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

by

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Abstract: 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. To date the National Park Service has placed 71 bat-compatible closures in 11 parks. Habitat surveys for bats and other species are an integral part of the abandoned mine inventory process. When surveys outside mines slated for closure reveal potential habitat, qualified wildlife biologists accompanied by experienced abandnoned mine safety personnel conduct internal surveys. Several internal surveys are often 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 slated for closure 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. The National Park Service and Bat Conservation International recently developed an interpretive warning sign which attempts to prevent vandalism of bat gates by educating the public on the potential hazards inside the mine, the value of bats in ecosystems, and the importance of bat conservation efforts. These signs are available through Bat Conservation International.

Additional key words: habitat, hibernaculum, maternity roost, night roost, migratory roost

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 habitat these mines provide. Preservation of significant bat habitat is one of the major objectives of the National Park Service (NPS) abandoned mine closure program.

NPS Abandoned Mineral Lands Program

The NPS established an Abandoned Mineral Lands (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. A major aspect of the program is the closure of abandoned underground mines which present a hazard to park visitors and staff. The current NPS inventory has identified more than 8,000 mine openings in the National Park System, most of which require some form of mitigation. 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 must be demonstrated.

Bats and their Association with Abandoned Mines

Abandoned underground mines often provide significant, sometimes critical wildlife

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habitat. The most common species of concern are bats. Obviously, mine closures by backfilling, plugging, or constructing solid bulkheads eliminates a mine's potential to provide useful bat habitat. 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 and entire colonies were entombed (Tuttle 1994).

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 of which are crop pests that could cost farmers billions of dollars every year. A 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 saguaro cactus 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 North American bat species, 24 have been listed as endangered or potentially endangered under the Endangered Species Act.[3] Bat researchers generally agree that several other bat species should be added to the list.

Individual states have their own listings of endangered species, many of which include bat species not listed federally. Bat gates should be considered not only for mines known to be inhabited by endangered species, but also for mines that provide habitat for large colonies of unlisted species or species of concern.

Overall bat populations in the U.S. are dropping significantly, in part, because natural bat habitat is being destroyed by increased urban development, deforestation, and exploitation of caves. Habitat provided by abandoned mines is therefore becoming critical to the survival of numerous bat species.

Depending upon location, airflow, temperature, and other factors, bats may use portions of a mine for a maternity roost (a place to give birth and raise young), a night roost (temporary roost while hunting insects), a stop-over 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 usefulness 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 the size of a small hand-held radio which transforms the bats' inaudible calls (20-120 kHz, see Thomas 1987, Nowak 1994) into the audible range for humans. When bats are known to inhabit a mine, special traps and nets are used in capture surveys to determine bat species, sex, health, and reproductive status. Hibernation is more difficult to detect without entering a mine, although bats often display a characteristic swarming behavior at a mine entrance just before going into hibernation. Timing field research to witness pre-hibernation swarming is quite difficult.

The most complete and useful information on hibernacula and summer roosts can be gathered by conducting underground surveys. Several internal surveys are often useful to determine various species using a mine for different purposes through the seasons of the year. Underground surveys are becoming a significant part of bat researchers' duties. Underground survey safety is of concern, since most wildlife biologists have no underground or mining experience. The NPS requires that a qualified abandoned mine specialist accompany all underground survey participants to ensure their safety. (Burghardt, 1996) Since there is currently no formal certification process to license such an expert, this person is typically a geologist or mining specialist with extensive training and experience in abandoned mines, rock mechanics, and mine atmospheres. The designated specialist instructs survey participants on potential

[3]Personal communication between Dr. Merlin Tuttle and Thomas Kunz, December 9, 1996.

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.

Bat gate designs

Bat gates are designed to keep people out of mines while minimizing airflow restriction and allowing bats 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 into adit portals. Vertical shafts are more difficult to close, since laying a bat gate on the ground over a shaft would create a hazard where people and wildlife could fall or break a leg. Research also indicates that bats prefer to fly horizontally through vertically-oriented gates, rather than flying vertically through horizontally-oriented gates.[4] 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 consists of four sides and a top that allow for bat access. The Railroad Commission of Texas Division of Surface Mining and Reclamation recently developed a new bat-shaft closure using corrugated steel culvert secured in a shaft's collar with polyurethane foam, or secured to a hole cut in metal grating. The culvert protrudes above the shaft collar to a sufficient height to deter predation, and is cut at an angle to receive a bat gate.

Bat gate designs typically call for openings between bars of 5¾ inches high by a mimumum of 24 inches wide. Concern has been raised that this spacing may be too large to preclude very small children, so some gates are now being installed with 4-inch bar spacing in the lower portion of the gate.

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 gate design developed by professional engineer and conservationist Roy Powers in cooperation with the American Cave Conservation Association (Figures1a and 1b). The Powers 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 Abandoned Mine Program is now using Manganol steel bars in its bat gates. Manganol steel cannot be cut with a hack saw, and Manganol bar gates require less welding than Powers gates, thereby reducing the difficulty and cost of fabrication. The NPS will probably try Manganol gates in the next Utah/NPS bat-compatible closures. New materials and designs will undoubtedly be developed through time.

Gates must often be designed with a means of 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 openings. The National Park Service and Railroad Commission of Texas recently eliminated this problem by modifying the Powers bat gate design with a removable, lockable bar for access. 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.

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 are installed and closely monitored. Gates can also be installed in stages, 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, 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. Post-installation monitoring is also

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

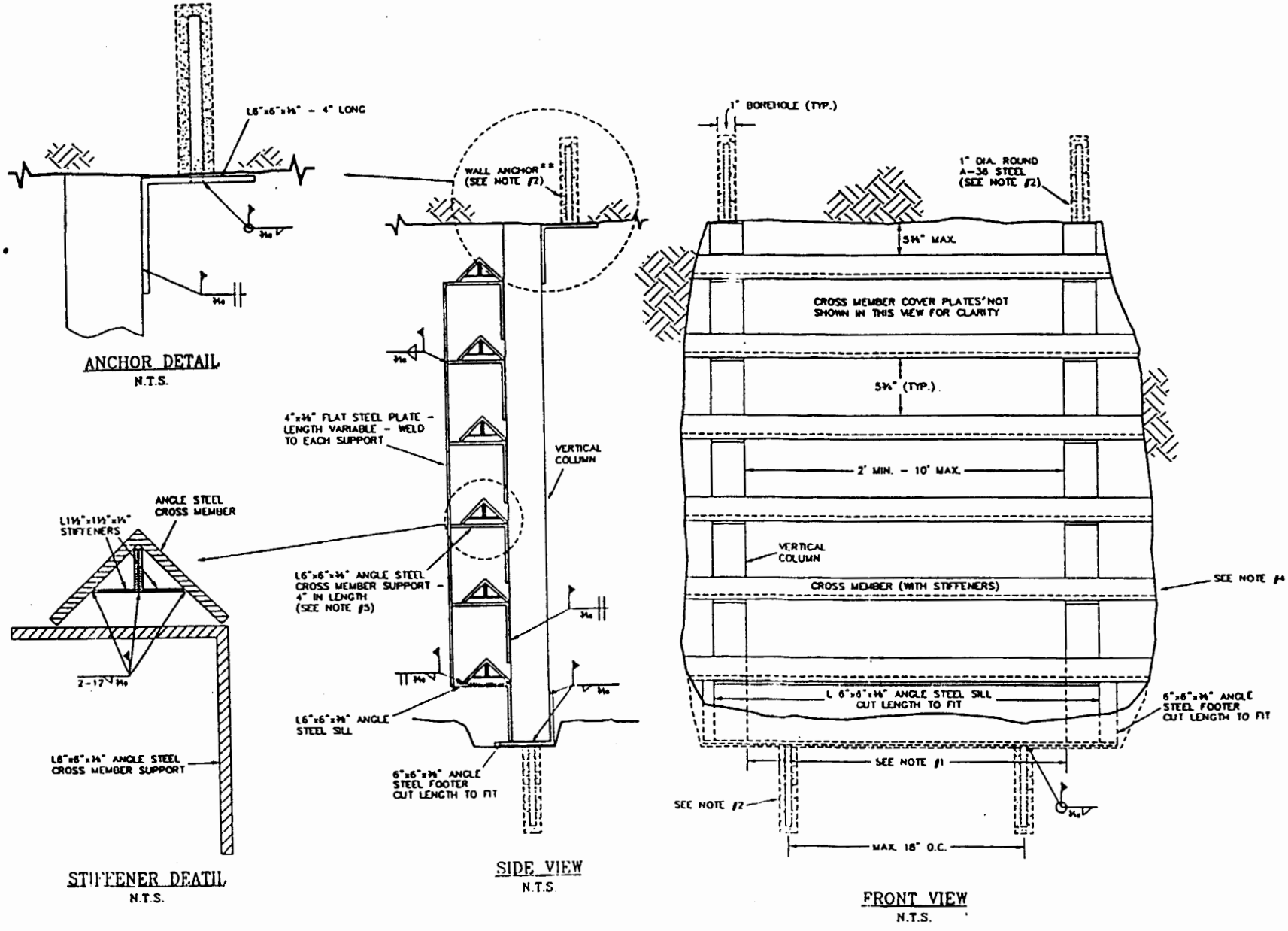

Figure 1a: Basic Powers Bat Gate Design (not to scale)

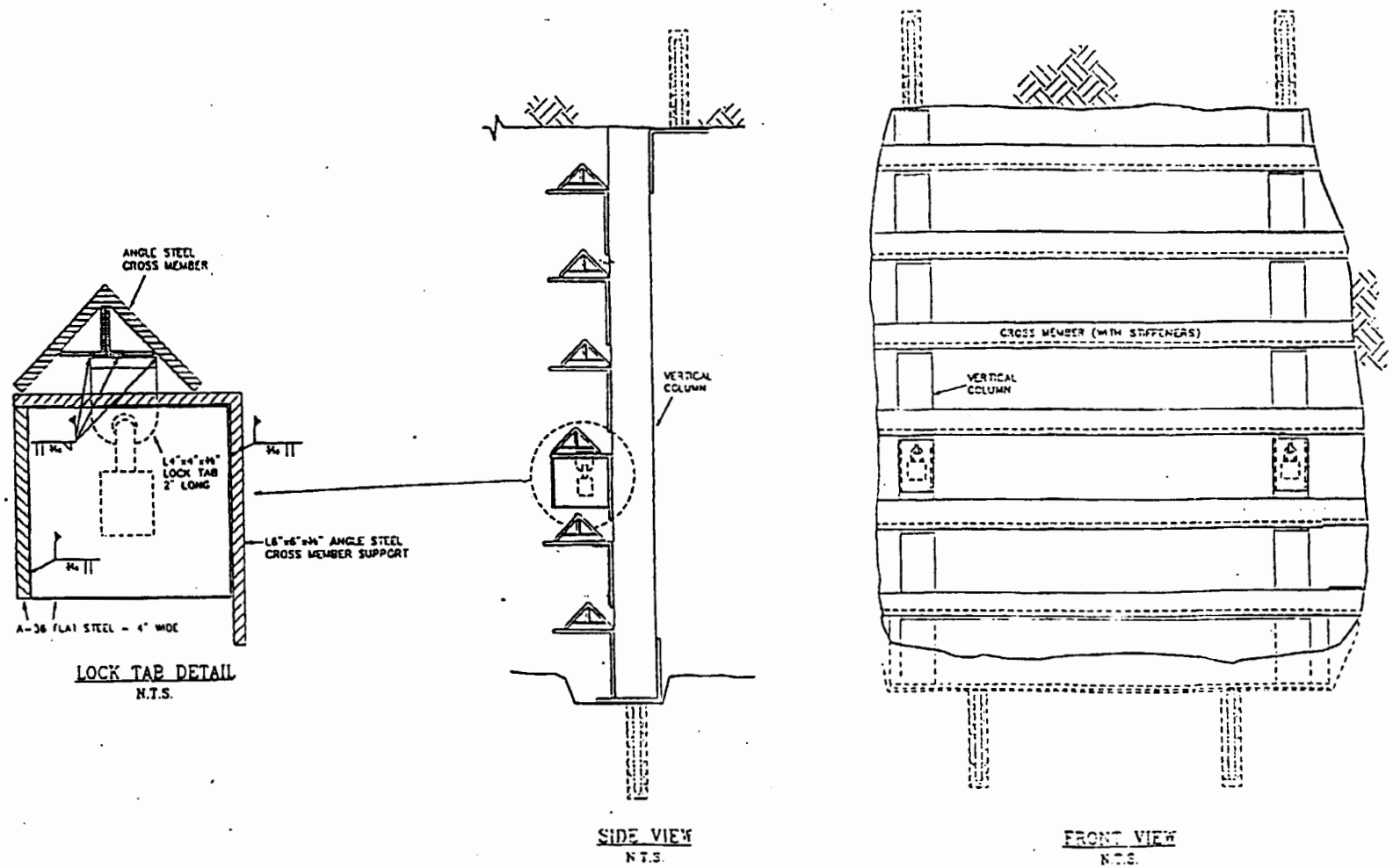

Figure 1b: Powers Bat Gate Design with Removable Bar (not to scale)

necessary to ensure that the gates have not been vandalized. Technical papers reviewing the success of various gate designs for different bat species are invaluable to future gating efforts. Bat Conservation International, which has full-time staff dedicated solely to bats and abandoned mines, serves as an effective clearing house 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. Their booklet entitled *Bats and Mines* is an excellent reference which should be acquired.

Bat gate installations in the National Park System

To date, 71 bat-compatible closures have been installed in 11 NPS units, and additional gates at 5 NPS units are planned for the near-future (Tables 1 and 2). Due to a lack of base funding for AML projects, the NPS AML Program has greatly benefitted 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 the Office of Surface Mining, Reclamation, and Enforcement (OSM), state members of the National Association of Abandoned Mine Land Programs, and Bat Conservation International.

OSM financed and contracted a major coal reclamation project from 1987 to 1992 at New River Gorge National River, Big South Fork National River and Recreation Area, and Friendship Hill National Historic Site. Included in this million-dollar project were twenty-six bat gates installed at New River and Big South Fork.

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 bat biologists from U.S. Fish and Wildlife Service. This gate protects one of the largest known hibernacula of Eastern big-eared bat.

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.

At the Chesapeake and Ohio Canal National Historic Park, three 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. Under the direction of bat gate designer Roy Powers, and with the aid of park staff and local volunteers, three bat gates were constructed.

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 fifty mine openings have been inventoried along this trail. Since 1993 the park has closed six of these openings using four gates under the direction of Roy Powers with partial funding assistance from Bat Conservation International.

In 1993 the Utah Division of Oil, Gas, and Mining contracted 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 scrap steel 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.

One bat gate was installed at Lake Mead National Recreation Area in 1994 using the assistance of an abandoned mine safety crew stationed at Death Valley National Park. This crew developed a 6-inch by 6-inch stainless steel cable netting to close many of Death Valley's estimated 5,000 abandoned mines before funding shortages terminated the program in 1990. These nets restrict access enough to effectively exclude maternity colonies, and therefore are not recommended on mines with significant summer bat activity. Cable nets appear to be acceptable to hibernating bats, however, since there is no need for nightly access in and out of a hibernaculum. In an attempt to make cable nets more bat-friendly, twelve of the cable nets at Death Valley were recently modified by removing one strand of cable between adjacent openings in several places to produce 12 inch wide by 6 inch high openings. No follow-up surveys have been conducted to see if this improved roosting conditions.

TABLE 1: BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS CLOSURES PLACED TO DATE (1996)

PARK	ST	MINE	COMMOD	DATES	#	BAT SPECIES PROTECTED	STATUS†
New River Gorge	WV	Kaymoor, others	coal	1987 - 1992	19	Eastern pipistrelle *(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 Mts	NC	Sugar Fork	copper	1988	1	Eastern big-eared bat *(Corynorhinus rafinesquii)*	Candidate
Big South Fork	KY	Blue Heron, others	coal	1988 - 1992	7	Eastern pipistrelle *(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	gold	1992	1	(not determined)	-
C & O Canal	MD	Round Top	limestone	1993	3	Big brown bat *(Eptesicus fuscus)* Little brown bat *(Myotis lucifugus)* Eastern pipistrelle *(Pipistrellus subflavus)* Indiana bat *(Myotis sodalis)** Eastern small-footed myotis *(Myotis leibii)** Northern long-eared bat *(Myotis septentrionalis)**	- - - Endangered Candidate Candidate

†federal status under the Endangered Species Act, which was reformed in 1995 to exclude Category 2 and 3 listings. These former listings are shown here to show species of particular concern. Species with no federal listing may be state-listed.
*species known to inhabit the area and suspected of using mines, but not confirmed.

TABLE 1: BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS CLOSURES PLACED TO DATE (1996)

PARK	ST	MINE	COMMOD	DATES	#	BAT SPECIES PROTECTED	STATUS†
Buffalo Ntl. River	AR	Monte Cristo	zinc	1993 1995	4	Gray bat *(Myotis grisescens)* Eastern Pipistrelle *(Pipistrellus suflavus)* Big brown bat *(Eptesicus fuscus)* Ozarks big-eared bat *(Corynorhinus townsendii ingens)* Indiana bat *(Myotis sodalis)**	Endangered Category 2 Endangered
Capitol Reef	UT	Oyler	radium	1993	5	Western big-eared bat *(Corynorhinus townsendii)* Western pipistrelle *(Pipistrellus hesperus)*	Category 2
Lake Mead	NV	Reid	gold silver	1994	1	California leaf-nosed bat *(Macrotus californicus)* Yuma myotis *(Myotis yumanensis)*	Category 2 -
Big Bend	TX	Mariscal, Rio Grand Village	mercury	1995	10	Western big-eared bat *(Corynorhinus townsendii)* Big brown bat *(Eptesicus fuscus)* Southwestern cave myotis *(Myotis velifer)* Mexican long-nosed bat *(Leptonycteris nivalis)**	Category 2 - Category 2 Endangered
Death Valley	CA	misc.	talc, gold, lead	1987 - 1995	16‡	Western big-eared bat *(Corynorhinus townsendii)* miscellaneous myotis	Category 2 -
Guadalupe Mountains	TX	Texas- Calumet	copper	1996	4	Western big-eared bat *(Corynorhinus townsendii)* Southwestern cave myotis *(Myotis velifer)* Western small-footed myotis *(Myotis ciliolabrum)** Big brown bat *(Eptesicus fuscus)**	Category 2 Category 2 - -
TOTAL 11	10				71	17 species	

† federal status under the Endangered Species Act, which was reformed in 1995 to exclude Category 2 and 3 listings. These former listings are shown here to identify species of particular concern. Species with no federal listing may be state-listed.

* species known to inhabit the area and suspected of using mines, but not confirmed.

‡ includes 12 cable nets modified in 1987 with 6"h x 12"w openings to accommodate *Corynorhinus townsendii* hibernacula.

TABLE 2: BAT-COMPATIBLE CLOSURES OF ABANDONED MINES IN NATIONAL PARK SYSTEM UNITS CURRENT PROJECTS (1997)

PARK	ST	MINE	COMMOD	#	BAT SPECIES TO BE PROTECTED	STATUS†
Coronado	AZ	State of Texas	lead, zinc	2	Lesser long-nosed bat *(Leptonycteris curasoae)*	Endangered
Fort Bowie/ BLM Safford	AZ	Quillian	gold	4	Southwestern cave myotis *(Myotis velifer)* Western big-eared bat *(Corynorhinus townsendii)* Fringed myotis *(Myotis thysanodes)*	Category 2 Category 2 -
Buffalo Ntl. River	AR	Rush District	zinc	20+	Gray bat *(Myotis grisescens)* Indiana bat *(Myotis sodalis)**	Endangered Endangered
Lake Mead	NV	Dupont	gold / silver	1	California leaf-nosed bat *(Macrotus californicus)* Yuma myotis *(Myotis yumanensis)*	Category 2 -
Organ Pipe	CA	Copper Mountain	copper	2	Lesser long-nosed bat *(Leptonycteris curasoae)* California leaf-nosed bat *(Macrotus californicus)*	Endangered Category 2
TOTAL 5	4			29	8 species	

† federal status under the Endangered Species Act, which was reformed in 1995 to exclude Category 2 and 3 listings. These former listings are shown here to identify species of particular concern. Species with no federal listing may be state-listed.

* species known to inhabit the area and suspected of using mines, but not confirmed.

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 may have been in response to the gate, but was more likely in response to vandalism. 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.

In 1995 the Railroad Commission of Texas financed and contracted closure of eighteen 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 seven conventional bat gates, two grated shaft closures with bat cupolas, and one corrugated steel pipe / bat gate closure in an adit portal prone to subsidence. 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 entry into the mine's intricate labyrinth spanning seven levels to a depth of 426 feet. These closures also excluded most of the bats that had been roosting in the mine. These bats then displaced a colony of federally endangered Lesser long-nosed bats in a nearby cave. The new gates 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 closure of ten 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.

Fort Bowie National Historic Site and Bureau of Land Management's (BLM) Safford District have entered into a cooperative project on their common boundary to close a number of openings along the Buterfield Overland Trail at the Quillian Mine. Four of these openings will receive bat-compatible closures, most notably a shaft and adjoining adit with interconnecting stopes that provide habitat to a maternity colony of 4,000 Southwestern cave myotis, a hibernaculum for Western big-eared bats, and a summer roost for Fringed myotis. (Burghardt 1996, Altenbach 1996, and recent site visit.)

Test closures will be constructed and closely monitored at Coronado National Memorial's State of Texas Mine where a migratory colony of 15,000-20,000 Lesser long-nosed bats (a nectar-feeding bat) have taken residence to take advantage of the local blooming season for agave. A similar colony of Lesser long-nosed bats inhabits the Copper Mountain Mine at Organ Pipe Cactus National Monument, which is also slated for closure pending availability of funds.

At Lake Mead National Recreation Area, a gate has been prefabricated to protect a colony of Lesser long-nosed bats and California leaf-nosed bats. When exact measurements can be taken and a completed gate can be transported to the site, prefabrication in the shop greatly reduces the difficulties encountered with field installations, reducing on-site work to anchoring the gate in the mine opening.

Bat Gate Interpretive Sign

The National Park Service and Bat Conservation International have jointly developed a bat gate interpretive sign (Figure 2). This sign will be posted 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.

Summary and 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

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 2: Bat Gate Sign (actual sign dimensions are 12" x 16")

closures will hinge on 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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