BAT-COMPATIBLE CLOSURES OF ABANDONED UNDERGROUND MINES IN THE NATIONAL PARK SYSTEM[1]

John E. Burghardt, Geologist, Certified Mineral Examiner
National Park Service Geologic Resources Division

Abstract: Abandoned mines have become critical to the survival of numerous bat species because increased urban development, deforestation, and exploitation of caves have significantly impacted natural habitat. The recent national emphasis on closure of abandoned mines for human safety and health therefore poses a further potential threat to bats. For this reason, habitat surveys for bats and other species are an integral part of the abandoned mine pre-closure inventory process. When surveys outside mines slated for closure reveal potential habitat, qualified wildlife biologists accompanied by experienced abandoned mine safety personnel conduct internal surveys. Several internal surveys are useful to determine various species using a mine for different purposes through the seasons of the year. Once the determination is made that a mine merits habitat preservation, a closure is designed to suit the specific needs of resident species. Construction takes place in a season when the mine is uninhabited or at a time and in a manner that will cause the least disturbance. To date the National Park Service has placed 102 bat-compatible mine closures in 16 park units, and plans 33 additional bat-compatible closures at 6 units.

INTRODUCTION

Many bat species rely on abandoned mines for habitat. The current effort to close and reclaim abandoned mine sites is therefore a potential threat to bat populations. Where abandoned underground mines slated for closure provide significant habitat, bat-compatible closures can be designed and constructed to meet closure objectives while preserving the valuable wildlife habitat these mines provide.

Bat Conservation as it Relates to the Mission of the National Park Service

The mission of the National Park Service (NPS) is articulated in the Organic Act of 1916 (16 USC §1), which charges the Service to "promote and regulate the use of the Federal areas known as national parks, monuments, and reservations (NPS "units"), … by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." In keeping with this charge, the National Park Service entered into a Memorandum of Understanding with Bat Conservation International in 1995. The stated purpose of the MOU is to encourage "the conservation, inventory, management

[1] This paper is posted on the National Park Service Geologic Resources Division website at **http://www.aqd.nps.gov/grd/distland/amlindex.htm#technicalreports**.

planning, scientific study, and protection of bats, bat roosts, and bat habitats located on lands administered by the National Park Service…." The NPS manages its Abandoned Mineral Lands (AML) Program, as well as its Cave/Karst Program, in accordance with these principles.

NPS ABANDONED MINERAL LANDS PROGRAM

The NPS Geologic Resources Division established an AML program in 1984 to address the adverse effects of past mineral development on NPS lands. This program includes abandoned mine and ore processing facilities, abandoned oil and gas wells, pipelines, and processing facilities, and abandoned geothermal steam wells. The AML program is now included as part of the broader Disturbed Land Restoration Program, which encompasses restoration of all human-caused disturbances to landscapes within the National Park System.

The goals of the NPS AML program are to inventory and prioritize sites for closure, eliminate safety hazards, mitigate impacts to NPS resources, preserve and interpret historically and culturally significant sites, and to manage sites for wildlife habitat. To date, largely through the efforts of park staffs with follow-up site assessments by the Geologic Resources Division, the NPS has amassed an inventory of 3,200 mine sites with 10,000 individual mine openings, encompassing all 7 regions of the NPS and 132 park units. This inventory is currently being entered into an automated database designed to record detailed site information, track status and cost of reclamation, and to prioritize sites for closure. This database will be fully compatible with databases of other federal and state land management agencies throughout the country.

A major aspect of the AML program is the closure of abandoned underground mine openings that present a hazard to park visitors and staff. Mine closures have most often been contracted, and in some cases, funded through the Office of Surface Mining Reclamation and Enforcement (OSM) and its various state programs. Before a mine closure can proceed, the NPS, as with any other land management agency, is required to obtain a variety of clearances to ensure that the action taken will have minimal adverse effect on the resources involved. Compliance with the statutory provisions of the Endangered Species Act and the National Environmental Policy Act must be demonstrated. This typically involves writing an Environmental Assessment, which in part, addresses the impacts of various closure alternatives on resident wildlife species identified in the mine inventory process.

The NPS realizes that abandoned underground mines have become critical to the survival of numerous bat species. To date the NPS has placed 102 bat-compatible underground mine closures in 16 parks. Habitat surveys for bats and other species are integral to the abandoned mine inventory process. When external surveys reveal potential habitat in a mine, qualified wildlife biologists accompanied by experienced abandoned mine safety personnel conduct internal surveys. Several surveys are useful to determine various species using a mine for different purposes through the seasons of the year. Where multiple surveys are not economically or otherwise feasible, winter surveys are conducted. Winter surveys enable direct observation of hibernating bats and indirect observation of summer use in the form of guano piles, urine stains, and discarded insect parts such as moth wings or beetle carapaces. Since hibernating bats leave

no such signs, summer surveys would yield little evidence of hibernal use aside from educated speculation on desirability of the habitat based on the mine's layout. Once the determination is made that a mine merits habitat preservation, gates are designed to suit the specific needs of resident species. Construction takes place in a season when the mine is uninhabited or at a time and in a manner that will cause the least disturbance. Throughout this process the NPS is in close collaboration with Bat Conservation International, U. S. Fish and Wildlife Service, state wildlife agencies, and locally-recognized bat biologists.

The Geologic Resources Division began receiving base funding for mine reclamation in 1998 with the establishment of its broader Disturbed Land Restoration Program. With this funding and ongoing commitment to visitor safety and biodiversity, the NPS continues to preserve significant bat habitat in abandoned mines throughout the National Park System.

BATS AND THEIR ASSOCIATION WITH ABANDONED MINES

Abandoned underground mines often provide significant, sometimes critical wildlife habitat. The most common species of concern are bats. Obviously, closure by backfilling, plugging, or constructing a solid bulkhead eliminates a mine's potential to provide useful bat habitat. Restrictive closures such as chain link fence or steel grate bulkheads may also cause bats to abandon a site. Although some closure designs may leave adequate room for bat access, they may restrict airflow or divert water drainage in ways that change the underground environment significantly, rendering once-desirable habitat useless after the closure is installed. In a few very unfortunate instances mines have been closed when bats were hibernating, entombing entire colonies. (Tuttle 1998).

Bats are among the world's most beneficial, yet vulnerable mammals (Kunz 1982, Altringham 1996). They play prominent roles in temperate and tropical ecosystems. Most North American bats eat insects, many which are crop pests that could cost farmers billions of dollars every year. A single bat may consume thousands of insects in one night. Other bats feed on nectar from flowers, and consequently, by getting covered with pollen while feeding, these bats are the primary pollinators of many desert plants such as the columnar cacti and agave. In tropical climates fruit-eating bats rank among nature's primary agents in dispersing seeds. Contrary to common belief, bats are no more prone to carrying diseases such as rabies than most other wild animals and they are passive toward humans. Of the 45 species of North American bats, the U. S. Fish and Wildlife Service and most state wildlife agencies consider 6 wholly or partially endangered of extinction throughout a significant portion of their range (Harvey 1999). Additionally, 20 species and subspecies are considered to be of special concern and may be proposed for listing as threatened or endangered in the future. Other bat species are believed to be in decline, particularly cave dwellers. The decline of bat populations throughout the U. S. is largely attributed to loss of natural habitat due to increased urban development, deforestation, and exploitation of caves.[2] Habitat provided by

[2] Other human impacts include direct killing, vandalism, disturbance of hibernating and maternity colonies, use of pesticides (on their food – insects), and other chemical toxicants. Predation by other wildlife species such as owls, hawks, raccoons, skunks, and snakes is part of nature's balance and has a relatively insignificant affect on regional bat populations (Harvey 1999).

abandoned mines is therefore becoming critical to the survival of numerous bat species. For this reason consideration of bat gates should not be limited to endangered or special concern bat species.

Depending upon location, airflow, temperature, humidity, and other factors, bats may use different portions of a mine for a day roost, night roost (temporary roost other than the day roost used for rest and digestion during foraging), maternity roost (a day roost to give birth and raise young), a stopover site during migration, or as a hibernaculum (a place to hibernate in winter). People entering an occupied mine could cause the bats to abandon their home, threatening bat survival particularly during hibernation and maternity seasons.

It is essential to properly assess an underground mine's utility as bat habitat prior to designing and constructing closures for its openings. Initial external surveys can be conducted from late spring to early fall by making visual observations at dusk as bats exit the mines to forage through the night. External surveys are greatly aided by the use of a bat detector: an instrument that can be as small as a transistor radio, which transforms the bats' inaudible calls in the frequency range of 20-120 kHz (Thomas 1987, Nowak 1994) into the audible range for humans.[3] When bats are known to inhabit a mine, special traps and nets are used in capture surveys to determine bat species, sex, reproductive status, and health. Hibernation is more difficult to detect without entering a mine, although bats often display a characteristic swarming behavior at a mine entrance in fall just prior to hibernation. Timing field research to witness pre-hibernation swarming is difficult, however.

The most complete and useful information on hibernacula and summer roosts is gathered by conducting underground surveys. Several internal surveys are useful to determine various species using a mine for different purposes through the seasons of the year. Underground surveys have become a significant part of bat researchers' duties. Underground survey safety is of particular concern, since most wildlife biologists have no underground mining experience. Although the NPS does not currently have an official policy on abandoned underground mine entry, the NPS Geologic Resources Division policy is to have a qualified abandoned mine specialist accompany all underground survey participants to ensure their safety. Since there is currently no formal NPS process to certify such an expert, this person is typically a geologist or mining engineer with extensive training and experience in abandoned mines, rock mechanics, and mine atmospheres.[4]

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[3] Various bat detectors are available, from basic models at a cost of about $150, to larger, very sophisticated models costing thousands of dollars. The more sophisticated units produce diagnostic graphic images of an individual bat's echolocation signature, which is useful in species identification of bats in flight.

[4] The author has been an instructor in abandoned mine safety courses offered by U.S. Forest Service and the Bureau of Land Management which are available to federal employees and other organizations. These courses emphasize that caving experience is no substitute for abandoned underground mine expertise. Abandoned underground mines have many unique safety concerns that distinguish them from caves. Caves are generally formed by gradual, stable processes, and typically have better airflow than mines except where portions of the cave have collapsed or been buried. By contrast, mines are often located along fault structures that are inherently unstable. The blasting used to develop a mine further destabilizes the overlying rock. Timbers, rock bolts, and other means of roof support, originally placed to stabilize "incompetent ground," tend to deteriorate and loose their effectiveness after the mine has been abandoned. Ventilation systems used to evacuate toxic gasses are no longer operational in abandoned mines, so there is a strong likelihood of encountering oxygen-deficient or toxic atmospheres. Abandoned explosives

The designated safety specialist instructs survey participants on potential underground hazards and ensures that they have appropriate personal safety gear. The safety specialist has instrumentation to monitor air quality, uses a scaling bar to test rock stability and remove loose rock, and has authority to abort the survey if he or she deems conditions to be too dangerous.

Most underground mines are closed by means that are not bat-friendly such as backfilling, installation of polyurethane foam plugs or other bulkheads, or blasting. This can be for a number of reasons. A mine may provide only marginal or occasional bat habitat where alternative habitat that is less dangerous is readily available nearby. Sometimes, regrettably, a mine that provides good bat habitat must be plugged or sealed for overriding safety considerations such as unstable rock or high levels of radiation. In active mining areas, previous underground mine workings are sometimes reworked or incorporated into larger open pit mines and valuable habitat is sacrificed. Whatever the reason, when potential or known bat habitat in underground mines must be destroyed, bats that may be inside should first be excluded. For mines that might have bat activity throughout the year exclusion should be done in spring or fall with particular care to avoid maternity colonies and hibernacula, where the most harm could be done to non-volant young or hibernating bats that cannot escape (Tuttle 1998). Exclusion is accomplished by placing 1-inch chicken wire over all openings of the mine after the bats have exited for night foraging on a warm evening. Details of proper exclusion techniques and protocols are described in Brown 1997 and Tuttle 1998. It is most important to consult a bat biologist with extensive experience and equipment when a large bat colony is at risk.

Bat Gate Designs

Bat gates are designed to keep people out of mines while minimizing airflow restriction and allowing bats relatively uninhibited access. Preventing human access and maintaining natural airflow minimizes disturbance of the bats' home. After the mine entrance is cleaned of loose rock and stabilized as needed, gates are fitted just inside adit portals and anchored into the surrounding competent bedrock. Vertical shafts are more difficult to close, since laying a bat gate on the ground over a shaft would create a hazard that could cause people and wildlife to fall and possibly break a leg. Additionally, research indicates that bats prefer to fly horizontally through vertically-oriented gates, rather than flying vertically through horizontally-oriented gates.[5] Numerous shafts have been closed by installing an I-beam frame anchored to bedrock or in cement and covered in steel grating, with a hole cut out of the grating to receive a "bat cupola." A cupola is typically a box-like structure placed over the vertical opening. Researchers are experimenting with variations on the basic cupola design.

Bat gate designs typically call for openings between bars of 5¾ inches high by a minimum of 24

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and hazardous substances are commonly encountered. Heavy equipment, deteriorating structures, and flooded areas present numerous hazards. Underground surveys should only be conducted under the direction of a fully experienced and properly equipped abandoned mine specialist whose sole duty is the safety of the survey team. For more information consult http://www.aqd.nps.gov/grd/distland/amlindex.htmtechnicalreports.

[5] Personal communication, Dr. J. Scott Altenbach.

inches wide. Concern has been raised that this vertical spacing of the horizontal bars may be too large to preclude small children, so some gates are now being installed with 4-inch vertical bar spacing in the lower portion of the gate in compliance with the Universal Building Code for railings.

A number of different materials have been used in gate fabrication. Earlier designs called for simple webs of rebar cut and welded to fit each opening. Other designs use angle iron and the stainless steel bar such as that used in jail cell construction. Recent NPS gates use a popular design developed by professional engineer and conservationist Roy Powers and others in cooperation with the American Cave Conservation Association (Tuttle 1998, pp. 34-46). The ACCA design uses L4"x4"x⅜" angle steel for structural members and cross member supports with two L1½"x1½"x¼" angle steel "stiffeners" welded inside each horizontal cross member. These stiffeners provide integrity to allow cross member spans of up to 10 feet between the uprights, making the gates much more accessible for bats and less restrictive to airflow. Additionally, the massiveness of the reinforced cross members effectively discourages vandalism, which is a major concern for any gate closure. The Utah AML Reclamation Program now uses Manganal steel bars for its bat gates. Manganal steel cannot be cut with a hack saw, and Manganal bar gates require less welding than ACCA gates, thereby reducing the difficulty and cost of fabrication. Through a Memorandum of Understanding, the NPS and Utah AMLRP have recently installed 5 Manganal gates in Canyonlands National Park. New materials and designs will undoubtedly be developed through time.

Gates must often be designed with a secured means of human access into the mine. Many designs for lockable hatches have been used, but these often take up a significant portion of the gate and inhibit bat access in small mine openings. Most current designs incorporate one or more removable bars for this purpose. These bars are often secured with locks. Since the lock itself is often the weakest part of the closure, a great deal of thought has gone into designing "lock boxes" which prevent vandals from tampering with locks. More recently the favored technology is to secure the removable bars with special vandal-proof bolts that require a unique, custom tool for removal.

Vandalism is a potential problem with any closure short of total backfill. Perhaps the most formidable threat to a well-constructed bat gate is a portable cutting torch, but it is unlikely that this type of equipment would be carried to many of the remote settings where NPS gates have been installed. The primary means of thwarting properly installed NPS gates has been to mine a new passage in the rock around them, but this is a rare occurrence. This is a good reason for situating gates well inside the portal in competent bedrock if at all possible.

Gates are not necessarily a panacea for protection of all bat species. Two well-intended bat gate installations in Arizona recently caused colonies of Lesser long-nosed bats and Western big-eared bats to abandon their roosts, for reasons yet to be understood. Qualified bat biologists should be consulted prior to gate installation to identify all species present and to recommend appropriate gate designs. In some cases, inexpensive and easily removable test gates constructed of plastic or other materials are installed and closely monitored. Pending the results of these test gates, they are replaced with permanent steel gates that optimize the potential for bat acceptance. Gates can also be

installed in stages, placing the upper bars one at a time over a period of weeks or months, enabling bats to adjust gradually to the new structure. Timing of gate installations is very important. Construction should take place when the mine is uninhabited by bats, or at a time and in a manner that will cause the least disturbance.

The importance of monitoring bats' acceptance of a gate after installation cannot be overemphasized. Technical papers reviewing the success of various gate designs for different bat species are invaluable to future gating efforts.[6] Aside from technical journals and conference presentations, Bat Conservation International, which has full-time staff dedicated solely to bats and abandoned mines, serves as an effective clearinghouse for such information and should be given a copy of all such papers. Bat Conservation International can be reached by mail at P.O. Box 162603, Austin, TX 78716, or by phone at (512) 327-9721 or through their website at **http://www.batcon.org**. Another emerging group to consult is the Coalition of North American Bat Working Groups at **http://www.batworkinggroups.org**.

BAT GATE INSTALLATIONS IN THE NATIONAL PARKS

To date, 102 bat-compatible closures have been installed in 16 NPS units and 33 additional gates at 6 NPS units are planned for the near-future (Tables 1 and 2). The NPS AML Program has greatly benefited from partnerships with a number of different agencies. In most cases, NPS mine closure projects would not have been possible without the generous assistance gained from partners such as OSM, the National Association of Abandoned Mine Land Programs (under the direction of OSM), other state AML agencies, and Bat Conservation International.

OSM financed and contracted a major coal reclamation project from 1987 to 1992 at New River Gorge National River and, Big South Fork National River and Recreation Area, and Friendship Hill National Historic Site. Included in this million-dollar project were 25 bat gates installed in coal mines at New River and Big South Fork (Figure 1, page 14). These earlier gates were mostly constructed of L3"x3"x¼" angle steel and are much less substantial than the more recent ACCA gates, but have seen minimal vandalism. One gate in New River was damaged due to roof collapse and was replaced recently with an ACCA gate that has aided in stabilizing the mine entrance. The rock in most of these mines is highly unstable. For that reason and due to problems with bad air generally inherent to coal mines, current park policies forbid any underground access to these mines. Most of the original bat survey work in these parks was conducted using external monitoring and trapping.

A bat gate at the Sugar Fork Copper Mine in Great Smoky Mountains National Park was installed by the park in 1988 in collaboration with the U.S. Fish and Wildlife Service. A large, adjoining open stope was also fenced off and posted with warning signs at that time. This mine serves primarily as a hibernaculum for Rafinesque's big-eared bats. To date the fence has not been vandalized, most likely due to the foreboding nature of the open stope. Also in Great Smokies,

[6] Post-installation monitoring is also necessary to ensure that the gates have not been vandalized.

Eagle Creek (a.k.a. "Fontana") Copper Mine is the second deepest abandoned mine in the National Park System, with massive workings to a depth in excess of 3,000 feet that are now totally flooded except for the uppermost 100 feet. The mine is in highly incompetent weathered schist bedrock that could easily be excavated around even the most perfectly fabricated gate. A maternity colony of several hundred Rafinesque's big-eared bats and numerous hibernating bats of the same species have been studied at this mine since 1986. To date, counts of hibernating Rafinesque's big-eared bats in Sugar Fork and Eagle Creek Mines have been documented as high as 570 and 228, respectively, making these the largest known hibernacula of this species (Currie 1986). A survey conducted in September 2000 revealed a previously unknown maternity chamber at Eagle Creek Mine that undoubtedly hosts many more bats than previously known to inhabit the site, as attested by numerous guano piles up to 2 feet in height. Participants in this survey agreed that fencing is the best closure for the Eagle Creek Mine due to its huge openings that would require gates as wide as 30 feet and as high as 20 feet, and because of the weak bedrock through which gates could easily be compromised. The current fence around 4 of the openings is 6 feet tall. Although it shows little sign of vandalism, it could stand some improvements. In the course of the recent survey, 3 additional interconnected openings were found, and others may open up through time due to subsidence. A new fence 8 feet tall encompassing all 7 openings and the subsidence area is planned for installation in 2001.

In 1992, one adit was gated in Curecanti National Recreation Area with the contracting assistance of the Colorado Division of Mines and Geology. Bat presence had been confirmed at this site, although not thoroughly studied. The bat gate closure was selected to protect the known bat population and because it was an economical closure for the site, given its remote location.

At Chesapeake and Ohio Canal National Historic Park, 3 adits of the historic Round Top Limestone Mine were closed with bat gates in 1993 for protection of the public, cave fauna, and historic resources. Cases of vandalism, pilfering of historic artifacts, and one case where bats were shot off the mine walls were documented prior to gating. All three adits were closed under the direction of Roy Powers, with the aid of park staff and local volunteers from the American Cave Conservation Association.

A popular hiking and interpretive trail near a well-used boat ramp winds through the Historic Rush Zinc Mining District at Buffalo National River. More than 50 mine openings have been inventoried along this trail and across the river where canoeists typically stop and explore. Since 1993 the park has closed 14 of these openings using 13 bat gates, with partial funding assistance from Bat Conservation International (Figure 2, page 15). Bat gating efforts at Rush will continue at a pace of 3 or 4 gates per year until all mines known to provide significant habitat have been closed with state-of-the-art bat gates.

In 1993 the Utah Division of Oil, Gas, and Mining contracted ACCA bat gate closures of five adits of the historic Oyler Radium Mine in Capitol Reef National Park. These mines are situated along the park's main scenic drive about one mile from park headquarters. The previous closures of steel pipe and chain link fence were frequently vandalized and ineffective at excluding park visitors. Radiation levels at the mine were monitored to ensure that park visitors would not be irradiated

when standing at the gated portals. Radiation levels inside the mines are also quite low, so are thought to have minimal impact on roosting bats.[7]

An abandoned mine safety crew was stationed at Death Valley National Park in the 1980s to close many of the park's estimated 4,800 abandoned mine openings and to assist with closures in several other southwestern parks. Funding shortages terminated this program in 1990. This crew developed an economical 6-inch by 6-inch stainless steel cable net closure. Time has proven cable nets to be more prone to vandalism than more expensive steel gates, but they have been very useful at numerous sites, particularly in closing large vertical openings. Since a bat cannot fly freely through these nets, they are generally not recommended on mine openings with significant bat activity. However, cable nets appear to be used by some hibernating bats since these bats do not require nightly access in and out of the mine. In an attempt to make cable nets more bat-friendly, 11 of the cable nets at Death Valley were modified by removing one or more vertical cable segments to produce 12 inch wide by 6 inch wide openings near the top of the nets. Indications are that the bats are using these mines. In addition, Death Valley has constructed 7 conventional bat gates of varying designs. After a conventional bat gate was installed at the Leadfield Mine in Death Valley, a maternity roost population dropped from 200 to 20. This radical reduction was most likely in response to vandalism after the gate was installed. Individuals annoyed by being excluded from the mine and aware of the bat colony threw burning sticks through the gate directly under the roost. The resulting smoke most likely caused most of the maternity colony to abandon the site.

Two bat gates have been installed at Lake Mead National Recreation Area using the assistance of staff from Death Valley staff. The gate installed at Dumont Mine in 1997 was prefabricated in the shop before transporting it to the site. When exact measurements can be taken and a gate can be transported to the site, prefabrication in the shop greatly reduces the difficulties and expense encountered with field installations, reducing on-site work to anchoring the gate into the mine opening. In 1999 and 2000 Lake Mead installed 3 additional gates on isolated precious metal mines. For reasons similar to those at Eagle Creek Mine in Great Smoky Mountain National Park, a large fence was erected around three shafts and a subsidence-prone area to protect a Yuma myotis bat

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[7] To date there has been little study on the effects of radiation on bats. This is a potential problem in many mines and caves. Being long-lived mammal species like humans (life spans of 30 years have been documented through bat banding studies (Harvey 1999)), it is reasonable to speculate that high levels of radiation would be similarly deleterious to bats. Some researchers believe that the chronic effects of radiation may be offset by the advantages gained from the habitat provided by abandoned uranium mines, for instance, in longevity and reduced infant mortality realized through otherwise favorable habitat. No somatic effects from radiation have been documented in bats. Current studies on the effects of radiation on other wildlife being conducted at Los Alamos National Laboratory, New Mexico might be helpful in understanding the effects on bats. Bat researchers are hopeful that more work will be done on this issue, and it is suggested as an excellent topic for post-graduate study. In the meantime, the NPS has a policy not to gate a site that might expose park visitors to excessive levels of radiation, rather excluding wildlife from such sites, then backfilling to reduce radiation levels to acceptable levels. For a discussion of this issue, consult a paper entitled, *Effective Management of Radiological Hazards at Abandoned Radioactive Mine and Mill Sites,* on the NPS Geologic Resources Division's website at **http://www.aqd.nps.gov/grd/distland/amlindex.htmtechnicalreports.**

colony at Katherine gold mine.

In 1995 the Railroad Commission of Texas financed and contracted closure of 18 abandoned mine openings in Big Bend National Park. Seventeen of the openings were located at Mariscal Mercury Mine, a National Register Historic District. Included in this project were 7 conventional bat gates, 1 corrugated steel culvert bat gate closure in an adit portal prone to collapse, and 2 grated shaft closures with bat cupolas (Figures 3 and 4, page 16). Most of the openings at Mariscal Mine were closed previously with aircraft cable and chain link fence, but visitors had bypassed several of these to gain access to the mine's intricate maze spanning seven levels to a depth of 426 feet. These closures also excluded most of the bats that had been roosting in the mine. Excluded from Mariscal Mine, these bats apparently moved to nearby Emory Cave and displaced a colony of federally endangered Greater long-nosed bats. The new gates at Mariscal should, in time, restore roosting conditions at both sites. The cooperative closure project with the Railroad Commission won the 1996 National Park Foundation's Partnership Award in the category for Protection and Visitor Services "for correcting health and safety hazards posed by abandoned mine openings as well as for preserving bat habitat and historic resources."

The Railroad Commission of Texas also financed and contracted the closure of 10 openings at the Texas-Calumet Mine in 1996 in Guadalupe Mountains National Park. Four bat-compatible closures were included in this project. Mobilization of equipment and materials for the project was accomplished by helicopter to limit impacts in this designated wilderness area.

One of the primary experimental gating sites in the NPS is the State of Texas Mine at Coronado National Memorial in southeast Arizona. Dr. Yar Petryszyn from the Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, is the principle researcher for this project. The mine currently serves as a transient roost for as many as 30,000 endangered Lesser long-nosed bats, despite installation of 6-inch-mesh cable net closures in 1986. These bats inhabit the mine from late July through early September each year as they migrate north from Mexico following the bloom of the agave plant. As noted above, cable nets are generally not conducive to bat access. Although the current bat colony seems to have adjusted to the cable nets, researchers believe that the colony was once much larger. There is additional concern since these and other cable nets installed in the area have been vandalized by park visitors for underground access. For these reasons the park initiated a study in 1997 to find a means of closure that would be more effective at excluding people and less restrictive for bats. Little is known about Lesser long-nosed bats' acceptance of gates, although there have been two cases reported in southern Arizona where this species rejected gates and abandoned former roost sites, as noted above. Dr. Petryszyn removed the cable net over the bats' secondary access to the mine, which is used by a small percentage of the bat population, and constructed a cupola in its place in April 1997. Interchangeable side panels measuring 72 inches wide by 36 inches high were constructed of 6 different materials to see how the bats react to each. The panels were constructed from ½-inch rebar, ½-inch square tube, 1 ½-inch ID pipe, 2-inch square tubing, 2-inch angle iron, and 4-inch angle iron, all with 5 ¾-inch spacing between the horizontal bars. These panels fit into the south and east sides of the cupola structure, the rest of which has stationary panels that are covered in chicken wire for the experiment to force the bats through the experimental panels. The results of

bats using the experimental panels, as monitored by visual counts using a night vision camera and an infrared light source, are scheduled for publication early in 2001. Pending these results, permanent steel panels of the optimum materials will be placed in the existing cupola and the cable net at the main entrance to the mine will be replaced with a similarly constructed bat gate.

The Utah AML Reclamation Program helped the NPS again in 1998 by contracting and managing closure of 5 uranium mines along the popular White Rim Road in Canyonlands National Park. This time Utah used Manganal steel gates (Figure 5, page 17). Due to concerns of preserving the fragile desert environment between the White Rim Road and the mines, materials and equipment were carried by hand to the site using prison labor that was otherwise occupied in constructing native rock backfill closures in mines where bat habitat was not an issue. The reduced materials needed for Manganal gates over much heavier L4"x4"x⅜" angle steel gates saved greatly on time, effort, and expense, yet yielded competent closures that will withstand vandalism at these remote sites.

Joshua Tree National Park has begun an aggressive 5-year program to mitigate most of its 289 AML sites. Each year staff from the Geologic Resources Division, Bat Conservation International, and the park team up to conduct winter surveys of sites thought to have potential bat use. Closure recommendations are developed for each opening depending upon bat use, logistics, and safety considerations. Summer follow-up surveys are being considered for sites where further study may be needed. To date one bat gate has been installed at Sullivan Mine (Figure 6, page 18), where supplies and equipment were mobilized to the site by a mule pack team borrowed from Sequoia and Kings Canyon National Parks. Other sites may require helicopter support, which may be arranged in cooperation with the nearby Twenty-Nine Palms Marine Base. As a result of the cooperative survey program 17 additional bat gate closures are planned at Joshua Tree in the near future.

Fort Bowie National Historic Site and Bureau of Land Management's (BLM) Safford District entered into a cooperative project on their common boundary to close a number of openings at Quillin Mine, located along the historic Butterfield Overland Trail. Four of these openings, all actually on BLM land, are known to host significant bat populations, most notably Mine BOT #1, situated 100 feet from the park boundary. The primary roosting chamber is a stope measuring approximately 15 feet wide by 30 feet long by 15 feet high, situated midway between adit and shaft entrances to the mine. The original survey of the mine was conducted in April 1996, at which time 20 Western big-eared bats were found emerging from hibernation, but guano approximately 6 feet deep attested to the heavy summer use (Burghardt, 1996). Subsequent summer surveys confirmed a maternity colony of 4,000 Cave bats and several hundred Fringed bats. (Altenbach 1996) A bat gate was constructed on the adit in stages during 1998 as the bats' acceptance was tested, then an innovative cupola design was constructed in early 2000 over the shaft. The colony has been receptive of the closures.

Another experimental closure project was initiated in 2000 at the Wildhorse gold mine in the Tucson Mountains at Saguaro National Park. As many as 8,000 bachelor Cave bats have been documented at this, which is naturally heated by geothermal activity. Due to the importance of this roost site and some uncertainty of how the bats would react to a bat gate, a mock gate designed to mimic the ACCA gate design was constructed of fiberglass fence posts. A system of wooden

wedges and strapping tape was used to construct the gate rather than using glues that would produce toxic fumes. Initially the bats took longer to emerge from the mine once the gate was placed, but they soon seemed to accept the gate and the outflight returned to normal. The park will replace the test gate with a permanent steel gate in 2001.

Bat Gate Interpretive Safety Sign

The National Park Service and Bat Conservation International have jointly developed a bat gate interpretive sign (Figure 7, page 19) which is placed behind each gate to explain the gate's design and purpose. The sign informs the public of the potential hazards at abandoned mine sites, the beneficial aspects of bats, and the importance of preserving bat habitat. Hopefully this information will minimize the temptation to vandalize the gate. The bat gate signs are designed so that the NPS logo can be replaced with that of any other agency. Signs are available through Bat Conservation International.

CONCLUSIONS

The National Park Service has expended considerable effort to protect the public and preserve significant bat habitat by installing bat-compatible closures on abandoned underground mine openings. Preliminary results indicate that these closures have been effective at protecting humans and bats, alike. In the broader AML community, the future success of bat-compatible closures will hinge on funding, the quality of pre- and post-gate monitoring, and on agencies' ability to network information learned from individual bat gating projects.

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Figure 1. Bat gate installed at Kaymoor Coal Mine, New River Gorge, West Virginia. (1988)

Figure 2. Bat gate installed at Monte Cristo Zinc Mine, Buffalo National River, Arkansas. (1993)

Figures 3 and 4. Culvert-mounted bat gate installed to preserve unstable mine entrance, and bat cupola installed on shaft, Mariscal Mercury Mine, Big Bend National Park, Texas. (1995)

Figure 5. Manganal steel bar bat gate installed at Shafer Uranium Mine, Canyonlands National Park, Utah. (1998) Several perfectly-preserved wooden dynamite boxes dated 1953 were found in the mine, and were left within view of the gated entrance as part of the park's effort to interpret the mining history of the park.

Figure 6. Inspecting bat gate at Sullivan Gold Mine, Joshua Tree National Park, California. (1999) (middle bar removed for access)

PROTECTED HABITAT

This gate was installed for your safety and for the protection of important bat habitat. Your cooperation is greatly appreciated in helping to preserve this environment by not attempting to bypass or vandalize this gate. If you manage to get inside, you could place yourself in great danger from oxygen-deficient air, toxic gases, unstable rock, and vertical drop-offs, and you might harm the bats within by disturbing their habitat.

Bats play vital roles in ecosystems worldwide. Most North American bats eat insects, many of which are crop pests that cost farmers billions of dollars every year. A single bat may consume thousands of insects in one night. Other bats feed on flower nectar and are primary pollinators of desert plants such as the saguaro cactus and the agave. In tropical climates, fruit-eating bats are primary agents in dispersing seeds and thus maintaining forest ecosystems. Contrary to common belief, bats are passive toward humans and are no more prone to carrying diseases such as rabies than most other wild animals. However, any bat or other wild animal that can easily be caught is more likely than others to be sick, and should never be handled.

Because bat habitat is threatened by increased urban development, deforestation, and exploitation of caves, abandoned mines have become critical to the survival of numerous bat species. Depending upon specific factors such as location, airflow, and temperature, bats may use portions of a cave or mine to hibernate in winter, to give birth and raise young, or to stop over during migration or nightly foraging. People entering this mine could cause the bats to abandon their home and could threaten their survival—particularly during hibernation and maternity seasons.

Bats are among the world's most beneficial, yet vulnerable, mammals.
Please help us to protect them.

For more information on bats and their protection, contact:

Bat Conservation International, Inc.
P.O. Box 162603 Austin, TX 78716
(512) 327-9721

Figure 7. Bat gate interpretive safety sign.

TABLE 1: BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS
CLOSURES PLACED TO DATE (November 2000)

PARK	STATE	MINE	COMMODITY	DATES	#	BAT SPECIES PROTECTED	STATUS †
New River Gorge	WV	Kaymoor Brooklyn Bench others	Coal	1987-1998	18	Eastern pipistrelle bat *(Pipistrellus subflavus)* Little brown bat *(Myotis lucifugus)* Big brown bat *(Eptesicus fuscus)* Indiana bat *(Myotis sodalis)** Virginia big-eared bat *(Corynorhinus townsendii virginianus)** Northern long-eared bat *(Myotis septentrionalis)**	- - - Endangered Endangered -
Great Smoky Mountains✶	NC	Sugar Fork Eagle Creek	Copper	1988	6	Rafinesque's (Eastern) big-eared bat *(Corynorhinus rafinesquii)*	Special Concern
Big South Fork	KY	Blue Heron Others	Coal	1988-1992	7	Eastern pipistrelle bat *(Pipistrellus subflavus)* Little brown bat *(Myotis lucifugus)* Big brown bat *(Eptesicus fuscus)* Indiana bat *(Myotis sodalis)** Virginia big-eared bat *(Corynorhinus townsendii virginianus)** Northern long-eared bat *(Myotis septentrionalis)**	- - - Endangered Endangered -
Curecanti	CO	Gateview	Precious metals	1992	1	(not determined)	-
Capitol Reef	UT	Oyler	Radium	1993	5	Western big-eared bat *(Corynorhinus townsendii pallescens)* Western pipistrelle *(Pipistrellus hesperus)*	Special Concern -
C & O Canal	MD	Round Top	Limestone	1994	3	Eastern pipistrelle bat *(Pipistrellus subflavus)* Little brown bat *(Myotis lucifugus)* Big brown bat *(Eptesicus fuscus)* Indiana bat *(Myotis sodalis)** Eastern small-footed bat *(Myotis leibii)** Northern long-eared bat *(Myotis septentrionalis)**	- - - Endangered Special Concern -

† (Harvey 1999)

* Species known to inhabit the area and suspected of using mines, but not confirmed. Some species suspected due to guano found in underground surveys when bats were not present.

✶ Includes one bat gate in an adit that connects to a large open stope that has been fenced and signed at Sugar Fork Mine. At Eagle Creek Mine a large fence encloses an area with 4 massive incline openings in very unstable and incompetent rock. Conventional bat gates are not practical in the fenced openings at Great Smoky due to the size of the openings, and because it would take little effort to excavate around gates at Eagle Creek mine in the weathered schist bedrock. A new fence enclosing the original 4 openings and 3 additional openings is planned.

TABLE 1 (cont'd.): BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS CLOSURES PLACED TO DATE (November 2000)

PARK	STATE	MINE	COMMODITY	DATES	#	BAT SPECIES PROTECTED	STATUS †
Buffalo National River	AR	Monte Cristo White Eagle McIntosh	Zinc	1993-2000	13	Gray bat *(Myotis grisescens)* Eastern pipistrelle bat *(Pipistrellus subflavus)* Big brown bat *(Eptesicus fuscus)* Ozark big-eared bat *(Corynorhinus townsendii ingens)* Indiana bat *(Myotis sodalis)**	Endangered - - Endangered Endangered
Lake Mead	CA	Reid Dupont	Precious metals	1994 1997	1 1	California leaf-nosed bat *(Macrotus californicus)* Yuma myotis bat *(Myotis yumanensis)*	Special Concern Special Concern
		Katherine ✶		2000	3	Yuma myotis bat *(Myotis yumanensis)*	Special Concern
		Eldorado Jeep Trail		1999	1	California leaf-nosed bat *(Macrotus californicus)*	Special Concern
		Dupont ES			1	California leaf-nosed bat *(Macrotus californicus)* Yuma myotis bat *(Myotis yumanensis)*	Special Concern Special Concern
		Golden Gate Golden Mile		2000	1 1	Western big-eared bat *(Corynorhinus townsendii pallescens)*	Special Concern
Big Bend	TX	Mariscal Rio Grande Village	Mercury	1995	10	Western big-eared bat *(Corynorhinus townsendii pallescens)* Big brown bat *(Eptesicus fuscus)* Cave bat *(Myotis velifer)* Greater long-nosed bat *(Leptonycteris nivalis)**	Special Concern - Special Concern Endangered
Death Valley ‡	CA	misc.	Talc, lead, precious metals	1987-1995	18	Western big-eared bat *(Corynorhinus townsendii pallescens)* Miscellaneous myotis species*	Special Concern -
Coronado	AZ	State of Texas	Precious metals	1997	1	Lesser long-nosed bat *(Leptonycteris curasoae)*	Endangered
Guadalupe Mountains	TX	Texas-Calumet	Copper	1996	4	Western big-eared bat *(Corynorhinus townsendii pallescens)* Cave bat *(Myotis velifer)* Western small-footed bat *(Myotis ciliolabrum)** Big brown bat *(Eptesicus fuscus)**	Special Concern Special Concern Special Concern -

† (Harvey 1999)

* Species known to inhabit the area and suspected of using mines, but not confirmed. Some species suspected due to guano found in underground surveys when bats were not present.

✶ A large fence encloses 3 openings and an unstable subsidence-prone area at this site.

‡ Includes 11 cable nets modified in 1987 with 6"h x 12"w openings to accommodate Western big-eared bat hibernacula.

TABLE 1 (cont'd.): BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS CLOSURES PLACED TO DATE (November 2000)

PARK	STATE	MINE	COMMODITY	DATES	#	BAT SPECIES PROTECTED	STATUS †
Canyonlands	UT	Shafer, Lathrop, Musselman, Airport Tower	Uranium	1998	5	Western big-eared bat *(Corynorhinus townsendii pallescens)* Big brown bat *(Eptesicus fuscus)** Western pipistrelle bat *(Pipistrellus hesperus)** miscellaneous myotis species*	Special Concern - - -
Joshua Tree	CA	Sullivan	Precious metals	1999	1	California leaf-nosed bat *(Macrotus californicus)* Western big-eared bat *(Corynorhinus townsendii pallescens)* Big brown bat *(Eptesicus fuscus)* miscellaneous myotis species*	Special Concern Special Concern - -
Fort Bowie / BLM Safford District ✶	AZ	Quillin	Precious metals	1998 2000	1 1	Western big-eared bat *(Corynorhinus townsendii pallescens)* Cave bat *(Myotis velifer)* Fringed bat *(Myotis thysanodes)*	Special Concern Special Concern Special Concern
Wrangell St-Elias	AK	Bremner	Precious metals	1999	1	Little brown bat *(Myotis lucifugus)*	-
TOTAL 16	**12**				**102**	**18 Species**	

† (Harvey 1999)

* Species known to inhabit the area and suspected of using mines, but not confirmed. Some species suspected due to guano found in underground surveys when bats were not present.

✶ This was a cooperative project between the NPS and BLM. Quillin Mine straddles the BLM/NPS boundary. The bat gate and cupola are actually on BLM land 100 yards from the NPS boundary. Since these closures were financed by the BLM they are not counted in the totals column for NPS bat-compatible closures.

TABLE 2: BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS CURRENT PROJECTS (November 2000)

PARK	STATE	MINE	COMMODITY	#	BAT SPECIES PROTECTED	STATUS †
Buffalo National River	AR	Capps	Zinc	3	Gray bat *(Myotis grisescens)* Indiana bat *(Myotis sodalis)**	Endangered Endangered
Great Smoky Mountains ✶	NC	Eagle Creek Sugar Fork	Copper	4	Rafinesque's (Eastern) big-eared bat *(Corynorhinus rafinesquii)*	Special Concern
Joshua Tree	CA	Hexahedron Johnny Lang Sunrise #7 Eagle Cliff Golden Bell Standard Load Desert Queen	Precious metals Base metals	1 1 1 3 5 5 1	California leaf-nosed bat *(Macrotus californicus)* Western big-eared bat *(Corynorhinus townsendii pallescens)* Big brown bat *(Eptesicus fuscus)* miscellaneous myotis species*	Special Concern Special Concern - -
Saguaro ❖	AZ	Wildhorse	Precious metals	1	Cave bat *(Myotis velifer)*	Special Concern
Lake Mead	AZ	Joker Copper Mountain Katherine's Landing	Precious metals	1 3 2	California leaf-nosed bat *(Macrotus californicus)* Yuma myotis bat *(Myotis yumanensis)* Western big-eared bat *(Corynorhinus townsendii pallescens)*	Special Concern Special Concern Special Concern
Organ Pipe ✻	CA	Copper Mountain	Copper	2	Lesser long-nosed bat *(Leptonycteris curasoae)* California leaf-nosed bat *(Macrotus californicus)*	Endangered Special Concern
TOTAL 6	4			33	9^{+} species	

† (Harvey 1999)

* Species known to inhabit the area and suspected of using mines, but not confirmed. Some species suspected due to guano found in underground surveys when bats were not present.

✶ The existing gate at Sugar Fork Mine has been corroded by acid rock drainage and will be replaced by a gate designed to divert the drainage. A better fence that will enclose 3 additional openings will replace the existing fence around 4 openings at the Eagle Creek Mine.

❖ An experimental plastic gate has already installed to test the bats' acceptance. A long-term steel gate will be installed pending results of the experimental gate.

✻ This mine receives minimal human disturbance. Gates will not be installed until results from the Coronado experimental gate for Lesser long-nosed bats are determined.

Appendix

Detailed photographs of NPS AML sites,
external and internal mine survey procedures,
bat gate fabrication, and finished gates.

Safety precautions used in conducting underground surveys. Staff with experience in active and abandoned mine safety check rock stability, monitor air quality for oxygen and contaminant levels, and assume primary responsibility for the safety of the group. *(Photo sequence on barring bad rock at Blue Notch Mine, Glen Canyon National Recreation Area, compliments of Sheryl Ducummon, Bats/Mines Coordinator, Bat Conservation International.)*

External mine survey techniques using ultrasonic bat detector, harp trap, mist net, and radio telemetry. Captured bats can be fitted with a radio transmitter and traced back to their roost site. The transmitter is glued to the bat's back and drops off after several days with no harm to the bat. *(The first two photographs are compliments of Colorado Division of Wildlife and Bat Conservation International, respectively.)*

Bat gate fabrication at Big Bend National Park (ACCA design). Notice 1”-diameter steel pin anchors to sill and ribs, L4"x4"x⅜" angle steel for structural members and cross member supports with two L1½"x1½"x¼" angle steel "stiffeners" welded inside each horizontal cross member, and grinding of all rough edges to avoid sharp spots that would otherwise injure bats.

Completed bat gates at Mariscal Mercury Mine in Big Bend National Park. Note protective lock box for removable bar locking mechanism, and culvert gate used to maintain opening on unstable slope. This project was funded and contracted by the Railroad Commission of Texas Division of Surface Mining and Reclamation.

Bat gate and cupola at Quillin Mine on the BLM Safford District adjacent Fort Bowie National Historic Site. These closures were part of a cooperative NPS/BLM effort to close Quillin openings that were on either side of the Fort Bowie / Safford boundary line. Note guano pile and urine-stained roof from maternity colony of cave myotis bats, and removable horizontal bar secured with special vandal-proof bolts that require a custom tool for removal. Bat guano on the bars indicate the bats' receptivity of the gate.The cupola was designed with a low profile so as not to be visible from the main park road.

The National Park Service has closed numerous mines in the Utah parks with the assistance of the Utah Division of Oil, Gas, and Mining Abandoned Mine Reclamation Program. Early bat gates were of the ACCA design, such as those installed at Oyler Radium Mine in Capitol Reef National Park. More recently Utah AMRP has used 1” Manganal steel bar gates, such as those installed at the Airport Tower Mines in Canyonlands National Park. These gates are highly vandal resistant and impervious to hacksaws, and are particularly good for remote locations due to less material to transport and quicker fabrication time.

Bat gates constructed at Sullivan Gold Mine in Joshua Tree National Park (above), Monte Cristo Zinc Mine in Buffalo National River (middle), and Kaymoor Coal Mine in New River Gorge. Objects of interest such as the small hoist at Monte Cristo Mine are left onsite and protected for public enjoyment. The Monte Cristo Mine closure was partially funded by Bat Conservation International. The Kaymoor closure was fully funded and contracted by the Office of Surface Mining in 1988: one of the first bat gating attempts in the National Park System.