BATS IN AMERICAN BRIDGES

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Abstract

Bridges and culverts were evaluated as bat roosting habitat in 25 U.S. states at elevations from sea level to 10,000 feet. Field surveys were conducted at 2,421 highway structures. Scientific literature was reviewed, and local biologists and engineers were interviewed, leading to the discovery of approximately 4,250,000 bats of 24 species living in 211 highway structures. Only one percent of existing structures had ideal conditions for day roosting, but at little or no extra cost a much larger percentage could provide habitat for bats in the future. Most species chose concrete crevices that were sealed at the top, at least 6-12 inches deep, 0.5-1.25 inches wide, and 10 feet or more above ground, typically not located over busy roadways. Retrofitting existing bridges and culverts proved highly successful in attracting bats, especially where bats were already using them at night.

Providing bat habitat in bridges or culverts, either during initial construction or through subsequent retrofitting, is an exceptionally feasible and popular means of mitigation that is highly cost-effective in demonstrating a pro-active commitment to the environment. Advice for incorporating bat roosts, both before and after construction, is provided. Environmental and economic benefits, impacts on structural integrity and public safety, and management of occupied structures are discussed.

Introduction

Twenty-four of the 45 U.S. species of bats have been documented to use bridges or culverts as roosts, and based on their known preferences at least 13 others are likely to do so. Although only one percent of American highway structures provide ideal day roost conditions, minor modifications in the design of future structures could easily provide homes for millions of bats.

Transportation departments can incorporate bat roosting spaces as a key element of on-site mitigation, to demonstrate pro-active commitments to the environment, aid farmers, and gain positive publicity, often at little or no extra cost to the taxpayer.

The Bats in American Bridges Project was designed to help transportation departments provide bat habitat where appropriate while avoiding it where nuisances could result. This report describes nationwide survey results for bat use of highway structures, preferred roost characteristics, roost enhancement techniques, and information on how state transportation departments are handling bat-related issues.

Methods

Field studies, literature reviews, and interviews with biologists and engineers were conducted to determine which bat species use American highway structures, to identify their roosting preferences, and to develop methods of predicting where bats will use them.

A total of 2,421 structures (1,312 bridges and 1,109 culverts) were surveyed for bat use along a route that passed through 25 states primarily in the southern half of the U.S. Sixty different characteristics were used to determine bat roosting preferences.

Field surveys were impractical for bridges and culverts in the remaining 23 northern states because few are warm enough to meet bat needs. For these states we relied only on interviews. Hawaii has no bats likely to use highway structures.

Results

Bats use highway structures either as day or night roosts. Day roosts are places that protect bats from predators and buffer weather changes while resting or rearing their young. Such roosts are usually in expansion joints or other crevices. In contrast, night roosts, where bats gather to digest their food between nightly feeding bouts, are often found in open areas between bridge support beams that are protected from the wind.

Two hundred and eleven highway structures were used as day roosts and 94 percent were occupied by crevice-dwelling bat species. Seven hundred and fourteen highway structures were used as night roosts.

Day Roosts

Only 281 of the 2,421 structures surveyed had characteristics that met the minimum needs of day-roosting bats. Ideal day roost characteristics for crevice-dwelling bat species that use high way structures, include (in descending priority):

Bridges:

$ location in relatively warm geographic regions, primarily in southern half of the U.S.
$ construction material: concrete
$ vertical crevices: 0.5 to 1.25 inches (0.25 to 3 cm) wide
$ vertical crevices: 12 inches (30 cm) or greater in depth
$ roost height: 10 feet (3 m) or more above the ground
$ rainwater-sealed at the top
$ full sun exposure of the structure
$ not situated over busy roadways

Culverts:

$ location in relatively warm geographic regions
$ concrete box culverts
$ between 5 and 10 feet (1.5 and 3 m) tall and 300 feet (100 m) or more long
$ openings protected from high winds
$ not susceptible to flooding
$ inner areas relatively dark with roughened walls or ceilings
$ crevices, imperfections, or swallow nests

Bats use parallel box beam bridges as day roosts more than any other kind. The next most preferred bridges are cast in place or made of prestressed concrete girder spans. These designs are the most likely to contain spaces suitable for bats. Although parallel box beam bridges were rarely encountered during the survey, they can provide numerous crevices of suitable width. Metal and small concrete culverts are the most frequently encountered highway structures and are the least preferred as roosts.

We found substantial regional variation in the frequency with which bats used suitable highway structures as either day or night roosts. Even ideal structures were rarely used by bats in areas dominated by open plains, perhaps due to a lack of appropriate habitat.

Many of the day-roosts were found in open crevices exposed to weather and predation, making them highly vulnerable to disturbance and injury by humans or vehicles. Although concrete is the preferred roost material, bats sometimes used wooden roosts or, when desperate, metal.

Night Roosts

Bats frequently use highway structures as night roosts. In fact, 29 percent of all structures surveyed had signs of night-roost activity. In some regions of the southwest, all suitable structures were used by night-roosting bats.

Night-roosting bats are believed to be attracted to bridges that provide protected roosts and have a large thermal mass that remains warm at night. Bridges constructed of prestressed concrete girder spans, cast-in-place spans, or steel I-beams are preferred. Vertical concrete surfaces located between beams provide ideal protection from wind and are especially used when they are heated by full sun exposure. Bats typically do not use bridges with flat bottomed surfaces that lack inter-beam spaces. They will avoid small culverts but will roost at night in the long concrete box culverts that often pass under divided highways, if the culverts are at least 5 feet (1.5 m) tall.

Bats use night roosts in bridges mostly between 10 p.m. and midnight. Some remain for most of the night, periodically feeding and returning to digest their meals. Night roosts appear to play important roles in body temperature regulation and social behavior.

Species Preferences

Seventeen of the twenty-four species reported to use bridges or culverts were encountered during the field surveys. Occupied day roosts ranged in size from a single male to nursery colonies with more than one million mothers and their pups. Bridges and culverts are used by both bachelor and nursery colonies, and as temporary roosts during migration and mating. Culverts were sometimes also used for hibernation in southern areas.

Mexican free-tailed bat (*Tadarida brasiliensis*) colonies were found in southern bridges and culverts from coast to coast, representing 26 percent of all species encountered. Although most colonies are composed of fewer than 100 individuals, Mexican free-tailed bats have the potential to form bridge colonies numbering in the millions. The largest colonies exist in Texas, New Mexico, Arizona, and California.

Big brown bats (*Eptesicus fuscus*) were the second most abundant bridge-dwellers. This species represented 21.5 percent of the day-roosting colonies encountered. This species was found throughout the U.S. in small colonies ranging from two to seventy individuals.

Cave myotis (*Myotis velifer*) colonies represented 19 percent of the roosts encountered. Most were small with 2 to 10 individuals, but one nursery colony in a south Texas culvert included approximately 35,000 individuals. Abandoned swallow nests were regularly used.

The evening bat (*Nycteceius humeralis*) and most of the remaining myotis species were typically found in colonies of 2 to 200 individuals in bridge crevices, although some colonies consisted of more than 1,000. Southeastern myotis (*Myotis austroriparius*) use both bridges and culverts as nursery roosts, sometimes with as many as 2,000 to 3,000 mothers and their pups.

Unlike other bridge-dwelling species, both eastern and western pipistrelles (*Pipistrellus subflavus* and *hesperus*) and both Townsend's and Rafinesque's big-eared bats (*Corynorhinus townsendii* and *rafinesquii*) were found roosting in the open between bridge beams. Rafinesque's big-eared bats were found rearing young between open beams in low bridges darkened by thick vegetation bordering the sides. In one case a colony of big-eared bats abandoned its roost immediately after vegetation was removed. They returned three years later, when it had regrown (J. MacGregor, pers. comm.). In the southwest, individual male Townsend's big-eared bats were occasionally found roosting in 5-foot-diameter (1.5 meters) or larger corrugated metal culverts. The nectar-feeding Mexican long-tongued bat (*Choeronycterus mexicanus*) has been reported using small diameter corrugated metal culverts (18 to 24 inches/45 to 61 cm) as day roosts in Arizona. Evidence of night roosting by small groups of nectar feeding bats was found in Arizona bridges.

Maternity colonies of both the endangered gray myotis (*Myotis grisescens*) and Indiana myotis (*Myotis sodalis*) live in bridges (Barbour and Davis, 1969). Hundreds to thousands of gray myotis were found rearing their young in long concrete box culverts in three states.

The most frequent night roost signs encountered appeared to be from the genus Myotis. Similar signs from big brown and big-eared bats were also common regionally. Although Mexican free-tailed bats seemed to prefer to use their roost crevices as both day and night roosts, they were sometimes found night roosting in large numbers between open bridge beams and in long, tall concrete box culverts.

Bats and Highway Structure Temperatures

Bats have the largest surface area to body mass of any mammal, and this requires greater energy to maintain body temperatures. Sun-warmed bridges help adult bats to conserve energy and foster development of their young.

During the summer months, sun-exposed bridges act as thermal sinks, often achieving and holding temperatures above the ambient average for most of the 24-hour cycle. Comparisons of ambient and bridge temperatures from roosts in Kentucky, Texas, Oregon, and California show a similar pattern (J. MacGregor and D. Clayton, pers. comm.). The higher, more consistent bridge temperatures are especially important in mountainous or desert regions where ambient temperatures fluctuate dramatically within a 24-hour cycle.

An Oregon study found that bats prefer bridges with greatest sun exposures. Bridges receiving no sun had little or no bat use. This preference was especially obvious within partially shaded bridges, where roosting activities occurred only in the sun-exposed halves of bridges (Keeley, 1998).

The northernmost day roost discovered in this study was occupied by a maternity colony of roughly 300 little brown myotis (*Myotis lucifugus*) in an Idaho bridge at 44° north latitude. In the eastern U.S. we found occupied bridges as far north as Virginia and Kentucky and have reports of occupied bridges from Indiana and New Jersey. However, the number of day roosts appears to drop rapidly above 42° north latitude.

Major Topical Areas

Mitigation

Transportation departments faced with balancing human needs and sensitive wildlife issues will find incorporation of bat roosts into highway structures to be ideal for mitigation as well as for proactive habitat enhancement. Roadway construction negatively impacts bats both directly and indirectly. Roads built along rivers or rock faces can permanently destroy roosts in cliffs or caves within or near the right of way. In addition, road construction through riparian forests removes roost-bearing trees. Roads also increase human accessibility to sensitive roosts in caves or mines, forcing bats to abandon these roosts when they are disturbed. It is essential to minimize environmental damage, especially when state or federally listed endangered species are present.

Unlike many other mitigation efforts, bat roost enhancement projects for roadways can be conducted onsite. As described in the previous section, there are many options for helping bats in new or existing structures. For example, while planning a highway through the Tonto National Forest, the Arizona Department of Transportation and the U.S. Forest Service are collaborating on a project to incorporate bat habitat into a new highway bridge.

The highway department is including mounting brackets in the bridge design plans, and the Forest Service is constructing artificial roosts that the highway department will install (R. Orr, pers. comm.).

Another means of providing alternative roosts is by retrofitting nearby highway structures with habitat or using free -standing bat house designs. There are commercially produced bat houses available that can accommodate up to tens of thousands of bats (see Bat Conservation International=s web-site: www.batcon.org). These are ideal for use in off -site mitigation projects.

Benefits of Accommodating Bats in Highway Structures

A colony of 1.5 million Mexican free-tailed bats living in the Congress Avenue bridge in Austin, Texas consume approximately 10 to 15 tons of insects nightly, and these include large quantities of the most costly agricultural pests in the state (McCracken and Westbrook, in man.). The impact of even small colonies of bats in bridges can be considerable. Just 150 big brown bats (a common nationwide bridge -dweller) can consume enough adult cucumber beetles in one summer to prevent egg -laying that could produce 33 million of their costly root-worm larvae (Whitaker, 1995). Also, some insect pests tend to avoid areas where bat echolocation calls are heard (Belton and Kempster, 1962; Agee, 1964). Press coverage of projects to incorporate bat habitat into highway structures has been excellent and extremely positive.

Bats and Structural Integrity

During the nationwide surveys, no structural damage attributable to bats was observed, nor were any reports of such damage received. Mark Bloschock, a Texas Department of Transportation bridge design engineer, inspected the Congress Avenue bridge and the University of Texas football stadium and found no damage of consequence within the normal life span of concrete structures. The bridge has been occupied for more than 15 years by approximately 1.5 million bats, the stadium 63 years by tens of thousands.

Organic materials that retain moisture, such as bat droppings, could facilitate oxidation on unprotected metal parts. Thus, bat roosts above exposed metal components should be discouraged.

Bats and Environmental Impacts

During our nationwide surveys, no negative impacts on natural or human environments were observed, nor were any reported. Even exceptionally large bat colonies numbering in the hundreds of thousands have not been associated with environmental degradation. Two water quality studies were conducted on Town Lake beneath the Congress Avenue bridge bat roost by the City of Austin and the Lower Colorado River Authority respectively. These studies found a negligible impact caused by the bat colony (Lyday, 1994; Guajardo, 1995). Large guano deposits can produce odors in the immediate vicinity that are unpleasant to some people, though there are few complaints in Austin, despite having 1.5 million bats.

Bats and Maintenance Schedules

Bats roosting in highway structures are habituated to vibrations and sounds associated with normal traffic and will be minimally disturbed if maintenance operations create these conditions. Structural maintenance only affects bat colonies if the roost is suddenly exposed or if foreign materials (water, tar, gravel, etc.) are introduced. During our field surveys, we observed crews working on and around occupied structures without apparent affects on bats.

Minimizing Disturbance to Bat Colonies During Construction Activities

Bats that occupy bridge crevices often ignore workers in the general area. Where work must be performed above crevices that are open at the top, disturbance can be minimized by covering them with tarps. Bats such as big -eared species, that roost in larger open areas between beams, are highly susceptible to disturbance, but they typically do not occupy bridges year round. Transportation departments can avoid accidentally providing roosts where bats are unwanted by minimizing the inclusion of preferred characteristics.

Timing Maintenance Activities

In most states, bats leave their summer bridge roosts to overwinter in more protected locations. Maintenance conducted between November 1 and February 1 will minimize disturbance. In the southernmost regions, where freezing temperatures rarely occur for extended periods some bats may remain year round. Still, proceeding with winter maintenance activities will affect fewer bats and avoid the disturbance of flightless young that would occur in summer. When questions arise, we recommend consultation with experienced bat biologists.

Exclusion

Excluding bats from a roost is a process that allows them to exit unharmed, but not re -enter. This reduces the potential for humans to come in contact with bats. If maintenance work has to be done while bats are in a roost, exclusion may be necessary. To conduct an exclusion, primary exit points are identified and marked. All other escape routes greater than 0.25 inch (0.6 cm) are sealed. Access to unused portions of long crevices can be minimized by filling them with suitable material, such as wood, backer rod, expanding foam, or caulk. Care should be taken to avoid sealing bats into the roost. A one-way valve is placed over the primary exit points to prevent re -entry. Simple one-way valves have been constructed using wire me sh cones, PVC, and strips of clear plastic sheeting attached over exit points. Once the bats have been excluded, roost spaces can be permanently filled with a suitable substance. Bats do not chew or remove materials. Bats displaced during exclusions may try to return to the roost for a short time following the procedure.

The Florida Department of Transportation used all aspects of this process during reconstruction of a bat -occupied bridge. In order to minimize disturbance to the bats, the project was initiated during the winter months when the fewest bats were present. Properly sized wood strips were used to fill unused portions of the roost crevice, and one -way valves constructed of wire mesh were installed over the exit points. In this case, bats di d not move into bat houses mounted on nearby poles within the project period, but the department hopes that the bats will return to roosts being built into the new bridge.

Human Health and Safety

Most small bridge bat colonies pose no threat to humans and probably will remain unnoticed throughout the life of the structure. However, spectacular emergences of large bat colonies from highway structures can attract public attention, as has been demonstrated at the Congress Avenue bridge. Tens of thousands of visitors have come to view this spectacle each summer for more than a decade. Measures to minimize human contact as well as signs warning about handling bats may be needed at heavily visited locations. Even though the Congress Avenue bridge is located in the midst of a large metropolitan area, no one has contracted any disease from the 1.5 million bats in the 16 years since they arrived. A fence prevents access to areas where young or sick bats sometimes fall, and signs warn visitors not to handle bats.

Only two diseases, rabies and histoplasmosis, have been transmitted from bats to humans, and exposure risks are easy to avoid. Rabies can be transmitted only from the bite of a rabid animal or from contact between an infected animal=s nerve tissue and an open wound. The virus is not found in urine or feces. The occasional bat that does contract rabies is almost never aggressive and becomes a problem only if handled. Any animal bite should be professionally evaluated as a potential rabies exposure. A safe, effective, and painless vaccine is now available, for either pre- or post-exposure protection.

Histoplasma capsulatum is a fungus that lives in soil enriched by animal droppings and can cause a respiratory illness called histoplasmosis, which is most often contracted from birds. Humans risk infection only when they inhale spore-laden dust. Bridge workers should minimize dust inhalation where there are either bird or bat droppings. A respirator capable of filtering 2 to 3 micron-sized particles should be worn in work areas where inhalation of dust from animal droppings cannot be avoided (Kunz, 1998).

Endangered and Threatened Species

Transportation departments can often mitigate alteration of sensitive roost habitats by providing space for bats in highway structures. There are currently six federally endangered bat species on the U.S. mainland. The gray myotis (*Myotis grisescens*) has successfully used both bridges and culverts as maternity roosts. The Indiana myotis (*Myotis sodalis*) has been documented to use bridges as day roosts, but bridge suitability for this species remains poorly investigated. Although the two endangered big-eared bat subspecies (*Corynorhinus townsendii virginianus* and *C. t. ingens*) have not been documented in highway structures, western big-eared bats regularly use bridges as day roosts. Endangered lesser (*Leptonycteris curasoae*) and greater long-nosed bats (*Leptonycteris nivalis*) found in the extreme southwestern U.S., have not been documented using highway structures.

In contrast to other endangered plant and animal species, bats have a mobility and behavioral adaptability that allows greater bridge maintenance and replacement flexibility. Bridges or culverts occupied by endangered bat species often can be worked on without disturbing the bats by simply choosing a time when bats are not present. Varied mitigative measures are also available (see Mitigation).

Transportation Departments and Bats

The Federal Highway Administration was the lead agency initiating the national study of bat use of bridges followed by contributions from Texas, Florida, Georgia, Tennessee, Oklahoma, Wyoming, Utah, and New Mexico transportation departments. Individually, growing numbers of transportation departments are integrating bat management techniques into maintenance schedules. California evaluates every project for impacts to bats. Significant local wildlife resources and species of concern listed by the state or federal governments are given special consideration (G. Erickson, pers. comm.). The Arizona Department of Transportation also includes bats in its environmental impact statements with an emphasis on species of concern (T. Snow, pers. comm.).

The Texas Department of Transportation has conducted a statewide study of bat use in highway structures and is using the information to actively preserve and promote bat roosts where appropriate. Thousands of bats have new homes throughout the state in both bridges and culverts modified to accommodate bats. In south Texas, methods of trimming palm trees within the right of way have been altered to retain dead fronds where bats are roosting.

The Importance of Highway Structures to Bats

In many cases, bridges and culverts now serve as havens of last resort for bats that have lost their natural roosts in caves and old-growth forests. Surrounding habitat often remains suitable for feeding, if bats can only find safe places to rear their young. Typically, where traditional roosts have been protected, or new ones have been provided, even endangered species are recovering.

Though less than one percent of American bridges are currently suitable for use by bats, these bridges already shelter millions of bats of at least 24 species, including some of our continent=s most regionally important populations. The fact that bats were often found attempting to rear young in sites unprotected from rain, or where many were killed by passing cars as they emerged, demonstrates that roost shortages are common.

Bats are often forced into dangerous conditions when safe roosts are in short supply. In one instance, bats were found emerging from a bridge located over a busy highway where they were frequently hit by cars. In another instance, several hundred Mexican free-tailed bats died apparently from hypothermia during an early winter cold front, when rain leaked into an unsealed crevice soaking them. These incidents emphasize the importance of providing adequate conditions when planning habitat enhancement for bats.

Retrofitting

Creation of day-roost habitat for bats in new or existing highway structures is easy, often at little or no extra cost to the taxpayer. For new structures, the minimum needs for day-roosting bats can be met by specifying the proper dimensions for crevices such as expansion joints. Retrofitting habitat into existing highway structures has become a popular and successful method of accommodating bats. Pre-surveys to look for bat signs in nearby bridges are useful to predict the success of proposed enhancement projects. Four bridges in Oregon (D. Clayton, pers. comm.) and five bridges and two culverts in Texas with signs of night roosting were retrofitted with ideal crevices, and all were occupied by bats within the first year. All retrofit designs tested in bridges and culverts so far have successfully attracted bats, and at least six states are already using retrofitting projects to accommodate bats.

Retrofitting projects have many appealing features for habitat enhancement. They

$ are adaptable to almost any structure
$ can be placed where they will have a high potential for success
$ can be placed in locations that minimize disturbance from maintenance or vandalism
$ can be sized to accommodate small or large colonies
$ are beneficial to agriculture
$ are inexpensive (can be constructed from recycled materials)
$ can be expanded by adding additional units if initial efforts are successful
$ can be easily moved if necessary

Two basic designs, the Texas Bat Abode and the Oregon Wedge, can be used to retrofit almost any bridge or culvert. The Texas Bat-Abode contains many roosting crevices that can accommodate thousands of bats each, and have been modified to fit three different bridge designs. Four of the five tested were fully occupied, one within the first month. The Oregon Wedge provides a single roosting crevice that can house several hundred bats and has been accepted for day roosting by 12 species, including a maternity colony of Yuma Myotis (*Myotis yumanensis*) in Oregon (D. Clayton, pers. comm.). This design has been successful in both bridges and culverts in Oregon, Arizona, and Texas. The Texas Department of Transportation developed a concrete version that also attracted bats within a year. Design plans for the Texas Bat Abode and Oregon Wedge are available on the BCI web-page (www.batcon.org).

Locations with evidence of attempted bat use are ideal for retrofitting projects. Roadways with structures that pass through public lands, such as parks or national forests, are especially good candidates for bat habitat enhancement programs. In most cases, transportation department costs are minimal. In fact, local businesses are often willing to donate materials, assisting school children or private agencies in constructing required structures. News media coverage and positive publicity of such projects has been extraordinary.

When old bridges must be replaced, some of those occupied by bats have been retained as wildlife sanctuaries. The Santa Barbara Public Works Department and the California Department of Transportation are collaborating to preserve a colony of 10,000 Mexican free -tailed bats and 200 pallid bats (*Antrozous pallidus*) by retaining a portion of an old bridge that is surrounded by agricultural fields (Storrer, 1994). It is calculated that these bats consume roughly 10,000 pounds (4,540 kg) of insects each summer, many of which are pests.

In Oregon the Departments of Transportation and Fish and Wildlife have cooperated in retaining a bridge occupied by a colony of Yuma myotis that had been slated for destruction (S. Cross, pers. comm.). Removal costs were avoided, while valuable wildlife habitat was protected.

Incorporating characteristics into new structures specifically for bats can be relatively inexpensive and easy to do. The Texas Department of Transportation has constructed a bat-friendly domed culvert. The cost to customize standard culvert designs is minimal, and modifications can even be implemented during construction (M. Bloschock, pers. comm.).

Bridge habitat enhancement techniques are also being developed in other countries. In Australia, the roost portion of an old wooden bridge was retained and incorporated into the underbelly of a new replacement bridge (G. Hoye, pers. comm.). In England, special bat -friendly bricks and concrete bat boxes have been provided to create roost spaces, and alterations to new bridge designs are being used to incorporate bat habitat into bridges during mitigation projects (Billington, 1997).

Discussion

It is estimated that within the southern U.S., 3,600 highway structures are being used by approximately 33 million bats. The fact that 43 percent of bridges suitable for night roosting are used, indicates that in many areas bat habitat enhancement projects would be successful and could help stabilize bat populations by providing roosts needed for rearing young.

Roost loss and disturbance are the most important known causes of bat decline. Yet, as we have documented, bridges and culverts can provide essential substitutes. Transportation departments are ideally positioned to help reestablish one of America =s most valuable wildlife resources at little or no cost to taxpayers, through highly popular pro-active measures.

Other countries are also beginning to recognize the value of providing roosts in bridges and are initiating their own projects. Information from the Bats in American Bridges project has already been requested from 17 countries, suggesting that habitat enhancements in highway structures may become a powerful conservation tool worldwide.

As illustrated at the Congress Avenue bridge, the public has firmly demonstrated its support for bats in highway structures. Furthermore, research documenting the impact of bats in reducing crop pests is rapidly increasing support in the agricultural community. People support what they value, and the relationship between bats and highway structures is clearly valuable to both humans and bats.

Additional information on conducting surveys and creating bat roosts in highway structures is available through BCI in the Bats in American Bridges publication on our web-page (www.batcon.org) and in hard copy by request.

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