AN EVALUATION OF ALTERNATIVE METHODS FOR CONSTRUCTING BAT GATES AT MINE CLOSURES

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Introduction

Construction of bat compatible closures at abandoned mine entrances requires a careful balance between the needs of the species occupying the site and the hazard reduction required to protect the public. Leaving an entrance completely open may be satisfactory for bat conservation but ignores the responsibility to protect the public. Backfilling may eliminate most hazards but will not meet the need to protect the declining and vulnerable species that depend on abandoned mines. Bat compatible closures have evolved as we have gained a better understanding of both the needs of the species, and of the effectiveness of different techniques and materials in producing vandal resistant structures. This process of evolution will continue. Various construction materials and techniques have been used to provide bat compatible closures. The merits and disadvantages of several alternative gate designs and alternative construction materials are discussed. Each project requires development of a site specific plan that addresses safety, bat use, air flow, vandal resistance, maintenance and monitoring. No single design is applicable in all situations. Shafts and open stopes require special considerations during project design and construction. Post construction monitoring is an important component of a successful program and will provide the data needed to continue to improve the effectiveness of bat compatible closures.

Purpose of Closures

The primary purpose of installing a gate or fence at a mine entrance is to control human access. The motivation for this can be to protect vulnerable natural resources or historically significant artifacts within the mine but more often it is to protect the public from the hazards inherent in abandoned underground workings. Many of the cave dependent bats found in the US have come to depend upon abandoned mines for their maternity and hibernation roosts. These bats include several that are Federally endangered or have declined to the point that they may need to be added to the Federal list in the near future (Altenbach, J. S. and E. Pierson 1995, Belwood, J. 1991,Currie 2001a).

What Makes an Abandoned Mine Important to Bats?

All bats have a series of microclimate requirements that determine if an abandoned mine will provide suitable conditions for hibernation and maternity roosts. Each species inhabits sites with specific temperature and humidity ranges. Generally hibernation sites are cold, ranging from near freezing for species like the big brown bat (*Eptesicus fuscus*) to relative warm (12-14 degrees C) for species like the eastern pipistrelle (*Pipistellus subflavus*). Most of the endangered and Federal concern species prefer temperatures between 3 and 10 degrees C for hibernation. Maternity sites for species such as the gray bat (*Myotis grisescens*) or the endangered and non-endangered subspecies of Townsend's big-eared bat (*Corynorhinus townsendii*) require warm sites to raise their young. Abandoned mines that provide optimum conditions for bat use are configured in a manner that facilitates trapping cold air for hibernation or warm air for maternity use (Tuttle and Stevenson 1978). The physical mechanisms that result in these pockets of cold or warm air are the same in both caves and mines (Tuttle and Taylor 1998).

Bad Gates, Good Gates, and The Ideal Gate

Early gates were often designed to protect significant, non-biological cave resources or to restrict access to commercial caves. The first gates and gate construction guidelines (Hunt and Stitt 1981) often concentrated upon controlling cave access alone, rather than controlling access while maintaining the internal microclimate. Early attempts to control mine access with gates often had this same priority. While sometimes successful in restricting unauthorized access to a cave or mine, these structures often had disastrous impacts upon bats.

Wyandotte Cave, in Southern Indiana, is a significant hibernation site for the endangered Indiana bat (*Myotis sodalis*) that originally supported at least 10,000 bats. Human disturbance and an early, restrictive rock wall caused the population to decline to less than 1,000 bats by the time another gate and wall were built in 1970 (Figure 1). The 1970 gate and wall was successful in controlling access to the cave but compounded the problem caused by the earlier rock wall. Temperatures behind the wall were generally too warm for successful Indiana bat hibernation (Richter, et al. 1993). In 1978 the stone wall and restrictive doors were removed and a new gate (Figure 2) was installed. Although not an optimal solution, this gate was less restrictive to airflow and bat movement and temperatures started to return to normal. Although the hibernating Indiana bat population responded positively to the 1978 gate, the gate still caused problems for the Indiana bats since the flat steel bars still restricted airflow and the small openings in the gate still restricted bat movement. An additional problem, noted by Dr. Virgil Brack, (Environmental Solutions and Innovations, personal communication, 2000), was significant predation by feral house cats at the gate. In 1991, an angle iron gate was installed at Wyandotte Cave (Figure 3) (Johnson 1992). The angle-iron gate eliminated the airflow restriction and bat movement problems at the gate and seems to have significantly reduce the predation that occurred at the 1978 gate. Between 1991 and 1999, the Indiana bat population increased from about 13,000 bats to almost 27,000 bats. (Virgil Brack, personal communication, 2000).

"Bad" gates can significantly alter air flow or act as a physical barrier to bats or other species using the cave or mine. They can also be so poorly constructed that they are easily vandalized and bypassed. A "good" gate is effective in controlling human access and is vandal resistant while maintaining unrestricted airflow and bat movement. The design of an ideal gate is constantly evolving. At this time the bat friendly, minimal airflow restriction, angle-iron gate is the recommended standard for protecting colonies of bats in mines and caves (Figures 4 and 5). This gate design was developed by Roy Powers (Mountain Empire Community College, Big Stone Gap, Virginia) working with others in the caving community to meet the need for a strong, effective bat gate that has minimal air flow resistance and provides maximum space for bat movement. This is the design recommended by the U.S. Fish and Wildlife Service for use at caves or mines that support bats that accept full gates. The angle-iron gate is used by the: National Park Service's abandoned mine reclamation program (Burghardt 1997); U.S. Forest Service in the Pacific Northwest and other parts of the country (Jim Nieland, U.S.F.S., personal communication, 2000); New Mexico abandoned mine program (John Kretzmann, New Mexico Energy, Minerals and Natural Resources Department, personal communication, 2000); and many others. Prior to using this design, the American Cave Conservation Association, Horse Cave, Kentucky, should be contacted to obtain the most recent general drawings of this gate. Gate designs in general and the angle-iron gate in particular are constantly being improved (Tuttle and Taylor 1998, Powers 1993).

Other Gate Designs

The first gates installed to protect bats were constructed of 1" or 3/4" round steel bars. Round bar gates have minimal affect on airflow and if proper spacing is maintained between the vertical and horizontal bars they have minimal affect on bat movements. Their greatest disadvantage is that the small size of the bars allows vandals to easily cut through them. This was particularly true at many early round bar gates that were constructed of mild steel or even rebar. Round bar gates constructed of alloyed steels, such as the gates constructed of Manganol by the Utah Division of Oil, Gas and Mining, are much more resistant to vandalism (see Figure 3 in Currie 2001b). Detailed information about the Manganol steel gates can be obtained from Mark Mesch, at the Utah Division of Oil, Gas and Mining (see list of attendees at this forum for contact information).

The Colorado Division of Minerals and Geology (Mining, Mine Safety and Mine Reclamation) has developed an approach to mine closures that incorporates a prefabricated bat window/door into a gate constructed of non-bat compatible grating (Figure 6). This design has been used successfully in some situations and is probably suitable at mines that have small populations of bats. Because of the reduced flight space available through this gate, caution should be exercised in using this design at mines supporting a large number of bats. Kirk Navo (Colorado Division of Wildlife, personal communication, 2000) reported that Townsend's big-eared bat (*Corynorhinus townsendii*) maternity colonies supporting up to100 females have accepted this gate, for summer colonies supporting over 200 bats he recommends that a full bat gate be used.. This design also may restrict air movement through the gate and therefore may have an adverse effect on mine microclimate, especially at hibernation roosts. For more information on the Colorado approach to bat gates at abandoned mines contact Jim McArtle, Colorado Division of Minerals and Geology, contact Kirk Navo for information on Colorado's gate monitoring efforts (see list of attendees at this forum for contact information).

Open Stopes, Shafts, and Large Adits

The standard angle-iron gate is best suited for use on small to medium sized horizontal mine entrances or on inclines or declines of less than 45 degrees. Large entrances, open stopes and shafts often require a different type closure. Often a mine closure plan will address a combination of entrances that include shafts, adits, inclines, declines, and open stopes. The structure designed to close each type of entrance should be developed to meet the biological and hazard abatement needs of each site.

Shafts often have an integral function in the maintenance of the temperature and humidity regimes that make an abandoned mine complex important to bats. Shafts may or may not be used by bats but are often essential for optimum airflow. If a shaft is only important for airflow the closure design only needs to maintain airflow and provide for public safety (Figures 7 and 8). If bats also fly through the entrance then the closure should not only provide for unrestricted air flow but should also minimize restriction of bat movement (Figure 9).

Open stopes are often difficult problems to deal with from the standpoint of hazard reduction with bat protection. Cable netting is one useful tool to use in securing this type of area (Figure 10). If bats must fly through the open stope, then unrestricted bat movement may be accomplished by combining cable netting with a more substantial structure that incorporates a cupola (cage gate), or other bat friendly design. Alternative closures for very large adits, shafts, declines, inclines, and open stopes include some type of fencing such as chainlink (Figure 11) or the more secure (and expensive) iron fence (Figure 12).

General Gate Considerations

The type of structure constructed to control access to an abandoned mine must be designed to meet the physical conditions at the site and nature of bat use of the mine. Some species, such as Brazilian free-tailed bats (Tadarida brasiliensis) and gray bats at their maternity colonies, will not accept full gates at the entrances to their roosts. Fences, iron gates and half-gates are the only acceptable structures at mines supporting these types of bat colonies [see Table 1 in Currie (2001b) for a list of species that will accept full gates at their roost sites].

The strength, integrity and vandal resistance of the angle-iron gate make it an excellent choice for most closures. If alterative designs are used, the designer should insure that the alternative gate will produce an acceptable closure. The basic criteria for an acceptable gate is one that protects the public, maintains current airflow patterns and is accepted by the species using the mine. At a minimum, a gate should have structural strength, correct bar spacing (5 3/4"x24" minimum, or 5 3/4"x 4' for angle-iron gate), a secure foundation, adequate horizontal and vertical bar anchors, and a protected lock.

Gate foundations must be secure or vandals can easily tunnel under the gate. The first choice is to anchor the base of the gate directly into bedrock. A second choice is to build a steel barrier extending along the ground in front of the gate and cover the barrier with concrete or rocks. A third choice is to use expanded metal sheeting or fabricated steel grid under the foundation. In some situations another alternative is to drive 1" diameter steel bars into the ground every 6-8 inches along the base of the gate and weld these to the back of the gate. In constructing the foundation and in installing structures to prevent tunneling under the gate the designer should be careful to avoid restricting airflow at the entrance.

Anchors for the horizontal and vertical bars are an important part of any gate. These anchors should firmly attach the gate to the mine in order to prevent someone from pulling the gate out of the entrance with a wench, or pulling the side of the gate away from the wall. Anchors pins generally should be at least 1" in diameter and inserted into holes drilled 6" to 10" deep, depending upon the strength of the rock. The pins should be protected from easy hacksaw access (Figures 13 and 14).

Gate access door locks are often the most vulnerable portion of the gate and they should be protected from hacksaws, torches, and hammers as much as possible. There are several types of lock guards available and the angle-iron gate drawings in Tuttle and Taylor (1998) show a very effective one for a gate with a removable access bar. McGard security bolts are an effective alternative to locks (Figure 15).

Regardless of which gate design is used, avoid incorporating plate steel or concrete or stone walls into the gate. These can adversely affect bat movement and airflow at the entrance. Use adequate sized openings and be sure to maintain at least the minimum 5 3/4"x24" bar spacing (four foot minimum between vertical bars with angle-iron design). An exception to this spacing may be necessary in some situations. If the gate will be accessible to small, unsupervised children and a smaller spacing between the horizontal bars is needed, it may be appropriate to decrease the spacing to 3 ½ or 4 inches between the horizontal bars in the bottom half or bottom third of the gate. Bats usually fly through the upper portion of a gate and using smaller dimensions in a portion of the gate that is not in their flight path is appropriate.

Evaluating Success–Post Construction Monitoring

In simplest terms a gate can be considered successful if it keeps people out, does not adversely modify mine microclimate and the bat population remains stable or increases. To insure that gates continue to serve their purpose a regular monitoring program should be incorporated into mine closure plans. Closures should be regularly checked for vandalism and repaired as soon as vandalism is detected. Biological monitoring is needed to determine if the bats using the mine accept the closures (Figure 16). The information gained through security and biological monitoring will expand the data base on the use of gates to protect bats and can be used to make positive modifications to future closure plans. Monitoring and incorporation of the information gained through monitoring into mine reclamation programs will benefit the public by developing more successful and effective closure plans and will benefit endangered and declining bats by providing the secure roosts that are essential for their survival.

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List of Figures

Figure 1. Early stone wall and gates constructed at Wyandotte Cave, Indiana. This structure severely restricted airflow and bat movement and contributed to a drastic decline in Wyandotte Cave's hibernating Indiana bat population. (Photograph Credit Virgil Brack, Environmental Solutions and Innovations, Cincinnati, Ohio).

Figure 2. Gate that replaced the stone wall shown in Figure 1. This gate was an improvement but still restricted airflow and bat movement. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 3. Modern, well-constructed angle-iron gate at Wyandotte Cave, Indiana. The Indiana bat population has increase from about 17,000 to 27,000 bats since this gate was installed. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 4. Angle-iron gate drawing. The design is by R. Powers, drafting is by M. Washburn and the copyright for the drawing is held by the American Cave Conservation Association.

Figure 5. Selected detailed drawings of the angle-iron gate. The design is by R. Powers, drafting is by M. Washburn and the copyright for the drawings is held by the American Cave Conservation Association.

Figure 6. Gate installed in Colorado at a mine that supports a colony of Townsend's big-eared bats. (Photograph credit Kirk W. Navo, Colorado Division of Wildlife, Monte Vista, Colorado).

Figure 7. Culvert with a round bar gate used to secure an air shaft on an abandoned mine in central New Mexico. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 8. Angle-iron cage constructed over a shaft in New Mexico. This type of structure is suitable for entrances that must be kept open to maintain airflow but are not used by bats. (Photograph credit, John Kretzmann, New Mexico Mining and Minerals Division, Sante Fe, New Mexico).

Figure 9. Angle-iron cage built over the vertical entrance to a West Virginia cave that supports and maternity colony of the endangered Virginia big-eared bat. (Photograph credit

Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 10. John Kretzmann, New Mexico Mining and Minerals Division, standing at the edge of a large open stope that has been secured with a cable net. He designed this closure as a part of the reclamation plan for a large mine complex in central New Mexico. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 11. Chain link fence around one of the multiple entrances to an abandoned copper mine in Great Smoky Mountains National Park, North Carolina. The Rafinesque's big-eared bat population that uses this mine during both summer and winter has increased from about 400 bats to about 1,400 bats since fences were installed around the entrances to the mine. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 12. Iron bar fence constructed around the entrance to Cave Mountain Cave on lands managed by the National Park Service as a part of Buffalo National River, Arkansas. This fence has been very effective in reducing human disturbance. This fence resulted in an increase in the cave's endangered gray bat population from less than 1,000 bats in 1980 to about 200,000 bats in 1999. (Michael J. Harvey, Tennessee Technological University, personal communication, 2000). (photograph credit M. J. Harvey.)

Figure 13. Anchor pin attached to a piece of 1/4"x6" flat bar welded to the top of a gate column. The pin is behind the gate and is not readily accessible to vandals. The end of the pin was cut off with a oxy-acetylene torch before the gate was completed. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 14. Anchor pin for this gate column is enclosed within a steel collar welded to the top of the column. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 15. Angle-iron gate in New Mexico designed by John Kretzmann. The left side of the bottom three bars are attached with McGard security bolts. These bolts require a uniquely patterned socket for installation and removal and have proven a very effective means of securing removable bars. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

Figure 16. U. S. Fish and Wildlife Service biologist Fred Bagley at the entrance of a Virginia big-eared bat maternity cave in West Virginia. This photograph illustrates some of the equipment used to monitor bats flying through the a cave or mine entrance. Fred is holding a tape recorder in his right hand for recording his observations. The night vison scope in his left hand is used to make bat behavior observations. The bank of lights with infrared filters that can be seem behind his right shoulder are needed to provide light for the night vision scope. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

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Culvert with a round bar gate used to secure an air shaft on an abandoned mine in central New Mexico. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

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Angle-iron cage constructed over a shaft in New Mexico. This type of structure is suitable for entrances that must be kept open to maintain airflow but are not used by bats. (Photograph credit, John Kretzmann, New Mexico Mining and Minerals Division, Sante Fe, New Mexico).

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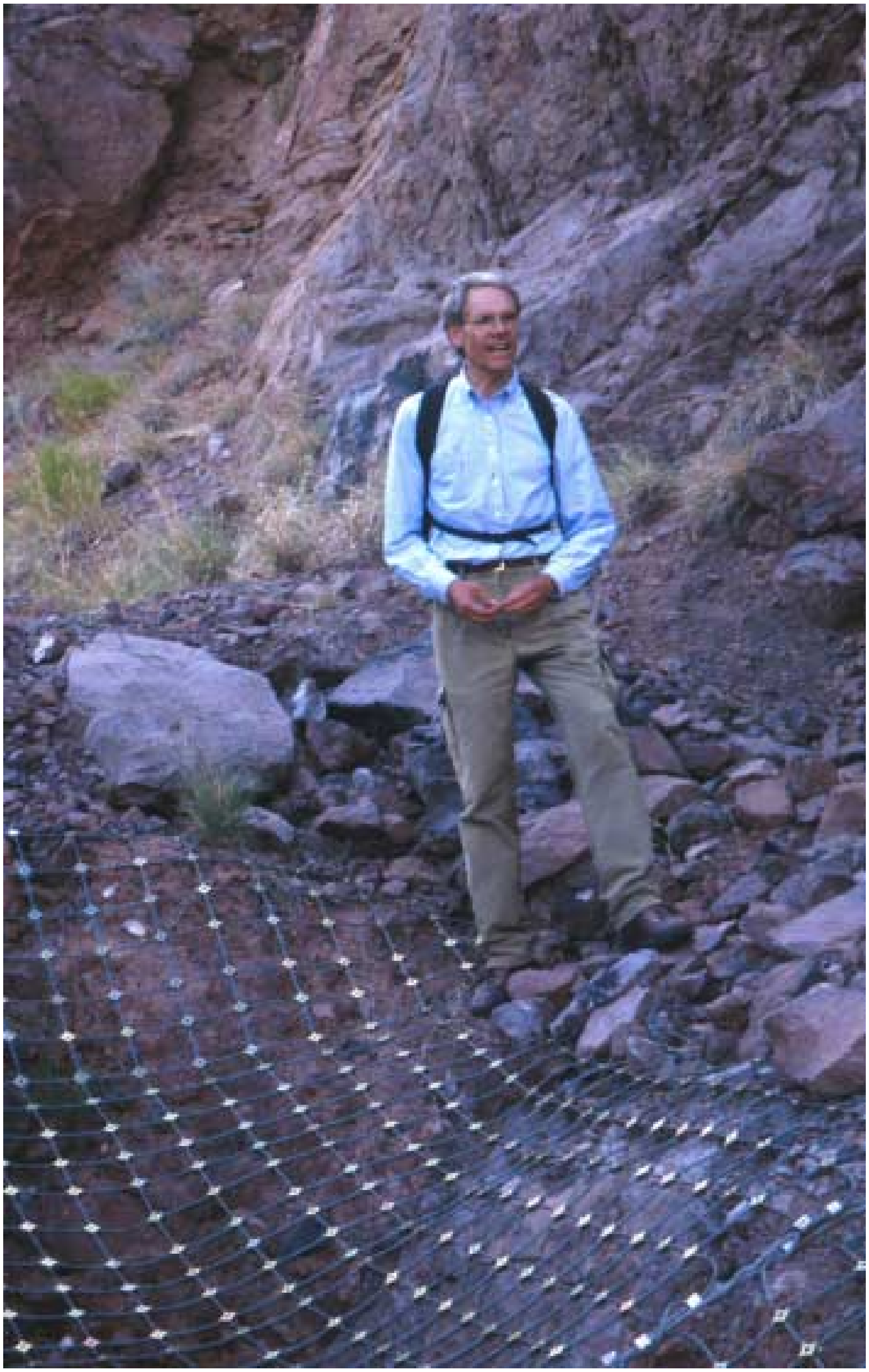

Figure 10

John Kretzmann, New Mexico Mining and Minerals Division, standing at the edge of a large open stope that has been secured with a cable net. He designed this closure as a part of the reclamation plan for a large mine complex in central New Mexico. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina.)

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