Efficacy of Acoustic Deterrence for Bat Occupancy of Highway Structures

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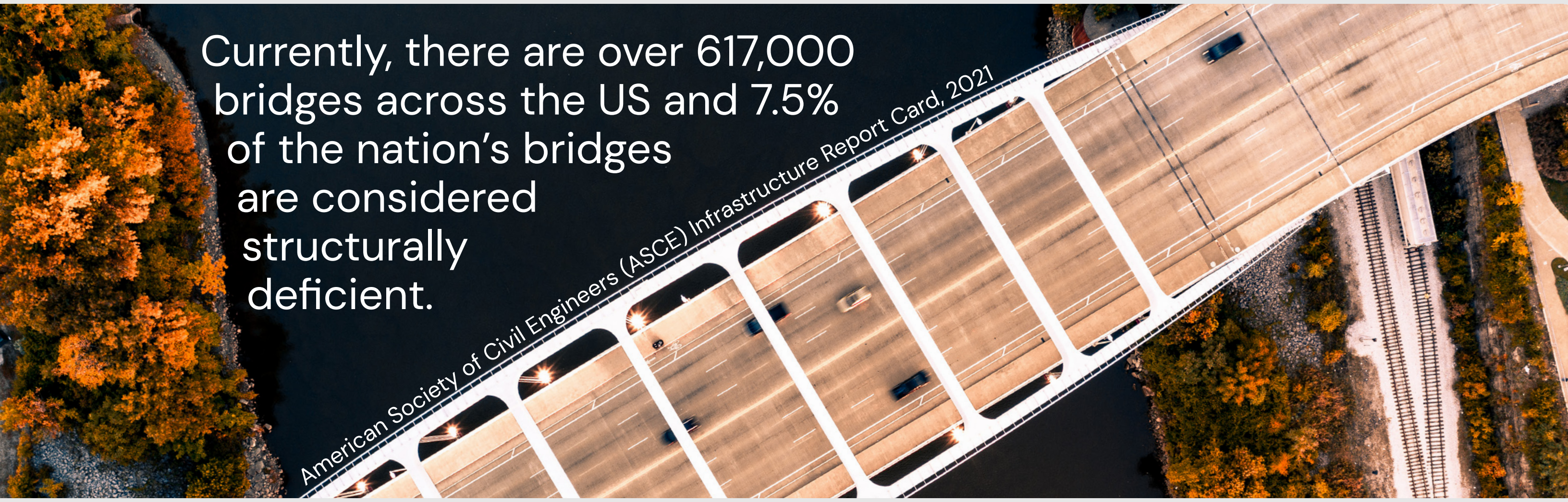
Executive Summary

Bats can be found almost everywhere on the planet, excluding the polar regions and extreme deserts, and make up one-fifth of the entire planet's mammal population (Bat Conservation International, BCI). In some regions they provide valuable services like insect suppression, seed dispersal, pollination, and have even inspired technology that can help the blind see with the use of sound (Kunz et al., 2011; Al-Hudhud et al., 2019). There are several issues, both anthropogenic and biological, that promote the need for bat conservation and habitat protection. Human disturbances, paired with the introduction of White Nose Syndrome (WNS) into the United States (US), are among the main causes for bat population declines. Perpetual human population growth directly influences the destruction and fragmentation of natural winter and summer bat habitats, thus resulting in many populations being forced to seek alternative roosting options. With natural roost availability becoming more scarce, bridges and culverts provide some species of bat with features that closely mimic their general roost preferences.



Wildlife occupancy of existing bridges and culverts may create human/wildlife conflict when the integrity of these structures dictates the need for maintenance, construction, or demolition (Erickson et al., 2002). The use of physical exclusion barriers and methods can typically increase the instances of direct human and wildlife interaction, which can potentially create unsafe situations. In an attempt to move away from traditional physical bridge exclusion methods and minimize harm to roosting bats, a less intrusive exclusion method was necessary.

Acoustic deterrence was first introduced to the wind industry to try and reduce the amount of bat and bird mortalities occurring at wind farms each year (Romano et al., 2019). With this technology proving to be successful in deterring bats from wind turbines, researchers from California utilized this technology and applied it to transportation related issues, with results being moderately successful (Szewczak, 2011). Recently, ICF conducted four case studies for the Georgia Department of Transportation (GDOT) across the state of Georgia. Each approach to exclusion was different due to the variability in bridge structure design. Throughout the case studies, the treatment areas of the bridges that received ultrasonic broadcast over the course of three nights showed a reduction in bat usage up to 75% - 95%. From these results, we can conclude that the use of acoustic deterrence as a method of bridge exclusion is a valuable and useful tool to help reduce human and wildlife interactions, minimize physical harm to roosting bat species, and expedite state departments of transportation routine bridge maintenance processes.

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Introduction

Bats are inherent to healthy ecosystems all around the world, providing valuable services like insect suppression, seed dispersal, and pollination (Kunz et al., 2011). With the current ever-expanding human population and constant need for space to aid in economic growth, bats face multiple direct and indirect threats from human actions (Kasso & Balakrishnan, 2013).

Several issues, both anthropogenic and biological, promote the topic of conservation of bats and their habitats. Human disturbances are typically the main source of negative effects toward bat population abundance, resulting in the need for increased regulatory concerns (Moretto & Francis, 2017). Human population growth, paired with the perpetual expansion of urban development and the destruction and fragmentation of natural winter and summer bat habitats, encourages the need for species conservation (Kasso & Balakrishnan, 2013). Additionally, the distribution of environmental contaminants still poses a threat to bat populations around the world, although the use of more harmful pesticides for agricultural activities have reduced over the years, such as DDT (dichlorodiphenyltrichloroethane) (Clark, 1988; Universität Koblenz-Landau, 2012).

In recent years, White Nose Syndrome (WNS), first detected in the United States in 2006, is a disease that has contributed to steep declines in temperate bat populations across North America. These issues are compounded by low birthrates in bats, with females typically giving birth to only one or two pups per year.

Additionally, the age of reproductive maturity is typically not met until the second year (Johnston et al., 2004). With WNS spreading and ultimately expected to become established in the western United States, the number of imperiled species could increase, promoting the need for added regulations.

As natural roost availability and abundance become scarce, many bat populations are forced to seek alternative roosting options (Moretto & Francis, 2017). For many bat species, artificial structures such as roadway bridges and culverts have been found to be important roosting habitat. As such, state departments of transportation (DOTs) continue to increase resources allocated to bat conservation, environmental compliance, and stewardship within transportation planning and operational processes (White-nose Syndrome Conservation and Recovery Working Group [WNSCRWG], 2018).

Wildlife occupancy of existing bridges and culverts may create human/wildlife conflict when the integrity of these structures dictates the need for maintenance, construction, or demolition (Erickson et al., 2002). Given the magnitude of present-day threats and associated bat population declines, it is becoming increasingly important to minimize additional stressors (WNSCRWG, 2018). Throughout many states, bats are protected under state law and some species are protected under the federal Endangered Species Act of 1973 (ESA).

Eastern cave-dwelling bat populations have been decimated due to the spread of WNS, which is quickly working its way westward (Gillies, 2017).

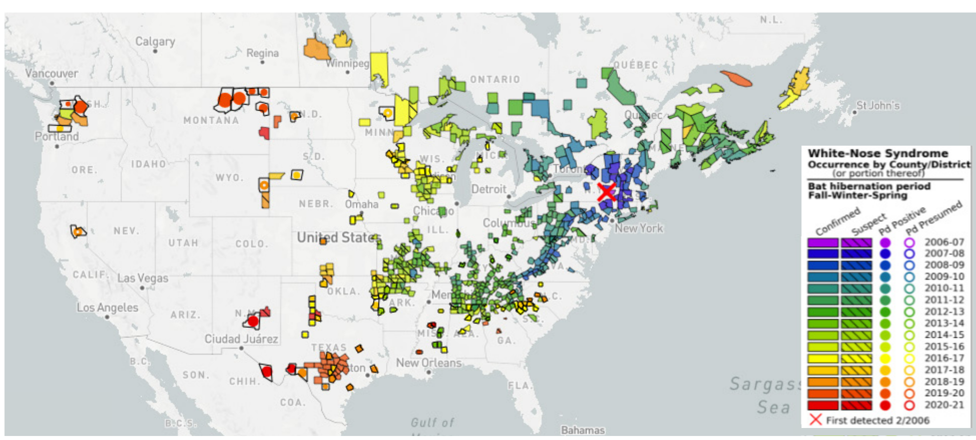

Figure 1. 2021 White Nose Syndrome Spread Map

Bats in Bridges

Bats have been known to use bridges as roosting sites for some time (Davis & Cockrum, 1963). Bridges can serve as surrogates for temporary night roosting (Adam & Hayes, 2000), day roosting (Riskin & Pybus, 1998), and/or seasonal maternity roosts (Adam & Hayes, 2000). Bats can utilize small crevices within bridge expansion joints, handrail joints, weep and drain holes, areas of concrete spalling, and any other rough surfaces throughout the underdeck of bridge structures (Feldhamer et al., 2003; Sasse, 2019). Bridges act as thermal sinks when exposed to sunlight throughout the day, providing thermoregulatory benefits to roosting bats by achieving and sustaining temperatures above the ambient average for most of the 24-hour cycle (Keeley & Tuttle, 1999).

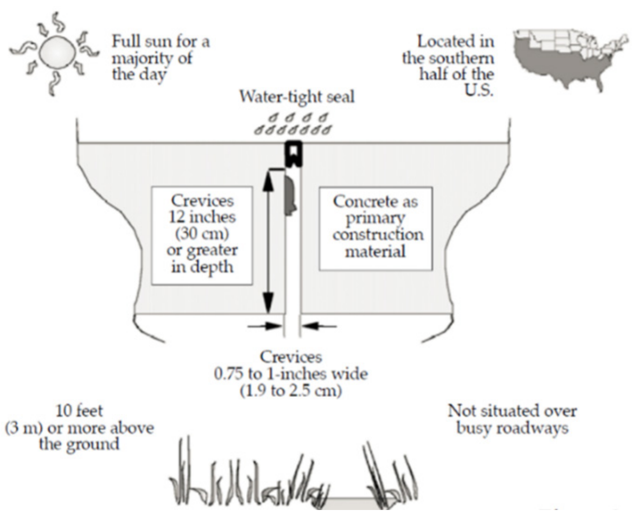

Figure 2. Cross Section of Bridge Expansion Joint

Day roosting within bridges is commonly associated with migratory species (Sasse, 2019) and female bats rearing their young (Keeley & Tuttle, 1999) or as a result of natural habitat destruction (Frick et al., 2020). Males and nonreproductive females tend to prefer day roosts that exhibit cooler temperatures (Riskin & Pybus, 1998; Ferrara & Leberg, 2005). This type of roost selection can lead to energy savings by reducing the cost of thermoregulation during warmer summer days, which can reach temperature levels that can potentially be stressful for bats (Lance et al., 2001).

Bats utilize bridges and culverts as temporary night roosts to conserve energy during nightly foraging activities, food digestion, social interactions, and locations for information transfer among species (Kunz, 1982; Perlmeter, 1996). Bridges also provide protection from adverse weather and potential predation (Lance et al., 2001).

The most common bridge traits that bats seek are ample amounts of narrow spaces, heights equal to or greater than 10 feet, and darker areas of bridges (Keeley & Tuttle, 1999; Ferrara & Leberg, 2005). When combined, these traits should provide optimal roost positioning; although to overlook any bridges that do not possess these traits would be inadvisable (Lance et al., 2001). Additionally, bridges with underdecks comprised mostly of concrete are commonly associated with optimal roosting features (Keeley & Tuttle, 1999). Bridge structure designs such as parallel box beam, prestressed girder, cast-in-place, flat slab, etc., influence roost preferences among bat species (Feldhamer et al., 2003).

Bridge Maintenance and Construction Issues

Maintenance of highway structures is an ongoing and unavoidable issue. Deterioration over time occurs due to exposure to the elements (sun, wind, rain, freeze and thaw, etc.) and preventative procedures such as deicing and salt dispersion (National Academies of Sciences, Engineering, and Medicine, 2012). Typical examples of maintenance activities include cleaning, deck resurfacing or repairs, preventative maintenance to extend the service life, welding and grinding, and stream channel maintenance (WNSCRWG, 2018).

During torpor-inducing periods (low temperatures) or summer maternity roosting, unresponsive adults or non-volant pups may be unable to evacuate a roost during human disturbance (Erickson et al., 2002). As such, bridge construction activities can place bats at risk of unintended mortality or promote unwanted human/bat interactions.

The timing of maintenance activities on highway structures containing roosting bats is essential.

This can be heavily influenced by the basic ecology and ethology of local bat species, which can vary geographically (WNSCRWG, 2018). Some maintenance activities may require the operation of specialized support vehicles and equipment that can cause heavy vibrations and excessive noise (Goffinet & Keefe, 2018). More substantial maintenance activities can result in larger impacts to adjacent bat colonies, which would require additional impact evaluations (Bat Conservation Ireland, 2010). To avoid any potential harm and harassment to roosting bats within a structure, exclusion measures should be completed before any disturbing maintenance activities occur (WNSCRWG, 2018).

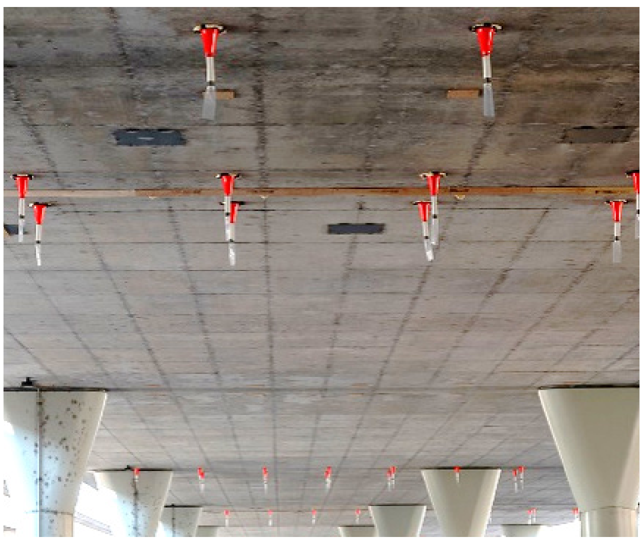

Figure 3. Physical Exclusion Methods Used by California Department of Transportation, Sacramento, CA.

Traditional Minimization and Avoidance Measures

Under Section 3(18) of the ESA, the term take is defined as harassing, harming, pursuing, hunting, shooting, wounding, trapping, capturing, collecting, or attempting to engage in any such conduct. Conservation measures implemented for bridge maintenance activities are put into place to avoid or minimize the "take" of individuals (Weaver et al., 2020).

Take can often be avoided by establishing construction and maintenance schedules that focus disturbing activities into periods where bats are not present. However, certain construction activities require warmer temperatures to adequately complete maintenance such as deck resurfacing and asphalt setting. These schedules can often occur during bat maternity seasons (Newbolds & Olek, 2002; Sparks et al., 2019).

Throughout the majority of North America, maternity colonies are typically formed in the late spring and stay together until late summer or early fall (Johnston et al., 2004). The main goal of knowing these ecological schedules is to minimize the amount of disturbance to any potentially roosting individuals during their essential breeding season (Frick et al., 2020). Ideally, bridge maintenance would be scheduled and performed outside of these timeframes, although that is not always possible.

For most latitudes, highway structure maintenance should occur between late August and early April to minimize any potential impacts to roosting bats (Keeley & Tuttle, 1999). Within the lower latitudes, this timeframe could be significantly reduced since bats could potentially remain in structures year-round due to fewer freeze events (Bennett et al., 2008). These instances could push that window back to as late as November through February.

Common methods for physically excluding bats on highway structures include installing escape tubes, netting or screens, expandable foam, plywood, and the use of artificial light as deterrence (Rowse et al., 2016). Although these methods can be cost-effective for select construction activities, the majority of them require materials to be physically attached to the structure. In some cases, this could potentially alter the structural integrity or unknowingly entomb bats within the roost (WNSCRWG, 2018). In some situations, the implementation of physical barriers can appear as an eyesore to the general public and bring attention to something that would otherwise go unnoticed. The application of expandable foam is commonly used as a means of bridge exclusion across the nation.

Figure 4. Roosting Bat Trapped in Tar from Road Maintenance

Acoustic Deterrence

Acoustic deterrents were originally developed to reduce the growing number of bat mortalities caused by interactions with wind turbines, primarily pertaining to migratory species (Romano et al., 2019). The concept behind acoustic deterrence is a set of speakers that emit a constant ultrasonic broadcast that "jams" the bats' ability to orient and forage (Bates et al., 2008). The ultrasonic broadcast creates a "bubble" of noise within a treated airspace that creates an auditory overstimulation, thus resulting in the bat eliciting erratic movements (Szewczak, 2011). This continuous broadcast of ultrasonic "noise" ensures that any bat encountering the treated airspace will not habituate to the broadcast (NRG Systems, 2020).

Various studies have been performed by multiple manufacturers at wind farms across the United States and Europe, all with promising deterrent results (Weaver et al., 2020; Arnett et al., 2013; Romano et al., 2019). Multiple companies, including Binary Acoustic Technology, Deaton Engineering, General Electric, and NRG Systems Inc., have developed and manufactured their own acoustic deterrent systems to assist in combating the issues with bats and wind turbines.

With the successes of deterring bats from wind turbines, researchers subsequently utilized the technology for transportation related issues. The use of acoustic deterrence was first implemented as a measure of bridge exclusion in 2009 with moderate success. The initial testing of this methodology was performed on multiple wooden railway bridges in northern California, which was contracted through the environmental division of the California Department of Transportation (Szewczak, 2011).

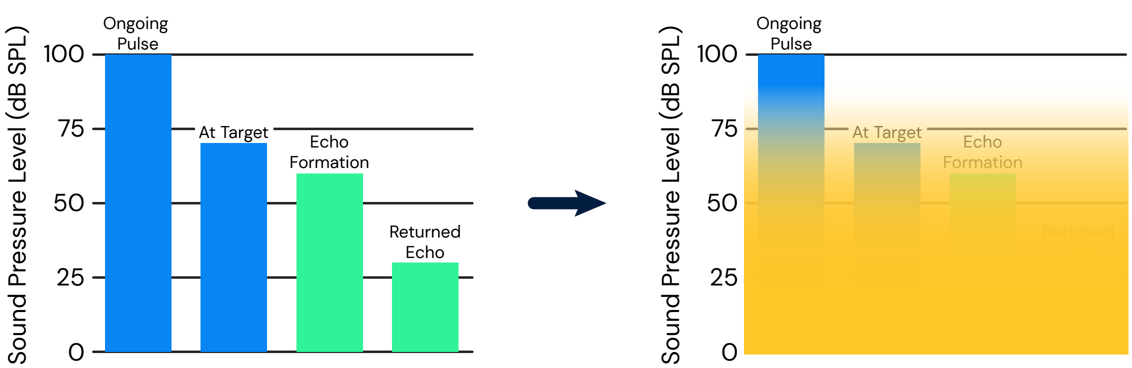

Figure 5. Frequency Jamming of Acoustic Bat Deterrents (NRG Systems, Inc.)

The direct and adverse effects on bats when exposed to prolonged periods of ultrasonic broadcasts remains uninvestigated, but it can be generally hypothesized from human guidelines set forth by the Occupational Safety and Health Administration (OSHA) (West, 2016).

Although ultrasonic deterrence has previously been proven moderately successful in deterring bats from bridge structures, the application should always be assessed on a project-to-project basis. Depending on the complexity of the exclusion, and conditions underneath the bridge, acoustic deterrence may not be applicable for every situation. Physical exclusions could provide a more simple and cost-effective solution, however when faced with a more difficult and complex situation, acoustic deterrence becomes more appealing (Szewczak, 2011). Bridges and culverts that contain multiple small, hard-to-access crevices or nearly inaccessible areas of the structure can result in challenging and potentially expensive exclusion projects. When trying to decide the most effective approach to an exclusion project, a simple comparative cost-benefit analysis could assist with the decision-making process.

Although bats and human ears perceive levels of frequencies differently, the neural receptor action functions similarly enough to expect comparable results. According to OSHA guidelines for human audible sound, a decibel level of 90 for 8 hours is permittable (Driscoll, 2013). As that decibel level increases, the safe exposure time decreases. Because prolonged exposure to ultrasonic broadcasts from acoustic deterrents could potentially damage a bat’s hearing, no deterrents should be activated if the bats cannot safely and voluntarily evacuate the roost. This precaution also applies to situations where bats would not be able to readily move out of range of the treated airspace.

Recent Case Studies

With the recent developments and technology advancements in ultrasonic acoustic deterrent systems, ICF biologists teamed with NRG Systems to perform a series of studies for the Georgia Department of Transportation (GDOT). Georgia provides great opportunity for testing given the long seasonality of bat activity, state-level protections of bats, federal protections for bats in portions of the state, and a DOT actively trying to solve bat issues associated with bat bridge roosting. This collaboration occurred throughout the state with the Georgia Department of Natural Resources (GDNR), GDOT, and ICF providing field services, with NRG providing deterrent materials and remote software support.

All colonies were regularly inspected for factors that could inhibit the use of acoustic deterrence (i.e., presence of flightless pups, cold weather, high winds, rainfall event during emergence or foraging, sick, or diseased individuals). No bat deterrent units (BDU s) were activated until complete emergence to avoid and minimize extended harassment or lasting harm to the bats. Generally, the BDUs ran throughout the night until 15 minutes after sunrise, with a search for roosting bats being conducted each morning.

Case Study 1: Initial Testing of Acoustic Deterrence on Bat Colony (Ben-Hill, GA)

An existing two-lane bridge over a body of water was scheduled for parallel replacement and demolition in the summer of 2018 in Ben-Hill County, Georgia. This original bridge design was a pre-cast expanded box beam style with open expansion joints present above the pile structures. The bridge was known as an annual maternal roosting site for big brown bats (*Eptesicus fuscus*) and Brazilian free-tailed bats (*Tadarida brasiliensis*), with the occasional southeastern bat (*Myotis austroriparius*) passing through. This multi-species colony utilized several expansion joints as well as partially covered handrail joints along the upper bridge structure. Bat guano had also been observed along various rough surfaces of the underdeck that may provide temporary night roosting. Surrounding the bridge was forested wetland habitat, open water, and bottomland forest, providing an alternative diurnal roosting and foraging habitat. The study site did not fall within any federally protected bat ranges.

ICF installed six BDUs, the power supply, and four infrared video recorders along a small section of bridge containing the highest concentration of diurnal roosting bats. No bats were physically touched or relocated by hand and diurnal activities were limited for minimal disturbance to day roosting bats. The treatments occurred between March and April 2018, before non-volant pups were present.

Figure 6. BDU Arrangement Around Expansion Joint

Figure 7. Big Brown Bat Inside of Expansion Joint

First Treatment *(Week 1)*

Prior to deterrent deployment during the first week of treatment, an emergence count survey revealed most of the bat colony being located along the southern side of the bridge. The BDUs were arranged under the corresponding expansion joint, where the bat colony had an initial estimate of at least 187 bats.

The effects of the ultrasonic broadcast after three nights of treatment was evident. All but three (n=3) bats were successfully deterred from the core cluster to the available roosting areas on the northern end of the bridge. The bats that still remained in treatment area did not roost within the expansion joints but rather within the handrails. The treatment side (south) had a reduction of 98%, but the untreated side (north) had an increase of 320%.

Second Treatment *(Week 2)*

For the second treatment, most of the bat colony remained along the northern section of the bridge, specifically within the expansion joint where the colony was last seen (n = 131). BDUs were deployed underneath the expansion joint with the largest cluster observed. After three nights of ultrasonic broadcast, the treatment side (north) had a reduction of 82%. The largest cluster of bats moved to the southern untreated side of the bridge. Several remaining bats in the treatment area were found in handrails along the bridge deck, not within the underside expansion joints.

Third Treatment *(Week 3)*

For the third treatment, most of the bat colony was along the northern section of the bridge. Treatment methodology was altered with a BDU array being deployed under each end of all expansion joints. The bat colony before the third treatment saw a general decline in bat counts in the expansion joint level and the handrails as well. By the end of the third night, the northern side had a deterrent success rate of 86%. The southern untreated side, however, saw a 183% increase in bat presence. When only considering sections of the bridge with expansion joints, the treatment area had an 87% reduction of individuals and the non-treatment area had a 282% increase.

Case Study 2: Large Colony Test With Hybrid Approach (Muscogee County, GA)

Two three-lane bridges crossing over a six-lane highway were scheduled for cleaning and painting in the fall of 2018. The bridges were part of a larger cloverleaf interchange with a surrounding habitat comprising commercial, residential, and small patches of woodland habitat. Ecologists examined suitable roosting cracks within expansion joints and railings from above the deck and curb (more than 30 feet above the roadway). The inspection revealed a colony of big brown and Brazilian free-tailed bats inhabiting the expansion joints of both bridge structures. Extensive urine and guano staining on the bent structures could be observed from the abutments and median. Muscogee County is not within the assumed range of federally endangered or threatened bat species.

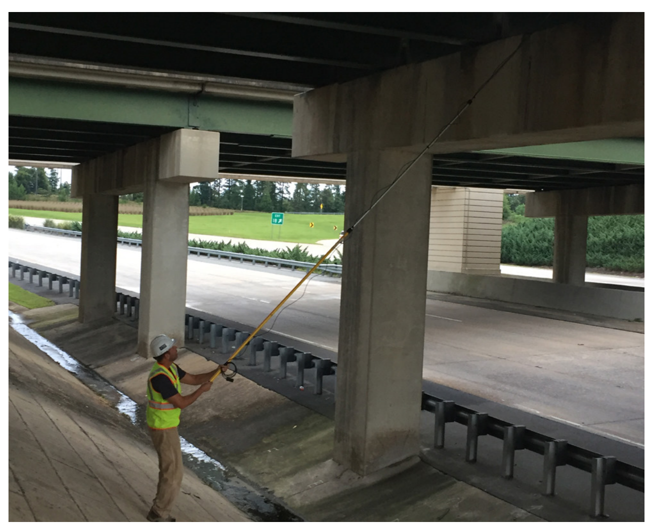

Figure 8. Borescope Inspection of Expansion Joint

Contractor scheduling for the bridge maintenance activities was variable, so a hybridized approach for deterring and excluding bats from the bridge was formed. Before deterrence, the largest observed colony size was 887 bats. BDU arrays were arranged underneath two expansion joints per night with a foam backer rod being wedged in between the expansion joints just before dawn or during daylight hours. The inherent surface tension between the foam backer rod and the concrete expansion kept them in place until maintenance activities. The number of expansions joints open for bat use progressively went from six to one.

After two nights of successful deterrence and progressively moving BDUs after backer rod was placed in the excluded joints the size of the bridge colony was reduced by 75% (n = 216). These bats were located in one remaining untreated joint. Post-emergence on the third night, this remaining location was physically excluded with backer rod placement.

One month after bat deterrence and physical exclusion, only 1.7% of the colony returned to the two bridge structures (n = 15) and were found roosting either where a single piece of backer rod had fallen, on the underside of backer rod, or behind a plate joining the I-beam girders. The methodology employed using acoustic bat deterrents and physical exclusions encouraged bats to seek roosts elsewhere before complete physical exclusion and had deterred 98.3% of bats from returning to the bridge structures. The bats that were found on this return visit immediately prior to construction activities were manually removed and placed in a nearby bridge alternate roost.

Case Study 3: Small Colony Test With Acoustic Deterrence (Gilmer County, GA)

Two two-lane bridges crossing over a railroad and two-lane county road were scheduled for maintenance of the bridge deck during the late fall of 2018 in Gilmer County. The surrounding habitat comprised primarily large woodland patches and residential areas. With the deck being resurfaced, six expansion joints would be removed and resealed, presenting a direct hazard to the bat colony primarily made up of big brown and Brazilian free-tail bats (n = 179). Although no federally protected species were observed, Gilmer County is within the range of federally endangered

Figure 9. BDU Arrangement

Figure 10. BDU Arrangement Around Expansion Joint

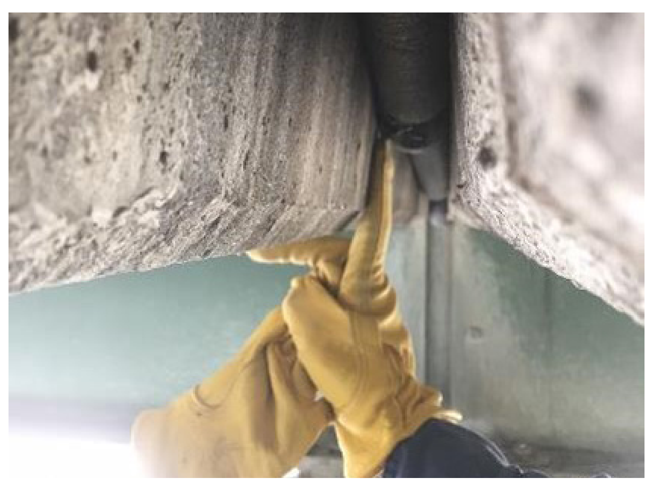

Figure 11. Installation of Physical Exclusion Materials

bats. To conduct acoustic deterrence activities, concurrence was gained from the U.S. Fish and Wildlife Service's Georgia Field Office to allow testing.

Upon initial inspection, bats were found to be occupying four of the six expansion joints at the time of testing setup. The two unoccupied expansion joints were physically excluded with foam backer rod. With the use of acoustic deterrence, we were able to "herd" the colony from the four occupied expansion joints down to one manageable joint. Once an expansion joint was cleared of bat occupancy, a foam backer rod was installed to ensure that bats could not reenter the joint. After two nights of BDU deployment on the last expansion joint, the bat colony decreased significantly (98.9%; n = 2). All bridge expansion joints were physically excluded from bat use with the backer rod, ensuring that there would not be any bats present until the contractor initiated maintenance the following morning.

Case Study 4: Testing on Myotis Colony (Bibb County, GA)

A single two-lane bridge crossing a non-wadeable creek was scheduled for demolition and reconstruction in the summer of 2020. The contractor had initiated demolition activities, deck milling and bore drilling, but was stopped because the bridge was a known annual maternal roosting site for southeastern Myotis. This was confirmed from periodic monitoring earlier in the year (n = 340). Ample foraging habitat was available due to the bridge being surrounded by a large stream and forested wetland complex and the creek receiving outflow from the dam release of a reservoir upstream.

Due to timing, the demolition was postponed until after the nursing pups became fully volant (i.e., flight capabilities). Once the colony was fully volant, BDUs were deployed at the abutments and on a small pontoon platform boat with four bat deterrent units, a control unit, generator, and all associated cables secured directly underneath the center of the bridge, also known as the "bat barge." Monitoring and BDU deployment occurred over the course of six nights with a 100% deterrence rate of day roosting bats during the construction period. This allowed demolition activities to proceed until the bridge was uninhabitable and deterrence activities were halted. The area provided an ideal flight corridor with almost all bats redirecting when coming in range of the sonic deterrence. Only two southeastern Myotis juveniles were observed night roosting on the bridge in areas out of range of the BDUs and unsuitable for day roosting (i.e., fully open to daylight). This bat deterrence effort allowed the project demolition to move forward while avoiding direct or long-term harm to the bats.

Figure 12. Southeastern Bat Maternity Colony Roosting Underneath Bridge

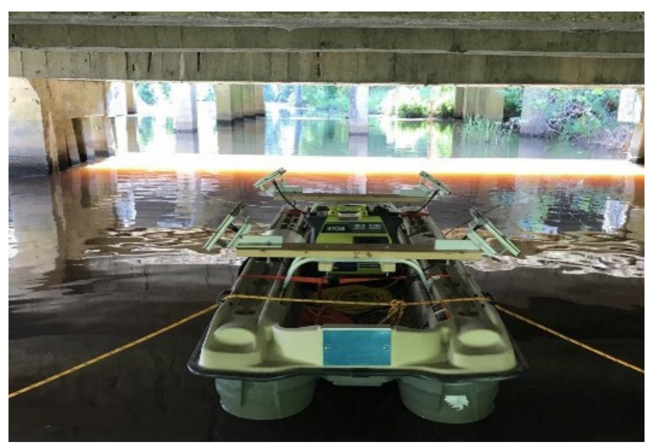

Figure 13. "Bat Barge" Deployed Underneath Bridge

The Future of Avoidance and Minimization

Despite many regulatory protections and measures for mitigation, bats will continue to pose intensive time and planning implications, specifically considering current and future threats to bats and the opportunistic nature of bat roost choice (Arnett et al., 2007; Arnett et al., 2016; Laurindo et al., 2019). Acoustic deterrence is proposed as a notable addition to the toolboxes of DOTs, resource agencies, and contractors, allowing affected organizations to address increasing regulatory pressures. Acoustic deterrence has been demonstrated as a useful tool to preemptively deter bats, for unanticipated events such as the avoidance measures for federally protected bats (Minnesota Department of Transportation, 2020) and for minimizing impacts as with Case Study 4.

Acoustic deterrence has been proven most effective when there are no attenuation issues for BDUs, coupled with physical exclusion, abundance of adjacent habitat, and consecutive nightly treatments. The methodology has already been integrated with other forms of preventing impacts to bats (Case Studies 1–3) and provides support that acoustic deterrence could avoid take mitigation measures and bat loss (Lintott & Mathews, 2018; Taber, 2018). By avoiding loss of bats and related resources (i.e., bridges post-rehabilitation), agencies can continue operations and be more responsive to a variety of species (Erickson et al., 2002).

Final Thoughts

Wildlife occupancy has been documented in highway structures throughout most states across the nation, and many of those structures require or will require routine maintenance. Due to this, cost-effective and cost-efficient methods of exclusion are necessary for DOTs to keep projects moving forward. Although bats are protected to some degree on a state level, and some species are federally protected, ensuring the safety of bats utilizing bridges and culverts before any construction or maintenance is of utmost importance. The implementation of acoustic deterrence offers an advanced alternative that is temporary and does not require any alterations of the superstructure. It can also minimize physical "take" to any potentially roosting individuals. Although acoustic deterrence has been proven as an effective method of temporarily deterring bats, the implementation should be assessed by evaluating the complexity of structure features present.

State DOT time frames for bridge maintenance can be small depending on geographic location, and when the issue of wildlife occupancy is taken into consideration, these windows can become even smaller. The implementation of acoustic deterrence, paired with bats' natural processes of nightly emergence, can provide contractors with a quick, nonlethal alternative for temporary exclusion. The use of some physical exclusion measures, although potentially cost-effective, could potentially be an eyesore to the public and draw more attention to something that otherwise would go unnoticed (e.g., hanging plastic sheeting or use of road cones as escape tubes). By state DOTs continuing to incorporate environmental compliance and stewardship into their routine practices, this will result in a general increase in biological conservation and decrease in environmental impacts.

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Figure Citations

Figure 1 - https://caves.org/WNS/

Figure 2 - Keeley, B. W., & Tuttle, M. D. (1999). Bats in American bridges (Resource Publication No. 4.). Bat Conservation International Inc.

Figure 3 – https://www.sacbee.com/news/local/transportation/back-seat-driver/article248052970.html

Figure 4 – ICF

Figure 5 – NRG Systems Inc. Presentation

Figures 6 –13 – ICF

Thank You

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