able to emerge without disturbance, and the humans are able to have a more engaging experience during the program, to the point where visitors can even hear the bats and the flutter of their wings.

In addition to minimizing sound and light pollution at bat ecotourism sites, parks are also working to minimize the spread of white-nose syndrome. As mentioned in the literature review, humans can spread the fungus which causes white-nose syndrome on shoes, clothing, and caving equipment. Parks are working to minimize the spread of white-nose syndrome by creating policies for visitors to follow during their visits to caves.

During my time at Mammoth Cave National Park, I spoke with an educational ranger who used to be the white-nose outreach ranger at the park. Before white-nose syndrome arrived at Mammoth Cave National Park, this ranger's job was to ask visitors if they had visited a cave or mine recently and disinfect the shoes and gear of those who had visited a cave or mine prior to Mammoth Cave. However, now that white-nose syndrome is present at Mammoth Cave National Park, the park is taking preventative measures to try to stop the spread of white-nose syndrome from Mammoth Cave to other caves and mines in the country. To do this, visitors must walk across mats soaked in a disinfecting solution after leaving the cave. When I asked the ranger about these policies, the ranger said:

> People are okay with it. It's a lot easier now because people know more about it. Years ago, when it was brand new, a lot of my job was just explaining that it's a fungus, the spores can travel, and stuff like that. But now it seems like people are more aware of it. And so, it also depends on how you explain it to people. We try to make them invoke a feeling of the bats. So it's like you're helping by walking through here rather than a hindrance.

For this ranger, having visitors sympathize with the decline of bat populations helps alleviate any negative attitudes the visitors might have about getting their shoes wet. I also found it interesting that the ranger mentioned that people seemed to know more about white-nose syndrome in recent years. When I asked the ranger if increased

awareness could be linked with the educational programs, the ranger stated that she believes increased awareness about white-nose syndrome is definitely linked to the educational outreach programs the park conducts with schools in the local area. The ranger said:

> When our school groups come here, it's kind of cute because the kids already know about [white-nose syndrome] from us going into the schools, and they take it really seriously. And they're like, "When are we going to clean our shoes? We don't want the bats to get sick," and stuff like that… They get really into it because they know they get to help the bats. We just tell the kids we're going to help the bats. We don't want the bats to get sick, so we have to clean our shoes off so they don't make other bats sick.

By having visitors clean their shoes, Mammoth Cave is helping contain the spread of white-nose syndrome, but it is also a great educational opportunity for visitors. Visitors who do not know about white-nose syndrome can ask questions and learn about the spread of white-nose syndrome in North America and its impact on bat populations.

Illustration 17: After visiting Mammoth Cave, visitors walk across disinfecting mats to help prevent the spread of white-nose syndrome to other caves and mines in the area. (Photo by the author.)

At Carlsbad Caverns National Park, another park whose main attraction is a cave, preventing the introduction of white-nose syndrome to the park is important as well. At the visitor center, where visitors purchase tickets to gain entry into the cave, a sign asks visitors to let the rangers know if they had been to another cave or mine recently. If the visitor answers yes, they are given material to disinfect shoes and equipment before entering the cave. By having these policies at national parks, the parks are helping contain the spread of white-nose syndrome and educate visitors on this disease killing millions of North American bat species.

Great Smoky Mountains National Park has also created policies to decrease the disturbance of bats in the park in the wake of white-nose syndrome. The park has closed all caves to visitors, both to decrease the amount of disturbance in the caves and minimize the spread of white-nose syndrome throughout the park. When I spoke to the ranger at Great Smoky Mountains National Park, the ranger mentioned that many of the caves had been gated to ensure little disturbance to the bats roosting in the caves. The eastern coast of North America has experienced high numbers of bat mortalities, and the park is working to minimize these losses through their protective policies.

Carlsbad Caverns is also actively promoting bat conservation through their "Adopt a Bat" program. Visitors can symbolically adopt a Brazilian free-tailed bat at the park, and the proceeds go towards bat research and bat-related education in the park. The adoption kit, which costs $10.00, includes an adoption certificate, a brochure that gives details about the bat species, a sticker, and a bookmark. The adoption certificate reads, "This adoption helps to preserve and protect the bats at Carlsbad Caverns National Park through scientific research and public education." Through this creative marketing mechanism, the park is raising money for research and education that will ultimately help benefit the conservation of bat species in the park. At the same time, visitors can feel that they have supported bat conservation, and it is also a mechanism for visitors to share information about bats with their communities once they return home.

Having bat educators at these rural sites allows for there to be a human mediator to create a healthy viewing environment for the visitors and the bats. Without an employee or educator at these rural bat sites, bats could be disturbed by unmonitored human visitors, or human visitors could risk injury if they were to come into contact with

a sick bat. Also, by having educators at the sites, visitors can learn about the bats and gain an appreciation for them. As exhibited by the "Adopt a Bat" program at Carlsbad Caverns, visitors can also provide monetary support for research related to bat conservation and education.

Illustration 18: Visitors to Carlsbad Caverns can symbolically adopt bats at the park, while also supporting bat-related research and education. (Photo by the author.)

Creative ways to engage in bat education.

During my interviews with the educational leaders at bat ecotourism sites, a few educators mentioned that they were looking for new ideas to engage visitors with bat education. Since I witnessed a variety of educational activities during my study, I decided to include this section for educators looking for new ideas for their programs. To begin, educators emphasized that visualization and engaging activities were the most powerful tools for bat education. Visualizations can include pictures of bats, taxidermy bat

displays, or live bats. The ranger at Carlsbad Caverns has noted that throughout her career, she has noticed that once visitors are able to visualize a bat up-close, they often find them cute and less frightening. This ranger is in the process of rehabilitating an injured bat, named Anna, to be used as an educational bat at Carlsbad Caverns National Park. Anna was injured by a human in a shopping center in Carlsbad, New Mexico, and as a result, her wing had to be amputated.

Illustration 19: In the future, Anna the bat will be used as an educational bat at Carlsbad Caverns National Park. The ranger caring for Anna hopes that visitors will have better perceptions of bats after encountering a real bat. (Photo by Virginia Moyers-Appleton.)

Another powerful tool in bat education is having some sort of engaging activity. At areas in the Southwestern US, large bat emergences are thrilling activities for visitors that really engage the audiences. Educators can speak about bats before the emergences, which really excites visitors that are waiting for the bats to fly out of the cave or bridge.

However, in areas of the country where bat emergences do not take place at the same enormous scale as the Southwest, educators have learned to be creative in their educational programs. This is especially important in the case of Mammoth Cave National Park, since they conduct a lot of educational outreach to local schools. Engaging activities in this context include bat hikes, games, and community festivals.

Bat-related games and activities

Bat hikes or night hikes are also exciting activities that present the opportunity for bat-related education. Three sites that I visited, Great Smoky Mountains National Park, Mammoth Cave National Park, and the New Orleans Audubon Nature Institute, conduct this type of activity. The New Orleans Audubon Nature Institute held a bat hike during the Bat Appreciation Day festival, which took place during Bat Week. Before the hike took place, a professor gave a lecture on bats; afterwards, visitors who had signed up for the bat hike gathered in the visitor center and were given IPads equipped with echometers. An echometer is a device that detects bat echolocation sounds, plays the sounds back to the user, and identifies what type of bat species is making the noises. Visitors walked the trails of the Nature Institute with the professor, listening to and identifying bats in the surrounding areas.

At Great Smoky Mountains National Park, the educator I spoke with conducts a similar type of night hike in the park. The ranger discussed how he carries a bat box on the hike, which also detects bat echolocation sounds. The ranger said that he uses the night hike as an opportunity to talk about bats, astronomy, and the history of Cades Cove. Interestingly, this ranger also mentioned that he had recently conducted a night hike

around Halloween focused on “fears of the night.” During this Halloween night hike, the educator wore his bat wings and talked about how there are many “fears of the night” (like bats, spiders, snakes, and bears), but once you are educated about them, you learn to appreciate them for their ecological significance. The night hikes conducted at these sites are great examples of engaging educational activities. Visitors can experience nature while also learning of its significance.

For educators who are confined to a classroom setting, there are still many bat-related educational activities to do. During my time at Mammoth Cave National Park, the educator I spoke with talked about many bat education activities they use in the park and in local schools. One educational activity Mammoth Cave does with smaller children is making bat finger puppets. Kids are able to color the puppet while the educators talk about the basics of bat behavior with the children. The educators will turn the lights off in the room, since most bats fly at night, and the kids will pretend like their puppets are flying. This is an interesting activity to help introduce younger age groups to the basics about bats, while also holding their attention.

For older age groups, Mammoth Cave has created an innovative white-nose syndrome educational activity. For this activity, the ranger will put glow germ powder on his/her hands. The glow germ powder represents white-nose syndrome, but the kids are unaware of the powder in the beginning of the activity. While the kids gather in a circle, the ranger will shake hands with one kid while introducing who they are, where they work, etc. Then, the ranger will ask the kids to shake hands around the circle, beginning with the kid who shook the ranger’s hand. Once the introductions have ended, the ranger uses a black light to show how the glow germ powder has spread around the group. The

ranger will then talk about how the powder represents white-nose syndrome, and how this bat disease is gradually diffusing across the country. It is an engaging educational activity to easily explain white-nose syndrome and the effect it has on bats to school-age groups.

Another educational activity utilized at Mammoth Cave is called “Bat-Moth.” This activity teaches kids about the diets of bats, while also teaching them the basic concepts behind echolocation. Essentially, this game is a bat version of Marco-Polo. Kids are divided into two groups: the bats and the moths/mosquitos (which the educator calls the M&Ms). The “bats” are blindfolded to replicate darkness at nighttime, and the moths/mosquitos disperse around the room or outdoor area. When the “bat” says bat, the “moth” will say moth or the “mosquito” will say mosquito. The bat then follows the sounds in order to “catch its food.” The educator acknowledged that it is not true echolocation, but the activity helps kids understand the basics of the concept. The educator also uses the opportunity to dispel myths about bats being blind, as well as teach the kids about bat diets and how they are important for pest control.

A couple of activities I observed at both Mammoth Cave and Great Smoky Mountains National Park are designed to help kids understand more about bat biology, as well as understand how unique bats are. One activity teaches kids about the heart rates of bats and compares it to the human heart rate. First, kids learn about how a bat’s heart rate can rise from 100 beats per minute to 900 beats per minute during flight. Then, the educator will have the kids check their resting heart rate, do jumping jacks, and then check their heart rate after exercise. This activity helps kids understand just how fast a bat’s heart rate escalates during flight and how fast it is compared to that of a human’s. Another activity asks kids to “flap their wings” (arms) as many times as they can in thirty

seconds, then multiply the number by two. The kids learn how bats can flap their wings up to 600 times per minute, and they compare their own numbers to a bat's.

One activity at Great Smoky Mountain National Park that was engaging for both the children and adults was a true or false activity. Visitors were asked to stand while the ranger read a mixture of bat myths and facts. After each myth or fact, visitors would move to one side of the area if they believed it to be true or the other side of the area if they believed the information to be false. After each person decided on true or false, the ranger would tell everyone the answer. It was an interesting activity to debunk bat myths, spread bat knowledge, and excite visitors all at the same time.

One opportunity to get involved in bat education is through a local bat conservation group, such as the Mississippi Bat Working Group. This group invites the public to join bat scientists during mist net events. During mist net events, scientists erect large nets to catch bats, record species information, and check the bats for white-nose syndrome. The public is invited to help the scientists with setting up the net and recording data, and those who are up-to-date on rabies vaccinations can even assist in handling the bat species. This is a really creative way to involve the community in citizen science and educate the public about bats.

Social media as an educational outlet

For many Americans, social media has become a popular means for obtaining news, socializing, and finding entertainment. In 2018, one study found that 68 percent of American adults have Facebook, and of those Americans, most (around 3/4) used the social media app daily (Smith and Anderson 2018). Since so many people use social

media outlets on a daily basis, social media can be used as an educational tool to reach a large audience outside of an ecotourism site or classroom. Bat Conservation International has an active Facebook page, and through the page, the organization shares bat-related research news, photographs, bat events, and information about different bat species (BCI Facebook site). People can also raise money for the organization by doing Facebook birthday fundraisers. In addition to the Bat Conservation International page, there are also other bat pages on Facebook, including the BatWeek page. This page shares the same types of materials as the Bat Conservation International page, but it emphasizes the promotion of Bat Week (BatWeek Facebook site).

Bat Week is the annual, international celebration of bats during the week of October 24-31. During this week, the BatWeek Facebook page promotes a different bat species each day, while also promoting the benefits of bats and dispelling common bat myths (BatWeek Facebook site). The page also promotes state declarations of Bat Week, as pictured below.

The State of Washington

Proclamation

WHEREAS, bats provide important ecological services that contribute substantially to the economy of the United States by protecting American forests and agriculture from crop-damaging insect pests and by providing the fundamental benefit of pollination; and

WHEREAS, recent bat population losses from white-nose syndrome and other factors require attention to ensure the sustainability of our food production systems and protect environmental and human health; and

WHEREAS, it is critically important to develop new public-private partnerships and increase citizen engagement to promote the health of bat populations; increase the quality and quantity of bat roosting and foraging habitat; and help restore bat populations to healthy levels; and

NOW, THEREFORE, I, Jay Inslee, Governor of the state of Washington, do hereby proclaim October 24-30, 2019, as

Bat Week

in Washington, and I encourage all people in our state to join me in this special observance.

Signed this 21st day of October, 2019

Governor Jay Inslee

Illustration 20: Official Bat Week proclamations can help draw the public's attention to the ecological significance of bats, as well as the economic significance. (Photo by BatWeek Facebook site.)

State declarations such as these can draw the public's attention to bats in their region and promote the good that bats do in our world. Statewide Bat Week declarations

can also garner more media attention, which is helpful in disseminating the truth about bats. For people who are passionate about bats, sharing bat-related social media posts with friends and family is a great way to engage in bat education without having to be at an ecotourism site or in a classroom.

Chapter 5: Conclusion

In the early 1980s, citizens of Austin, Texas, were in a state of fear over the 1,000,000+ bats moving into the Congress Avenue Bridge (Tuttle 2015). Citizens wanted the bats exterminated over rabies concerns and rumored bat attacks, and the media steadily reported on the dangers the bats posed to the city of Austin (Tuttle 2015). Dr. Merlin Tuttle, upon hearing of this news, moved to Austin, Texas, after establishing the organization Bat Conservation International in 1986 (Tuttle 2015). Through educating city officials and the public on the benefits of the Brazilian free-tailed bats to the city, as well as showing the people how "cute" the bats were up-close, Tuttle helped change the city's attitude toward the urban bat population (Tuttle 2015). Today, the bat colony at Congress Avenue Bridge is the largest urban bat colony in the world, and visitors travel to the city from all over the world to witness the bat emergence take place. The city of Austin has gained a new reputation as a bat city, and they have set a leading example of how humans can share space with wildlife. The city receives monetary benefits from this ecotourism site, and the bat bridge has become a symbol that makes the city of Austin proud. The Congress Avenue Bridge is an excellent example of a mutualistic relationship between humans and wildlife, and through education, Austin has become a city that has truly learned to love their bats.

Conserving bat species worldwide requires a lot of scientific research, but as in the case of Congress Avenue Bridge, conservation begins with education. People are willing to fight to protect things that they love or believe to be important, and in the case of the bat, hatred and ignorance has plagued their well-being for centuries. In order to

combat the pervasive myths and legends that have hindered bat conservation throughout time, educators must help change people's minds about bats.

Through my research, I learned about the best practices guiding bat education today. It is important for educators to dispel bat myths and educate the public on the importance of bats to our ecosystem and our economy. Fostering positive attitudes towards bats is imperative in educational programs, and by doing so, educators can hope that their audience will engage in more conservation-related activities or support organizations that do so. For example, it is essential that we monitor bat and bird populations and implement fatality reduction strategies as wind energy expands across the US. In order to do this, we as a community must demand that wind energy facilities allocate enough resources to monitor bat and bird populations. This is only possible if the public is educated on the pros and cons of wind energy and their effects on wildlife. Organizations such as Bat Conservation International also rely on memberships to fund conservation research, which is only possible if people learn to appreciate bats and join these types of organizations.

Having educators at bat ecotourism sites also allows for the experience to be safe for both the humans and the bats. Educators can make sure that humans do not touch bats or try to harm them, and educators can help protect the bats by strictly monitoring noise and light pollution. Educators at cave locations can also help prevent the human-caused spread of white-nose syndrome by making sure shoes and equipment are properly sanitized before entering a cave.

Bat-related education can take place at ecotourism sites where large bat emergences occur, but it can also take place in classroom settings or through social media

outlets. Educators emphasized that visualization and engaging activities seemed to be most effective at captivating an audience, and educators can employ these strategies through activities such as bat hikes and games. Social media can reach audiences who are not able to attend an ecotourism site or festival directly, and educators can also use social media sites to raise money for research to benefit bat conservation.

Personally, through this research, I have learned a lot about the impact that bat education and ecotourism sites can have on people. One person I interviewed, now a professor who studies bats at wind-energy facilities, was inspired to begin her career with wildlife after visiting the Congress Avenue Bridge with her father as a child. Another person I interviewed, a ranger at Carlsbad Caverns National Park, has become so passionate about bats and bat conservation that she is now known around the park as the "bat ranger." She has made it her mission to educate people about bats in the park and promote positive attitudes towards bats.

Through this research, I have also learned how the emerging positive attitudes towards bats in Texas have influenced city infrastructure. The bats at the Congress Avenue Bridge have been such a success that the Texas Department of Transportation has started to design bridges more suitable for bat populations. The positive attitudes towards bats have also influenced various cultural landscape elements in Texas, and one can find artwork, infrastructure, and informational displays advertising the bats in many different places scattered throughout Austin and San Antonio. However, during this research I have also learned about more emerging threats impacting bat populations. For example, humans have not yet experienced the full extent of anthropogenic climate change, but it is slowly starting to affect bat populations through changing temperatures

and decreasing water levels in arid regions. More than ever, it is essential that humans support bat conservation efforts.

I have disseminated my research to different classes at the University of Southern Mississippi, as well as prospective students at the University at USM's "Honors Day" in the fall of 2019. I have also shared aspects of my research on bat mythology with the Mississippi Bat Working Group, and I plan to share this document with them as well. During my time interviewing educators, many expressed that they wanted new educational ideas, such as games and activities, to engage with their audiences. I will share this document with the people who I interviewed, as well as any other bat educators who are interested in reading about the topic.

My research provides an overview of the current practices currently conducted in bat-related education, but there are some limitations to my study. Although I observed the educational programs and spoke with the educators, I have little way of knowing whether or not the programs are actually effective in promoting positive attitudes and conservation behaviors in the visitors to the sites. For future research, social scientists can speak with visitors to bat ecotourism/conservation education sites and test their knowledge of bats before and after being exposed to educational material related to bats. One could even conduct a follow-up survey a month after the visit to the ecotourism site to see if the visitor has engaged in any conservation behaviors since the educational program.

Kirstin Fagan and Emma and Adam Wilcox have surveyed visitor's attitudes towards bats at Smoky Mountains National Park (Fagan, Wilcox, and Wilcox 2018), but one could potentially replicate the study at other parks, such as Mammoth Cave National

Park or Carlsbad Caverns National Park. A similar study could also be conducted at bat festivals and events, such as the evaluation done by researchers at the Great Lakes Bat Festival (Hoffmaster, Vonk, and Mies 2016). A researcher could also replicate the aforementioned study or the format of my study in a different region of the United States. For example, a future bat researcher could focus their study strictly on the eastern coast of the United States, where white-nose syndrome first arrived in North America. Given the "batty" reputation of Texas, one could focus a research project exclusively on Texas and bat-related ecotourism in the state, or one could focus a study on rural regions where the population is not as frequently exposed to bats. A researcher could also focus on a different country or region of the world, where perceptions of bats might be different due to different cultural beliefs and a different level of exposure to negative portrayals of bats in the media.

Throughout this research process, I have learned of the value of bats to our world and our economy. Mostly, I learned of the value of education in encouraging positive attitudes and interactions with bats and other forms of wildlife. During the timeframe in which I was writing the final portions of this paper, the world has been inflicted with the novel virus COVID-19. Bats are quickly becoming the scapegoat for this pandemic, and it is creating conservation problems worldwide. Merlin Tuttle's Bat Conservation has reported conservation crises and deliberate bat killings in multiple regions of the globe. This crisis demonstrates that the world is still very much in need of educational initiatives for bats, and I hope that this paper can provide organizations with some guidance on the best practices regarding bat-related conservation education.

Lastly, I have learned that research is not possible without the help and participation of others. This project would not have been possible without the guidance of my advisor Dr. Mark Miller and the other geography professors in my department. It also would not have been possible without my interviewees and their willingness to participate in this project. I hope to distribute the information I have learned to bat conservation groups across the country, as well as utilize the information in my own home state through the Mississippi Bat Working Group. Through both small and large bat organizations, we can make the world a better, safer place for bats to live and encourage positive interactions between humans and wildlife.

Appendices

Interview Question Guide

- Can you describe your current job/role as it is related to conservation education?
  - Can you describe the density of bat populations in your area?
  - Why did you decide to work with bat-related conservation education?
- Do you believe bat-related conservation education is important?
  - Can you describe some of the threats bat face in your area? Outside your area?
  - Tell me about the impact of white-nose syndrome in your area.
  - Do you believe humans are a threat to bats?
- Can you describe your work with bat-related conservation education?
  - Tell me about your education programs related to bats.
  - What type of educational materials do you distribute to the public? Are people receptive to this material?
  - On average, how many people do you encounter during your education programs and how often?
  - Do you ever have people visit your area for the sole purpose of seeing the bats?
  - Can you describe the average level of knowledge the public has about bats?
  - Do the people you encounter generally have a positive or negative attitude towards bats?
  - Have you noticed a trend in recent years of more positive or negative attitudes towards bats?
  - Do you believe there is a need for more bat-related conservation education programs? Why or why not?
- Can you tell me about any misrepresentations of bats you see in the media?
  - Do any of the people you encounter still believe myths portrayed about bats in the media?
  - What tactics do you use to mitigate their fears towards bats?
  - Do you ever use social media as a tactic to spread more positive information about bats?
- Can you describe any environmental impacts bats have in your area?
  - Is the public aware of these benefits? Do you describe these benefits in your educational programs?
  - Do you encourage your audience to participate in bat-related conservation strategies, such as building bat houses? Do you believe these activities are important?
- Do you have any ideas or strategies you would like to implement in your program that you do not employ right now?
- Do you have any advice for other professionals implementing bat-related education in their communities?

IRB Approval Letter

Office of
Research Integrity

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NOTICE OF INSTITUTIONAL REVIEW BOARD ACTION

The project below has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services regulations (45 CFR Part 46), and University Policy to ensure:

- The risks to subjects are minimized and reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered involving risks to subjects must be reported immediately. Problems should be reported to ORI via the Incident template on Cayuse IRB.
- The period of approval is twelve months. An application for renewal must be submitted for projects exceeding twelve months.

PROTOCOL NUMBER: IRB-19-279
PROJECT TITLE: Learning to Love Bats
SCHOOL/PROGRAM: Geography and Geology
RESEARCHER(S): Bethany Lawson, Mark Miller

IRB COMMITTEE ACTION: Exempt
CATEGORY: Exempt

Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording). Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

APPROVED STARTING: June 19, 2019

Donald Sacco Jr.

Donald Sacco, Ph.D.
Institutional Review Board Chairperson

ORI | Office of Research Integrity

INSTITUTIONAL REVIEW BOARD

STANDARD (SIGNED) INFORMED CONSENT

STANDARD (SIGNED) INFORMED CONSENT PROCEDURES

This completed document must be signed by each consenting research participant.

- The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval.
- Signed copies of the consent form should be provided to all participants.

Last Edited May 13th, 2019

Today's date: May 29, 2019

PROJECT INFORMATION

Project Title: Learning to Love Bats		
Principal Investigator: Bethany Lawson	Phone: 601-744-6065	Email: bethany.lawson@usm.edu
College: University of Southern Mississippi	School and Program: School of BEES - geography	

RESEARCH DESCRIPTION

1. **Purpose**:

The ultimate goal of my thesis is to contribute more knowledge to the field of bat conservation. I believe that my research will provide educators with a comprehensive overview of what other organizations are doing to benefit bat conservation efforts. By researching organizations conducting bat conservation, their methods, and the effect of the various programs, I hope to illuminate which methods of bat conservation are effective or ineffective in influencing human perceptions of bats and ultimately their behaviors towards bats. By doing so, conservation organizations will have a better framework on which to model their conservation education strategies.

2. **Description of Study:**

The study will include interviews ranging from thirty minutes to two hours. The participant population will consist of adults over the age of 18 in professional fields related to bat conservation. There will be approximately 20 participants. Criteria for selection is they need to be involved in bat-related conservation education in some way.

3. **Benefits:**

A potential benefit to the participants is the opportunity to gain insight from other conservation educators through the findings of this study. The summary of findings from the research and insights gained will be shared with participants.

4. **Risks:**

There are no risks associated with this study. Participants can choose to leave the study at any time or skip any questions.

5. **Confidentiality:**

Physical data will be locked in a file drawer. The data will be submitted to Dr. Mark Miller at the end of the study, who will properly dispose of the data as required by university regulations.

6. **Alternative Procedures:**

N/A

7. **Participant's Assurance:**

This project and this consent form have been reviewed by USM's Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5125, Hattiesburg, MS 39406-0001, 601-266-5997.

Any questions about this research project should be directed to the Principal Investigator using the contact information provided above.

CONSENT TO PARTICIPATE IN RESEARCH

Participant's Name: _____

I hereby consent to participate in this research project. All research procedures and their purpose were explained to me, and I had the opportunity to ask questions about both the procedures and their purpose. I received information about all expected benefits, risks, inconveniences, or discomforts, and I had the opportunity to ask questions about them. I understand my participation in the project is completely voluntary and that I may withdraw from the project at any time without penalty, prejudice, or loss of benefits. I understand the extent to which my personal information will be kept confidential. As the research proceeds, I understand that any new information that emerges and that might be relevant to my willingness to continue my participation will be provided to me.

Include the following information only if applicable. Otherwise delete this entire paragraph before submitting for IRB approval: The University of Southern Mississippi has no mechanism to provide compensation for participants who may incur injuries as a result of participation in research projects. However, efforts will be made to make available the facilities and professional skills at the University. Participants may incur charges as a result of treatment related to research injuries. Information regarding treatment or the absence of treatment has been given above.

_____	_____
Research Participant	**Person Explaining the Study**
_____	_____
Date	**Date**

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