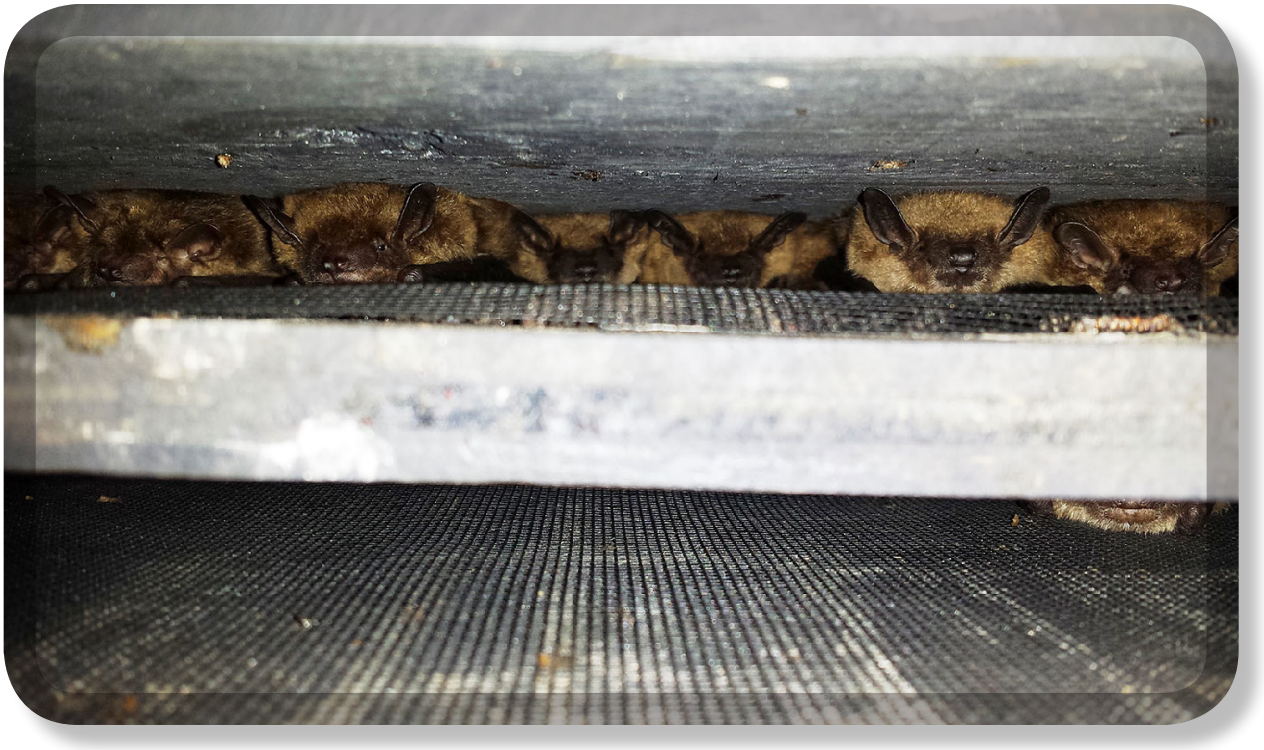
United States Department of Agriculture

Bats, People, and Buildings

Issues and Opportunities

Martin J. Pfeiffer



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Abstract

Bats are amazing animals. They are among the best flyers of the natural world and are able to maneuver in the dark to intersect small flying insects. Bats consume large quantities of insects, and this helps hold down the populations of pests that could otherwise destroy agricultural crops and forests. Bats also pollinate many species of plants that provide us with food and medicine. Most people in the United States view bats as pests, and this view has undoubtedly contributed to precipitous declines for some species. However, in much of Europe, bats are protected and measures are taken to incorporate bat housing into buildings and bat-friendly habitat into neighborhoods. Many bat species in the United States also take advantage of human structures. With good design, bat housing could be incorporated into buildings and other structures and could provide support for U.S. bat populations. This publication provides an overview of resources available to help people who want to support bats with their existing structures and/or new building projects.

Keywords: bats, buildings

Contents

English unit	Conversion factor	SI unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
$T_{°F}$	$T_{°C} = (T_{°F} - 32)/1.8$	$T_{°C}$

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Bats, People, and Buildings

Issues and Opportunities

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Introduction

Buildings pose unique opportunities and challenges for wildlife. The structural components of buildings can mimic conditions found in natural landscapes and can provide homes for wildlife. In some cases, these "homes" can help sustain species of wildlife that are experiencing loss of their natural home sites. For example, bats that roost in buildings may do so because of the loss of old, decaying trees that provided natural roosts under bark or within cavities.

Building sites can also benefit wildlife by providing oases for food, water, and/or other necessities of survival. Bird feeders supplement natural food sources for not only birds but voles, mice, squirrels, rabbits, raccoons, bears, and other wildlife. The smaller animals may, in turn, attract hunters such as hawks, owls, fox, and coyotes. Landscaping may add water features, berry- and nut-producing shrubs, and cover for animals.

Buildings can also create problems for wildlife. A significant source of problems arise from conflicts with people. Bats that enter homes and office spaces may cause distress for some people and can result in undue harm to the animal itself. Woodpeckers that drum on wood siding can damage buildings and frustrate owners. Skunks who make dens near buildings may not be welcomed by landowners or resident pets. These are but a few examples of the conflicts that can occur when wildlife intersect with buildings and surrounding land.

Buildings can also cause direct issues for wildlife. Estimates range as high as one billion birds lost each year to collisions with building glass. Feral cats, primarily found near buildings, account for an additional billion bird deaths every year. Artificial lighting associated with buildings can discourage bats and disorient migrating birds.

Many species of wildlife found in the United States are threatened by loss of habitat and population declines. A number of bat and bird species, in particular, are showing precipitous declines in their populations. Some of these species are capable of or, in some instances, thrive on living among human populations.

A number of bat species, in particular, are attracted to building structures. This report will address issues and opportunities associated with bats and buildings.

Bats

Bats in North America have historically been persecuted by humans. There are undoubtedly multiple, interconnecting factors that account for negative reactions to bats. However, much of what people think and feel about bats is based on misinformation. Bats in most mythology and folklore are dirty and blind, get tangled in people's hair, and associate with vampires. Bats are often depicted in television and movies as ominous creatures and bad omens. These myths are incorrect and obscure many marvelous characteristics of bats. *The Truth about Bats* from Bat Conservation International (Austin, Texas, USA) gives more information on this topic (BCI 2018a).

The Amazing Bat

Bats are amazing animals, and no less so than well-regarded animals such as (wise) owls, (majestic) eagles, and (cunning) foxes. Bats form the second largest order of mammals in the world. There are more than 1,000 species of bats in the world, and all can fly (USDI 2017). In fact, they are the only species of mammal that fly under their own power. Because of their unique wing structure, bats are capable of incredible maneuvers to capture insects in flight.

Bats are nocturnal and feed primarily at dusk, dawn, and night. Although bats can see as well as humans, they use echolocation to maneuver in the dark. This involves emitting high frequency sounds and listening for the return echo that occurs when sound reflects off an object. Bats can discern minute differences in these echoes and it is this ability that allows them to fine tune flight speed and direction and time their arrival to intersect a small flying insect. This same ability enables bats to navigate around buildings, trees, and other obstacles in flight.

Bat echolocation is so advanced that the United States Navy has studied bats with the hope of improving sonar capabilities (ONR 2002). Bats can separate two sounds received just a few microseconds (three-millionths of a second) apart. This is faster than historical sonar capabilities (at 12 microseconds) and gives bats a unique advantage: they can distinguish objects whose size and shape differ only by the width of a human hair, even while flying at high speed in the dark. Scientists are also studying bat echolocation for other purposes. For example, someday, blind people may be able to take advantage of echolocation

technology and "hear" their way through a room (NOVA Next 2013).

Benefits of Bats

Bats benefit forests and farms by pollinating flowering plants and distributing seeds. Bats, together with birds, predominate the distribution of seeds and reforestation of rainforests worldwide. In one study, bats occupying artificial roosts distributed the seeds of 69 different plant species to deforested areas in Costa Rica (Kelm and others 2008). Worldwide, more than 300 species of fruit, including bananas, dates, Brazil nuts, coconut, vanilla, and avocado, depend on bats for pollination (USDA FS 2018). Eighty different medicines come from plants that are dependent on bats for pollination (USDI 2017).

Bats also eat insect pests that can damage forests and agricultural crops such as tomatoes, beans, carrots, apples, peaches, grapes, oats, rice, wheat, almonds, pecans, and peanuts. One California farm has incorporated bat houses to host approximately 1,000 bats that consume codling moths, a major source of damage to walnut crops (Donahue 2015). Research in Indiana concluded that an average colony of 150 big brown bats consumes sufficient cucumber beetles to avert 33 million rootworms, a major corn pest, every year (Whitaker 1995). An estimated 100 tons of insects are consumed each summer night by Mexican free-tailed bats living in Bracken Cave near San Antonio, Texas, USA (TPW 2016).

Bats at Risk

Almost half (22 of 47) of the bat species in the United States are at risk because of precipitous declines in population, loss of habitat, disease, or other causes (Table 1). Seventeen species or subspecies are listed as vulnerable, imperiled, critically imperiled, possibly extinct, or presumed extinct on NatureServe Explorer, an authoritative source for conservation information about more than 50,000 plants, animals, and ecological communities of the United States and Canada (NatureServe 2018). Eight species or subspecies are listed under the Endangered Species Act (ESA) (USDI FWS 2018a). Nine species have been confirmed susceptible to a significant new disease (white-nose syndrome) that threatens their survival (USDI FWS 2018b).

White-nose syndrome is a fungal disease causing unprecedented mortality and precipitous declines in populations for some species of hibernating bats. An estimated 6 million bats have died, mostly in the eastern United States, since the disease was first documented in 2006. The disease was first discovered in the United States on the east coast, is currently found in 32 states, and continues to move westward. Sixteen species of bats have been detected with the fungus (*Pseudogymnoascus destructans*) thought to cause the disease, and nine species are susceptible to the disease itself (USDI FWS 2018b).

Protections for Bats

Bats have relatively few protections in the United States. Of the 47 species found in the United States, only eight species are either completely protected or have subspecies protected under the ESA. It is illegal to import, export, take, possess, sell, or transport species listed under the ESA. The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct (USDI FWS 2018c). The prohibition against "take" includes destruction of critical habitat (Hodges 2010).

Aside from the ESA, bats are not consistently protected across species and state lines. For some species, federal, state, and other partners have developed and continue to improve management plans for their protection. Some states have developed specific legislation to protect bats. For example, several states prohibit exclusion of bats from buildings that are hosting active maternity colonies during critical time periods. Bats are also protected from control by pesticides. Environmental Protection Agency (EPA) regulations only allow the application of pesticides for species listed on labels, and bats are not listed on the labels of any pesticides (BCI 2018b).

Bats and Buildings

Importance of Buildings

Of the 47 species of bats found in the United States, 35 are known to use human structures, including buildings and bridges (BCI 2018c; Table 1). Fourteen species use bat houses (BCI 2013). By virtue of their ability to fly and, for many species, crawl through small openings, bats are adept at entering buildings. Buildings can provide space for feeding, mating, rearing young, hibernation, thermoregulation, and protection from predators.

For some bat species, human structures have become a lifeline, slowing population declines and perhaps even staving off extinction. For these species, something has changed, causing their historical, natural roosts to no longer be available or sufficient to meet their needs for shelter and reproduction.

Use of Buildings

Different bat species take advantage of different structural features of buildings. In general, structural features used by bats can be simplified to four main categories: (1) cracks, crevices, and small cavities; (2) exterior roosts; (3) attics or similarly sized protected open spaces; and (4) flyways for bats that cannot crawl and must fly to roosts.

1. Cracks, Crevices, and Small Cavities

Cracks, crevices, and small cavities are defined as small spaces that provide sufficient space for one or more bats to

Table 1—Bat species of the United States

Species	States found	Uses structures?	At risk to *P. destructans*?	At risk to white-nose syndrome?	NatureServe at risk?	Listed per Endangered Species Act (ESA)?
Pallid bat *Antrozous pallidus*	AZ, CA, CO, ID, KS, MT, NM, NN, NV, OK, OR, TX, UT, WA, WY	Yes			Yes[a]	
Jamaican fruit-eating bat *Artibeus jamaicensis*	FL	Yes				
Mexican long-tongued bat *Choeronycteris mexicana*	AZ, CA, NM, TX	Yes			Yes	
Rafinesque's big-eared bat *Corynorhinus rafinesquii*	AL, AR, FL, GA, IL, IN, KY, LA, MO, MS, NC, OH, OK, SC, TN, TX, VA, WV	Yes	Yes		Yes	
Townsend's big-eared bat *Corynorhinus townsendii*	AR, AZ, CA, CO, ID, KS, KY, MO, MT, NC, NE, NM, NN, NV, OK, OR, SD, TN, TX, UT, VA, WA, WV, WY	Yes	Yes		Yes[b]	Yes[c]
Big brown bat *Eptesicus fuscus*	AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NN, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	Yes	Yes	Yes		
Eastern small-footed bat *Myotis leibii*	AR, CT, GA, KY, MA, MD, ME, MO, NC, NH, NJ, NY, OH, OK, PA, SC, TN, VA, VT, WV	Yes	Yes	Yes		
Gray bat *Myotis grisescens*	AL, AR, FL, GA, IL, IN, KS, KY, MO, NC, OK, SC, TN, VA	Yes	Yes	Yes		Yes
Indiana bat *Myotis sodalis*	AL, AR, CT, GA, IA, IL, IN, KY, MA, MD, MI, MO, MS, NC, NJ, NY, OH, OK, PA, SC, TN, VA, VT, WV	Yes	Yes	Yes	Yes	Yes
Little brown bat *Myotis lucifugus*	AK, AL, AR, CA, CO, CT, DC, DE, FL, GA, IA, ID, IL, IN, KS, KY, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, UT, VA, VT, WA, WI, WV, WY	Yes	Yes	Yes	Yes	
Northern long-eared bat *Myotis septentrionalis*	AL, AR, CT, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, ND, NE, NH, NJ, NY, OH, OK, PA, RI, SC, SD, TN, VA, VT, WI, WV, WY	Yes	Yes	Yes	Yes	Yes
Yuma bat *Myotis yumanensis*	AZ, CA, CO, ID, MT, NM, NN, NV, OK, OR, TX, UT, WA, WY	Yes	Yes	Yes	Yes[d]	

Table 1—Bat species of the United States—continued

Species	States found	Uses structures?	At risk to *P. destructans*?	At risk to white-nose syndrome?	NatureServe at risk?	Listed per Endangered Species Act (ESA)?
Southeastern bat *Myotis austroriparius*	AL, AR, FL, GA, IL, IN, KY, LA, MO, MS, NC, OK, SC, TN, TX, VA	Yes	Yes	Yes		
Tri-colored bat *Perimyotis subflavus*	AL, AR, CT, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, NE, NH, NJ, NM, NY, OH, OK, PA, RI, SC, TN, TX, VA, VT, WI, WV	Yes	Yes	Yes	Yes	
Cave bat *Myotis velifer*	AZ, CA, KS, NM, NV, OK, TX, UT	Yes	Yes			
Silver-haired bat *Lasionycteris noctivagans*	AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MT, NC, ND, NE, NH, NJ, NM, NN, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	Yes	Yes		Yes	
Florida bonneted bat *Eumops floridanus*	FL	Yes			Yes	Yes
Greater bonneted bat *Eumops perotis*	AZ, CA, NV, TX	Yes				
Lesser long-nosed bat *Leptonycteris yerbabuenae*	AZ, CA, NM	Yes			Yes	Yes
California leaf-nosed bat *Macrotus californicus*	AZ, CA, NV, UT	Yes			Yes	
Peters's ghost-faced bat *Mormoops megalophylla*	TX	Yes				
Pallas's mastiff bat *Molossus molossus*	AZ, NM, TX	Yes				
Southwestern bat *Myotis auriculus*	AZ, NM	Yes				
California bat *Myotis californicus*	AK, AZ, CA, CO, ID, MT, NM, NN, NV, OR, TX, UT, WA	Yes				
Western small-footed bat *Myotis ciliolabrum*	AZ, CA, CO, ID, KS, MT, ND, NE, NM, NN, NV, OK, OR, SD, TX, UT, WA, WY	Yes				
Long-eared bat *Myotis evotis*	AZ, CA, CO, ID, MT, ND, NM, NN, NV, OR, SD, UT, WA, WY	Yes				
Dark-nosed small-footed bat *Myotis melanorhinus*	AZ, CA, CO, ID, KS, MT, ND, NE, NM, NN, NV, OK, OR, SD, TX, UT, WA, WY	Yes				
Arizona bat *Myotis occultus*	AZ, CA, CO, NM	Yes				
Fringed bat *Myotis thysanodes*	AZ, CA, CO, ID, MT, NE, NM, NN, NV, OR, SD, TX, UT, WA, WY	Yes			Yes[e]	
Long-legged bat *Myotis Volans*	AK, AZ, CA, CO, ID, MT, ND, NE, NM, NN, NV, OR, SD, TX, UT, WA, WY	Yes				

Table 1—Bat species of the United States—continued

Species	States found	Uses structures?	At risk to *P. destructans*?	At risk to white-nose syndrome?	NatureServe at risk?	Listed per Endangered Species Act (ESA)?
Evening bat *Nycticeius humeralis*	AL, AR, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MD, MO, MS, NC, NE, NJ, OH, OK, PA, SC, SD, TN, TX, VA, WI, WV	Yes				
Pocketed free-tailed bat *Nyctinomops femorosaccus*	AZ, CA, NM, TX	Yes				
Big free-tailed bat *Nyctinomops macrotis*	AZ, CA, CO, KS, NM, NN, NV, OK, TX, UT	Yes				
Canyon bat *Parastrellus hesperus*	AZ, CA, CO, ID, NM, NN, NV, OK, OR, TX, UT, WA	Yes				
Mexican free-tailed bat *Tadarida brasiliensis*	AL, AR, AZ, CA, CO, FL, GA, KS, LA, MS, NC, NE, NM, NN, NV, OK, OR, SC, TX, UT	Yes				
Eastern red bat *Lasiurus borealis*	AL, AR, CO, CT, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NY, OH, OK, PA, RI, SC, SD, TN, TX, VA, VT, WI, WV		Yes		Yes	
Mexican long-nosed bat *Leptonycteris nivalis*	NM, TX				Yes	Yes
Underwood's bonneted bat *Eumops floridanus*	FL					
Western red bat *Lasiurus blossevillii*	AZ, CA, NM, NV, TX, UT					
Hoary bat *Lasiurus cinereus*	AL, AR, AZ, CA, CO, CT, DC, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NN, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY				Yes	Yes[f]
Southern yellow bat *Lasiurus ega*	TX					
Northern yellow bat *Lasiurus intermedius*	AL, FL, GA, LA, MS, NC, SC, TX					
Seminole bat *Lasiurus seminolus*	AL, AR, FL, GA, LA, MS, NC, OK, SC, TX					
Western yellow bat *Lasiurus xanthinus*	AZ, CA, NM, NV, TX					
Spotted bat *Euderma maculatum*	AZ, CA, CO, ID, MT, NM, NN, NV, OR, TX, UT, WA, WY					
Allen's big-eared bat *Idionycteris phyllotis*	AZ, NM, NV, UT					
Keen's bat *Myotis keenii*	AK, WA				Yes	

[a]Only subspecies *pacificus* (OR) is considered at risk.
[b]Only subspecies *ingens* (AR, MO, OK), *pallescens* (AZ, CA, CO, NM, NN, NV, OK, OR, TX, WA), *townsendii* (CA, ID, NV, OR, WA), and *virginianus* (KY, NC, VA, WV) are considered at risk.
[c]Only subspecies *ingens* (AR, OK) and *virginianus* (KY, NC, VA, WV) are ESA-listed.
[d]Only subspecies *oxalis* (CA) is considered at risk.
[e]Only subspecies *pahasapensis* (NE, SD, WY) and *vespertinus* (CA, OR) are considered at risk.
[f]Only subspecies *semotus* (HA) is ESA-listed.

occupy. Not all bats will use these spaces, but bats that do will typically crawl into the space. Besides cracks and crevices, typical points of entry into buildings include expansion joints and holes (BCI 2012). Bats can navigate holes with diameters as small as 5/8 to 7/8 in. Other entryways must be at least 5/16 by 1 1/2 in. Internal cavities can be as small as the size of a bat (minimally 0.5 by 2 in. for the smallest of species) or much larger (BC Ireland 2014).

2. Exterior Roosts

Some bat species use "night roosts" for shelter while digesting their food. These exterior roosts serve as temporary rest stops during nightly feeding activities. Night roosts are chosen for warmth and are often close to feeding sites. Areas under small eaves near doorways or under overhangs at the corners of buildings may be used. The bats are gone by daylight but may leave telltale signs via urine stains and guano. Somewhat related, there are also bat species that use exterior surfaces as roosts during the day. These are generally small populations that hide behind shutters or signs on buildings.

3. Attics and Similar Openings

Attics and similarly sized spaces are larger, open spaces that provide sufficient space for bats to fly as necessary within the space. Entryways for bats must be at least as large as those indicated above for cracks, crevices, and small cavities. Internal dimensions for the roosting space should be 9 by 16 ft or larger (BCT 2012). Joists or beams may be necessary for bats to roost. These spaces should be completely open and exclude trusses and other potential obstacles to flight.

4. Flyways

Flyways allow bats that cannot crawl to fly directly to a roost in an attic or other large open space. The needed dimensions of the opening depend on the size and wingspan of the bat species.

Opportunities for Bats and Buildings

A number of European countries have passed laws that protect all resident bat species. Various organizations in these countries have developed brochures and booklets to help property owners and architects accommodate bats in buildings. These include detailed diagrams of the structural components useful to bats and how to "build in" housing for bats. See Table 2 for a listing of publications for this purpose.

Most designs that incorporate space for bats in buildings include specially designed bat boxes inside exterior walls or decorative boxes on the outside of these walls (Fig. 1). Bat boxes incorporated into exterior walls are designed to fit between wall insulation and exterior finishing material. Bat boxes attached to the outside of exterior walls oftentimes incorporate design elements that add to, rather than detract from, the overall building aesthetics.

Farms, nature lovers, and other individuals with interest in bats will often accommodate bats in larger open spaces, such as attics, barns, garages, outbuildings, abandoned buildings, and other structures without human occupants.

Specifications for building components to accommodate bats can be obtained from the sources and publications identified in Table 2. Several important considerations are briefly described in the following sections.

Special Considerations

Surface Requirements

Bats require surfaces with texture for grip. This is important for both roosting and maneuvering. Additionally, surfaces must be nontoxic and noncorrosive (BCT 2018).

Thermal Regulation

Bat boxes need to create favorable thermal conditions before they will be used by bats. Proper design and location are essential. The internal bat box temperature for maternity colonies should be between 80 and 100 °F (BCI 2018d). Optimal design and location will depend on local climate. Some features to consider are bat box color (dark for heating), venting (for cooling), sun exposure, and caulking (to trap heat). Experimenting and offering multiple boxes, designs, and locations will improve your odds of attracting bats. See Bat Conservation International's excellent publication *Criteria for Successful Bat Houses* for more information (BCI 2018d).

Landscaping

Bats rely on the same key elements as other wildlife. They require habitat that offers food, water, and protection from predators. Some species of bats will generally only roost in close proximity to water. Ponds and native vegetation, besides adding to the beauty and value of urban property, can serve as excellent sources of food, water, and cover for bats. See *Landscape and Urban Design for Bats and Biodiversity* for specific ideas (Gunnell and others 2012).

Chemical Applications

It is against the law to use poisons to remove bats (BCI 2018b). Likewise, wood surface treatments containing toxic chemicals should be avoided.

Lighting

Although bats have good eyesight, they are nocturnal animals. They are adapted to operating in the dark. This means that lighting is usually not beneficial, and may be problematic, for bats (Stone and others 2015). Lights should be situated to avoid shining on bat roosts, openings, and

Table 2—Publications providing detailed information for incorporating bats into building design

Publication	Citation	Website
Bats & Buildings	BCI 2012	www.batcon.org
Bats and Buildings	BCT 2012	www.bats.org.uk
Bat House Builder's Handbook	BCI 2013	www.batcon.org
Bats in Buildings	BC Ireland 2014	www.batconservationireland.org
Building Bat Friendly	Landschapsbeheer Flevoland 2011	www.eurobats.org
Designing for Biodiversity: A Technical Guide for New & Existing Buildings	Gunnell and others 2013	www.ribabookshops.com

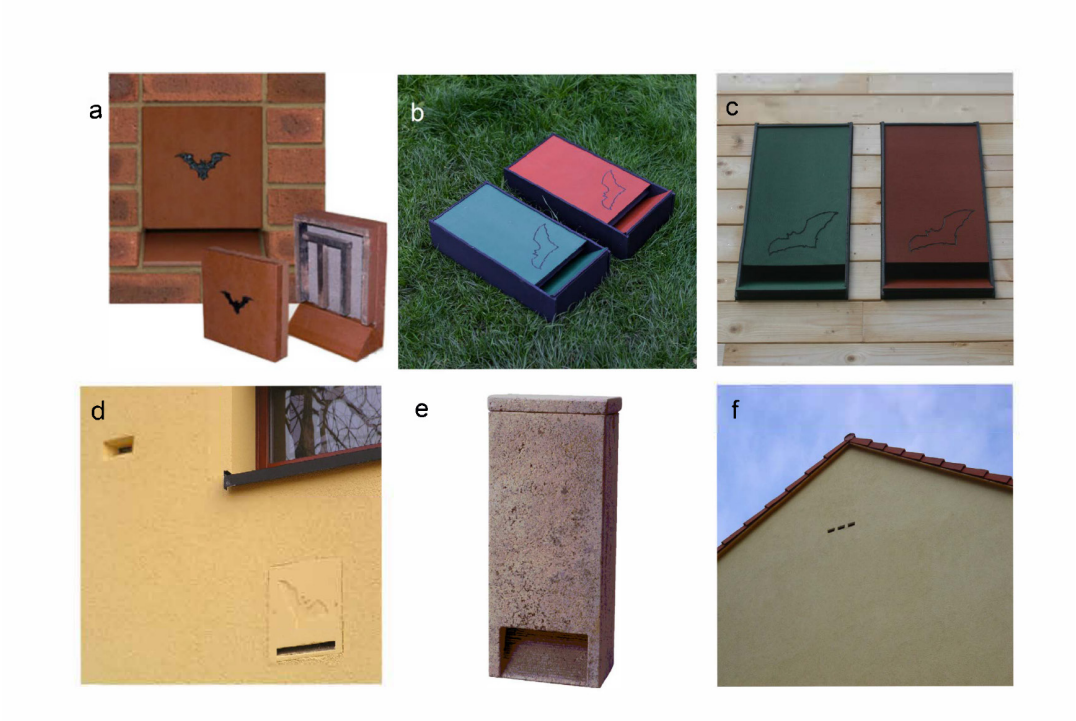

Figure 1. Examples of bat boxes available: (a) Bat Box C from Ibstock Kevington (Leicestershire, UK); (b) integrated Eco Bat Box from The Nestbox Company (Hampton-in-Arden, UK), preinstallation; (c) integrated Eco Bat Box from The Nestbox Company, postinstallation; (d) bat access panel from Schwegler (Heinkelstraβe, Schorndorf, Germany) (with optional back plate); (e) bat tube from Schwegler (preinstallation); (f) bat tube from Schwegler (postinstallation). ((a) copyright Ibstock Kevington, (b) and (c) copyright The Nestbox Company, and (d), (e), and (f) copyright Schwegler GmbH. All photos used with permission.)

flight lines to and from the roost. See *Bats and Lighting in the UK* for ideas on how to avoid the potential negative effects of lighting on bats (BCI/ILE 2009).

Remodeling

If a remodeling project is planned for a building hosting bats, the project should be timed to avoid disturbance. In the summer, some buildings may host maternity colonies. In winter, some species of bats hibernate in buildings. In either case, disturbance would be detrimental. Some states have passed legislation protecting bats during the maternity season.

Protecting Human Space

Bat forays into homes and offices are generally not well received. It is essential that areas incorporating roosts for bats be well sealed from the spaces used by people.

Guano

Bat droppings are called guano. Guano is largely made up of the exoskeletons of insect prey. It crumbles easily, and because of its high nitrogen content, it makes good fertilizer. Bat roosts in or attached to buildings should provide a vertical drop, which will allow gravity to remove the guano. Bats also excrete urine. A small ledge at the base of the roost opening can help decrease staining to the building siding.

Human Health Risks

Bats are one of many wild animals that can carry rabies. Rabies is a deadly disease. If you are bitten or scratched by a bat, you should seek medical treatment. If possible, capture the bat and have it tested for rabies. See Bat Conservation International's publication *Bats and Rabies: A Public Health Guide* for additional information (BCI 2018e).

Accumulations of guano in the soil or attic can be colonized by the fungus *Histoplasma capsulatum*. Humans can become susceptible to the disease histoplasmosis by inhaling spores of the fungus. Most infections result in mild symptoms, but outcomes can be severe for high-risk individuals. With precautions, small quantities of guano can be cleaned up with soap and water. Larger quantities should be left to environmental health professionals. See the Illinois Department of Human Health publication *Health Hazards Associated with Bird and Bat Droppings* for guidance (IDPH 2018).

Excluding Bats

As mentioned above, some states have passed legislation protecting bats during their maternity season. If a bat is found within a building and must be removed, contact your state or county wildlife specialist for a recommended approach and/or list of reputable contractors.

Seeking Help

A wildlife biologist or similarly trained professional specializing in bats should be consulted before undertaking any project to incorporate bat housing within buildings. A professional can help identify species found in your area, narrow down options and develop specifications for bat housing, and provide other ideas (for example, landscaping) for ensuring an effective solution.

Further Research

Bats have historically not received as much scientific attention as other charismatic species (for example, birds, deer, and wolves). It's only recently, with the discovery of white-nose syndrome, that research time and money has turned to bats. This means that there is a lack of information about bat behavior. However, this presents opportunities for further research.

One particular research need involves bats and urban areas. What bat species are attracted to urban areas of the United States? Which species are the "winners" and "losers" as landscapes begin to urbanize? Does urbanization help or harm at-risk species? How might the long-term trend toward larger urban areas affect bat species?

Another area of opportunity for scientific research involves bats and urban design. How can urban design help bat and other wildlife species survive and thrive in urban areas? What are the most significant needs of bat species living in U.S. urban areas? What are specific urban design elements (for example, landscaping configurations) that can help species in urban areas? What are the effects of supplemental housing (bat boxes) on bat populations in urban areas?

There is a need for additional information about the specific housing needs of bat species living in the United States. For species that occupy human structures, what are the design specifications for building owners who want to encourage bats? How can bat biologists, green builders, and other architectural innovators work together to ensure sustainable building practices that also help secure the future of bats and other at-risk wildlife species?

What are the ecological and economic implications of bats in urban areas? Do bats significantly affect other flora and fauna in urban areas? Do bats in urban areas contribute significant insecticide services locally and to adjacent agricultural areas? These are all questions that deserve further research.

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