# II. CAVE MANAGEMENT PRACTICES

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The use of subterranean features, such as caves, as bat roost sites is well documented. In the US, many species of bats rely on cave roosts as winter hibernacula, summer nurseries (Pierson 1998; Tuttle 2003), summer bachelor roosts, and migratory stopover sites between seasons, and for swarming activity in the fall (Parsons et al. 2003; Ingersoll et al. 2010). Swarming behavior in and around caves is an activity that is not well understood in western North America (Schowalter 1980; Navo et al. 2002), but could play an important social role for various bat species in Colorado. Consequently, caves are critical resources for bats and have been classified as "essential" for at least 18 species in the continental U.S. (McCracken 1989; Medellin et al. 2017). Caves also provide sites where unusually large aggregations of bats may occur, making the population more vulnerable to disturbance than in other settings (Sheffield et al. 1992). Threats to cave-dwelling bats include disturbances from recreational activity in and around roosts, cave development for tourism and guano mining, improper cave gate design, inappropriate or excessive scientific research (e.g., excessive banding of bats and general disturbance by researchers during critical time periods; Rabinowitz and Tuttle 1980; White and Seginak 1987; Richter et al. 1993; Tuttle 2000; O'Shea et al. 2004), and, more recently, the introduction of White Nose Syndrome (WNS; see chapter VII. Bats and Disease). Direct disturbance to suitable cave roosts can be a serious threat and has resulted in the listing of several bat species under the Endangered Species Act (ESA; USFWS 1976), and population declines of more common taxa (O'Shea and Vaughan 1999). Disturbances to caves can be unintentional (bat disturbance from cavers moving through an area, shining lights or talking) or intentional (shooting or hitting bats, burning torpid bats with torches, or setting fires in caves; Speakman et al. 1991). Commercialization of caves for tourism or guano mining has caused partial or complete abandonment of sites by bats (Elliot 2012). Natural disturbances, such as flooding, can also reduce bat population numbers (DeBlase et al. 1965).

Biologists conducting winter cave survey for bats. Photo by J. Siemers.

In Colorado, karst caves are found primarily in carbonate rocks (Parris 1973; Kolstad 1996) and solution caves are found in gypsum, anhydrite, and quartzite (Reames 2011). Caves are also scattered throughout claystone, alluvial, and talus deposits where they develop along faults and fissures in metamorphic and igneous rock (Parris 1973; Kolstad 1996; Reames 2011). Among cave habitats, areas of karst are known to be most important to Colorado bats (Fig. 2.1) with some notable exceptions, such as a few claystone caves (Davis 1998). Currently, over 1,000 caves are known in Colorado (Derek Bristol, Colorado Cave Survey, pers. comm., 2017), though it is unknown what portion is used by bats. Cave exploration has become more popular, leading to increased year-round visitation at well-known caves (Fish 1999). Many Colorado caves are located at higher elevations which limits access during the winter. However, the popularity of winter recreation such as snowmobiling and skiing has likely increased both cave visitation during winter at these sites and the possibility of disturbing hibernating bats. With increased interest in recreational caving, more people are trying to discover new caves and locate or excavate new passages within known caves (Fish 1999), sometimes using drilling and explosives (Kolstad 1996; Rhinehart 2000).

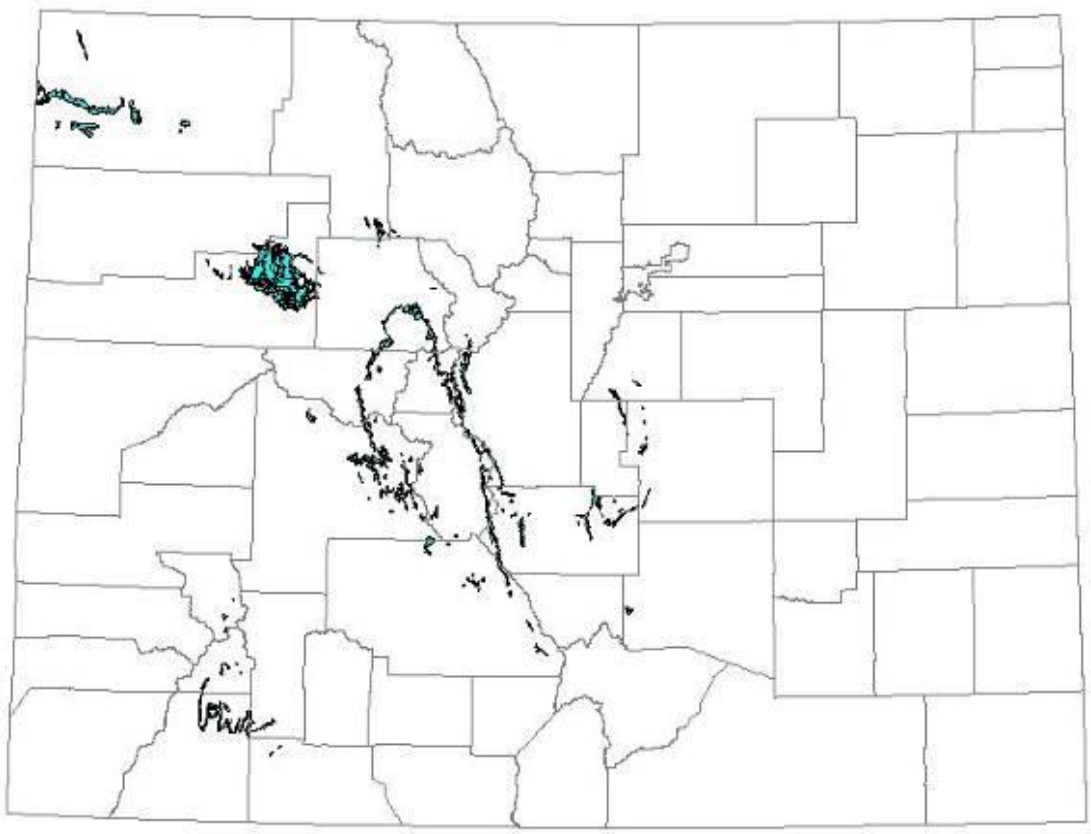

**Figure 2.1.** Karst and limestone formations in Colorado extracted from the digital geological map of Colorado (Green 1992).

Cave access for recreation or research not only risks direct disturbance of bats, but also may introduce invasive diseases, particularly WNS (see chapter VII. Bats and Disease). Since 2007, cave-dwelling bats in the Eastern US have suffered die-offs of 90% or higher due to WNS. Models have shown that areas of Colorado with greater cave concentrations have some of the highest probabilities of susceptibility for introduction of WNS in the country (Ihlo 2013). Consequently, management of cave resources has become increasingly complicated (CPW 2011; USFWS 2011; USFS 2013; Neubaum et al. 2017).

Maternity colony of Towsend's big-eared bats in a cave. Photo by J. Siemers.

Historically, Colorado cave resources were protected because few people knew their locations or gates were installed to limit access. Olson et al. (2011) found that reduced visitation by recreational cavers and researchers to a known cave hibernacula in Alberta, Canada led to increased bat use over time. Where disturbance is a concern, gating is a common method used to protect bat populations. Use of gates should be weighed carefully as both positive and negative outcomes can occur (Elliot 2012). Currently 30 caves in Colorado are gated to limit human access (D. Bristol and K. Manley, Colorado Cave Survey, pers. comm., August 2014). Of these, 12 caves are privately owned with 3 commercially operated as tourist attractions. Ten of the 30 gates were designed to allow some level of bat use. Two additional caves have gates designed only to prevent human access yet continue to have bat use as well. Several gated caves have multiple entrances, some of which are inaccessible to humans but could still be used by bats. In cases where caves were dug open to gain access, gates are designed to minimize changes in variables such as air flow, which in turn prevents alterations to cave climate and protects speleological formation growth and/or persistence. The Townsend's big-eared bat (*Corynorhinus townsendii)*, a state and federal species of concern, has been found in at least 7 of the gated caves (CPW Bat Database, unpublished data). It is unknown if the level of bat use has changed at most gated sites in Colorado as pre-gating surveys were either not conducted or gates have been installed only recently.

Cave protection has also been formalized through legislation (Jones et al. 2003) such as the 1988 Federal Cave Resources Protection Act (16 USCS 4301 et seq., FCRPA). The FCRPA requires protection of caves on federal lands that have been designated as significant as defined in the act. A number of caves in Colorado have met the criteria and been designated as significant. Three of these caves are gated, of which 2 are bat-friendly, and have resource management plans in place. Other laws and regulations that may provide additional protection for cave resources include: the 1897 Organic Administration Act (16 U.S.C. 551), the 1973 ESA (87 Stat. 884, as amended; 16 U.S.C. 1531), the 1906 Antiquities Act (34; 16 U.S.C. 431 et seq.), and the 1979 Archaeological Resources Protection Act (16 U.S.C. 470aa).

Bat populations may be negatively impacted by surface disturbances near caves, such as logging, fuels treatments, wildfire, controlled burns, siltation/erosion events, or slash deposition (Poulson 1976; Sheffield et al. 1992; Jones et al. 2003; Elliott 2012). However, specific impacts to bats using caves have not been studied for many of these threats. Surface energy development may disturb caves when drilling intersects these features at a subterranean level or when surface runoff of contaminants and erosion occur at entrances (Brooke 1996). In Colorado, this risk is highest where energy development has intersected caves occurring in non-carbonate rocks, such as clay stone (see chapter VIII. Energy Development). Application of buffer zones and general best management practices (BMP's) for caves should be implemented (Jones et al. 2003; Elliott 2006, 2012).

Unlike the Eastern U.S., caves in Colorado generally do not support large bat colonies. Historically, efforts to identify use of caves by bats in Colorado were opportunistic in nature relying on occasional reports, often from cavers. A limited number of follow-up investigations were made that resulted in the identification of caves used by relatively large numbers (> 50 individuals) of bats (Armstrong 1972; Finley et al. 1983). Investigations of bat use at caves gained momentum with Navo et al. (2002) documenting swarming activity. This work was followed by efforts to understand what environmental variables influence swarming behavior (Englert 2008; Ingersoll 2010). Siemers (2002) made the first systematic survey of caves in Colorado for bats, observing 8 species, generally in small numbers, across 19 of 99 caves surveyed. The first edition of the Colorado Bat Conservation Plan (Ellison et al. 2004) suggested there is insufficient knowledge regarding caves in Colorado to provide adequate protective conservation and management actions for bats. Select caves on the White River National Forest were periodically surveyed from 2005–2011 (Potter 2005; Mosch 2009) to investigate previous reports of bat use. In 2011, the National Speleological Society's annual convention was held in Glenwood Springs (Reames 2011), raising concerns about the potential to spread WNS, and its causal agent *Pseudogymnoascus destructans* (*Pd*), from infected caves in the eastern US to those in Colorado. Since that time, intensive surveys to investigate seasonal use and swarming at caves on the White River National Forest and Colorado River Valley Field Office of the BLM have improved our understanding of bat use in caves for this part of the state (Neubaum 2016; Siemers and Neubaum 2015).

In this plan, we address four categories of issues related to cave- and karst-inhabiting bats: inadequate knowledge of bat dependence on cave habitat; surface and subsurface land management practices; managing recreation impacts; and intentional disturbance and vandalism.

## INADEQUATE KNOWLEDGE OF BAT DEPENDENCE ON CAVE HABITAT

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

### GOAL

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

**Objective 1:** Identify caves that currently support, or historically supported, bat populations.

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

**Objective 3:** Standardize protocols for both external and internal surveys of caves to minimize impacts to bats, reduce impacts to other sensitive cave features, and provide standardized comparable data.

**Objective 4:** Determine the seasonal (summer, transitional, swarming, hibernation) dependence of bats on cave resources by region and species.

### MANAGEMENT RECOMMENDATIONS

- Inventory caves for bat use, including maternity, hibernation, migration, and swarming use, and monitor those with confirmed use to better understand population dynamics.
- Implement the standards presented in the Species Conservation Assessment and Conservation Strategy for the Townsend's big-eared bat (Pierson et al. 1999; see chapter XI: Species Status, Population Trends, and Monitoring)
- Conduct surveys of caves identified in the Colorado Parks and Wildlife WNS Surveillance Plan (2012), and by district Forests.

### RESEARCH NEEDS

- Develop and improve remote survey techniques including infrared photography, acoustic monitoring, electronic entry and exit counting, and species identification.
- Identify characteristics, both external and internal to the cave, to evaluate potential use by bats. These characteristics may include cave microclimate, elevation, access and egress restrictions created by snow, and proximity to foraging and drinking areas.
- Utilize radiocarbon analysis using accelerator mass spectrometer techniques to age bones or mummified bat remains to confirm historic use of caves.
- Study the relationship between cave water quality and the trace mineral needs of bat species. Monitor water chemistry, especially calcium and sulfate concentration, as well as

microorganisms, pollutants and contaminants. Investigate the possible relationship between the presence of water resources inside caves and bat roost site preference during all seasons.

- Model cave environments to determine optimal roost conditions and factors important for bats. This may include monitoring temperature, humidity, airflow patterns, cave passage geometry and complexity, presence of cave water, and entrance location and cover.
- Determine if and why bats are using multiple caves, as is seen for other roost types. What is an individual bat's fidelity to a given cave?
- Investigate the use of caves for swarming. Can the behavior be quantified and does it lead to use of the site as a hibernacula?
- Evaluate gate designs used on caves. Do gates inhibit or encourage use of caves by bats? Which caves need gates?
- Assess the fungal fauna at caves to identify the diversity and potential surrogate species to *Pd* that may help predict locations that support *Pd* and potential outbreaks of WNS.

Bat friendly gate at cave entrance. Photo by D. Neubaum.

## SURFACE AND SUBSURFACE LAND MANAGEMENT PRACTICES

Surface and subsurface land management practices can change cave 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, CONSERVE THEIR USE OF CAVE ROOSTING ENVIRONMENTS, AND PROTECT NEARBY HABITAT ASSOCIATED WITH THESE SITES FOR FEEDING, DRINKING, AND RESTING.

**Objective 1:** Develop and implement surface and subsurface land management practices and plans that protect cave and karst ecosystem components crucial to bat habitat.

**Objective 2:** Promote surface land management policies that preserve the integrity of karst-dependent ecosystems and groundwater (Poulson 1976; Brooke 1996; Elliott 2006, 2012).

### MANAGEMENT RECOMMENDATIONS

- Avoid filling cave entrances, sinkholes, and open karst depressions with slash debris.
- Minimize topsoil erosion and the removal of vegetation in karst areas during practices such as timber sales to maintain existing hydrologic and microclimate functions. If water sources, microclimates, and entrance portals to caves are modified bats may abandon them.
- Avoid use of persistent pesticides and herbicides in areas where they may permeate into karst systems. Contaminated water supplies may affect bats that drink from these sources, particularly females that may be targeting such resources if they are rich in calcium (Brooke 1996; Adams et al. 2003).
- Protect springs and established wetlands in areas that support historically occupied caves. Resources for these recommendations include Jones et al. (2003) and Veni (2006).

### RESEARCH NEEDS

- Delineate catchments and recharge zones in karst areas to determine extent of land vulnerable to impact.

**Objective 3:** Promote surface land management policies and guidelines that minimize degradation of subsurface air quality and microclimates. See BMP's in Elliot (2012) and guidelines in Jones et al. (2003).

### MANAGEMENT RECOMMENDATIONS

- Preserve natural airflow in and out of occupied cave entrances and passages. Actions that may adversely alter the cave microclimate include back-filling of cave entrances, modifying sinkholes, installing entrance gates or other structures that modify airflow patterns, and digging in cave passages.
- Minimize the use of prescribed burning in karst areas and near caves (Pierson et al. 1999). Fire can impact cave and karst features by exposure to smoke and ash, lead to degradation of cave entrances due to increased erosion, and cause leaching of carbon deposits into caves (Jones et al. 2003). Maintain high standards for atmospheric conditions that allow for good ventilation before proceeding with burns around caves (Sheffield et al. 1992; Elliott 2012).

**Objective 4:** Encourage land managers to use guidelines that maintain critical cave resources for bats. Management plans with BMP's and cave management recommendations should be referenced for bat-specific management guidance.

## MANAGEMENT RECOMMENDATIONS

- Identify nearby foraging, drinking and roosting sites critical to bat species. Protecting these features for bats roosting in nearby caves will reduce energy expenditures.
- Implement zones of "no impact" or "limited impact" from surface management activities around all caves with significant bat roosts (contact bat biologists from CBWG if guidance is needed).
- Require surveys for bat roosts when proposing surface management activities such as timber sales, prescribed burning and road building when they are near caves known to be used by bats. Provide guidelines for such surveys.
- Apply seasonal restrictions to avoid disruption of maternity, swarming, hibernation, or other critical life-cycle activities when timber sales or 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 0.25 mi 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 a buffer zone of 2 mi for pesticide spraying around bat roost sites used by species of concern or considered biologically important for a given species. Allow spot applications of herbicides as a weed management tool.
- Maintain or improve riparian and wetland habitats near roosts inhabited by species of concern or considered biologically important to a population to achieve healthy and diverse foraging structure.

## RESEARCH NEEDS

- Examine the relationships between external characteristics of surface features associated with caves, particularly in karst areas, that may relate to the microclimate in the roost. These features include entrance elevation and configuration, local environmental characteristics, vegetation cover surrounding entrances, and water sources. Monitor the effectiveness of these restrictions to see if they aid bat populations.

**Objective 6:** Encourage the siting of large scale water impoundment projects in areas other than canyons composed of cliff bands and intact riparian drainages so that caves are not inundated by water and permanently lost.

## MANAGEMENT RECOMMENDATIONS

- 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; Nilsson and Berggren 2000; 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 caves are prevalent (e.g., karst deposits).

## MANAGING RECREATION IMPACTS

Recreation impacts to bats using caves may result from casual or organized cavers. Historically, the management of recreational use in caves has not focused on bat viability or use. Cave visitation at inappropriate times can disturb bat colonies resulting in roost abandonment, and the direct or indirect mortality of juvenile or hibernating bats. Managing recreation activities at caves using best management practices will insure continued enjoyment of these resources by recreationists while protecting the sensitive resources of the sites (Elliott 2006, Elliott 2012, Jones et al. 2003).

### GOAL

#### DEVELOP AND IMPLEMENT SOUND CAVE RESOURCE MANAGEMENT PRACTICES THAT BENEFIT BATS, AS WELL AS OTHER CAVE RESOURCES. RECRUIT COOPERATIVE SUPPORT FROM THE CAVING, RESEARCH, AND MANAGEMENT COMMUNITIES.

**Objective 1:** Prioritize protection of caves 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 cavers in the development of cave management guidelines.

**Objective 3:** Install bat-compatible closures at caves when necessary to protect sensitive bat populations and other cave resources.

**Objective 4:** Enforce existing laws and regulations pertaining to wildlife and cave resources.

**Objective 5:** Consider the need to protect suitable cave roosts where WNS is a concern.

**Objective 6:** Enlist the caving community to help educate the public about the need for cave resource protection and decontamination protocols to reduce the spread of WNS (https://www.whitenosesyndrome.org/topics/decontamination, Accessed March 5, 2018).

## MANAGEMENT RECOMMENDATIONS

- Federal and state agencies, as well as private commercial operations, should enforce WNS decontamination protocols at all caves and the caving community should promote use of such standards.
- Consult with agencies, owners, and the caving community to identify caves where bats are currently roosting or have historically roosted.
- Develop cave management guidelines that provide for recreational use when consistent with protecting bats and other cave resource values (Jones et al. 2003). The FCRPA provides a basis for developing management guidelines.
- Implement protective strategies for all significant cave 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 in caves with sensitive bat resources by developing cave management plans, cooperative agreements, memoranda of understanding, and cave entry permits for both recreation and research, if appropriate (e.g., USFS 2013).
- Consider implementing seasonal or diurnal use restrictions at caves during critical bat use periods. Close caves to recreational use from mid October–mid March to protect hibernacula and from early May–late August to protect maternity colonies using caves if disturbance is likely. 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; Neubaum et al. 2017).
- When bat compatible gates are required, design structures that minimize changes to the cave microclimate and entrance configuration, and that provide secure access control. Recruit recreational cave user support to construct and install bat gates when possible. Plans for such structures have been developed for many caves (Bat Conservation International, USFWS, and CPW).
- Protect caves historically occupied by sensitive bat species.
- Monitor numbers of bats at caves before and after management restrictions are put in place to document effectiveness.

## RESEARCH NEEDS

- Develop methods to determine if seasonal closures of caves are effective and if so, to what degree.
- Investigate if cave visitations during swarming season impacts use by bats. Do impacts vary if visitations only occur by day versus night?

## GOAL

### MINIMIZE OR PREVENT IMPACTS BY RECREATIONAL CAVE USERS, RESEARCHERS, AND THE GENERAL PUBLIC IN CAVES WHERE BIOLOGICALLY IMPORTANT POPULATIONS OR SENSITIVE SPECIES OF BATS ARE PRESENT.

**Objective 1:** Provide information to cavers, researchers, and other public users about "bat friendly" caving techniques.

**Objective 2:** Coordinate with owners of private caves to establish protective measures for caves supporting critical bat populations.

**Objective 3:** Establish seasonal protection measures for caves that support critical populations of bats, including the construction of bat compatible gates when deemed necessary.

**Objective 4:** Standardize protocols for both external and internal surveys to minimize stress to bats and impacts to other sensitive cave features.

## MANAGEMENT RECOMMENDATIONS

- Encourage agencies and private cave owners to require cave visitors to utilize "bat-friendly" caving techniques.
- Offer support or assistance to cave managers (particularly for show caves) by providing educational programs or materials relating to bat conservation.
- Offer bat management and conservation technical support to private cave owners.

## RESEARCH NEEDS

- Evaluate the impact of entrance signs and other education efforts on caving practices.
- Investigate alternative caving and research techniques that reduce impacts to bats.
- Research the human-use trends in individual caves that are past, current or potential bat habitats to determine appropriate management strategies. Supporting information may be obtained from entry registers, caving publications, personal accounts, and surveillance devices.
- Determine if gate design at caves affects bat use such as swarming behavior. Do gates impede ingress and egress activities associated with swarming? Conduct monitoring surveys to answer such questions pre and post gate installation.

# INTENTIONAL DISTURBANCE AND VANDALISM

## GOAL

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

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

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

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

**Objective 4:** Consider installation of bat friendly gates at caves where vandalism cannot be controlled and significant or sensitive bat populations are present and/or in decline.

## MANAGEMENT RECOMMENDATIONS

- Encourage agencies and private cave owners to ask cave visitors to practice "bat-friendly" caving techniques.
- Utilize left over mitigation funds from mining and energy development to pay for gate installation at vandalized caves. Consider building mitigation funding into the planning process for such activities in areas where known cave roosts are present.

## RESEARCH NEEDS

- Evaluate the impact of entrance signs and other education efforts on vandalism and intentional disturbance.
- Research trends in vandalism and intentional disturbance in caves that are past, current or potential bat habitats to determine appropriate management strategies.

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