VI. URBAN DEVELOPMENT

By Amy C. Englert and Daniel J. Neubaum

The management of bats in the rapidly urbanizing West is becoming an increasingly important undertaking. Colorado's population growth was second in the U.S. from 2014-2015, increasing by almost 100,000 people, with similar increases projected into the future (Garner 2016). The Front Range has been impacted the most, accounting for 96% of the growth between 2010 and 2015 (Fig. 6.1). Research on bat use of anthropogenic features clearly shows that the spread of urban environments is a multifaceted and complex issue with each bat species found in Colorado reacting differently to the associated factors.

Threats related to urban development include loss of foraging habitat, effects from pollution, and a negative image of bats due to roosting in urban structures. Bats using buildings, particularly large maternity colonies, may have undesirable effects, especially when guano accumulations create odors and stains, or become large enough to stress the structural integrity of building components such as ceiling supports and sheathing. Use of anthropogenic structures by bats also carries implications for public health as it increases the chances of interactions with people, particularly when animals become

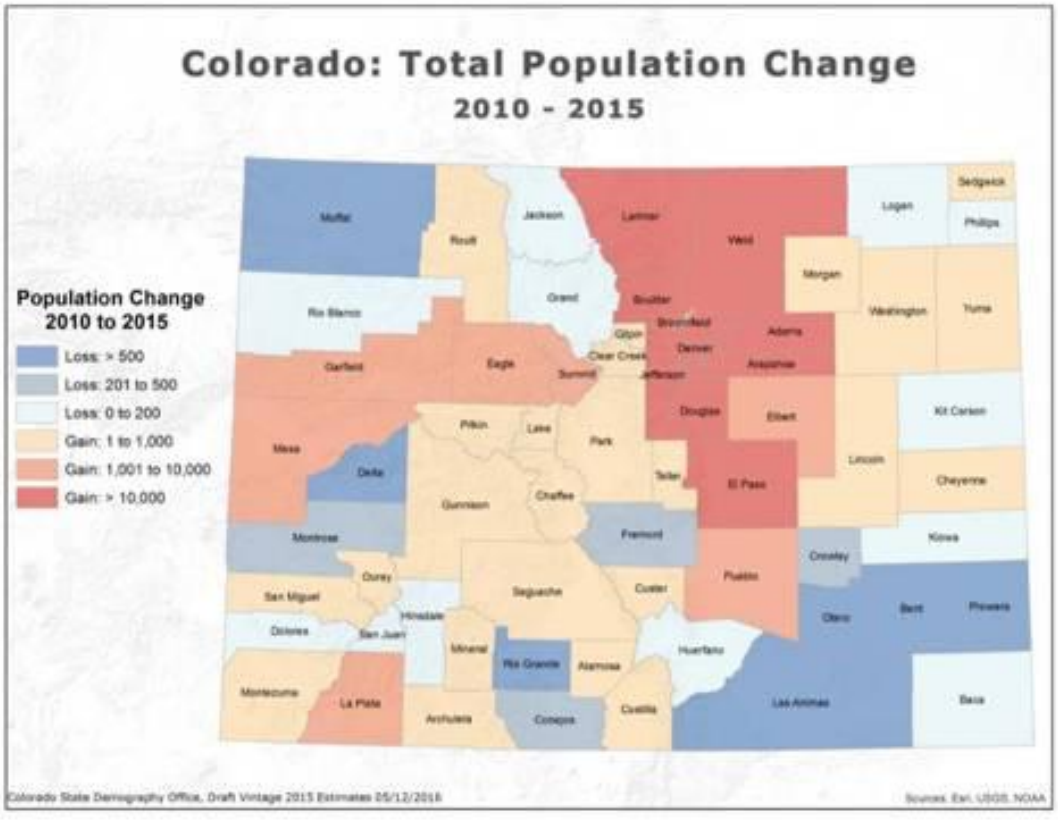

Figure 6.1. Total population change in Colorado from 2010 – 2015. Colorado State Demography Office, 2016.

sick. Conversely, Neubaum et al. (2007) found urban development may increase the number of potential roosts for Colorado bat species that commonly use anthropogenic structures such as the big brown bat (*Eptesicus fuscus*) and little brown myotis (*Myotis lucifugus*). Not surprisingly, the natural adaptations of different species help to determine how likely they may be to use urban environments. Bats that are adapted to cluttered environments generally do not become accustomed to urbanization as readily as faster-flying species that select open environments (Avila-Flores and Fenton 2005; Luck et al. 2013).

We address five categories of issues relating to urban development in Colorado: changes in urban habitats, roosting ecology of anthropogenic structures, foraging, pollution, and disease.

URBAN HABITAT

Urban landscapes differ from natural bat habitats in many obvious ways, but some habitat modifications have the potential to affect bat populations to a higher degree, including habitat fragmentation, artificial lights, and noise pollution. Roads and bridges may fragment habitat even in lightly developed areas. Bats have been shown to adjust their flight paths to avoid crossing roads, especially low-flying species (Bennett and Zurcher 2012; Berthinussen and Altringham 2012). Bats using urban areas may also be at a higher risk for motor vehicle collisions, which can be a significant source of bat mortality (Bennett and Zurcher 2012) and have been found to select roosts in areas with lower traffic densities (Neubaum et al. 2007). One study documented more bats turning away from roads where noise levels exceed 88 dB, but this disturbance threshold may differ among species (Bennett and Zurcher 2012). Noise pollution is more likely to be present in heavily urbanized areas than less developed suburban areas. Although studies of urban noise pollution impacts on bats are limited (Bennett and Zurcher 2012), a study in northwestern Colorado found that bats were less likely to use areas of oil and gas development due to noise pollution (Warner 2016). Greenbelts, urban parks, and other natural areas can provide good habitat and safe travel corridors for bat use, and are important considerations when planning new urban development. Artificial lights in urban environments have been shown to affect some species negatively, and others positively (Berthinussen and Altringham 2012; Williams 2012; Lewanzik and Voigt 2014).

GOAL

MAKE URBAN AREAS MORE SUITABLE FOR SPECIES THAT ARE SENSITIVE TO THE PRESENCE OF ROADS, ARTIFICIAL LIGHT, AND NOISE POLLUTION.

Objective 1: Partner with Colorado Department of Transportation (CDOT) and local transportation departments on issues regarding bat use of roads and bridges for roosting habitat and travel corridors.

Objective 2: Increase knowledge of baseline bat populations using urban and transitional areas.

MANAGEMENT RECOMMENDATIONS

- Construct structures to increase road permeability in areas near large urban bat colonies. These can include over or underpasses, or guidance systems (Altringham 2011).
- Plant vegetation along roads as sound buffers near large urban bat colonies (Bennett and Zurcher 2012).
- Promote "Dark Sky" practices.

RESEARCH NEEDS

- Determine which bat species are most susceptible to light and noise pollution.
- Determine which bat species are most affected by road construction.
- Determine the effectiveness of methods used to increase road permeability.
- Determine the size needed for natural areas to benefit urban bat colonies.

URBAN ROOSTING ECOLOGY OF ANTHROPOGENIC STRUCTURES

The relationship between roosting ecology and urbanization is a complex one. Some species seem to benefit from new urban structures, in some cases actually preferring them to natural roosts (Lausen and Barclay 2006; Allen et al. 2010; O'Shea et al. 2010). Other species, like pallid bats (A*ntrozous pallidus*), seem to be intolerant of urbanization (Miner and Stokes 2005). Tree-roosting bat species may be negatively impacted by urbanization because tree snags are likely to be removed for aesthetics or safety concerns (Duchamp and Swihart 2008). Conversely, urbanization of former grasslands and shrublands along the Front Range has resulted in the planting of more live trees which may benefit other bat species (Neubaum 2005). Bat populations may be impacted by the loss of roosting habitat through the modification and/or replacement of bridges (Keeley and Tuttle 1999) and the eviction and/or killing of bats roosting in houses and other buildings. Urban sprawl may increase roosting opportunities for those species which appear to accept the hazards of anthropogenic roost use in exchange for potential benefits such as warmer roost temperatures (Racey and Swift 1981; Neubaum et al. 2007).

Maternity roost in a building, and large guano pile in an attic. Photos by D. Neubaum.

On the northern Front Range of Colorado Neubaum et al. (2007) documented big brown bats using a wide array of anthropogenic structures for maternity colonies including barns, houses, businesses, churches, schools, a stadium, and apartment buildings. The timing and extent of anthropogenic structure use may vary by species as well. Little brown myotis were shown to use buildings for short stints in late summer and early autumn as transition roosts once maternity colonies began to disperse (Neubaum 2018). Roosts in urban areas may put bats at a higher risk for predation by owls, human commensals like magpies, and domestic animals like cats (Van Horne 1983; Ancillotto et al. 2013). Disturbance of bat roosts in urban settings may negatively affect bat populations. For example, big brown bats were excluded from 30-35% of maternity roosts in anthropogenic structures that were studied over a 5 year period (Neubaum et al. 2007, O'Shea et al. 2011). No long-term effects on reproduction or survival were noted for the marked bats from the study, suggesting that this species can tolerate some level of disturbance. The need to exclude bats from anthropogenic structures may arise for a number of reasons, such as health concerns (e.g., roosts in schools and day care centers; O'Shea et al. 2011), remodeling efforts, or special management (e.g., roosts in historic buildings; Fagan et al. 2017). Use of anthropogenic structures outside of highly urbanized settings is not uncommon and presents owners with many of the same challenges noted above. Inconveniences to building owners or managers may reinforce negative stereotypes regarding bats as pests in the eyes of the general public.

GOAL

PREVENT THE DECLINE OF BAT SPECIES ASSOCIATED WITH URBAN ROOSTS IN COLORADO, WHILE PROMOTING THE BENEFICIAL EFFECTS OF BATS LIVING IN URBAN AREAS AND PROPER TECHNIQUES FOR DEALING WITH SITUATIONS WHERE BATS BECOME A NUISANCE.

Objective 1: Encourage use of humane exclusion methods that incorporate seasonal timing stipulations and suitable/safe exclusion materials.

Objective 2: Promote the use of properly constructed bat houses in urban settings to alleviate nuisance bat problems, control insect pests, and advance bat conservation.

Objective 3: Promote awareness of the implications of bats to human health in Colorado. Work with the Colorado Department of Public Health and Environment, the public school system, and others to reduce fear of bats, and educate on the proper approach to bat/human interactions.

MANAGEMENT RECOMMENDATIONS

- Provide information to state, federal, and county pest control agencies, and to private companies regarding best management practices on excluding bats from houses, and encourage non-lethal techniques.
- Promote the use of bat houses in urban settings with nuisance bat problems using designs and placement shown to be most effective (White 2004; Mering and Chambers 2014).
- Promote exclusions rather than extermination if owners wish to remove bats. Encourage proper timing of exclusion work to coincide with when bats are not using the structures (generally

- October – March for maternity colonies) to avoid entrapment of bats inside the roost. If exclusion work cannot wait until bats are gone for the season, suggest use of humane devices such as mesh netting or one-way doors that allow egress but not entrance.
- Work with the Colorado Historical Society and others to promote the preservation of important bat roosts in historic buildings.
- Work with CDOT and local transportation departments to make staff more aware of the relationship of bats and bridges, and to conserve roosts in those structures when opportunities develop.
- Provide information to CDOT regarding bridge designs and modifications that are compatible with bats.

Large Brazilian free-tailed bat colony using an overpass. Photo by D. Neubaum.

RESEARCH NEEDS

Biologist inspecting a maternity roost under a bridge. Photo by J. Gore.

- Obtain data on the use and importance of bridges in urban versus rural locations. Complete basic bridge surveys.
- Research the roosting potential provided in new developments to determine if loss of historic roosts in old buildings and bridges is offset by new development. (See Williams and Brittingham 1997 and Neubaum et al. 2007 for opposing views on this topic.)
- Determine if bat species that are roosting in urban settings are expanding their range or vacating natural historic habitat.
- Determine if predation due to human commensals or feral/outside domestic cats is a large factor in urban bat mortality (Ancilloto et al. 2013).

URBAN FORAGING

Some bat species are able to successfully forage in urban developments, while others may have difficulty. This variability probably depends on the preferred type of insect, flight speed, maneuverability, and tolerance to artificial light by bats. For instance, Brazilian free-tailed bats (*Tadarida brasiliensis*) have been documented to be more active in lighted areas (Avila-Flores and Fenton 2005; Williams 2012). Larger urban colonies may create more foraging competition, resulting in bats that need to travel longer distances to forage effectively. This can lead to lower individual fitness,

which is partially determined by body condition (Van Horne 1983). Everette et al. (2001) noted that big brown bats foraging at the Rocky Mountain Arsenal moved from 9.2–18.8 km back to houses in Denver where they roosted during the day. In Fort Collins this species averaged 5.9 km between maternity roosts and foraging areas with some individuals moving as far as 18 km a night (O'Shea et al. 2011). In both studies, big brown bats were leaving a highly urbanized setting to forage in adjacent natural areas and agricultural lands. Some green building practices, like "green roofs", may increase bat foraging in dense urban landscapes (Pearce and Walters 2011). Additionally, open space, parks, and artificial water sources in urban environments have been shown to foster bat activity, and could increase survivability (Kurta and Teramino 1992; Everette et al. 2001). This is especially true with the loss of wetland habitat due to urbanization.

GOAL

TO PROTECT AND AUGMENT AREAS THAT FOSTER GOOD FORAGING CONDITIONS FOR BATS.

Objective 1: Promote acquisition of open spaces within and adjacent to urbanized areas that retain native plant and insect communities.

Objective 2: Restore native plants in natural areas and large parks to increase insect populations for bat species that are specialized feeders.

Objective 3: Work with other agencies to help maintain populations of native insects that are important parts of the food base for urban bats.

Objective 4: Work to conserve the quality and accessibility of urban water sources, which may provide important foraging and drinking sites, especially in the arid west.

Objective 5: Preserve and improve wetland habitat through land use planning.

MANAGEMENT RECOMMENDATIONS

- Locate large urban colonies with the help of the public, and work with city governments to conserve and protect water resources in the immediate areas.
- Work with current wetland conservation programs to protect wetland habitat, such as the Wetland Wildlife Conservation Program through Colorado Parks and Wildlife, and the Marsh Program through Ducks Unlimited, etc.
- Promote the use of bat houses in urban wetland areas.

RESEARCH NEEDS

- Verify whether green roofs, gardens, and small parks in heavily urbanized areas are used by foraging bats.
- Determine the degree to which bats use greenbelts, and whether they use them for roosting, foraging, commuting, and/or other purposes.

- Expand current knowledge of the use of wetlands by bats in urban settings.
- Document the benefits of insect control by bats in urban settings.

POLLUTION

As more pollution from point and nonpoint sources impact water and air quality in urban and agricultural areas, the question of how this may affect bat populations becomes more salient. Bats may be directly poisoned by water, air, or roost contaminants, but they may also be indirectly impacted by contamination of the insects they consume (O'Shea and Johnston 2009). Biomagnification of toxins can be a serious threat to bats due to their consumption of insects with high contamination levels, high levels of food intake, and long lifespans. This is especially true if the bat species in question has a high dependence on aquatic insects. In Colorado, O'Shea et al. (2001) found concentrations of several pesticides in carcasses, brains, stomach contents, and guano from big brown bats captured at the Rocky Mountain Arsenal National Wildlife Refuge adjacent to the city of Denver. Bats in that study showed higher contamination levels than other mammals tested at the site, suggesting that the chemicals could be concentrated in the food sources bats are selecting. The liberal use of insecticides and herbicides in both urban and agricultural areas can erode the prey base of bats. Wickramasinghe et al. (2004) documented that bats discern differing levels of insect abundance tied to use of chemicals and are subsequently more apt to forage over organic rather than conventional farms. Urban mosquito control efforts may be another method that introduces such chemicals to wetlands. Wastewater treatment plants can drastically change the composition of species in riverine habitats downstream (Pilosof et al. 2013). In a 2007 study, Kalcounis-Rueppell et al. reported that the complement of bat species foraging over rivers upstream and downstream from wastewater treatment plants was notably different, and hypothesized that this is due to the different populations of insects present due to eutrophication downstream of the treatment plants. A similar study by Vaughan et al. (1996) found that results varied depending on the species under consideration. Again, impacts of urbanization on bats are likely to vary by species so careful determination will be required to manage for all bats in an area.

GOAL

DETERMINE THE EFFECTS OF AIR AND WATER POLLUTION ON URBAN BAT POPULATIONS, AND FORMULATE REALISTIC STRATEGIES FOR MITIGATION.

Objective 1: Promote awareness of potential impacts to bat populations from urban pesticide spraying programs.

Objective 2: Work with local agencies to enact water quality standards and appropriate disposal of pollutants.

Objective 3: Test water quality and insect communities for bioaccumulation of residues at sites with a known or suspected history of contamination.

MANAGEMENT RECOMMENDATIONS

- Work with urban managers and landowners that perform weed and pest-control spraying to use more sustainable practices and promote public awareness about bats.
- Partner with clean water initiatives to provide suitable water sources for bats.
- Promote organic farming practices that reduce chemical use while reducing contamination issues of bats.

RESEARCH NEEDS

- Develop studies to evaluate the impacts to bat populations from urban and natural area pest spraying programs (e.g., mosquito spraying for West Nile virus control).
- Perform studies to determine the concentrations of toxins being stored in bat tissues as a result of biomagnification through the food chain.
- Determine how water pollution from wastewater treatment plants and agricultural effluvia affect insect and bat populations.

DISEASE RISK

Much of the negative stigma regarding bat colonies using anthropogenic structures relates to disease. Disease is addressed in its own section of the plan (see chapter VII. Bats and Disease), but it is worth questioning whether disease ecology is different in urban colonies, and what impact this may have on bat populations and human health. Diseases associated with bats, particularly rabies, often drive fears and perceptions of bats, and ultimately dictate whether people choose to exterminate or evict them from structures (O'Shea et al. 2011). Spread and susceptibility of rabies in a population of big brown bats using a highly urbanized setting along the northern Front Range of Colorado provided a number of insights into the relationship of this disease and the bat hosts (O'Shea et al 2014). Exposure to the disease, measured by prevalence of neutralizing antibodies, or seroprevalence, varied in bats by roost site, sex, and age. Histoplasmosis, a fungus associated with guano accumulations in anthropogenic structures, is not considered to be a human disease concern in Colorado based on the absence of known cases in the state and the dry climate which inhibits fungal growth (Baddley et al. 2011; Benedict and Mody 2016; see chapter VII. Bats and Disease).

GOAL

DETERMINE IF A BETTER UNDERSTANDING OF DISEASE ECOLOGY OF BATS CAN POSITIVELY INFLUENCE PUBLIC PERCEPTION AND TOLERANCE OF BATS THAT ARE USING ANTHROPOGENIC STRUCTURES AS ROOSTS AND URBANIZED AREAS FOR HABITAT.

Objective 1: Encourage safe watchable wildlife opportunities with bats through educational programs for both children and adults.

Objective 2: Determine if urban bats are at a higher risk for disease, especially zoonotics, compared to bats living in natural areas.

Objective 3: Work with and educate public health officials, pest control companies, and the public about the risks of rabies and histoplasmosis in Colorado.

Objective 4: Educate the public, particularly those at high risk such as children, how to deal with sick bats when encountered.

MANAGEMENT RECOMMENDATIONS

- Educate the public on safe interaction with bats, especially where roosts are present in occupied buildings.

RESEARCH NEEDS

- Determine whether roosting behavior and colony size are different in urban colonies.
- Determine if colony size or parasite load can affect the transmission of other diseases besides rabies (Pearce et al. 2007).

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