III. ROCK CREVICE MANAGEMENT PRACTICES

By Daniel J. Neubaum

Of the roughly 34 bat species that regularly occur in the western regions of North America, 25 of these species use rock crevice or cavity roosts (Bogan et al. 2003). As O'Shea and Bogan (2003) emphasize, the lack of knowledge about the use of such structures by bats is largely due to the difficulty of observing and studying them in such situations. With the recent improvements made to miniature radiotransmitters, several studies have recently described the characteristics of rock crevices used by several bat species in Colorado and western North America. Summer roosts in rock crevices may be used by bats even in areas where other suitable roosts such as trees, caves, and buildings exist. Chung-MacCoubrey (2008) tracked reproductive females of several bat species to rock crevices and erosion tubes in the Book Cliffs near Grand Junction, CO. Work by O'Shea et al. (2011) and Snider et al. (2013) at Mesa Verde National Park found that several species, including spotted bats (*Euderma maculatum*), little brown myotis (*Myotis lucifugus,* noted as *Myotis occultus* in study), long-eared myotis (*M.evotis*), fringed myotis (*M. thysanodes*), and long-legged myotis (*M. volans*), used rock crevices as maternity roosts despite the availability of potential tree roosts. Similar findings in Colorado National Monument documented 10 species using rock crevices as maternity roosts, generally on east-to-southeast facing cliffs (Neubaum 2017). Male pallid bats (*Antrozous pallidus*) were found using only rock crevices, typically in cliff faces, as summer bachelor roosts in southeast Colorado (Schorr and Siemers 2013). Navo and Gore (2001) noted a maternity colony of big free-tailed bats (*Nyctinomops macrotis*) using a rock crevice in west-central Colorado, which corresponds with findings for this species in adjacent western states. Recent radiotracking of little brown myotis in the Crystal River Valley found these bats leaving maternity roosts in anthropogenic structures and using rock crevices and boulder fields, among other features, as fall transition roosts and presumed winter hibernacula (Neubaum 2018). Similarly, big brown bats (*Eptesicus fuscus*) undertook short migrations in elevation from maternity roosts in urban structures along the Front Range of north-central Colorado to winter hibernacula in rock crevices in the adjacent foothills and mountains (Neubaum et al. 2006). Thus, use of such rock crevices by bats as summer maternity roosts, fall transition roosts, and hibernacula in Colorado is more extensive than supported by the literature as recently as a decade ago. Rock resources in the form of cliffs, talus, and boulders are abundant across much of Colorado (Fig. 3.1).

Big brown bat in rock crevice. Photo by D. Neubaum.

Figure 3.1. Terrain Roughness Index of Colorado where brighter white colors reflect steeper, more rugged terrain that is more likely to be composed of cliff faces, talus slopes, and other rock crevice resources at the ground surface that could be used by bats (layer development by M. Flenner, CPW GIS section).

Management implications for bats using rock crevices as roosts in Colorado may be particularly important in forested areas where large surface disturbances such as fire, logging, or fuel reduction have occurred (Sheffield et al. 1992; see chapter IV. Forest and Woodland Management Practices). In desert and rolling plains ecosystems where trees are rare, surface mining, collection of landscape material and energy exploration may have an impact on rock crevice and cavity roosting bats (see chapters I. Mining Issues and V. Rangeland Management). In addition, a geographical region where a plains–mountain interface occurs also provides a likely area where bats may undertake local migrations to use rock crevices as hibernacula during the winter period (Neubaum et al. 2006). Water impoundments in large valleys where scree slopes and cliff bands are submerged pose significant risks to local bat populations through the loss of roost sites and riparian foraging areas (Rebelo and Rainho 2009). Thus, management considerations should not overlook the importance of seasonal variation in the use of rock crevices by bats. Recreational climbing is increasing in popularity in Colorado (e.g., Jefferson County Open Space, http://climbjeffco.com/). The cracks and crevices in rock faces that provide attractive climbing routes

may also provide sites for rock crevice roosting bats (e.g., Mountain Project, https://www.mountainproject.com/area/106527523/bat-cave-area). Sixteen of 19 Colorado bat species are known to roost in rock crevices along cliff faces that could potentially be disturbed by recreational climbing. However, some species are more likely to be disturbed than others based on the type of rock crevices they typically use. For example, pallid, spotted and big free-tailed bats are known to use large cliff faces (Haymond et al. 2002; O'Shea et al. 2011; Schorr and Siemers 2013; Neubaum 2017) that tend to be popular with climbers while western long-eared myotis in summer (Snider et al. 2013) and big brown bats in autumn (Neubaum et al. 2006) have been found using small cliffs and boulders that are less desirable for such activities. Recreational climbing may disturb or displace bats using rock crevices as maternity roosts if the route is climbed often, increasing the threats to species of concern (Adams and Thibault 2000). Threats related to recreational climbing have been well documented with cliff nesting birds (Boyle and Samson 1985; Camp and Knight 1998) and have led to seasonal route closures. Similar seasonal climbing route closures have recently been implemented by the city of Boulder for bats (https://bouldercolorado.gov/osmp/bat-roosting-closures). Projects like Climbers for Bat Conservation are engaging the climbing community in a collaborative effort to expand our knowledge of crevice roosting bats and examine the potential for impacts from climbing (Fig. 3.2; http://www.climbersforbats.colostate.edu/). The project allows climbers a venue to report how often bat-to-climber encounters are occurring, identify roost sites, and provide new knowledge about bat roosting ecology.

Disturbance of bats using rock crevices is likely to occur through both inadvertent and intentional acts. For example, a documented big free-tail roost in southwestern Colorado (Navo and Gore 2001) has experienced vandalism such as graffiti applied to the rock face below the roost and party activity at the site. The visitors are likely unaware that the bats are using the site but the disturbance may have led to its abandonment as several subsequent surveys in recent years have not found a colony present (D. Neubaum, unpublished data, 2018). O'Shea and Vaughn (1999) noted declining populations of bats, a change in species composition, and roost abandonment of rock crevices and cavities and suggested it may be the result of increased recreational use at the site. Although such occurrences are likely common, reports tend to be anecdotal and infrequent. Sampling historic locations where rock crevice and cavity records exist for bats would help determine how prevalent the issue of disturbance is and suggest avenues of preventing such disturbances in the future.

Although use of rock crevices has been documented for most bat species in Colorado, insight for a number of questions continue to lack defensible data, including the characteristics of crevices used in the selection of a given site by different species and in different habitats and seasons, as well as improved knowledge about colony dynamics (O'Shea and Bogan 2003). We address four categories of issues for rock crevice and cavity roosting bats: inadequate knowledge of bat dependence on rock crevice habitat; surface and subsurface management practices; managing recreation impacts; and intentional disturbance/vandalism.

Figure 3.2. Schematic chart of the relationship between climbers, bats, and conservation. This was developed during meetings between climbers, biologists, and land managers as part of Climbers for Bat Conservation. Artwork by ConverSketch (ConverSketch.com; Karina Branson). Photo by Rob Schorr.

INADEQUATE KNOWLEDGE OF BAT DEPENDENCE ON ROCK CREVICE HABITAT

Current knowledge of bat resources in Colorado rock crevices is insufficient to provide adequate conservation and management actions.

GOAL

GAIN A COMPREHENSIVE KNOWLEDGE OF BAT ROOSTING IN COLORADO ROCK CREVICES INCLUDING IDENTIFYING, PROTECTING AND RESTORING ECOSYSTEMS AND HABITATS CRITICAL TO THE VIABILITY OF BAT POPULATIONS ASSOCIATED WITH THESE FEATURES.

Objective 1: Identify rock crevices that currently support or historically supported bat populations, particularly those within management areas of interest where threat potential is high (e.g., popular climbing areas, large scale water impoundments, areas vulnerable to catastrophic fire events).

Objective 2: Identify the ecosystem components and associated habitats that contribute to viability of bat populations using rock crevices.

Objective 3: Standardize protocols for external surveys of rock crevices to minimize impacts to bats, reduce impacts to other sensitive cliff features (e.g., raptor nests), and provide standardized comparable data.

Objective 4: Determine the seasonal (summer, transitional, swarming, hibernation) dependence of bats on rock crevice features by ecoregion and species.

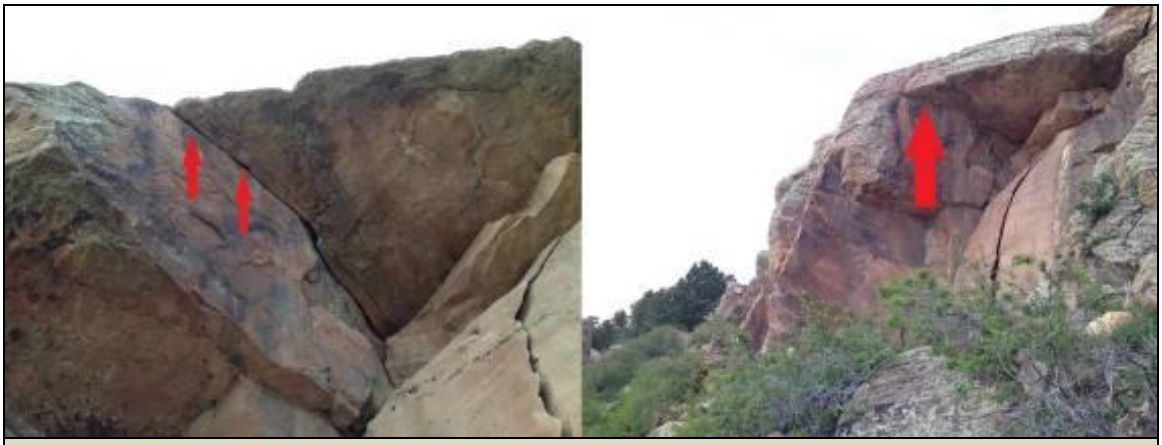
MANAGEMENT RECOMMENDATIONS

- Inventory rock crevices for bat use during maternity, hibernation, migration, and swarming seasons, and monitor those with confirmed use to better understand population dynamics.
- Conduct surveys of rock crevices identified by previous inventory efforts.

- Management of rock crevices used by bats should follow recommendations established for caves to limit the introduction or spread of White Nose Syndrome (WNS), and its causal agent *Pseudogymnoascus destructans* (*Pd*), when appropriate.

RESEARCH NEEDS

- Identify characteristics, both external and internal to the rock crevice to evaluate potential for future use by bats. These characteristics may include microclimate, aspect, elevation, and proximity to foraging and drinking areas.
- Model rock crevice environments to determine optimal roost conditions and factors important for bats. This may include monitoring temperature, humidity, airflow patterns, proximity to water, and location and cover at the entrance.
- Determine if and why bats that use rock crevices roost switch as is seen for other roost types. What is an individual bats fidelity to a given rock crevice?
- Assess the fungal fauna in rock crevice roosts to identify the diversity and potential *Pd* surrogate species that may help predict locations that support *Pd* and potential outbreaks of WNS.



Arrows point to rock crevices where male pallid bats were found roosting in southeastern Colorado. Photo by D. Neubaum.

SURFACE AND SUBSURFACE MANAGEMENT PRACTICES

Surface and subsurface land management practices can change rock crevice roosting environments and lead to their abandonment by bats. Important associated habitat used for foraging, drinking, and night roosting may also be disturbed by such practices.

GOAL

ENCOURAGE SURFACE AND SUBSURFACE LAND MANAGEMENT PRACTICES THAT REDUCE IMPACTS TO BAT POPULATIONS, ROCK CREVICE ROOSTING ENVIRONMENTS, AND NEARBY HABITAT ASSOCIATED WITH THESE SITES FOR FEEDING, DRINKING, AND RESTING.

Objective 1: Encourage land managers to use guidelines that maintain critical rock crevice resources for bats. Management plans with best management practices (BMP's) should be referenced for bat-specific management guidance.

MANAGEMENT RECOMMENDATIONS

- Identify nearby foraging, drinking and roosting sites critical to rock crevice-obligate or -affiliate bat species. Protecting these features for bats roosting in nearby rock crevices will reduce their energy expenditures.
- Implement zones of "no impact" or "limited impact" from surface management activities around known rock crevice roosts (contact bat biologists from CBWG if guidance is needed).
- Apply seasonal restrictions to avoid disruption of maternity, swarming, hibernation, or other critical life-cycle activities when surface management activities such as timber sales and road building are proposed near known roost sites. These buffer zones should reflect the species composition and sensitivity of roost sites. For example, at Townsend's big-eared bat sites, seasonally restrict timber harvest activities and road building within a 0.25mi radius buffer around roost sites with bat use. In addition, these activities should be restricted seasonally to avoid disturbance to Townsend's maternity roosts (early May–late August) and hibernacula (mid October–mid March). The critical time periods of hibernation and maternity activity may vary by species regionally and should be determined by a qualified biologist (Pierson et al. 1999).
- Maintain or improve riparian and wetland habitats near roosts, which are inhabited by species of concern or considered biologically important to a population, to achieve healthy and diverse foraging structure.

RESEARCH NEEDS

- Study use of rock crevices as roosts before and after large scale forest alterations such as fire, beetle kill, and timber sales.

Objective 2: Encourage the siting of large scale water impoundment projects in areas other than canyons composed of cliff bands and intact riparian drainages so that rock crevice roosts and associated habitat are not inundated by water and permanently lost.

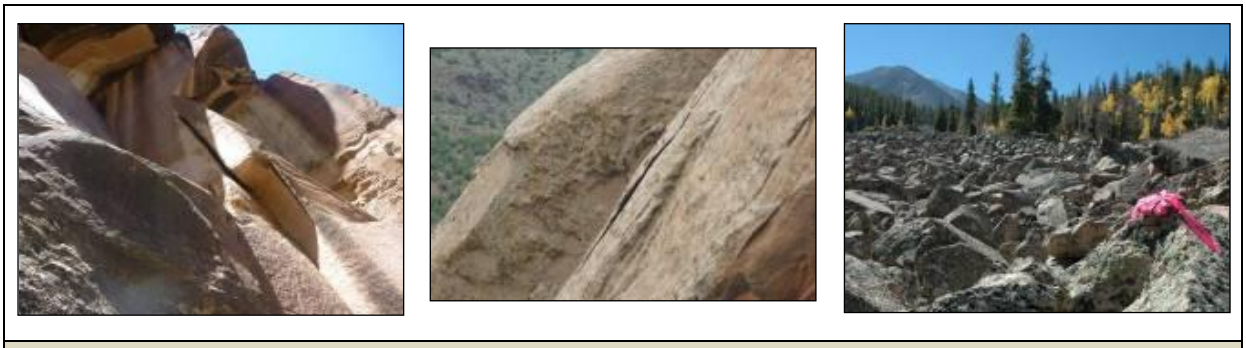
MANAGEMENT RECOMMENDATIONS

- Avoid construction of large scale water impoundments in drier portions of the state, where rock crevices appear to be utilized more extensively by a wide array of bat species, if alternative sites exist (Nilsson and Berggren 2000).
- Conduct surveys of bat use pre- and post-development for large scale water impoundments to identify changes in activity levels, displacement from roosts, and increased competition in habitat adjacent to the inundated area.
- Develop and restore nearby or adjacent riparian zones to provide alternative habitat for displaced bats. Riparian habitat that provides important foraging, drinking, and night roosting

habitat is lost when large scale water impoundments are installed (Nilsson and Dynesius 1994; Rebelo and Rainho 2009). Ideally, such restoration would use mitigation funds and start well before the impoundment occurs so that the time lag between displacement and newly established and functioning riparian areas is minimal.

RESEARCH NEEDS

- Evaluate the potential habitat loss and population impacts resulting from large scale water impoundment in areas where rock crevices and cavities are prevalent (e.g., canyons).
- Investigate the dependence of bats on larger riparian/river systems as ephemeral water sources are lost or where they are rare. Climate change may reduce the number of ephemeral water sources in areas with drier climates (Adams and Hayes 2008) or where catastrophic fire events fill them with silt (O'Shea et al. 2011).
- Evaluate use by bats of newly created riparian areas along the edges of water impoundments.



Rock crevices utilized by bats during summer in cliff faces and autumn/winter in talus. Photos by D. Neubaum

MANAGING RECREATION IMPACTS

Recreation impacts to bats using rock crevices may occur from disturbance by rock climbers. Recreational climbing at high activity levels may displace roosting bats and compound threats to species of concern.

GOAL

DEVELOP AND IMPLEMENT SOUND ROCK CREVICE RESOURCE MANAGEMENT PRACTICES THAT BEST BENEFIT BATS, AS WELL AS OTHER ROCK CREVICE AND CLIFF RESOURCES (CAMP AND KNIGHT 1998). RECRUIT COOPERATIVE SUPPORT FROM THE CLIMBING, RESEARCH, AND MANAGEMENT COMMUNITIES.

Objective 1: Prioritize protection of rock crevices that contain bat species of concern, especially where these species demonstrate high roost fidelity such as at maternity colonies or hibernacula.

Objective 2: Involve recreational climbers in the process of developing rock crevice/cliff management guidelines in areas where climbing is popular.

Objective 3: Consider the need to protect suitable rock crevice roost sites used by bats by implementing seasonal closures.

Objective 6: Enlist the climbing community to help educate the public about the importance of crevice habitats to bats and the need to report bat use of rock crevices.

MANAGEMENT RECOMMENDATIONS

- Consult with agencies, owners, and the climbing community to identify rock crevices where bats are currently roosting or have historically roosted.
- Develop rock crevice management guidelines that provide for recreational use when consistent with protecting bats and other cliff resource values.
- Implement protective strategies for all significant rock crevice roost sites. The American Society of Mammalogists recommends guidelines to help protect bat roosts (Sheffield et al. 1992). These guidelines were adopted in the Strategy for the Townsend's big-eared bat (Pierson et al. 1999). In addition, the Colorado Bat Working Group has developed a tool to help managers discern roosts that are biologically important to bats (Neubaum et al. 2017).
- Regulate human use for rock crevice roosts with sensitive bat resources by developing climbing management plans, cooperative agreements, and memoranda of understanding, if appropriate.
- Implement seasonal or diurnal use restrictions at known rock crevice roosts during critical bat use periods. Close climbing routes to recreational use from mid October–mid March to protect hibernacula if conditions are warranted and from early May–late August to protect maternity colonies using shallow rock crevices (Neubaum et al. 2017). Additional closures from late August–mid October may be needed if swarming behavior is occurring. The critical time periods of swarming behavior, hibernation and maternity activity may vary regionally and should be determined by a qualified biologist (Pierson et al. 1999).
- Protect rock crevices historically occupied by sensitive bat species.
- Monitor numbers of bats at rock crevice roosts before and after management restrictions are put in place to document effectiveness of actions.

RESEARCH NEEDS

- Develop methods to determine if seasonal closures of cliffs with rock crevice roosts are effective and, if so, to what degree.
- Determine if rock crevice roosts used as hibernacula provide suitable microclimates to harbor *Pd* to inform disease spread management strategies.

GOAL

MINIMIZE IMPACTS OF RECREATIONAL CLIMBING ON CREVICE-ROOSTING BATS THROUGH EDUCATION AND PROACTIVE MANAGEMENT.

Objective 1: Work with the local climbing communities to educate members about the importance of rock crevices to bats and the potential for disturbance by recreational climbing during critical time periods (See the Climbers for Bat Conservation program developed by Colorado Natural Heritage Program, http://www.climbersforbats.colostate.edu/).

Objective 2: Identify localities where recreational climbing activities are high and/or increasing, and may impact bats. Work with management agencies and the climbing community to develop a management plan that helps minimize negative impacts.

Objective 3: Identify sites of overlap where significant bat roosts may occur in cliffs or rock crevices and where future climbing activities may become popular.

Objective 4: Enlist the climbing community to report encounters with bats while climbing so that a better understanding of the threat can be assessed (See the Climbers for Bat Conservation program).

MANAGEMENT RECOMMENDATIONS

- Fund survey efforts to identify roosts for different bat species in areas where climbing is popular to determine if conflicts may be occurring.
- Encourage grass roots efforts such as the Climbers for Bat Conservation program as a way of learning about bat/climber encounters and roost sites (http://www.climbersforbats.colostate.edu/).

RESEARCH NEEDS

- Are all rock crevices created equal or is selection by bats occurring? Determine if crevice-roosting bats are selecting specific rock crevices or areas related to seasonal or regional variations.
- Research the extent of impacts to crevice-roosting bats resulting from recreational climbing.

INTENTIONAL DISTURBANCE AND VANDALISM

GOAL

REDUCE OPPORTUNITIES FOR INTENTIONAL DISTURBANCE OR VANDALISM IN ROCK CREVICES WHERE BIOLOGICALLY IMPORTANT POPULATIONS OR SENSITIVE SPECIES OF BATS ARE PRESENT.

Objective 1: Educate the community about the importance and sensitivity of rock crevice resources, especially where vandalism has occurred.

Objective 2: Consider installing educational and warning signs at sensitive rock crevices used by bats where disturbance and vandalism is occurring.

Objective 3: Monitor rock crevice roost sites where disturbance/vandalism has occurred with devices such as trail or surveillance cameras.

MANAGEMENT RECOMMENDATIONS

- Promote public education about the effects of vandalism at or near sites where bats use rock crevices.

RESEARCH NEEDS

- Evaluate the impact of entrance signs and other education efforts on vandalism, and intentional disturbance.
- Survey historic locations where rock crevice and cavity records exist for bats to determine how prevalent vandalism and intentional disturbance is and suggest avenues for preventing such activities.

LITERATURE CITED

Adams, R. A., and M. A. Hayes. 2008. Water availability and successful lactation by bats as related to climate change in arid regions of western North America. Journal of Animal Ecology 77:1115-1121.

Adams, R. A., and K. M. Thibault. 2000. Location and distribution of diurnal roosts, roost site parameters, home ranges, and water use of Boulder County bats. Boulder County Open Spaces, Boulder, CO.

M. A. Bogan,P. M. Cryan, E. W. Valdez, L. E. Ellison, and T. J. O'Shea. 2003. Western crevice and cavity-roosting bats. Pages 69-77 *in* O'Shea, T. J., and M. A. Bogan, editors. 2003. Monitoring trends in bat populations of the United States and territories: problems and prospects: US Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR--2003-0003, 274 p.

Boyle, S. A. and Samson, F. B. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin. 13(2):110-116.

Camp, R. J. and Knight, R. L. 1998. Rock climbing and cliff bird communities at Joshua Tree National Park, California. Wildlife Society Bulletin. 26(4):892-898.

Chung-MacCoubrey, A. L. 2008. Book Cliff Survey for BLM Sensitive Bats. USDA Forest Service- Rocky Mountain Research Station. Report Interagency Agreement No. BLM-IA #06-IA-11221602-150.

Haymond, S., M. A. Bogan, E. W. Valdez, and T. J. O'Shea. 2002. Ecology and status of the big free-tailed bat (*Nyctinomops macrotis*) in southeastern Utah with comments on Allen's big-eared bat (*Idionycteris phyllotis*), P. 22 pp (B. R. D. US Geological Survey, Midcontinent Ecological Science

Center, Department of Biology, University of New Mexico, ed.). US Geological Survey, Albuquerque, NM.

Navo, K. W., and J. A. Gore. 2001. Distribution of the big free-tailed bat (*Nyctinomops macrotis*) in Colorado. The Southwestern Naturalist 46:370-376.

Neubaum, D. J. 2017. Bat composition and roosting habits of Colorado National Monument & McInnis Canyons National Conservation Area: 2014 to 2016. Colorado Parks and Wildlife. Grand Junction, CO.

Neubaum, D.J. 2018. Unsuspected retreats: autumn roosts and presumed hibernacula used by little brown myotis in Colorado. Manuscript submitted for publication.

Neubaum, D. J., K. W. Navo, and J. L. Siemers. 2017. Guidelines for defining biologically important bat roosts: A case study from Colorado. Journal of Fish & Wildlife Management 8:272-282.

Neubaum, D. J., T. J. O'Shea, and K. R. Wilson. 2006. Autumn migration and selection of rock crevices as hibernacula by big brown bats in Colorado. Journal of Mammalogy 87:470-479.

Nilsson, C., and K. Berggren. 2000. Alterations of riparian ecosystems caused by river regulation: dam operations have caused global-scale ecological changes in riparian ecosystems. How to protect river environments and human needs of rivers remains one of the most important questions of our time. BioScience 50:783-792.

Nilsson, C. and M. Dynesius. 1994. Ecological effects of river regulation on mammals and birds: a review. Regulated Rivers: Research and Management 9:45-53.

O'Shea, T. J., and M. A. Bogan, editors. 2003. Monitoring trends in bat populations of the United States and territories: problems and prospects: US Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR--2003-0003, 274 p.

O'Shea, T. J., and T. A. Vaughan. 1999. Population changes in bats from central Arizona: 1972 and 1997. The Southwestern Naturalist 44:495-500.

O'Shea, T. J., P. Cryan, E. A. Snider, E. W. Valdez, L. E. Ellison, and D. J. Neubaum. 2011. Bats of Mesa Verde National Park, Colorado: composition, reproduction, and roosting habits. Monographs of the Western North American Naturalist 5:1-19.

Pierson. E. D., M. C. Wackenhut, J. S. Altenbach, P. Bradley, P. Call, D. L. Genter, C. E. Harris, B. L. Keller, B. Lengus, L. Lewis, B. Luce, K. W. Navo, J. M. Perkins, S. Smith, and L. Welch. 1999. Species conservation Assessment and strategy for Townsend's big-eared bat (*Corynorhinus townsendii townsendii and Corynorhinus townsendii pallescens*). Idaho Conservation Effort, Idaho Department of Fish and Game, Boise, Idaho. 63 pp.

Rebelo, H., and A. Rainho. 2009. Bat conservation and large dams: spatial changes in habitat use caused by Europe's largest reservoir. Endangered Species Research 8:61-68.

Schorr, R. A., and J. L. Siemers. 2013. Characteristics of roosts of male pallid bats (Antrozous pallidus) in southeastern Colorado, Southwestern Naturalist 58**:**470-475.

Sheffield, S. R., J. H. Shaw, G. A. Heidt, and L. R. McClenaghan. 1992. Guidelines for the Protection of Bat Roosts. Journal of Mammalogy 73:707-710.

Snider, E. A., P. M. Cryan, and K. R. Wilson. 2013. Roost selection by western long-eared myotis (Myotis evotis) in burned and unburned piñon--juniper woodlands of southwestern Colorado. Journal of Mammalogy 94:640-649.