Cliffs, Canyons, Caves, and Rock Outcrops

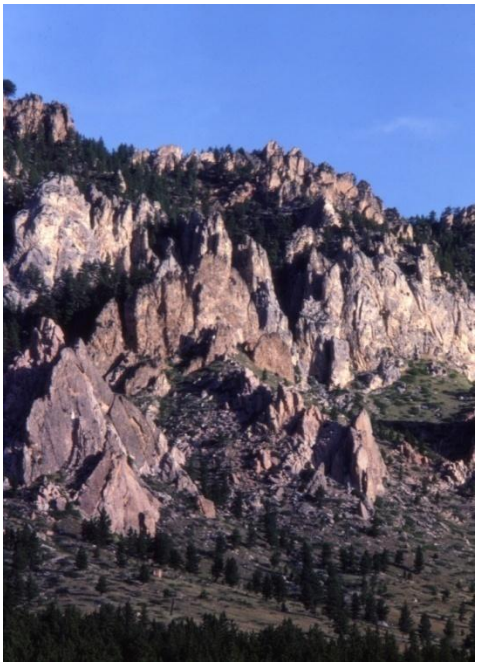


Photo courtesy of WGFD

Table of Contents

Much of the information for this section pertaining to caves and bats was derived from A Conservation Plan for Bats in Wyoming *(Hester and Grenier 2005). Those desiring additional information on bat conservation not covered in this section should consult this document.*

Habitat Description

Cliffs, canyons, and rock outcrops are common features of the mountainous West. Formation of the Rocky Mountains by uplift and volcanism, followed by erosion by glacial and other forces, led to the development of a landscape with high topographic relief (Hester and Grenier 2005). This habitat type is found across a wide elevational range—from high, wet, cold alpine landscapes all the way down to dry desert and warm plains environments. Cliffs, canyons, caves, and rock outcrops are unique habitats that can provide topographic diversity in otherwise homogeneous landscapes.

Cliffs are steep rocky outcrops with greater than 65° in slope and 4 ft in height (New Hampshire Fish and Game Department 2005). Cliffs are exposed to the elements, do not accumulate significant amounts of snow pack, and may be protected from runoff by overhangs. Vegetation of cliffs and outcrops is typically sparse, and often restricted to shelves, cracks, and crevices in the rock, or other areas where soil accumulation allows growth (Colorado Natural Heritage Programs 2010). Larson et al. (2000) describe three basic parts of a cliff habitat: 1) the relatively level plateau at the top, 2) the vertical or near-vertical cliff face, and 3) the pediment or talus at the bottom of the face. These three elements share some physical characteristics, are linked by similar ecological processes, and often support similar plants and animals (Larson et al. 2000). Within larger cliffs, a mosaic of microhabitats can occur including steep slopes, small terraced ledges, overhangs, and cracks and crevices, which contribute to the biodiversity that cliffs can support (Graham and Knight 2004). On the faces of cliffs, there is less hydraulic pressure retaining water than within the rock, so liquid water is more consistently found here than in surrounding habitats (Larson et al. 2000). Erosion by wind, water, and the force of gravity are the primary natural disturbances in cliff habitats. The lack of vegetation on many sites protects them from fire.

Caves and/or rock shelters are associated with cliffs, canyons, and rock outcrops. A cave is any naturally-occurring cavity, recess, or system of interconnected passageways beneath the surface of the earth or within a cliff or ledge that is large enough to be traversed by humans (Kerbo 2002). In Wyoming, caves are found in widely scattered locations, from 4,000 to 11,000 ft. in elevation. Although at least 23 different types of caves exist, including lava tubes, tectonic fractures, sea caves, and ice caves (Kerbo 2002), caves in Wyoming have primarily karst and pseudokarst features. Karst caves are formed by dissolution of rock rather than mechanical erosion, and they occur most frequently in limestone and dolomite. Caves similar to karst, but occurring in nonsoluble rocks are classified as pseudokarst caves which are formed by the process of piping. Cavities form by the action of certain clays that swell and contract with the presence or absence of water (Hester and Grenier 2005). Although most caves in Wyoming have karst features, pseudokarst features are common in Wyoming's basins (Hill et al. 1976).

Caves generally provide an overall climate that is less variable than at the surface, with stable temperatures, high humidity levels, low evaporation rates, and an absence of light (Washington Department of Wildlife 1994). Most have temperatures between 30–50 °F (Hill et al. 1976). Although relatively constant, not all cave temperatures are similar, and may be influenced by a number of factors, including the number, size, and position of portals; the size, slope, and contour of passages; the cave's overall volume; the seasonality and dynamics of airflow; and water intrusion (Washington Department of Wildlife 1994). Cave habitats may be simple or complex, and often include many smaller tubes, cracks, and fissures

(Washington Department of Wildlife 1994; Altenbach et al. 2002).

Caves are irreplaceable natural resources, taking centuries to form, having limited distributions, and containing unique biological communities. Additionally, about 25% of the groundwater in the U.S. is located in cave and karst regions, further increasing their value for society (Kerbo 2002).

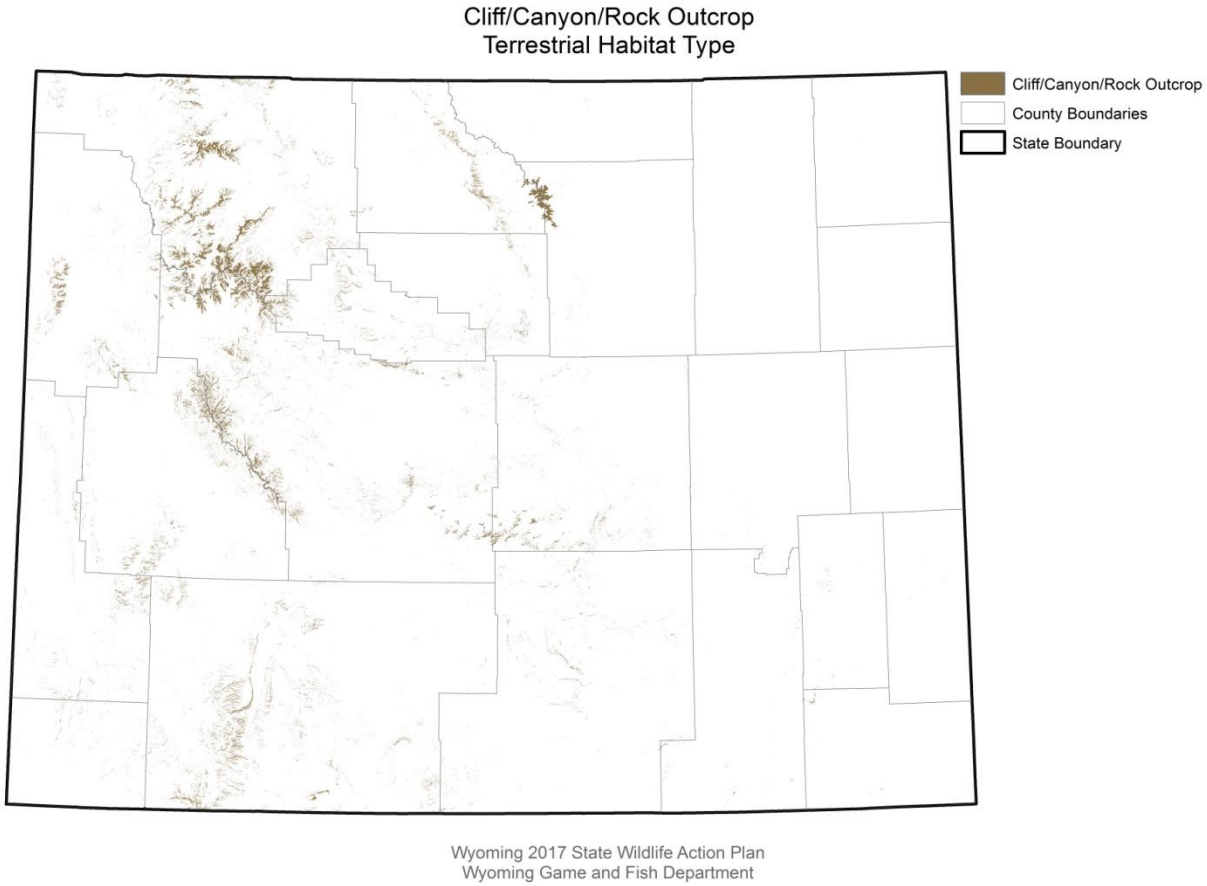


FIGURE 3. **Wyoming Cliffs, Canyons, and Rock Outcrops** (*Note: This map does not depict the location of any caves which were not represented as a NatureServe Ecological System*)

TABLE 3. Wyoming Cliffs, Canyons, and Rock Outcrops NatureServe Ecological Systems[1]

1. Rocky Mountain Cliff, Canyon, and Massive Bedrock
2. North American Alpine Ice Field
3. Rocky Mountain Alpine Bedrock and Scree
4. Western Great Plains Cliff and Outcrop
5. Inter-Mountain Basins Cliff and Canyon
6. Rocky Mountain Alpine Fell-Field

[1] Descriptions of NatureServe Ecological Systems which make up this habitat type can be found at: NatureServe Explorer: an online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, VA. http://www.natureserve.org/explorer.

TABLE 4. Wyoming Cliffs, Canyons, Caves, and Rock Outcrops Species of Greatest Conservation Need

Mammals
American Pika
Bighorn Sheep
Canyon Mouse
Cliff Chipmunk
Dwarf Shrew
Eastern Spotted Skunk
Fringed Myotis
Little Brown Myotis
Long-eared Myotis
Long-legged Myotis
Northern Long-eared Myotis
Pallid Bat
Piñon Mouse
Plains Harvest Mouse
Ringtail
Spotted Bat
Townsend's Big-eared Bat
Uinta Chipmunk
Western Small-footed Myotis
Western Spotted Skunk
Wolverine
Yuma Myotis

Birds
Black Rosy-finch
Brown-capped Rosy-finch
Canyon Wren
Clark's Nutcracker
Golden Eagle
Peregrine Falcon

Reptiles
Great Basin Gophersnake
Great Basin Skink
Midget Faded Rattlesnake
Northern Tree Lizard
Plains Black-headed Snake
Plateau Fence Lizard
Prairie Lizard
Prairie Rattlesnake

Cliffs, Canyons, Caves, and Rock Outcrops Wildlife

Cliffs, canyons, caves, and rock outcrops occupy a small percentage of the land base, but they are disproportionately important as wildlife habitat. The uniqueness of this habitat often results in entirely different communities during the breeding season compared with adjacent habitats, increasing overall species richness and diversity (Hester and Grenier 2005). Cliffs, canyons, caves, and rock outcrops benefit birds and mammals directly by providing shelter and breeding sites, and indirectly by providing diverse vegetation structure. For example, some shrub species, such as skunkbush sumac, chokecherry, currant, and juniper, are primarily associated with rock outcrops.

The wildlife that use these habitats are highly specialized and are often dependent upon cliffs, rock outcrops, or canyons for reproduction, foraging, or predator avoidance. The stability and persistence of cliff, rock, and canyon formations encourage the repeated use of specific areas as breeding habitat. Well-known cliff-nesting raptors include the peregrine falcon, prairie falcon, golden eagle, and turkey vulture. Big game species such as bighorn sheep and mountain goat feed on the vegetation found on cliffs, canyons, and rock outcrops and also use these habitats to escape predators such as mountain lions. Pika, dwarf shrew, canyon mouse, cliff chipmunk, bushy-tailed woodrat, and spotted skunks are examples of smaller mammals found in this habitat type. Permanent snow and ice in proximity to exposed rock are important features of breeding habitat for black rosy finches and brown-capped rosy finches, as well as wolverine, the latter using snow drifts to cache food. Rock shelters also provide very important roosts for several species of bats (Hester and Grenier 2005). In southern Sweetwater County in proximity to juniper habitats, rock outcrops are particularly valuable to several SGCN mammals. The distribution of the cliff chipmunk, canyon mouse, and piñon mouse is restricted to this portion of the state. Important habitat components include high diversity of invertebrates, as well as vegetative seeds and berries.

The preservation of bat roosts in caves is one of the most important issues in bat conservation (Sheffield et al. 1992). At least 21 of the 45 bat species in North America use caves regularly, and many of the remaining species use them at

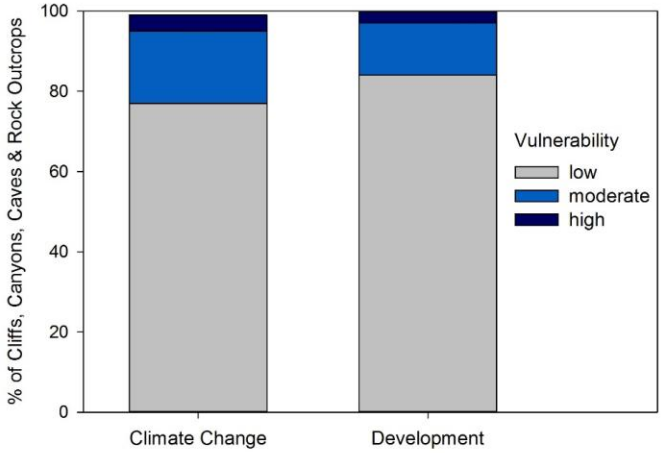
least occasionally (Racey and Entwhistle 2003. Eighteen species of bats are found in Wyoming and occupy all areas of the state, constituting 15% of all Wyoming's mammal species (Hester and Grenier 2005). Bats use caves as winter hibernacula, summer maternity roosts, day roosts, and even night roosts (Sheffield et al. 1992, Hinman and Snow 2003). Caves may serve as refugia for bats in the event of loss or degradation of other roosts in the surrounding landscape, and in some areas, the availability of suitable caves plays a major role in determining the size and distribution of bat populations (Christy and West 1993). Important roosts are often traditional and are used by successive generations of bats over many years (Hester and Grenier 2005). There have been 161 caves documented in Wyoming that could provide bat habitat (Luce 1998).

Even though they are manmade features, many abandoned mines share characteristics with caves that make them some of the most important roosting sites for bats (Hinman and Snow 2003). At this time, approximately 1,000 abandoned mines that have not undergone reclamation are known to exist across Wyoming. The Wyoming Game and Fish Department (WGFD) has located and surveyed only about 300 of these mines. Nearly 100 have been confirmed to be occupied by bats, although WGFD personnel have identified numerous others as having significant habitat potential for bats (Hester and Grenier 2005).

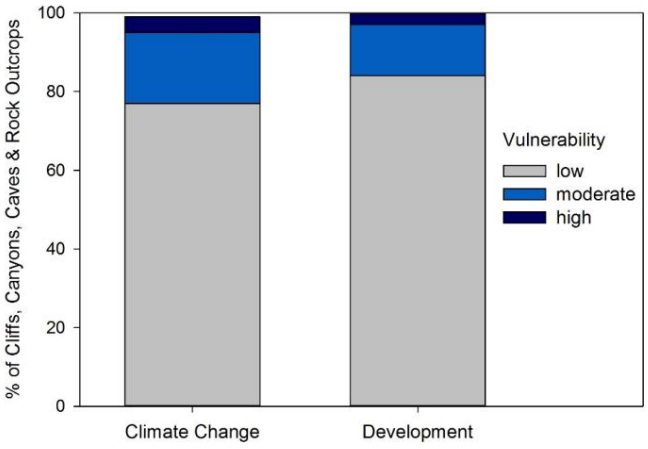
Cliffs, canyons, caves, and rock outcrops are also immensely important to a variety of reptile species. These habitats provide thermally favorable refuges, cover, and hibernacula. These habitats do not need to be expansive to harbor reptile populations, and the presence of only a few exposed rocks could attract snakes and lizards. Snakes are particularly dependent on rock outcroppings for winter dens. Rocky outcrops often provide crevices or other geologic features that allow snakes to travel below the frost line to escape freezing temperatures during winter. Often snakes are intimately tied to their hibernacula, returning to the same den their whole lives. The destruction of a den site often results in the reduction or elimination of local snake populations.

Cliffs, Canyons, Caves, and Rock Outcrops Habitat Threats

Figure 4. Cliffs, Canyons, Caves, and Rock Outcrops Vulnerability Analysis



The colored bars show the proportion of the habitat type that was identified as having low, moderate, or high vulnerability to climate change or development, based on classification of scores ranging from 0 to 1 into the following categories: low (<0.34), moderate (0.34-0.66), and high (>0.66). Rankings for climate change or development vulnerability were based on the land area of the habitat type classified as having high vulnerability: low (<10%), moderate (10-33%), or high (>33%). Vulnerability was calculated as exposure minus resilience. Development vulnerability includes existing and projected residential, oil and gas, and wind energy development. Further details are provided in the Leading Challenges section of this report and in Pocewicz et al. (2014).



The colored bars show the proportion of the habitat type that was identified as having low, moderate, or high land management status or habitat intactness. For land management status, high corresponds to the percent of the habitat occurring in GAP status 1 or 2, moderate to the percent occurring in GAP status 2b or 3, and low to the percent occurring in GAP status 4. Rankings for land management status were based on the land area of the habitat type classified as having high status or legal protection: low (<10%), moderate (10-33%), or high (>33%). For habitat intactness, scores ranging from 0 to 1 were assigned to categories as follows: low (<0.34), moderate (0.34-0.66), and high (>0.66). Rankings for intactness were based on the land area of the habitat type classified as having high intactness: low (<25%), moderate (25-75%), or high (>75%).

Recreation and human disturbance – Locally High
Recreational activities such as rock climbing, hiking, camping, bouldering, bicycling, horseback riding, and spelunking are common in cliffs, canyons, caves, and rock outcrop habitats. Disturbance to birds can be caused by the presence of humans and associated noise or erosion. Rock climbing, in particular, has become more popular during the last few decades and may have reduced the nesting success of some cliff and rock outcrop nesting birds (Nicholoff 2003). Such disturbance may gradually reduce the total number of suitable nesting sites available for birds dependent upon this habitat.

Recreation in caves and abandoned mines impacts roosting bats by the disruption of hibernacula and maternity colonies. Even when bats are not currently present, recreation can diminish the quality of caves and abandoned mines through accumulation of garbage or damage to cave walls from graffiti and smoke from fires. Excessive disturbance may result in the loss of subpopulations and can present a significant threat to bats and bat habitat (Hester and Grenier 2005). Interest in recreational caving is increasing in the U.S. The National Speleological Society currently has more than 12,000 members (National Speleological Society 2010). Disturbance during hibernation may cause bats to arouse prematurely and burn stored energy reserves that usually cannot be spared (Sheffield et al. 1992). Even disturbances that may seem trivial, such as light or body heat emitted from humans, as well as noises from movements or whispering that produce high-frequency sounds, can disturb bats (Hester and Grenier 2005). Because bats can require up to an hour or more to arouse from hibernation, they may appear to be undisturbed, but become fully awakened only after humans have left the cave. Furthermore, repeated disturbances may force bats to abandon optimal hibernacula and move to alternative, less-suitable locations where survival rates are lower (Hester and Grenier 2005).

Recreational searching for reptiles may also affect this habitat type. Rock flipping is a common method to search for snakes and lizards, and numerous rocks can be moved during the course of one afternoon. If disturbed rocks are not placed back into their original positions, microclimates necessary to reptiles can be destroyed. If enthusiasts disturb a large area of rocky habitat, reptile populations could be directly impacted.

Mining – Moderate
Mine reclamation projects have provided habitat for a diversity of wildlife species including cliff-nesting birds, bighorn sheep, mule deer, and others. Where ledges and crevices occur in open-pit mine walls, bats and some species of cliff-nesting birds utilize these sites for nesting or roosting.

However, mining and construction can have negative impacts when they occur at the base or the top of cliffs, rock outcrops, or canyons. Gravel quarries may actually remove buttes and cliffs and disturb or destroy the cracks and crevices where bats roost (Hester and Grenier 2005). The potential for oil shale development in southwestern Wyoming threatens rock outcrop habitats occupied by SGCN including the midget faded rattlesnake, cliff tree lizard, cliff chipmunk, canyon mouse, pallid bat, spotted bat, and Townsend's big-eared bat.

Bat roosting habitat has been lost in Wyoming and continues to be threatened by abandoned mine reclamation or the resumption of mining operations. New mining techniques usually produce open pits, which are unsuitable as bat habitat, and often destroy existing mine entrances and shafts (Brown 1995, Pierson 1998). Some gates or other closures on caves and abandoned mines do not allow access for bats (Oakleaf et al. 1996).

Inappropriate wind-energy development siting and design – Moderate
Wind has become the world's fastest growing power source, increasing about 30% annually since 1996 (Kunz 2004) (see Wyoming Leading Conservation Challenges – Energy

Development). Suitable sites for wind development are often found on or near cliff, canyon, and rock outcrops.

Raptor collisions with wind turbines are more common when wind turbines are sited on steep slopes and hillsides, in canyons and draws, on ridge crests and peaks within canyons, and when rock piles that attract prey species are located near turbines (Hoover and Morrison 2005, Kingsley and Whittam 2003, Smallwood and Thelander 2004). Excessive or continuous noise from wind turbines can interfere with the vocal communication of birds, particularly during the breeding season (March through July for most raptors and April through July for most passerines) (Wyoming Game and Fish Department 2010).

Of the 18 bat species found in Wyoming, almost half have been identified in turbine-related mortality assessments conducted throughout the U.S. (Johnson 2005, Arnett et al. 2008). The average bat fatality rate for U.S. wind projects is 3.4 fatalities per turbine per year (Johnson 2004). Nearly 90% of bat fatalities occur in late summer and early fall, during the peak of fall migration (Keeley et al. 2001, Erickson et al. 2002, Johnson 2004). Migrating and commuting bats often follow linear landscape features, and may be drawn to ridges where wind energy facilities are located (Erickson et al. 2002, Kunz 2004). The physical characteristics of wind turbines might also attract bats. It has been hypothesized that light, heat, or high-pitched sounds emitted by wind turbines, or their tall, vertical structures, may attract bats or the insects upon which they feed (Hester and Grenier 2005). Wind turbines may also attract bats as potential roost sites.

Housing development and construction – Low

Development or construction activity that significantly increases human activity levels may decrease habitat use by wildlife. Additionally, development that removes vegetation above caves can alter internal cave climate and light levels, reducing insect populations, and eliminating visual barriers to the entrance of caves, which may increase human visitation (Washington Department of Wildlife 1994). As housing development and construction occur in an area, humans may be motivated to destroy snake hibernacula. This is often a common practice in regards to venomous species. Rattlesnake dens are located and destroyed to ensure the safety of others. The destruction of these dens often results in the modification of rocky habitats.

Current Cliffs, Canyons, Caves, and Rock Outcrops Conservation Initiatives

Caves on federal lands are protected through the Federal Cave Resources Protection Act of 1988, which requires federal agencies to inventory and list significant caves on federal lands and to protect such caves from harm, either to the cave or its biota (Hester and Grenier 2005).

Before 1994, bats were not legally protected in Wyoming. In 1994, the Wyoming Game and Fish Commission approved nongame wildlife regulations protecting several wildlife species, including bats. In 1998, the Western Bat Working Group was formed as an outgrowth of a range-wide effort to protect the Townsend's big-eared bat. Subsequently, each participating state, including Wyoming, has established its own working group. The Wyoming Bat Working Group (WYBWG), comprised of multiple agencies, meets annually to prioritize and discuss bat conservation efforts in Wyoming.

In 2003, the WGFD and the WYBWG initiated the development of *A Conservation Plan for Bats in Wyoming* which was completed in 2005 (Hester and Grenier 2005). The overall goal of the plan was to consolidate current knowledge about bats in Wyoming and to provide a cooperative framework to identify and coordinate actions to facilitate bat conservation in Wyoming. The plan includes management recommendations for cliff, rock outcrop, and cave habitats. Since the 1990s, the WGFD Nongame Program, U.S.

Fish and Wildlife Service, Bureau of Land Management (BLM), U.S. Forest Service, Wyoming Department of Environmental Quality (DEQ), and private landowners have actively taken steps to conserve caves and abandoned mines in Wyoming that are important to bats. Identifying caves and mines that provide important hibernacula and maternity roosts remains a priority for bat conservation in Wyoming. Where these areas have been or have the potential to be negatively impacted by human disturbance, the Department, in collaboration with other state and federal agencies and private landowners, installs bat-friendly closures that exclude humans during important life-history stages. Currently, 72 caves and mines have closures that exclude humans for at least part of the year, and additional closure projects are planned.

Recommended Cliffs, Canyons, Caves, and Rock Outcrops Conservation Actions

Inform land managers about potential negative effects and mitigation measures for recreational activities on or near cliff, canyon, cave, and rock outcrop habitats.

- Outlets such as the WYBWG, Wyoming Wildlife magazine, recreational clubs, schools, and public education programs can be used to inform the public and agency personnel about potential negative impacts on wildlife caused by recreation and discuss associated mitigation techniques. In addition to distributing educational materials, recreational clubs, such as climbing and spelunking organizations, can be useful sources for collecting information on wildlife observations.
- In cooperation with land management agencies, wildlife agencies, recreational clubs, and private landowners, review current human use levels for cliffs, canyons, caves, and rock outcrops that serve as crucial wildlife habitat. Potential impacts should be evaluated and management scenarios developed where necessary. Where recreational cavers may come into conflict with key maternity or hibernation sites, close hibernation sites to visitation from November 1 to April 1 and maternity sites from April 1 to October 1 (Hester and Grenier 2005). The critical time periods of hibernation and maternity activity may vary regionally and may allow some site-specific flexibility in seasonal closures. At some caves where human disturbance is affecting bat populations, it may be necessary to install bat-friendly closures to allow passage by bats while restricting human access.
- Keep the locations of caves, bat roosts, and cliff-dwelling bird nests confidential. Avoid including them on maps, road or trail signs, brochures, or press releases.
- Use signs and other interpretive media to help people appreciate bats and understand the fragility of roosting bats, and enlist professional outfitter/guides and climbing organizations as allies.

Work with the appropriate federal and state agencies to protect and maintain cliffs, caves, and abandoned mines that provide valuable habitat for bats and other wildlife.

- Where possible, avoid renewed mining activities above, inside, or near abandoned mines inhabited by bats.
- Maintain the microclimate of cliffs and rock outcrops used by bats as roosts by protecting and managing the vegetation up to 790 feet from the roost area (Ormsbee 1996).
- After construction or mining has been completed, reclaim lands with consideration for the unique foraging and roosting needs of bats. All components of bat habitat must be in close proximity (within several miles) for bats to use them efficiently (Keinath 2004). Maintain all vegetation above caves inhabited by bats and near cave portals to avoid altering the internal cave climate and light levels and reducing insect populations, and to avoid removing visual screening barriers that may discourage human use (Hester and Grenier 2005). Avoid timber harvest activities and prescribed burning within

a quarter-mile radius of caves inhabited by bats (Stringer et al 1991; Keinath 2004). Time construction and mining activities to avoid disturbing known maternity colonies between April 1 and October 1 (Hester and Grenier 2005).

- Avoid building roads within 300 feet of caves inhabited by bats. Where caves will be visible from roads, or where roads will cause erosion into caves or alter the climate or flow of water in or around caves, institute a quarter-mile buffer (Washington Department of Wildlife 1994). Close roads or apply seasonal restrictions on roads that increase public access to vulnerable bat cave habitat (Oakleaf et al. 1996).
- Where human recreation is or has the potential to negatively impact roosting or hibernating bats, install bat-friendly closures that exclude humans while allowing access for bats and other cave-dwelling wildlife species. Where bat use is season-specific and recreational use is high, investigate the potential for bat-friendly gates that can be locked during hibernation or pup-rearing but opened to recreational caving when not in use by bats.

Work with state and federal agencies, as well as private landowners, to reduce potential negative impacts to wildlife from mining and abandoned mine reclamation projects.

- Enhance habitat for birds and other wildlife by placing suitable rocks on reclaimed mined land. Rock should be placed in piles of varying sizes up to 6 feet in height. Rocks and rock piles should be grouped—as opposed to evenly scattered—over large areas with approximately four rock piles taller than 3 feet per acre. The minimum area to include in outcrop habitats should be about 2.5 acres (1 ha), and shrub species should be planted in and around piles to encourage establishment of unique plant communities (Nicholoff 2003).
- Utilize the WYBWG to enhance current cooperative efforts and communication between land management agencies, the Abandoned Mine Lands Division (AML) of the DEQ, WGFD, and private landowners to reduce impacts from the reclamation of abandoned mines that provide bat habitat. Integrate ongoing Office of Surface Mining and AML abandoned-mine safety campaigns with bat habitat education programs and actively discourage recreation in abandoned mines. Identify abandoned mines that have gates or other closures that exclude bats and appear to have significant bat habitat potential.
- Prior to mine closure or renewed mining, evaluate all abandoned mines as bat habitat. Multiple surveys within and across seasons are essential to determine the significance of mine structures to bats for hibernation and maternity, as well as day, night, and lek roost activities (Hester and Grenier 2005).
- Where possible, avoid hard closure of mines that include activities such as bulldozing, backfilling, blasting, sealing with concrete, and foaming that make mines inaccessible to bats and other wildlife. If the destruction of bat-occupied abandoned mines or caves is unavoidable, safely exclude or remove bats during a non-critical season to avoid mortality (Altenbach et al. 2002). Identify and protect replacement roosts or consider reopening already closed mines in nearby habitat within five miles (Hester and Grenier 2005).

Consult the WGFD *Wildlife Protection Recommendations for Wind Energy Development in Wyoming* (2010) when planning and constructing wind energy development projects.

Recommendations most relevant to the cliff, canyon, cave, rock and outcrop habitats include:

- In coordination with WGFD and U.S. Fish and Wildlife Service, determine appropriate set-backs from ridges, bluffs, or other features to avoid or minimize impacts to bats, neotropical birds, migratory birds, raptors, and reptile hibernacula. Determinations should be made on a

project-specific basis based upon site-specific data and information.

- Construction around raptor nests on cliffs, canyons, and rock outcrops should be suspended within specified buffers and seasonal dates to be found in Appendix B of *Wildlife Protection Recommendations for Wind Energy Development in Wyoming* (Wyoming Game and Fish Department 2010).
- Adopt appropriate turbine design and siting standards to minimize bird and bat collisions (see U.S. Fish and Wildlife Service 2003 and Department of the Interior Wind Turbine Guideline Advisory Committee Recommendations 2010).

Cliffs, Canyons, Caves, and Rock Outcrops Monitoring Activities

Continue monitoring SGCN in cliff, canyon, cave, and rock outcrop habitats in order to detect population trends or changes in distribution that may reflect habitat problems.
Implement cliff, canyon, cave, and rock outcrop monitoring programs to establish baseline data and identify changes in habitat quality, both positive and negative, over time. This information should be used to guide future monitoring and research, as well as habitat conservation needs. Monitoring should include documentations of caves and abandoned mines that receive significant bat use.

Monitor recreational use in cliff, canyon, cave, and rock outcrop habitats.
Increase educational efforts and develop management plans for sites where the level, timing, or type of recreational activity may negatively impact wildlife.

Bat monitoring should be conducted using appropriate protocols for areas of wind energy development. This could include determining annual bat activity patterns in project areas, mortality transects, and monitoring resident populations during the active season.

Hibernacula in areas of development should be monitored for species use, and white-nose syndrome presence. Closures should be considered for important hibernacula to ensure population health.

Continue to monitor the distribution and condition of cliff, canyon, cave, and rock outcrop habitats through remote sensing and ground surveys.
Remote sensing is useful in tracking the size and distribution of this habitat in Wyoming. Information gathered would be helpful in determining the cumulative impacts of activities such as mining.

Literature Cited

ADAMS, R. A. 2003. Bats of the Rocky Mountain West: natural history, ecology, and Conservation. Boulder: University Press of Colorado.

ALTENBACH J. S., W. AMY, P. V. BRADLEY, P. E. BROWN, K. DEWBERRY, D. B. HALL, J. JEFFERS, B. LUND, J. E. NEWMARK, AND M. J. O'FARRELL. 2002. Nevada Bat Conservation Plan. Austin: Nevada Bat Working Group.

ARNETT, E. B., W. K. BROWN, W. P. ERICKSON, ET AL. 2008. Patterns of fatality of bats at wind energy facilities in North America. Journal of Wildlife Management 72:61–78.

BROWN, P. E. 1995. Impacts of renewed mining in historic districts and mitigation for impacts on bat populations. Pages 138–140 *in*: B. R. Riddle, editor. Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Reno: Biological Resources Research Center, University of Nevada.

CHRISTY, R. E. AND S. D. WEST. 1993. Biology of bats in Douglas-fir forests. Portland, OR. USDA Forest Service, Pacific Northwest Research Station. Report nr PNW-GTR-308.

COLORADO NATURAL HERITAGE PROGRAMS. 2010. http://www.cnhp.colostate.edu/download/projects/eco_systems/pdf/IMB_Mixed_Salt_Desert_Scrub.pdf.

DEPARTMENT OF INTERIOR. 2010. *Draft.* Wind turbine guideline advisory committee 850 recommendations. ver. 6.

ERICKSON, W., G. JOHNSON, D. YOUNG, D. STRICKLAND, R. GOOD, M. BOURASSA, K. BAY, AND K. SERNKA. 2002. Synthesis and comparison of baseline avian and bat use, raptor nesting and mortality information from proposed and existing wind developments. Cheyenne: WEST, Inc.

GRAHAM, L., AND R. L. KNIGHT. 2004. Multi-scale comparisons of cliff vegetation in Colorado. Plant Ecology 170:223–234.

HESTER, S. G., AND M. B GRENIER. 2005. A conservation plan for bats in Wyoming. Wyoming Game and Fish Department, Nongame Program, Lander, WY.

HILL, C., W. SUTHERLAND, AND L. TIERNEY. 1976. Caves of Wyoming. The Geological Survey of Wyoming, Bull 59. Laramie: University of Wyoming.

HINMAN, K. E. AND T. K. SNOW, editors. 2003. Arizona bat conservation strategic plan. Phoenix: Arizona Game and Fish Department, Nongame and Endangered Wildlife Program. Report nr 213.

HOOVER, S. L., AND M. L. MORRISON. 2005. Behavior of red-tailed hawks in a wind turbine development. Journal of Wildlife Management 69(1):150–159.

JOHNSON, G. D. 2005. Review of bat mortality at wind-energy developments in the United States. Bat Research News 46:45–49.

JOHNSON G. 2004. A review of bat impacts at wind farms in the US. Pages 46–50 *in*: S. S. Schwartz, editor. Proceedings of the wind energy and birds/bats workshop: understanding and resolving bird and bat impacts; 2004 May 18–19; Washington, D.C. Washington: RESOLVE, Inc.

KEELEY, B, S. UGORETZ, AND D. STRICKLAND. 2001. Bat ecology and wind turbine considerations. *In*: Proceedings of the national avian-wind power planning meeting 4:135–146. Washington: National Wind Coordinating Committee. www.nationalwind.org/pubs/avian00/default.htm.

KEINATH, D. A. 2004. Fringed myotis (*Myotis thysanodes*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Online http://www.fs.fed.us/r2/projects/scp/assessments/fringedmyotis.pdf.

KERBO, R. C. 2002. Cave and karst resources. *In*: K. C. Vories and D. Throgmorton, editors. Proceedings of bat gate design: a technical interactive forum; 4-6 March 2002; Austin, TX. Alton (IL): US Dept Interior, Office of Surface Mining; Carbondale (IL): Coal Research Center, Southern Illinois University. http://www.mcrcc.osmre.gov/bats.

KINGSLEY, A., AND B. WHITTAM. 2003. Wind turbines and birds, a guidance document for environmental assessment. Phase 3 draft report prepared by Bird Studies Canada for Canadian Wildlife Service, Gatineau, QC.

KUNZ, T. H. 2004. Wind power: bats and wind turbines. Pages 50–56 *in*: S. S. Schwartz, editor. Proceedings of the wind energy and birds/bats workshop: understanding and resolving bird and bat impacts; 2004 May 18–19; Washington, D.C. Washington: RESOLVE, Inc.

LARSON, D. W., U. MATTHES, AND P. E. KELLY. 2000. Cliff ecology: pattern and process in cliff ecosystems. Cambridge University Press.

LUCE, B. 1998. Wyoming's bats: wings of the night. Wyoming Wildlife 62(8):17–32.

NATIONAL SPELEOLOGICAL SOCIETY. 2010. http://www.caves.org/info/member.shtml.

NEW HAMPSHIRE FISH AND GAME DEPARTMENT. 2005. Wildlife action plan. Concord, NH.

NICHOLOFF, S. H., compiler. 2003. Wyoming bird conservation plan, version 2.0. Wyoming Partners In Flight. Wyoming Game and Fish Department, Lander, WY.

OAKLEAF, B., A. O. CEROVSKI, AND B. LUCE. 1996. Nongame bird and mammal plan: a plan for inventories and management of nongame birds and mammals in Wyoming. Wyoming Game and Fish Department, Nongame Program.

ORMSBEE, P. C. 1996. Characteristics, use, and distribution of day roosts selected by female *Myotis volans* (long-legged myotis) in forested habitat of the central Oregon Cascades. Pages 124–131 *in*: R. M. R. Barclay and R. M. Brigham, editors. Bats and forests symposium; 1995 Oct 19–21; Victoria, BC. Victoria: Canadian Research Branch, British Columbia Ministry of Forests. Working Paper 23/1996.

PIERSON, E. D. 1998. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. Pages 309–325 *in*: T. H. Kunz and P. A. Racey, editors. Bat biology and conservation. Washington: Smithsonian Institute Press.

POCEWICZ, A., H. E. COPELAND, M. B. GRENIER, D. A. KEINATH, AND L. M. WASHKOVIAK. 2014. Assessing the future vulnerability of Wyoming's terrestrial wildlife species and habitats. The

Nature Conservancy, Wyoming Game and Fish Department, Wyoming Natural Diversity Database, Lander, Wyoming.

RACEY, P. A., AND A. C. ENTWHISTLE. 2003. Conservation ecology of bats. Pages 680–743 *in*: T. H. Kunz and M. B. Fenton, editors. Bat ecology. Chicago: University of Chicago Press.

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(3):707–10.

SMALLWOOD, K. S., AND C. G. THELANDER. 2004. Developing methods to reduce bird mortality in the Altamont Pass wind resource area. Final Report. P500-04-052. Prepared for California Energy Commission, Public Interest Energy Research Program, Sacramento, CA, 1208 by BioResources Consultants, Ojai, CA.

STRINGER, J. W., B. L. SLOVER, AND T. ALLEY. 1991. Speleoforestry: planning for an unseen resource. Journal of Forestry 89(12):20–1.

U.S. FISH AND WILDLIFE SERVICE. 2003. Interim guidelines to avoid and minimize wildlife impacts from wind turbines. Washington, D.C.

WASHINGTON DEPARTMENT OF WILDLIFE. 1994. Priority habitats management recommendations: caves. Unpublished draft report. Olympia: Washington Department of Wildlife.

WYOMING GAME AND FISH DEPARTMENT. 2010. Wildlife protection recommendations for wind energy development in Wyoming. Cheyenne, WY.