Proceedings of

Bat Conservation and Mining: A Technical Interactive Forum

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A Technical Interactive Forum held November 14-16, 2000
at the Airport Hilton,
St. Louis, Missouri

Edited by:
Kimery C. Vories
Dianne Throgmorton

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FOREWORD

It has only been within the last several years that the Office of Surface Mining (OSM) has become aware of the significant but complex relationship between bats and mining. According to the U.S. Fish and Wildlife Service, many of North America's largest remaining bat populations roost in mines. These include a majority of the 45 bat species living in the continental United States and some of the largest populations of endangered bats. More than half of these bat populations are already listed as endangered or species of concern. Closure of abandoned mines without first conducting biological surveys could endanger these and even other currently-abundant species. Given the key ecological role of bats as primary predators of night-flying insects, which cost American farmers and foresters billions of dollars annually, additional threats to bat survival are cause for concern. Closure or other alteration of old mines without a biological assessment can, in single events, eliminate some of America's largest remaining bat populations.

On December 15, 1998, OSM signed a Memorandum of Understanding (MOU) between OSM and Bat Conservation International to establish a framework for cooperative efforts between the two organizations to maintain and increase the conservation of bats and their habitats. The two organizations agreed to assist each other in educating OSM staff, States, and the Tribes about the beneficial roles of bats, cooperate in the protection of bats and their habitats, and utilize OSM authorities, including technical and financial assistance, to promote and aid the conservation of bats and their habitats on State and Tribal lands. In this MOU, OSM agreed to:

- consider the conservation of bats and their habitats in the development and implementation of abandoned mine land reclamation standards and recommendations to States and Indian Tribes.
- provide assistance in the development of program criteria, consistent with the practices of abandoned mine land reclamation, which will help manage bats and their habitats effectively and economically.
- for the Federal Reclamation Program, monitor non-emergency Abandoned Mine Land shaft and portal areas for bat activity prior to reclamation and, as appropriate, require the use of bat gates to seal the shafts or portals where bat habitation is known and would be endangered if sealed otherwise. OSM will encourage the States and Tribes to do likewise.
- promote the education of OSM staff, State agencies, and Indian tribes of the beneficial aspect of conserving bats, tested methods to safeguard bat habitat and public health, and ways to mitigate for loss of bat roosts and habitats.

In February of 1999, OSM initiated a the creation of a multi-agency, multi-interest group steering committee in order to initiate planning for a technical interactive forum on the subject of Bat Conservation and Mining. These proceedings are the result of that forum and mark a major step toward increased cooperation between concerned State and Federal agencies and conservation groups interested in protecting these important species.

STEERING COMMITTEE MEMBERS

Kimery C. Vories (Forum Chairperson)
Mid-Continent Region
USDI Office of Surface Mining

Sheryl Ducummon
Bat Conservation International

Julie Annear
Colorado Division of Minerals and Geology

Kirk Navo
Colorado Division of Wildlife

Sally Imhof
Kansas Surface Mining Section

Stephen Cawood
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Becky Hatmaker
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Ron Sassaman and Sandy Vana-Miller
Western Region
USDI Office of Surface Mining

Len Meier
Mid-Continent Region
USDI Office of Surface Mining

Mark Mesch
Utah Division of Oil, Gas, and Mining

STEERING COMMITTEE RECOMMENDATIONS
BAT CONSERVATION AND MINING

The following are recommendations made by the Bat Conservation and Mining Steering Committee immediately following the end of the forum. The recommendations represent areas that have the potential for future efforts by the committee.

1. Develop a Website with user friendly access to information on Bat literature, research, training, gate design, experienced contractors, monitoring, and assessment.

2. Improve public awareness and education.

3. Bat Conservation International should complete and make available its "Gate Manual."

4. Publish information on how bats react to gates.

5. Develop and make available a bat friendly closure database that would include input from all States involved with this activity (Utah's database would be a good model).

6. Distribute proceedings to the mining industry.

7. Conduct a workshop on permitting issues related to bats including habitat monitoring and assessment.

8. OSM should take a leadership role in encouraging State Abandoned Mine Land (AML) programs to become more actively involved in bat conservation.

9. Make State AML program expertise more available.

10. OSM should investigate potential partnerships with other Federal agencies such as the Bureau of Land Management, Forest Service, and the National Park Service.

11. Conduct a workshop on mine safety related to bat habitat assessment, potentially including the involvement of the Mine Safety and Health Administration, experienced bat assessment personnel, and existing Federal Agency training programs.

12. OSM should communicate to the States that the protection of bats and their habitats through the appropriate and effective use of bat friendly closures is a desirable alternative to mine closure through back filling.

13. Make success stories related to bat conservation and mining available in an attractive and user friendly format.

14. Expand contacts to include all agencies that are doing bat work related to bat conservation and mining.

WHAT IS A TECHNICAL INTERACTIVE FORUM?

Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

I would like to set the stage for what our expectations should be for this event. The steering committee has worked hard to provide you with the opportunity for a free, frank, and open discussion on issues related to the conservation of bats and their habitats associated with mining and reclamation that is both professional and productive. Our rationale for the format of the technical interactive forum is that, unlike other professional symposia, we measure the success of the event on the ability of the participants to question, comment, challenge, and provide information in addition to that provided by the speakers. We do this in the hope that, by the end of the event, a consensus will emerge concerning the issues discussed.

It has been my experience that most of the heated controversies I have been aware of, related to mining and reclamation, have been a result of:

- the lack of sufficient scientific and technical information on the issue and
- the lack of the means to communicate such information to all of those concerned with the issue.

Therefore, one of the main purposes of this event is to bring as much scientific light as possible to bear on this issue. It has been my personal experience, that the most progress I have seen, toward making advances in the field of mine reclamation, has come when we have been able to work as a team of professionals toward a consensus on:

- the facts related to the actions we have proposed, and
- the state of the science in terms of our most workable options and alternatives.

During the course of these discussions, we have the opportunity to talk about technical, regional, and local issues, while examining new and existing methods for finding solutions, identifying problems, and resolving issues. The forum gives us the opportunity to:

- share our experiences and expertise concerning the integration of conservation efforts toward bats and bat habitats with mining operations and reclamation,
- outline our reasons for taking specific actions, and
- give a rational for why we should or should not be promoting the conservation of bats and their habitats at mines in a specific manner.

A basic assumption of the interactive forum is, that no person present, has all the answers or understands all of the issues. It is also assumed that some of these issues, solutions, and concerns may be very site, regional, or State specific.

The purpose of the forum is to:

- present you with the best possible ideas and knowledge, during each of the sessions,
- promote the opportunity for questions and discussion, by you the participants, and
- let each person decide what is most applicable to their situation.

We are not here to come up with new policies or regulation, but to empower you the participants with better knowledge, new contacts, and new opportunities for problem solving and issue resolution.

The format of the forum strives to improve the efficiency of the discussion by providing:

- a copy of the abstract for each speaker's talk which you may want to read before hand in order to improve your familiarity with the subject matter.
- We are tape recording the talks and discussions for later inclusion in a post forum publication so that you do not have to worry about taking notes. For this reason, we will require that all participants speak into a microphone during the discussions.
- In order for us to make the most efficient use of time, we require our session chairpersons to strictly keep to the schedule.
- In the post forum publication, issues raised during the discussions will be organized based on similar topic areas and will not identify individual names. All registrants will receive one copy of this publication. This publication will be very similar to the proceedings of earlier forums conducted by OSM and are available for your viewing at the OSM exhibit.

It is important to remember that there are four separate opportunities for you the participants to be heard:

- 5 minutes will be provided for questions at the end of each speaker's talk
- 20 minutes of participant discussion is provided at the end of each topic session. The chairperson will recognize each participant that wishes to speak and they will be requested to identify themselves and speak into one of the portable microphones so that everyone can hear the question.
- At the end of the forum, we will conduct an open discussion on where we should go from here.
- and finally, a blue forum evaluation form has been provided in your folder. This will help us to evaluate how well we did our job and recommend improvements for future forums or workshops. Please take time to fill it out as the forum progresses and provide any additional comments or ideas. These should be turned in at the registration desk at the end of the forum.

One of the reasons for providing refreshments during the breaks and lunch is to keep people from wandering off and missing the next session. In addition, the breaks and lunch provide a better atmosphere and opportunity for you to meet with and discuss concerns with the speakers or other participants. Please take advantage of the opportunity at break time to visit the exhibits in the break area. When the meeting adjourns today all participants are invited to a reception where refreshments will be provided.

Finally, the steering committee and I would like to thank all of the speakers who have been so gracious to help us with this effort and whose only reward has been the virtue of the effort. I would also like to thank each of you the participants, for your willingness to participate and work with us on this important issue.

THE OFFICE OF SURFACE MINING (OSM) PERSPECTIVE ON BAT CONSERVATION

Kathrine L. Henry
Acting Director
Office of Surface Mining
U.S. Department of the Interior
Washington, D.C.

INTRODUCTION

It is indeed a pleasure to be here today at the beginning of three days of discussion and information-sharing on an important environmental topic. I am glad that so many people from so many parts of the country are participating, from all levels of government, and from industry, universities, and the general public. This is an excellent opportunity for communicating problems, solutions, and concerns related to bat conservation and mining.

I especially want to thank our colleagues from Bat Conservation International (BCI) and Southern Illinois University at Carbondale for co-sponsoring this forum and the following organizations that helped to plan this event:
— Colorado Division of Minerals and Geology.
— Colorado Division of Wildlife.
— Kansas Surface Mining Section.
— McBrayer, McGinnis, Leslie, & Kirkland PLLC.
— the Pennsylvania Bureau of Abandoned Mine Reclamation
— the Pennsylvania State Game Commission
— Tennessee Technological University
— U.S. Fish and Wildlife Service
— U.S. Geological Survey
— the Utah Division of Oil, Gas, and Mining

Many of us in the mining community do not associate bats with mining. But as with so many other environmental aspects of both coal and non-coal mining and reclamation, it turns out there's much more to it than we may think.

It has only been within the last several years that OSM has become aware of the significant but complex relationship between bats and mining. According to the U.S. Fish and Wildlife Service (FWS), many of North America's largest remaining bat populations roost in mines. These include a majority of the 45 bat species living in the continental United States and some of the largest populations of endangered bats. More than half of the bat populations in the United States are already listed as endangered or species of concern. Closure of abandoned mines without first conducting biological surveys could endanger these and even other currently-abundant species. Given the key ecological role of bats as primary predators of night-flying insects, which cost American farmers and foresters billions of dollars annually, additional threats to bat survival are cause for concern. Closure or other alteration of old mines without a

biological assessment can, in single events, eliminate some of America's largest remaining bat populations.

A recent article in the August 2000 Issue of the West Virginia Coal Bell devoted three pages to the opportunities and concerns that the endangered Indiana Bat presents to the West Virginia mining industry. The article focused on the complicated nature of trying to protect bats associated with the coal mining industry due to their dependence upon abandoned mine sites for suitable habitat. This shortage of habitat was noted as presenting a enormous opportunity for the mining industry to make a positive contribution to wildlife conservation and to bolster the industry's public image. It also underscored the concern to miners of actions by the U.S. Fish and Wildlife Service in protecting species like the endangered Indiana Bat and citizen law suits that could present problems for mine operations that propose new permits within the bat's range.

As a lawyer, I promise not to come before this audience as a technical expert, because my area of expertise is not mining engineering, biology, reclamation, revegetation, or any of the related fields we depend on for scientific solutions to environmental problems related to mining. But I would like to summarize where we are in dealing with issues related to bat conservation and coal mining, and how we got there.

On September 24, 1996, OSM completed Formal Section 7 Biological Opinion consultation with the U.S. Fish and Wildlife Service concerning the incidental taking of listed species under the Endangered Species Act. At that time, a total of 308 species listed as threatened or endangered occurred within States with primacy, and 337 listed species occurred within States with Federal regulatory programs. I will speak in more detail about this later.

In December of 1998, OSM signed a Memorandum of Understanding between OSM and Bat Conservation International, Inc. in order to establish a framework for cooperative efforts between the two organizations to maintain and increase the conservation of bats and their habitats.

In February of 1999, OSM initiated a meeting with a multi-agency, multi-interest group to form a steering committee that would plan for this technical interactive forum we are now attending.

That brings us to today. The meetings we are now participating in are the result of the combined efforts of numerous interested parties to make this timely and much-needed discussion possible.

Background on SMCRA

For those not familiar with the Surface Mining Act, I would like to give you a little background on the unique nature of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) program. In fashioning SMCRA, Congress recognized the need to protect society and the environment from the adverse effects of surface coal mining operations while fulfilling the nation's need for coal. Signed into law on August 3, 1977, SMCRA was the first Federal statute specifically directed toward regulation of the environmental impacts associated with surface coal mining. The Act created two major programs:

- A reclamation program for abandoned mine lands, funded by fees that operators pay on each ton of coal mined; funds are used to reclaim land and water resources adversely affected by pre-1977 coal mining; and
- An environmental protection program to establish standards and procedures for permitting and inspecting surface and underground coal mining and for reclamation operations.

Section 101(f) of SMCRA specifies that because of the diversity in terrain, climate, and other physical conditions under which mining operations occur, the primary governmental responsibility for regulating surface coal mining and reclamation operations should rest with the States. To achieve primary regulatory responsibility (often referred to as primacy), a State must develop and obtain OSM approval of a program which demonstrates the State's capability to carry out applicable provisions of SMCRA.

At present, 24 States (Alabama, Alaska, Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Utah, Virginia, West Virginia, and Wyoming) have approved State regulatory programs (primacy) under SMCRA for non-Federal, non-Indian lands within their borders. These States are responsible for 98 percent of the nation's surface coal mining and reclamation operations. Following approval of a State program, OSM assumes a monitoring role and provides funding and technical assistance. Section 517(f) of SMCRA requires that OSM evaluate the administration of approved State programs. In this role, OSM conducts oversight inspections of selected mine sites and undertakes oversight reviews of selected topics in States with primacy.

OSM administers Federal regulatory programs for 13 States (Arizona, California, Georgia, Idaho, Massachusetts, Michigan, North Carolina, Oregon, Rhode Island, South Dakota, Tennessee, and Washington), although only Tennessee and Washington have active coal mines at the present time. OSM directly regulates all surface coal mining and reclamation operations on Indian lands, which at present consist of operations on the Navajo, Hopi, and the Ute Mountain Ute reservations. On the Crow Ceded Area in Montana, OSM and the Montana Department of State Lands administer applicable surface mining requirements. OSM also directly regulates surface coal mining and reclamation operations on Federal lands in primacy States that have not entered into cooperative agreements with the Secretary of the Interior to assume this responsibility.

SMCRA Requirements Regarding the Protection of Wildlife

The specific regulations that pertain to protection of fish and wildlife and related environmental values require the following:

- compliance with the Endangered Species Act during coal exploration
- compliance with Endangered Species Act, the Fish and Wildlife Coordination Act, the Migratory Bird Treaty Act, and the Bald Eagle Protection Act during surface mining.
- notification for State and Federal Fish and Wildlife agencies whenever OSM or the State Regulatory Authority receives a permit application

- a description by the permit applicant on how the operation will minimize disturbances to wildlife and enhance and restore wildlife habitat where practical.

OSM Involvement in Bat Protection Associated with Abandoned Mine Land

State and Federal agencies estimate that there are over 300,000 open underground mines across the United States. Government agencies have closed approximately 33,000 dangerous mine openings since the passage of SMCRA, the vast majority of which were funded by the OSM-administered, Abandoned Mine Land (AML) Reclamation Fund. A survey conducted by OSM this summer revealed that approximately 1,234 of the mine closures have involved some form of bat friendly closure method such as bat gates or bat pipes.

OSM has been playing an active role in Bat protection on many AML sites. Since the passage of SMCRA, 60 bat-compatible mine closures have been installed in five States through the OSM high priority and emergency reclamation programs. Three more closures are scheduled for the coming construction season. These closures include traditional bat gates and bat pipes which eliminate the possibility of human access but allow bats to use the mines for hibernation or for daily shelter. Thirteen bat gates have been installed on designated National Rivers: six at New River Gorge in West Virginia and seven at Big South Fork in Kentucky. Of the remainder, 23 are located in Washington, 8 in California, and 16 in Pennsylvania. Bat gates and pipes are planned and installed in close coordination with local land management and wildlife agencies. In California, OSM worked with the East Bay Regional Park District to close mines and install bat gates in the Black Diamond Mines Preserve. OSM also works with the Washington State Parks Department and the Kings County, Washington Parks System to gate mine openings on State and county park lands.

The MOU Between OSM and U.S. Fish and Wildlife Service (FWS)

The Memorandum of Understanding (MOU) between OSM and FWS is not specifically about bats, but would apply where a listed bat species may be affected by surface mining activities. In order to be exempt from the prohibitions of Section 9 of the Endangered Species Act, SMCRA regulatory authorities must comply with the following terms and conditions:

1. The regulatory authority, acting in accordance with the applicable SMCRA regulatory program, must implement and require compliance with any species-specific protective measures developed by the Service field office and the regulatory authority (with the involvement, as appropriate, of the permittee and OSM).
2. Whenever possible, the regulatory authority must quantify the take resulting from activities carried out under this program. Whenever a dead or impaired individual of a listed species is found, the local Service office must be notified within one (1) working day of the discovery.
3. Whenever the regulatory authority decides not to implement one or more of the species-specific measures recommended by the Service, it must provide a written explanation to the Service. If the Service field office concurs with the regulatory authority's action, it will provide a concurrence letter as soon as possible. However, if the Service does not

concur, the issue must be elevated through the chain of command of the regulatory authority, the Service, and (to the extent appropriate) OSM for resolution.

In addition to the above terms, based on Section 7(a)(1) of the Endangered Species Act, FWS directs OSM to further the purposes of that Act by implementing conservation programs for the benefit of endangered and threatened species to the extent that the agencies have the authority to do so. The Service may make discretionary conservation recommendations to OSM to minimize or avoid the adverse effects of a proposed action on listed species or critical habitat. These recommendations may include assistance in recovery plan implementation and monitoring and information collection efforts.

The MOU also contains the following language "The Service recommends that OSM, in partnership with the States, develop draft candidate species conservation guidelines and procedures where those species are affected by OSM-regulated operations. The Service is committed to providing technical assistance to both OSM and the States in such an endeavor."

At OSM, we are supportive of State efforts to develop appropriate guidelines and procedures. We will do what we can to help, on request. OSM and the States will be working with the FWS in the coming months to improve the implementation of this MOU.

OSM MOU with Bat Conservation International (BCI)

The MOU between OSM and BCI was formed to establish a framework for cooperative efforts between the two organizations to maintain and increase the conservation of bats and their habitats. The two organizations agreed to assist each other in educating OSM staff, States, and the Tribes about the beneficial roles of bats, cooperate in the protection of bats and their habitats, and utilize OSM authorities, including technical and financial assistance, to promote and aid the conservation of bats and their habitats on State and Tribal lands.

OSM agreed to:

- consider the conservation of bats and their habitats in the development and implementation of abandoned mine land reclamation standards and recommendations to States and Indian Tribes.
- provide assistance in the development of program criteria, consistent with the practices of abandoned mine land reclamation, which will help manage bats and their habitats effectively and economically.
- for the Federal Reclamation Program, monitor non-emergency AML shaft and portal areas for bat activity prior to reclamation and, as appropriate, require the use of bat gates to seal the shafts or portals where bat habitation is known and would be endangered if sealed otherwise. OSM will encourage the States and Tribes to do likewise.
- promote the education of OSM staff, State agencies, and Indian tribes of the beneficial aspect of conserving bats, tested methods to safeguard bat habitat and public health, and ways to mitigate for loss of bat roosts and habitats.

Conclusion

It is always true that the more we know, the more options we have. I am optimistic that constructive dialogues such as those held here will lead to better understanding of the benefits and risks involved with incorporating methods for protection and enhancement of bats and their habitats associated with mining.

Thank you for inviting me here today. I commend all the forum participants for being part of this valuable information exchange. The public and the coalfield residents can only benefit from the information that is shared and the knowledge that is gained at this event. I thank you for applying your minds to the task and I wish you success in your efforts on behalf of the coalfield environment.

Session 1

Why Bats?

Session Chairperson:
Sheryl Ducummon
Bat Conservation International
Austin, Texas

Ecological and Economic Importance of Bats
Sheryl Ducummon, Bat Conservation International, Austin, Texas

Importance of Mines for Bat Conservation
Len Meier, Office of Surface Mining, Alton, Illinois

Challenges in Protecting Bats
Homer E. Milford, Abandoned Mine Land Bureau, Mining and Minerals Division, New Mexico Energy, Minerals, and Natural Resources Department, Sante Fe, New Mexico

Eastern Bat Species of Concern to Mining
Dr. Michael J. Harvey, Department of Biology, Tennessee Technological University, Cookeville, Tennessee

Western Bats and Mining
Dr. Michael A. Bogan, U. S. Geological Survey, Department of Biology, The University of New Mexico, Albuquerque, New Mexico

Federally Listed Threatened and Endangered Species of Concern to Mining
Robert Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

ECOLOGICAL AND ECONOMIC IMPORTANCE OF BATS

Sheryl L. Ducummon
Bat Conservation International, Inc.
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Abstract

Abandoned mines now serve as important year-round sanctuaries for bats. Many of North America's largest remaining bat populations roost in mines. These include more than half of the continent's 45 bat species and some of the largest populations of endangered bats. Bats have lost countless traditional roosts in caves and old tree hollows and many have gradually moved into abandoned mines, which can provide similar environments. Mine closures without first surveying for bats can have potentially serious ecological and economic consequences. Bats are primary predators of night-flying insects, and many such insects rank among North America's most costly agricultural and forest pests. These include cucumber, potato, and snout beetles; corn-earworm, cotton-bollworm, and grain moths; leafhoppers; and mosquitoes. A single little brown bat (*Myotis lucifugus*) can catch more than 1,200 mosquito-sized insects in an hour. A mine roosting colony of just 150 big brown bats (*Eptesicus fuscus*) can eat sufficient cucumber beetles each summer to protect farmers from 33 million of these beetles' root worm larvae, pests that cost American farmers an estimated billion dollars annually. And a colony of Mexican free-tailed bats (*Tadarida brasiliensis*) living in the old Orient Mine consumes nearly two tons of insects nightly, largely crop-consuming moths. In the western states, pallid bats (*Antrozous pallidus*) benefit ranchers by consuming large quantities of grasshoppers and crickets. Lesser and greater long-nosed bats (*Leptonycteris curasoae* and *L. nivalis*) and long-tongued bats (*Choeronycteris mexicana*) are believed to be important pollinators for some 60 species of agave plants and serve as both pollinators and seed dispersers for dozens of species of columnar cacti, including organ pipe and saguaro, which rank among the southwestern deserts' most familiar and ecologically important plants. Despite their critical role in our environment and economy, available evidence suggests that millions of bats have already been lost during abandoned mine safety closures or renewed mining in historic districts. These actions could endanger even currently abundant species, forcing the need for Federal listing at considerable taxpayer expense. The loss of bats can increase our reliance on chemical pesticides (which often threaten both environmental and human health), jeopardize whole ecosystems of other plants and animals, and harm human economies. The cost of surveying and protecting key mine roosts is small compared to the benefits provided by these valuable night-flying allies.

Introduction

Bats are one of the most important, yet least understood, groups of animals in the world. Across North America, bats play a vital role in both natural and managed ecosystems. Bats are key predators of night-flying insects that cost American farmers and foresters a billion dollars annually, and they are pollinators of several keystone desert plants in the American southwest

and Mexico. Despite their importance, bats are often persecuted both intentionally and unintentionally, and their numbers continue to decline from habitat loss, environmental toxins, and disturbance at key roost sites. Bats currently represent the most imperiled order of land mammals in the United States and Canada.

Due to disturbance of bats' traditional roosts in caves and tree hollows, abandoned and inactive underground mines have now become refuges of last resort for more than half of the 45 bat species found in the United States and Canada, including some of the largest remaining populations. As thousands of abandoned mines are being reclaimed, available evidence suggests that millions of bats have been inadvertently buried or have lost crucial habitats. Closure of abandoned mines without first evaluating their importance to bats is perhaps the single greatest threat to many North American bat populations.

The Role of Bats in Ecosystem Management

Bats are primary predators of vast numbers of insects that fly at night, including many that rank among North America's most costly agricultural and forest pests. Just a partial list of the insects these bats consume includes cucumber, potato, and snout beetles; corn-borer, corn earworm, cutworm, and grain moths; leafhoppers; and mosquitoes. Just one of the little brown bats that hibernate in Michigan's Millie Hill Mine can catch 1,200 mosquito-sized insects in an hour. Bats are just one of several groups of animals that naturally prey upon mosquitoes. Although not the only insect consumed, from 77.4 to 84.6 percent of little brown bats living in the northern U.S. and Canada eat mosquitoes (Anthony and Kunz, 1977; Fascione, et. al., 1991). A Florida colony of 30,000 southeastern myotis (*Myotis austroriparius*) eats 50 tons of insects annually, including more than 15 tons of mosquitoes (Zinn and Humphrey, 1981). The loss of bats increases our reliance upon chemical pesticides that typically cause more long-term problems than they solve. Chemical poisons often kill natural mosquito predators more effectively than mosquitoes. Over time, predators such as fish, insects, and bats die out while mosquitoes develop resistance, multiplying in ever larger numbers in a losing battle often referred to as "the pesticide treadmill."

Mexican free-tailed bats, like those living in the famed Carlsbad Caverns and Bracken Cave, eat incredible numbers of insects nightly and just one colony living in Colorado's old Orient Mine consumes nearly two tons of insects nightly. In Texas' largest bat caves alone, up to 1,000 tons (2 million pounds) of insects, primarily moths, are eaten each night by Mexican free-tailed bats. U.S. Department of Agriculture research shows that in early June, billions of corn earworm moths (America's number-one agricultural pest) emerge from agricultural regions of Mexico, flying at high altitudes into the U.S. on prevailing winds—often traveling more than 250 miles a night. Days later, the moth's peak egg-laying occurs on corn, cotton, and other crops in agricultural regions of Texas. Their destructive larvae, which have fattened on the crops for about three weeks, give rise to the next generation of moths that emerge and continue a northward "hopscotch," infesting crops through much of central North America.

Doppler radar studies confirm that Mexican free-tailed bats fly at altitudes from 600 to 10,000 feet or more above the ground, sharing the same winds as moths, in the season when bats have their greatest energy needs (McCracken, 1996). To prove that bats prey upon this prime

agricultural pest, fecal pellets were collected as bats returned to a Texas bat cave. In mid-June, moths comprise about 96 percent of the diet of these bats (Whitaker, et. al., 1996). Using DNA markers it was confirmed that corn earworm moths were the species being consumed (McCracken, 1996). Further proof came when bat detectors were affixed to weather balloons floating freely with the moths, recording bat calls and feeding buzzes to corroborate that free-tailed bats are indeed flying and feeding at the same altitudes and locations as the moth migrations (*ibid.*). The regional impact these bats are having on corn earworm moths is staggering.

Mexican free-tailed bats are also known as "guano bats" for the enormous quantities of droppings they produce. From 1903 to 1923, at least 100,000 tons were removed from Carlsbad Caverns alone and sold to fruit growers in California (Tuttle, 1994). Railroad officials estimated that, early this century, they annually transported 65 carloads at 30,000 pounds each from Texas, making bat guano the State's largest mineral export before oil (*ibid.*). Guano extraction for use as a natural fertilizer is still being extensively used in developing countries and is making a comeback with organic gardeners. Free-tailed bats have supported several American war efforts since gun powder's most valuable ingredient, saltpeter, is made from guano. And a single ounce of guano contains billions of bacteria useful in detoxifying industrial wastes, producing natural insecticides, improving detergents, and converting waste byproducts into alcohol.

Another common North American species, the big brown bat, specializes on beetles and true bugs, including cucumber beetles, May beetles or June bugs, green and brown stinkbugs, and leafhoppers. In one summer season the 150 bats of an average Midwestern maternity colony can conservatively eat 38,000 cucumber beetles, 16,000 June bugs, 19,000 stinkbugs, and 50,000 leafhoppers (Whitaker, 1995). By eating 38,000 adult cucumber beetles in a season, these bats control about 33 million of these beetles' rootworm larvae (*ibid.*). Both cucumber beetle adults and larvae attack crops, costing U.S. farmers about one billion dollars annually, with the larvae doing considerable damage—they can reduce corn productivity 10 to 13 percent and force farmers to spray $15 to $25 in insecticides per acre (Whitaker, 1993). Adult June bugs defoliate trees and their larvae (grubworms) feed on the roots of grasses and other plants. Stinkbugs are often pests in orchards and on soybeans. Leafhoppers are serious pests of many plants since they feed on the sap, rendering the plant vulnerable to various plant diseases and reducing the plant's productivity. In one study, these four bugs collectively totaled 37.8 percent of the food eaten by 184 big brown bats from various parts of Indiana (*ibid.*). At certain times and places, however, they often total nearly 100 percent of the diet of big brown bats.

With the growing agricultural emphasis on biological control and integrated pest management, more and more farmers are using bats as a weapon in the war against insect pests. Instead of eradicating bat colonies from their farmhouses and barns, farmers are exploring ways of attracting bats to their fields. Many farmers are living with their bat allies and even encouraging their colonization by constructing artificial habitats. In addition to consuming insect pests, it is suggested that bats protect crops from pests by "chasing" away insects with their echolocation calls. Researchers saw a 50 percent reduction in damage to corn plots by corn borers when they broadcast bat-like ultrasound over test plots (Belton and Kempster, 1962).

North American bats are boosting local economies by encouraging tourism at renowned locations like Carlsbad Caverns and Austin's Congress Avenue Bridge. In Austin, just one decade ago, citizens petitioned for the bridge's bat colony to be eradicated. In 1999, Bat Conservation International (BCI) initiated a study which showed that the Congress Avenue Bridge bat colony generates nearly $8 million in tourism revenue each year (Ryser and Popovici, 2000). More than 100,000 people watch the bat emergence annually, including many who specifically travel to Austin to view the bats, spending millions on lodging, transportation, food services, and entertainment.

Bats are also key pollinators of many familiar desert plants. The endangered lesser and greater long-nosed bats, and Mexican long-tongued bat, serve as both pollinators and seed dispersers for dozens of columnar cacti species including organ pipe, and saguaro, and are important pollinators for some 60 species of agave plants. Agaves have been closely associated with man since the beginning of civilized America as a food item, a fermented beverage, and a fiber source. Today, tequila, made from distilled agave juices, is by far the best known Mexican liquor, and its rising popularity in international markets contributes to a multi-million dollar industry. Yet agave propagation, in the absence of bats, falls to 1/3000th of normal (Howell, 1980; Fleming, 1991). The bat-plant association is so strong that the disappearance of one would threaten the survival of the other.

In addition to consumptive uses, cacti rank among the southwestern desert's most ecologically important plants (Howell, 1980). Bees, moths, lizards, hummingbirds, woodpeckers, orioles, finches, sparrows and field mice all depend on plants pollinated by bats for food and shelter, and are affected indirectly by the loss of bat pollinators and subsequent decrease in plant populations, such that entire ecosystems are damaged.

Habitat destruction is likely the major factor affecting pollinating bats and contributing to their endangered or "at risk" status. Their specialized nectar diet and disappearance of their food plants could explain population declines. The fragile bat-plant relationship is magnified in the case of the long-nosed bats because of their migratory habits. These bats depend not only on the plants in a given region, but on a continuous supply of food along their migratory routes. The destruction of habitat in Mexico, for example, could have severe effects, through the bats, on the plant communities in Arizona. Mexican cattlemen, in misguided attempts to control numbers of vampire bats (*Desmodus rotundus*), have also indiscriminately destroyed countless colonies of highly beneficial bats, including pollinators.

In tropical ecosystems, bats play a critical role in seed dispersal and pollination. And because loss of rain forest habitats is one of the most serious environmental problems today, the loss of bats can have serious environmental and economic consequences. In one recent West African study, bats were shown to be far more effective seed dispersers than birds. Because most bats prefer to carry fruit away from the tree before eating, apparently to avoid predators, they cross cleared areas and sometimes travel up to 50 km or more in a single night. In Africa, up to 95 percent of forest regrowth on cleared land comes from seeds dropped by bats (Tuttle, 1983). In contrast, birds and other animals drop seeds mostly beneath existing trees.

Bats also are the primary pollinators of numerous tropical plants. More than 130 genera of trees and shrubs are already known to rely on bats for pollination, and many more such relationships await discovery (*ibid.*). Recent studies demonstrate that seed dispersal activities of bats can be critical to reforestation of clear-cut areas, and that many of the tropics' most economically important plants depend on bats for propagation. The nearly endless list of valuable products from these plants includes many grocery store fruits such as peaches, bananas, and avocados, as well as kapok and hemp fibers for surgical bandages, life preservers, and rope, latex for chewing gum, prized lumber for furniture and crafts, beads for jewelry, and carob for candy. The harvest of Durian fruits in Southeast Asia and iroko timber in West Africa accounts for annual sales of over 100 million dollars. The former requires bats for pollination and the latter for seed dispersal.

In the Old World, exaggerated reports of crop damage from fruit bats have led to bat killings. Farmers are alarmed by the sight of large bats eating fruit that ripens prematurely or that is missed during picking. Because fruit bats prefer strong-smelling, ripe fruits, commercial crops that are picked green for shipping are seldom damaged. Birds and rats are not so picky, leaving their depredations to be blamed on the more conspicuous bats. As a consequence, large colonies of big flying fox bats are being destroyed. In the Old World and throughout the South Pacific Islands, bats are considered a delicacy and are over harvested for human food, folk medicine and even aphrodisiacs. Many populations of large flying fox bats are seriously threatened. On Guam, bat dinners may sell for $25 a plate, and in West Africa, bats are so valuable that two poachers working together can make $1,000 in a single day.

The Importance of Mines to Bats

Although caves are numerous in some regions, most are now too frequently disturbed by humans to permit bat use. In addition, bat populations have lost countless traditional roosts in old tree hollows due to logging. Over the past 100 or more years, displaced bats have gradually moved into abandoned mines, which often provide microclimates similar to caves. In regions where natural caves do not occur, mines represent new “super habitats” that have concentrated colonial bat populations formerly distributed in smaller numbers across the landscape (Brown and Berry, 1991).

Mines are key to the life history of bats and are critical for many purposes such as rearing young in the summer, winter hibernation, gathering for social activities (such as courtship and mating), and night roosting (places where bats temporarily rest to digest their prey between foraging bouts). Mines also serve as crucial rest stops between spring and fall migration. Abandoned mines are often the only suitable shelters left midway between summer and winter roosts. Without these protected resting places, migratory mortality could increase tremendously. Although mines are utilized for many reasons, their use as bat maternity and hibernation sites is essential to the survival of several North American species. The microclimate, most importantly the temperature, determines whether bats will use a particular mine. Warm sites are selected for maternity roosts, while cold sites are chosen for hibernation.

Bats that roost in smaller groups typically require temperatures between 70 and 90EF for

maternity use. Big-eared bat (*Corynorhinus* spp.) maternity roosts have sometimes been recorded in colder sites where ambient temperatures are as low as 60EF. Approximately one-quarter of the bat species in the United States and Canada are believed to hibernate almost exclusively in old mines or caves (Tuttle and Taylor, 1994). Suitable hibernation sites for bats in all regions must protect bats from freezing, and for most species, should provide stable temperatures throughout the winter above the freezing point but below 50EF. Some desert dwelling bats may be an exception and often hibernate in mines with temperatures up to 58EF (Brown, pers. com., 1997).

While any abandoned mine may be important to bats, the larger, more complex and dangerous mines, with multiple entrances, often harbor the most significant populations. This is because large and complex mines offer bats a measure of security no longer found in caves. The complexity and associated airflow of these mines provides a range of internal temperatures suitable for bats (Altenbach, 1995). These complex sites are most often found on private mining industry lands.

Of the more than 8,000 mines surveyed by researchers in Arizona, California, Colorado, New Mexico, Oregon, and Washington, approximately 45 to 75 percent showed signs of use by bats, with an average of 10 percent containing important bat colonies. From the Great Lakes Region north and eastward in the United States and Canada, up to 70 percent of open, unflooded subsurface mines having sufficient volume to protect bats from freezing, may be used by hibernating bat populations.

Abandoned Mine Closures: Effects on Bats

In the last decade alone, thousands of abandoned mines have been permanently closed by backfilling, capping, blasting, or other method, and until recently few were first evaluated for their importance to bats. Available evidence suggests that millions of bats have already been lost, or their roosts destroyed. Bats now have few alternatives to abandoned mines, and are so instinctively committed to certain sites that they often cannot change roosts in the time allowed by current rates of mine closure (Altenbach, pers. com., 1996). Due to their colonial nature, many bat species are especially vulnerable to mine closures, and hundreds of thousands of bats can be lost in a single closure.

Little brown bats are among North America's most abundant bat species. However, in the northern United States and Canada, these bats rely almost exclusively upon abandoned mines for hibernation sites. If a mine is closed during winter months (trapping the bats inside), a multi-state region can be affected. This is due to the fact that little brown bats travel from summer colonies that may be thousands of miles away to hibernate in mines. Closure of mines without first checking for bats could drastically reduce bat numbers, needlessly endangering many species.

In the western United States, Townsend's big-eared bats (*Corynorhinus townsendii*) are particularly dependent on abandoned mines (Altenbach, 1995). The largest known populations, numbering up to 10,000, have been found in deep, complex workings, however, even shallow or

simple workings will often be used by small groups of up to several hundred. Endangered Indiana bats (*Myotis sodalis*) and southwestern cave myotis (*M. velifer brevis*) have been found in mines in numbers approaching 100,000. Similarly, the largest known hibernating populations of the southeastern big-eared bat (*Corynorhinus rafinesquii*), a candidate for the endangered species list, live in abandoned iron and copper mines in small groups ranging from a few dozen to more than 500.

All of the known remaining nursery roosts of the endangered lesser long-nosed bat in the United States are found in mines. In California, all winter roosts and all but one maternity colony of California leaf-nosed bats (*Macrotus californicus*) are found in abandoned mines (Brown, pers. com., 1997). Many other bat species rely heavily on mines for hibernation, even though they may congregate in smaller colonies throughout a greater number of abandoned mines. Table 1 provides a list of North American bats known to use mines (Tuttle and Taylor, 1994).

Many examples underscore the magnitude of potential bat losses from abandoned mine closures. More than 50,000 little brown bats were temporarily entombed in a western Wisconsin mine closure before biologists were able to have the mine reopened. The old Neda Mine in Iron Ridge, Wisconsin, was threatened with closure before being acquired by a local University. It is now home to nearly half a million little brown bats, as well as large populations of big brown bats, eastern pipistrelles (*Pipistrellus subflavus*), and northern long-eared myotis (*Myotis septentrionalis*).

The largest hibernating population ever recorded of another species in decline, western big-eared bats (*Corynorhinus townsendii pallescens*), was destroyed in a New Mexico mine shaft when vandals set old timbers on fire (Altenbach, pers. com., 1996). In New Jersey, the State's largest population of hibernating bats was inadvertently trapped in the Hibernia Mine when it was capped in 1989. These bats would also have died had biologists not convinced state authorities to reopen the entrance immediately. Likewise, the Canoe Creek State Park limestone mine in Pennsylvania was reopened in time to save its bats and now shelters a population of endangered Indian bats and the largest hibernating bat population in that state.

In December 1992, an estimated three quarters of a million little and big brown bats were found in the Millie Hill Mine in Iron Mountain, Michigan. It was slated to be backfilled the following spring. Instead, BCI convinced the town to close the mine with a large steel cage, protecting the bats and human safety (Tuttle and Taylor, 1994). These bats comprise the second largest hibernating bat population ever discovered in North America. A local mine inspector from Iron Mountain, Michigan, reported that of the 12 mines closed prior to 1993, some contained significantly large bat populations, perhaps even more than were saved in the Millie Hill Mine.

Mine and cave roosting bats are exceptionally vulnerable to human disturbance in their nursery and hibernation caves. Entire populations can be destroyed in single incidents, emphasizing the need for public education and protection of critical sites. Requiring up to an hour or more to arouse from hibernation, bats cannot quickly fly away from danger, and in any event cannot survive outside of their roost in winter. Helpless, thousands at a time have been intentionally killed by vandals. Many more die as a result of inadvertent disturbance by mine or cave

explorers who do not realize the dire consequences of their actions. When hibernating, bats must conserve energy until spring when insects are once again abundant. A single disturbance can cost a bat over 60 days of stored fat reserves (Thomas, et. al., 1990). Excessive disturbances can cause the bat to burn up all its fat reserves and perish.

Large colonies of bats are at risk as well. Mexican free-tailed bats have declined at Carlsbad Caverns from over 8 million to just a few hundred thousand. Likewise, the bats at Eagle Creek Cave in Arizona that once numbered between 25 and 50 million have declined by 99.9 percent to just under 30,000 (Tuttle, 1991).

Pesticide poisoning can also affect bats in many ways. By reducing non-target insects, bats are unable to find adequate sources of insect prey. Bats also can ingest sub-lethal doses of pesticides, which become stored in their fat reserves. During times of stress, such as hibernation or migration, when large stores of fats are released, pesticides are released too, sometimes at lethal levels.

Because bats are consuming vast quantities of insect pests, the general health of entire ecosystems are compromised in the absence of bats. How many bats can we lose before their numbers become too few to survive and service our ecosystems? When humans modify ecosystems for natural resource production such as timber, minerals, or agriculture, maintaining habitat for bats will not only ensure the survival of these important wildlife species, but will also benefit the sustainable production of natural resource products.

The North American Bats and Mines Project

BCI and the United States Bureau of Land Management founded the North American Bats and Mines Project (NABMP) in 1993 to address conservation issues facing mine-roosting bats. The purpose of the NABMP is to eliminate the loss of bats during abandoned mine-land reclamation, while still protecting human safety. The NABMP has five primary objectives: (1) to educate natural resource managers and the public on the importance of mines for bats; (2) to train wildlife and mine-land managers on mine assessment and closure methods that protect both bats and people; (3) to assist agencies and industry in protecting and enhancing bat roosts in abandoned mines; (4) to provide leadership and coordination among Federal, State, and private agencies and the mining industry, thus minimizing bat losses; and (5) to aid with active research and monitoring efforts. By establishing and achieving these goals, BCI and its agency partners will ensure that bat conservation measures are incorporated into the planning and operating procedures of agencies and organizations responsible for mine-land management and wildlife conservation. To date, we have already provided funding and technical support to protect critical habitats for more than 2 million mine roosting bats, hosted 18 bats and mines workshops, distributed 20,000 copies of our resource publication, *Bats and Mines*, and translated this publication into Spanish for our Latin American Partners. As we continue to learn about our vital and fascinating bat species, we are better suited to manage for their long-term survival.

Table 1. North American bats that use mines for maternity and/or hibernation sites.

Species	Colony Sizes	Range	Use Time
Ghost-faced bat *Mormoops megalophylla*	Dozens to hundreds	AZ & TX	Year-round
California leaf-nosed bat *Macrotus californicus*	Dozens to over a thousand	AZ, southern CA & NV	Year-round
Mexican long-tongued bat *Choeronycteris mexicana*	A dozen or fewer	AZ, southern CA & NM	Summer
Lesser long-nosed bat *Leptonycteris curasoae**	Hundreds to thousands	AZ & NM	Summer
Greater long-nosed bat *Leptonycteris nivalis**	Hundreds to thousands	TX & NM	Summer
Southeastern myotis *Myotis austroriparius*	Hundreds to thousands	Southeastern U.S.	Year-round
California myotis *Myotis californicus*	Up to a hundred	Western U.S.	Year-round
Western small-footed myotis, *Myotis ciliolabrum*	Up to hundreds	Western U.S.	Year-round
Long-eared myotis *Myotis evotis*	Dozens	Western U.S.	Year-round
Gray bat *Myotis grisescens**	Hundreds to 50,000 or more	Southeastern U.S.	Year-round
Small-footed myotis *Myotis leibii*	Dozens	Eastern U.S.	Winter
Little brown bat *Myotis lucifugus lucifugus*	Hundreds to a million or more	Northern U.S.	Year-round
Arizona myotis *M. l. occultus*	Hundreds	Southwestern U.S.	Year-round
Northern long-eared myotis *Myotis septentrionalis*	Hundreds to thousands	Eastern U.S.	Winter
Indiana bat *Myotis sodalis**	Hundreds to 100,000 or more	Eastern U.S.	Winter

Table 1. (Cont.) North American bats that use mines for maternity and/or hibernation sites.

Species	Colony Sizes	Range	Use Time
Fringed myotis *Myotis thysanodes*	Dozens to hundreds	Western U.S.	Year-round
Cave myotis *Myotis velifer*	Hundreds to 100,000 or more	Southwestern U.S.	Year-round
Long-legged myotis *Myotis volans*	Hundreds	Western U.S.	Year-round
Yuma myotis *Myotis yumanensis*	Hundreds to thousands	Western U.S.	Year-round
Western pipistrelle *Pipistrellus hesperus*	Dozens	Western U.S.	Year-round
Eastern pipistrelle *Pipistrellus subflavus*	Dozens to thousands	Eastern U.S.	Winter
Big brown bat *Eptesicus fuscus*	Dozens to hundreds	North America	Year-round
Allen's lappet-browed bat *Idionycteris phyllotis*	Dozens to about two hundred	Mostly AZ, also parts of NV & CO	Year-round
Southeastern big-eared bat *Corynorhinus rafinesquii*	Dozens to several hundred	Southeastern U.S.	Year-round
Pacific big-eared bat *C. townsendii townsendii*	Dozens to hundreds	Western U.S.	Year-round
Ozark big-eared bat *C. t. ingens**	Dozens to hundreds	Ozark Mountains	Year-round
Western big-eared bat *C. t. pallescens*	Dozens to thousands	Western U.S.	Year-round
Virginia big-eared bat *C. t. virginianus**	Dozens to thousands	KY, VA & WV	Year-round
Pallid bat *Antrozous pallidus*	Dozens to hundreds	Western U.S.	Year-round
Mexican free-tailed bat *Tadarida brasiliensis*	Hundreds of thousands	Southwestern U.S., north to OR	Mainly summer, some year-round

* Endangered

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IMPORTANCE OF MINES FOR BAT CONSERVATION

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National Petroleum and Technology Office

Abstract

Bat populations in the United States are in decline. Of the 45 species present, six are listed as threatened or endangered and twenty more are considered species of special concern by wildlife management agencies. Abandoned mines provide important habitat for many bats and some mines have been identified as critical to the continued existence of local populations and species. Bats use abandoned underground mines for protection from predators, for maternity roosts to bear and raise their young, and for hibernation. Abandoned surface mines are important foraging and summer roosting areas for many species. Abandoned mine land (AML) reclamation programs and public land management agencies have unique opportunities to both enhance and to damage bat populations through the way reclamation projects are evaluated, designed and constructed. Hundreds of mine shafts and portals are closed each year and thousands of abandoned surface mine acres are graded and revegetated by AML Programs. Modern surface mining operations manipulate thousands of acres of land annually, changing vegetation characteristics, disturbing feeding and roosting areas and modifying the contour of mined areas. Mine regulatory and land management agencies have opportunities to affect protection and enhancement of bat habitat through both regulatory and industry education efforts. This paper presents a broad overview of bat conservation opportunities and accomplishments associated with mines in the U.S. by reviewing the number of abandoned mine openings, and comparing the total number of openings closed by reclamation agencies, with the number closed or protected using bat-friendly methods. It also outlines the scope of bat protection opportunities associated with both the reclamation of abandoned surface mines and of active surface mining and reclamation through a discussion of acres disturbed each year by such activities. By educating reclamation agency personnel, mining industry officials, and the regulatory community on the scope of the potential impacts, we can improve the conservation and protection of bat populations and species, without sacrificing public safety, environmental quality, or the utilization of our coal and mineral resources.

Introduction

Bat Populations in the United States are declining. Of the 45 species present, six are either threatened or endangered and twenty more are species of special concern by the U.S. Fish and Wildlife Service (Harvey, Altenbach and Best, 1999[1]). Population declines can be attributed to a number of human activities. Hibernation and summer roost caves in many areas of the country are disturbed by recreational users and vandals. Commercial and residential development

eliminates bat access to many natural caves by closing surface openings. Mining also eliminates access to caves when openings are destroyed by excavation or road building processes or when old mines are reactivated. Human activities also disturb spring and summer feeding, watering, and roosting areas critical for many bat species. Over much of the U.S., natural vegetation has been lost due to land clearing for conversion to agricultural crop and pasture land and for conversion to residential, highway, and commercial uses. Construction of major irrigation and flood control reservoirs has flooded millions of acres and closed many natural cave openings along rivers and streams. Loss of native plant communities because of these activities has disrupted insect and plant food supplies, changed roosting and hibernation patterns, and presented obstacles to historic migration routes.

Mines provide important habitat for many bat species. Sixty two percent, or 28 of the 45 continental U.S. bat species, roost in mines. While, for some species the use is only occasional, for most of the 28 species, mines constitute important roost areas (Altenbach and Pierson 1995[2]). Underground mines provide both winter and summer roosting areas for bats. During winter, many abandoned mines contain areas with constant, above-freezing temperatures necessary for hibernation. During summer, underground mines may act as cold-sinks similar to caves, protecting bats from extreme summer temperatures while providing shelter from predators at the same time.

Use of underground mines by bats has been demonstrated all across the U.S. Of more than 6,000 mines in Arizona, California, Colorado, and New Mexico surveyed for bat use prior to 1994, 30 to 70 percent showed signs of bat use, with an average of 10 percent containing important colonies. In the northern and eastern United States, up to 70 percent of open underground mines may also be used by bats (Tuttle and Taylor 1994[3], Altenbach and Pierson 1995[2], Mesch and Lengas 1996[4]). Twelve of the 16 species of bats found in Wyoming are known to use mines (Luce 1993[7]). For some western species, such as Townsend's big-eared bat *(Corynorhinus townsendii)* and California leaf-nosed bat *(Macrotus californicus),* the largest colonies now are found in man made habitat (Brown and Berry 1997, Luce 1993[7]). Mines are known to be the most significant bat hibernation sites in Michigan (Kurta 1999,[3]). Many other examples are available which have not been illustrated here. In summary, bats have been shown to use underground mines all across the U.S. for hibernation, day roosting, maternity shelter, feeding, and watering.

Closure of mines can have both immediate and long term impacts on bat populations. Historically, mine closure meant filling the mine entrance with solid fill or constructing a solid door over the opening. Closure of old mines during hibernation season, while bats are inside, can have disastrous results. A mine in Pennsylvania's Canoe Creek State Park was closed without regard to bat use but was reopened in time to save hibernating bats. The largest known hibernating population of bats in New Jersey was also trapped when the Hibernia mine was closed. Luckily, these bats were also rescued by the quick actions of biologists who convinced authorities to reopen the mine. Many other bat populations have not been so lucky.

For these reasons, we conducted a study to identify the scope of potential positive and negative impacts on bat conservation that may be realized by mining and abandoned mine reclamation activities. This paper presents the findings and conclusions of that study.

Methods

The study was conducted in two parts:

1. An E-mail/telephone survey of State mine reclamation and State wildlife agencies and Federal land management agencies.
2. A literature search on bat conservation, mine reclamation and mine permitting/production information.

The survey was conducted over a four month period from May to August, 2000. The following questions were asked of each survey recipient:

1. Number of coal mine openings
2. Number of non-coal openings
3. Number of mines closed
4. Number of bat-friendly closures
5. Acres of abandoned mine land reclaimed annually

E-mail surveys were initially sent to State mining and reclamation agencies and the U.S. Bureau of Land Management (BLM); U.S. Forest Service(USFS) and U.S. National Park Service (NPS). After receiving initial responses and tallying results, additional email and telephone contacts were made to State wildlife agencies and other organizations recommended by initial respondents. The intent was to continue attempting to make contacts until we had a high level of confidence that data represented a profile of the best information available across the nation. It was not assumed that any specific confidence interval could be reached due to the almost complete lack of comprehensive National tracking systems for data related to non-coal mines.

Trend information regarding mine closures was derived by querying the U.S. Department of Interior, Office of Surface Mining (OSM), Abandoned Mine Land Inventory System (AMLIS) on October 23, 2000. Numbers of completed vertical openings and portals were queried for all program areas, and all States, for the period 1978 to September 30,1994, and for the subsequent two year periods ending September 30, 1996; September 30, 1998; and September 30, 2000.

OSM and the NPS have more complete data sets. NPS has an inventory that includes mine openings and bat-friendly closures installed in each park. OSM has an extensive inventory of coal mine openings in the States, but the non-coal inventory is inconsistent and incomplete. OSM does not have a comprehensive inventory of bat-friendly closures constructed by either OSM or the States or Tribes.

Limitations of Survey Data

The reported numbers of coal mine openings are based primarily on input from State programs that administer the Surface Mining Control and Reclamation Act (SMCRA). State responses were correlated with data from the OSM AMLIS system and significant discrepancies were discussed and reconciled with respondents. Discussions with State respondents indicate that the reported numbers of openings in the eastern U.S. are less than actual because there are so many coal mining problem features in the Appalachian States that inventories have not been completed.

The reported numbers of non-coal mine openings were derived primarily from State respondents. The confidence levels of these numbers vary dramatically from State to State and agency to agency. Data in some States are derived from detailed field inventories while data in others are merely educated guesses by State officials. At the present time, there is no national requirement to inventory and catalog non-coal data.

Numbers of bat-friendly closures are expected to be quite accurate. These numbers came entirely from survey respondents who are the local bat experts, or who worked with reclamation agencies involved in the mine closure programs.

Data for Indian Tribes were derived only from the OSM AMLIS System. Data were not solicited from Tribal governments because of time constraints. The number of Mine Openings and Bat-friendly closures on Tribal lands are unknown.

The numbers of closed mines in this report do not necessarily reflect the number of instances where bat habitat was lost. Many States were unable to separate the number of mine shafts and portals from the number of openings that resulted from mine subsidence. Subsidence openings often occurred as sudden events, and were only accessible to the surface for days or weeks making it unlikely that bats were making use of them. Many other openings probably did not exhibit proper conditions for bat habitation. They may have been full of water to the ground surface or may have not exhibited proper temperature or humidity conditions for bat use.

Even with these stated limitations, we believe that the data represents a reasonably accurate picture of the breath and scope of mine related openings that are or were available for bat habitation.

Results

Underground Mines

Responses were received from 47 states. No response was received from Georgia, Rhode Island, or Hawaii. The BLM and National Forest Service were unable to provide comprehensive summaries of Federal lands that they manage. Certain BLM and Forest Service district offices did provide data and this was combined with State provided data to create more complete State by State summaries.

The survey indicates there are more than 367,000 abandoned mine openings in the U.S. This estimate is probably conservative because many of the survey respondents stated that detailed inventories are not available for their area. Numbers were based on best available information for each State. For example, the author used an estimate of 165,000 openings for the State of Nevada provided by the Bureau of Land Management, yet other sources estimate with less confidence that the number may be as high as 300,000 openings. As another example, the Missouri estimate of 258 openings includes only 200 lead mine openings from a 2 county area. Missouri has been the leading State in lead production for much of the nation's history, producing lead in many counties in the southern one third of the State. While the actual number of lead mine openings is expected to be much greater, detailed inventories are just not available to support accurate estimates and State officials did not speculate on the number. While these two examples probably indicate that the number of mine openings may be much greater, the

367,000 openings reflected in our study serves to illustrate that a great many open mines exist that may serve as seasonal habitat for bats. Table 1 provides the number of mine openings reported by State during the 2000 survey.

TABLE 1 - NUMBER OF MINE OPENINGS REPORTED BY STATE

STATE	NUMBER OF COAL MINE OPENINGS	NUMBER OF NON-COAL MINE OPENINGS	TOTAL MINE OPENINGS
Alabama	230	150	380
Alaska	50	350	400
Arizona	0	80,000	80,000
Arkansas	30	Unknown	30
California	4	48,944	48,948
Colorado	150	18,000	18,150
Connecticut	0	5	5
Delaware	0	Unknown	ND
Florida	0	0	0
Georgia	0	Unknown	ND
Hawaii	0	Unknown	ND
Idaho	20	5,000	5,020
Illinois	68	15	83
Indiana	6	24	30
Iowa	7	Unknown	7
Kansas	424	100	524
Kentucky	1,362	Unknown	1,362
Louisiana	0	0	0
Maine	0	Unknown	ND
Maryland	26	Unknown	26
Massachusetts	0	Unknown	ND
Michigan	50	Unknown	50
Minnesota	0	100	100
Mississippi	0	1	1
Missouri	58	200	258
Montana	0	281	281
Nebraska	0	0	0
Nevada	0	165,000	165,000

STATE	NUMBER OF COAL MINE OPENINGS	NUMBER OF NON-COAL MINE OPENINGS	TOTAL MINE OPENINGS
New Hampshire	0	Unknown	ND
New Jersey	0	Unknown	ND
New Mexico	71	20,000	20,071
New York	0	100	100
North Carolina	0	Unknown	ND
North Dakota	0	Unknown	ND
Ohio	141	11	152
Oklahoma	169	481	650
Oregon	24	Unknown	24
Pennsylvania	964	Unknown	964
Rhode Island	0	Unknown	ND
South Carolina	0	Unknown	ND
South Dakota	0	Unknown	ND
Tennessee	560	Unknown	560
Texas	0	100	100
Utah	43	20,000	20,043
Vermont	0	Unknown	0
Virginia	2,085	Unknown	2,085
Washington	115	Unknown	115
West Virginia	1,932	Unknown	1,932
Wisconsin	0	Unknown	ND
Wyoming	10	5	15
Total	8,599	358,867	367,538

ND = No Data Available

Mine Closures

According to survey respondents in 47 States and information contained in OSM's AMLIS system, over 32,000 mine openings have been closed by local, State, Tribal, and Federal agencies. Table 2 summarizes the number of mine closures by State and Indian Tribe. This number includes 25,075 mine closures reported in the OSM - AMLIS, from 31 States and 11 Indian Tribes. The AMLIS numbers are expected to be less than the number derived from survey respondents because they do not contain data from 16 States, the National Forest Service, Bureau of Land Management, State wildlife agencies, or local governments. The authors therefore believe that the survey results represent the best data currently available.

TABLE 2 - NUMBER OF MINE OPENINGS CLOSED IN THE UNITED STATES

STATE	NUMBER CLOSED BY ALL METHODS	
Alabama	1400	15
Alaska	34	0
Arizona	83	68
Arkansas	143	14
California	68	198
Colorado	5254	321
Connecticut	5	5
Delaware	0	0
Florida	0	0
Georgia	123	0
Hawaii	0	0
Idaho	13	51
Illinois	1282	22
Indiana	596	15
Iowa	22	0
Kansas	10	0
Kentucky	1985	114
Louisiana	0	0
Maine	0	0
Maryland	66	8
Massachusetts	0	0
Michigan	64	14
Minnesota	2	2
Mississippi	0	0
Missouri	109	2
Montana	1856	5
Nebraska	0	0
Nevada	5615	28
New Hampshire	8	1
New Jersey	1	1
New Mexico	1252	127

New York	11	11
North Carolina	11	6
North Dakota	160	0
Ohio	557	17
Oklahoma	216	0
Oregon	15	4
Pennsylvania	1039	24
Rhode Island	0	0
South Carolina	0	0
South Dakota	6	0
Tennessee	346	20
Texas	394	55
Utah	4500	300
Vermont	1	1
Virginia	1024	52
Washington	106	24
West Virginia	2112	20
Wisconsin	31	11
Wyoming	1500	75
Tribal Lands	Mine Closures Reported in OSM - AMLIS	Hopi, Navaho and Crow Tribes Surveyed for Bat Gates
Wind River	36	Not Surveyed
Ute Mountain Ute	8	Not Surveyed
Unitah Ouray	10	Not Surveyed
Southern Ute	15	Not Surveyed
Hopi	11	1
Northern Cheyenne	7	Not Surveyed
Fort Peck	11	Not Surveyed
Jicarilla Apache	3	Not Surveyed
Navajo	592	4
Rocky Boys	6	Not Surveyed
Crow	19	0
Total State and Tribe	**32738**	**1639**

Bat-Friendly Closures
No previous attempt had been made to count bat-friendly closures on mines across the U.S. Survey results indicate that 1,639 Bat-friendly mine closures have been installed by State, Federal, Tribal and local government agencies. Several respondents stated that bat gates were only installed when endangered species were suspected to use the opening. When other species were the only users, mines were completely sealed. Other respondents said that bat gates were installed when any significant bat population was found.

Tribal governments were not surveyed due to lack of time, however, available data indicated that at least 5 gates were installed by Tribal governments. The National Park Service has installed 103 bat-friendly closures as of August 2000. Most of these are included in the State summary totals, however, because some State respondents did not provide itemized lists of closures by location, we are not sure that all NPS sites were included in the total. The survey results may include a small number of closures performed by mining companies on Bureau of Land Management (BLM) lands, because some BLM offices were unable to separate them from agency closures. However, mining companies were not surveyed. Table 2 shows the number of bat-friendly closures, listed by State and Tribe.

Active Surface Mining and Surface Effects of Underground Mines
Underground mine openings are not the only mine features to potentially effect bats. Surface mining activities including transportation facilities, milling and processing sites, and mine waste disposal areas also present opportunities for both positive and negative impacts on bat survival. We attempted to evaluate the scope of potential impacts by these mining activities by researching the acres of land disturbed annually by mining and processing activities. Reviews of U.S. Government and mining industry documents revealed detailed and extensive records of mineral, metal, stone, and coal production on a tonnage basis and even recorded tons of waste rock for some industries, but acres disturbed by mining were found on a national level only for coal mining. The basis of coal mining acres are the 1998 and 1999 Office of Surface Mining - Annual Reports, published by the agency in January 1999 and January 2000 respectively. At the close of 1999, there were 4,722,404 acres of land in 27 States and 4 Indian Tribes in the U.S. under permit for coal mining and processing activities. On the average, during the late 1990's an additional 86,000 acres of land are permitted for coal mining operations annually.

To get some idea of how non-coal mining disturbance may compare to coal mining, we looked at the tons of non-coal minerals mined by surface and underground methods compared to the tons of coal mined. In 1998, 58 non-fuel minerals were mined over all 50 States. This mining removed 6 billion metric tons of ore from the ground, a 9 percent increase over the previous year. Ninety seven percent of this was mined by surface mining methods. By contrast, the average 86,000 annual acres of new coal mining permits produced 1.1 billion tons of coal. Only 52 percent of the coal was by surface mining methods.

Abandoned Mine Reclamation
Abandoned mine reclamation offers many opportunities to change surface habitat of bats such as summer roosting areas, watering and foraging areas, migration and daily commuting routes. Because of this, the authors asked survey participants how many acres of abandoned mine land are reclaimed annually by their respective programs. Most respondents suggested that we refer to the OSM AMLIS for this information. While accomplishments of some States without OSM funded reclamation programs are not represented in the AMLIS, the number of acres reclaimed

by those State programs is small compared to the overall total. Therefore, we decided to use the annual reported acreage from AMLIS for this measure of overall potential effect on bat habitat. Information from 27 States and 11 Indian Tribes reported in AMLIS indicates that approximately 9,000 acres of abandoned mine lands are reclaimed each year in the US.

Discussion

Open underground mines offer thousands of opportunities nationwide, for bat use. The 367,000 open mines reported by respondents are scattered across 34 States from the Atlantic to the Pacific coasts. The majority of mine openings are in the western 1/3 of the U.S. and nearly 80 percent are reported in just 3 States: Nevada, Arizona, and California. Table 1 provides a breakdown by State. Some openings provide winter hibernation sites because they exhibit the right combination of temperature, humidity, and air flow for bat survival. Many mines have been found to be critical hibernation sites for certain species. Closure of these mines without allowance for continued bat use could prove disastrous for certain species. Other mines are used as summer day or night roosts, or for maternity habitat when young are most vulnerable. These mines may also be critical for the survival of specific populations or species due to the loss of natural cave habitats to development or other human activities. On the other hand, many mines receive only occasional use by bats and complete closure of such would not be expected to harm bats as long as none were trapped inside during the closure effort.

Government agencies have closed over 32,000 mine openings in 40 States and 11 Indian Tribes (Table 2), and the rate of closures is increasing. According to AMLIS, 12,557 mine openings were closed between 1978 and 1994, reflecting an average annual rate of 785 openings (Table 3). The average rate of mine closures between 1994 and 2000, was 2000 per year, with the average going up to 2813 openings annually in the last 2 years. With the rate of mine closures continuing to increase, the possibilities go up each year that critical habitats will be lost.

Table 3 - MINE CLOSURES REPORTED IN OSM AMLIS 1978 - 2000*

Reporting Period	Total Vertical Openings and Portals Closed - Cumulative	Average Openings Closed Per Year
1978 to 9/30/94	12,557	785
10/1/94 to 9/30/96	4,645	2322
10/1/96 to 9/30/98	2,247	1,123
10/1/98 to 9/30/2000	5,626	2,813

*AMLIS data does not include all States or time periods covered by the Summer 2000 survey and may not include U.S. Forest Service or Bureau of Land Management Data. The total reported in AMLIS is less than that in the Survey.

Federal agencies are also increasing the number of mine closure projects. The Office of Surface Mining is working in Tennessee, Michigan, Oregon, Washington, and California to address the remaining abandoned coal mines problems. Beginning in 1998, the BLM and FWS each began receiving in the range of $10 million annually for mine relation activities. These funds are being used for abatement of numerous mining related problems including closure of mine openings. The NPS has worked throughout the late 1990's to inventory health and safety hazards on Park Service lands. The Service is now working to address the worst safety hazards, many of which are open mines.

In recent years, more government agencies and offices have begun taking the needs of bats into consideration by surveying mines for bat use prior to closure and by installing bat-friendly closures (gates, fences and cages) over mine openings when they are found to be important bat habitat. Most mines are closed by government agencies for one of two reasons: either to exclude people for public safety reasons, or to keep people out to protect important bat populations. In either case, closure methods must be permanent and vandal proof.

We found that approximately 1,639 of the mine closures reported in Table 2 have been bat-friendly closures. This represents a mere 5 percent of all reported closures. There may be many reasons for this small percentage. We list some of them here. One primary reason is that many mines openings are not occupied by bats due to physical and environmental conditions in the mine. Some mines are flooded nearly near the surface, naturally prohibiting bat use. Other reported closures involved mine subsidence openings that were only open for days or weeks prior to closure, leaving little opportunity for bats to take up residence. Some mines probably contained bat populations that were never discovered because proper bat surveys were not conducted. In some States, mines are only surveyed or protected when endangered species are known to inhabit the area, or are specifically known to use the mine slated for closure. Mines that are not located in the territory of endangered species may not even be surveyed. Another reason for failure to use bat-friendly closures is concern by some agency officials that gates and cupolas are not as secure from vandalism as solid fill closures. This concern is based largely on old information and experience involving gates installed prior to today's improved designs and materials. Other reasons could surely be found, but we will not speculate on those here. However, we believe that improved education of agency officials about bat values and bat habitat needs would increase the percentage of bat-friendly closures installed.

Bat-friendly closures can generally be grouped in the following five categories:

- **Bat gates** are made of welded steel bars, plates or angle irons, placed horizontally across a mine entrance at pre-determined spacings. These are generally installed in the mouth of horizontal or sloping openings and are anchored into solid rock or into poured concrete footers.
- **Bat cages** or **copulas** are installed over vertical openings and are also constructed of steel tubing, angle iron or other bar stock.
- **Gated culvert** pipes are sometimes used in openings where the near-surface materials are too unstable to construct traditional bat gates and cages.
- **Cable nets** and **fences** are sometimes used to exclude human entrance into mines, but are not as secure as welded gates or cages and they often do not provide the same level of bat access. These have been used where access is extremely difficult and where funding is inadequate for other closure methods. Fences were used in years past when other closure designs were not well known by agency officials.

Increased awareness of bat habitat needs protects bat populations in another way. While surveys find considerable bat use of some mines, many others find no, or find only occasional bat use by small populations of non-threatened species. Survey respondents told us that many of these small, non-critical bat populations have been spared entrapment in mines because they were detected by a bat survey. Once the populations were determined to be non-critical or non-endangered, the bats were spared entrapment by the agency simply waiting for bats to leave the mines prior to installation of solid closure methods. This shows that the completion of bat surveys prior to development of preliminary reclamation plans resulted in protection of bat

populations while allowing the agencies to complete their missions.

Agencies across the U.S. do not necessarily give equal consideration to the needs of bats during mine closure. Table 2 shows us that the majority (58 percent) of all bat-friendly closures in the U.S. have been installed in four western States, Colorado (321), Utah (300), California (198) and New Mexico (127). Kentucky has also installed a considerable number of bat-friendly closures, with 114 reported. Other States reporting large numbers of mine closures reported few bat-friendly closures. This may reflect a prevalence of mines that do not support bats. Alternately, it may indicate that bat surveys are not conducted in many States prior to closure design.

Active mines

Active mining operations disturb contemporary habitat in many ways. Mining removes surface vegetation, changes the physical configuration of the land and modifies or eliminates associated streams and lakes. Mining companies construct facilities to clean and refine mined commodities. These include slurry ponds, cyanide leach piles, and holding ponds. Open cyanide ponds and other toxic chemical impoundments can poison bats, especially in desert areas where clean water sources are scarce (Brown and Berry 1997 [3]). For example, one study conducted in Arizona, California, and Nevada from 1984 to 1989 found that 33.7 percent of 519 animals found dead near cyanide extraction gold mines were bats (Clark and Hothem 1991[4]). Active mines also disturb abandoned underground mines that have become roosts for bat populations. Geologic exploration may disturb roosting bats due to increased human activity (Brown and Berry 1997). Reactivation of old mining districts often eliminates underground roosting habitat by reworking mined areas using open pit methods.

Because of State and Federal laws, most mining companies must take actions to reclaim mined land and replace vegetation removed by mining activities. The nature and extent of these reclamation activities vary substantially across the nation. While coal mines are governed by the Federal Surface Mining Control and Reclamation Act which provides a strict set of national standards that must be adhered to by all coal mining operations, other types of mining are covered by a mixed bag of State and local reclamation regulations and land management agency permit requirements. All these mining and reclamation activities provide opportunities for protection of bat habitat during mining and for restoration and enhancement of bat habitat during the reclamation process.

Our study found that 86,000 acres of land are affected by coal mining annually to remove 1.1 billion tons of coal. Not all land placed under permit for coal mining is actually mined. Many acres are permitted for roads, processing areas and buffer zones. Native vegetation and topography in these areas are disturbed in different ways than in areas actually mined. Some lands are included in permits merely for convenience and are not disturbed at all. It would be extremely difficult on a national level to separate the acres physically disturbed from the total permitted acres. Yet we know it is somewhat less. For purposes of this study, we must assume that acres permitted equals acres affected in some way by mining processes.

Government records show us that six billion metric tons (2204 pounds or 6.6 billion short tons) of non-coal minerals are mined annually in the U.S., nearly six times the tonnage of coal produced. However, we found no estimate of acreage disturbed by those operations and no industry standard for converting mine tonnage to acreage disturbed. Based upon the tonnage figures, we speculate that the total acreage disturbed by mining activities may be two to three times the coal acreage. This level of disturbance provides many opportunities for protection, creation and enhancement of bat surface habitat each year. These opportunities can best by

realized by educating the mining industry about the benefits of considering bat habitat needs in the mining and reclamation planning processes. Education of State permitting personnel can also help realize these opportunities by providing a conduit of information to the mining industry.

Abandoned Surface Mines

Approximately 9,000 acres of abandoned mine lands are reclaimed annually in the U.S. These lands range in vegetative quality from barren land and acid water to lush, well vegetated mine spoil piles with high quality water impoundments and wetlands. Lands are most often reclaimed to eliminate serious public health and safety hazards. Environmental quality and wildlife habitat enhancement receive varying levels of emphasis depending on the attitude of the reclamation agency, the wishes of landowners, and the availability of funds.

Reclamation of abandoned surface mines provides many of the same opportunities for bat habitat protection, creation, and enhancement as do active mining operations, with the additional opportunities provided by the fact that reclamation and environmental restoration rather than mineral extraction are top goals of the reclamation agencies. Bat habitat has been successfully restored through abandoned mine reclamation projects. On a series of reclamation projects during the late 1990's in Crawford County, Kansas, strip mine pits located adjacent to roads were known to be critical feeding and travel habitat for the Federally Endangered Gray Bat (Myotis grisescens). Through the reclamation process, mine pits were filled in and relocated a safe distance from the roads and native trees were reestablished along the banks of the new ponds. Ponds with varying depths replaced the deep, steep sided strip pits to enhance the variety and number of insects that the gray bats feed on. Visual and bat detector surveys conducted after completion of reclamation demonstrated that Gray Bats and other species have returned to feed along the new water bodies (Imhof, 2000[8]).

Conclusion

Abandoned mines provide important bat habitat. With over 367,000 open abandoned mine shafts and tunnels in the U.S., mines must be considered a valuable resource for bat conservation efforts. Closure of abandoned mine shafts and tunnels can significantly affect the availability of roost habitat for many species. Reclamation and land management agencies have closed over 32,000 mine openings through August, 2000, and at the current closure rate of over 2,800 openings per year, opportunities are abundant for bat protection or bat harm. Mine surveys in the western U.S. indicate that 30 to 70 percent of mines are used by bats. And yet, out of 32,000 mine closures nationwide, approximately 1,639 or 5 percent, utilized bat gates and other bat-friendly closure devices. While no conclusions may be directly drawn from this percentage, it suggests that more mines should be surveyed for bat use prior to closure. It may also suggest that agencies may be permanently sealing some mines used by non-endangered species merely because there is no statutory requirement for maintaining bat access to those mines.

Surface mining and reclamation activities can have significant positive or negative impacts on amount of available habitat, the quality of habitat and the security of roosting areas from human disturbance. With over 9,000 acres of land reclaimed annually by AML agencies and more by local governments, chances to create or enhance bat foraging, watering and summer roosting habitat abound. Contemporary coal mining operations affect another 86,000 acres of land annually by mining, processing, transportation and power transmission activities. Mining for non- coal commodities may double or triple that acreage figure. While bat conservation is unlikely to be important to mining companies, education of mining officials on the importance of bat protection and the low cost of including bat conservation actions into the mining process, can

result in significant positive impacts on habitat protection and creation.

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Importance of Mines for Bat Conservation

A National Perspective

Len Meier, Office of Surface Mining
Jesse Garcia, University of Oklahoma

Bats

Photo by Scott Altenbach

Overview

- What do bats need for survival?
- How do underground and surface mines effect these needs?
- What opportunities do mining and reclamation present for bat conservation?
- How big are those opportunities.

Needs of Bats

- Shelter
- Food
- Water
- Safe Travel Routes

Underground Mines

Provide Shelter for:

- Winter hibernation areas
- Summer roosting areas
- Maternity and nursery areas

Surface Features of Mines and Land to be Mined

- Shelter
- Food
- Water
- Travel routes

Mines Provide Possibilities

Three Kinds of Possibility:

- Damage and degrade bat habitat
- Protect existing habitat values
- Create or enhance habitat

Study To Determine National Scope of Mining - Reclamation

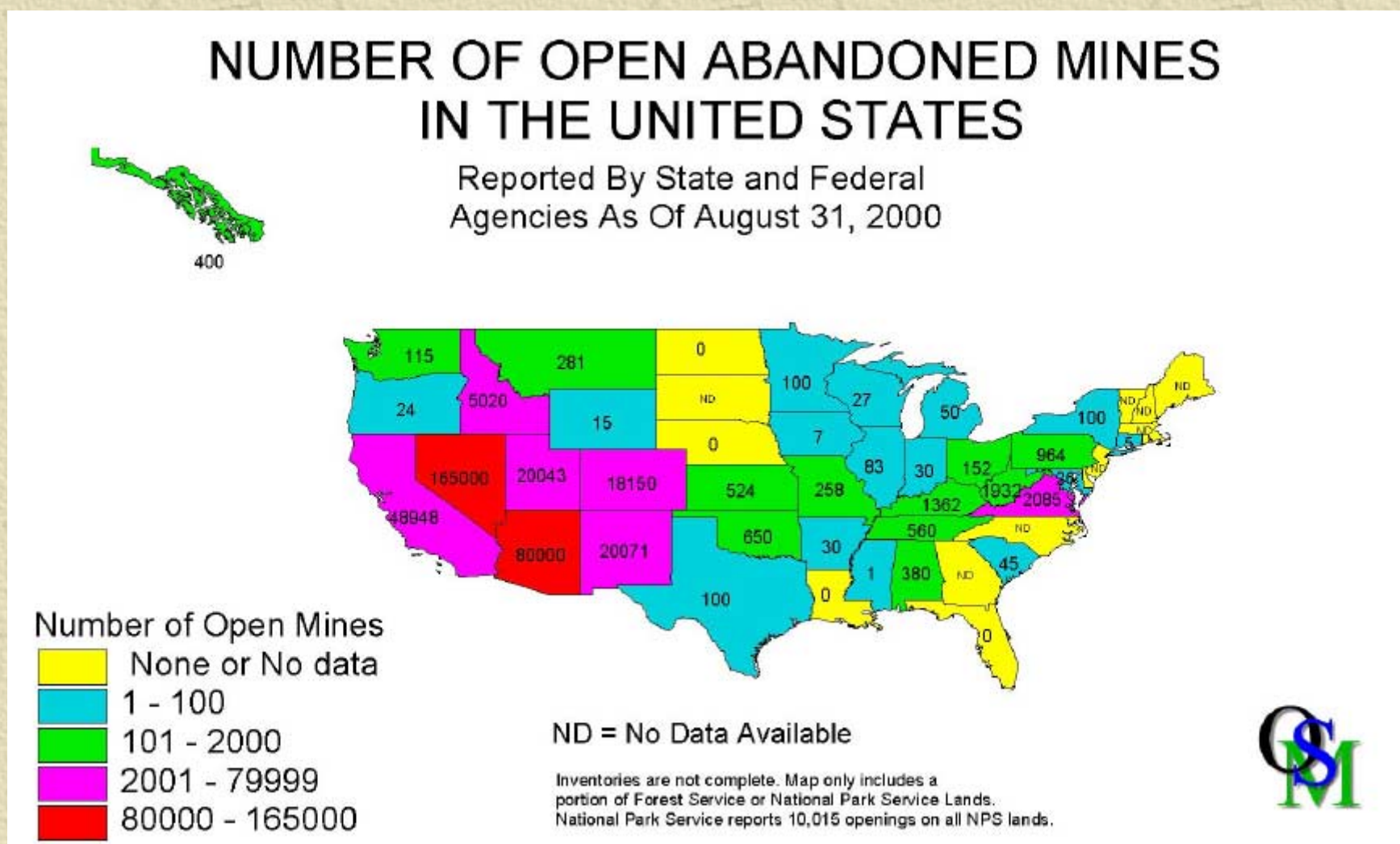
- Three month study
- E-mail and telephone survey – Response from 47 states.
- Research of mine permitting and production records
- Research on bats and mines literature.

Open Underground Mines

Bats and Mines Facts

- 30% to 70% of mines in western, northern and eastern U.S. are used by bats
- 12 of 16 Wyoming species use UG mines
- Largest colonies of some western species are found in mines
- Most significant hibernation sites in Michigan are UG mines

More Than 367,000 Abandoned Mine Openings In The U.S.



Over 32,000 Mine Openings Have Been Closed.

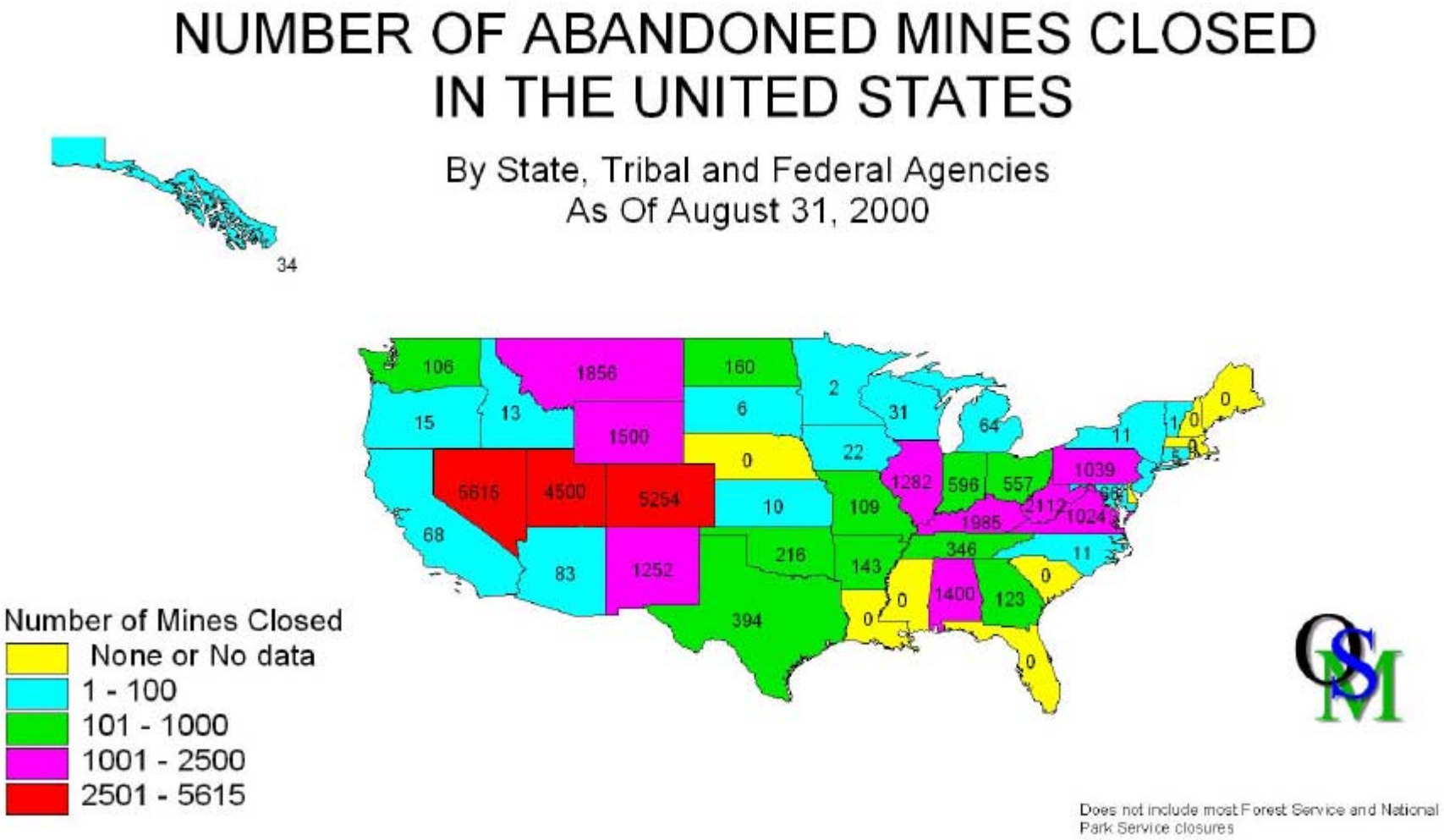


Table 3 - MINE CLOSURES REPORTED IN OSM AMLIS 1978 - 2000*

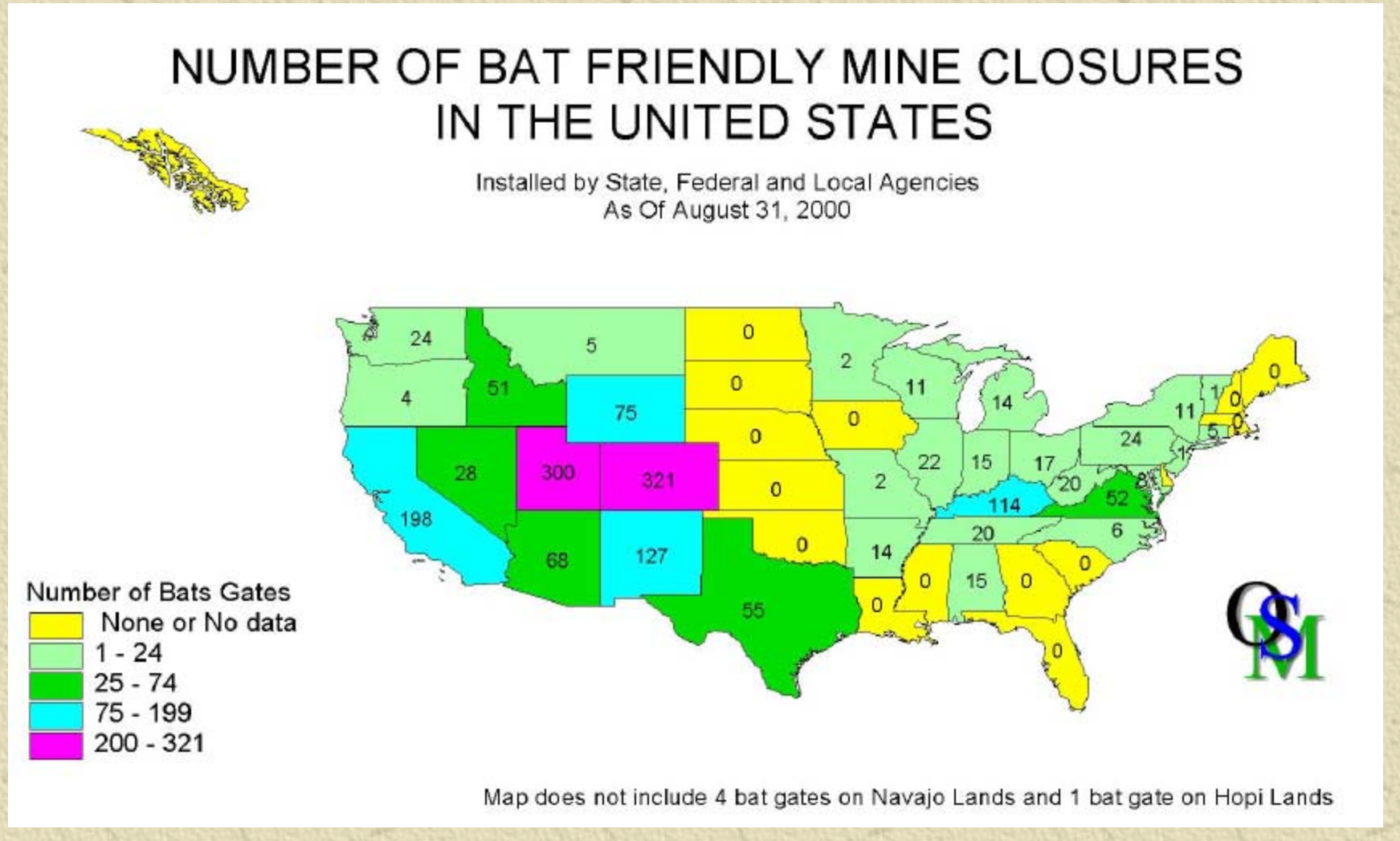
Reporting Period	Total Vertical Openings and Portals Closed - Cumulative	Average Openings Closed Per Year
1978 to 9/30/94	12,557	785
10/1/94 to 9/30/96	4,645	2322
10/1/96 to 9/30/98	2,247	1,123
10/1/98 to 9/30/2000	5,626	2,813

Possibilities

- Protect bat colonies from disturbance
- Protect habitat with Bat-Friendly closures
  - 600,000 bats protected in Wisconsin by survey of just 2 mines
- Lose Habitat
- Entrap bats during closure
  - Canoe Creek State Park PA
  - Hibernia Mine in New Jersey
  - Others

Bat Friendly Closures

Roughly 1,634 Bat Friendly Closures Nationwide



-Above Ground-

Surface Features Provide

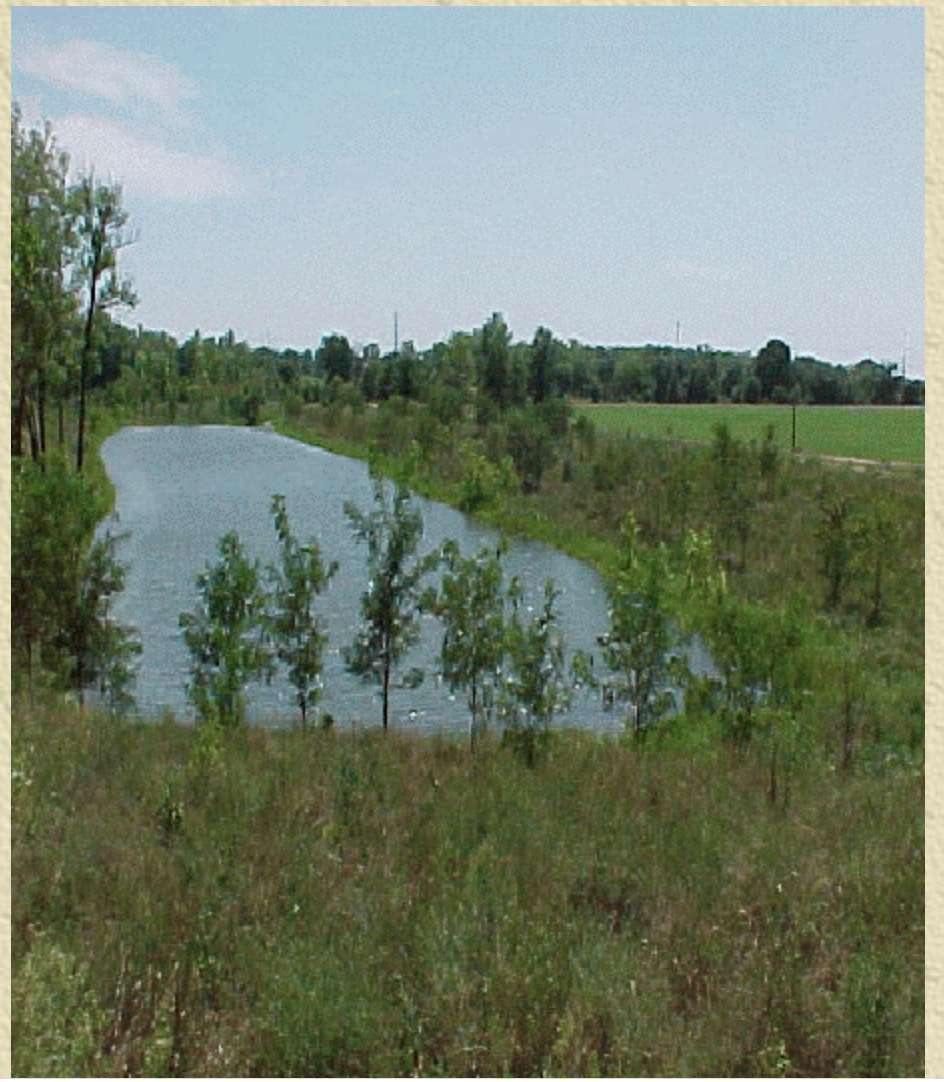
- Shelter
- Food
- Water
- Travel routes

Abandoned Surface Mines

Abandoned Surface Mine Reclamation

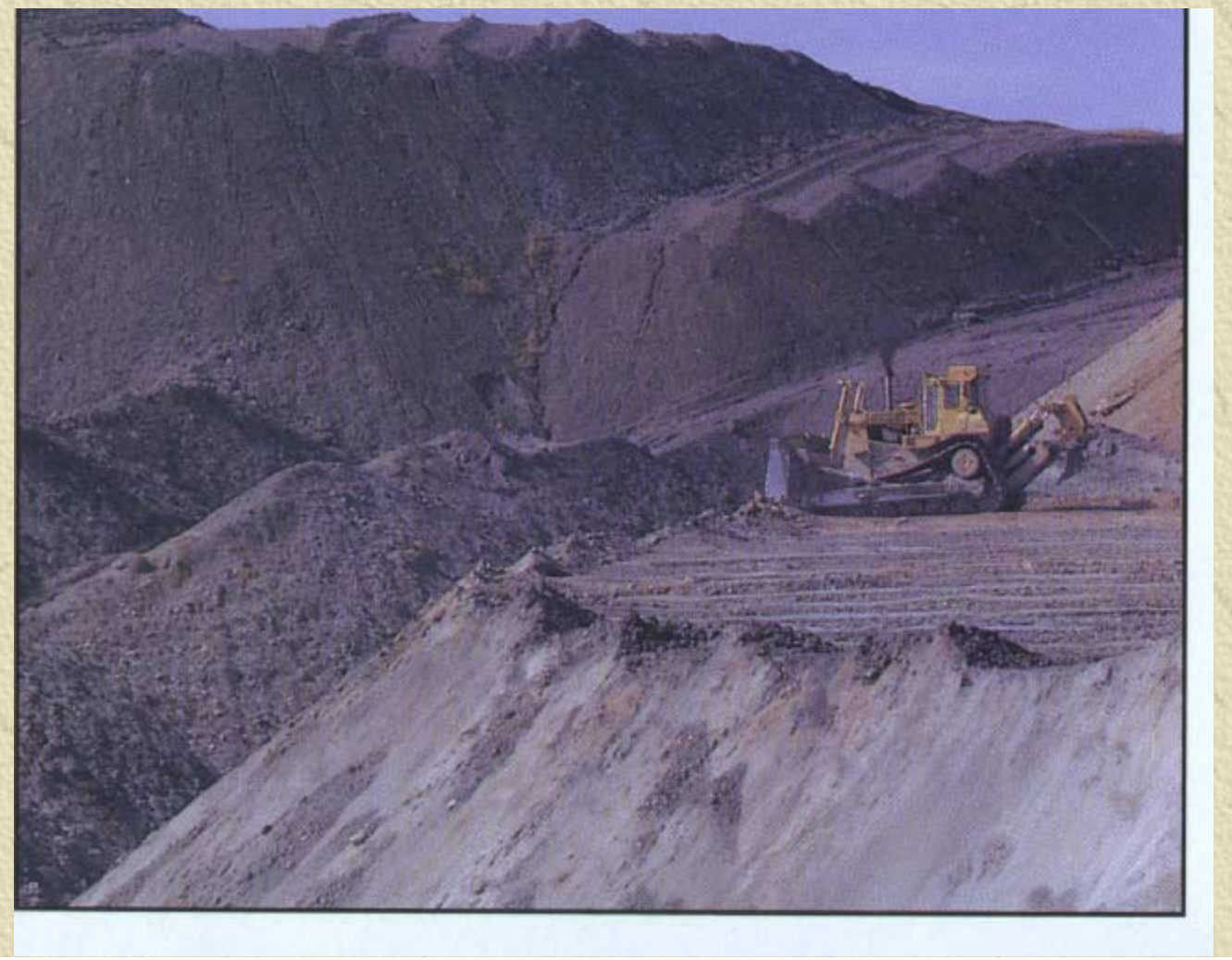
- 9000 acres AML reclaimed each year by government agencies
- Reclamation expected to increase as states, Tribes, BLM, Forest Service and Park Service begin to use Clean Water Action Plan and other AML funds

Bat Friendly Reclamation



Not So Friendly Reclamation

Active Mining and Reclamation



Active Mining Possibilities

- Destroy or degrade habitat
- Destroy nursery populations
- Protect existing bat populations
- Maintain habitat by temporary measures during mining
- Create new habitat during reclamation

National Scope of Active Mining

- 86,000 acres new coal permits annually for 1.1 billion tons coal
- 6.6 billion tons of metal ore mined annually.
- Actual acres effected annually may be 200,000 or more.

Summary

- Abandoned mines provide important bat habitat:
  - 367,000 open mines, 32,000 closed, 1,634 bat friendly.
- Abandoned surface mines can provide food, water, shelter for bats - 9000 acres reclaimed/year.
- Reclamation activities can have positive or negative impacts on bat habitat.
- Active mining operations can diminish or enhance bat habitat – 86,000 acres permitted for coal mining/year. ? acres disturbed by other mining.

Bat Populations are in the United States are in Decline

Of the 45 species present:

- Six are either threatened or endangered
- Twenty more are species of special concern
- Habitat destruction continues to escalate

Why Are Mines So Important?

- Caves have been disturbed
- Areas where bats historically lived have been changed by human activity:
  - drained for agriculture
  - cut over and converted to farms, subdivisions, highway interchanges, commercial uses
  - Mined and in some cases reclaimed

Survey Questions

- Number of Coal Mine Openings
- Number of Non-coal openings
- Number of Mines Closed
- Number of Bat Friendly Closures
- Acres of Abandoned Mines Reclaimed Annually

CHALLENGES IN PROTECTING BATS

Homer E. Milford
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Abstract

During the past century, abandoned mines have become an important part of the habitat of cave dwelling bat species in many parts of the United States. This paper focuses on the current challenges to individuals and agencies trying to safeguard abandoned mines from human entry. The challenges can be divided into two broad categories. The first category is the cost both in time and money for habitat assessment and the design and construction of bat compatible closures. The second category is the lingering concerns in many agencies over the increased liability that bat compatible closures may have over conventional backfill closure of mines. Each State varies in its liability laws, funding of reclamation programs, number of abandoned mines, and their importance as bat habitat. Resolution of these challenges will continue to occur on a project by project basis by each State, Tribe or local group. The goal of this talk is to provide only a general understanding or framework. Later presentations will provide the detailed information needed to evaluate the challenges faced in each project. When this conference is completed, you should have the knowledge needed to better serve the public needs in both safety and bat conservation.

Introduction

During the past century, abandoned mines have become an important part of the habitat of cave dwelling bat species in many parts of the United States. Following the passage of the Surface Mining Control and Reclamation Act (SMCRA) by Congress in 1977, programs were established to safeguard coal mines. SMCRA provided funds for States and Tribes with a history of coal mining to develop Abandoned Mine Lands (AML) programs. AML programs were started in the 1980's and safeguarded almost all mine openings by backfilling them. By 1990, many of the western States were safeguarding non-coal as well as coal mines. Around 1990, AML programs also became aware of the importance of evaluating old mines as bat habitat. Though less than a decade old, the AML programs had developed a “program tradition of backfilling” as the quickest, cheapest, and easiest way of safeguarding mine openings. The world changes and agencies must change with it. This paper focuses on the challenges commonly raised by the old backfilling tradition toward efforts to include wildlife values as a major consideration in AML programs.

The technical challenges of bat habitat assessment and bat grate design will be covered in later sessions. Many of the topics I mention now will be covered in detail later in the conference. I will focus on the challenges caused by old attitudes that still linger in many agencies. The first talk this morning stressed the importance of bats, and the second talk the importance of mines to many species of bats. If you accept these concepts, as most people do, then why has government

been slow to develop and implement mine reclamation programs that fully meet the needs of bat habitat preservation? The AML programs supervised by OSM have come a long way in the past decade. However, the challenges to OSM and each State and Tribal AML and active coal mine reclamation program still exist and will continue to exist after this conference.

The competing goals faced by AML programs result in compromises at almost every level in most projects. OSM and local governments want maximal public safety and reclamation as quickly as possible. This is to be done at the minimum cost. Obviously, compromises must occur. An abandoned mining site's historic and wildlife values can not always be preserved while providing for public safety and environmental restoration. The preservation of a mining site's historic values as well as its bat habitat has only recently been recognized as of equal importance with public safety. The balancing of safety with preservation of the nation's historic and biological heritage is the goal we are all striving to achieve. How well those goals are reached will continue to evolve. The degree of success will continue to vary from AML program to AML program depending on local pressures. The challenge to OSM and State AML programs is to find a balance that meets the goals the public wants us to achieve.

Everyone from the AML program managers down to the decision makers in the field have to constantly evaluate and balance the conditions that conflict with maximal bat habitat preservation. The costs and time delays involved in the assessment and construction of bat compatible treatments of mine sites will always exist. However, these can be minimized by long range planning and the exchange of information. The questions of safety and liability of bat grates in underground mines may be resolvable through State laws and diligent monitoring. These conflicts will not be resolved at this conference, but have to be dealt with in each project. The decisions on how a century and a half of abandoned mines are safeguarded will all be made in the next 20 years. Safeguarding will virtually be completed by 2020, after which only active mine reclamation will continue. It is the goal of this conference to provide a state of the art understanding of the challenges you and the bats face in mine safeguarding and reclamation.

The Challenges to Bat Habitat Preservation in Mine Safeguarding

I will focus on two categories of concern that have been challenges to AML programs in their bat habitat protection programs. First, the concern that liability is increased by bat grates and second, that they increase costs both in time and money.

1. Liability or Legal Questions on bat compatible closures.

The concern that the liability of an agency may increase by building bat grates has been one of the most common objections to them in the past. In order to evaluate this, we did a search to see if any law suits had occurred that set any legal precedent relating to bat grates. Our attorney did a search of the on-line computer law service, 'Westlaw.' for bats, bat grates and abandoned mines. To our surprise, we found that there have been a lot of law suits related to liability and bats over the years. However, none of them related to animals that fly. The cases all related to a game called "base ball." He found no cases dealing specifically with liability for bat grates and only one case dealing with abandoned mines.

This case dealing with abandoned mines was decided by the Missouri Court of Appeals in 1992. In that case, Miller v. River Hills Development, 831 S.W.2d 756 (Mo.App.1992), a private land owner was sued on behalf of a fourteen-year-old boy who fell into an abandoned mine shaft. The boy breached a steel barricade and a fence, ignored a sign warning of the danger of the abandoned mine, and knew of the danger. The Missouri Court of Appeals affirmed a lower court ruling that the landowner was not liable.

The Federal Government, States, and Tribes have varying degrees of immunity to prosecution. Private industry and land owners face greater potential risk of law suits. Government has broader protection against liability than private landowners. However, those differences have little bearing on the likelihood of a law suit being filed. They only bear on the potential cost of settlement. In this age of litigation, all governments get sued regardless of their immunity to prosecution and settlements of cases are often made just to avoid the costs of litigation. Lawyers are well aware of this and thus encourage their clients to name governmental units in their law suits. In New Mexico, the AML program was named, along with the property owner, in a wrongful death suit on an un-safeguarded mine in a remote area. The charge was that the State was negligent for not having closed all the abandoned mines in the State. The case did not go to trial.

To my knowledge, there has not yet been a case specifically related to someone being injured by breaching a bat compatible closure. We have been fortunate that the bat closures that have been vandalized, allowing people to later enter a mine, have not resulted in a death or injury. The odds are that some day it will happen and the agency building the gate will be charged in a law suit. Until then, there is no "Case Law" as termed by attorneys. There have been no cases of people being killed or injured in a mine that they entered through a breached bat grate.

Any engineered closure probably involves additional potential liabilities over total backfilling of a mine portal. It is unlikely that a litigant would claim engineering design failure. That potential exposure is eliminated by modern designs and good engineering. This risk can be covered by careful design of the bat compatible closure. The increased exposure comes from vandalism, such as individuals breaking through the bat compatible closure with blow torches, electric saws or other devices. Vandal breaching of bat closures can not be eliminated by engineering, but can be greatly reduced by engineering and will be discussed in a later session. Litigants will claim that they found the site breached prior to their entry of the mine. Although there is a small liability increase by bat grate installation over that from backfilling, it is very small.

The liability exposure is probably different from State to State due to State law. There is no specific legal precedent (i.e. case law) on bat grates. How then do we judge the liability question? The answer is in your agency's general exposure to 'torts,' or charges of wrong doing. In New Mexico, State governmental liability is governed by the New Mexico Tort Claims Act, NMSA 1978, Section 41-4-1 et seq. The purpose of the Act is to recognize that "while a private party may readily be held liable for his torts [negligent acts] within the chosen ambit of his activity [for his actions], the area in which the government has the power to act for the public good is almost without limit, and therefore government should not have the duty to do everything that might be done." Section 41-4-2(A). Consequently, the Act limits governmental liability. It

provides that "[a] governmental entity and any public employee while acting within the scope of duty are granted immunity for any tort" except as defined in the Act. In layman's language this means that the New Mexico AML program is immune to suits for negligence, providing reasonable caution was followed.

> The exceptions are relatively narrow. Government is liable for negligent operation of motor vehicles and water craft, or negligent operation, design, or maintenance of buildings, public parks, machinery, equipment and furnishings, airports, public utilities, medical facilities, negligence of health care providers, and negligent design and maintenance of highways and streets, and the negligence of law enforcement officers. Sections 41-4-5 to –12. " Nothing in the Act applies to mines or mine closures. **Therefore, I conclude that our agency would be immune from liability, under the Tort Claims Act, for any tort resulting from a mine closure. ... I believe that a governmental agency would not be liable so long as reasonable care was used in designing the grate and warning signs were used.** " (Informal opinion by memorandum, Bruce Rogoff, 9/21/00)

Thus the increase in liability exposure created by bat grates is reasonable. Virtually all States/Tribes and land management agencies seem to have decided that this is the case and started the construction of bat grates during the past decade.

> Generally, an owner or occupier of premises must exercise ordinary care and make safe an unreasonably dangerous condition known to, or discoverable upon reasonable investigation, by the owner or occupier. Brooks v. K-Mart Corp., 125 N.M. 537, 964 P.2d 98 (1998). A dangerous condition means a condition which a person using ordinary care would foresee as being likely to cause injury to one using ordinary care for his own safety. Id. The landowner may have a duty to warn of dangerous conditions, as well. Koenig v. Perez, 104 N.M. 664, 726 P.2d 341 (1986)("The law requires…warnings for the unwary—not for those who have knowledge of a dangerous condition and choose to ignore ordinary precautions necessary to protect themselves); Ryan v. New Mexico State Highway Dept., 964 P.2d 149 (N.M.Ct.App.1998)(Highway Department had a duty to warn of elk on the roadway). (Informal opinion by memorandum, Bruce Rogoff, 9/21/00)

Though laws vary from State to State on agency liability, if the following two criteria are met the chance of losing a liability suit are very small: (1) The bat grates are designed and constructed in as reasonably secure a fashion as current knowledge allows; and (2) that signs warning of the danger are placed on, in front of, or behind the bat grate.

It is doubtful that anything can be made 'child proof.' This was a challenge posed to bat grates in the early years. Generally coming from staff members whose attitudes were developed when AML programs were nothing but 'backfill programs.' Grates can be made child resistant just as they are adult resistant. This will be discussed in the session on bat grates. A third element in minimizing liability is monitoring bat closures at reasonable intervals. It is incumbent upon the State/Tribal agency or land manager doing the construction that they monitor the grates

periodically, as long as their agency exists. This monitoring requirement will vary by location as to what is a reasonable frequency. Repairs to vandalism should be as rapid as possible. Not only will this prevent trespass potential for accidents, but act as a further discouragement to the vandals.

All closures, including backfill, should be monitored. Bat grates are no exception. Other closures such as doors for land owner or mineral right owner access have also increased potential for vandalism.

The added costs in dollars and time with bat compatible closures.
DOLLARS:

- The added cost of bat habitat assessment is minimal in most projects.
- In most situations, the construction cost of bat grates is greater than backfill. At mine sites with mechanical access and adjacent waste piles that can be used for backfill material, backfilling is more economical. However, at sights without mechanical access, such as remote areas or wilderness areas, the cost may even be less than hand backfill, especially with deep shafts. The Colorado AML has an informal cooperative agreement to share bat grate costs. State AML programs should try to get similar agreements with the Forest Service or wildlife agencies to help cover the added costs of bat grates. Depending on the number of bat grates and their location, the added costs may or may not be significant for a project. However, on a program-wide basis, they are a small percentage of the total costs.
- Cost of monitoring visits and repairs should be very small. Federally funded AML program projects are supposed to be monitored yearly. Unless more frequent visitation seems warranted, there is no additional cost in monitoring past projects with bat grates. However, vandalism does create additional repair costs. In some states, the BLM has agreed to cover maintenance costs of bat grates on their lands. Grate designs all have one or more weak links that will be the site of vandalism. Well equipped professional vandals can not be stopped by any design. The design of bat grates should anticipate vandalism and be built to facilitate quick and easy repair.

TIME/DELAYS:
Time delays can be minimized or totally eliminated with adequate advance planning. Bat grates will delay projects unless advance planning takes them into consideration:

- Delays due to habitat assessment: One to one and a half years should be allowed for bat habitat evaluation. Added time may be needed for contract preparation if assessment is done by outside contractors. Project development needs to be started a year earlier to allowed for bat habitat evaluation studies.
- Delay due to engineering design: Engineering delays can be reduced by the exchange of bat grate designs between government agencies.
- Delay due to longer construction time: Actual increases in the amount of on-site construction time can generally be reduced to a matter of days per bat grate in most projects. Also, some habitat values will restrict the seasons during which safeguarding construction of any type can occur.

Conclusion

Laws are on the book for endangered and threatened species of bats and we obey them. At this time, there are only a few States that have endangered bat species. Those States must do extensive evaluations. Some bat species not currently listed, but under study, have wide ranges and, if they become listed as endangered in the future, this will impact almost all States. The degree to which future safeguarding of mines prevents other bat species from joining the endangered list is a day by day or project by project decision. OSM and the agencies it supervises will make the decisions that will determine future species status. We do not write the laws, but in our daily actions we function like judges in interpreting them. The more bat species that become threatened, the more restrictive will be the environment in which future mine safeguarding and reclamation will have to occur. Thus, unless you plan to change occupations in the near future, the future of America's bat species will dictate your working environment. If any additional bat species are added to the endangered species list, it will impact your work conditions and make your job more difficult. Self interest, if not enlightenment, should persuade your agency of the importance of bat habitat preservation.

Homer Milford has served as the Environmental Coordinator for the New Mexico AML Program for the past 10 years. He received his bachelors in Biology from the University of New Mexico and Masters in Biology from University of Idaho followed by two years at the State U of New York. He has conducted hundreds of underground bat habitat assessments in conjunction with Dr. Scott Altenbach over the past 10 years. He coauthored with Dr. Altenbach the publication "Evaluation and Management of Bats in Abandoned Mines in the Southwest."

EASTERN BAT SPECIES OF CONCERN TO MINING

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Abstract

Forty-five species of bats inhabit the United States. Twenty species occur in the eastern United States, herein defined as those 31 states east of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. Mines provide important winter and/or summer habitat for several of these species. Ten eastern United States species, often referred to as cave bats, usually inhabit caves and/or mines during all or part of the year. Three eastern cave/mine bat species, Indiana bat (*Myotis sodalis*), gray bat (*Myotis grisescens*), and Townsend's big-eared bat (*Corynorhinus townsendii*) are considered endangered by the U.S. Fish and Wildlife Service, as well as by most state wildlife agencies (U.S. Fish and Wildlife Service 1982,1984, 1995, 1999). Three additional eastern cave/mine species, southeastern bat (*Myotis austroriparius*), eastern small-footed bat (*Myotis leibii*), and Rafinesque's big-eared bat, *Corynorhinus rafinesquii*) are considered to be of special concern and may be proposed for listing as endangered or threatened in the near future. The other four eastern cave/mine species, big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), and eastern pipistrelle (*Pipistrellus subflavus*) are thought to be declining in portions of their ranges.

The additional 10 eastern United States bat species (Jamaican fruit-eating bat, *Artibeus jamaicensis;* silver-haired bat, *Lasionycteris noctivagans;* eastern red bat, *Lasiurus borealis;* hoary bat, *Lasiurus cinereus;* northern yellow bat, *Lasiurus intermedius;* Seminole bat, *Lasiurus seminolus;* evening bat, *Nycticeius humeralis;* Wagner's mastiff bat, *Eumops glaucinus;* Pallas' mastiff bat, *Molossus molossus;* and Brazilian free-tailed bat, *Tadarida brasiliensis*), usually referred to as tree bats, seldom enter caves or mines.

Certain mining activities, especially those involving deforestation and those resulting in stream degradation, can be detrimental to bats. All eastern United States bats are dependent, to some degree, on forest for shelter, roost sites, and/or foraging areas. Good quality water sources provide drinking water and are important to bats as sources of aquatic insects and foraging habitat.

Eastern U.S. Bat Species

Following are brief species accounts of the 10 eastern United States bats that inhabit caves and/or mines. Accounts are similar to those in Harvey et al. (1999), with additional information added.

Indiana Bat – *Myotis sodalis* – Endangered
Weight is 6-9 grams (0.2-0.3 ounce), wingspan is 24-28 centimeters (9-11 inches). Distribution includes cave regions in the eastern United States and, during summer, areas to the north, of cave regions. Indiana bats usually hibernate in large dense clusters of up to several thousand individuals in sections of the hibernation cave or mine where temperatures average 3-6°C (38-43°F) and with relative humidities of 66-95 percent. They hibernate from October to April, depending on climatic conditions. Females depart hibernation sites before males and arrive at summer maternity roosts in mid-May. The summer roost of adult males often is near maternity roosts, but where most spend the day is unknown. Others remain near the hibernaculum, and a few males are found in caves during summer. Between early August and mid-September, Indiana bats arrive near their hibernation sites and engage in swarming and mating activity. Swarming at cave or mine entrances continues into mid- or late October. During this time, fat reserves are built up for hibernation. When pregnant, females eat soft-bodied insects; they eat moths when lactating, and moths, beetles, and hard-bodied insects after lactation. Males also eat a variety of insects. One baby is born in June, and is raised under loose tree bark, often in wooded streamside habitat. Life spans of nearly 14 years have been documented. The present total population of this endangered species is fewer than 360,000, with more than 85 percent hibernating at only nine locations, making them extremely vulnerable to destruction. Most important hibernation caves have been gated. However, populations continue to decline in spite of protection and recovery efforts. Relatively large numbers of Indiana bats hibernate in several abandoned mines in Missouri, Illinois, and Ohio.

Until recently, Indiana bat maternity colonies were not known to exist in the southeastern United States, although a few reproductively active females had been reported, primarily in Kentucky. During the summer of 1999, a maternity colony was discovered in the Nantahala National Forest in western North Carolina; during the summer of 2000 an additional maternity colony was found in Great Smoky Mountains National Park in eastern Tennessee.

Gray Bat – *Myotis grisescens* – Endangered
Weight is 8-11 grams (0.3-0.4 ounce), wingspan is 27-32 centimeters (11-13 inches). Distribution includes cave regions of Arkansas, Missouri, Kentucky, Tennessee, and Alabama, with occasional colonies found in adjacent States. Gray bats are primarily cave residents year-round, but different caves usually are occupied in summer and winter. Few have been found roosting outside caves or cave-like habitats. They hibernate primarily in deep vertical caves with large rooms acting as cold-air traps (5-11°C or 42-52°F). In summer, females form maternity colonies of a few hundred to many thousands of individuals, often in large caves containing streams. Maternity colonies occur in caves that, because of their configuration, trap warm air (14-25°C or 58-77°F) or provide restricted rooms or domed ceilings capable of trapping combined body heat from clustered individuals. Because of their specific habitat requirements, fewer than 5 percent of available caves are suitable for gray bats. Males and non-reproductive females form bachelor colonies in summer. Gray bats primarily forage over water of rivers and lakes. Moths, beetles, flies, mosquitos, and mayflies are important in the diet, but gray bats also consume a variety of other insects. Mating occurs in September and October,

and females enter hibernation immediately after mating, followed by males. Females store sperm through winter and become pregnant after emerging from hibernation. One baby is born in late May or early June, and begins to fly within 20-25 days of birth. Life span may exceed 14-15 years. Listed as endangered, about 95 percent of these bats hibernate in only eight caves, making them extremely vulnerable to destruction. Most important gray bat hibernation caves, and several summer caves, are now protected by gates or fences. Populations appear to be increasing throughout most of their range. Gray bats are known to inhabit some mines.

Townsend's Big-eared Bat – *Corynorhinus townsendii* – Endangered
Weight is 8-14 grams (0.3-0.5 ounce), wingspan is 30-34 centimeters (12-13 inches). Distribution includes western Canada, the western United States to southern Mexico, and a few isolated populations in the eastern United States. These bats hibernate in caves or mines where the temperature is 12°C (54°F) or less, but usually above freezing. Hibernation sites in caves often are near entrances in well-ventilated areas. If temperatures near entrances become extreme, they move to more thermally stable parts of the cave. They hibernate in clusters of a few to more than 100 individuals. During hibernation, the long ears may be erect or coiled. Solitary bats sometimes hang by only one foot. Maternity colonies usually are located in relatively warm parts of caves/mines. During the maternity period, males apparently are solitary. Where most males spend the summer is unknown. No long-distance migrations are known. Like many other bats, they return year after year to the same roost sites. It is believed to feed entirely on moths. Mating begins in autumn and continues into winter, sperm are stored during winter, and fertilization occurs shortly after arousal from hibernation. One baby is born in June. Babies are large at birth, weighing nearly 25% as much as their mother. They can fly in 2.5-3 weeks and are weaned by 6 weeks. Life span may be 16 or more years. The two subspecies in the eastern United States, *C. t. virginianus* (Virginia big-eared bat) and *C. t. ingens* (Ozark big-eared bat), are considered endangered. Two western subspecies, *C. t. townsendii* (Townsend's big-eared bat) and *C. t. pallescens* (western big-eared bat), are of special concern. A few have been reported inhabiting mines.

The endangered subspecies *Corynorhinus townsendii virginianus*, Virginia big-eared bat, inhabits caves in Virginia, West Virginia, Kentucky, and North Carolina. The total population numbers only ca. 20,000. The endangered subspecies *Corynorhinus townsendii ingens*, Ozark Big-eared bat, is currently known to exist only in northwestern Arkansas and eastern Oklahoma. The total population is estimated to number less than 1500.

Southeastern Bat – *Myotis austroriparius* – Special Concern
Weight is 5-8 grams (0.2-0.3 ounce), wingspan is 24-29 centimeters (9-11 inches). Distribution includes the southeastern United States from southern Illinois and Indiana to northeastern Texas and northern Florida. Caves are favorite roosting sites, although buildings and other shelters sometimes are used. Maternity colonies comprised of thousands of individuals inhabit caves. Throughout much of the South, these bats reside in buildings and hollow trees, but in the northern part of their range they roost primarily in caves. In winter, they leave the maternity caves and take up residence in small groups

at outdoor sites. Predators include opossums, snakes, and owls, but by destruction of roosting sites and killing of these bats humans are the major threat to the species. Southeastern bats usually are associated with bodies of water, over which they feed. They forage low, close to the water's surface. A variety of insects are consumed, but the diet of this species has not been studied. Mating time is unknown, but about 90 percent of pregnant females bear twins in late April or mid-May. The production of twins is unique among bats of the genus *Myotis* in the United States; all other *Myotis* usually produce one baby. Clusters of babies often are separate from adult females during the day. Young bats can fly when 5-6 weeks old. Once common, populations of the southeastern bat have decreased significantly; it is now considered a species of special concern.

Eastern Small-footed Bat – *Myotis leibii* – Special Concern
Weight is 3-5 grams (0.1-0.2 ounce), wingspan is 21-25 centimeters (8-10 inches). Distribution is from eastern Canada and New England south to Alabama and Georgia and west to Oklahoma. This is one of the smallest bats in the United States. Eastern small-footed bats hibernate in caves or mines and are among the hardiest of bats. They are one of the last to enter caves/mines in autumn and often hibernate near cave or mine entrances where temperatures drop below freezing and where humidity is relatively low. Several have been found hibernating in cracks in cave floors and under rock slabs in quarries and elsewhere. The tolerance for cold, relatively dry places for hibernation is remarkable for such a small bat. In summer, they often inhabit buildings and caves; one small summer colony was behind a sliding door of a barn. Small colonies have also been found in bridges. They often fly repeated patterns within less than 1 meter (3 feet) of the floor of a cave or crevice, hang up on the wall, and then fly again. These bats emerge to forage shortly after sunset, and fly slowly and erratically, usually 1-3 meters (3-10 feet) above the ground. Apparently these bats fill their stomachs within an hour after beginning to forage in the evening. They consume flies, mosquitos, true bugs, beetles, ants, and other insects. One baby is born in late spring or early summer. Nursery colonies of up to 20 bats have been reported from buildings. Life span is unknown, but may be more than 9 years. It is uncommon throughout most of its range and is a species of special concern.

Rafinesque's Big-eared Bat – *Corynorhinus rafinesquii* – Special Concern
Weight is 8-14 grams (0.3-0.5 ounce), wingspan is 26-30 centimeters (10-12 inches). Distribution is the southeastern United States. This species is one of the least known of all bats in the eastern United States. In the northern part of its range, it hibernates in caves, mines, or similar habitats, including cisterns and wells. In contrast, Rafinesque's big-eared bats usually are not found in caves during winter in the more southern parts of their range. Maternity colonies usually are found in abandoned buildings, sometimes in rather well-lighted areas. They usually consist of few to several dozen adults. Maternity colonies are found more rarely in caves and mines. Males generally are solitary during summer, roosting in buildings or hollow trees. When approached in summer, these bats are immediately alerted and begin to wave their ears, apparently trying to keep track of the intruder. This species and the eastern pipistrelle bat choose more open and lighted day roosts than other kinds of bats. Both species commonly hang in the open in plain

sight. Rafinesque's big-eared bats emerge late in the evening to forage; apparently it does not forage at twilight. Its flight is remarkably agile. Moths and other night-flying insects are eaten. One baby is born in late May or early June in the northern part of the range and about mid-May in the South. The young shed their milk teeth in mid-July and reach adult size by August or early September. This species is uncommon over most of its range and is of special concern. Some of the largest known colonies of this species (numbering in the hundreds) inhabit abandoned copper mines, during both summer and winter, in Great Smoky Mountains National Park.

Big Brown Bat – *Eptesicus fuscus*
Weight is 14-21 grams (0.5-0.7 ounce), wingspan is 32-40 centimeters (13-16 inches). Distribution is from southern Canada through southern North America into South America, including many islands in the Caribbean. These bats are closely associated with humans and are familiar to more people in the United States than any other species of bat. Most summer roosts are in attics, barns, bridges, or other man-made structures, where colonies of a few to several hundred individuals gather to form maternity colonies. They move into caves, mines, and other underground structures to hibernate only during the coldest weather. Where most of these bats spend the winter remains unknown. They emerge at dusk and fly a steady, nearly straight course at a height of 6-10 meters (20-33 feet) in route to foraging areas. Their large size and steady flight make them readily recognizable. Apparently, some individuals use the same feeding ground each night, for a bat can sometimes be seen following an identical feeding pattern on different nights. After feeding, the bat flies to a night roost to rest; favored night roosts include garages, breezeways, and porches of houses. These bats consume beetles, ants, flies, mosquitos, mayflies, stoneflies, and other insects. Mating occurs in autumn and winter, females store sperm, and fertilization takes place in spring. In the eastern United States, big brown bats usually bear twins in early June. In the western United States, usually only one baby is born each year. It is common throughout most of its range.

Little Brown Bat – *Myotis lucifugus*
Weight is 7-14 grams (0.3-0.5 ounce), wingspan is 22-27 centimeters (9-11 inches). Distribution is from central Alaska to central Mexico. The little brown bat usually hibernates in caves and mines. During summer, it often inhabits buildings, usually rather hot attics, where females form nursery colonies of hundreds or even thousands of individuals. Where most males spend the summer is unknown, but they likely are solitary and scattered in a variety of roost types. Colonies usually are close to a lake or stream. This species seems to prefer to forage over water, but also forages among trees in rather open areas. When foraging, it may repeat a set hunting pattern around houses or trees. It eats insects, including gnats, crane flies, beetles, wasps, and moths. Insects usually are captured with a wing tip, immediately transferred into a scoop formed by the forwardly curled tail and interfemoral membrane, and then grasped with the teeth. Mating occurs in autumn, but also may occur during the hibernation period. One baby is born in May, June, or early July. When the mother is at rest during the day, she keeps the baby beneath a wing. Life span may be more than 20 years. This species is one of the most common bats throughout much of the northern United States and Canada, but is scarce or only locally common in the southern part of its range. A subspecies found in

the southwestern United States, *M. l. occultus* (Arizona bat), is considered to be of special concern.

Northern Long-eared Bat – *Myotis septentrionalis*
Weight is 6-9 grams (0.2-0.3 ounce), wingspan is 23-27 centimeters (9-11 inches). Distribution includes southern Canada and the central and eastern United States southward to northern Florida. Northern long-eared bats hibernate in parts of caves and mines that are relatively cool, moist, and where the air is still. Hibernation may begin as early as August and may last for 8-9 months in northern latitudes. In summer, they roost by day in a variety of shelters, including buildings and under tree bark and shutters, but at night they commonly use caves as night roosts. Northern long-eared bats seem much more solitary in their habits than other members of the genus *Myotis*, and they generally are found singly or in small groups containing up to 100 individuals. Although they frequently hang in the open, they seem to prefer tight crevices and holes. Sometimes only the nose and ears are visible, but they can be distinguished from most other species of *Myotis* by their long ears. These bats forage mainly on forested hillsides and ridges rather than in streamside and floodplain forests. They consume a variety of small night-flying insects. Presumably most mating occurs in autumn prior to hibernation. Apparently small nursery colonies are formed in June and July where pregnant females give birth to one baby. Mothers may be able to retrieve their young that fall from roost sites. Life span may be more than 18 years. This species is common over much of its range.

Eastern Pipistrelle – *Pipistrellus subflavus*
Weight is 6-8 grams (0.2-0.3 ounce), wingspan is 21-26 centimeters (8-10 inches). Distribution includes eastern Canada, most of the eastern United States, and southward through eastern Mexico to Central America. Caves, mines, and rock crevices are used as hibernation sites in winter, and occasionally as night roosts in summer. These bats rarely occur in buildings, and apparently most roost in trees in summer. This species inhabits more caves and mines in eastern North America than any other species of bat, usually hanging singly in warmer parts of the cave/mine. An individual may occupy a precise spot in a cave/mine on consecutive winters; it usually has several spots in which it hangs, shifting from one to another during the winter. This bat emerges from its daytime retreat early in the evening. It is a weak flier and so small that it may be mistaken for a large moth. Eastern pipistrelle bats usually are solitary, although occasionally in late summer four or five will appear about a single tree. The flight is erratic and the foraging area is small. It often forages over waterways and forest edges and eats moths, beetles, mosquitos, true bugs, ants, and other insects. Mating occurs in autumn, sperm are stored during winter, and fertilization takes place in spring. These bats usually bear twins in late spring or early summer. Babies are born hairless and pink with eyes closed, and they are capable of making clicking sounds that may aid their mothers in locating them. They grow rapidly and can fly within a month. This species is common throughout its range.

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WESTERN BATS AND MINING

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Abstract

In North America north of Mexico, there are 45 species of bats and 32 of these species occur west of approximately 100° W longitude. At least 22 of the western species are known to use abandoned mines to some extent and all 32 species could be affected by mine-related activities. Two species are listed as Federally Endangered and another 11 taxa are species of concern. As a group, bats have a low reproductive potential and disturbance to colonies or loss of roosting or foraging habitat can depress population levels. Aspects of their natural history, roosting habitat, and foraging habitat are discussed herein and related to potential impacts of mining.

Introduction

There are about 4200 different kinds or species of mammals and bats (Order Chiroptera) are the second largest group, after rodents, comprising about 1000 species. Globally, only primates (including humans) are more widely distributed, as bats occur on all continents except Antarctica, from tree line to tree line, as well as on many remote oceanic islands. The majority of bats, about 88 percent of all species, are tropical in distribution with fewer species in the temperate zones (Table 1). Among bats in temperate regions (e.g., North America) most belong to the family Vespertilionidae (vespertilionid or evening bats), primarily in the genera *Myotis*, *Pipistrellus*, and *Eptesicus* (Findley, 1993).

One of the clearest geographic patterns that bats exhibit is that of increasing species diversity towards the equator. In the New World for example, bats demonstrate a clear latitudinal gradient. At the Equator, there are about 100 species; at 15° N latitude, 70 species; at 20° N, 50 species; at 30°N, 20 species; above 35° N latitude, 10 species; and above 55° N latitude, only a handful (Findley, 1993). Exact reasons for this decline in diversity towards the poles are unknown but probably include absence of suitable roosting sites, extreme seasonality of food (primarily insects), and extreme weather conditions.

In North America north of Mexico, there are 45 species of bats representing 19 genera and 4 families. West of approximately 100° W longitude in the United States there are about 32 species of bats (Table 2). Of this number, roughly 26 species are exclusively western in distribution with an additional 6 species occurring more or less continent-wide. In contrast, the East has only about 12 species that occur there exclusively (Pierson, 1998). Humphrey (1975) demonstrated that increasing bat species diversity in the West is due in part to increasing topographic relief, which in turn translates into greater availability of roosting sites.

Of the 32 species occurring in the West, at least 22 species are known to use mines to some extent (Table 3; Altenbach and Pierson, 1995), and all 32 species could be affected in some way by mine-related activities. Two of the 22 species are Endangered nectar-feeding bats of the genus *Leptonycteris* and are discussed by Currie (this volume). An additional 11 species (including *Myotis lucifugus occultus*) are former U.S. Fish and Wildlife Service Category 2 Candidate Species, now usually referred to as species of concern. These 11 species, and others, are frequently listed by various states as "at-risk" species.

Although we have some understanding of regional and global patterns of species diversity and life history, we have very little rigorous data on population numbers of most species and almost no data on population trends. For some species of colonial bats in the eastern United States we do have data that document population declines and, in a few cases, recovery of populations. However, for most western bats we have almost no satisfying population data (O'Shea and Bogan, 2000). What is clear is that there are many instances of large numbers of bats disappearing from known roosts. Such disappearances are often linked with known events such as frequent disturbance, vandalism, alteration of caves or mines that make them unsuitable for bats, or various types of land-use change.

Life History Features of Western Bats

There are several unifying features of the life history of bats in western North America. Most are insectivorous and pursue their insect prey in a variety of ways; three are nectar-feeders and occur only seasonally in the United States. All the species have low reproductive rates for a small mammal of this body size, typically having only one young per female per year (Findley, 1993). In North America, bats of the genus *Lasiurus* may have up to five young in a litter although the average is lower. Gestation is usually two to three months long and following birth in early summer there is an extended period of maternal care of up to 1.5 months before the young are able to forage on their own. Juvenile mortality is high but once an individual survives its first year, there is a good probability of a relatively long life. Maximum known age of a North American bat is over 30 years (Findley, 1993) and the average is probably 4 to 7 years or so, depending upon the species. Although there are a variety of predators on bats, the assumption by most biologists has been that predation risks are low for most bats.

Once the young are independent in late summer, both they and the females have a narrow window of time during which they must obtain energy in the form of insect prey to last them through the rigors of winter. Most western species probably travel relatively short distances to winter quarters where they hibernate. However, some species are known or believed to escape winter by migrating longer distances to areas where temperatures and insect populations remain high enough for continued activity (Findley, 1993). In the spring, bats typically return to their natal areas where young are born and grow to maturity. Mating in most species occurs in the fall, just before hibernation, and sperm are "stored" in the uterus of the female over the winter. In spring, the female ovulates, the egg is fertilized, and development of the young bat ensues.

Western bats occur in a wide variety of ecological situations and, based on their life histories and distributions, some species appear to be rather general in their requirements whereas others appear to have more specific requirements. Generally, bats need two kinds of habitat to survive:

roosting habitat and foraging habitat. Roosting habitat is critical to long-term survival of bat populations and may be limiting to North American bats (e.g., Humphrey, 1975). Equally important however, and not always equally considered, (but see Pierson, 1998) is the importance of areas where bats can forage and drink.

Roosts used by Western Bats

Western bats use a variety of roosts and differences are correlated with gender, reproductive condition, time of the year, and feeding strategy. During summer, females of most species aggregate in colonies within which the young are born and nursed; colony sizes range from scores to thousands of mothers and young (Barbour and Davis, 1969). At this time, males are usually dispersed across the landscape, often in different areas or even regions of the country (e.g., Findley and Jones, 1964), and frequently roost alone. One reason for this is that males and females have different thermoenergetic strategies during the summer. Males forage nightly and then typically seek a roosting site during the day that allows them to lower their body temperature to conserve energy. Females, however, appear to seek roosting sites that are somewhat cooler than ambient temperatures during the day and warmer than ambient at night. Development of the embryo and growth of young is dependent on maintaining a more or less constant body temperature; generally, torpor is uncommon in pregnant or lactating females and growing young (Racey, 1982). Maternity roosts also appear to be chosen to provide security from predators and disturbance.

Once the young are independent, all individuals begin to pursue the “male” strategy of obtaining as much energy at night as possible and then conserving energy during the day. Thus maternity colonies begin to break up and individuals seek roosts that allow torpor (lowering of body temperature) to occur. As fall progresses, and depending on the species of bat, individuals may move among a network of roosts, where mating may occur. Subsequently, they move to the winter roost where hibernation occurs; such roosts are called hibernacula. In the western U.S., some species (e.g., California myotis, western pipistrelle, pallid bat) may not enter hibernation or may hibernate only short periods of time. Individuals of these species may be observed on winter evenings and nights (O’Farrell et al., 1967). In the case of migratory species, once sufficient energy has been obtained and stored as fat, they begin their flights to areas to the south (Cockrum, 1969).

Thus, over the course of a year, most species will use several different kinds of roosts. As noted above, summer roosts used during daylight hours tend to be gender specific with females typically aggregated in a few, historically-used roosts and males often using sites that are more abundant on the landscape; both types of sites must meet certain thermal requirements. However, at night between foraging bouts both sexes may use the same kind of roost. Night roosts are usually occupied only for short periods of time, are frequently common across the landscape, and may be relatively open, allowing bats to arrive and depart freely. Although night roosts may just be sites for rest and digestion of food, they also may serve a social function as well. During the day, night roosts are unoccupied and can be recognized by the presence of stains and guano. We know little about the extent to which western bats use temporary night roosts in the spring and fall. In the eastern U.S. swarming of bats occurs at temporary roosts in

the fall; this is thought to be important for reproduction and as a precursor to entering hibernation. It seems likely that such roosts are important in the West as well.

Lewis (1995) has suggested that fidelity of bats to their roosts is related to the type of roost that is occupied. In particular, high fidelity appears to be directly related to roost permanency and inversely related to roost availability. Bats, that occupy spatially abundant but less permanent roosts, are more likely to change roosts frequently. Conversely, bats appear to show high site fidelity to roosting sites that are uncommon and permanent within an area.

Overall, two kinds of roosts are of particular importance: maternity roosts and hibernacula. Mines are known to provide both kinds for some species. Maternity roosts, where young are born and develop, are critically important, especially given the relatively low reproductive potential of most species of bats. When such roosts are destroyed or made uninhabitable, bat populations may be locally depressed due to failure of reproduction. This may be especially true if the roosts do not occur commonly across the landscape. Disturbance to bats while they are in either maternity roosts or hibernacula can be devastating to local populations. Disturbance at maternity roosts may cause females to drop and abandon their young; if the young are unable to forage on their own they will die.

Hibernating sites where bats can escape the rigors of winter and food scarcity are equally important and appear to be chosen based on strict temperature, humidity, airflow, and security requirements. Hibernacula are usually uncommon across the landscape and some species are known to be completely dependent upon only a very few sites for hibernation. Closing or alteration of such hibernacula is known to have caused population declines in some species. Often, relatively slight changes in temperature or airflow are sufficient to cause bats to abandon a roost. Disturbance in hibernacula causes bats to arouse, a process that results in expenditure of limited energy stores. It is generally believed that most bats enter hibernation with only a narrow safety margin in terms of stored energy (Humphrey and Kunz, 1976). If disturbances occur frequently, bats may be forced out of the hibernaculum to feed at a time when insects may not be available.

Actual natural sites used by western bats over the course of a year include cavities and cracks in trees, under the bark of trees, foliage of trees (including palms and yuccas), caves (both complex and simple), cracks and crevices in sheer cliffs, under rocks and boulders, and cracks in boulders. These sites, and similar ones, provide security and meet the physiological requirements of roosting bats. With settlement and development of the West, bats have lost some natural roosts but now also roost in structures such as houses, garages, barns, silos, warehouses, hangars, bridges, as well as abandoned mines. Tuttle and Taylor (1998) note that of 8,000 mines that were surveyed for bats nationwide, 30 to 80 percent showed some signs of use by bats and 10 percent contained important colonies. Factors that contribute to making a mine desirable to bats include location, proximity to foraging and drinking areas, internal structure, volume, temperature and temperature stability, airflow, ventilation, presence of other species, and absence of predation. Mines, especially those at high latitudes or altitudes, may be too cool for reproductive females in the summer but may be very desirable for hibernation. Alternatively, warmer mines, such as those in the southern U.S., may not be good for hibernation but may be

used by reproductive females. A good discussion of how attributes of mines affect bat use can be found in Tuttle and Taylor (1998).

Foraging Habitat

Although North American bats are mostly insectivorous, they display an impressive array of feeding types (Table 4). Aerial insectivory, the capture of flying insects, is the "classic" form of feeding by bats but some scientists now distinguish between two different types of this feeding mode. Some bats capture flying insects in open space that is unfettered by obstacles, such as above a forest canopy, whereas others forage for flying insects in or near vegetation, such as in forests. Two other foraging modes are the capture or "gleaning" of insects directly from vegetation or trees and the capture of insects off the surface of the water or directly above it. Finally, among North American bats, three species specialize on the pollen and nectar of selected species of flowering plants (e.g., columnar cacti and agaves).

The extent to which bats are "specialists" in any of several areas, including diet, is a subject of some discussion among bat biologists (e.g., Fenton, 1982). Nonetheless, an awareness of the basic ways that bats forage (Table 4), coupled with the understanding that in most bat communities there will be multiple species using different modes, suggests that the concept of foraging areas or habitat for bats is likely to be complex. Additionally, it seems likely that just as bats show fidelity to some types of roosts (Lewis, 1995), they also continue to use productive foraging sites over time (Pierson, 1998). In terms of how western bats and mining may interact, it is fairly intuitive that closure or modifications of an abandoned mine may have direct effects on bats in the vicinity. However, foraging habitat for bats is neither obvious nor intuitive and this may obscure the effects of mining on potential foraging areas. Negative effects may be direct or indirect. If water sources are contaminated or drained bats may be affected directly, due to poisoning or loss of a place where they can drink. More subtly and indirectly, if land use causes changes in vegetation, there also may be changes in the insect community upon which the bats depend. For example, bats are known to forego foraging in lush non-native vegetation and instead travel some distance to forage in more natural vegetation (e.g., Brown et al., 1994).

Most western bat communities probably consist of six to twelve species (or more). Depending on the region, the community may include species that forage for insects over water surfaces (e.g., stock ponds, settling pools, or rivers), ground foragers that actually alight on the ground to feed, aerial insectivores feeding in open spaces above the vegetation, and finally species that pursue insects in and near vegetation. Usually, nearly all bat species in a community are dependent on nearby sources of water. Habitat change or loss of water sources due to land management, mining, or other activities have the potential to affect insect populations that bats depend upon as well as preferred foraging areas. To fully assess the effects of land-use practices on bats we need information on the habitat associations of insect prey (Pierson, 1998). Unfortunately, this information is not available for most bats. It seems likely that conversion of formerly diverse plant communities to various monocultures (e.g., agriculture, urbanization) has impacted bat communities to some degree. Invasion by, or reclamation with, non-native plants may also affect foraging opportunities for bats.

Loss of Habitat from Mining

Historically, most early mining in the West was directed at high-grade veins of precious metals that were most efficiently mined through underground workings. Although underground mining probably had some direct effects on bats (e.g., tailings, road-building, contaminants), it may have been more benign than some modern practices. Most mining today is focused on more disseminated, lower-grade, deposits that are most efficiently mined by surface or open-pit mines. This type of mining has a greater potential to modify large areas and consequently impact foraging habitat for bats.

Henry (1995) discussed environmental issues associated with mining and noted three general topics: impacts on surface and ground water, effect on wildlife habitat, and visual-aesthetic values. He notes that the greatest negative impact of mining has been on surface and ground water. Contaminated water sources are certainly a concern for bats, especially in arid areas, but there are other issues as well. O'Shea et al. (this volume) discussed the effects of mining-related contaminants on bats and their foraging habitat.

The negative effects of mining and reclamation (or lack thereof) on habitat are issues for wildlife in general (Henry, 1995). In the case of bats, habitat loss can occur in multiple ways. Initial mining efforts, including road building, site clearing, blasting, excavation, and disposal of waste rock may disturb bats roosting in the vicinity and will probably have negative effects on bat roosting and foraging habitat. Quarrying operations may disturb or destroy cracks and crevices in cliffs where bats roost. Open pit mining may have significant impacts on foraging habitat through destruction of native vegetation and loss of the native insect communities; water sources may be destroyed or polluted. Renewed mining in historic underground workings may displace bats that have found roosts in abandoned mines and have negative consequences for foraging areas as well. Other than the use of abandoned mines as roosts, I suspect that few reclamation specialists ever consider bat habitat needs during reclamation of abandoned mines. Nonetheless, the often sterile, monocultural aspect of many reclaimed areas is probably a barren wasteland for most bats. This may be especially true if non-native vegetation has been used in the reclamation.

Conclusions

Although we lack conclusive evidence of actual population declines in many western bat species, scientists and managers are in general agreement that such declines have occurred, both locally and regionally. Furthermore, most authorities believe that such declines are continuing. It seems obvious that with settlement of the West bats have lost both roosting and foraging habitat and have been subjected to disturbance and destruction in many areas. Although many bats have proven to be adaptable and have moved into anthropogenic structures we have no way of knowing the extent to which this has compensated for loss of natural habitat. Certainly, abandoned mines have become important to many species, vitally so for a few (e.g., *Macrotus californicus*). It is imperative that as abandoned mine closures are contemplated, adequate surveys for roosting bats are conducted prior to closure and alternative gating methods are considered (Altenbach et al.; Currie; Sherwin et al.; this volume).

If abandoned mines, properly gated and secured for use by bats, are the good news, then the bad news, arguably, is that existing mines and mining practices have the potential to alter or destroy both roosting and foraging habitat for bats in the West. Although research is badly needed on the interactions between bats and mining (e.g., impact of loss of natural vegetation on insect prey of bats), much can be done to alleviate potential negative impacts. We know enough about bat foraging and roosting habits to be able to develop some understanding of the potential effects in a given area and to implement mitigation measures in many cases. Pre-project surveys for bats, roosts, and foraging areas should be conducted, especially for species of concern. Hopefully, areas of importance, especially roosts, can be protected during actual mining. During the mining project, if roosts or important foraging areas have been found, monitoring of these resources should be continued. Where bat roosts conflict with mining plans, appropriate times and techniques for exclusion of bats should be used (Sherwin, personal communication). If possible, alternative roost structures should be provided. Finally, reclamation of abandoned mine lands should consider the unique needs of bats, both for foraging and roosting, and use native vegetation and appropriate real or artificial roosting habitat.

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Table 1. Summary of numbers of families, genera, and species of bats in the major geographic divisions of the world (after Altringham, 1996).

Taxon	North America	South America	Europe and Asia	Ethiopan Region	Oriental Region	Australian Region
Families	4	9	8	8	9	6
Genera	19	67	23	44	57	48
Species	45	230	90	190	270	166

Table 2. Species of bats occurring in the western United States.

Family Mormoopidae (Mormoopid or ghost-faced bats)
Mormoops megalophylla (Ghost-faced bat)

Family Phyllostomidae (Phyllostomid or leaf-nosed bats)
Macrotus californicus (California leaf-nosed bat) C2
Choeronycteris mexicana (Mexican long-tongued bat) C2
Leptonycteris curasoae (Southern long-nosed bat) E
L. nivalis (Mexican long-nosed bat) E

Family Vespertilionidae (Vespertilionid or evening bats)
Myotis auriculus (Southwestern myotis)
M. californicus (California myotis)
M. ciliolabrum (Western small-footed myotis) C2
M. evotis (Long-eared myotis) C2
M. keenii (Keen's myotis)
M. lucifugus (incl. *M. occultus*; Little brown myotis) C2
M. septentrionalis (Northern myotis)
M. thysanodes (Fringed myotis) C2
M. velifer (Cave myotis) C2
M. volans (Long-legged myotis) C2
M. yumanensis (Yuma myotis) C2
Lasionycteris noctivagans (Silver-haired bat)
Lasiurus blossevillii (Western red bat)
L. borealis (Eastern red bat)
L. cinereus (Hoary bat)
L. xanthinus (Western yellow bat)
Pipistrellus hesperus (Western pipistrelle)
Eptesicus fuscus (Big brown bat)
Euderma maculatum (Spotted bat) C2
Corynorhinus townsendii (= *Plecotus townsendii*; Townsend's big-eared bat) C2
Idionycteris phyllotis (Allen's big-eared bat) C2
Antrozous pallidus (Pallid bat)

Family Molossidae (Molossid or free-tailed bats)
Tadarida brasiliensis (Brazilian free-tailed bat)
Nyctinomops femorosaccus (Pocketed free-tailed bat)
N. macrotis (Big free-tailed bat) C2
Eumops perotis (Western mastiff bat) C2
E. underwoodi (Underwood's mastiff bat) C2

E = Federally Endangered
C2 = Former Category 2 Candidate Species (now Species of Concern)

Table 3. Species of western bats known to use mines (after Altenbach and Pierson, 1995). Common names of species especially dependent on mines are in bold-faced type.

Family	Species	Common Name
Mormoopidae		
	Mormoops megalophylla	Ghost-faced bat
Phyllostomidae		
	Choeronycteris mexicana*	Mexican long-tongued bat
	Leptonycteris curasoae E	**Lesser long-nosed bat**
	Leptonycteris nivalis E	Greater long-nosed bat
	Macrotus californicus*	**California leaf-nosed bat**
Vespertilionidae		
	Antrozous pallidus	Pallid bat
	Conrynorhinus townsendii*	**Townsend's big-eared bat**
	Eptesicus fuscus	Big brown bat
	Idionycteris phyllotis*	Allen's big-eared bat
	Lasionycteris noctivagans	Silver-haired bat
	Myotis auriculus	Southwestern myotis
	M. californicus	California myotis
	M. ciliolabrum*	Western small-footed myotis
	M. evotis*	Long-eared myotis
	M. lucifugus (occultus*)	Little brown myotis
	M. septentrionalis	Northern myotis
	M. thysanodes*	Fringed myotis
	M. velifer*	**Cave myotis**
	M. volans*	Long-legged myotis
	M. yumanensis*	Yuma myotis
	Pipistrellus hesperus	Western pipistrelle
Molossidae		
	Tadarida brasiliensis	Brazilian free-tailed bat

E = Species listed as Endangered under Endangered Species Act
* = Former U.S. Fish and Wildlife Service Category 2 Candidate Species

Table 4. Foraging strategies of some western bats (after Findley, 1993).

Forest/Clearing aerial insectivores

Eptesicus fuscus
Lasionycteris noctivagans
Mormoops megalophylla
Myotis californicus
M. ciliolabrum
M.volans
Pipistrellus hesperus

Open-air aerial insectivores

Eumops perotis
E. underwoodi
Lasiurus blossevillii
L. borealis
L. cinereus
L. xanthinus ?
Nyctinomops femorosacca
N. macrotis
Tadarida brasiliensis

Gleaning insectivores

Antrozous pallidus
Euderma maculatum
Idionycteris phyllotis
Corynorhinus townsendii
Macrotus californicus
Myotis auriculus
M. evotis
M. septentrionalis
M. thysanodes

Water-surface foragers

Myotis lucifugus
M. velifer
M. yumanensis

Nectarivores

Leptonycteris curasoae
L. nivalis
Choeronycteris mexicana

FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES OF IMPORTANCE TO MINING

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Abstract

Six North American bats are listed as endangered under the Endangered Species Act of 1973, as amended. All of these Federally listed species are dependent upon caves or abandoned mines during all or part of the year. The Indiana bat (*Myotis sodalis*), a species that is currently undergoing a serious population decline, uses caves or mines for hibernation. The gray bat (*Myotis grisescens*) is dependent upon cold caves or mines during hibernation and warm caves or mines during the summer maternity season. The Virginia big-eared bat (*Corynorhinus townsendii virginianus*) is restricted to small populations in four eastern States and uses caves or mines year-round. The Ozark big-eared bat (*Corynorhinus townsendii ingens*) is the rarest of the endangered bats and is dependent on caves year-round. Historically, it was found in three States, Arkansas, Oklahoma and Missouri. It has apparently been extirpated from Missouri and only about 2,000 bats remain in Arkansas and Oklahoma. Although only one mine roost for this species is currently known, it could potentially be found in some of the abandoned mines found just south and west of its currently known distribution. The Mexican and lesser long-nosed bats *(Leptonycteris nivalis* and *Leptonycteris curasoae yerbabuenae*) are migratory non-hibernating species found in the southwestern US and Mexico. Both species are integral components of southwestern desert ecosystems and mines provide essential roosting habitat for them. Threats to all these species include; roosting and foraging habitat destruction and alteration, chemical contamination of their food supply and human disturbance at their summer and winter roosts. Intensive disturbance of the bats at their maternity and/or hibernation caves has increased the importance of protecting and maintaining bat access to mines. Without this protection it will be difficult to meet the Service's long-term protection and recovery goals for these endangered species.

Endangered Species Act of 1973

The Endangered Species Act of 1973 (Act) was enacted in 1973, by the 100th Congress of the United States. Section 2 of the Act states that the purposes of the Act are "...to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered and threatened species..." This is a noble objective that continues to be a valid, although sometimes problematic, goal for all involved in implementation of the Act. The Act defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range." A threatened species is - "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Critical habitat has been formally designated for some listed bats that occur in areas impacted by active

and abandoned mine programs. Critical habitat is defined as "The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features,(I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the Act, upon a determination by the Secretary that such areas are essential for the conservation of the species."

Section 4 of the Act establishes the process the Departments of Interior and Commerce must use in identifying endangered and threatened species, designating critical habitat, and developing recovery plans.

Section 7 of the Act prohibits Federal agencies from undertaking, permitting, authorizing or funding any activity that will jeopardize the continued existence of Federally listed species. This Section also requires Federal agencies to be proactive and use their programs to enhance the status of Federally listed species.

Section 9 of the Act prohibits taking a listed species without a permit issued under Section 10 of the Act. Take is defined by regulations promulgated to implement the Act to mean "..to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect (a listed species) , or to attempt to engage in any such conduct."

There are six Federally listed endangered bats that occur within the continental U.S. In implementing abandoned mined land reclamation activities and other mine related programs, Federal and State agencies must insure that all of their activities are in compliance with Section 7 of the Act and that these activities do not violate Section 9.

Indiana bat (*Myotis sodalis*)

The Indiana bat was listed on March 11, 1967, as an endangered species throughout its range. Critical Habitat which includes most of its most important hibernation sites was formally designated on September 24, 1976. A recovery plan for the species was issued on October 14, 1983. This plan is currently under revision and an Agency Draft Indiana Bat Revised Recovery Plan was published in March 1999 (U.S. Fish and Wildlife Service 1999.)

The Indiana bat is a medium sized bat with a wingspan of about 11 inches and a weight of 5 to ll grams. It is differentiated from other species in the genus by its smaller foot, short toe hairs, keeled calcar and fur texture and coloration. It occurs in the eastern U.S. from North Carolina west to Oklahoma and North to Iowa, Michigan, and Vermont. During the winter the Indiana bat hibernates in cold (4-8 C) caves and mines in the central portion of its range. In Summer the species disperses out from its hibernation sites to form small (30-300 females with young) maternity colonies. These colonies roost under the sloughing bark of dead and dying tress and under the exfoliating bark of live trees like shagbark hickory. Roosts are found in riparian, bottomland hardwood and upland forests (Barbour and Davis 1969, U.S. Fish and Wildlife Service 1999.) Excellent photographs and generalized range maps for the Indiana bat and all of

the other bats that occur in the U.S. can be found in the recent booklet on bats entitled: *Bats of the United States* (Harvey, et al. 1999.) This booklet is available, free of charge, from the U.S. Fish and Wildlife Service's Field Office in Asheville, North Carolina.

Historically, the primary threat to the species was believed to be disturbance at its hibernation sites. Early emphasis of recovery efforts was to protect these sites with suitable gates or fences to control human access and thereby eliminate disturbance. Despite these efforts, the species continues to decline. At the present time, the cause of this decline is unknown. Potential explanations include: (1) currently unidentified changes with the species' summer habitat, (2) inappropriate protection efforts at hibernation sites, and/or (3) pesticides. The current draft of the Indiana bat Recovery plan identifies a series of tasks that should determine what is causing the current decline and permit more effective recovery of the species. The Indiana bat has experienced a serious decline over the past 40 years. We estimate that in 1960 there were approximately 808,505 Indiana bats, by 1980 the population had declined to about 589,120, and during the 1995-1997 survey period only 353,185 were found (U.S. Fish and Wildlife Service 1999.)

Abandoned mines are extremely important to the continued existence of the Indiana bat. Two abandoned mines were designated as Critical Habitat for the species in 1976 and the species has since been found in numerous abandoned mines throughout its range. Most of the mines used by the species are hard rock mines or quarries. However, in 1981, John MacGregor (U.S. Forest Service, personal communication,1981) observed the Indiana bat in an abandoned coal mine in Kentucky and the potential thus exists for this species to depend upon abandoned coal mines.

Gray bat (*Myotis grisescens*)

The gray bat was listed on April 28, 1976, as endangered throughout its range. No critical habitat has been designated for the species. The Gray Bat Recovery Plan was issued on July 1, 1982 (U.S. Fish and Wildlife Service, 1982).

The gray bat is slightly above average size for the genus, the gray bat is easily distinguish from other members of the genus by its uniformly gray fur and the attachment point of the wing membrane to the foot. Its wingspan is about 12 inches and it weighs 5 to10 grams.

The gray bat is primarily found in the cave regions of Alabama, Kentucky, Tennessee, Arkansas, and Missouri, however, small populations also occur in Kansas, Indiana, Illinois, Oklahoma, and Florida.

The gray bat is dependent upon caves or mines all year. During the winter it primarily hibernates in cold caves in the heart of its range. During the summer the females disperse out to suitable warm caves and other cave-like structures. Foraging habitat is primarily along large to medium sized streams and rivers and reservoirs. Although most foraging takes place over open water, the species occasionally feeds in wooded areas adjacent to their primary foraging areas. (Barbour and Davis 1969, U.S. Fish and Wildlife Service 1982.)

The primary threat to the gray bat, at the time it was listed, was human disturbance at its summer and winter roost sites. Other factors that caused the decline that lead to its addition to the Federal list included loss of roost sites to commercialization and reservoir construction. Persistent pesticides such as DDT probably also played a role in the decline of the species (U.S. Fish and Wildlife Service 1982.)

Since 1982, the severe declines that resulted in the Federal listing of the species have been reversed by the positive conservation actions undertaken by States and Federal agencies. All appropriate agencies have taken part in this effort but some, such as the Missouri Department of Conservation and the Tennessee Valley Authority deserve special mention. Because of these conservation activities we may be at the point where the species may qualify for downlisting to threatened status. Dr. Michael J. Harvey, Tennessee Technological University (personal communication 2000) is now in the process of reviewing the current status of the species and will have a preliminary report completed in February 2001.

The gray bat primarily uses caves for its roost sites, it does however, readily use man-made structures whenever these provide the right microclimate and are protected from disturbance. Gray bats have been found roosting in abandoned coal mines, bridges, culverts, and dams. Any abandoned mine within the range of the species that has the appropriate temperature and humidity could support the species.

Virginia big-eared and Ozark big-eared bats
(*Corynorhinus townsendii virginianus and C. t. ingens*)

The genus Corynorhinus is the most distinctive group of species found in the eastern US. They are similar in size to the gray bat but all have distinctive, large ears that are not found on any other bats in the Eastern U.S. Two subspecies of Townsend's big eared bat (Ozark and Virginia big-eared bats) are listed as endangered. The closely related Rafinesque's big-eared bat (Corynorhinus rafinesquii) is easily distinguished by gray colored dorsal fur. Both subspecies of Townsend's big-eared bat have brownish colored dorsal fur.

Virginia big-eared (*Corynorhinus townsendii virginianus*)

The Virginia big-eared bat was listed as endangered throughout its range on November 30, 1979. Critical habitat, that included many of its most important roost sites, was designated at the time it was listed. A recovery plan was prepared for the species on May 8, 1984 (U.S. Fish and Wildlife Service, 1984.)

The Virginia big-eared bat is a medium-sized bat with forearms measurin
(mm) long and weighing 7 to 12 grams. Total body length is 98 mm, th
hind foot is 11 mm long. This bat's long ears (over 2.5 centimeters) an
side of the snout are quite distinctive. Fur is light to dark brown in colo
bats that resemble the Virginia big-eared bat are Rafinesque's big-eared
rafinesquii)and the Ozark big-eard bat. Rafinesque's big-eared bat has t
beyond the end of the toes and the dorsal fur is gray rather than brown.

Rafinesque's big-eared bat is white or whitish rather than light brown or Barbour and Davis 1969.) This subspecies is found in Kentucky, North Carolina, Virginia, and West Virginia.

The Virginia big-eared bat roosts in caves and mines year-round. During the winter it hibernates in cold caves and mines and during the summer the females establish maternity colonies in warm caves or mines.

The primary threat to this subspecies is disturbance at its roost sites, it seems to be more susceptable to disturbance than other endangered bats. There are several instances of colonies abandoning favored roosts sites after only one intensive disturbance (John MacGregor, personal communication, 2000, Barbour and Davis 1969.) Once disturbance is eliminated the species will usually return to its favored roost after a few years.

The Virginia big-eared bat's current county distribution and population estimates follow:

- West Virginia (Pendleton, Grant and Tucker Counties) - 10,927.
- Virginia (Tazewell County) - 2,200.
- Kentucky (Lee County) -5,105.
- North Carolina (Avery County) - 260.

The current population of the Virginia big-eared bat population is estimated to be 18,442 individuals, the estimated total population in 1996 was 15,360 individuals. At the time the species was listed, the population was thought to contain only a few thousand individuals. (Traci Wethington, Kentucky Department of Fish and Wildlife Resources, personal communication, 2000, Craig Stihler, West Virginia Department of Natural Resources, personal communication, 2000, Rick Reynolds, Virginia Department of Game and Inland Fisheries, personal communication, 2000, Chris McGrath, North Carolina Wildlife Resources Commission, personal communication, 2000.)

This subspecies has a limited distribution. Its microhabitat requirements for roost sites are specific and any site that meets these requirements, whether it is natural or manmade, can support the species. An abandoned mine in North Carolina supports a small population of the Virginia big-eared bat. This mine is one of the best hibernation sites in the State and if the mine can be protected from the regular human disturbance that it now receives, the population should dramatically increase. The largest known population (about 1,700 bats) of the closely related Rafinesque's big-eared bat uses an abandoned series of mines in the North Carolina portion of Great Smoky Mountains National Park during both the summer and the winter.

Ozark big-eared bats (*Corynorhinus townsendii ingens*)

The Ozark big-eared bat was listed as endangered throughout its range on November 30, 1979, no critical habitat has been designated for the species. The most recent recovery plan for the Ozark was released on March 28, 1995 (U.S. Fish and Wildlife Service 1995.)

This subspecies is very similar to the Virginia big-eared bat in appearance and habitat

requirements. Historically it was found in Arkansas, Missouri, and Oklahoma. It is believed to have been extirpated from Missouri.

The current threats to the Ozark big-eared bat are believed to be low population numbers, human disturbance and loss of habitat. When this subspecies was listed only a few hundred individuals were known to exist. The current estimated population of the Ozark big-eared bat is about 1,800 bats in Arkansas and Oklahoma (Steve Hensley, U.S. Fish and Wildlife Service, personal communication, 2000)

All other members of the genus Corynorhinus readily use abandoned mines when these are available and are suitable. Any mines found within the range of the species could, it they provide suitable conditions, support the species. Michael J. Harvey (personal communication, 2000) reports that a few individuals have been observed in an abandoned lead mine in Arkansas.

Lesser long-nosed bat (*Leptonecterius curasoae yerbabuenae*)

The lesser long-nosed bat was listed as endangered throughout its range on September 30, 1988, no critical habitat has been designated for the species. A recovery plan for the species was released on May 4, 1994 (U.S. Fish and Wildlife Service 1994.)

The lesser long-nosed bat is a migratory, non-hibernating species that feeds almost exclusively on nectar, pollen, and fruit of columnar desert cacti and agave plants. It is a medium sized bat that weighs 20-25 grams and has a wing span of about 16 inches. Fur color is gray to reddish brown dorsally and brownish ventrally. Seasonally the bats move very long distances. Their distribution appears to be directly related to food supply and the availability of suitable roost sites (U.S. Fish and Wildlife Service 1994.)

In the U.S. the species is found in Arizona and New Mexico. It also occurs in Mexico and Central America.

The lesser long-nosed bat inhabits warm caves and mines year-round. The species is an important component of the southwestern desert ecosystem. They pollinate agave plants and several of the columnar cacti such as the saguaro. Later they return and feed on the fruits of the cacti and then play a role in the dispersal of seeds.

This species is vulnerable to disturbance at its cave and mine roost sites and to loss and changes in the composition of the desert flora that provides its food supply. The current population level of this species is much larger now than at the time it was listed, however, it is still considered to be vulnerable (U.S. Fish and Wildlife Service 1994.)

The lesser long-nosed bat is very dependent upon abandoned mines as roost sites and loss of these roosts would seriously impact the species. Six of the eight roost sites for the species in Arizona and New Mexico listed in the recovery plan for the species are mines. Several of the known Mexican winter roost sites are also mines. Protection of the known roost sites and evaluation for potential use by this species of mines for which closure plans are under

consideration is essential if we are to protect this species.

Mexican long-nosed bat (*Leptonecterius nivalis*)

The Mexican long-nosed bat was listed as endangered throughout its range on September 30, 1988, no critical habitat has been designated for the species. A recovery plan for the Mexican long-nosed bat was released in September 1994 (U.S. Fish and Wildlife Service 1994.)

The Mexican long-nosed bat is slight larger than the lesser long-nosed bat with a wingspan of about 17 inches. It also has more brownish colored fur. In the U.S. it occurs in New Mexico and Texas. It is primarily a Mexican and Central American species with its range barely extending into the Big Bend area of Texas and the southwest corner of NM.

The habitat and threats to the continued existence of the Mexican long-nosed bat are similar to those listed for the lesser long-nosed bat. It is however, a much rarer species.

The largest known U.S. site for the species is a cave in Big Bend National Park, Texas. Because the Mexican long-nosed bat's habitat requirements are similar to those for the lesser long-nosed bat, mines may plan a similar role in their survival and recovery.

Summary

Abandoned mines have become extremely important to the conservation and recovery of most of the bats that are currently listed as endangered species under the Endangered Species Act. Closure of abandoned mines, reclamation of abandoned mined land, renewed mining and new mines can all adversely affect these endangered species. Federal agencies, State agencies implementing Federal programs, and State agencies and private organizations and individuals that need some form of Federal authorization or permit for their activities must comply with the provisions of Section 7 of the Act. Everyone must insure that their activities do not violate Section 9 of the Act. Bats are a unique, vulnerable and valuable part of naturally functioning ecosystems. Past human activities have pushed many cave and mine dependent bats to the brink of extinction. To reverse these declines and to provide for their long-term protection and recovery, we must incorporate impact analysis and proactive bat conservation measures into all of our mine related activities. If we don't, the recovery and eventual delisting of these bats will be difficult, if not impossible.

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Robert R. Currie has worked for the U.S. Fish and Wildlife Service in Asheville, North Carolina, for the past 22 years. He holds Bachelors degree in botany and ecology from North Carolina State University. Since joining the staff in the Asheville office he has been primarily responsible for Federal endangered species activities for cave dependent species in Kentucky and Tennessee. He has developed an extensive knowledge of the endangered cave-dependent bats in the Eastern United States and regularly assists State and Federal agencies throughout the country in designing structures to protect these endangered species from human disturbance. He has worked with other Federal agencies and volunteer organizations in developing and conducting a series of training seminars for private, State, and Federal cave managers. He has worked with Bat Conservation International and various State and Federal agencies in conducting a series of seminars and workshops on the importance of abandoned mines to listed and special concerns bats. His activities in the protection of endangered bats in Kentucky, North Carolina, and Tennessee include: regular roost-site monitoring; cooperative efforts with landowners to ensure protection of significant caves and other roost sites; and design and implementation of research activities needed to gain the understanding required to protect endangered bats and the habitat they need to survive.

Session 2

Interest Group Perspectives on Constraints, Experiences, Trends, and Needs

Session Chairperson:
Vance Greer
USDI Office of Surface Mining
Washington, D.C.

National Association of Abandoned Mine Land Programs
Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

Perspective of the Interstate Mining Compact Commission/Eastern Regulatory Authority States on Bat Conservation and Mining
Dr. Richard Wahrer, Kentucky Department for Surface Mining Reclamation and Enforcement, Frankfort, Kentucky

Bat Conservation in Mine Reclamation in Eleven Western States and the Western Interstate Energy Board Perspective on Habitat Preservation
Homer E. Milford, Abandoned Mine Land Bureau, Mining and Minerals Division, New Mexico Energy, Minerals, and Natural Resources Department, Sante Fe, New Mexico

Kentucky Coal Industry Perspective on Bat Conservation and Mining
Stephen Cawood, McBrayer, McGinnis, Leslie, and Kirkland, PLLC, Lexington, Kentucky

The U.S. Fish and Wildlife Service's Perspective on Bats and Mining
Dave Flemming, U.S. Fish and Wildlife Service, Atlanta, Georgia

Bat-Compatible Closures of Abandoned Underground Mines in National Park System Units
John Burghardt, National Park Service, Denver, Colorado

The Evolution of Federal Policy and Practice to Conserve Bats on Lands Managed by the Forest Service
Laurie Fenwood, U.S. Forest Service, Vallejo, California

The Role of the Bureau of Land Management in Bat Conservation
Fred Stabler, Bureau of Land Management, Washington, D.C.

International Association of Fish and Wildlife Agencies
Terry Johnson, Arizona Department of Game and Fish, Phoenix, Arizona

NATIONAL ASSOCIATION OF ABANDONED MINE LAND PROGRAMS

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Abstract

In 1977, Congress passed the Surface Mining Control and Reclamation Act (SMCRA). Title IV of the Act established the Abandoned Mine Land Reclamation Program (AML). The purpose of AML is to address both land and water resources that have been: 1) adversely affected by past mining activity; or 2) left in an unreclaimed or inadequately reclaimed condition. The Act levees fees on currently mined coal in the United States to pay the costs of this nationwide reclamation effort. With a National program in place, Congress authorized States and Native American Tribes to establish their own AML programs and, in 1983, the States and Tribes organized an informal association.

Today, the National Association of Abandoned Mine Land Programs (NAAMLP) is comprised of 26 State abandoned mine programs and three Native American programs. With representation covering virtually the entire nation from Alabama to Alaska and West Virginia to Wyoming; and over 20 years of reclamation experience that has addressed the entire gambit of mining including surface and underground coal, hard-rock, and even uranium, the NAAMLP has a depth and breadth of on-the-ground experience unmatched by any other organization.

The mission of the National Association of Abandoned Mine Land Programs is to: (1) Provide a forum for current issues, common problems, and new technologies regarding abandoned mine reclamation, (2) Foster positive and productive relationships between the States and Tribes represented by the Association and the Federal government; (3) Serve as an effective, unified voice when representing the States/Tribe's common viewpoints; and (4) Coordinate, cooperate, and communicate with the Interstate Mining Commission Compact and Western Interstate Energy Board and all other organizations dedicated to wise use and restoration of our natural resources.

During this session, I will highlight the constraints AML programs face, their varied experiences, current trends and future needs as members of the Association attempt to deal with the issues of conserving bats and reclaiming past mining impacts.

Results of State AML Program Survey

Based on my survey of AML programs in our States, Alabama they have closed about 1,200 mine openings. They have installed about 35 bat compatible closures associated with the closure of 900 horizontal openings. Most of their bat surveys are based on external surveys. Alaska works closely with the Forest Service to determine the presence of bats in mines. They have not yet done any bat compatible closures. Arizona works with their fish and game department who

conducts the bat surveys both internally and externally. The Arizona fish and game program makes recommendations based on its surveys to the State AML program concerning protecting bats during mine closure. Most of the protective effort for bats involves fencing rather than the construction of gates. Arkansas AML has not yet installed any bat gates although gates have been installed by the National Park Service. The program relies on visual checks prior to closure. Colorado has mobilized a force of volunteers that conduct a preliminary external survey. Mines indicating promise as bat habitat are then prioritized for internal surveys by professionals. Colorado currently leads the nation in the number of bat gates installed. Indiana is investigating bat habitat on both AML sites and on active mining surface disturbances as it affects forested areas utilized by the Indiana Bat. They have been installing bat gates for about the last 2 years. They have installed 12 gates on adits and 4 other types of closures. They do an initial external survey with AML staff, then if the mine appears to have been used by bats, they have a survey conducted by a professional from Indiana State University to determine the bat species and type of bat use of the mine. Indiana is also doing post gate installation monitoring through the use of Hart traps, mist netting, or ANABAT detection. Iowa reports that have primarily surface mining areas with no underground mine openings. Iowa consults its fish and game department to determine the methods necessary to protect Indiana Bat habitat during surface mining. Kansas has no mine closures so their focus is on surface mining disturbance. Kansas works with their fish and game department to enhance bat habitat by tree plantings during reclamation. Kansas AML does its own bat surveys with mist netting and ANABAT detection. Mine pits reclaimed by Kansas to promote Gray Bat habitat are now showing use by the Gray Bat. Kentucky AML is installing bat gates. Kentucky AML does not do any survey work because of the dangers involved with abandoned mine openings. They install gates wherever they is any chance of the site being used by bats. Currently, Kentucky has installed 50 bat gates. Maryland has installed one bat gate where the mine was known to be inhabited by bats. It received a large aircraft cable net style closure. They rely on their State fish and game to identify mine openings with potential for bat usage. Michigan has no active coal mining and has no AML funds. Michigan has lot of abandoned iron mines and has used State funds to protect bats at these mines. Missouri has not yet installed any bat gates although they are making plans for installation in the future. Most of their mines are very shallow and are usually flooded. Their survey work to date has been with State AML staff. Missouri is also considering bat habitat mitigation with surface structures. Montana works with the Nature Conservancy to perform internal and external surveys on mine sites scheduled for reclamation. All of their gate designs are based on a bate gate built into a large culvert. They have installed 12 of these gated culverts. The Navajo nation has gated about 10 mine openings. They only do external surveys. They are doing some post installation monitoring of the gates. New Mexico has gated over 186 mine openings. They have excellent bat survey techniques and do extensive post installation monitoring. Ohio has installed 13 gates at mine openings, 11 at coal mines and 2 at old gravel bars. Ohio only uses external surveys and installs a gate wherever the mine opening appears to provide suitable bat habitat whether or not they find bats actually using the site. Oklahoma has not yet installed any bat gates but has three in the design phase for installation in coal mines. Oklahoma works with the U.S. Fish and Wildlife Service in order to conduct the bat surveys. Texas works extensively with the National Park Service who does the bat survey work and design planning. They have typically used cable nets for the bat closures. Utah AML does its own internal surveys and has installed 120 bat compatible closures. Utah is in the development stage of building a data base that would link all

available bat gate information to habitat characteristics that could be accessed by other bat researchers. West Virginia has installed 10 bat gates. They work with the Forest Service to obtain bat surveys of mine openings. Wyoming has installed from 75 to 100 bat gates both in coal and non-coal settings. They had worked with their State fish and game department for the initial bat surveys and now work with a private consultant. Wyoming uses angle iron bat gates because of the common incidence of vandalism.

Mark Mesch is a reclamation biologist with the Utah Abandoned Mine Reclamation Program since 1988 and currently administers that program.

PERSPECTIVE OF THE INTERSTATE MINING COMPACT COMMISSION EASTERN REGULATORY AUTHORITY STATES ON BAT CONSERVATION AND MINING

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Kentucky Department for Surface Mining Reclamation and Enforcement
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Abstract

The Interstate Mining Compact Commission (IMCC) is an advisory or consultative agency that provides a collective voice for its member States and serves as a liaison with Federal agencies and Congress. With its informational research service and networking capabilities, these IMCC members are able to discuss unique and innovative approaches to regulation, successful experimental practices and offer input to policy development.

For the purpose of this presentation, the member States were queried as to the specifics of their own Protection and Enhancement Plans of Federally endangered bat species. Additionally, the working relationships of the coal industry, fish and wildlife agencies, and mining regulators on developing these plans are discussed. Most State programs did not have Plans as few, if any, endangered species of bats were found near mining areas, though fish and wildlife agencies required stringent tree clearing dates. Even when these species were found in permit areas, there was no universal agreement between the States and the U.S. Fish and Wildlife Service (FWS) on when to implement Plans and the development of short and long-term habitat enhancements.

The Interstate Mining Compact Commission (IMCC) is a multi-State governmental organization representing the natural resource interests of its member States. These member States, consisting of Alabama, Arkansas, Illinois, Indiana, Kentucky, Louisiana, Maryland, Missouri, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, and West Virginia, have significant interests in the mining of coal and noncoal minerals. The purposes of the Compact are not only to advance the protection and restoration of land, water and other resources affected by mining, but also to maintain an efficient and productive mining industry and increase economic and other benefits attributable to mining. The functions of the IMCC are: (1) to be the liaison between the State regulatory agencies and Federal government and Congress; (2) to monitor regulatory and legislative developments; (3) to communicate State positions on Federal rulemakings and national legislation; (4) to interact with environmental and industry groups; and (5) to provide mining and mineral education outreaches to the public.

Status of Bat Protection Programs

In an effort to ascertain the status of bat protection programs among the IMCC States, a questionnaire was mailed out to the mining regulatory agency. Twelve States responded with

follow up phone conversations with relevant personnel. Often, the questionnaire was answered by that State's fish and game agency. The questions and a summary of responses are given below:

1. List the endangered species of bats that are found in, or near, your mining permit areas.

   Response: Eight States reported the presence of the Indiana bat (*Myotis sodalis*) though not always near their coalfield regions. Four States responded with records of the gray bat, (*Myotis grisescens*). The Virginia big eared bat (*Coryrhinus townsendii virginianus*) was found in one State and the Ozark big eared bat (*Coryrhinus townsendii ingens*) was also found in one State. Four States reported no Federally listed endangered bat species.

2. Enclose your agency's protection and enhancement plans for endangered species of bats.

   Response: The majority of the States that responded did not have a formal bat protection and enhancement plan generated by the regulatory agency. These States deferred to the recommendations of their State wildlife agency and the FWS. Two States have a plan that address only potential roost tree removal. One State uses a plan developed by Bryan and MacGregor (1988) that applies to rare and endangered wildlife species found in abandoned mine portals. One State has developed bat protection and enhancement guidelines for the coal industry for tree clearing through reclamation.

3. Discuss the parameters that are used to trigger a bat protection and enhancement plan. List any databases that you use in location determination.

   Response: Before action is taken developing a protection and enhancement plan for the endangered species, most States accessed various databases (Nature Conservancy, Nature Preserves, FWS Ecological Services, or State fish and game reports) to identify any records near the proposed mining permit areas. Three States reported that biologists from their fish and game or regulatory agency conducted site visits to the permit area to assess potential habitat. One State uses a "critical distance," or, the proximity of bat records to the permit area, that will initiate a preliminary site inspection.

4. Describe the methodologies used to determine if a specific permit area might qualify as bat habitat.

   Response: Though a few of the States defer to FWS, who, in turn, determine bat presence by mist netting, State biologists assess proposed permit areas in most States. Potential habitat is evaluated based on the presence of potential roost trees, abandoned mine portals, caves, wooded riparian areas and the proximity of a watering area. Again, if the database reveals bat records in or adjacent to the permit area, suitable habitat is usually assumed.

5. List short-term bat habitat enhancements you implement after mining.

   Response: Eight States either do not implement short-term enhancements because the bat species do not occur in the coal regions, or defer to the development of long-term enhancements. The remaining four States use a combination of tree girdling, the installation of bat boxes, and the creation of wetlands and shallow water depressions to provide suitable bat habitat until long-term enhancements, such as tree planting, can take effect.

6. List long-term enhancements and any specific revegetation plans you implement after mining.

   Response: Only three States do not have reforestation/revegetation plans. States that do not contain bat species in their coalfields often still plant potential roost tree species. States that have endangered bat species in the vicinity of the permit will usually encourage fish and wildlife or forestland post mining land uses and request that exfoliating bark species be used in their reclamation plans. Four States actively participate in the gating of caves and abandoned mine portals, supplemented with reforestation in these areas and along riparian zones.

7. With regard to bat protection, describe your agency's relationship with state and/or federal fish and wildlife agencies. Specify these agencies' concerns with mining impacting the endangered bat species.

   Response: States that do not have bat species in their coalfield regions maintain an excellent relationship with State and Federal fish and wildlife agencies. The States that recorded bat species in the coalfields interacted well with their State fish and game groups, although communication with the regulatory agency and FWS ranged from good to poor. Criticisms of FWS by State agencies included an increased demand for mist netting; the inclusion of all tree species, regardless of size, as potential roost trees; the requirement of a mandatory stream buffer zone; the shortening of the tree clearing period from eight months to six and the requirement of bat habitat enhancements in areas that the species has never been recorded.

8. List the main concerns of your state's coal industry with regard to bat protection procedures and plans.

   Response: The primary concern of the coal industry with bat protection and enhancement plans is time. Permit acquisition can be delayed due to preliminary environmental assessments in potential bat habitat areas and the corresponding bat protection and enhancement plan development. Scheduling of mine operations is difficult to accomplish as tree clearing dates may vary depending on the distance from a hibernaculum or elevation. Another major concern is the requirement by FWS for maintaining a stream buffer zone, which may cause a significant change in the mining plan.

Conclusion

Among the IMCC states, bat protection and enhancement measures vary from nearly non-existent to highly detailed. Deference should be given to USFWS for consultations involving endangered bat species. Nevertheless, the mining regulatory agencies are charged to review and issue permits that allow maximum resource recovery with minimal environmental impact, consistent with State or Federal regulations.

Based on this questionnaire and conversations with the regulators and State fish and wildlife biologists, three issues must be addressed in order to provide consistency in the review and implementation of bat protection and enhancement policies. First, an updated and approved bat protection document is needed for all of the States where bats are found in the resource mining areas. Endangered species recovery plans need to be revised and approved. These documents would set forth the standards from which regional protection and enhancement plans could be assembled. Second, the FWS field offices need to be consistent with all of the affected States when developing, and consulting on, protection plans. As it is now, some field offices require stream buffer zones and other offices are mainly concerned with the determination of potential roost trees. Third, all documents and protection and enhancement plans need to be based on published research. More research is needed on foraging behavior, diet and summer habitat as well as the success of present enhancements, to legitimize the bat policy of a regulatory agency.

References

Bryan, H.D. and J.R. MacGregor. 1988. A guide to the suitability of abandoned mine portals as habitats for rare or endangered wildlife in Alabama. Alabama State Department of Industrial Relations, Montgomery, Alabama. 16 p.

Dr. Richard J. Wahrer is an Environmental Scientist for the Kentucky Department for Surface Mining Reclamation and Enforcement in the Division of Permits.

BAT CONSERVATION IN MINE RECLAMATION IN ELEVEN WESTERN STATES AND THE WESTTERN INTERSTATE ENERGY BOARD PERSEPCTIVE ON HABITAT PRESERVATION

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Sante Fe, New Mexico

Abstract

The Western Interstate Energy Board (WEIB) is an association of 12 western States and 3 western Canadian provinces. The Board serves as the energy arm of the Western Governors' Association. The ultimate purpose of the Board, as established in Public Law 91-461, is to "…enhance the economy of the West and contribute to the individual and community well-being of the region's people" by providing the instruments and framework for cooperative efforts among western States on energy-related topics. Within that broad charge, the Board, which is comprised of one-gubernatorial appointee per State, has set certain priorities and created committees to address these priorities in depth.

One of those committees is the Reclamation Committee, which is comprised of representatives of the five western States with active coal mining. These States have Office of Surface Mining (OSM)-funded abandoned mine land (AML) programs: Colorado, Utah, New Mexico, Wyoming, and Montana. This talk will summarize the information collected from these AML Programs on their bat conservation activities. The experience and trends in native-American Tribes and non-OSM funded western State AML reclamation programs will also be presented.

Disclaimer: Only the abstract has been approved by WIEB. The rest of the paper may or may not reflect the position of WIEB.

Introduction

Neither the five member States of the WIEB Reclamation Committee nor the 12 western States and 3 western Canadian provinces of the full board have a formal bat policy. However, the five western States that make up the membership of WIEB are the five western States that have OSM funded Abandoned Mine Land (AML) programs. These five States are Colorado, Montana, New Mexico, Utah, and Wyoming. You have and will continue to hear much about the experiences of these five States in bat conservation activity in their AML programs. The game and fish departments of the majority of these States are also active in bat conservation. This talk will summarize the information collected from the WIEB State AML programs on their bat conservation activities. The experience and trends in native-American tribes and 11 western States in bat habitat conservation in mine safeguarding will be summarized.

Survey Method

In the non-OSM funded States, mine safeguarding has only become a State function in the recent past. Though Nevada has had an AML program since 1987, its funding has been so small that only fencing of mine shafts could be preformed. In Arizona, the State mine inspector's office safeguarded a small number of mines, but a State AML program only got underway last year. Idaho's AML program also started in 1999. California, Oregon, and Washington's programs are or may become active during the year 2000.

The survey was conducted between May and November 2000. A number of questions were asked but, due to the different levels of development of the AML programs in different States, only information common to the majority of States will be discussed.

In the past, no comprehensive national data has been collected on bat-friendly closures of mines. There are not even reliable estimates on the number of abandoned mines for most States. The majority of abandoned mines in the west are non-coal mines and few, if any, States have completed an inventory of them. OSM has a data bank for coal mines. That data bank also has information on non-coal mines in the States whose AML programs have OSM funding. Len Meyer is collecting data for his paper at this conference on Bat Friendly Closures (BFCs) from all States. The five State AML programs funded through OSM are now safeguarding more non-coal mines than coal mines. The opportunity now exists for OSM to start collecting extensive data on the mine habitat of bats in the United States. If OSM, in cooperation with other agencies, could decide on the nature of the data that should be collected, OSM's database would be the logical place for storage of this information. A national database would be helpful in future evaluations of the status of bat species.

AML programs are housed in different agencies in different States. In some States, the AML programs are only beginning to be formed and BFC information was only available from the State game and fish agencies. Information on OSM activity in building BFCs was obtained for the States of Washington and California. Information on other Federal agency programs was generally obtained from State game and fish or AML programs. Federal agencies that have constructed BFCs include: U.S. Bureau of Land Management (BLM); U.S. Forest Service (FS), U.S. National Park Service (NPS), U.S. Department of Defense (DOD), OSM, and a few BFCs by other agencies. Some local governmental groups have also built BFCs. Mining companies in Arizona, California, and Nevada have also built BFCs in response either to awareness of their importance to bat conservation or to comply with a governmental agency requirement. Mining companies have also built a small number of BFCs in OSM funded States, but reliable data on them was not available.

Limitations of Survey Data

The level of confidence in the data is moderate at best. For the OSM funded States, the number of BFCs is probably accurate, but there are differences in what is counted as a BFC. The original

intent was to collect information on different subtypes of BFCs: bat grates/gates; cable net modified with bat windows; plain cable net; and portals safeguarded with something to allow continued airflow. This effort was abandoned because the information was not available. Thus, all reported BFCs are included in one count for the entity. The OSM-funded State AML programs have little or no knowledge of other agency BFCs within their State.

For the non-OSM funded AML program States, information was collected generally from both a geological or AML reclamation agency as well as game and fish department. In most cases, the numbers represent the best available estimate. In spite of these disclaimers as to reliability, the data provides an overall assessment of BFCs in the western States. It is estimated that the region-wide error on BFCs numbers is less than 5%, excluding the questions of how a BFC is defined.

Survey Results

Table 1 provides a little information on the status and starting dates of the AML programs in eleven western States and two tribes. Following this are columns giving: (1) the name of the agency within that jurisdiction that has been performing bat habitat assessments; and (2) the agencies that make the decision on which mines have bat habitat values warranting safeguarding by BFCs. In many cases, BFCs have been installed for reasons other than to protect known bat habitats. No effort was made to collect information on how many BFCs were built for non-bat reasons. As there is a different definition of BFCs in different jurisdictions, this term has been used for bat grates, bat gates, cable net, or any other possible closure that may allow bat usage. I in other words, whatever the State reported as a BFC. The number of BFCs completed by the year 2000 and then the number currently in some stage of planning for construction are separated by a colon. As AML programs differ in the length of the planning phase, these numbers have little meaning, but generally refer to the next one to three years. The five States with OSM-funded AML programs have little knowledge of the number of BFCs constructed by other agencies within their State. In non-OSM funded States, information was more commonly known about non-State BFC construction. Information was not collected from Alaska, Hawaii, or the Canadian provinces.

The following are some of the individuals providing information for this survey. Arizona: Alene Jones/AML, Tim Snow/GF & Ron Kerns/USFW; California: Stephen Reynolds/AML, Steve Newton-Reed/AML; Colorado: Julie Annear/AML, Jim McArdle/AML; Hopi: Riley Blinkwell/AML; Idaho: Erick Wilson/AML; Montana: Jack Yates/AML; Navajo: Daryl Martinez/AML; Nevada: Dave Pullion/AML, Doug Hunt/FW, Pete Bradley/FW. Oregon: Ben Mundy/AML; Utah: Mark Mesh/AML; Washington: John Fleckstein/GF, Dave Norman/AML; Wyoming: Ed Francis/AML. From OSM: Ginger Kaldenbach & Len Meier.

Table 1: Bat Friendly Closures (BFCs) by States, Tribes and Other Programs in the West

State or Tribe	AML Program Started	Assessment	BFC Decision by	BFC's by AML Program		BFC's by other Agencies (BLM, FS, OSM, etc.)	Follow-up studies done by
				Completed	Planning		
Colorado	OSM Funded	G&F	G&F	321	28	BLM 30? Other ?	G&F
Hopi	Started	AML	AML	1	0	-0-	AML
Montana	In 1980's	NHP (G&F)	G&F and AML	5	0	-?-	AML
Navajo	Bat	AML	AML	4	0	-0-	AML
New Mexico	Habitat Evaluation	AML and Contractor	AML and Contractor	127	31	Private 4? Other ?	BCI Contractor
Utah	Started between	AML and Contractor	AML	290	30	-?-	AML
Wyoming	1990 - 1995	G&F or Contractor	G&F and Contractor	69	3	-?-	G&F
Arizona	1999	G&F	Just starting	0	4	Total – 71? USF & WS 1:3 BLM 28:? NPS 10:? FS 1:? Other Gov. 12:? Private 16:?	
California	2000	AML, but recognize the need for better assessment	AML Just starting	0	0	Total 200? FS & BLM 150? NPS 60? OSM 8:2 Private Some	
Idaho	1999	G&F	G&F and AML	6	12	FS 45?	
Nevada	1987-fencing only 2000?-closures?	G&F just starting	Just starting	0	0	BLM 12 Private 8+?	
Oregon	2000 inventory phase to choose 10 sites.	Probably will be Federal G&F	Just starting	0	0	BLM 4 FS ?	
Washington	2000	Program just starting	Just starting	0	0	OSM 23:1 FS 2:? BLM 1:?	

Summary

The trend of the past decade is remarkable. We have gone from a very small number of BFCs on caves to over 1,200 BFCs in 11 States. The following summary table highlights the great progress made in the past decade by the WIEB States in the protection of bat habitat through assessment and the construction of BFCs.

Summary of Bat Friendly Closures (BFCs) In Eleven Western States as of the Year 2000

OSM Funded AML Programs

	AML Program BFCs completed: planned	BFC closures by other agencies (BLM, FS, NPS, OSM, etc.)
Colorado	321:28	? BLM-30
Hopi	1:0	0
Montana	5:0	?
Navajo	4:0	0
New Mexico	127:31	4?
Utah	290:30	?
Wyoming	69:3	?

Non-OSM Funded AML Programs

Arizona	0:4	69?
California	0:0	200?
Idaho	6:12	45?
Nevada	0:0	20+?
Oregon	0:0	4?
Washington	0:0	26?
Totals =	817:108	398?

This data is variable in its accuracy. Due to different definitions of a BFC, all closures that bats could possibly pass through are included. Record keeping is also variable in different programs regarding BFCs. OSM funded programs started bat assessments and BFCs between 1990 and 1995. The other State AML programs only started in 1999 or 2000.

Of the 1,200 BFCs in 11 western States, about 800 have been constructed in the five States with OSM funding. The education of the public as well as agency staff on the need for bat habitat preservation must be continued. The cooperative effort between Bat Conservation International and the BLM has made great strides in this area. However, the major problem in most States is a lack of funds for bat habitat assessment as well as for mine safeguarding. Though education must be continued, the major impediment to progress is funding.

The most important change that could occur to improve bat habitat conservation in mines would be the release of the funds due the State AML programs under SMCRA. The diversion of these funds by the Congress remains the major funding problem for those five WIEB States. Funding is an even greater problem in the non-SMCRA funded States. To date, State funding is totally inadequate and Federal land management agencies have not even made significant contributions to efforts on the lands they own and manage, with the possible exception of the National Park Service. Assistance must be given to Arizona, California, and Nevada where a significant proportion of the Nation's abandoned mine problem exits.

If the mine bat habitat is going to be adequately preserved in these States, greater funding is essential for their AML programs. Federal land management agencies have not yet moved from the planning stage to construction on a meaningful scale in these States. The BLM and Forest Service in Arizona and Nevada have safeguarded only about a tenth of one percent of their mine openings. Hopefully these States are on the threshold of getting funding from their legislatures that will allow them to take a more active role in safeguarding and BFC construction. However, the responsible parties in most western States, the Federal land management agencies that own the majority of the abandoned mines, must start active programs to correct the problem. The OSM-funded States are carrying the burden on Federal lands in their States. The BLM and Forest Service must carry the burden in the other States. It is unfair to lump the two agencies together, as the BLM has made commendable efforts. However, Federal land management agency activity remains totally inadequate. The trends are encouraging, but unless adequate funding is developed, we will not see these trends continue.

Homer Milford has served as the Environmental Coordinator for the New Mexico AML Program for the past 10 years. He received his bachelors in Biology from the University of New Mexico and Masters in Biology from University of Idaho followed by two years at the State University of New York. He has conducted hundreds of underground bat habitat assessments in conjunction with Dr. Scott Altenbach over the past 10 years. He coauthored with Dr. Altenbach the publication "Evaluation and Management of Bats in Abandoned Mines in the Southwest."

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Survey Results

Table 1 provides a little information on the status and starting dates of the AML programs in eleven western States and two tribes. Following this are columns giving: (1) the name of the agency within that jurisdiction that has been performing bat habitat assessments; and (2) the agencies that make the decision on which mines have bat habitat values warranting safeguarding by BFCs. In many cases, BFCs have been installed for reasons other than to protect known bat habitats. No effort was made to collect information on how many BFCs were built for non-bat reasons. As there is a different definition of BFCs in different jurisdictions, this term has been used for bat grates, bat gates, cable net, or any other possible closure that may allow bat usage. I in other words, whatever the State reported as a BFC. The number of BFCs completed by the year 2000 and then the number currently in some stage of planning for construction are separated by a colon. As AML programs differ in the length of the planning phase, these numbers have little meaning, but generally refer to the next one to three years. The five States with OSM-funded AML programs have little knowledge of the number of BFCs constructed by other agencies within their State. In non-OSM funded States, information was more commonly known about non-State BFC construction. Information was not collected from Alaska, Hawaii, or the Canadian provinces.

The following are some of the individuals providing information for this survey. Arizona: Alene Jones/AML, Tim Snow/GF & Ron Kerns/USFW; California: Stephen Reynolds/AML, Steve Newton-Reed/AML; Colorado: Julie Annear/AML, Jim McArdle/AML; Hopi: Riley Blinkwell/AML; Idaho: Erick Wilson/AML; Montana: Jack Yates/AML; Navajo: Daryl Martinez/AML; Nevada: Dave Pullion/AML, Doug Hunt/FW, Pete Bradley/FW. Oregon: Ben Mundy/AML; Utah: Mark Mesh/AML; Washington: John Fleckstein/GF, Dave Norman/AML; Wyoming: Ed Francis/AML. From OSM: Ginger Kaldenbach & Len Meier.

Table 1: Bat Friendly Closures (BFCs) by States, Tribes and Other Programs in the West

State or Tribe	AML Program Started	Assessment	BFC Decision by	BFC's by AML Program		BFC's by other Agencies (BLM, FS, OSM, etc.)	Follow-up studies done by
				Completed	Planning		
Colorado	OSM Funded	G&F	G&F	321	28	BLM 30? Other ?	G&F
Hopi	Started	AML	AML	1	0	-0-	AML
Montana	In 1980's	NHP (G&F)	G&F and AML	5	0	-?-	AML
Navajo	Bat	AML	AML	4	0	-0-	AML
New Mexico	Habitat Evaluation	AML and Contractor	AML and Contractor	127	31	Private 4? Other ?	BCI Contractor
Utah	Started between	AML and Contractor	AML	290	30	-?-	AML
Wyoming	1990 - 1995	G&F or Contractor	G&F and Contractor	69	3	-?-	G&F
Arizona	1999	G&F	Just starting	0	4	Total – 71? USF & WS 1:3 BLM 28:? NPS 10:? FS 1:? Other Gov. 12:? Private 16:?	
California	2000	AML, but recognize the need for better assessment	AML Just starting	0	0	Total 200? FS & BLM 150? NPS 60? OSM 8:2 Private Some	
Idaho	1999	G&F	G&F and AML	6	12	FS 45?	
Nevada	1987-fencing only 2000?-closures?	G&F just starting	Just starting	0	0	BLM 12 Private 8+?	
Oregon	2000 inventory phase to choose 10 sites.	Probably will be Federal G&F	Just starting	0	0	BLM 4 FS ?	
Washington	2000	Program just starting	Just starting	0	0	OSM 23:1 FS 2:? BLM 1:?	

Summary

The trend of the past decade is remarkable. We have gone from a very small number of BFCs on caves to over 1,200 BFCs in 11 States. The following summary table highlights the great progress made in the past decade by the WIEB States in the protection of bat habitat through assessment and the construction of BFCs.

Summary of Bat Friendly Closures (BFCs) In Eleven Western States as of the Year 2000

OSM Funded AML Programs

	AML Program BFCs completed: planned	BFC closures by other agencies (BLM, FS, NPS, OSM, etc.)
Colorado	321:28	? BLM-30
Hopi	1:0	0
Montana	5:0	?
Navajo	4:0	0
New Mexico	127:31	4?
Utah	290:30	?
Wyoming	69:3	?

Non-OSM Funded AML Programs

Arizona	0:4	69?
California	0:0	200?
Idaho	6:12	45?
Nevada	0:0	20+?
Oregon	0:0	4?
Washington	0:0	26?
Totals =	817:108	398?

This data is variable in its accuracy. Due to different definitions of a BFC, all closures that bats could possibly pass through are included. Record keeping is also variable in different programs regarding BFCs. OSM funded programs started bat assessments and BFCs between 1990 and 1995. The other State AML programs only started in 1999 or 2000.

Of the 1,200 BFCs in 11 western States, about 800 have been constructed in the five States with OSM funding. The education of the public as well as agency staff on the need for bat habitat preservation must be continued. The cooperative effort between Bat Conservation International and the BLM has made great strides in this area. However, the major problem in most States is a lack of funds for bat habitat assessment as well as for mine safeguarding. Though education must be continued, the major impediment to progress is funding.

The most important change that could occur to improve bat habitat conservation in mines would be the release of the funds due the State AML programs under SMCRA. The diversion of these funds by the Congress remains the major funding problem for those five WIEB States. Funding is an even greater problem in the non-SMCRA funded States. To date, State funding is totally inadequate and Federal land management agencies have not even made significant contributions to efforts on the lands they own and manage, with the possible exception of the National Park Service. Assistance must be given to Arizona, California, and Nevada where a significant proportion of the Nation's abandoned mine problem exits.

If the mine bat habitat is going to be adequately preserved in these States, greater funding is essential for their AML programs. Federal land management agencies have not yet moved from the planning stage to construction on a meaningful scale in these States. The BLM and Forest Service in Arizona and Nevada have safeguarded only about a tenth of one percent of their mine openings. Hopefully these States are on the threshold of getting funding from their legislatures that will allow them to take a more active role in safeguarding and BFC construction. However, the responsible parties in most western States, the Federal land management agencies that own the majority of the abandoned mines, must start active programs to correct the problem. The OSM-funded States are carrying the burden on Federal lands in their States. The BLM and Forest Service must carry the burden in the other States. It is unfair to lump the two agencies together, as the BLM has made commendable efforts. However, Federal land management agency activity remains totally inadequate. The trends are encouraging, but unless adequate funding is developed, we will not see these trends continue.

Homer Milford has served as the Environmental Coordinator for the New Mexico AML Program for the past 10 years. He received his bachelors in Biology from the University of New Mexico and Masters in Biology from University of Idaho followed by two years at the State University of New York. He has conducted hundreds of underground bat habitat assessments in conjunction with Dr. Scott Altenbach over the past 10 years. He coauthored with Dr. Altenbach the publication "Evaluation and Management of Bats in Abandoned Mines in the Southwest."

KENTUCKY COAL INDUSTRY PERSPECTIVE ON BAT CONSERVATION AND MINING

Stephen C. Cawood
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Lexington, Kentucky

Introduction

Good Afternoon. My name is Steve Cawood, and I am a lawyer in private practice in Lexington, Kentucky. I have been asked to share with you this afternoon some of the coal industry's concerns about how those involved with the mining industry can best protect and enhance the habitat for bats in the areas where mining is expected to take place.

By way of background, it may be helpful to you to understand that for more than 25 years I practiced in Pineville, Kentucky, a small town in the center of the Southern Appalachian coal industry. I have represented two small city governments and private citizens groups in bringing the first two successful Lands Unsuitible Petitions thus far practiced in Kentucky, the Cannon Creek Resevoir case, on behalf of the City of Pineville, and the Fern Lake/Cumberland Gap case, on behalf of the City of Middlesboro. I have also represented the State of Kentucky in takings litigation stemming from a Lands Unsuitable Petition. Back in the early 70's (when God first began to give shape to the earth), I represented a Kentucky citizens group intervening in the Tellico Dam litigation, the first major endangered species act litigation in the Eastern United States.

I come to you today as a designated hitter for what remains of the coal industry in Eastern Kentucky. This is because I happen to represent both a surface mining company and a deep miner, conducting mining operations on the Western side of the Pine Mountain. Pine Mountain is a faulted upthrust of limestone lying just west of Kentucky's border with Virginia, a geological feature which is prime habitat for the Indiana bat, *myotis socalis* .

I would also like to make clear that I'm not speaking to you today on behalf of the National Mining Association, the Kentucky Coal Association, or for that matter, any specific client that our firm represents. I come here today as a lawyer somewhat familiar with the problems experienced in the field by those producing coal in Southern Appalachia.

The first major concern of the coal industry I think would be that there is an amazing dirth of knowledge about our subject matter. I would suggest to you that the airline ticket packages issued for our collective travel here to St. Louis today would far exceed all of the scientifically valid knowledge that's currently in print about the endangered bats we seek to protect and enhance. The mining industry, those regulators charged with protecting bats, and those members of the public concerned with encouraging both regulators and the mining industry to be concerned with the protection and enhancement of bats, have an amazingly small amount of guidance available to them.

The work of this symposium is vitally important to all of those associated with it. If we can come up with a nuts and bolts of a scientifically based program of recommendations to enhance bat conservation associated with America's mining, then we will have taken a giant step forward.

Stream Buffer Zones

The first concern of the coal industry, when we begin a discussion concerning the protection of bats, has to begin with some rational assessment of the term "stream buffer zone."

The first problem is that we have no accurate maps to equip those in industry, or those regulating industry, as they seek a rational basis for protecting the water supply and the food supply for those bats which might inhabit a specific area. Kentucky has currently in place the most comprehensive topographical mapping program in the nation. We have an annual program that is addressed in both the Federal and State budget to revise this mapping on a county-by-county basis in a systematic way. But, as we all know, those "blue line" streams that are portrayed on a topographical sheet do not accurately portray anything more than the fact that a particular hollow is the lowest point in elevation in the surrounding mountainside. By the very nature of our mountain topography in Appalachia, and I'm also speaking of the relatively flat, horizontal nature of the geology beneath our mountains, there is, generally speaking, little or nothing which lies on the surface of these mountainsides, or within the strata lying beneath, that will act as a sufficient reservoir to feed and to sustain a free-flowing stream that would exist for any significant part of the year. The huge majority of the upper stretches of the drainage basins which form the sides of our mountains in Southern Appalachia have nothing more than ephemeral streams that serve to drain off rainfall downward, but which in no true sense, biologically speaking, act as a stream that would serve any animal species as either a water source or food supply on an ongoing basis.

We urgently need a program in our State geological survey agencies that would actually systematically assess each drainage basin overlying significant coal reserves to assess their potential for a perennial stream. For those anomalies which we can document to sustain a perennial stream, perhaps we need to formulate strict barriers of protection, but to the best of my knowledge, none of the mist-netting conducted in the coal fields of Southern Appalachia has produced a bat of any kind, let alone an endangered Indiana bat, over an ephemeral stream.

There is relatively little known about the diet of the Indiana bat, though what we do know seems to point to the idea that bat tends to take advantage of whatever is available in the area where he finds himself at any particular time of the year. There seems to be nothing in the literature to suggest that the Indiana bat requires any stream-born source of food, let alone that any of these sources might be found in any of the ephemeral draws that form the upper, coal bearing hillsides in the mountains of Appalachia.

What we have found, in the mist-netting that has been conducted over the last five years in large areas of Eastern Kentucky and Southwest Virginia, is that a variety of different bat species seem to frequent the old logging roads with their shallow tire depressions that criss-cross the mountains. These roads form an open fly-way which serve as a thoroughfare for the bats, generally too small to serve as a foraging area for the owls that might prey upon the bats.

Beyond the "stream buffer zone issue" all of the other ideas and suggestions for permitting restrictions on the coal industry that are circulating among the Fish and Wildlife agencies, and the various State and Federal regulatory proposals proposed as guidelines are really secondary, and I would simply urge common sense.

Bat Habitat Assessments by Mine Operators

There needs to be some rational approach for determining whether mine permitees ought to even be required to assess for the bat's potential. It doesn't make any sense to draw these lines along State or county boundaries, because bats certainly aren't any respecter of political boundaries. The only solid data we have about a firm, consistent location for Indiana bats, is that limestone deposits with a free-flowing volume of air that maintains a temperature above freezing, may serve as a hibernacula for the bats in winter. Conducting the bat surveys that biologists deem appropriate can be a relatively expensive operation. By their very nature, bat surveys are restricted to a narrow, short portion of the calendar year. Common sense and all of the scientific knowledge we can muster needs to be applied to the decisions made in determining the scope of the geographical area in which the surveys will be required relative to the known habitat to the bats.

Permit Conditions to Protect Bat Habitat

None of the companies that I'm familiar with would have any problem with following the timbering practices which are under discussion for the protection of bat habitat. However, thus far, the land companies, which generally serve as lessors for the coal industry, seem to have been left out of the discussion.

None of the mining companies I'm familiar with would have any problem with leaving shallow, wading depth depressions in cleared areas, where permitting agencies will agree that they will be allowed, and where land holders will consent. Many mines are already installing bat boxes where mist-netting has indicated potential bat habitat.

The Mine Safety & Health Administration (MSHA)

There is one regulatory agency that is being completely omitted from these proceedings, as best I can tell. The Mine Safety & Health Administration needs to be involved in addressing the need for the protection of old mine portals. The hillsides of Appalachia are literally speckled with old, abandoned deep mine portals, or adits. Miners simply walked away from, or deliberately abandoned these portal at a time when there was no regulatory requirement for a "closure" that would protect the human population. Most of these have probably fallen in to the point that they present no problem to anyone but the inquisitive child. However, many of them remain accessible to bats frequenting the area, and a few have been documented as providing bat habitat.

It should be born in mind that these old abandoned mine shafts are extremely dangerous. Hardly a year goes by, that someone, somewhere in Appalachia doesn't die when entering them even though the use of them, for any purpose, is strictly prohibited by both State and Federal law. Whatever measures we may end up suggesting, as a means of protecting these old portals, needs

to be done with the involvement and the advice of the MSHA. We certainly do not need to even suggest (as does some of the literature currently in circulation) that engineers preparing permits, or that regulatory officials go about entering old underground mine works in search of bat populations! While discussing these deep mine works, I should also point out again that topographical maps currently in use do not reflect all of these old mine adits that may be found in a prospective site. Care needs to be taken when prospecting these areas prior to permitting. Then, any examination of these portals needs to be undertaken only with the advice and permission of underground mine inspectors.

Conclusion

Finally, I would suggest that when a regulatory scheme is devised and settled upon, one agency be designated as the prime enforcement agency for the application of the endangered species act with respect to prospective miners in each given State. This would avoid requiring the mining industry to shop a permit application with more than one agency.

Thank you for the opportunity of addressing some of the concerns of the coal industry. We look forward to working with you in the future.

Stephen P. Cawood is an attorney with McBrayer, McGinnis, Leslie & Kirkland PLLC in Lexington, Kentucky concentrating on natural resources law. He holds a B.S. and Juris Doctorate from Eastern Kentucky University. He has served as a Kentucky State Representative and served as Chair of the Special Committee on Surface Mining and the Natural Resources Committee.

THE U. S. FISH AND WILDLIFE SERVICE'S PERSPECTIVE ON BATS AND MINING

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Abstract

The Fish and Wildlife Service (Service) has a vital interest in the Office of Surface Mining's (OSM) mining and abandoned mined land reclamation programs. We are charged, under the Endangered Species Act of 1973, as amended (ESA), and other legislative mandates, such as Surface Mining Control and Reclamation Act (SMCRA), Fish and Wildlife Coordination Act (FWCA), Clean Water Act (CWA), and National Environmental Policy Act (NEPA), to protect endangered species and other trust resources (migratory birds and anadromous fish). To successfully meet this challenge, the Service must work cooperatively with OSM, other Federal agencies, State agencies that implement mining and mined land reclamation programs, and the private sector. About 40 percent of the bats of the U.S. are either listed as endangered or are of Federal concern. Bats are an integral part of naturally functioning ecosystems and their protection, conservation, and recovery must become a high priority. Most of the bats of Federal concern (listed species and species of special concern) are now dependent to some degree upon abandoned mines. New mining, renewed mining, and reclamation all have the potential to directly impact this unique group of mammals. If carefully planned and executed, these impacts can be positive or their negative effects minimized. The Service looks forward to a successful Forum on the bats and mines issue and to future cooperative efforts to protect these vulnerable species. If we are successful, the currently listed species will benefit and the threats to bats of Federal concern may be reduced to the point that adding them to the Federal list of Endangered and Threatened Species is unnecessary.

Introduction, Background, and Past Experiences

The Fish and Wildlife Service (Service) has recognized the importance of mining and mine reclamation issues to natural resource conservation for many years. One of the early efforts to deal with the subject was a Symposium, similar to this one, held in West Virginia in 1978. That Symposium was conducted in response to the 1977 passage of the Surface Mining Control and Reclamation Act of 1977 (PL 95-87). Lynn Greenwalt, the Director of the Service at that time, noted in the preface to the Symposium proceedings that "While surface mining coal is important in meeting the Nation's energy needs, mine reclamation plans that consider fish and wildlife habitat as either a primary or secondary land use are important for the Nation's living resources." This is as true today as it was then. It is also true for mineral resources other than coal, we need these minerals, but we must not neglect our other natural resources as we extract them.

In addition to the traditional game and non-game species that were the focus of the 1978 Symposium, we must now recognize that mining and the reclamation of abandoned mines have

the potential to affect many of the species that are now protected under the ESA. These species include a large number of endangered and threatened fish and freshwater mussels as well as the currently listed bats and those that are of Federal concern and may be listed in the future.

Soon after the ESA was passed, the Service learned that abandoned mines provided important roosting habitat for a few populations of the endangered Indiana bat. Two abandoned hard rock mines, the Blackball Mine in Illinois and Pilot Knob Mine in Missouri, were designated as Indiana bat Critical Habitat. Since then, this severely declining species has been found to depend upon abandoned mines in Ohio, New York, New Jersey, Pennsylvania, West Virginia, Virginia, Kentucky, and Tennessee. Not only has the number of mines known to support the species increased, the types of mines it uses is now known to include abandoned coal mines as well as hard rock mines.

Research in both eastern and western States has revealed that most of the six Federally listed bats and most of the bats of Federal concern are dependent, to some extent, upon abandoned mines as maternity and hibernation sites. An example of the significance of mines to some of our Federal concern bats was the discovery of the largest know hibernation and maternity colonies of the Southeastern big-eared bat (*Corynorhinus rafinesquii*) in a series of abandoned mines in the Great Smoky Mountains National Park.

We learned of the potential of abandoned coal mines to support hibernating Indiana bats in the early 1980's. One of the first systematic efforts to determine the potential impacts of abandoned underground coal mine reclamation on bats was made by our Cookeville, Tennessee, Field Office. They conducted a bat inventory of many of the old mines within the Big South Fork National River and Recreation Area. This inventory was used to assist the agencies establishing the Recreation Area in addressing the numerous abandoned mines found on the site. Since that time we have, primarily through Section 7 of the ESA, worked with Federal land management agencies, the Natural Resource Conservation Service, OSM, and the State abandoned mined land reclamation programs to insure that reclamation activities address the Federally listed bats that could potentially depend upon these mines.

The potential effects of mining and mined land reclamation on underground bat roosts are clearly understood. However, there are additional mine related impacts that are more subtle, but can have equally significant impacts. Acid mine drainage, spoil area soils that are poor in plant nutrients or are contaminated with toxic chemicals and the loss of trees used as day roosts can adversely affect bats by contaminating their food and water supplies and altering or removing their foraging and roosting habitat. If projects are properly planned and conducted, these adverse impacts can be avoided, at least when viewed in the long term. Proper planning for the protection and restoration of natural resources must be incorporated into the site management and restoration plans or significant long-term losses can result.

Trends

The Service believes that in the future abandoned mines can play a increasingly significant role in bat conservation in the U.S. As natural roosts are lost to development or have such high levels

of human disturbance that they are no longer suitable for bat use, mines may provide essential alternative roosts for these vulnerable species. Pressure to abate the hazards associated with abandoned underground mines will increase as the human population continues to expand and to move into areas containing abandoned mines. We must all work together to eliminate the dangers inherent to abandoned mines while maintaining those sites that are significant bat roosts. The adverse impacts associated with new mining and re-mining of old underground mines will increase with time. Therefore, as mining continues, we must also ensure that these bats continue to exist. This will best be accomplished through the minimization of adverse impacts and by supplying necessary foraging and roosting habitat for the recovery of bats. As the public becomes more involved in bat conservation and mining issues, we will all be challenged to insure that the extraction of essential mineral resources is undertaken in a manner that does not affect the long-term survival of bats and other natural resources.

Constraints

Our abilities to successfully meet the challenges posed by bats in mines is only constrained by the limited amount of money available and the hazardous nature of many of the underground mines. These hazards make inventory and protection activities more difficult than when dealing with natural roosts such as caves.

Needs

We have identified two major needs for continued successful interactions dealing with listed bats and mining activities.

The first need is the continued education of the mining industry. All involved in the mining and mine reclamation industry must gain and maintain a better understanding and appreciation for the fragile natural resources that can be affected by their activities. We need to consider the protection, conservation, and recovery of both listed and Federal concern bats in future mining and mine reclamation activities. This includes providing the habitat that is needed to meet the long-term bat foraging and roosting needs in our reclamation efforts. In many cases, we may need to reestablish a forest cover rather than just the grass, forb, and shrub habitats that have been used in the past. This may be more difficult, but may be more beneficial in meeting the long-term needs of the many forest dependent bats.

Our second need is for increased education of the public. In 1993, Bat Conservation International, the Bureau of Land Management, and the Service, working with other Federal agencies, began a National effort to increase public and private sector awareness of the importance of abandoned mines to bats. In that year, we began our participation in a series of workshops addressing this issue. These workshops have been held on a regular basis throughout the U.S. and will continue as long as they are needed. The Service provided funding, through a grant to BCI, for the development of the informative booklet *Bats and Mines*. This booklet, in conjunction with the Bats and Mines Workshops, has been an effective tool in increasing awareness and appreciation of the importance of abandoned mines to bats. This Forum provides an opportunity for us to share information on this topic with a larger audience.

Summary

We recognize that if we are to safe-guard the public from the hazards of abandoned mines while protecting and enhancing the natural resources that have become dependent upon them, we have to work together. In addition to working together, we must all be involved as early in the process as possible and utilize our collective resources and expertise to assure the continuation of both listed species and mining.

I thank you for the opportunity to speak to you today, and look forward to a successful forum on bats and mining issues. I believe that our continued cooperative efforts to protect this vulnerable group of species is of vital interest to all.

David P. Flemming is a 21 year career employee of the U. S. Fish and Wildlife Service. He currently serves as one of the Ecological Service Supervisors in the Atlanta Regional Office with oversight of 8 field offices in the southeast region dealing with endangered and threatened species, wetlands, and environmental contaminants. He received his B.S. in biology from Grove City College in 1975 and his M.S. in biology from Bowling Green State University in 1977. Mr. Flemming's interest in bats and mining, begin in high school as part of a class project monitoring a surface mine and continued in course work in pursuit of his degrees and in work with the Service, primarily through recovery implementation actions for listed bats and activities associated with Section 7 consultations under the Endangered Species Act of 1973, as amended.

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

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Abstract

Because increased urban development, deforestation, and exploitation of caves have significantly impacted bat habitat, abandoned mines have become critical to the survival of numerous bat species. To date, the National Park Service (NPS) has placed 102 bat-compatible mine closures in 16 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 abandoned 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 NPS recently developed an interpretive warning sign through its partnership with and Bat Conservation International that 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.

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.

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, … 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

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

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 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 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 because a great deal of their natural habitat has been lost to urban development, deforestation, and recreational exploitation of caves. 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 often necessary 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, 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. 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 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 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, particularly cave dwellers, are also believed to be in decline. 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 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

[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).

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] 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.

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[3] A variety of 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 an abandoned mine safety courses offered by U.S. Forest Service and the Bureau of Land Management that 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 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.

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, old 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 rock. 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. Research also 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 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 vertical bar spacing in the lower portion of the gate in compliance with local building codes 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 gate design developed by professional engineer and conservationist Roy Powers in cooperation with the American Cave Conservation Association (Tuttle 1998, pp. 34-46). The Powers design uses L4"x4"x?" angle steel for structural members and cross member supports with two L1½"x1½"x¼"

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

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 Powers 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 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 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 rock 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, 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. 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

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

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 Powers gates, but have seen minimal vandalism. One gate in New River was damaged due to roof collapse and was replaced recently with a Powers 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 in general, 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 methods.

In 1988, a bat gate was installed by the park at the Sugar Fork Copper Mine in Great Smoky Mountains National Park 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. The 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 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 at 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. 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 Powers 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 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

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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, as cited by 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.**

developed an economical 6-inch by 6-inch stainless steel cable nets 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, the Death Valley has constructed 7 more 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 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.

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, Joshua 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 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 pipe / bat gate closure in an adit portal prone to subsidence, 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 entry into 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 displaced a colony of federally endangered Greater long-nosed bats in nearby Emory Cave. 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 was 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, and there is an additional concern since these and other cable nets installed in the area have been vandalized for access by park visitors. For this reason, 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 bat access. 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. 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 vertical spacing. 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 bat gate of the same optimized materials.

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"x?" 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 naturally, geothermally heated site. 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 Powers 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 Sign

The National Park Service and Bat Conservation International have jointly developed a bat gate interpretive sign (Figure 7) 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.

Conclusion

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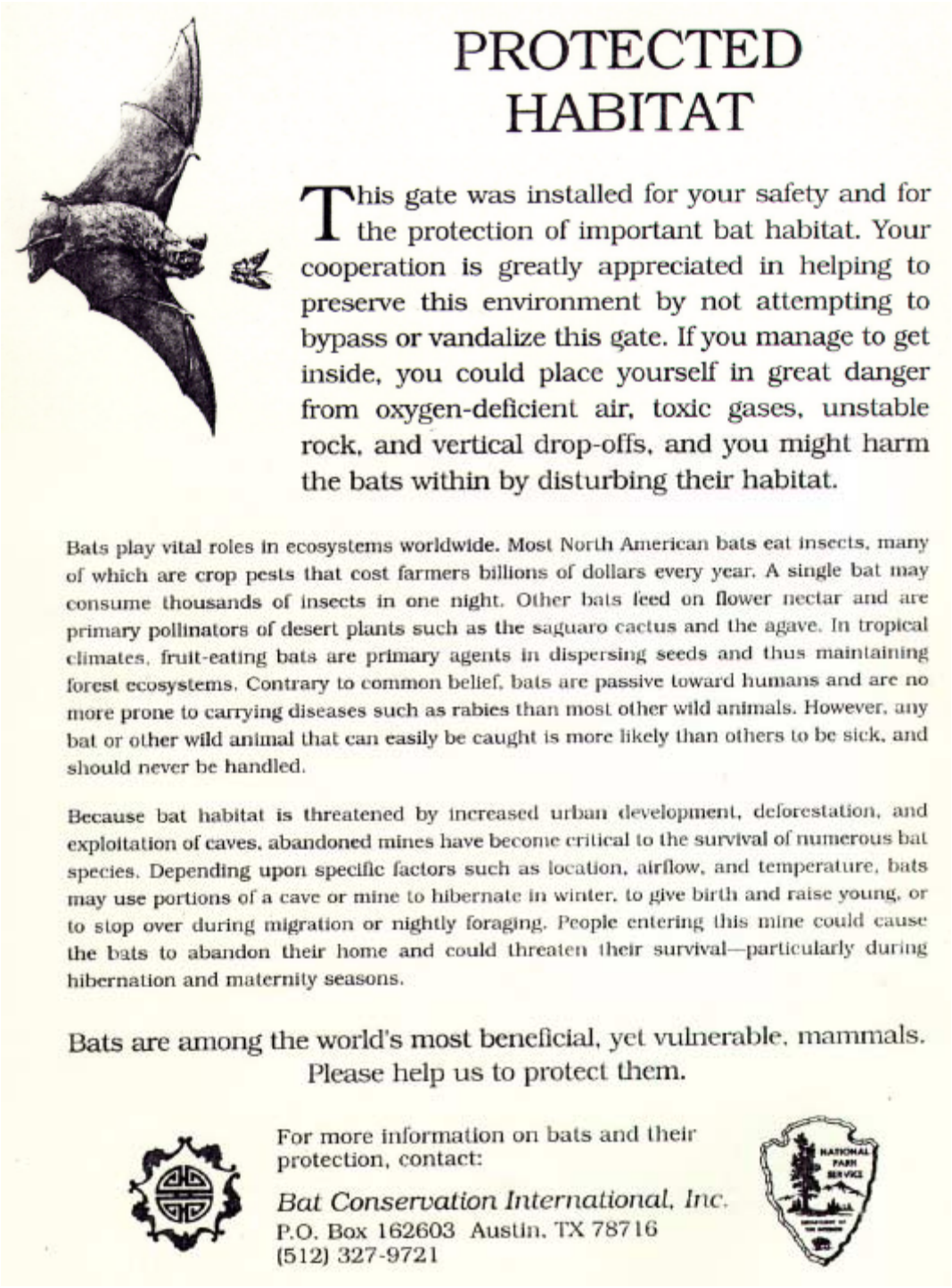
Figure 1. Bat gate installed at Kaymoor coal mine, New River Gorge, West Virginia. (1988)

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 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 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 ϖ	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.

ϖ 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.

SEX, LIES, AND VIDEOTAPE: MY VIEW OF THE EVOLUTION OF FEDERAL POLICY AND PRACTICE TO CONSERVE BATS ON LANDS MANAGED BY THE FOREST SERVICE

Laurie Fenwood
U.S. Forest Service
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Abstract

Focusing only where we can best comply with our goals for maintaining species viability through habitat protection and restoration is not always enough. We must take opportunities and develop partnerships that make use of unconventional locations and methods to meet bat conservation goals. Additionally, we must use all agency authorities and programs to meet these and other conservation goals including conservation education, outreach to private landowners, and international assistance. A key challenge will be coordination of all these efforts to evaluate their success and maintain accountability for publicly funded programs.

Introduction

The Forest Service is the habitat manager on about 192 million acres of public land across the U.S. and is very concerned about habitat management. The Forest Service has been in the conservation business for about the last 100 years. Our first approach in the forest planning process in the early to mid 80s was don't violate the Endangered Species Act and do good things for fish and wildlife. The start up involved thinking about leaving a few trees for fish and wildlife and as a seed source and thinking about leaving a buffer around streams.

The Forest Service has had to learn that conservation is more than just saving rare species. We are also looking at keeping common species common and trying to prevent a species from becoming so rare that it must be listed under the Endangered Species Act. Abandoned mine lands have been viewed as a problem that needed to be solved and now we are starting to look at them as a resource.

Sex

The Forest Service is concerned about the viability of bat species on public land including factors influencing reproduction, food, and shelter. The Forest Service has had to become a complete manager of the habitat of species that live on Forest Service land.

Lies

Historically bats have been given a bad reputation. The focus of conservation and species protection has been elsewhere. Most of the conservation efforts have been on species listed under the Endangered Species Act. The Forest Service has had to learn that conservation is more

than constraints on other programs, planning, and saving rare species.

Videotape

On the positive side, people do care now about the natural environment . We also have a number of bat evangelists that have been very effective at getting the word out about protecting bats and their habitats. Litigation has also helped the Forest Service focus on doing what they are supposed to do. Committed agency personnel also help to maintain a focus on important but common non game species. The Forest Service has also developed a partnership with Bat Conservation International that has helped to provide education and training about bat conservation.

Challenges

The Forest Service has committed to the concept of ecosystem management, however I feel that we are still going to have to focus on individual species management in order to be effective. We are going to have a crisis in the next 10 years because of the loss of Forest Service personnel. Meetings with the Forest Service are starting to look like God's waiting room. This is not good because that wealth of experience will leave when the people leave. This will also effect our partnerships and the Forest Service will have to develop more partnerships with associated organizations in the future. The new Forest plan will focus us on a larger scale assessment. It will have a much better collaboration with the science and the public. The new roadless policy will also change the focus to conservation for several million acres of public land. The new focus and funding on fire fighting will require additional staff time and effort.

Opportunities

The Forest Service must look to appropriate partnerships with State and private forest owners and State and Federal agencies. It must place a high priority on education of its own staff and the people and agencies we work with. Part of that education must emphasize that conservation is good business due to the revenues resulting from tourism and land uses dependent upon a healthy environment. The Forest Service must explore new partnerships with organizations like Bat Conservation International that can assist in this education process.

Laurie Fenwood is the Director of Ecosystem Conservation for the Pacific Southwest Region of the USDA Forest Service. The regional office provides technical support to the national forests in California as well as program direction, oversight, budget formulation, policy interpretation, and accountability. She has served as Threatened, Endangered, and Sensitive Species Program Manager and Assistant Director for Wildlife and Terrestrial Ecology where she developed a successful partnership with Bat Conservation International. She holds a a Master of Science in Wildlife Management and a Bachelor of Science in Biology.

THE ROLE OF THE BUREAU OF LAND MANAGEMENT IN BAT CONSERVATION

Fred Stabler
Bureau of Land Management
Washington D.C.
and
Michael Herder
Bureau of Land Management
St. George, Utah

Abstract

The Bureau of Land Management (BLM) and Bat Conservation International (BCI) have been in a productive bat conservation partnership since 1993. In 1994, BLM and BCI entered into a cooperative agreement to fund the first position ever to completely devoted to the issue of protecting bat habitat in mines. The associated "Bats and Mines Project" has been extremely productive resulting in millions of bats being saved and the program has become international in scope. The Bats and Mines coordinator position is now completely funded by BCI supporters. As part of this project, BLM cooperatively funded the publication "Bats and Mines" which is currently in its second printing. This year the BLM assisted in the printing of the first edition in Spanish. For the last two years, BLM and BCI have developed educational materials on bats in Western U.S. forests. BLM has also been active in supporting the development of the new, tri-national North American Bat Management Partnership between Canada, the U.S. and Mexico. BLM and BCI invite financial participation in a proposed new Federal position to coordinate land-managing agency activities with BCI and the bat conservation community.

Introduction

The Bureau of Land Management (BLM) manages 264 million acres of Federal lands, primarily in the Western U.S. The BLM has a multiple use mandate in managing public lands that was set forth in the Federal Land Policy and Management Act (FLPMA). As an agency, BLM strives to provide for a wide spectrum of uses, opportunities, and activities on public lands.

Mineral production from BLM lands is important for the nation and the economy. There are many thousands of abandoned mines on BLM public lands. Abandoned underground mine workings pose serious threats to human safety. In recent years, there has been substantial pressure to close these mines, primarily to mitigate public health and safety concerns, but also to restore and rehabilitate sites to a more natural and healthy condition. In an effort to protect the public from the hazards of abandoned mines, public land managers have implemented large-scale closure efforts, often at significant expense. Unfortunately, many mines on BLM had already been closed prior to agency recognition of their importance as habitat for bats and other wildlife species.

Bat Habitat on BLM Land

The most economically feasible mine closure methods include blasting, plugging, backfilling, and other permanent solutions. Recent studies have shown that numerous wildlife species use these artificially created habitats including bats, mice, woodrats, skunks, ringtail cats, mountain lions, and a variety of bird and reptile species. As much as 80 percent of the mines in the Western U.S. show some evidence of bat activity. Permanent abandoned mine closure methods have not only resulted in destruction of roosting habitat, but have also caused direct mortality of bats by entombing them within the sealed mine.

In an effort to change this, the BLM was one of the first Federal agencies to actively and voluntarily pursue the protection of bats in mines. Initial efforts began in the early 1990s with the goal of managing abandoned mines for the protection of sensitive and ecologically important species, while allowing for the safe and orderly reclamation of mines. New policy was implemented by the agency to inventory all mines for bat use prior to closure. Current BLM policy is to utilize all means possible to protect bat habitat in mines by avoiding permanent closure methods in mines occupied by bats. This policy allows for protection of human health and safety while allowing continued access to important wildlife habitat.

These efforts have not come about without problems or conflicts. The most prominent of these include: lack of funds for non-permanent closures such as gates; vandalism of facilities and protective structures for bats; conflicts between the need to determine presence of bats versus the danger of entering abandoned mines for internal surveys; lack of understanding of the need for such protective actions on the part of the public, other agencies, and BLM managers; lack of trained biologists to conduct pre-closure surveys and implement necessary protective actions; and lack of gating design technology.

Many other agencies and private groups were also involved in this effort to protect bats and their habitat in abandoned mines. BLM recognized early on that this effort would be best accomplished by partnering with these groups. In 1993, BLM entered into a productive partnership with Bat Conservation International (BCI) by signing a memorandum of understanding (MOU). This MOU commits the partners to taking a variety of proactive measures to conserve bats and their habitats on BLM administered public lands. In 1994, BLM and BCI entered into a cooperative agreement to fund the first position ever to be completely devoted to the issue of protecting bat habitat in mines. BLM provided $50,000 per year for three years to fund a Bats and Mines Project Coordinator at BCI. The Bats and Mines Project has been extremely productive, resulting in protection of habitat for millions of bats on public lands. The project has grown and is now international in scope. The Bats and Mines coordinator position is now completely funded by BCI supporters.

As part of this project, BLM cooperatively funded the publication “Bats and Mines,” currently in its second printing. This 50 page color booklet was written by BCI founder Dr. Merlin Tuttle and Bats and Mines Project Coordinator Daniel Taylor. Many of the foremost bat biologists in the U.S. contributed to the development of this book. The second edition has an updated section on gate designs representing substantial increases in our knowledge. The booklet continues to be

one of the best references available on managing mines as habitat for bats. This year the BLM assisted in the printing of the first edition in Spanish.

The BLM has also funded many projects to benefit bats on public lands. These include on-the-ground projects, such as internal and external bat surveys at abandoned mines, installation of bat-compatible gates and grates to prevent human entry, and extensive monitoring efforts to determine the effectiveness of these protective structures. Successful gating projects have been completed in most States with BLM-administered lands. The agency has also sponsored habitat studies have in an effort to better understand the habitat requirements of bats and provide for their needs. Many of these studies were funded by grants from BCI and the National Fish and Wildlife Foundation (NFWF) and through cooperative cost-sharing agreements with State wildlife agencies.

BLM has been actively involved with numerous partners in developing and implementing studies to monitor bat use of mine gates and evaluate the effectiveness of the bat-compatible closures. These studies have shown that bat-compatible gates are an important tool in conservation of wildlife habitat within underground mine workings. For the most part, gates have been effective in protecting the public from the dangers of abandoned underground mine workings, though vandalism continues to be a problem. Unfortunately, many early gate designs impeded bats in flight, allowing predators to take them easily. In some areas, bats have abandoned historic roosting areas despite the addition of bat compatible gates. BLM sponsored studies are currently assessing the effects of gates on bats in underground mine workings using infrared counters and video equipment. Preliminary results from these studies are providing important insights into bat behavior and habitat use.

Recognizing a critical need for specialized training in working with bats and conducting mine pre-closure surveys, BLM, BCI and the U.S. Forest Service have co-sponsored over twenty sessions of the Bats and Abandoned Mines workshop. The curricula for this course was developed by the partnership and presented by leading bat biologists. The workshops have been taught all over the U.S. and have raised the awareness of the plight of bats among resource specialists and land managers from a wide variety of State and Federal agencies and private organizations. Other training courses have evolved from these initial workshops including cave and mine gating seminars, bat capture and handling techniques, and methods for acoustic surveys. The BLM National Training Center has recently developed an Underground Mine Safety Training that alerts resource specialists conducting inventories in abandoned mines about the dangers and hazardous conditions there. This course and a similar one taught by the U.S. Forest Service, while highly controversial, provide the only available safety training for conducting surveys in abandoned underground mine workings.

BLM and BCI are seeking to unite many bat conservation efforts by establishing a multi-agency Federal Bat Coordinator position. This position would be tasked with the responsibility to coordinate land-management agency activities with BCI and the bat conservation community. BLM invites other Federal agencies to discuss the role of this coordinator and assist in cooperatively funding the effort.

Finally, BLM has been active in supporting the development of the new, tri-national North American Bat Management Partnership between Canada, the U.S. and Mexico. This partnership is now fully functional and participation is invited and encouraged from all interested parties. As a part of this effort, a network of four Regional and numerous State Bat Working Groups have developed to focus bat conservation efforts where they are most needed. BLM biologists were heavily involved in the inception of this effort and continue to work toward development of State Bat Conservation Plans.

The idea that bats and their habitats are in desperate need of protection, range-wide in some cases, is far from a universally-held concept among land managers. The majority of work that has gone forward in protecting bat habitats on public lands has been accomplished by individual wildlife biologists with a vision for the conservation of these ecologically important species. These individuals have sought out partnerships and funding to make projects happen. Only through partnerships that focus efforts to educate and inform the public about bats, through projects, training, and workshops can we make real progress in protecting bats and their habitats.

INTERNATIONAL ASSOCIATION OF FISH AND WILDLIFE AGENCIES AND STATE CONSERVATION EFFORTS FOR BATS

Terry Johnson
Arizona Department of Game and Fish
Phoenix, Arizona

Abstract

The International Association of Fish and Wildlife Agencies (the Association) was founded in 1902 as a quasi-governmental organization of public agencies charged with the protection and management of North America's fish and wildlife resources. The association's governmental members include the fish and wildlife agencies of the States, Provinces, and Federal governments of the United States, Canada, and Mexico. A wide variety of sportsman, conservation, and environmental non-governmental organizations are affiliate members of the Association. The International Association is a key organization in promoting sound resource management and strengthening Federal, State, and private cooperation in protecting and managing fish and wildlife and their habitats in the public interest. The Association's twice annual meetings (March-April and September) are attended by several hundred representatives from member agencies and organizations and affiliate members. Issues are addressed through a variety of committees, many of which have working groups or task forces that meet and work throughout the year. In the 1990s, one of the primary focal points for the Association and its members has been establishing a stable funding base for State conservation efforts for non-game wildlife. In the past few years, this Teaming With Wildlife initiative has evolved into the Conservation and Reinvestment Act (CARA). CARA would provide as much as $3 billion annually for a variety of coastal and inland programs revolving around protection and enhancement of cultural, historical, recreation, and natural resources and opportunities. Title III of the proposed CARA legislation would provide as much as $35 million annually to State wildlife agencies for wildlife conservation, education, and recreation programs. Among the Top Ten suggested wildlife programs for the States to implement with CARA funding is the North American Bat Conservation Partnership, which has grown from Bat Conservation International's innovative bat conservation concept, "Masters of the Night Sky Universe." Meanwhile, as we await Congressional action in Fall 2000 on CARA, the States are engaged in a wide variety of bat conservation efforts. This presentation will provide an update on CARA, how its funds could used to benefit bat conservation by the States, and a representative sampling of current State bat conservation efforts in the North American Bat Conservation Partnership.

Funding Issues

On of the issues the Association has been involved with over the last several years has been to develop additional funding for non game species called Teaming with Wildlife. This initiative began in 1977 and became law in 1980 and was called the national non game Act. It has received since its enactment $0 in funding from Congress. The Teaming with Wildlife initiative has evolved into the Conservation and Reinvestment Act which is little more than the Teaming

with Wildlife Act revisited. CARA has actually made its way into the Congressional budget process and over the next year the U.S. Fish and Wildlife Service will be spending as much as $50 million to invest in non-game species. In order to insure that this money is not spent on charismatic megafauna, you need to be communicating the need to protect bats to you local fish and wildlife agency. There is another $50 million in funding available for bat protection through the U.S. Fish and Wildlife Service through the expansion of the Endangered Species Act under Section 6. Most of this money will be going into habitat conservation planning efforts and the conservation of native species for listed species.

One of the problems of funding for wildlife is there is no funding for common species because the Endangered Species Act drives our funding priorities. An analogy would be that most people are willing to spend the money to buy a new car. These same people, however, are very unwilling to spend the money to maintain that car. The same problem exists within the Fish and Wildlife agencies, people who make the budget decisions rarely are willing to spend money unless they have to because of pressures due to litigation or an important constituency. People who care about non game species like bats are not very experienced in how to work this process and as a result little money is spent on bats.

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Terry B. Johnson is the Chief of the Nongame and Endangered Wildlife Program for the Arizona Game and Fish Department. He has worked on conservation issues in the Southwest for the past 30 years. He is a member of various committees on the International Association of Fish and Wildlife Agencies. He is the current Chair of the Western Association of Fish and Wildlife Agencies' Nongame and Endangered Species Committee, and is or has been a member of variety of endangered species recovery teams, working groups, and similar undertakings. He was a member of the Executive Steering Committee that just helped Bat Conservation International build a framework for developing and implementing the North American Bat Conservation Partnership, and is working with State wildlife diversity program managers nationwide to see that Partnership implemented as fully as possible. His own agency, Arizona Game and Fish, has been especially aggressive in building a comprehensive State bat program that fully involves Federal, private, and other collaborators in conserving these sensitive and still under-appreciated species.

Session 3

Methods for Protecting Bat Habitat Associated with Underground Mines

Session Chairperson:
Mark Mesch
Utah Division of Oil, Gas, and Mining
Salt Lake City, Utah

Methods for Determining Local Mine Characteristics of Importance to Bats
Richard E. Sherwin, J. Scott Altenbach, Department of Biology, University of New Mexico, Albuquerque, New Mexico and Dr, Patricia E. Brown, Department of Physiological Sciences, University of California Los Angeles, Bishop, California

Pre-mine Closure Bat Survey and Inventory Techniques
J. Scott Altenbach, Richard Sherwin, Department of Biology, University of New Mexico, Albuquerque, New Mexico, and Dr. Patricia E. Brown Department of Physiological Sciences, University of California Los Angeles, Bishop, California

An Evaluation of Alternative Methods for Constructing Bat Gates at Mine Closures
Robert Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

New Mexico Experience with Bat Grates at Abandoned Mines
John A. Kretzmann, P.E., New Mexico Abandoned Mine Land Bureau, Mining and Minerals Division, Energy, Minerals and Natural Resources Department, Santa Fe, New Mexico

A Colorado Case Study To Secure Underground Mines for Bat Habitat
Navo, Kirk W., Thomas E. Ingersoll, Lea R. Bonewell, Antoinette J. Piaggio, Nancy Lamantia-Olson, and Carole E. Wilkey, Colorado Division of Wildlife, Denver, Colorado; University of Colorado Museum, Boulder, Colorado

Pennsylvania Case Studies to Secure Underground Mine Workings for Bat Habitat
Emanuel T. Posluszny, Office of Surface Mining,Wilkes-Barre, Pennsylvania, and Calvin M. Butchkoski, Pennsylvania Game Commission, Bureau of Wildlife Management, Harrisburg, PA

A Midwestern Case Study to Secure an Underground Mine For Bat Habitat: The Unimin A Magazine Mine@ in Alexander County, Illinois
Joseph Kath, Illinois Department of Natural Resources, Division of Natural Heritage, Springfield, Illinois

An Overview of the Response to Bats to Protection Efforts
Robert Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

Evicting Bats when Gates will not work: Unstable Mines and Renewed Mining
Dr. Patricia Brown Department of Physiological Sciences, University of California Los Angeles, Bishop, California

Monitoring and Evaluating Results of Bat Protection Efforts
Dr. Kate Grandison, Southern Utah University, Cedar City, Utah

METHODS FOR DETERMINING LOCAL MINE CHARACTERISTICS OF IMPORTANCE TO BATS

Richard E. Sherwin and J. Scott Altenbach
Department of Biology, University of New Mexico
Albuquerque, New Mexico
and
Patricia E. Brown
Department of Physiological Sciences, University of California
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Abstract

When attempting to address questions regarding specific characteristics of mines that can be used to predict occupancy by bats, investigators need to identify several important criteria. We propose that the key questions that need to be articulated are: 1) what species is being addressed -- no two species have the same physiological/natural history requirements, 2) what type of use is being investigated (maternity, hibernation, etc.)-- this can greatly impact the conditions that are being sought, 3) what is the spatial scale of interest -- a tremendous amount of variability can be exhibited both within and among populations, 4) what temporal scale is being investigated -- a mine may appear unused for years and even decades, but that does not necessarily indicate that it is not actual habitat, 5) how will occupancy be interpreted -- what does occupancy indicate about roost "quality", and 6) how will habitat be defined -- where the bat roosts in a mine, the mine itself, a mine complex, etc. A decade of research has revealed that bat occupancy of mines is a highly complex issue. While simple explanations of complex phenomena may be attractive for management purposes, there is no accurate list of mine characteristics that can be used to gauge quality of habitat. When individual bats or colonies select roosts, they are most likely selecting for a set of conditions that a roost provides, not selecting for specific roost attributes. These conditions include (but are not limited to) temperature, humidity, protection from predators, density of local roosts, and protection from ambient conditions. Suitable conditions can be realized in mines of all type, structure and configuration. Conversely, local surface effects (such as climate, elevation, aspect, number of openings), may constrain subsurface conditions, making specific characteristics of a given mine irrelevant. Likewise, these same surface conditions may make seemingly unsuitable mines (small, simple workings) excellent habitat. As stated, no template is available against which mines can be compared to infer actual or potential use. Therefore, techniques for identifying constraints and important characteristics of roosts, on a local scale, will be discussed.

Key Words: Bats, abandoned mines, habitat, roosts, habitat selection, variability

Introduction

The use of abandoned mines by bats has become an important issue to the mining industry, management agencies, conservation groups and wildlife biologists. While documentation of bats using abandoned mines as roosts has long been known (Pearson, 1962), it has only been in the

past two decades that the management and protection of abandoned mines has become a serious, industry-wide issue. The challenge of locating, identifying, and protecting critical roost locations, while concurrently providing for human safety and ongoing mineral exploration and extraction, is daunting. Techniques associated with locating (i.e., survey techniques) and protecting (education, signing, gating, etc) roosts are being addressed elsewhere in these proceedings (Altenbach *et al.*, this issue; Brown,*et al*., this issue). Here we discuss how to identify specific characteristics of abandoned mines that are important to bats.

There is no list of variables that can be used to absolutely gauge the quality of a particular abandoned mine to local bats. In reality, the use of abandoned mines by bats is far too complex to suppose that a "cookbook" approach that lists attributes of all mines, that all bats select for can be effective. At best, sweeping inference about large scale biological processes is inaccurate, at worst, it can cause the implementation of inappropriate management and result in the destruction of the very resources needing protection. Examples of misappropriate extrapolation of data across spatial scales, are the following statements: "bats don't use coal mines," "bats won't use shafts," "mines less than 50' long won't be used by bats." Unfortunately, these statements were used to excuse conducting biological surveys of mines prior to site destruction (through reclamation, renewed mining activity, etc).

When attempting to identify habitat associations of a given species or group of species, it is imperative that the proximate and ultimate constraints of the system be understood (Krebs, 1989). As a general rule, the smaller the geographic range and more simple the natural history of a given organism, the more narrow will be the constraints imposed on the system (Krebs, 1989). The more narrow the constraints, the lower the potential variability, and the more easily definable the habitat associations. For example, habitat associations of the Rocky Mountain Bighorn Sheep (*Ovis canadensis*) are much more easily identified than those of the Great-horned owl (*Bubo virginianus* – Krebs, 1989).

Habitat associations of bats are difficult to define for several reasons. First, the proximate and ultimate constraints on the system are not clearly understood. Second, the natural history of most bats is complex, and in most species is still not well understood. Bats spend a significant amount of time roosting, and the first step in determining habitat affinities is to understand the types of roosts used. Approximately 25 species in the US are known to roost in abandoned mines and 22 of these are considered to be dependent upon abandoned mine workings during at least part of the year (ex. for hibernating – see Bogan, this issue; Harvey, this issue--). The association of these bat species with abandoned mines, coupled with the loss of abandoned mines to reclamation and renewed mining activity make it critical that we understand specific attributes of individual mines that make them suitable or unsuitable to bats.

The Problem

Unfortunately, no data set currently exists from which a model can be generated that can be used to identify specific variables of all abandoned mines that make them suitable to all bats as roosting habitat. It is important to remember that when individual bats or colonies select roosts, they are likely selecting for a set of conditions within a roost and are not selecting for specific

roost attributes. Conditions of importance can be realized in mines of all size and configuration. In addition, local surface effects (climate, elevation, aspect, etc), often constrain subsurface conditions, making specific attributes of a given mine irrelevant (See Kurta, this volume).

For example, models of use by Townsend's big-eared bat (*Corynorhinus townsendii*) in northern Utah indicate that this species is distributed independent of internal characteristics of mines. Additionally, they are randomly distributed among available roosts in lower elevations associated with juniper woodlands (Sherwin, *et al.*, 2000b). However, this model does not work beyond the sub-regional level (scale dependent); in addition, this same model may not be applicable across temporal scales (Sherwin, *et al.*, 2000a). Models of roost affinities are both spatially and temporally scale-dependent, and will likely be extremely effective at local scales. However, applying these models to other locations and/or other systems is inappropriate at best (Sherwin, *et al.*, 2000a).

Investigating the Problem

The sensitivity of local models to variation in spatial and temporal scales make it critical that resource managers and researchers collect appropriate data in their system of interest and consider important variables driving selection of roosts at the local level. Due to the inherent complexity of this system, investigators need to clearly define specific problems and objectives of interest. Therefore, we propose that the a *priori* answering of six questions will aid managers and researchers in identifying local mines of importance to bats.

What species is being addressed?

No two species of bats have the same physiological or natural history requirements (Hill and Smith, 1984), therefore, it is essential that researchers clearly identify which species is/are being studied. Merely stating an investigation of roost selection by "bats" supposes that the entire system is static, with all populations of all species driven by the same constraints. In fact, enough variability exists among populations, and across ranges, that even species-level generalizations are rarely accurate (Sherwin, et al., 2000a).

What type of "use" is being investigated?

When discussing selection of abandoned mine roosts by bats, it is imperative that the type of use being discussed is clearly articulated. Types of use include maternity (pre-birthing, birthing, pre-weaning, weaning, post-weaning), bachelor, mating (lek sites), night roosts, migratory, hibernation, etc. Variables driving selection of roosts differ dramatically depending on the specific type of use being investigated.

What is the spatial scale of interest?

Effects of spatial scale are often ignored when attempting to identify variables of significance to selection of roosts by bats. Spatial scale should be clearly articulated *a priori*, as level of inference is limited to the level of spatial scale of collected data (i.e. data can never be applied at smaller spatial scales). For example, a landscape level study provides no data from which micro-climate inference should be made (see Channel and Lomolino, 2000; Sherwin, et al, 2000b; Sherwin, et al., 2000a; Strayer, 1999).

What temporal scale is being investigated?
Temporal scales range from within and among seasons to use of roosts within and among years. Some species exhibit tremendous variability in relative fidelity to specific roosts (Lewis, 1995; Sherwin, et al., 2000a; Sherwin, et al., 2000b). While all scales of temporal investigation are valuable, care must be made when attempting to impose short-term patterns on larger temporal scales. Systems can only be interpreted as simple (black and white—presence/absence) by a single visit. Only through the implementation of multiple surveys, across temporal scales, can accurate resolution of biological processes be achieved. This is particularly important when attempting to investigate more subtle patterns of roost fidelity and complex use of roosts reflecting complex behaviors (e.g., mating, intra/interspecific behaviors).

Temperature is probably the most important feature affecting use of roosts by bats and can be extremely temporally sensitive. The high surface-to-volume ratio of bats increases thermal stress, making activity metabolically costly. To offset these physiological costs, many temperate bat species respond to environmental stressors (decreased ambient temperatures, lowered concentrations of prey, etc.) by entering torpor and/or hibernation. There is an optimal temperature range that individuals seek, at which they minimize energy output, while maintaining some theoretical minimum of physiological activity. Temperatures below this range may induce permanent cellular damage while higher temperatures may result in costly output of energy. Similarly, other seasonal use requires equally complex thermal requirements (ex. maternity). When attempting to create a thermal profile of internal mine conditions, researchers must be aware of the difference between mean internal temperatures and the variance of internal temperatures. Some species appear to select for stable mean temperatures while others appear to prefer areas with low temperature variance. In addition, resolution of internal temperature profiles can only be achieved through the use of continuous recording devices (data loggers), as temperatures can vary dramatically within a site and can fluctuate tremendously (Figure 1). Point measurements at time of survey are not accurate estimates of internal temperature profile (Sherwin, *et al*., 2000b – Figure 2). Other potentially significant variables that are temporally sensitive include human disturbance and predation.

What level of biological significance will be attributed to occupancy, and what will occupancy infer about roost quality?
This will vary due to specific natural history requirements and current management status of individual species. For example, maternity sites are often viewed as more significant than bachelor sites. This assumes that constraints on reproductive females (with regards to roost selection) are more pronounced than those imposed on males. In addition, this may vary across a species' range. For example, in Utah, groups of hibernating Townsend's big-eared bats are generally small (1-2 individuals), with groups exceeding 5 individuals considered rare. So in Utah, a gate might be recommended for a mine used by a single individual, whereas this same standard may not be valid in New Mexico where wintering groups tend to be much larger.

How will habitat be defined?
The spatial scale of habitat is critical to the management of abandoned mines. It is vital that habitat be clearly and concisely defined. For example, will a roost be defined as the point of

actual interface between the organism and the substrate (i.e. the contact point), the feature of use (i.e. the crack, crevice, rock), the working providing the feature (the drift, stope, etc.), the entire mine (all drifts, stopes, etc), the opening(s) providing access to subterranean workings (many mines include dozens of openings), all mines in a complex (complexes often include hundreds of workings), all complexes in a landscape, etc. The definition of habitat dictates what kind of data will be collected. For example, if habitat is defined as the actual interface of the bat and the mine (point of roosting), only intensive, non-invasive techniques are appropriate to provide data necessary to elucidate selection of micro-climates (i.e. data loggers, continuous video, etc). If habitat is defined as "the mine" – including all openings, less intensive monitoring is necessary, but less resolution is provided. In addition, habitat should not be limited to specific roost attributes (however defined), but should include adjacent vegetative communities and other landscape data, because mines do not exist in a vacuum and selection of roosts can be completely independent of subsurface conditions.

Summary

While the use of abandoned mines by bats is a complex system we do not propose that it is unmanageable. However, it is only through understanding and appreciating the potential variability and reflected complexity of this system that biologically valid data regarding roost affinities of bats can be obtained. If the inherent complexity of this system is ignored and simplistic measures applied, mismanagement will result. By appreciating the potential variability in this system, researchers and managers will collect data applicable to the specific problems being investigated. We propose that by addressing the above questions before initiation of data collection, the likelihood of suitable techniques being applied increases.

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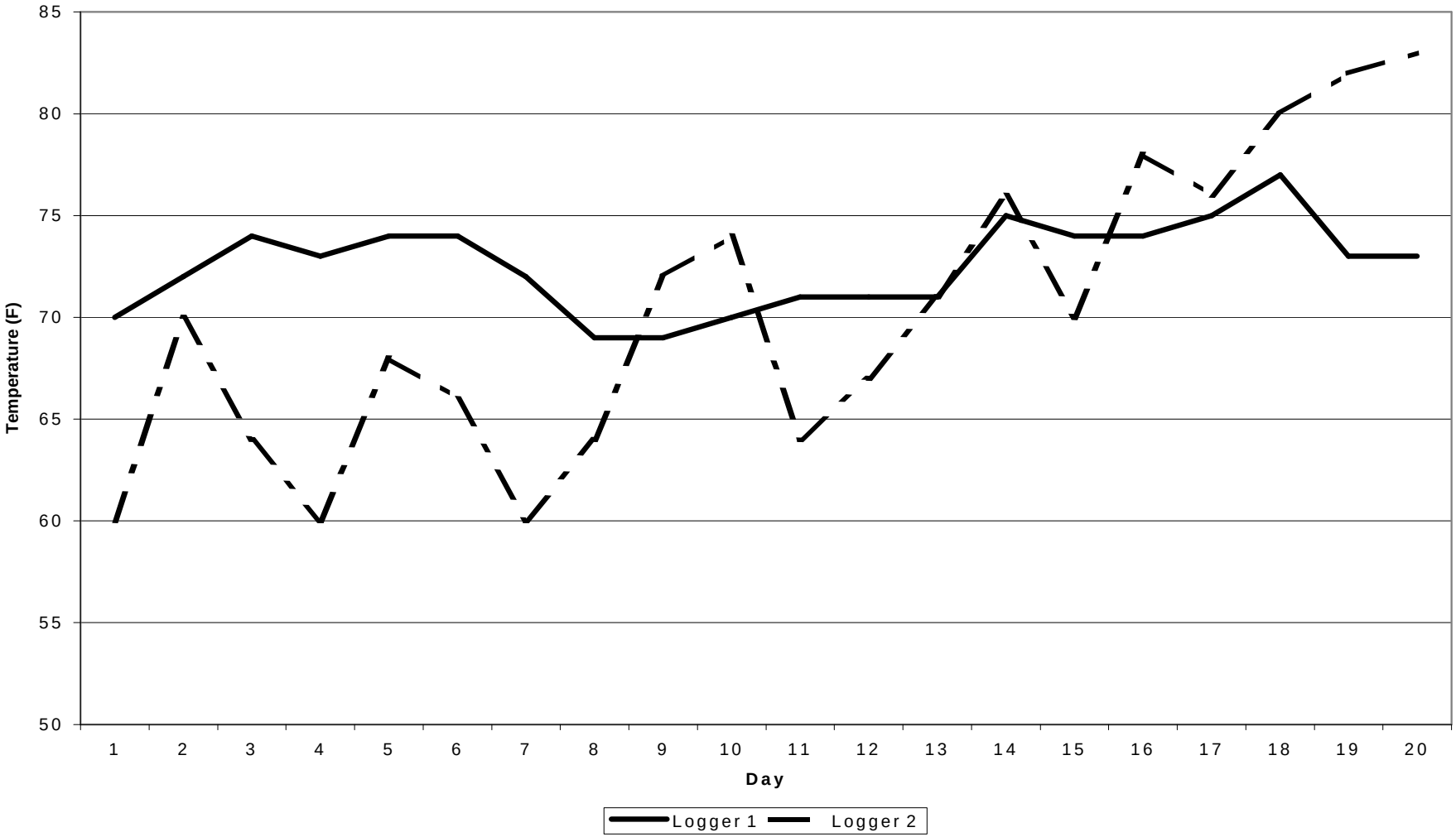

Figure 1. Two data loggers placed two feet apart in the same mine. These data suggest that caution be taken when attempting to create a thermal profile of mine with limited data.

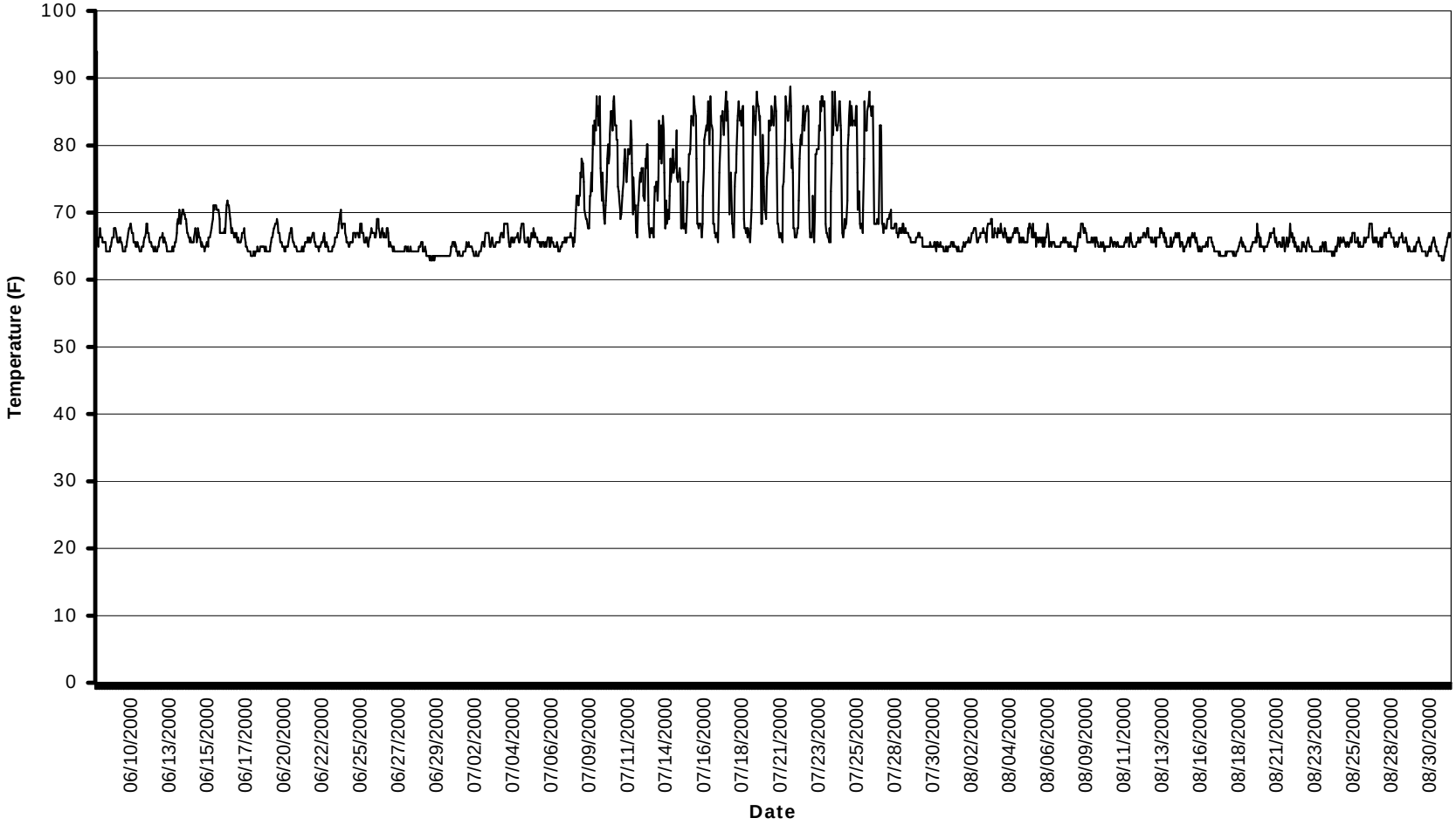

Figure 2. Temperature data collected at the interface of substrate and a maternity colony of Townsend's big-eared bat (*Corynorhinus townsendii*). Maternity colony present between 07-07-2000 and 07-29-2000. Internal micro-climate is regulated by the roosting colony and would appear to be "unsuitable" for a maternity colony based on simplistic sampling of temperatures.

PRE-MINE CLOSURE BAT SURVEY AND INVENTORY TECHNIQUES

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Abstract

Programs to safeguard abandoned mines have stimulated active programs to evaluate them for wildlife use, particularly use by bats. Experience gained over more than a decade of surveying abandoned mines has demonstrated that we still do not understand enough of the biology of the bat species commonly using abandoned mines, particularly in the West, to accurately predict patterns of use. Surveys are required and experience again has demonstrated that external surveys require specialized equipment and vastly more time than internal surveys. They are virtually incapable of detecting several types of bat use common in the West and those relying on them must be willing to err on the side of excessive caution to keep from making disastrous decisions about destructive closure based on negative survey results. Although internal surveys require proper equipment, experience and training, they are the most reliable and least labor intensive type of survey for evaluating roost quality. Internal surveys provide data from which more informed decisions about appropriate types of closures of mines, particularly those which are complex and have multiple entrances. They can provide critical information for the design of both protective and destructive closures. A small, steadily-growing pool of qualified surveyors makes internal evaluation more feasible and an enlightened attitude on the part of several agencies now permits formal training and experience in abandoned mine entry. In recent times, shaft evaluation has become feasible and can make a considerable contribution to informed closure decisions where shafts comprise a high proportion of abandoned workings. Orders of magnitude more complicated than entry of horizontal workings, specialized equipment and experience is required. Although marginally effective for bat surveys in shafts, relatively new down-hole camera technology has proven itself to be useful in identifying blind shafts and thus eliminating time intensive internal evaluation of working with virtually no bat potential. In districts with large numbers of shafts, this technology has saved hundreds of hours of survey time.

Introduction

As illustrated by Sherwin *et. al*. (this volume), the use of abandoned mines by bats is complex, as is the environment provided by the mines they use. The use of abandoned mines by bats is sensitive to both spatial and temporal scale, making any short term evaluation of abandoned mines difficult. As more time has been devoted to understanding this system across these scales, the more we have learned, and the better we are able to evaluate and predict the use of mines by bats. Experience over the last decade demonstrates we had only limited understanding of the capabilities, habits and requirements of many species of bats using mines and we still have a great deal to learn. Sherwin *et. al*. (this volume) emphasize that extrapolation from one temporal or spatial scale to another is risky. For example, use of correlative data of internal temperature and specific bat use at one site to judge another abandoned working as suitable or unsuitable, without appropriate survey, courts disastrous decisions. These problems are magnified when this same data is applied across larger spatial or temporal scales.

The following should not be taken as a comprehensive manual on mine evaluation, rather it points out stumbling blocks and factors that can be easily overlooked. It should be used as a starting point and a guide for refinement of a local program. The process of evaluation of abandoned mine use by bats is complicated and must be adjusted to accommodate regional differences, time schedules and availability of expertise. The material presented in this document is only applicable within the framework of the question which is being asked. For example, a biologist wishing to understand local population dynamics would apply these techniques over several years and gradually accumulate a more complete picture. Several years of surveys would be required to resolve patterns exhibited over a multi-year period. In contrast, a local manager who is limited to a single year of survey time, or worse, a single survey, is unlikely to resolve complex spatial and temporal patterns of use. Therefore planning of surveys must consider the least labor intensive and most productive approach and the limitations of the data must be understood prior to its interpretation. Sherwin, et al. (2000a) present effort curves which show average times required to resolve patterns of use in abandoned mines by *Corynorhinus townsendii*. This work emphasizes the need to understand what could be learned from single compared to multiple visits to the same mine workings.

Inventory and Initial Survey

Even though persons doing external surveys (either initial surveys or external bat surveys) are not required to go underground, they should realize that hazards exist on the surface around abandoned mine openings and they should have proper training on these hazards and how to avoid or minimize them. Shafts are very dangerous and surveyors should be specifically trained to approach them. Navo (1995) discusses possible levels of training for personnel as does Perkins and Schommer (1993).

An inventory is simply the location and generation of a map of all mine features in a project (an inactive mine or group of inactive mines scheduled for closure). An initial survey involves description of the mine openings (features) and recording of all information that can be gathered without underground entry including: dimensions, elevation relative to other openings, airflow direction and airflow temperature, obstacles in opening (rocks, vegetation, limbs, trash, portal or headframe timbers), potential hazards, depth of the mine feature (vertical or horizontal) as can be observed from outside, presence of internal complexity (drifts, crosscuts, raises, winzes or stopes) which can be observed from outside, and observations of any wildlife or wildlife sign (excrement, carcasses, staining, discarded parts of insect prey etc.). In some cases mine maps are available that can provide insight regarding the size, internal configuration and possible interconnection of multiple openings. However, for many older mines, no maps exist, or workings may have been modified subsequent to the creation of maps. The size of the mine dump is not a reliable indicator of internal volume. Typically a large dump indicates a proportionally high volume of internal workings but the inverse may not be true.

Airflow can indicate at least moderate size, multiple openings at different elevation, and complexity, but lack of airflow does not indicate their absence. Airflow in mines with single openings may be caused by barometric pressure changes. In mines with multiple openings at different elevation, airflow will typically change direction with season, and will cease for varying periods at seasonal turnover points. As the outside temperature drops below the mean annual temperature, air will generally exhaust from higher openings. It will exhaust from lower openings as the outside temperature rises above the mean annual temperature. However, there are numerous examples where this does not occur and no explanation of airflow patterns exists.

In an initial survey, a mine can sometimes be eliminated as a possibility for bat habitat. If the rib (side), back (ceiling) and floor of shallow adits and the rib (side) of shallow shafts can be observed to determine that no lateral workings are present (blind) and no sign of wildlife is seen,

the mine probably has low potential as bat habitat. If a shaft is flooded above any lateral workings or if an adit is flooded to the back, even periodically, it can be considered to have low potential. However, even in some very shallow mine features, it is sometimes impossible to distinguish depressions from lateral workings. Adits as shallow as 10 ft have been found to have maternity colonies and guano accumulations from them are easily obscured by rock or debris on the floor. Significant colonies of bats have been found in lateral workings, impossible to see from the shaft collar, off of shafts as shallow as 10 ft. Reliable determination from the surface that a shaft is blind can be difficult in shafts as deep as 10 ft, highly unreliable in most down to 30 ft and virtually impossible in those deeper than 30 ft. The presence of shaft timbers makes reliable evaluation even more difficult. The use of a current generation of small, light video cameras offers a technological solution to the difficulties of finding lateral workings in shafts without the necessity of shaft entry. This is discussed below in the section on Shaft Evaluation.

Internal or External Surveys

If a mine feature cannot be eliminated as wildlife habitat by an initial survey, an external or internal survey is warranted. A decade of experience by many surveyors has demonstrated that external surveys are generally much more time consuming and can be less reliable for determining some kinds of use than internal surveys. Although this discussion treats external surveys as a fall-back option to be used when restrictions or underground hazards prevent a thorough internal survey, external surveys can provide data that internal surveys cannot. Some of the situations which favor internal surveys include: 1) large, complex underground mines with the possibility of multiple openings, 2) an area has a high number of scattered openings and underground connections are unknown, 3) time to conduct surveys is limited, 4) an understanding of interconnections required to maintain airflow to support significant bat use is needed. Some of the situations which favor external surveys include: 1) accurate counts are required for subsequent establishment of population trends, 2) data is required to establish which of several entrances are used by bats, 3) situations described below in A. In many situations, detailed knowledge of bat use requires a combination of both internal and external surveys.

Bat Survey Decision Key

The following decision making processes are presented in the form of a dichotomous key where each couplet references additional options. These are presented below and subsequently discussed in greater detail.

A Complete Internal Survey Possible.....B (below)

An internal survey should be conducted until at least a high proportion of the mine is evaluated before declaring that no bats or sign have been encountered. Generally, if bat use in a mine is significant, bats, sign, or both are encountered before the entire mine has been evaluated. It is seldom possible to see all of large and complex mines but it is also seldom necessary. If no evidence of bats has been encountered and the mine has inaccessible levels, large stopes which cannot be accessed, or levels in shafts which cannot be accessed, either the search must be expanded or an external evaluation is required.

A' Complete Internal Survey Not Possible.....G (below)

Reasons in A, hazards prevent or force termination of internal survey, authorities will not permit.

When it is determined that an internal survey is possible the following approach is one that has been used by one of the authors (JSA). Although continuously updated as understanding has changed, it was originally proposed by Altenbach and Milford (1991) and modified by Altenbach

(1995, 1999). It has been used, sometimes with modification necessitated by local conditions, for mines in much of the United States.

B Cold Season Survey

No Guano, Sign or Residents.....**F**
Guano or Other Sign.....**C**
Residents.....**E**
Internal Conditions (Water) May
Obscure Sign.....**C**
All, or enough, of the mine cannot be seen.....**G**

C Warm Season Survey

No Residents - Night Roost, Migratory Use,
Specialized Reproductive Behavior,
Undocumented Use.....**D**
Residents.....**E**

D Fall or Spring Survey, Dropping Boards

No Residents, No Additional Sign
(Roost Abandoned, Used Periodically).....**E, F**
Residents, Additional Sign.....**E**

E Decision to Bat Gate Involving Following Questions

Is a threatened or endangered species involved?
Is use significant (determined regionally)?
Are alternative features, used in the same way, nearby?
How feasible is bat-compatible gating?
Will preservation of an abandoned roost provide habitat or mitigate habitat destruction elsewhere?
Is it likely survey missed periodic use?

F Closure By Any Means

Could survey have missed periodic use? Realization of assumptions which must be made if an external survey was applied. If any concern, final internal inspection, mist netting and tarping, or smoke bombing before closure.

G External Survey

By similar accumulation of data, involving observation of activity at openings, then decisions to E, F or G but with realization of the severe limits of external survey. With external survey techniques, significant kinds of use, eg. hibernation, reproductive behavior, migratory stopover, have a high probability of being missed.

Discussion of Internal Surveys (A)

An internal survey, conducted by an experienced bat biologist (experienced with the bat species which are likely involved based on geographic region, and experienced with bats and bat sign in underground workings), also trained and experienced in abandoned mine entry, has proved to be more reliable and less labor intensive than any other survey option. A team approach combining an experienced bat biologist, familiar with the hazards of abandoned mines, with a safety monitor, with a higher level of abandoned mine training and experience is equally appropriate. The safety monitor must make a decision that an internal survey is possible within the limits of safety or must make a decision to abort an internal survey if warranted. It is difficult for a safety

monitor to watch every move of someone unfamiliar with basic mine hazards. Their lack of awareness of common and obvious underground hazards (eg. open winzes) invites catastrophic injury or death. A bat biologist, inexperienced in abandoned mine evaluation is often unaware of common hiding places and bat sign in underground workings.

Training and Safety Considerations for Abandoned Underground Mine Entry
As little as ten years ago, agencies and many private entities generally prohibited employees from entry of abandoned underground mines and were hesitant to hire even qualified consultants. Over the last ten years, a gradual and cautious change in attitude about entry of abandoned mine workings has taken place on the part of some Federal, State and private entities. Formal training on Abandoned Mine Entry by the Bureau of Land Management (Course No.3000-83), Forest Service (National Minerals Training Office, Mine Safety), combined with MSHA New Miner and Annual Underground Refresher training, has provided a small, but growing pool of persons qualified for entry.

Appendix 1 lists some required safety equipment. Internal surveyors should realize it is useless without comprehensive training in its use and limitations. Both are useless without thorough training in, and understanding of, the hazards associated with underground mines.

The subsequent discussion of internal surveys of abandoned or inactive mine workings is provided to illustrate the extent to which such mines are used by bats and the difficulties inherent in assessing that use. This is not a recommendation for others to conduct such surveys nor is it intended as a "how to" description. Abandoned or inactive underground mines are not "safe" to enter and there is no way they can be "made safe". (By the same reasoning cars and airplanes are not safe to ride in and mountains and lakes are not safe to hike or swim in). Persons entering them must understand and accept the associated risks. Anyone entering abandoned underground workings must have appropriate training and experience with the associated hazards and with the ways to minimize them. Caving experience does not qualify someone to enter an underground mine.

Cold Season (Internal) Survey (B)

Hibernating bats typically leave no trace of their presence and mine entry during this period is required to survey for them. Exceptions would include situations where pre-hibernation swarming of large numbers of certain species would be detected by external surveyors. During the initial cold season survey note is made of the layout of the mine and the possibility that parts of the mine cannot be explored. If it is determined that significant parts of a mine cannot be explored and no bats or bat sign is observed, external, warm season evaluation of the mine is required. Careful checking of even tiny cracks or holes in the back and rib is necessary since several species of bats hibernate in such openings. The evaluation of sign (guano, staining, discarded invertebrate parts, remains of dead bats) unless present in very large quantities, requires an experienced eye. An experienced surveyor should be able to identify the guano of many of the species, or at least most of the genera, likely encountered.

If bats are encountered in a cold season survey they must be identified with minimum disturbance. An experienced surveyor should be able to correctly identify any species using an abandoned mine. Mine lamp beams should not be aimed directly at hibernating bats and any attempt at identification should be limited to the minimum time possible. Getting exact counts of clustered or scattered bats does not warrant the disturbance involved. A quick estimate of numbers or of the size of a cluster is adequate and disturbance is kept at a minimum.

The above descriptions emphasize the necessity for experience on the part of an underground surveyor. Only an experienced surveyor is likely to find the sign indicative of use by all but very large numbers of bats, and bats which may use mine workings in an unobvious way may be

overlooked. Highly experienced underground explorers with no bat experience (eg. miners, geologists) are notorious for completely missing obvious sign and conspicuous bats.

Warm Season (Internal) Survey (C)

Warm season generally means at a time when bats are active and flying in and out on a regular basis. The exact timing of these surveys will vary geographically and with yearly variations of local climactic conditions. For example, an unusually cold or prolonged Spring may cause a delay of a month in maternity activity. Consultation with local bat biologists is necessary to time warm season surveys. Maternity colonies may occupy one roost before delivery of pups, another for delivery, and a third after the pups are volant. This complexity must be considered in the timing of warm season evaluation.

Internal surveys during warm season are conducted with extreme care. Many species of bats are intolerant of disturbance at a roost site, especially during the time they are having and caring for pups. Disturbance can easily cause relocation of a colony and worse, mortality of pups (Mohr 1972, Humphrey and Kunz 1976). A mine is approached, entered and explored quietly during a warm season survey. Serious disturbance of alert bats in order to make identifications or counts is not warranted. If bats cannot be identified, or if an approximate count is not possible, without disturbing them, external evaluation involving capture or bat detectors and experienced interpretation is in order.

If no bats are found in residence, guano may contain discarded invertebrate appendages and wings that indicate night roosting. If night roosting is suspected, the mine is again entered at night to observe the species and numbers involved. The portal can be monitored with a bat detector or individuals can be captured with mist nets or harp traps. Bats are seldom encountered during an internal survey in mines used as migratory stopover roosts and identification of the species typically involves a careful search for carcasses which can then be identified. Repeated visits to the mine in the time period when migration is thought to occur makes encountering and identification of the residents more likely. Material placed on the floor where guano accumulation occurs (dropping boards) can resolve the time and amount of guano deposition. Recent discovery of mines used entirely for complex reproductive behavior (Brown, 1999) demonstrate highly significant, periodic use that can be difficult to resolve. Repeated external and internal observation was required to clarify this highly significant use after evidence was noted on an internal survey.

Shaft Evaluation

In many mining districts, shafts are common and may constitute a high proportion of the abandoned workings. In localities in many Western States, a high proportion are not flooded and many provide bat habitat. Because of the greater difficulties involved, many private interests and government reclamation programs have not been evaluating shafts as potential habitat prior to closure. Although sometimes sealed with non-destructive closures (ex., rebar grates), typically because of historic preservation requirements, most have been close destructively without evaluation or consideration of habitat potential. A notable exception is the Abandoned Mine Lands program in New Mexico where shafts have been evaluated and bat compatible closures have constructed if appropriate. Ten years of extensive experience evaluating shafts (over 2000) in New Mexico, California, Nevada, Utah, Minnesota, and Texas by the authors, has demonstrated that bats readily use them in all of the ways that horizontal workings are used, and the incidence of bat use of shafts is actually higher than in horizontal workings (Altenbach, et al., In Prep).

Lateral workings are notoriously difficult to detect in shafts and this is compounded by shaft timbering. A second issue is that even though internal shaft evaluation can be done safely, it is

an order of magnitude more difficult and time consuming than horizontal mine evaluation because of the highly specialized equipment required to compensate for the higher risks. It requires more experience and is generally not recommended unless a specialist is available. The use of vertical climbing techniques is extremely dangerous for shaft evaluation because of the probability of material falling from the collar or rib. Surveyors using climbing techniques to access vertical workings are reckless, and jeopardize a cautious acceptance of internal mine evaluation procedures!

Use of down-the-hole video cameras, hard-wired to a surface viewing screen, has proved an effective tool to determine if a shaft is shallow and blind and thus does not require time consuming additional evaluation. This technique can also identify shafts that have one or more levels where bat use is possible and internal evaluation or conservative assumptions about use warranted. Without internal evaluation, this information would make a bat compatible closure a more reasonable alternative than if the internal complexity remained a mystery.

This technique is not a substitute for internal evaluation of shafts with lateral workings, deep shafts, or timbered shafts where a bat, or bat sign is probably not visible to the video camera. If internal evaluation is not possible in these shafts, it must be assumed that at least appropriate habitat for a variety of bat use exists and the mine feature should be surveyed externally. Highly significant hibernation sites for several species have been found to depths of nearly 3000 ft and maternity and bachelor colonies have been discovered at depths of over 400 ft. In addition, even blind shafts (without lateral workings) can trap cold air providing ideal hibernation sites for bats. Other shafts are warmed at depth, perhaps by geothermal heating, and provide warm temperatures ideal for other kinds of use.

Discussion of External Surveys (G)

External surveys require experienced personnel and a larger number of person-hours than internal surveys. Specialized equipment which is vital for effective external surveys can be costly, eg. night vision and sophisticated acoustic monitoring equipment, and can require extensive experience to use properly, eg. acoustic monitoring equipment. If an external survey is the only option, techniques are discussed by Navo (1995), Navo et. al.(1995) and Tuttle and Taylor (1994). Rainey (1995) provides an excellent overview of equipment, and references, to assist external surveying.

Applications

External survey techniques are suited for resolving warm season use (maternity or bachelor colonies) where exit or entry flights occur nightly over an extended period. Pre-hibernation swarming typified by large colonies of *Corynorhinus townsendii* and *Myotis lucifugus* may be readily detected if the timing of these events is predictable in a given locality. If these types of use are expected, external surveys may be appropriately timed and implemented to detect them. External surveys can only provide positive data, so absence of evidence should not be interpreted as evidence of absence. Uses such as migratory stopover, short-term responses to climatic changes, use in cold season by small numbers of bats or by bats which do not swarm are difficult to detect. In addition, external techniques are not reliable for resolving events which happen inside a mine, such as reproductive behavior. Data from an external survey cannot be applied across temporal scales and inference cannot be made about past or potential future use.

External surveys are particularly useful when combined with internal surveys at large, complex mines. Some bats (eg. *Antrozous* and some species of *Myotis* and *Pipistrellus*) are very secretive and are easily missed by experienced internal surveyors. If no bat use is detected in a large mine and it is clear that many parts of the mine are not accessible for close evaluation, an external survey of entrances in warm season may be appropriate.

Timing and Implementation

The timing of surveys is critical and depends upon the seasonal changes in bat activity typical of the region in question. Publications on the biology of species that might be in a particular area, as well as consultation with local bat biologists, provide a good starting point for planning the timing of external surveys.

Surveys should be conducted on nights without rain or strong wind, by observers stationed at least 15 ft off to the sides of the mine opening. Setup must be kept quiet be completed at least 30 minutes before sunset. Although red lights have been recommended for external surveys, recent evidence suggests bats may be more sensitive to red light than previously thought. After bats can no longer be seen silhouetted against an evening sky, night vision or InfraRed (IR) video camera equipment can be used to observe a mine opening. Observations must be maintained for at least 2 hours after sunset.

Bats often prefer specific entrances of multi-entrance mine complexes and disturbance by surveyors at this entrance is likely to cause use of an alternate. Even when surveyors attempt to be quiet, a large body of evidence suggests that bats are likely to be aware of their presence. Therefore, all entrances in a particular complex should be surveyed on the same night.

Equipment

The technology for remote, data logging, acoustic or proximity detector monitoring of mine openings has grown over the last decade. Rainey (1995) gives an overview of some examples but the availability of relatively inexpensive video cameras has revolutionized the field. These small cameras with highly sensitive IR detection can record bat activity at mine openings at distances of well over 50 ft. Unattended cameras, set to actuate at predetermined times, can collect data at as many mine openings as a surveyor has cameras. At one sixth the cost of high resolution night vision devices, the external survey capabilities of a single surveyor is increased enormously. An added benefit is that a carefully positioned, unmanned camera will be less likely to cause disturbance and use of alternate mine opening by bats. An IR video camera, coupled with a sophisticated acoustic monitoring system, provides the capability of accurate timing and resolution of activity with improved species identification.

External Capture Survey

If active bats cannot be identified during an internal or external survey, or if determination of sex or reproductive status is required, capture of some individuals for close examination may be warranted. Persons conducting capture surveys must be capable of field identification, rabies immunized and have necessary state and/or federal collecting permits. The help of local bat biologists, experienced in the use of capture devices to minimize injury to bats, and familiar with handling of local species is appropriate. Setup of mist nets or harp traps is completed at least 30 minutes before sunset and is done as quietly as possible. Nets or traps (with someone in attendance at all times) are left up at least two hours after sunset or later if there is a possibility that the mine is used as a night roost. After enough bats have been caught for identification and released, the capture devices are taken down to minimize disturbance.

Decision to Install Bat Compatible Closure (E)

Significance

If a threatened or endangered species is using a mine the decision to use some type of bat compatible closure is clear but must involve consultation with appropriate State and or Federal authorities. Presence of a Species of Concern, formerly a USFWS Category II, might be more significant than species not so listed.

The question of significant use is difficult as it is dependant on location and community structure. For example a single, hibernating individual of one species might not be significant in one part of its range but would be in another. Variability in the use of roosts within a species' range makes it impossible to create range wide rules about significance. In some regions single hibernating individuals in small, scattered mines are typical, in others, small to large groups are typical. Input from local bat biologists is necessary to evaluate numbers and conditions of use in the light of comparison with other local populations or trends in population size. Significance must also be weighted against the presence or absence of a comparable mine feature or protected natural roost site, used in the same way, being nearby. All scenarios must be weighed against the complexity, feasibility, cost and reliability of such closures.

A maternity or bachelor colony of any species is significant and cause for installation of bat-compatible closure. The use of a mine by bats in any way not documented or not understood should be considered highly significant unless it can be demonstrated otherwise. All closures but must be weighed against involved costs, feasibility and availability of comparable, more easily gated features nearby.

Another complicating factor is the movement between roost sites over seasons or even years. Maternity colonies of some species such as *Corynorhinus townsendii* routinely move among available abandoned mines over the course of gestation, birth, growth and maturation of the pups (Sherwin, et al., 2000b). Before a site is declared abandoned, additional evaluation over at least a year to check for fresh sign, or bats, is prudent.

Timing of Mine Closure (E, F)

The selection of appropriate "time windows" for non-bat-compatible closure must minimize the chance that unknown residents will be trapped inside. Installation of bat-compatible closures must likewise be timed to minimize disturbance of residents. These time windows will vary with the type of use, the species present and the region of the country. Closure activities need to be coordinated with the help of local bat biologists.

Conclusions

When the systematic evaluation of bat use in abandoned mines was undertaken on a near national scale a decade ago, it was hoped that correlations between external characteristics of an abandoned mine and its use by bats could be established. This would at best eliminate the need for internal evaluation and at least simplify the survey process. Tuttle and Stevenson (1978) and Tuttle and Taylor (1994) have suggested that if the internal configuration, configuration of openings and mean annual surface temperature is known, internal temperature conditions, and thus suitability for bat occupancy, can be predicted. They infer, perhaps correctly, that mines with multiple openings and complex internal configuration are likely to have variations of internal conditions that maximize the chances parts will be suitable to bat use. However, as Sherwin *et. al* (this volume) have shown, correlations of use and temperature, especially microenvironmental temperature, have been difficult to establish. Small, uncomplicated mine workings can have large and significant use by bats. Even if we could make broad spatial and temporal scale predictions about temperature and use, we are still unable to predict internal temperature itself.

The size, internal configuration and number and configuration of openings of most mines is nearly impossible to determine by external evaluation. In some instances, mine maps may be available but our experience shows that these are seldom complete. The quantity of waste rock at a portal is not necessarily an indicator of internal volume. Ventilation openings, common in many mines (Hardesty, 1988), sometimes have no waste rock around them, are often small and

many times inconspicuous. Where there are several mines in a restricted area, the configuration of surface openings gives virtually no indication of how, or if, the internal workings connect. Airflow measurements must be made at all openings to even guess at internal configuration and a variety of conditions can influence airflow. Strong airflow at a mine portal suggests that there are other openings but lack of airflow does not indicate their absence. In addition, the airflow patterns of some mines as yet cannot be explained. Similar mines, close to each other, can have very different internal temperatures because of geothermal heating or for unknown reasons.

For the majority of abandoned mine sites no mean annual temperature data exists. Often a town for which temperature data is available is at a different altitude than a mine site only a few miles away and has different surface temperature conditions.

Bat biologists have a great deal to learn about even basic bat biology. This data has been accumulating for many years and a great deal is known about many species but even for very common species, large gaps exist. For example, *Myotis yumanensis* is an extremely common warm season resident of the Rio Grande and Pecos drainage in New Mexico but until a migratory stopover roost of this species was discovered in a deep shaft in the mountains of central New Mexico, **nothing** was known of the non-warm season activity of this species in New Mexico. In June the internal temperature of this mine is several degrees cooler than any known maternity roost site of any bat found in New Mexico. However, in June female *Myotis thysanodes* with near term foetuses were found in torpor in these workings. A possible hypothesis is that the animals may be driving embryonic diapause with this behavior. Both of these examples of bat use were considered highly significant and justified bat-compatible closure. We are continually surprised by finding bats at great depth in shafts in both warm season and cold season.

Until comprehensive research provides a measure of predictability, we believe the systematic evaluation of all mine features scheduled for closure provides the only possibility for combination of the goals of securing abandoned mines for human safety and protecting bats that may rely on them. We have to consider that almost any mine can be potential habitat for bats and the only way to know is to look.

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Appendix 1: Safety Equipment for Abandoned Mine Entry

The **MINIMUM** safety equipment required for underground work includes: Approved hard hat with chin strap, steel-toed boots, three sources of MSHA-approved light, multi-gas detector with at least O_2, CO, Combustible Gas capability, O_2 detector with remote sensor head. Additional equipment such as a respirator with filters is useful in some situations where particulates, radioactive particles or pathogens may be a factor. If any vertical climbing is required, the appropriate, specialized equipment and training (as well as practice) in its use is obviously vital. Vertical climbing in abandoned mines, especially in shafts, is an order of magnitude more dangerous than typical vertical mountaineering practice and is warranted under only rare circumstances. Training and supervised experience with this safety equipment, as well as thorough understanding of the circumstances and conditions which necessitate its use, is vital.

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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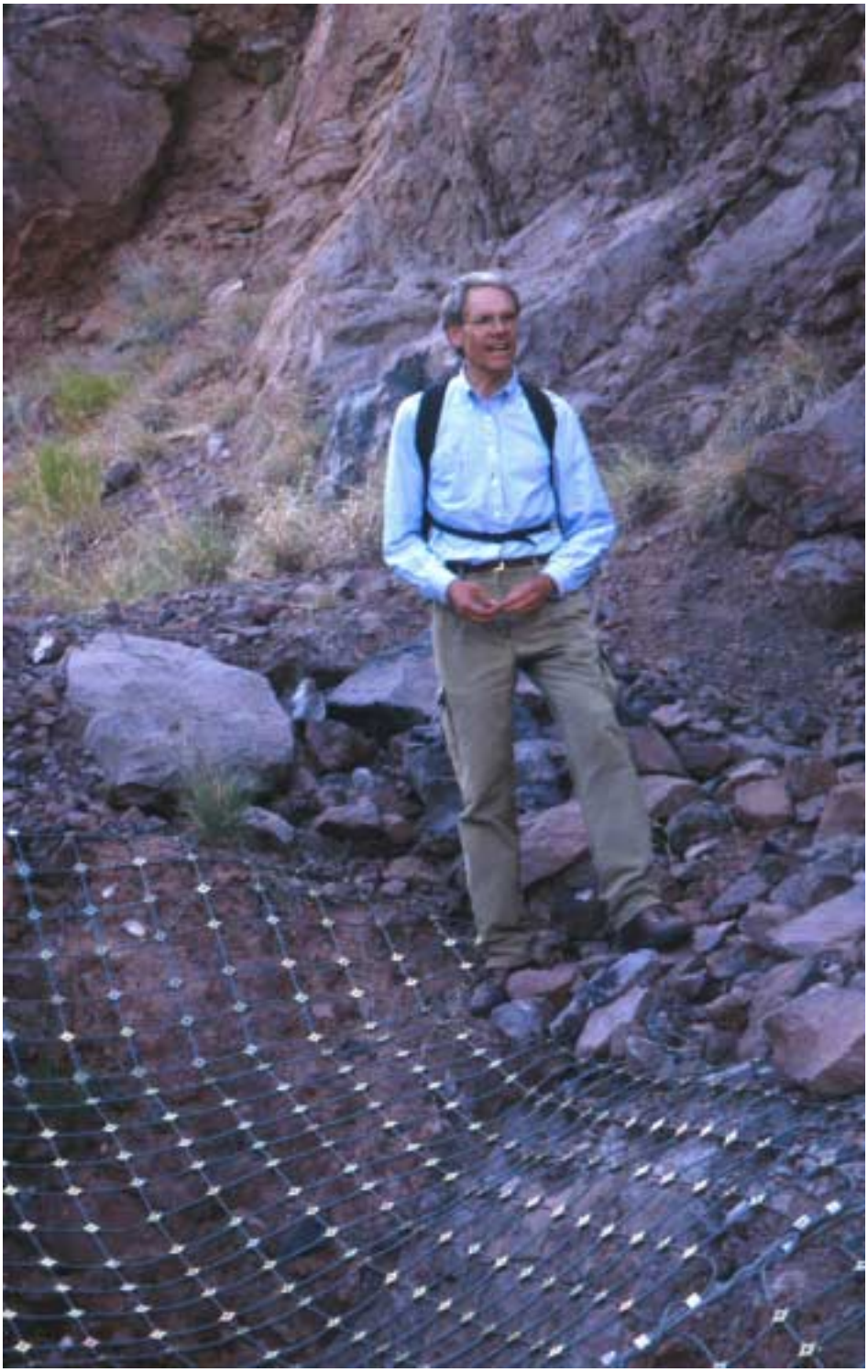

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Figure 16

NEW MEXICO EXPERIENCE WITH BAT GRATES AT ABANDONED MINES

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Abstract

Following external and internal surveys of abandoned mine workings, the New Mexico Abandoned Mine Land Bureau designs and installs bat-compatible and bat airflow closures for mines with significant bat habitat. The Bureau has developed various designs for shaft, adit and stope openings and for a variety of rock conditions at these openings. These closures seem compatible with most bat species in New Mexico that use abandoned mines and keep most people out. However, vandalism has been a problem and several grates have been breached. Solutions to reduce vandalism include refinements in design and use of materials, camouflage of the mine openings where bat grates are installed, and closure of roads and trails that lead to grated mine openings.

Introduction

The New Mexico Abandoned Mine Land Bureau (NM AML) closes and safeguards up to a couple hundred mine openings in the state each year. Before design of the closure method, the Bureau's biologists enter most abandoned mines to check for internal bat habitat, including use for winter hibernation, summer maternity roosting and night roosting. Where significant bat usage is found and a reasonable bat closure can be built, NM AML designs steel bat grates at or inside the mine openings. In the last ten years, the NM AML program has designed and constructed over sixty bat closures at shaft, adit and stope openings.

Any discussion of bat grate design inevitably ends up focusing on the problem of vandalism. People seek to enter and explore abandoned mines for a variety of reasons: to collect rock and mineral specimens, to search for old mining artifacts, or simply for the adventure of exploring dark and dangerous places. The fact of vandalism drives many of the decisions we make in bat grate design and raises issues regarding long-term inspection and maintenance.

General Design Criteria

To the extent that we understand the needs of bats, consideration of the following criteria[1,2] are important in designing bat grates:

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[1]Tuttle, M. D., and D. A. R. Taylor. 1998. Bats and Mines. Bat Conservation International, Inc. Resource Publication No. 3, Revised Edition. Austin, TX. 50 pp.

- avoidance of adverse impact to airflow and surface water drainage patterns to maintain mine temperature and moisture conditions;

- reduction of the number and sizes of vertical columns and other vertical obstructions and maximization of the number and sizes of horizontal bat fly-through areas;

- use of designs that are as simple and safe as possible to construct and that do not present a danger to the public; and

- use of durable, vandal-resistant designs that prohibit unauthorized entry, safeguard the general public from the hazards of unprotected abandoned mines, require minimum maintenance, and are easily repaired if breached or damaged.

Minimizing the impacts to airflow patterns is achieved by giving attention to several factors. The efficient use of construction materials decreases the reduction in cross-sectional area at the grate. Streamlining of the grate installation, particularly in adit grates where there is significant movement of air, can be important. It is also important to maintain air passage at mine openings that significantly contribute to ventilation of the mine workings, even where bats seldom or never use these openings.

Surface drainage into underground mines may be important for maintaining proper humidity conditions for bat habitat, particularly if groundwater is not present in the mine workings. Surface drainage patterns can be maintained by placing pipes through the concrete footing for the grate or by other means appropriate for the site. NM AML safeguarded one stope opening unused by bats in the mine, but which captured the surface runoff from a half-acre of rocky hillside, by partially filling the opening with riprap. This allows runoff from summer thunderstorms to continue to enter the mine.

Reducing the vertical obstructions and maximizing the number of bat fly-through spaces serve to eliminate the predation that occurs if bats need to alight, slow, or circle at the structure. Generally fly-through spaces are 5 3/4 inches high and a minimum of 24 inches wide. In openings that directly access areas used as nurseries, where the mother bats will make frequent trips through the grate, the uppermost two or three crossbar spaces are often increased to six inches.

Designers need to listen to their bat biologists for the particular needs of the bat species being protected and of the type of bat use in the mine workings. Grate requirements can vary according to the species and type of bat habitation in the mine, e.g., hibernaculum, maternity, or day or

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[2]Hawthorn, J., and J. Thornton. No date. The Common Sense Guide to Cave Gates. American Cave Conservation Association/CMS. 20 pp.

night roost. Some species do not accept bat grates, except at hibernation sites, and information on grate acceptance for some species is inconclusive.

It is important that bat grates be constructed when construction activities will cause the least disruption to the bats using the mine. This depends on the type of bat use of the mine. In New Mexico, we often build grates in the spring and fall, between the winter hibernating season and the summer nursery season.

All bat structures should be designed to ensure long-term public safety and constructibility. Professional engineers design all NM AML bat grates and ancillary structures.

Finally, I believe that bat grates should be not only durable but also beautiful. I see each one of them as a small monument to humankind's reawakening sense of responsibility for the fate of other species. They remind us of our responsibility to care for the world and those with whom we share it.

Current Design Approach in the New Mexico AML Program

Many bat grate designers have adopted the approach of using stout steel members to construct bat grates. These members are anchored to concrete or to the rock at or inside the mine opening to resist prying, jacking, and pulling of the grate components. We fill the vertical columns with reinforced concrete or grout and a continuous length of reinforcing steel. This prevents cutting by torch and stiffens the entire assembly against prying and pulling. Where rock conditions are competent at the adit portal, we anchor the columns and at least half the horizontal crossbars to the back and ribs using ¾-inch diameter steel rods tightly fitted into drilled holes. Grates are generally installed close to the mine entrance, to protect the public from as many hazards as possible.

For all of our bat grates, we use weathering steel (meeting ASTM A588 or ASTM A242) which has two to four times the corrosion resistance of mild steel. This steel weathers to a dark rust color and does not require field painting. The dark color helps to camouflage the grate inside or at the mine opening. A concrete sill is cast on the adit floor for column anchorage, to keep the steel above the dirt floor, and to discourage digging underneath the structure. An adhesive vinyl explanatory/warning sign is often placed on one horizontal member. Standardization of materials and design simplifies initial construction and repair of vandalized grates.

As shown in Figure 1, crossbars are usually built from four-inch angle iron rotated 45 degrees for improved airflow, with two small angle internal stiffeners. We place these stiffeners primarily to discourage vandalism; they add little to structural strength. My calculations show that an internally stiffened, weathering steel crossbar (L4x4x3/8), with supports four feet apart, can conservatively withstand a vertical force of at least 3800 pounds and a horizontal force of more than 6900 pounds. When supported eight feet apart, allowable forces are one-half those values.

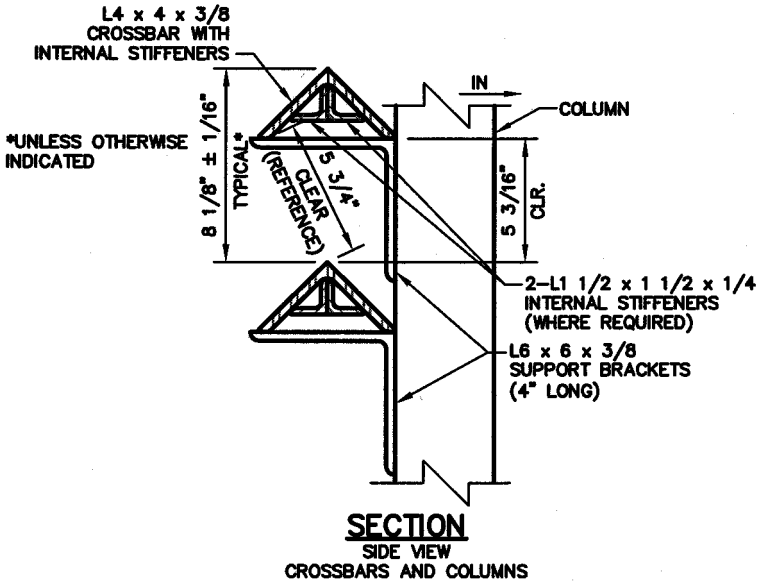

Figure 1

We are beginning to design gazebo-type structures over shafts using two-inch by four-inch structural tubing crossbars with quarter-inch wall thickness. This tubing has similar structural characteristics as the stiffened angle iron crossbars but with significantly less welding required. In areas of high vandalism potential, to address the reduced area of steel to cut through, we can place a continuous high-manganese "Manganal" steel rod inside each tube and fill the tube with concrete or grout. A hacksaw is unable to cut Manganal steel (and consequently is widely used in prison construction) and the concrete or grout discourages cutting with a torch or cutting wheel.

NM AML uses removable locking crossbars, rather than hinged doors, at bat grates where biologists or mineral claimants require authorized access. We specify two security bolts to lock each removable crossbar, which require a special matching pattern in the socket wrench keys. These bolts considerably simplify construction and are highly resistant to unauthorized attempts at removal. The bolts are now placed under the bar, rather than on the outside face of the crossbar, to make it difficult to shear the bolt with a sledgehammer.

Generally NM AML places one or two removable crossbars per grate, as shown in Figures 2 and 3. Short removable crossbars are more difficult to vandalize than long removable crossbars. After a cut near one end, a long removable crossbar may be able to be levered back and forth enough to loosen the opposite locking bolt. Consequently, we make removable crossbars as short as two feet. For removable crossbars this short, two cuts would be needed to breach the grate.

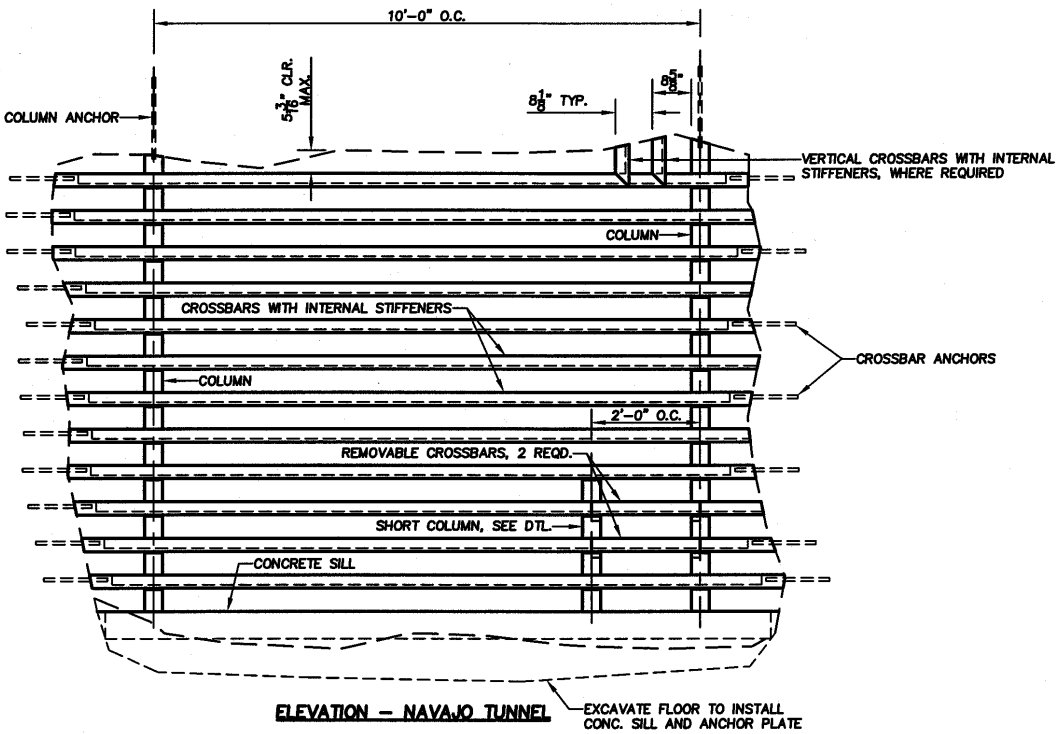

Figure 2

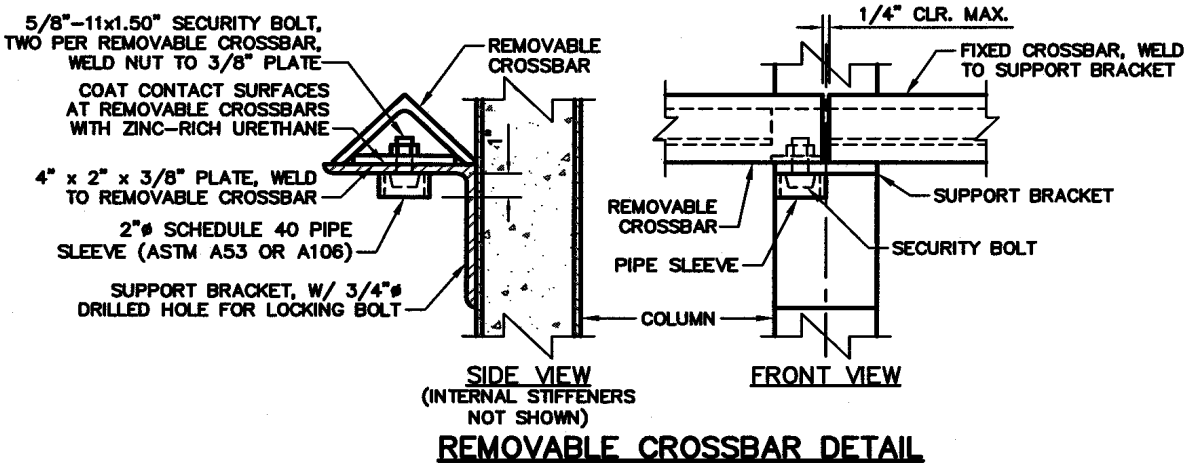

Figure 3

Where rock is soft, collapsing, or extensively fractured at an adit entrance, we have placed the bat grate inside a corrugated steel culvert. The grate is welded inside an octagonal steel frame bolted to the culvert. Melvin Tuttle of Bat Conservation International has recommended that, to reduce predation, the bat grate be placed toward the inside end of a minimum three-foot diameter pipe.

To insure that young children and small persons cannot crawl through the grate, some AML programs are spacing the lower crossbars more closely. This should have minimal impact on bat passage, since most bat flights through grates seem to take place near the top. NM AML is considering adopting this design refinement.

Design requirements for vertical mine openings (shafts and stope openings) are less well defined than for grates at horizontal openings, but we have used the following design solutions:

- fences (often chain link fencing with black PVC-coating to reduce visibility), with or without barbed wire, around the shaft or stope collar, sometimes combined with other bat closure methods such as horizontal steel grates;

- cable netting to maintain ventilation in the mine workings, sometimes with bat windows to provide ingress and egress for small bat populations and at mine openings infrequently used by bats;

- horizontal steel grates inside shaft collars where rock conditions, opening size and shape are favorable; generally for small bat populations that tolerate this design (predation of larger colonies could be a problem since space for exit is restricted) and at openings where bat passage is not significant and maintenance of air flow conditions is the primary consideration; and

- steel bat gazebos that can accommodate larger bat populations, either founded on a competent bedrock collar or using corrugated steel pipe risers held in place by concrete or polyurethane foam plugs cast against bedrock.

In complex mines with multiple openings, NM AML has on occasion used permeable closures that do not allow for bat passage, but simply help to maintain ventilation conditions for the internal workings. We use these at openings with little or no bat usage or where nearby openings offer better locations for bat passage and construction of bat-compatible closures. These airflow closures have included cable netting and grated shaft covers of various designs.

Success in Protecting Bat Habitat

At the Socorro West Mine Safeguard Project, we have the strongest verification of the success of our approach in protecting bat habitat. One of the two mines in this project once held the largest recorded hibernating colony of Townsend's big-eared bats, *Corynorhinus townsendii*, and a significant maternity colony until vandals set mine timbers on fire in the winter of 1992-93.

Carbon monoxide, carbon dioxide, and fire killed many of those bats. In 1996 NM AML safeguarded 12 of the 24 mine openings either with bat compatible closures or with closures that provide ventilation of the mine openings.

Scott Altenbach, bat biologist from the University of New Mexico, has visited the features several times since construction. Hibernating populations of bats have increased steadily since the mine features were protected and the guano piles beneath maternity roosts have markedly increased in size.

New Mexico AML Experience with Vandalism and Partial Solutions

Experience has shown that bat grates require inspection for vandalism and repair of damage. Longer experience may show the need to repair or replace corroded steel members and spalled concrete, to clear rock fall, and to take care of other problems at bat grates.

Of the approximately forty bat grates built in adits by NM AML, we know of seven grates that have been breached. One location was where the rock in the adit was highly fractured and soft. The vandals excavated the rock on one side of the grate to allow a crawl space around the closure. At the other locations, vandals breached the grates by cutting a removable crossbar. At one location the vandals accomplished this with a rotary cutting wheel, at another with a cutting torch, and in the other four by hacksaws.

The breached grates have had several things in common. All breach locations have been in adits at sites with significant visitation either before or after safeguarding. We discovered four of the breached grates at adits within a quarter mile of each other shortly following the publication of the discovery of a rare microcrystal at that site. Only one of the seven breached grates had internal stiffeners in the crossbars, and that one was opened using a cutting torch. To discourage future vandalism, we have fortified the breached grates, now place internal stiffeners in all new adit bat grate crossbars, and place grates inside of culverts where rock conditions near the adit entry are soft, weathered or highly fractured. Since making all of these changes within the last two years, we have not yet experienced further adit grate breaching at those sites.

We have not had significant bat grate vandalism problems at deep shaft and stope closures, and no breaching, presumably because once they were breached vandals would need climbing equipment to enter the mine workings. Bat grates at horizontal mine openings are the easier targets for vandals.

To reduce the necessity and expense of returning to a site to repair and harden breached bat grates, the Utah Abandoned Mine Reclamation Program has built grates made entirely of one-inch diameter Manganal steel bars. We have not adopted this approach because these grates do not have the structural strength and resistance to prying and pulling that our designs have. Manganal grates also remain as vulnerable as our designs to cutting with cutting wheels and torches. However, to increase resistance to hacksaw cutting, NM AML has built a few gates with loose high-manganese steel bars placed inside the internal stiffeners at horizontal crossbars. An

option we have not tried is laying down a hardening weld bead along those points where a saw can be used. Since these beads can be removed with a hammer and chisel, they need to be placed in relatively inaccessible locations on the grate members.

On the hypothesis that grates less frequently visited by the public are less likely to be vandalized (unless in well-patrolled areas), NM AML has restricted access to some sites and planted vegetation in front of some mine openings in an effort to eventually camouflage them. Vegetation is placed far enough from the opening so that when full grown it will not obstruct bat passage. We have limited access by closing jeep trails to mine openings with locking gates and earthen and rock berms and by building fences and bramble barriers in adit entry trenches and across jeep trails in steep terrain. Bramble barriers are dense plantings of cactus and thorny bushes. Barriers to access also make it difficult to get heavy tools, such as winches and oxygen-acetylene or oxygen-propane tanks, to the grate site. The disadvantage to trail closure is, of course, that access is more difficult if repairs are needed.

Prompt repair of breached grates is important to reduce the length of time that mine hazards are exposed. Prompt repair may also frustrate the vandals and, over time, lead to less vandalism. This implies that regular site inspections are necessary. For many Western abandoned mine programs, covering large areas with limited personnel, such a commitment is impossible to maintain with in-house staff. NM AML is just beginning to establish working relationships with public and private landowners to establish inspection schedules for bat grates and other structural closures on their lands.

Conclusions

The primary mandate of AML programs is to provide for the long-term public safety at abandoned mines. In deciding whether or not to protect bat habitat in a mine, the size and importance of that habitat need to be weighed against initial construction costs, the degree of public hazard, and the feasibility of long-term inspection and maintenance. Not all mines with bats should be or need to be grated.

Ultimately no perfect mine safeguard method exists. Backfilled adits can be dug through. Deep shaft fills sometimes settle or collapse. With sufficient time, tools, and desire, vandals can breach any type of structural closure. Nature will continue her work to corrode and weather construction materials. What AML designers can do, however, is to fashion durable closures with high levels of public safety and vandal resistance, acceptable construction and maintenance costs, and good aesthetics. AML programs need to work to provide for sensible inspection schedules and prompt repair not only of bat grates but also of all closures.

All AML safeguarding methods will benefit from continued improvements in design, implementation and maintenance. In this regard, bat grates are no different.

John Kretzmann works in abandoned mine reclamation for the New Mexico Energy, Minerals and Natural Resources Department. This work has involved not only design for bat preservation, but also design of other structural and nonstructural closures of abandoned mine openings as well as reclamation and revegetation of abandoned coal mine waste piles. He holds a B.S. in Civil Engineering from Valparaiso University

A COLORADO CASE STUDY
TO SECURE UNDERGROUND MINES FOR BAT HABITAT

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Abstract

The Colorado Division of Wildlife initiated the Bats/Inactive Mines Project in 1991 to evaluate the use of abandoned mines by bats before closure. The goals of the project are: (1) to identify important roosts for bats; (2) protect these roosts with bat gates; (3) obtain more information on the status and distribution of bats; and (4) educate the public and resource managers about bat conservation in the State. This project represents a cooperative effort between several State and Federal agencies, the National Fish and Wildlife Foundation, and volunteers from the general public. Trained volunteers conduct surveys outside designated mine entrances using bat detectors, and document bat activity at mine sites. Mines with bat activity are then surveyed by trained biologists to determine species and roost types. During the last nine years, over 1800 surveys have been conducted with volunteers contributing more than 26,000 hours. The project has evaluated 2,242 mines to date. Results show that 34 percent of the mines surveyed have bats associated with the site. Of these, 15 percent are determined to provide significant roosts for bats based on follow-up surveys. During the last nine years 1,903 bats representing 11 species have been documented roosting in mines. Four species make up 85 percent of the total bats captured at mines, *Corynorhinus townsendii, Myotis volans, Myotis evotis,* and *Myotis ciliolabrum*. The surveyed mines ranged in elevation from 4,960 to 12,842 feet, and averaged 8,404 feet. Bats were documented using mines as roosts at elevations ranging from 5,800 to 12,160 feet. The average elevation of mines used as roosts was 7,411 feet. Maternity roosts were documented at elevations up to 9,100 feet for *myotis volans,* and use by reproductively active females was documented at up to 10,580 feet. Bat gates have been installed at 142 mines, and an additional 188 mines are scheduled for gate installation. Gate monitoring indicates that all species documented using abandoned mines before gating continue to use the gated mines.

Introduction

Colorado, like many western States, has a rich mining history. Mining communities were found across most of the western two thirds of the state. This history has resulted in the occurrence of many abandoned or inactive mines, scattered across the State. During the early 80's, a push to safeguard these potentially hazardous features was initiated, and the Colorado Abandoned Mines Land Program was created to implement this program. While many of these mines present a hazard to the public safety, they also potentially provide roosting habitat for many species of bats (Altenbach and Pierson 1995; Tuttle and Taylor 1994).

There are currently six species of bats Federally listed as threatened or endangered in North America. Although no longer a formal category, in 1994 thirteen species and sub-species, eight of which occur in Colorado, were petitioned for Federal candidate status (FC-2). While there are many factors that could be responsible for declining populations of bats, the loss of habitat is an essential issue. Roost sites for bats may be the important conservation factor for most Nearctic bat faunas, especially for colonial species. The distribution and abundance of colonial bats is linked to the availability of suitable roosts. Although many species of bats use a variety of roosts, including mines, the natural history of most species in Colorado is poorly known, making it difficult to assess their status and potential impacts to populations from the loss of habitat. Abandoned mines provide roosting habitat used by many species of bats. Most cave/mine obligate species in North America have experienced declines, and many are current, or proposed, threatened or endangered species (Gates et. al. 1984; Perkins 1985). Townsend's big-eared bat (*Corynorhinus townsendii*) is considered a cave/mine obligate species, and, in Colorado, is a species of concern and listed as imperiled with the Natural Heritage Program. While mines are man-made habitats, they have been part of the natural landscape for over 100 years and some species of bats may have become dependent on them for survival.

Because of the concern for the status of many bat species in the State, the Colorado Division of Wildlife (CDOW) initiated the Bats/Inactive Mines Project in 1991 to evaluate the use of abandoned mines by bats before their closure. The goals of the project are: (1) to identify important roosts for bats, (2) preserve these roosts by the use of bat gates, (3) obtain more information on the status and distribution of bats, and (4) educate the public and resource managers about bat conservation in the State. The project is a cooperative effort between the Colorado Division of Wildlife, Colorado Division of Minerals and Geology, US Forest Service, Bureau of Land Management, the National Fish and Wildlife Foundation, and volunteers from the public. Because of the large volume of abandoned mines scheduled for closure each year, other options were needed to supply the manpower necessary to evaluate the mines for bat use. We recruited and trained volunteers to conduct most of the initial surveys, and narrow down the number of mines that required more in depth evaluations. In 1994, the Bureau of Land Management and US Forest Service entered the partnership and we hired additional seasonal biologists for the project.

Methods

Mines included in the project are located throughout the western two-thirds of the State. They are comprised of privately owned mines, and un-patented mines on public lands. The Colorado Division of Minerals and Geology, Bureau of Land Management, or the US Forest Service first inventories all mines included in the project. At that point, closure projects are developed and maps are provided to the Colorado Division of Wildlife to initiate bat evaluations. Bat evaluations start with a pre-survey of each mine, designed to collect information at the entrance of a mine to aid in prioritization of survey efforts.

We enter each mine into a project database and give it a project ID number. This number is utilized to track each individual mine site. Mines that are not eliminated during the pre-survey are then scheduled for initial detector surveys by volunteers, or capture surveys by biologists. Division personnel survey those sites that are determined to be too hazardous for volunteer work only. Methods for data collection and evaluation are those found in *Guidelines for the Survey of Caves and Abandoned Mines for Bats in Colorado* (Navo 1994). Also see Riddle (1995), for guidelines to the

evaluation of mines for bats.

Volunteers on the project are required to attend a training session before participation. The training consists of a three-hour classroom course. Topics include mine safety, survey techniques, and learning about the natural history of bats. The first 3 years of the project made extensive use of volunteer surveys. We established numerous safety rules. At no time do we allow volunteers to enter any of the mines.

The volunteer survey team monitors the mine entrance at sunset with bat detectors, instruments that detect the ultrasonic vocalizations of the bat. When bat activity is documented, teams of CDOW biologists, often supplemented by volunteers, perform capture surveys at indicated sites. A capture survey will determine what species are using the mine and what type of roost use is occurring. Bats are captured and identified as to species, sex, age and reproductive condition. The data are used to evaluate the roosting habitat provided by the mine and, thereby, the importance of the site to local bat populations. This information is the basis for recommendations to land management agencies and DMG for closure or protection of the mine. Survey work continues for each mine until all seasons are covered, or enough information is obtained to base a recommendation for the site. Recommendations will include final disposition of the mine as bat habitat and any bat gate recommendations.

Bats can use a mine as: a hibernacula, maternity roost, day roost during the warm season, night roost, transition roost during migration, or interim periods between the winter and summer seasons. Therefore, the season of use of a mine by bats can vary. This makes it critical that surveys take place at different times of the year in order to adequately evaluate the potential of a mine as roosting habitat for various species of bats. Winter roost habitat can only be inferred by the documentation of fall use by bats when using external survey techniques. Fall swarming behavior by bats is well documented in eastern populations (Davis 1964; Fenton 1969) and, in Colorado, has shown that it can serve as an indication of hibernacula.

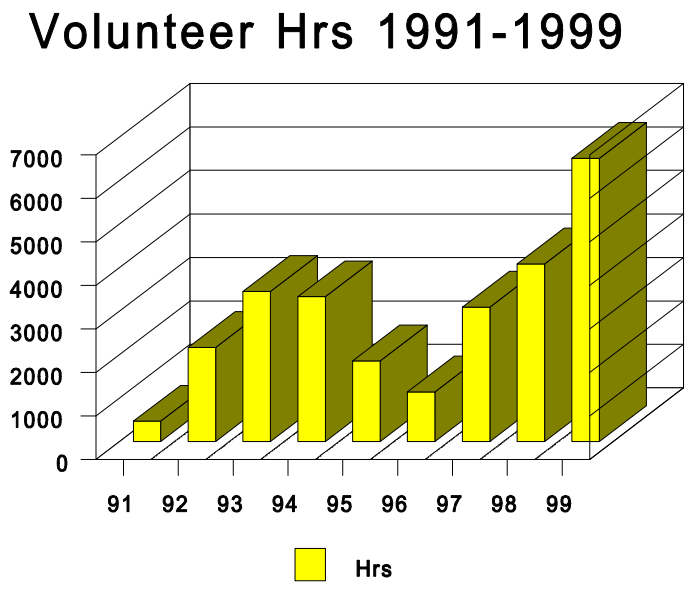
Little is currently known about gate designs and acceptance by various species of bats. Therefore, it is important that gate installation projects include some degree of monitoring and documentation in order to evaluate acceptance of gate designs by bats and their effect on populations. Some designs, such as the modified “window” gate used in Colorado, have preliminary results that are favorable. Tuttle (1977) stated that it might take several years to see the impact of an improper gate design on a bat colony.

Results

Over the 9 years from 1991-1999, we conducted more than 1800 external surveys during the evaluation of 2,242 mines. Additional internal surveys conducted by project biologists resulted in 453 more surveys. Survey results indicate that 34 percent of the mines surveyed have bats associated with the site. This means that bats were detected at or near the portal of the mine by visual or acoustic documentation, or captured at the mine. Of these, 15 percent were determined to provide significant roosts for bats. Significant roosts were considered those that provided: (1) maternity roosts, hibernacula, or transition roosts for Townsend’s big-eared bats, or (2) maternity roosts, or large hibernacula for other species of bats.

Volunteers have compiled more than 26,000 hours over the first 9 years of the project. This volunteer effort has saved the State of Colorado thousands of dollars and allowed for a large number of mines to be evaluated. In addition, the initial surveys conducted by the volunteers have allowed the project biologists to focus on those mines with bat activity. While the number of volunteers participating in the project has fluctuated over the years, a core group of volunteers has provided the bulk of the donated hours each year. In 1999, volunteers conducted and assisted with detector and capture surveys. This resulted in 5629 survey related volunteer hours in 1999. Volunteers donated a total of 6510 hours (including 445 training hours and 436 administrative hours) to the project. This volunteer effort has resulted in an estimated saving to CDOW of $61,409 in 1999 alone.

Over nine years, 1903 bats representing 11 species have been documented roosting in mines. These numbers do not represent the total numbers of bats using these mines because capture survey techniques are designed to catch just enough bats to base a decision on gating. Attempting to capture all bats using a mine would potentially be too disturbing to a colony of bats. Four species make up 85 percent of the total bats captured at mines, *C. townsendii*, *Myotis volans* (long-legged myotis), *Myotis evotis* (long eared myotis), and *Myotis ciliolabrum* (small footed myotis). These species were all considered as candidates under the 1994 Federal register species listing. In addition, the largest known colony of bats in the State resides in an abandoned mine. This colony of Brazilian free-tailed bats is estimated to be around 100,000-250,000 bats. However, unlike eastern mines that sometimes contain large colonies of hibernating bats, the largest colony documented in Colorado to date has been 200-300 bats. This may be a factor of the higher range of elevations that comprise the landscape of Colorado.



Mines surveyed over the 10 years of the project have ranged in elevation from 4,960 to 12,842 ft, and averaged 8,404 feet. Bats were documented using mines as roosts at elevations ranging from 5,800 to 12,160 feet. Night roosting by bats is very common at mines, and most mines are likely to be used by night roosting bats at some time or another. The average elevation of mines used as roosts was 7,411 feet. Maternity roosts were documented at elevations up to 9100 ft for *myotis volans.* Use by reproductively active females was documented at up to 10,580 feet.

The majority of roosts documented in Colorado have been fall transition and winter hibernacula. While the number of summer maternity roosts has been limited, there has been a significant number of roosts identified in the State. Complex mines systems can provide the range of microclimate conditions that provide all types of bat roosting habitat, even at the higher elevations that predominate in our State. Conversely, even simpler, single entrance mines can provide ideal roosting habitat for bats, but typically not at higher elevations.

Bat gates have been installed at 142 mines. An additional 188 mines are scheduled for gate

installation. Most gate designs were window (or ladder) style or slot gates. Window bat gates are typically installed at summer roosts or large hibernation sites. Slot gates are used at smaller hibernacula. Some special culvert gate designs have been used at mines with large trenches at the portals. Evaluation of their success is still underway. We initiated monitoring a subset of gated mines during the first year of the project and continue this effort every year. Monitoring indicates that all species documented using abandoned mines before gating continue to use the gated mines. At this point, the success rate of gated mines is over 90 percent. All styles of bat gates have had documentation of continued bat use.

Conclusion

Overall, the approach used in Colorado was been successful in identifying and protecting many bat roosts in abandoned mines. A combination of trained bat biologists and trained volunteers, working in concert with good mine inventories and closure planning, has provided the a sound approach to identifying and protecting mines important to bats. The use of volunteers has proved to be a viable approach to facilitating wildlife management activities. Volunteers can help prioritize survey work when large numbers of mines are scheduled for closure over short time frames. However, the effective use of volunteers requires a commitment of personnel to recruit, train, schedule, and coordinate their activities. External survey approaches have been the dominant technique used on the project. During the last 5 years, we have started using more internal surveys. Internal surveys allow for winter evaluations, if mines are accessible, and allow more mines to be surveyed in one day than external techniques. While volunteers have been helpful in our evaluations of abandoned mines, the limitations of their work in such hazardous situations, combined with the need for trained and experienced biologists to conduct the capture and handling of bats, requires use of adequately trained biologists, proper safety equipment, and a multi-technique approach to properly evaluate bat use of abandoned mines.

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PENNSYLVANIA CASE STUDIES TO SECURE UNDERGROUND MINE WORKINGS FOR BAT HABITAT

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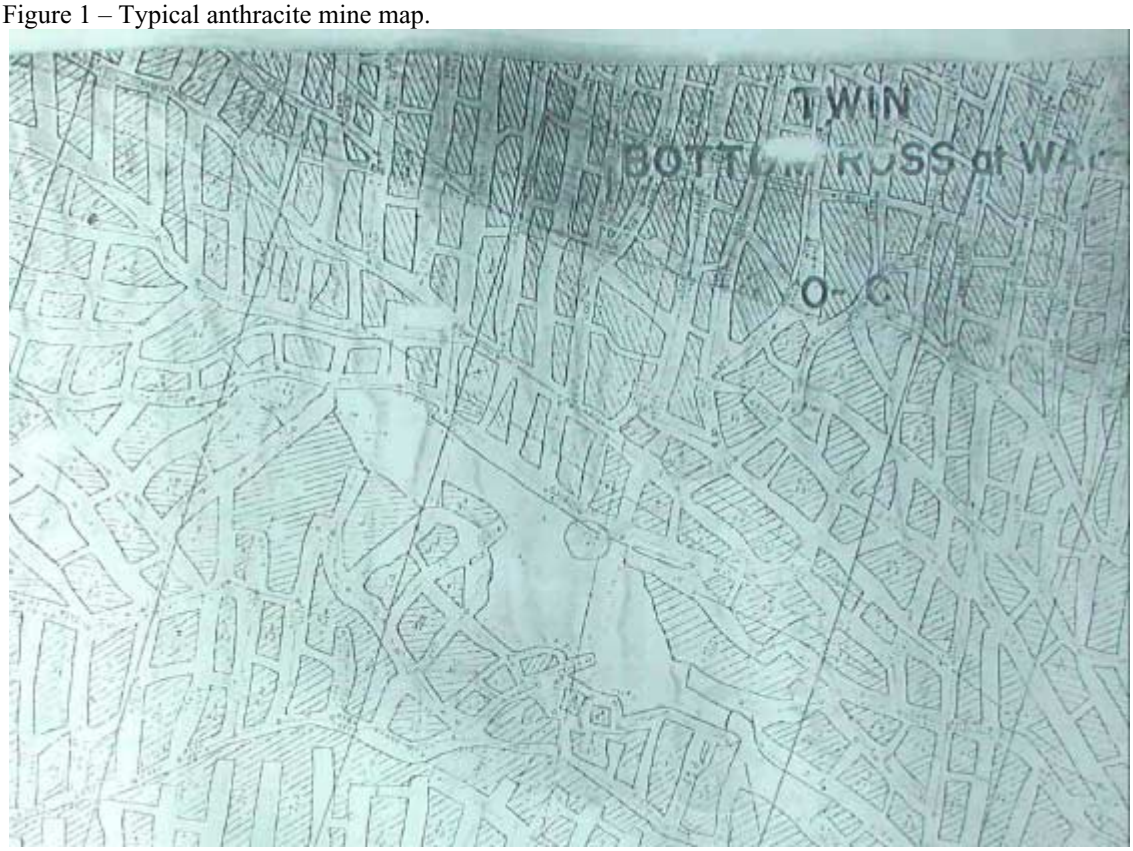
Abstract

Our objective is to protect the general public from hazardous abandoned mine entries, and to identify and protect bat populations that roost in the abandoned underground mine workings. In Pennsylvania the largest known bat concentrations are dependent on man-made habitat. Annual surveys to locate and monitor large winter roosts were begun in 1980. The Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), eastern small-footed bat (*Myotis leibii*), little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*) and eastern pipistrelle (*Pipistrellus subflavus*), use mine entries to access areas for winter roosts. Conservation management included but was not limited to construction of bat-friendly steel gates to protect hibernacula. Approximately 10 percent of the studied abandoned mine entries were occupied by bats and were preserved by gating. The vulnerability of such habitat and large concentrations of bats requires both proactive and reactive management.

Study Area

This study area is in the eastern part of Pennsylvania, where large deposits of anthracite coal were formed in the Appalachian Mountains section of the Valley and Ridge Physiographic Province. These deposits are within an area of 1,254 km² and are not continuous. The deposits are divided into four fields: Northern, Southern, Western Middle and Eastern Middle. Over five billion metric tons of anthracite were mined between 1807 and 1967 by underground room and pillar type mining. Much of this area is today considered abandoned mine land. Numerous entries to abandoned workings still exist. These entries probably contribute to a complicated and, for the most part, unknown airflow throughout thousands of kilometers of abandoned mine tunnels that can be used by bats. An example of an old map of a portion of the workings is shown in Figure 1.

Figure 1 – Typical anthracite mine map.



Entries are classified as:

1. Shafts - vertical openings constructed for ventilation, haulage, or personnel.

Photo #1 – An abandoned mine shaft used for ventilation of the mine workings Schuykill Co. PA)

2. Slopes - diagonal entries to the workings mostly for haulage or personnel.

Photo#2 – An abandoned mine slope used for personnel and coal haulage (Schuylkill Co., PA)

3. Drifts - horizontal entries to the coal mostly for haulage or personnel.

Photo # 3 – An abandoned mine drift used for personnel
And Coal haulage (Lackawanna Co., PA)

4. Cropfalls - caused by subsidence or mine collapse.

Photo # 4 – A cropfall within a surface mine (Schuylkill Co., PA)

The dangers to humans that exist from entries are: roof falls, uncharted abandoned underground mine workings, mine pools, and mine gases. Limiting factors for bats are: mine gases, temperature requirements, and collapses. Many of the entries are located in uninhabited. However most entries are accessible via abandoned haul roads or existing dirt roads. Many times, human visitation to these sites is apparent from discarded beverage containers, food wrappers, and other telltale signs.

Endangered Species Act

It is the policy of the Endangered Species Act that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of the act. It is further declares that Federal agencies shall cooperate with State and local agencies to resolve water resource issues in concert with conservation of endangered species. In order to close a mine entry potentially occupied by bats, we are required by law to consult with the US Fish and Wildlife Service and State wildlife agencies. This is done with consultation letters.

Site Evaluation

The first step in determining the possibility of bat use is a site evaluation. Criteria include:

1. **Flooding** - Is the interior of the site flooded to the ceiling, excluding bat use?

2. **Adequate Ventilation** - Does the site seem to have a significant amount of airflow? Some of the best bat sites have a large volume of air exchange with temperatures in the 4.5ºC to 10ºC range. The problem is airflow can vary by day or by time of year. Depending on time of year, three airflow conditions will prevail: intake, exhaust, and stagnant.
3. **Open Entry** -Can bats enter the opening? Some entries may be already gated with fine mesh that excludes bats or covered with a solid door.
4. **Guano** - Are bat droppings visible around the openings or on rocks within? This is a good indication of bat use, but absence of droppings is not reliable for excluding the possibility of use.

If the possibility of bat habitat exists, the site may be surveyed to detect their presence by live-trapping using harp traps and/or by mist netting, or through the use of bat detectors. These surveys are usually conducted in September and early October when bats are entering hibernation and some time in April and May when bats are exiting. Occasionally an entry is gated without surveying due to time and safety concerns or when gating is less costly than the survey.

Winter hibernacula surveys were begun in 1980. Surveyors enter caves and mines to count visible hibernating bats. In Pennsylvania, the largest concentrations of hibernating bats are found in mines rather than caves. Site totals have ranged from 0 to 17,695 bats. Species found during these surveys include the little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), eastern small-footed bat (*Myotis leibii*), Indiana bat (*Myotis sodalis*), big brown bat *(Eptesicus fuscus*), eastern pipestrelle (*Pipistrellus subflavus*) and, on one occasion, the silver-haired bat (*Lasionycteris notivagans*). The six largest sites, each containing over 3,500 visible bats, are in abandoned limestone, clay, or iron ore mines. Four of these sites have been gated to restrict human activity and allow bat access without altering airflow. Other, smaller sites with significant populations and good interior habitat have also been gated. The response of the hibernating bat population to gating has been an increase in numbers where human disturbance was formerly a problem, as shown in the Canoe Creek Limestone Mine (Figure 2).

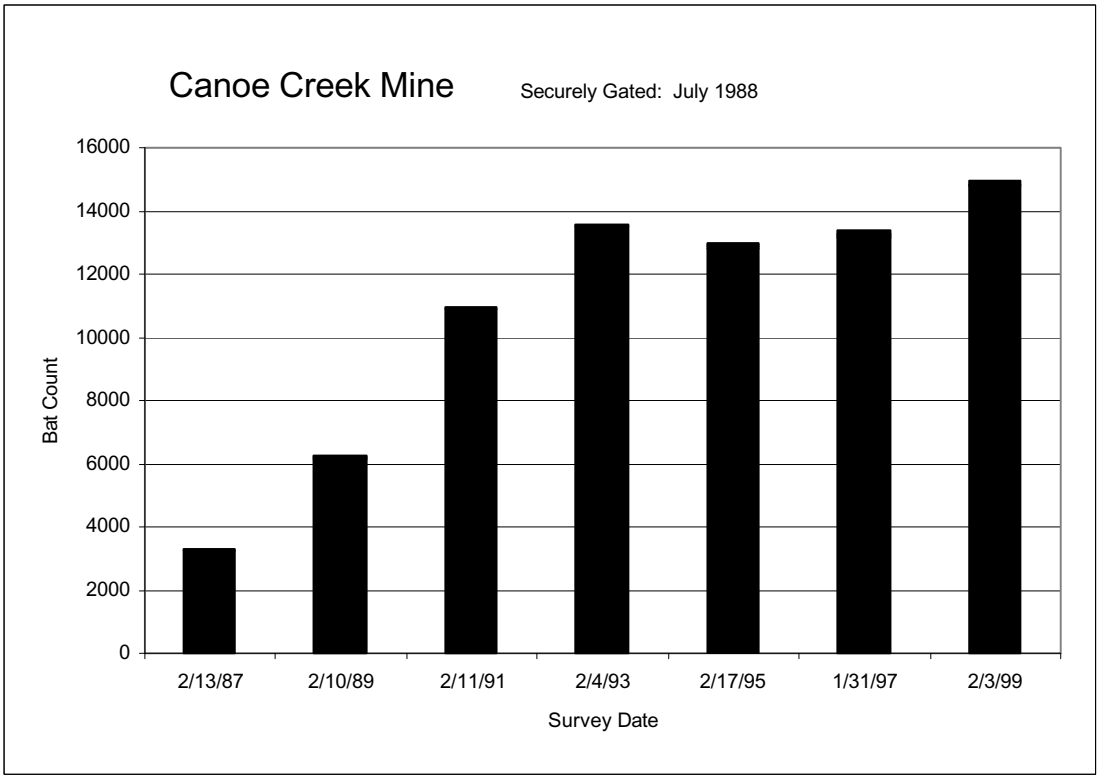
Installation of Bat Gates

Following gating, numbers have grown from 3,500 to over 15,000 visible bats counted during interior hibernacula surveys.

Gating must satisfy 3 objectives:

1. Keep people out, minimizing both human safety concerns and disturbance to bats.
2. Provide for airflow to maintain the interior environmental conditions.
3. Allow for bat access.

Figure 2 – Bat count during hibernation.



The abandoned openings in the anthracite coal fields of Pennsylvania pose a different gating dilemma. Gating prevents entrance of humans to the mine workings – thereby abating the threat to humans – and also allows access to the mines by bats. Further, the gates can be cheaper than backfilling the opening with material, which is the usual method of reclaiming these sites. Most of these site contain hibernation chambers. Several of these sites have been found to contain significant bat populations. These are surveyed by exterior live-trapping due to hazardous conditions that preclude interior surveys. The most significant mine site found thus far is a subsidence opening where over 1,000 bats were live-trapped in an evening, including the endangered (Federally listed) Indiana bat. Indiana bats have been found at two other anthracite sites. One of these is so large it is difficult to gate. At this site we are proposing to restrict road access to prevent dumping that may contribute to a mine fire. The other will be gated in the future. Because of the configuration of both entrances, human entry is unlikely.

Approximately 50 percent of all anthracite mines live-trapped or netted have bat activity. A number of these show considerable use by bats. Collectively, anthracite openings may provide significant habitat by allowing bats access and, just as important, contribute to the natural airflow of the miles of tunnel beyond. If entrances contributing to airflow are backfilled, the entire tunnel system used by bats could be altered. This is especially important where noticeable airflow is detected through rubble and passages. The question then arises as to how important are the marginal or unused openings to bats. For the most, part this is unknown. In all cases, the openings must be modified to protect the public, either through gating or backfilling.

Gating involves the use of: welding equipment, acetylene torches, steel, and manpower. Typically the cost ranges from $500 to $2,000 for a small opening. To date, larger openings with more elaborate preservation techniques have not exceeded $20,000.

Where used, the gating alternative:

1. Preserves bat habitat, including bat entrances and airflow to the underground environment, and

2. The hole remains without being hidden with backfill material. Dangerous building zones are then identifiable for future .

Since 1994, the Office of Surface Mining in Wilkes-Barre has gated approximately 10 percent of mine entries that were reported as emergency projects. Those entries gated were either assumed to have bats or the Pennsylvania Game Commission determined their presence with live-trapping at the entry or the use of sonar devices.

There are four types of entries for gate design. The horizontal entry requires placement of a louver type iron wall anchored to the exposed bedrock by drilling and pinning. This type of gating is relatively easy to install because there are no special considerations other than securing the gate to the sidewalls and floor of the bedrock.

Photo # 5 – Typical louver style bat gate panel.

Photo #6 shows a surface collapse around a slope, which required reconstruction of the site.

Photo # 6 – Surface collapse of an abandoned mine slope (Schuylkill Co., PA)

Excavation to the bedrock was followed by the placement of beams and installation of a cap.

Photo # 7 – Footer and "W" beam installation to support the surface (Schuylkill Co., PA)

Photo # 8 – Capping on top of "W" beam and footer with steel decking and rebar prior to concrete (Schuylkill Co., ,PA)

The cost of this gate was $18,810. Gating cost for this project are listed in Table #1.

Table #1 – Listing of lump sum items for a slope in Schuylkill Co., PA

Items Description	Cost
1. Mobilization	$1,000.00
2. Demobilization	$1,000.00
3. Bat Gate	$2,000.00
4. Reinforced Concrete Cap	$10,800.00
5. Reclamation	$400.00
6. Mod #1 Bulkhead	$3,250.00
7. Mod #2 Backhoe rental	$360.00

Vertical entries e.g., shafts or cropfalls, are typically more complex than horizontal entries. A horizontally-oriented gate requires a stable. Fitting and stabilizing a pipe into the opening is also problematic. Entries are not uniform in configuration and have irregularly shaped perimeters.

A typical design is illustrated by Bat Conservation International in Photo #9.

Photo # 9 – Typical vertical mine entry taken from CI Resources Publication #3

This design was used on two OSM projects in Schuylkill County. One of the projects was a modified version of BCI's design, in which the pipe fit snugly into the bedrock opening with grouting around the pipe. The cost of this project was $8,300. Costs are itemized as shown in Table #2.

Table #2 – Listing of lump sum items for a small vertical entry in Schuylkill Co., PA

Item Description	Cost
1. Mobilization	$500.00
2. Demobilization	$500.00
3. Footing	$1,800.00
4. Shaft Housing	$2,800.00
5. Bat Gate	$2,200.00
6. Restoration	$500.00

Photo # 10 – Shaft preserved with corrugated PVC pipe and protected by cement block structure (Schuylkill Co., PA)

The more remote and difficult the access, the more costly gating becomes, but it is still less costly than backfilling. The cost for a site with a remote access of about 400 meters, requiring hand carrying of equipment and materials, was $4,400. Typical costs are listed in Table #3.

Table # 3 – Listing of lump sum items for a remote site in Lackawanna Co. PA

Line Item Description	Cost
1. Mobilization	$400.00
2. Demobilization	$200.00
3. Gate Construction	$3,600.00
4. Restoration	$200.00

Conclusion

Abandoned mine workings in the anthracite fields of Pennsylvania provide suitable habitat for bat colonies. The absence of flooded workings and the presence of ventilation, open entry, and guano are criteria for evaluating suitability of mine openings as bat habitat. Gating must satisfy three objectives: (1) to keep people out, maximizing human safety and minimizing disturbance to bats, (2) to provide for airflow to maintain the interior environmental conditions, and (3) to allow for bat access. The four types of mine entries (shafts, slopes, drifts, and cropfalls) require gating designs specific to each. Gating is desirable because it minimizes disturbance to bats and preserves habitat and is generally less costly than backfilling.

A MIDWESTERN CASE STUDY TO SECURE AN UNDERGROUND MINE FOR BAT HABITAT: THE UNIMIN "MAGAZINE MINE" IN ALEXANDER COUNTY, ILLINOIS

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Abstract

Bats continue to rank among the world's most endangered wildlife despite extensive conservation efforts. Preserving these mammals and the ecosystems that rely on then for their existence is a prodigious task. Effective education, research, and conservation initiatives at the local, community, and corporate levels are essential to the long-term understanding and survival of these often neglected animals. Promoting bat conservation by changing attitudes, not by confrontation, has enabled professional resource managers throughout Illinois and the Midwest to work directly with local citizen groups, schools, and businesses. Extracting solutions to complex environmental problems through the power of community and industry partnerships has proven to be quite successful throughout rural Illinois. Recent public and private sector efforts at southern Illinois' "Magazine Mine" to directly protect resources critical to bat reproduction and hibernation have both strengthened and promoted a conservation ethic benefiting not only bats, but the fragile Shawnee National Forest ecosystem as a whole. "Magazine Mine" currently supports >9,000 wintering Indiana bats and is the largest winter hibernacula of Indiana bats ever documented within the State of Illinois. Because this mine has been abandoned for several years (>15 years), it requires immediate and permanent stabilization at the main entrance in order to prevent catastrophic collapse and eventual closure. Such a collapse at this Federal Priority II hibernacula would not only exterminate the large numbers of Indiana bats hibernating within this mine, but also permanently prohibit use of this mine by successive generations of *Myotis sodalis.* Stabilization of the 230 foot long "Magazine Mine" entrance using steel arches and lagging plates will take approximately 14 full work days and cost nearly $80,000.

Bat Monitoring

Summer mist-netting efforts and winter inventories of the abandoned Unimin Specialty Minerals Corporation "Magazine Mine" (silica-sand mine) conducted within the past three years have revealed the presence of significant Indiana bat maternity colonies and large hibernating groups (>9,000 *Myotis sodalis*). In order to better protect and inventory both maternity colonies and hibernating individuals, detailed surveys of this mine should continue to be performed every other year. Winter surveys of this mine were first conducted in February 1998. Most important, because this mine has been abandoned for several years (>15 years), it requires immediate and permanent stabilization at the main entrance in order to prevent catastrophic collapse and eventual closure. Such a collapse at this Priority II hibernacula would not only exterminate the large numbers of Indiana bats hibernating within this mine, but also permanently prohibit use of

this mine by successive generations of *Myotis sodalis.* Completion of this stabilization effort will directly improve and preserve on-the-ground conditions for this imperiled species.

Evaluation of Indiana Bat Habitat

Indiana bats require specific roost sites in caves or mines that attain appropriate temperatures to hibernate. Ideal sites are 50 degrees F (10 C) or below when the bats arrive in October and November. Early studies identified a preferred mid-winter temperature range of 39 to 46 degrees F (4 - 8 C), but a recent examination of long-term data suggests that a slightly lower and narrower range of 37 to 43 degrees F (3 - 6 C) may be ideal for this species (USFWS, 1999). Only a small percentage of caves and mines provide for this specialized requirement. Stable, low temperatures allow these animals to maintain a reduced rate of metabolism and conserve fat reserves through the winter, until spring. Data gathered by the Illinois DNR and Bat Conservation International, Inc. show that the Magazine Mine currently offers this narrow and specialized temperature regime (BCI, 1999).

Abandoned mines and caves change far more often than is generally recognized. Entrances and internal passages essential to air flow may become larger, smaller, or close entirely, with corresponding increases or decreases in air flow, temperature, and humidity. Blockage or collapse of entry points, even those too small to be recognized, can be extremely important in hibernacula that require chimney-effect air flow to function (i.e. Magazine Mine). Recent data shows that changes in airflow can elevate temperatures which can cause an increase in metabolic rate and a premature exhaustion of fat reserves. Such air flow changes may also force bats to roost near unsuitable entrances or floors to find low enough temperatures, thus increasing their vulnerability to freezing or predation. Overall, the fact that Indiana bats congregate in only a small percentage of known caves and mines suggest that very few caves/mines meet their requirements (USFWS, 1999). Exclusion of Indiana bats from such crucial hibernacula has been a major documented cause of Indiana bat declines.

Stabilization of Mine Entrance

Permanent/heavy-duty stabilization of the Magazine Mine entrance will allow Indiana bats to continue to use this mine for hibernation purposes. A licensed underground mining/civil engineering construction firm will conduct stabilization activities. Stabilization of the 230' long Magazine Mine entrance will take approximately 10 to15 full workdays. Construction will be scheduled sometime between May 1 and September 1, thereby eliminating any threat to hibernating *M. sodalis*. The long-term stabilization of the Magazine Mine entrance directly meets the management and recovery objectives addressed in the Federal Indiana bat Recovery Plan. The Illinois Department of Natural Resources strongly believes that completion of this abandoned mine stabilization effort will directly improve and preserve on-the-ground conditions for this imperiled species.

Itemized Project Budget
UNIMIN Specialty Minerals Corp. "Magazine Mine"

I. **SUPPLIES**

A. Steel Stabilization Arches:

*Needed for a total distance of 230 feet. Must maintain an opening that is 8' high by 14' wide.
*Total of 45 arches required.
*Cost per arch: $400.22
*Total arch cost: 45 x $400.22 = $18,010.00

B. Treated Timber Decking Plates to cover Arches:

*Needed for a total distance of 230 feet. Must maintain an opening that is 8' high by 14' wide.
*Total of 800 treated (.040 cca - copper/chromium/arsenic) 6x6x12 foot decking plates required.
*Cost per plate: $22.15
*Total decking plate cost: 800 x $22.15 = $17,720.00
*Total of 30 treated (.040 cca) 6x6x8 foot decking plates required.
*Cost per plate: $16.91
*Total decking plate cost: 30 x $16.91 = $507.30

ARCH CONSTRUCTION SUPPLIES COST: A+B = $36,237.30

II. **MANUAL LABOR/CONSTRUCTION COST**

Total manual labor cost for this mine stabilization project = $40,000 (all construction work to be completed by licensed and qualified steel fabrication and erection firm)

TOTAL MAGAZINE MINE ENTRANCE STABILIZATION COST: I + II = $76,237.30

Conclusion

Clearly, long-term stabilization of Magazine Mine will continue to foster a unique, cooperative partnership between: Private Industry, the Illinois Department of Natural Resources, the United States Forest Service, the United States Fish and Wildlife Service, as well as numerous environmental organizations and community groups. As evidenced by past newspaper, television, and radio segments explaining the significance of the UNIMIN Magazine Mine to hibernating bats, this stabilization project has tremendous potential for promotion and education. This project remains an integral component for the recovery of the Indiana bat.

Acknowledgements

The Illinois Department of Natural Resources-Division of Natural Heritage would like to sincerely thank Mr. Rick Fox of the UNIMIN Corporation for his continued support and cooperation. We also wish to thank the United States Forest Service-Shawnee National Forest and the United States Fish and Wildlife Service-Region 3/Illinois Offices. This project has received financial support from the United States Fish and Wildlife Service Region 3 Field Office located in Rock Island, Illinois; the Illinois DNR's Wildlife Preservation Fund; the

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AN OVERVIEW OF
THE RESPONSE OF BATS TO PROTECTION EFFORTS

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Abstract

Disturbance during the hibernation and maternity seasons is a significant factor in the widespread decline of cave and mine dependent bats. Early bat protection efforts concentrated on eliminating or reducing this disturbance through the installation of informative signs and the construction of gates and fences at cave entrances. The purpose of these structures was to control human access to important roost sites. These efforts sometimes failed or were counterproductive because of our limited understanding of bat behavior and our limited appreciation of the potential effect entrance modifications can have on cave microclimates. Each species responds differently to artificial barriers at their roost sites and we have had to modify and refine, primarily through trial and error, our protection efforts. There have been spectacular successes and equally spectacular failures in these efforts - one of the first structures erected to protect a gray bat colony resulted in the extirpation of the species from the site. Later protection efforts, tailored to the species needs, resulted in the restoration of colonies that had been extirpated from their roosts by human disturbance. A summary of our knowledge of the response of cave and mine dependent bats to protection efforts is provided. There is little information available on how many of these species respond to gates. A formal, voluntary survey of all agencies, organizations and individuals about the success or failure of their bat cave and mine protection efforts is needed. A method of conducting this survey and how to summarize and widely distribute the results is suggested. Failure to address this problem will limit our ability to protect bats from disturbance in caves and mines and make our efforts to protect the public from the hazards of abandoned underground mines more difficult.

Gates and Bats

A primary threat to cave dependent bats is disturbance at their hibernation and maternity roosts (Mohr 1976, U.S. Fish and Wildlife Service 1982, 1984, 1995, 1999). Disturbance at cave roosts is probably one of the factors that contributes to the increasing important role mines play in bat conservation efforts. As disturbance at natural roosts has increased, bats have abandoned their hibernation and maternity caves and moved into mines. Protection of natural and manmade roosts is one of the highest priorities in all of the recovery plans for listed bats. All of our early experience in trying to reduce this disturbance and protect bats was gained at their natural cave roosts. Like many human endeavors it was initially a process of trial and error, and we made many errors before we realized that just throwing up a gate at the cave entrance was not enough. A review of these early efforts and failures is provided by Tuttle (1977).

Problems with Past Gating Efforts

Early gate builders often did not recognize that during gate design and installation it is essential to consider the potential adverse effects that poorly or inadequately designed structures can have on cave or mine microclimate. As a result, the first bat gates often did not maintain pre-gate air flow, or did not provide adequate spaces for bats to fly through the gate, or, in some cases did not leave the open flight space over the gate that is needed by some species.

Maintenance of existing microclimate depends, primarily, upon maintenance of existing airflow patterns through the gated entrance. Other features such as internal cave or mine complexity and configuration, and the size, shape, number, and location of entrances are also important factors (Tuttle and Stevenson 1978). Although most underground microclimate research has focused on caves, the same airflow and microclimate principles apply to abandoned mines. Careful consideration of the data presented in this paper will provide a better understanding of how and why certain mines or caves are suitable for bat use while others are not. It reinforces the conclusion that all structures constructed at cave or mine entrance must be designed in a way that does not significantly alter air flow.

Ensuring that a gate design provides adequate flight space for bats requires a compromise between two extremes. One extreme provides maximum security for the public and the other provides maximum freedom for bat movement - a rock wall or back filling the entrance would provide maximum security from a safety standpoint while no physical barrier at an entrance would eliminate the possibility of restricting air and bat movement. Neither extreme is acceptable if we are to protect bats from disturbance and protect the public from the hazards of abandoned mines. The early standard for minimum spacing of gate components was 6 inches between the horizontal gate members and 2 feet between the vertical gate components (Figure 1). This was considered to be a good compromise between the two extremes. Most people can not or will not force there bodies through a six inch space. The recommended 2 feet between the vertical bars was believed to provide adequate space for bat movement while maintaining sufficient strength to keep vandals from easily bending the bars apart. Early bat gates were often constructed of mild round steel bars 3/4 inch to 1 1/4 inch in diameter. Although these gates provided a barrier that bats could fly through and had minimal effect on airflow, their greatest disadvantage was their vulnerability to vandalism. The current design standard for cave and mine bat gates is constructed of 4 inch angle iron with a minimum of 5 3/4 inches between the horizontal bars and a minimum of 4 feet between the vertical columns (Figure 2), however, the round bar gate is still successfully used in some parts of the U.S. The Utah Division of Oil, Gas and Mining has developed a modification of the round bar gate that they install at most of their abandoned mines that support significant colonies of bats(Figure 3). Their design incorporates a high strength steel that resists cutting by hacksaws and other low-technology vandalism attempts (Mark Mesch, Utah Division of Oil, Gas and Mining, personal communication, 2000).

How Bats Respond to Gates

Full gates at cave or mine entrances are not accepted by some species. The endangered gray bat (*Myotis grisescens*) will generally not accept full gates at their maternity roosts but will accept

them at their hibernation sites. Brazilian free-tailed bats (*Tadarida brasiliensis*) will not accept full gates at their roosts at any time of year. Alternative barriers, such as fences or half-gates (Figures 4 and 5) must be used when dealing with species that will not accept a full gate. Species such as the endangered Indiana bat (*Myotis sodalis*) and the four subspecies of the Western big-eared bat (*Corynorhinus townsendii*) that occur in the U.S. readily accept properly designed full gates at all of their roost sites. There may also be regional differences in how bats respond to gates. Although the gray bat will not accept a full gate at its maternity roosts throughout most of its range, it has accepted full gates at maternity sites in Oklahoma at the western edge of its range (Steve Hensley, U.S. Fish and Wildlife Service, Tulsa, Oklahoma, personal communication, 2000). The successful gray bat full gates in Oklahoma are all constructed in the dark zone well back from the entrance. This approach to gray bat protection may only work with the Oklahoma population. A full gate was constructed in the dark zone in an Alabama gray bat cave to test this approach with another population of the species. This test was not successful and after three years the gate was removed. After the gate was removed the gray bats returned to the cave (Keith Hudson, Alabama Department of Conservation and Natural Resources, Florence, Alabama, personal communication, 2000). The acceptability of full gates by cave and mine dependent bats is variable and not known for many species (Table 1).

Proposed Bat Gate Survey

We should be very cautious when considering the construction of a full gate at mines supporting any of the species with an unknown response to gates. Table 1 presents a limited, incomplete summary of our knowledge of the response of bats to gates. A complete survey of all the agencies and organizations that have built bat gates needs to be conducted. The information gained through this survey should be compiled, reviewed, summarized and made readily available to public and private land managers. The U.S. Fish and Wildlife Service (Service), Bat Conservation International (BCI), and Arizona Game and Fish Commission have developed a bat gate survey form (Form 1) to obtain this information. This form is designed to gather information on gate construction material and design specifications, on how different species respond to gates and, how resistant the various designs are to vandalism. This survey form will be distributed to as many of the organizations and individuals that have been involved in constructing bat gates as possible. Survey results will be widely distributed by BCI, the Service and the Office of Surface Mining. To increase the availability of this information the Utah Division of Oil, Gas and Mining may make the survey results available on the internet. During compilation of this information we recognized that we must insure that site specific locations of important roosts must be protected from unrestricted access. Misuse of location information could easily lead to increased vandalism and other threats to vulnerable roost sites.

Summary

Knowledge of the response of cave and mine dependent bats to gates has increased over the past 25 years resulting in the evolution of gate design from simple round bar gates to the current angle-iron standard gate. This evolution has resulted in substantial improvements in the security and effectiveness of closures for bats. This process will continue, the current design standard will be modified in the future as we learn more effective methods of protecting bats while we

protect the public from the hazards of abandoned mines. We must ensure that the information gained through gating efforts throughout the U.S. is made available to everyone involved in abandoned mine reclamation. Improvements in gate design and construction techniques will result in increased effectiveness in maintaining the roost sites that are essential for the protection and recovery of endangered and other declining cave and mine dependent bats.

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Table 1[1]

Acceptance of Full Gates By Cave and Mine Dependent Bats[2]

Species[3]	**Summer Roosts**	**Winter Roosts**
Ghost-faced bat (*Mormoops megalophylla*)	Unknown	Unknown
Mexican long-tongued bat (*Choeronycteris mexicana*)	Yes	Yes
Lesser long-nosed bat (*Leptonycteris curasoae*)	Yes	Yes
Mexican long-nosed bat (*Leptonycteris nivalis*)	Unknown (probably will)	Yes
California leaf-nosed bat (*Macrotus californicus*)	Yes	Yes
Pallid bat (*Antrozous pallidus*)	Yes	Unknown (Probably will)
Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)	Yes	Yes
Townsend's big-eared bat[4] (*Corynorhinus townsendii*)	Yes	Yes
Big brown bat (*Eptesicus fuscus*)	Unknown (probably will)	Yes
Allen's big-eared bat (*Idionycteris phyllotis*)	Yes	Unknown (Probably will)
Silver-haired bat (*Lasionycteris noctivagans*)	N/A	Unknown (Probably will)
Mexican long-eared bat (*Myotis auriculus*)	Unknown	Unknown
Southeastern myotis (*Myotis austroriparius*)	Unknown	Unknown
California myotis (*Myotis californicus*)	Yes	Yes

Table 1 (Continued)

Small-footed myotis (*Myotis ciliolabrum*)	Yes	Yes
Long-eared myotis (*Myotis evotis*)	Unknown	Unknown
Gray bat (*Myotis grisescens*)	No	Yes
Leib's bat (*Myotis leibii*)	N/A[5]	Yes
Little brown bat (*Myotis lucifugus*)	Unknown (probably will)	Yes
Eastern long-eared bat (*Myotis septentrionalis*)	N/A[5]	Yes
Indiana bat (*Myotis sodalis*)	N/A[5]	Yes
Fringed myotis (*Myotis thysanodes*)	Yes	Unknown (probably will)
Cave myotis (*Myotis velifer*)	Yes	Unknown (probably will)
Long-legged myotis (*Myotis volans*)	Unknown (probably will)	Unknown (probably will)
Yuma myotis (*Myotis yumanensis*)	Yes	Unknown
Western pipistrelle (*Pipistrellus hesperus*)	Yes	Yes
Eastern pipistrelle (*Pipistrellus subflavus*)	N/A[5]	Yes
Mexican free-tailed bat (*Tadarida brasiliensis*)	No	No

Notes:

1. The information presented in this table is based upon personal observations and personal communications over a period of years from Mike Bilbo (Bureau of Land Management (BLM), Roswell New Mexico), Pat Brown (Brown-Berry Biological Consulting, Bishop, California), Elizabeth Pierson (Consultant, Berkeley, California), Matt Safford (BLM, St. George, Utah), Tim Snow (Arizona Game and Fish Department, Tucson, Arizona), and

others.

2. A full gate is a structure that fully encloses the entrance to a cave or mine. (A half-gate is a structure that is constructed in a manner that leaves an unobstructed flight path over the top of the gate, or, alternatively a large open section within the gate.
3. This list of mine dependent bats is from Altenbach and Pierson (1995.)
4. Including the subspecies *P. t. virginianus*, *P. t. ingens*, *P. t. pallescens*, and *P. t. townsendii*, no information is available on how the Mexican subspecies (*P. t. australis*) will respond to gates.
5. Species not believed to use caves or mines as maternity roosts to a great extent, although males and non-reproductive females may use these sites during the summer.

Figure 1. Round bar gate installed at the entrance to a West Virginia cave supporting a maternity colony of endangered Virginia big-eared bats (*Corynorhinus townsendii virginianus*). This gate has been replaced by an angle-iron gate. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina)

Figure 2. Angle iron gate constructed at one of the entrances to an abandoned limestone mine in Ohio. This mine supports a hibernation colony of over 10,000 endangered Indiana bats (*Myotis sodalis*) and a large hibernation colony of little brown bats (*(Myotis lucifugus*) (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina)

Figure 3. Recent round bar gate installed by the Utah Division of Oil, Gas and Mining. This gate is constructed of Manganol steel. This material is much stronger and more resistant to cutting than the mild steel that was often used in early round bar gates. (Photo credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina)

Figure 4. Fence constructed at the entrance to an endangered gray bat (*Myotis grisescens*) maternity cave in Tennessee. (Photograph credit Robert R. Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina)

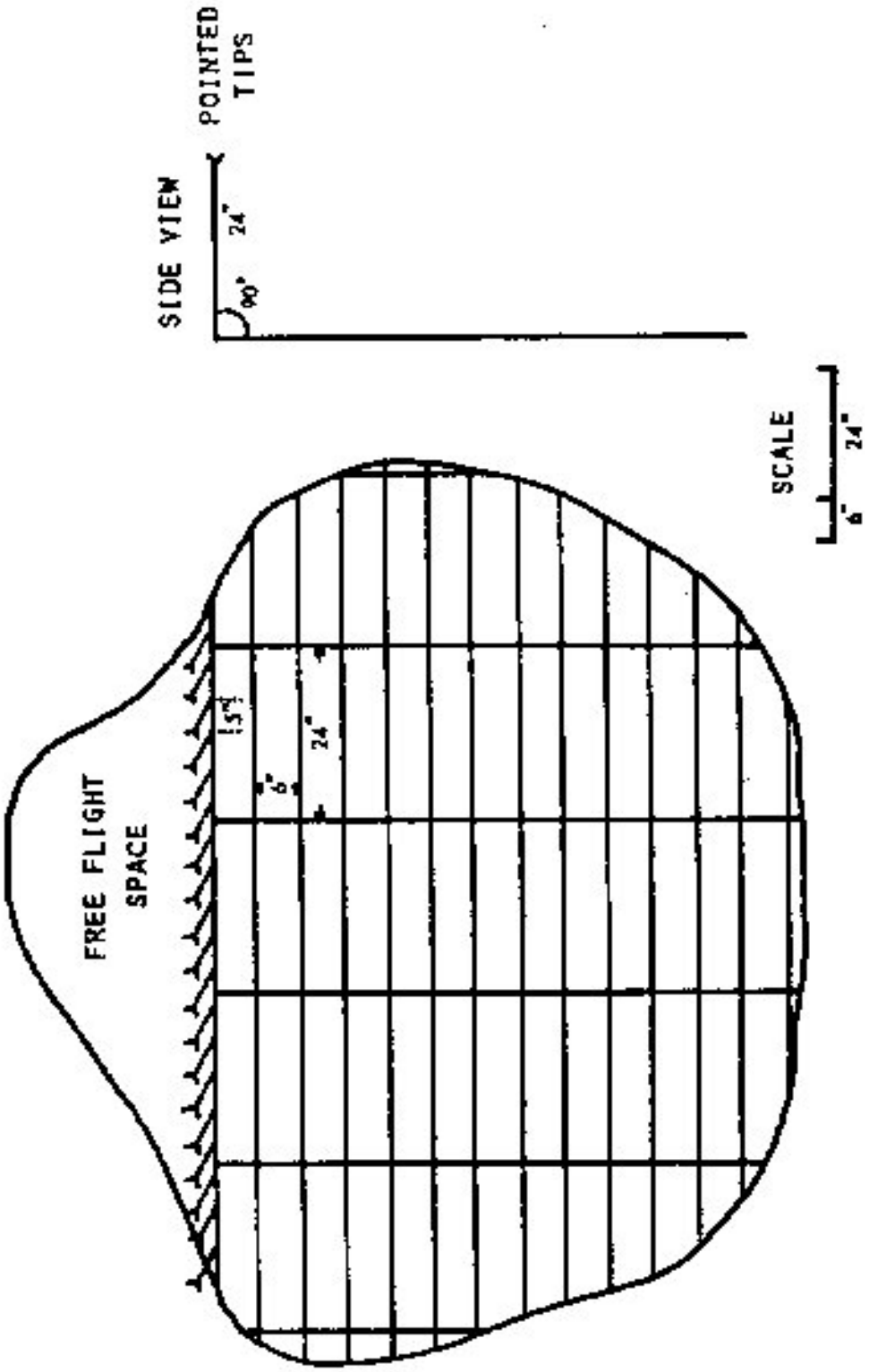

Figure 5. A ½ gate similar to this was constructed by the U.S. Fish and Wildlife Service at Sauta Cave in Northern Alabama. Caves and mines supporting species such as the gray bat (summer roosts) or the Brazilian free-tailed bat (*Tadarida brasiliensis*) usually must be protected with a ½ gate that provides an open flight space over the gate or with a fence installed far enough from the entrance to permit free bat flight over the fence. [From U.S. Fish and Wildlife Service (1982)]

BAT GATE MONITORING FORM

GATE/SITE LOCATION		
State:	County:	Name of Site:
Property Owner/Manager: (e.g., USFS, Tonto NF, etc.)		Administrating Agency:
Contact: (please include name, address, phone, fax, E-mail as appropriate)		

SITE DETAILS	
Describe opening(s): (e.g. mine shaft/adit, cave opening on hillside, etc.)	
Opening size: (adit or cave height x width, shaft collar length x width or diameter)	Number of openings (including vertical shafts and other entrances too small for human entrance):
Number of openings gated at sites with multiple openings: (if multiple openings to the same roost area were gated, describe each on a separate sheet but indicate their linkage)	Distance to driveable road:

PRE-GATING MONITORING

Are all openings monitored? Yes / No If no, how many are monitored? not monitored?

Date:	Method/Duration	Bat Species	# of Bats, by species	Reproductive Condition

GATING INFORMATION				
Date gate(s) installed:	Gate Details: (please attach copies of drawings, photos, etc. as available)	Height:	Width:	Depth: (if cage or other 3D structure)
Horizontal bar material and dimension, spacing (on center):		Vertical bar material and dimension, spacing (on center):		
Door or other access built in? If yes, please describe, include locking mechanism		Sill/foundation constructed? If yes, what type of materials used, dimensions.		
Additional supports? (e.g. perpendicular to the predominant bars) If yes, include number, material, dimensions, spacing, orientation .		Any signing erected? (warning or interpretive)		
Any breach attempts? (success of attempts, repair details, etc.)		Other information you think is relative:		

POST-GATE MONITORING				
All openings monitored? Yes / No				
Date*	Method/Duration	Bat Species	# of Bats, by species	Reproductive Condition
Assessment of the gating effort, suggestions for others considering similar gating:				

EVICTING BATS WHEN GATES WON'T WORK: UNSTABLE MINES AND RENEWED MINING

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Abstract

At most abandoned mine sites, the installation of bat gates can protect both humans and bats. However, sometimes the openings are too large or the mine too unstable to be considered for bat gates. The mine may be in danger of collapse, thereby entombing bats. Acid mine drainage may be polluting water supplies. Radioactivity could be a threat to people and bats. The only option may be to evict the bats and to seal the mine permanently.

While historic mining created new roosting habitat for many bat species, contemporary mining practices can adversely impact bats. Renewed mining in historic districts usually destroys old workings in the creation of open pits. Occasionally underground techniques are employed, but this method usually enlarges or destroys the original drifts. Even during exploratory drilling, historic mine openings can be covered as drill roads are bulldozed, or drills can penetrate and collapse underground workings. Nearby blasting associated with mine construction and operation can disrupt roosting bats. Finally, at the completion of mining, any historic mines still open on the property may be sealed as part of closure and reclamation activities. The net result can be a loss of bats, and bat roosting and foraging habitat. Sometimes in contemporary underground or surface mining operations, future roosting habitat for bats is created or can be fabricated. An experimental approach to the creation of new roosting habitat is to gate new underground workings or to bury culverts beneath waste rock. Different bat species with varying seasonal roost requirements will require customized designs. Temperature profiles of the bat mines that will be closed are useful in the identification of alternate habitat. Mining companies and agencies can mitigate for impacts to bats by: (1) identifying roosting habitat in non-impacted mines that can be protected with gates and fences, and (2) basic research to identify and protect critical foraging habitat.

Whether the concern is public safety or renewed mining, bats (and other animal tenants) may need to be evicted. The challenge is to accomplish this in a manner that removes the most bats with the least impact. Previous surveys for bats should provide knowledge of the seasonal occupancy and type of roost (maternity colony, migratory stopover, hibernaculum, breeding site, etc.) in order to plan the method and time of exclusion. If surveys conducted in another year or season did not disclose the presence of bats, it is important that a survey be conducted immediately prior to exclusion, since bats are mobile and can change roosts between seasons and years. For example, the closure of other mines in the vicinity may cause bats to relocate to a

previously unoccupied mine.

Introduction

Historic mining operations created new roosting habitat for many bat species. Some bat populations colonized mines when traditional roosts in caves or trees were disturbed or destroyed. In areas where natural caves never existed, bats may have congregated in abandoned mines because they offered protected roosting areas with stable temperatures that can shelter large colonies (Brown and Berry, 1991). Whatever the reason for colonization, mines have now become an important roosting habitat that concentrate large numbers of bats. This concentration of bats in relatively few roosts makes then vulnerable to disturbance and eradication (Tuttle and Taylor 1994). Determining why, how and when bats use mines presents many challenges (Sherwin *et al*. and Altenbach *et al.*, this volume). For some species in the western United States, such as the California leaf-nosed bat (*Macrotus californicus*) and Townsend's big-eared bat (*Corynorhinus townsendii*), the largest colonies now occur in man-made mine habitat (Bogan, this volume).

Now the same industry that was responsible for creating bat habitat has the potential to adversely impact bats (Meier, this volume; Brown, 1995a,b; Brown and Berry, 1997). Contemporary mining operations usually occur in historic mining districts where bats are commonly found. New methods of sampling ore bodies, such as drilling, often detect reserves that are now economical to extract. New mining activity typically produces an open pit and destroys historic adits and shafts. Occasionally underground techniques are employed, but only if high quality ore is located deep beneath the surface. This method usually enlarges or destroys the original drifts. Even if a mine working is not directly impacted, nearby blasting associated with mine construction and operation can disrupt roosting bats. Besides the physical disturbance of mining, other aspects of contemporary operations can have adverse impacts to bats and other wildlife, such as the introduction of cyanide and other contaminants (O'Shea, this volume) or the removal of foraging habitat (Kurta, this volume). At the completion of renewed mining, any historic mines still open may be sealed as part of closure and reclamation activities. The motivation for closing potentially hazardous mines is to reduce liability while at the same time possibly removing the unsightly scars of old dumps. Agencies might require this closure as part of the reclamation plan, without knowledge of the potential impacts to the bats and other wildlife inhabiting the mines. Safety is an issue since new or improved road access into the region can bring increased human visitation to an area after the cessation of active mining. The goal of protecting bat habitat in mines and excluding people by the installation of bat-accessible gates is the preferred option, although it may not be feasible if the mine entrance is too large or the substrate unstable. Acid mine drainage or radioactivity can pose threats that are only solved by permanently sealing the mine.

Ideally, when a mine needs to be closed either for renewed mining or public safety, all information on the use of that mine by bats and other wildlife has been determined in advance: what species, what season, for what purpose and how frequent the use (Sherwin *et al.*, this volume). In addition, alternate roost sites in the region (close to good foraging habitat) have been identified and protected with gates. The targeted mine can then be closed when bats are not in

residence, or at a time when eviction has the least impact. Unfortunately this is not an ideal world, and usually mining companies and land management agencies to not have the time, expertise and/or money to get the necessary data to make the best management decision. This paper aspires to provide some guidelines for mitigating impacts to bats when mine gates are not feasible.

Exclusion Considerations

The methods and timing of bat exclusion will need to be modified in specific situations. A bat biologist with the necessary equipment and experience should be involved in the preliminary surveys (Altenbach *et al.*, this volume). Surveying mine openings during the day is not an adequate method to determine bat use. More detailed surveys are required to determine when and how the mine is being used by bats (i.e. maternity colony, males, hibernation, mating, migratory stopover, etc.). This usually requires entering the mine to search for bats or guano (Altenbach, 1995). The size, shape, odor and deposition pattern of guano as well as culled insect remains can aid in bat identification and seasonal use even if bats are not present in the roost. If entry into the mine is not feasible due to safety considerations or the mine is so complex that it cannot be thoroughly surveyed even if entered, then an external survey using night vision equipment and/or infrared video is necessary to document bat habitation. All entrances of a mine should be monitored, although without an underground survey, connections between surface features may not be understood. During the winter, most bats hibernate and do not exit to forage; therefore an external survey will not determine presence or absence of bats. "Winter" will vary with altitude, latitude and between years, and signifies that time of year when bats remain torpid and survive on stored energy reserves.

Timing of Exclusion

Schedule the time of bat exclusion during that period when bats are absent or the fewest bats are using the mine. If there is any possibility of a maternity colony, then no closure should be made during that season, usually between April and August. The exact months of the maternity season may vary between years as well as with geographic location and species of bat. A local bat biologist should be consulted to determine when maternity colonies begin to form and when they will disperse. A maternity colony as a group may move between mines several times during the reproductive season. For example, in a survey of over 200 mine workings in Battle Mountain Nevada, the maternity colony of Townsend's big-eared bats used at least three mines: preparturition, post-parturition and after the young begin to fly. Additional mines were used for courtship and breeding activities in the fall (Brown and Berry, 2001). If only a single survey of a mine site is conducted during the warm season, the significance of some mines would be missed (Sherwin, *et al*., In Press), and exclusion might be scheduled for a time that bats are using the mine. Mine closures should avoid winter, especially if a mine cannot be safely entered to survey for hibernating bats. Even in mines that can be entered, torpid bats are often hidden in very small crevices. Attempting to arouse and move hibernating bats may lead to their demise.

In order to avoid hibernation and maternity periods, exclusion is usually scheduled for early spring or late summer/early fall (i.e. April or September-October). This is always subject to the local conditions in the year closure occurs. Eviction should not be attempted if the weather

during any month becomes cold and windy, since the bats may not exit to forage during these conditions. Always monitor the mine for bat activity using night vision equipment or infrared prior to any closure. We have been surprised to see large numbers of *Macrotus* entering a mine after dark in the fall for courtship activities (Berry and Brown, 1995). This could be the case with other species. A site may be used for a specific function for only a few weeks a year and may have been missed during an initial survey. Bats may have moved into a mine since an initial survey due to closure or disturbance at other mine sites. Be prepared to be flexible and return later if conditions are not favorable for exclusion.

Exclusion protocol

A "cookbook" approach should be used cautiously as no one method will work for all species in all locations. Our methods have evolved for mines in the arid southwest, and may not be applicable for bats in other regions. A sample protocol would require that a mine be watched with night vision equipment for at least an hour after dark or until most bats appear to exit the mine (the number of bats having been determined by a prior night exit count). The mine opening can be covered with one-inch chicken wire. After years of experimentation, this material has been selected for the following reasons: (1) Most bat species, if inadvertently trapped in the mine, can squeeze through the wire and escape, yet they do not appear to want to squeeze into the mine on subsequent nights; (2) Chicken wire can be molded to provide an awning effect so that bats inside the mine detect a window, yet bats approaching from outside the mine perceive a barrier; and (3) Woodrats and other rodents cannot incorporate chicken wire into their nests, while they will readily gather tarps, fish seine and other soft netting.

If the mine contains a large number of bats (i.e. >10), then the chicken wire should be partially removed prior to dusk on the next night to allow trapped bats to exit. Not all bats exit every night, especially if some detect the presence of a large predator (i.e. human) near the mine. Usually these bats will exit the following night. Two-way bat traffic is encountered in most mines. Little brown bats (*Myotis* sp.) and pallid bats (*Antrozous pallidus*) may be entering a mine to night roost before the Townsend's big-eared bats have exited. The use of two finger tallies (or tape-recorded voice notes) with the night vision equipment will help to keep track of bats entering and exiting the mine. In the case of two-way bat traffic, the creation of awnings and one-way valves may be necessary, so that bats can exit a mine through a "window", but the opening will not be apparent when bats approach it from the outside. If the mine can be safely entered, any bats remaining in the mine might be captured in hand nets and removed. This would be impossible in shafts and complex mines.

All entrances to a mine complex must be closed. Some of the best bat roosts are in mines with multiple entrances that provide a variety of temperatures at different seasons. Without conducting a thorough internal survey, multiple openings of a mine may not be known. Old mine maps (if they exist) may be outdated, since new openings may have been created or old connections destroyed. If only one access into a mine is sealed, the bats may continue to use a "back door". The conservative approach is to systematically close any opening that might possibly connect. Some of these might be on the other side of the hill or on the next ridge.

The chicken wire should be left in place a few days to allow bats to escape before being permanently closed or covered with a more opaque material. Whereas large colonies of bats may be deterred by the chicken wire, individual bats may enter the mine again. Especially prior to winter hibernation, bats have been known to squeeze through small openings (even chicken wire) to enter a favorable site. Additionally, if the covered mine is not destroyed or permanently sealed within a few weeks of covering, it will be necessary to periodically check it to be sure that openings do not erode open and bat access is restored. If this happens, then exclusion will need to be repeated at a favorable time.

Mitigation

Habitat Replacement

When bats are roosting in a mine slated for closure, then mines in a radius of about 5 miles from the closure site should be surveyed for potential replacement habitat. The exact distance that a bat will travel between roosts is a function of the species, geographic location and the season. The replacement mines should be evaluated with respect to prior or current bat use, complexity, temperatures (if entered), direction the entrance faces, etc. in order to select micro-environments similar to those in the mine(s) to be closed. Where critical roost temperature and/or configuration requirements of a particular species are known, alternate roosts are easier to identify (Sherwin *et al*., 2000). For example, *Macrotus* selects mines warmer then 80 F (Brown, 1999; Brown and Berry, 1996). If a mine has all the right qualities and no bat sign (but human disturbance is evident) then gating or fencing might result in an acceptable habitat for the evicted bats. If the mine to be closed is used by bats, it may be the "best" habitat in the area. The bats will not use another mine until they are disturbed or evicted from the original. When closure is inevitable and the mine slated for closure is safe to enter, the bats can be captured during the day and banded (but not during the maternity season or hibernation). Most of the bats will usually move to an alternate roost after this disturbance. The ability of bats to accept bands varies with species, and this method should not be used without prior research on any adverse effects.

Protection or Creation of Replacement Habitat

Mines selected as mitigation sites should be gated or fenced to provide protection from human disturbance prior to eviction of the bats from their current roosts (Currie, this volume). In situations where the bats cannot be captured, banded and allowed to relocate, the mines with the best bat potential as deducted from habitat requirements of the species should be selected for gating. In contemporary underground operations, future roosting habitat for bats can be created. For example, the American Girl Mining Joint Venture left some of the underground areas open when they finished mining, and gated the entrances (Brown *et al.*, 1995). An experimental approach to the building of new roosting habitat is to bury culverts with multiple openings beneath new waste rock, or old mining truck tires as Homestake Mining Company has done at the McLaughlin Mine (Enderlin, this volume). Bat Conservation International is encouraging innovative approaches to bat habitat creation (Ducummon, 1997). Different bat species with varying seasonal roost requirements will require customized designs.

Monitoring
Ongoing monitoring of the gated mines or replacement habitat over several years at different seasons is necessary to evaluate the effectiveness of the relocation. In a successful bat relocation project at Homestake's McLaughlin Mine in Northern California, remote monitoring of bat movements was automated (Pierson *et al.*, 1991). If after several seasons, the numbers of bats in the replacement habitat do not increase, additional surveys should be conducted to discover the roosting location of the excluded bats. Modifications may need to be made in the gate design.

Research
In addition to roosting habitat, critical bat foraging areas or water sites near mining districts need to be identified. In southeastern California, radio-telemetry studies sponsored by American Girl Mining Joint Venture have shown that *Macrotus* forages among desert wash vegetation (Brown *et al.*, 1993; Brown *et al*., 1995). When mining operations removed this vegetation near mine roosts, California leaf-nosed bat populations declined. Good foraging habitat within a mile of the roost is especially important in the winter, when bats spend most of the night in warm mines and relatively little time out in the cold. As new mines in the range of *Macrotus* plan for the future placement of waste dumps and facilities, they can avoid impacting the critical wash vegetation. More research is needed to determine foraging habitat for other bat species.

Reclamation
As mining projects enter their reclamation phase, historic mines still open on the property that could provide bat-roosting habitat should be fitted with bat-compatible gates or fenced. Educational signs (Currie, this volume) can be displayed to inform the public of the purpose of the barriers. Uncontaminated water sources on site will also attract bats. If specific vegetative communities are known to provide foraging habitat for bats (i.e. desert wash vegetation for *Macrotus*), these can be planted during the reclamation phase.

Summary

Historic mines provide roosting habitat for many bat species. Whenever possible, abandoned mines should be closed with bat-accessible gates to protect the bats and people. This may not be feasible or desirable for large or unstable mine openings, mines with radioactivity or acid drainage, or in areas of active mining. Renewed mining in historic districts impacts bats during the exploration, active mining and reclamation phases by death or disturbance of the bats and the removal of roosting and foraging habitat. Impacts to bats by mine closure for all reasons can be mitigated by initial surveys at appropriate seasons to identify bat roosting habitat, exclusion of bats prior to mine closure, identification and protection of alternate roost sites with gates and fences, creation of replacement habitat, and monitoring the success of relocation. Research to identify habitat requirements could be used in the development of mitigation plans.

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MONITORING AND EVALUATING RESULTS OF BAT PROTECTION EFFORTS

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Abstract

Title IV of the Surface Mining Control and Reclamation Act (SMCRA) authorizes State Programs to close abandoned mines to protect the public from potential hazards. As part of this process, abandoned mines are surveyed prior to closure to evaluate their potential as bat habitat. Those mines providing suitable habitat are sealed with bat-compatible gates that allow bats continued ingress and egress. However, a few studies suggest that for some population sizes and certain species of bats, bat gates may actually decrease bat use of mine openings; post-gate monitoring studies to document long-term effects of this technique for conserving bat populations are lacking. In Southwestern Utah, the Utah Division of Oil, Gas and Mining Abandoned Mine Reclamation Program closed 141 abandoned mine openings with bat compatible gates in the Silver Reef mining district. Additional mine openings in the nearby East Reef and the Tushar mountain areas are scheduled for closure in 2001. We are currently using these study areas to monitor and evaluate the effectiveness of gated mines on existing known bat populations. Objectives of the study include: (1) evaluating and ranking the effectiveness of techniques [e.g., night vision devices, infrared event counters (Trailmaster ™ 1500M), infrared video, ultrasonic detection equipment (Anabat™) and mist nets or harp traps] to monitor bat use; (2) using this information to develop a protocol for using the most reliable of these techniques; and (3) establish long-term monitoring sites. Evaluation criteria include: (1) purchase and operating costs; (2) security concerns; (3) equipment reliability and ease of operation; (4) number of personnel necessary to gather and evaluate the data; (5) the ease of analyzing the data; and (6) type of information needed. The results indicate that a combination of monitoring techniques are necessary to meet long-term study objectives. Infrared event counters are well suited to record relative bat activity inside mines over long periods of time with minimum observer disturbance and cost, but cannot be used to reliably gather information on bat behavior through gated entrances, or absolute numbers and species identification of bats. Ultrasonic detection equipment and mist net/harp traps are necessary techniques to reliably determine bat species composition. Infrared video cameras provide an accurate, permanent monitoring record of bat numbers and behavior. Protocols specific to each mine may be necessary to minimize observer and equipment effect on bat behavior. Efficient low cost monitoring can be accomplished using minimal equipment and personnel. Preliminary analysis suggests that bat behaviors do differ in gated and un-gated mine openings. Interpretation of these results and evaluation of their effects on protection of bat populations will require long term monitoring.

Dr. Kate Grandison is an associate biology professor at Southern Utah University. Her research interests are in behavioral ecology and conservation biology where she has been monitoring bats in southwestern Utah since 1996.

Session 4

Protecting Bat Habitat Associated with Surface Mining and Reclamation

Session Chairperson:
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Bats on The Surface: The Need for Shelter, Food, and Water
Dr. Alan Kurta, Department of Biology, Eastern Michigan University, Ypilianti, Michigan

Impacts of Mine Related Contaminants on Bats
Dr. Tom O'Shea, U.S. Geologic Survey, Fort Collins, Colorado and Donald R. Clark, Jr., U.S. Geologic Survey, College Station, Texas

Surface Habitat Disturbance, Protection, and Enhancement Associated with Active Surface Mining and Reclamation
Chris Yde, Montana Department of Environmental Quality, Helena, Montana

Endangered Species Habitat Replacement
Sally Imhof, Kansas Surface Mining Section, Frontenac, Kansas

Surface Mining Case Study from Kentucky
Dr. Richard Wahrer, Kentucky Department for Surface Mining Reclamation and Enforcement, Frankfort, Kentucky

BATS ON THE SURFACE:
THE NEED FOR SHELTER, FOOD, AND WATER

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Abstract

Most species of North American bats do not live in mines or caves, and many of those that do only spend a portion of each day or perhaps an entire season underground. Consequently, preservation of underground habitat is only part of the solution to maintaining the diversity of bats across the landscape. Central to survival of any species is availability of food, water, and shelter. In the United States and Canada, virtually all species of bats require a diet of arthropods, usually insects, although a few fruit- and nectar-feeding bats do cross our southern border. Bats do not feed on just any type of insect; instead some prefer moths or beetles, for example, and all bats will only take insects within a particular size range appropriate for the species. About 75-80 percent of the daily water requirement of insectivorous bats can be met by metabolic water or preformed water in the diet, but the remainder is drinking water, presumably gathered from a pond or stream. Reduction or pollution of available water can affect the diversity of bats directly through dehydration or toxic effects or indirectly by modifying the number and kinds of insects that are available. North American bats utilize a variety of roosting sites and commonly are found in buildings, rock crevices, and especially trees, with different species of bat roosting in hollows, under loose bark, or simply among the foliage. Successful management of bat populations likely will require a landscape approach that emphasizes maintenance of a diversity of habitats in proximity to each other.

Introduction

Bats are one of the most successful groups of mammals. Currently, there are over 925 species worldwide (Koopman, 1993), and about 45 of these live in the United States and Canada (Wilson and Ruff, 1999). Much of the success of bats can be traced to their ability for powered flight, which is unique among mammals, and to the bat=s ability to fly and forage at night. The nocturnal habits of these creatures, however, make them difficult for biologists to study and even objects of fear for many nonspecialists.

About 50 percent of North American species currently are considered endangered or threatened at the national or State level (O=Shea and Bogan, 2000). The decline of bat populations, to a large degree, is related to degradation or destruction of habitats needed by bats. Efforts to reverse this trend are hampered by public misconceptions of these intriguing creatures, lack of funding, and fundamental aspects of the animal=s biology. Perhaps most important among the latter is the fact that bats produce few offspring (Kurta and Kunz, 1987). All species in the United States and Canada, give birth only once each

year, and most produce only a single offspring, although a few consistently have twins. A low reproductive rate makes it difficult to reverse downward trends in population. Perhaps the best conservation strategy for bats, in general, is to provide each species of bat with the necessities of life *before* populations begin to decline (O=Shea and Bogan, 2000).

What do bats need in order to survive? In general, the most basic requirements for any kind of animal center around food, water, and shelter. Bats are no different. The topic of this conference is mainly the shelter provided to bats by abandoned mines. Nevertheless, one must understand that many bats do not roost in mines or caves. Most of those that do, use underground retreats only on a seasonal basis, and even species that live in caves or mines year-round must come to the surface for food and water. My goal in this paper is to give the audience a feel for the varying life-styles of North American bats, and hopefully, this information can be used to help develop management plans that cater to the needs of the entire bat community.

Food

Worldwide, the diet of bats is quite diverse. Some species feed on fish, shrimp, frogs, rodents, other bats, blood, insects, fruit, nectar, pollen, etc. In the United States and Canada, however, diets are somewhat boring. We have just one, rare, fruit-eating species (*Artibeus jamaicensis*) that occurs only in the Florida Keys, and three nectarivorous species (*Leptonycteris curasoe*, *L. nivalis*, and *Choeronycteris mexicana*) that migrate into the extreme southwestern United States every spring. The rest of our bats, about 90 percent of the species, consume only arthropods, most of which are insects. Most North American species of bat are aerial insectivores that capture prey while both the bat and insect are in flight, although a few species of bat (e.g., pallid bat, *Antrozous pallidus*) are capable of gleaning, i.e., plucking their unsuspecting prey from the ground or a tree trunk. Some North American bats use sounds produced by the prey itself to help capture the arthropod in the dark, and some bats actually rely on vision to a large degree (Bell, 1985); nevertheless, most species emit high-frequency sounds and use the returning echoes to detect, localize, and capture their prey.

What types of insects are eaten? Diet of insectivorous bats largely is determined through painstaking analysis of stomach contents or fecal pellets (Whitaker, 1988) or occasionally by examining uneaten items dropped beneath a roost (e.g., Burford and Lacki, 1998). Because insectivorous bats reduce their prey to a mass of tiny, chitinous fragments, such analyses typically are rather coarse-grained, and most only identify prey to higher taxonomic levels, such as order or perhaps family. Nevertheless, we do know that diet of insectivorous bats is quite varied, both within and among species. For example, in much of eastern North America, three of the most common and widespread species are the big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), and red bat (*Lasiurus borealis*). The big brown bat commonly specializes on beetles, whereas red bats prey heavily on moths and true bugs (Freeman, 1981). Little brown bats, in contrast, eat

primarily midges, mayflies, and caddisflies.

Why do some species of bat seemingly prefer certain kinds of insects and other bats prefer different types? Some of this apparent selectivity is related to interactions among echolocation strategy, morphology, and behavior (Bogdanowicz et al., 1999; Freeman, 1981; Norberg and Rayner, 1987), although it is not always possible to separate cause and effect. Little brown bats, for example, have a less robust skull and do not have a very strong bite compared with big brown bats; therefore, one would not expect little brown bats to concentrate on hard-bodied prey such as beetles. Big brown bats use ultrasonic frequencies between 25 and 50 kHz for echolocation. These frequencies are audible to many moths; hence the absence of moths in the diet of big brown bats is expected. Red bats are fast flyers with long, slender wings that make them less maneuverable than other species. Consequently, a red bat typically flies in open areasCover a field or above the forest canopyCand its prey, of course, can only be the types of insects found there. Little brown bats preferentially forage over streams and ponds, so the predominance of prey with aquatic larval stages in their diet is not surprising.

Diet also can vary within a species, and presumably even within individuals. Take the endangered Indiana bat (*Myotis sodalis*) as an example. The most common item in the diet of this bat was moths in southern Indiana (Belwood, 1979); caddisflies in Eaton Co., Michigan (Kurta and Whitaker, 1998), but true flies in Jackson Co., Michigan (Murray, 1999). Dietary variation also occurs between years, within years, and within nights at the same location. In Jackson Co., Michigan, for example, flies represented 25 percent of the diet in one year but 42 percent during the following season. Pregnant Indiana bats in May and June consumed more caddisflies, less moths, and fewer flying ants than did lactating females in July, and more beetles were eaten during post-sunset foraging bouts than during pre-dawn foraging (Murray, 1999). Dietary differences between sites (summarized in Freeman, 1981), within years (e.g., Anthony and Kunz, 1977; Whitaker 1995a), and within a single night (e.g., Best et al., 1997; Whitaker et al., 1996) are known for other species as well.

Does this mean that management must be situation-specific providing an insect community that is just right for the needs of each species of bat during any particular season, year, or night? The answer is probably not. Many bats appear to be opportunists and forage on any insect of appropriate size that happens to be common in the environment. This opportunism is exemplified by the presence of flying ants in the diet of many species. Flying ants occur at unpredictable times of the year in huge swarms. Ants often are absent from the diet or present in very low amounts, but suddenly, they become the dominant prey for a period of days or weeks, as the bats take advantage of the unexpected bonanza (Kunz et al., 1995; Whitaker and Rodríguez-Durán, 1999).

Although some studies claim that bats actively select prey from among the insects flying in the environment and that regional, seasonal, and nightly differences are somehow adaptive, such selectivity likely is limited (Whitaker et al., 1999). The speed of a flying bat and the short range of high-frequency sound, make it unlikely that bats are able to

determine much detail about a flying prey before it is captured (Barclay and Brigham, 1994). It seems more likely that bats exert selectivity by choosing the habitat that they forage in and then simply concentrate on whatever insect of the correct size is there and within the limits of the bat=s morphology and echolocation abilities (Brigham et al., 1992; Whitaker, 1995b). Maintenance of a variety of habitats that produce a variety of insects throughout the year is probably more appropriate for bat management than targeting the production of specific kinds of insect.

Bats obviously eat insects, and their activities can be extremely beneficial to humans. The Mexican free-tailed bat (*Tadarida brasiliensis*), for example, preys on corn earworm moths (*Helicoverpa zea*CMcCracken, 1997), and the big brown bat consumes cucumber beetles (*Diabrotica* spp.), the larvae of which are the destructive corn rootworm (Whitaker, 1995a). During late lactation bats typically consume more than their own weight in insects each night (Kurta et al., 1989a, 1990), and the number of insects eaten per year is staggering. For example, a single colony of 150 big brown bats conservatively consumes 1,287,000 insects during a single season, or about 8,600 beetle-sized insects per bat (Whitaker, 1995a). Similarly, a colony of 300 evening bats (*Nycticeius humeralis*), a species that takes somewhat smaller prey than big brown bats, devours 6,300,000 insects per year, or 21,000 insects per bat (Whitaker, 1992).

Unfortunately, most humans have little appreciation for these beneficial effects of bats and attempt to control insect populations primarily through the use of chemicals. What any wildlife manager must keep in mind is that bats are at the end of the food chain, and overuse of insecticides within the foraging area may have detrimental effects. Chemicals reduce the number of potential prey for the bats, and these mammals also suffer from toxic effects of chemicals that bioaccumulate in the bat=s tissues (Clark, 1981, 1988, 1996; Clawson and Clark, 1989; Swanepoel et al., 1999).

Water

Do bats require drinking water? Although one might think that the answer to this question is obvious, there are many examples of mammals in the world that do not need to drink, particularly species from arid environments (Schmidt-Nielsen, 1964). Instead of drinking, these mammals receive enough water in their food (i.e., preformed water) and/or produce enough water during biochemical processing of food molecules (i.e., metabolic water) that the animals do not have to drink.

It is possible to measure daily water consumption of a free-ranging animal using isotope-dilution techniques (Bassett and Studier, 1988). If one knows the energetic demands of the animal, as well as some information on the chemical makeup of its food, one can calculate the amount of preformed water consumed and metabolic water produced and, by subtraction, determine the amount of drinking water that is required. In North America, this has been done with two, common, insect-eating species, the little brown bat and big brown bat (Kurta et al., 1989b, 1990). For both species, drinking water amounts to 20-26

percent of the daily water requirement for pregnant and lactating females. These studies were performed in New England, and drinking requirements likely are even greater in more arid parts of the continent (but see Bell et al., 1986; Kunz et al., 1995).

The fact that insectivorous bats require water on a daily basis means that water must be considered when developing any management plan. In certain parts of the country, such as the Great Lakes region, standing water in the form of ponds, streams, lakes, etc., is ubiquitous. Nevertheless in many areas, such as the Southwest or Great Plains, manmade sources of water may be the only ones within miles.

Water quality also is critical. Bats, for example, may be killed by ingesting water laced with toxic chemicals (Clark, 1991; Clark and Hothem, 1991). In addition, water quality affects the number and kinds of insects that are available, which, in turn, may increase or decrease activity of members of the local bat community (Vaughan et al., 1996).

Shelter

Animals spend the majority of their time at rest (Herbers, 1981), and bats are no exception. Depending on latitude, a bat may occupy its roost for 15 hours or more each day during summer. Within their roosts, adult bats avoid the vagaries of the weather, hide from hungry predators, give birth, and raise their flightless young. Consequently adequate shelter is extremely important for maintaining both the number and kinds of bats in a community (Humphrey, 1975).

A number of bats, of course, will use mines, caves, or similar underground retreats. However, many of these species, particularly those living in the northern half of the United States and all of Canada or at high elevations, only do so on a seasonal basis, i.e., during winter. This seasonal use/avoidance of subsurface roosts largely is due to temperature. Hibernation is most energetically efficient at cool temperatures that are constant and just above freezing; these low temperatures allow the bat to reduce its body temperature, maintain a greatly lowered metabolic rate, and subsist off stored fat for up to 9 months.

In summer, however, bats are faced with the demands of reproduction. A female must produce a fetus and enough milk to support growth of her offspring, and she must do this in a timely manner so that the young can learn to fly and forage, and ultimately to store sufficient fat, before autumn frosts spell the end of flying insects. Although adult males take no part in raising the young, the males also have a time constraint, because they must complete the lengthy process of spermatogenesis in preparation for late-summer mating (Entwistle et al., 1998; Kurta and Kunz, 1988; Racey, 1982).

These reproductive processes, whether it is fetal growth, milk synthesis, or sperm production, are really nothing more than a series of chemical reactions, and all chemical reactions occur at a faster rate at warm temperatures. A bat in summer, therefore, can

promote these chemical reactions by either paying a huge energetic price to maintain physiologically a high body temperature (35-39 <C) while roosting in a cool (0-20 <C) cave or mine, or by choosing a shelter that is warmer than a cave or mine. In reality, bats do not have a choice because it simply is not physically possible for them to capture enough insects to meet the energetic demands of reproduction and to thermoregulate at cool ambient temperatures (<20 <C) for 15 or more hours each day.

In any event, some species that extensively use caves or mines year-round, such as the gray bat (*Myotis grisescens*), are restricted to the southern United States. A number of other species, such as the southeastern bat (*Myotis austroriparius*), form summer colonies in caves in southern areas (e.g., Florida), but abandon subsurface roosts on the northern edge of their range (e.g., Illinois), where caves are 10 <C or more cooler than in Florida (Hofmann et al., 1999). About 10 percent of North American bats, the lasiurines, never venture undergroundCeither in winter or summer. If they are not underground, where are our bats? In general, roosting sites outside of mines and caves are typically in rock crevices, buildings, or trees.

In mountainous areas or regions with exposed bedrock, some species of bat roost in horizontal or vertical cracks within the rock (Tuttle, 2000). Crevices usually are quite narrow, often only barely wider than the bat=s body, and generally located high on a cliff face, where the roost is inaccessible to humans and predators. This is a common roosting habit of pallid bats (*Antrozous pallidus*), spotted bats (*Euderman maculatum*), western pipistrelles (*Pipistrellus hesperus*), and western mastiff bats (*Eumops perotis*), among others (Lewis, 1996; Kunz, 1982). Some species, such as the Mexican free-tailed bat, secondarily have adapted to crevices found underneath concrete bridges or sports stadiums for their day roosts (Childs, 1996).

Some of the best-studied species of bats, and those that are most familiar to nonbiologists, are bats that roost in buildings (Barbour and Davis, 1969), including big brown bats, little brown bats, and Yuma bats (*Myotis yumanensis*). In reality, the number of species that rely heavily on buildings for day roosts is quite small, and these species often exhibit behavioral flexibility and still form colonies in more natural situations. Little brown bats, for example, frequently roost in buildings but they also form maternity colonies in trees (Crampton and Barclay, 1996). Artificial roosting structures designed for bats (i.e., bat houses) generally attract the species that commonly roost in buildings (Tuttle and Hensley, 1993).

In the mid-1980=s, miniature radiotransmitters suitable for use with even small bats (< 20 g) became available, and radiotracking studies since that time have demonstrated that many, perhaps most, species of North American bats rely on trees for day roosts. Some species simply hang from leaf petioles or small branches, or, in certain parts of the country, within clumps of Spanish moss (Menzel et al., 1998, 1999). Most foliage-roosting bats are heavily furred, cryptically colored animals within the genus *Lasiurus* (red bats, hoary bats, yellow bats, etc.) that usually roost alone. The eastern pipistrelle (*Pipistrellus subflavus*), unlike the lasiurines, forms small maternity groups. Although

colonies of pipistrelles occasionally find shelter in buildings, recent observations indicate that these tiny bats often hide inside a clump of dead leaves in an otherwise healthy tree (Kurta et al., 1998; Veilleaux, 1999, in litt.).

Radio tracking has shown that many species of bat roost underneath the loose bark of dead trees (Barclay and Brigham, 1996), a shelter that apparently is utilized by only one other warm-blooded vertebrateCa bird, the brown creeper (*Certhia americana*CKurta and Foster, 1995). Roost trees tend to be large-diameter snags that have a less-cluttered flight space around them than do randomly chosen trees (Barclay and Brigham, 1996 Vonhoff and Barclay, 1996). Roost snags also tend to receive large amounts of sunlight, which presumably facilitates thermoregulation. Although roost trees often are taller than surrounding trees, at least one species, the western long-eared bat (*Myotis evotis*) roosts in stumps left behind by loggers (Vonhoff and Barclay, 1997).

Finally, a number of species roost in crevices or cavities within trees. Some, such as the northern bat (*Myotis septentrionalis*) roost in crevices (Foster and Kurta, 1999) that form when branches or trunks break and splinter. On the other hand, cavities used by the big brown bat, often are the result of rot and excavations by woodpeckers (Kalcounis and Brigham, 1998). Although some species may prefer bark or crevices or cavities, use of one type of roosting site usually does not preclude use of the other types. The northern bat, for example, is found under bark about half the time and in crevices half the time (Foster and Kurta, 1999); the Indiana bat, in contrast, roosts under bark about 95% of the time, but crevices are used on occasion (Kurta et al., 1993, 1996).

There are three related facets of tree-roosting that are extremely important for management. First, foliage, exfoliating bark, and to a lesser degree, hollow trees are ephemeral compared with buildings, caves, or mines. Tree roosts may suddenly disappear in a storm and generally do not last for more than a few years; consequently a constant supply of new roosts must be available. Second, these bats may utilize a large number of trees in a single season, up to 18 in 1 year for Indiana bats (Kurta et al., 1996), and third, the bats change trees frequently, generally once every 2-4 days (Kurta et al., 1996; Foster and Kurta, 1999; Menzel, 1998, 1999). Although alternate roosts often are clumped so that different roosts are no more than 50-100 m apart, some alternate roosts may be separated by 5 km or more (A. Kurta, unpubl. observ.).

Management Implications

To many nonspecialists, a bat is a bat, and all species of bat are alike. Nevertheless, across the United States, the bat community in any particular area contains 4-23 different species, with most regions harboring between 6 and 15 species (Humphrey, 1975). As we have seen, a diversity of bat species means a diversity of diets, foraging areas, and roost types, and comprehensive management plans must address this diversity.
To complicate matters, bats are extremely mobile animals. The home range of an

individual bat is huge compared with that of a similar-sized mouse or shrew, and the home range of a colony of bats is even greater (Kurta et al., 1996). It is not unusual, for example, for bats to travel 2-20 km from their roost each night in search of food, water, or alternate roosts (Murray, 1999; Pierson, 1998). Along the way, bats often follow linear landscape elements (wooded fence lines, forest-field edges, forested streams, etc.) that connect foraging areas and roost sites (Murray, 1999; Verboom and Huitema, 1997), and many species utilize night roosts that can be some distance from the day roost (Adam and Hayes, 2000; Kunz, 1982; Lewis, 1994).

Obviously a management plan that addresses a single day roosting site or a single foraging ground is terribly incomplete. Management of bats ultimately will best be achieved by addressing the needs of the entire community at the landscape level to insure that a diversity of roosting sites, foraging grounds, and sources of water are available for each species. In addition, a final point to consider is that many bats are migratory, and events taking place hundreds or thousands of kilometers away may affect the status of local bat populations (e.g., Walker, 1995).

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IMPACTS OF MINE-RELATED CONTAMINANTS ON BATS

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Abstract

Although the impact of mining-related toxic substances on bat populations is an important conservation concern, it has not been studied intensively. We will review a few case studies in this paper and point out the potential for negative impacts of metal contamination on bat foraging habitat and insect prey. Modern gold mining operations that use cyanide extraction methods usually result in cyanide solutions stored in ponds. Small pools are also formed on heap piles. Large numbers of such mining operations have developed in the U.S. and abroad, and cyanide pools can be attractive to wildlife as sources of drinking water, particularly in arid locations. Surveys have shown that bats are among the most numerous of mammals found dead of cyanide poisoning at these pools. This method of mining also occurs in Alaska, the Great Plains and the southeastern U.S., with mortality of bats reported in ponds in South Carolina with cyanide concentrations that were surprisingly low. Straightforward management measures are available to reduce or eliminate some of these problems. There are no direct studies of the degree to which bats are exposed to or impacted by elevated concentrations of potentially toxic elements stemming from mining activities. However, we suggest this potential is strong. One study has shown a correlation of mercury in guano deposits with regional mine production of copper. It has been demonstrated that bats accumulate metals from the food chain in areas of pollution from other industrial sources. Emergent aquatic insects can have elevated metals in areas downstream from mining sites. More than half of the species of bats in the continental U.S. can be characterized as at least occasionally foraging over water and on emergent aquatic insects. Documentation on mortality of bats in sludge pits associated with western oil exploration is reviewed. Exposure to harmful levels of radiation is a potential issue to bats that roost in abandoned mines. Indirect impacts of toxic substances from mining can come from spills, alkaline or acidic discharges altering emergent insect or riparian-based food supplies, lowered water tables, and other sources of contamination and pollution. Further research is needed on

impacts of mine-related toxic substances on bats, including determination of exposure levels, health effects, and possible population impacts.

Introduction

The objective of this paper is to review the literature for evidence of harmful effects or potential effects of contaminants from mining processes on bats. The impact of mining-related toxic substances on bat populations is an important conservation concern, but it has not been studied intensively. However, the potential for contaminant impacts is great, and each category of mining and subsequent ore processing can produce an array of potential contaminants. In addition to effects of mining and the deposition of tailings, the extraction of minerals from the ores, smelting, and refining may pose additional threats due to release of contaminants. Effects of environmental contaminants on bats can be through direct exposure, or can be indirect due to ecological restructuring that may alter food supply, physical habitat, availability and quality of water, or other factors. Threats from deep rock mineral mining include acid drainage from extraction and draining adits placed deep in the mine to lower ground water. Mine tailings may also be a source of contaminants to the local terrestrial ecosystem and receiving surface waters. In some deep mines, local extractive processes that use chemical techniques may be an additional source of potential contamination. Where tailing piles are extensive, from either mining or processing, there may be an additional impact due to the physical alteration of the terrestrial and aquatic ecosystem. Streams and lakes may suffer from increased turbidity and siltation that may impact aquatic life thereby reducing food for foraging bats. Open pit mines may fill with water, becoming lakes with potentially toxic levels of heavy metals available to bats through drinking or through contaminated food chains. Abandoned strip mine coal pits and open-pit metal mines can become highly acidic lakes laced with potentially toxic levels of metals.

Cyanide Poisoning in Modern Gold Mining

Modern gold mining operations employ the use of cyanide to extract gold from ore that contains only minute traces of this element. This can involve both carbon-in-pulp vat leaching and heap leaching. The cyanide solutions used in these processes are stored in ponds. Vat leaching ponds can be large (ponds over 150 ha have been reported), whereas ponds of about a hectare in surface area are formed in heap leaching. Smaller pools can also form on tops of heaps. Various aspects of cyanide mining procedures, environmental fate of cyanide, and cyanide recovery and treatment methods have been reviewed by Eisler et al. (1999). The largest uses of cyanide in the U.S. and Canada are in these mining operations. Cyanide is quickly absorbed and distributed throughout the body of vertebrate animals where it acts rapidly as an asphyxiant, but sublethal doses are quickly detoxified and eliminated (Eisler et al. 1999). It is not persistent in ecosystems and does not biomagnify.

Ponds and pools resulting from cyanide-based mining operations provide an attractive threat to wildlife, especially in arid regions where numerous species readily drink at them. Large numbers of such mining operations have developed in Nevada, California, and Arizona, most on public lands. Surveys have shown that bats are among the most numerous of mammals found dead of

cyanide poisoning at these new water sources (Clark 1991, Clark and Hothem 1991). Many of these cyanide sources are in historic mining districts that are being re-worked because of the efficiency of modern methods, but unfortunately, these are also areas where bats often occur in shafts and adits of old abandoned mines. Cyanide-based mining is expected to expand into new locations, and is not limited to the arid west: operations also occur in the northern plains, Alaska and the southeastern U.S. (Clark 1991). Limited data suggest that bat mortality at these sites are concentrated in late summer and autumn, perhaps reflecting susceptibility during migration. Records in the published literature for the west generally do not distinguish bat deaths by species. However, red bats (*Lasiurus borealis*) have been found dead in South Carolina, where cyanide concentrations were reported at 20 ppm, in contrast to the 50 ppm previously thought to be safe for wildlife (Clark 1991). In California, the likely extirpation of a colony of western big-eared bats (*Corynorhinus townsendii*) due to cyanide in drinking water at a new mine has also been reported (Brown and Berry 1991, Clark and Hothem 1991). It is highly likely that some deaths of bats occur after they leave the immediate vicinity and carcasses are thus unlikely to be found. Cyanide bound to certain metals such as copper becomes dissociated in weak acids, suggesting that animals which drink weak cyanide solutions may die later when additional cyanide is liberated in the body by stomach acid (Eisler et al. 1999). Experimental dosing of little brown bats (*Myotis lucifugus*) with sodium cyanide resulted in delayed mortality that took place over much longer periods than in birds and mice (Clark et al. 1991).

There are some straightforward management measures that have been taken to reduce or eliminate some of these problems. These include covering ponds with net exclosures, floating plastic balls, or plastic sheeting, and decreasing or eliminating the cyanide concentrations left in the water prior to release to standing ponds. Reducing puddling by using covered drip systems rather than sprinklers has also been employed. Covering ponds with plastic sheeting decreased evaporation and loss of cyanide (which is a major expense for miners). Such steps have already been taken by conscientious mine operators. Heavy fines have also been levied at some mines due to large numbers of deaths of migratory birds from cyanide poisoning.

These extensive mining operations have other consequences for bat populations, as pointed out by Clark (1991), Brown et al. (1993), and Brown and Berry (1991). Large areas of landscape are altered, old mine openings are leveled, and water tables are reduced by removal of water for the gold extraction process. Use of groundwater can eliminate natural drinking sources in ephemeral streambeds and destroy riparian vegetation along desert washes necessary for foraging by some bats, for example, the California leaf-nosed bat, *Macrotus californicus* (Brown et al. 1993, Brown and Berry 1991).

Metals and Toxic Elements

Exposure to elevated metals and toxic elements can result in a variety of pathological conditions and death in mammals. These are well-known in the toxicological literature. Although experimental or epidemiological demonstrations of effects in bats have not been attempted, effects are to some degree consistent across the mammals. A number of metals associated with mining and their potential for effects on bats are listed in Table 1. Because some metals are

accumulated gradually in target organs before toxicity is manifested, the high longevity of bats (some live 20 years or more) may make them particularly susceptible. It is likely that some U.S. bats accumulate metals and other toxic elements from mining sources by exposure through the food chain, but this hypothesis has not been adequately investigated by direct study. Indirect support is based on evidence from two areas of research: 1) demonstration of the capacity of bats to accumulate these elements from food chains contaminated in other situations; and 2) demonstration of the capacity for accumulation of toxic elements by aquatic insects that emerge from mine-polluted water as flying adults, with corroboration that bats forage on emergent aquatic insects. Both exposure and uptake of metals by aquatic organisms can be variable and are functions of regional characteristics of water quality. Alkalinity, pH, and hardness are interrelated, and affect the bioavailability and toxicity of aluminum, cadmium, copper, chromium, lead, nickel, silver, and zinc. Some aquatic environments are chemically reducing, which produces the organic forms of some of these metals, thus adding to the potential that they may be incorporated into the food chain in a more toxic form.

Potential for Exposure and Accumulation in Bats

There have been very few investigations on exposure of bats to metals. There have been fewer directly related to mining, and, to our knowledge, none that have been extensive enough to directly assess the impacts of metals on individual health or population dynamics of bats. A few surveys have been carried out in various parts of the world that show the presence of some of these contaminants (arsenic, cadmium, chromium, copper, lead, mercury, methyl mercury, nickel, and zinc) in bat carcasses or organs (Table 2). This verifies that bats can accumulate metals. Most of these past studies analyzed for just 1-2 elements. Metal concentrations reported in tissues of bats have not been interpreted thus far to be indicative of serious problems that could impact populations. One possible exception is the finding of appreciable quantities of lead in bats living near a major highway in the Washington-Baltimore corridor, where lead deposition from automobile exhaust was a significant source of contamination (Clark 1979). Concentrations of lead in these bats were similar to those in which toxic effects had appeared in experiments with laboratory mammals, but Clark (1979) did not examine bats for such effects. Sampling efforts to survey bats for serious exposure to metals and toxic elements have been few, and, to our knowledge, have not included extensive corollary studies of physiology, histopathology, or reproduction.

Examination of guano to assess potential contamination of bats and their food supply with metals has promise but has only been carried out in a few studies. Petit and Altenbach (1973) reported that guano deposits from colonies of Mexican free-tailed bats in some caves show annual patterns of stratification, allowing chronological assessment of contaminants. Guano from one such site, located about 8 km from a major copper smelter near Morenci, Arizona (Eagle Creek Cave), was sampled for mercury in annual strata corresponding to the period 1956-1971 (Petit and Altenbach 1973). Mercury concentrations in guano were compared with smelter activity as indexed by annual copper production. Atmospheric mercury deposition into the terrestrial food chain and uptake by bats was apparent, with a lag time of about 1 year due to ecological uptake processes. Mercury and arsenic have also been examined in guano of big brown bats from

colonies likely to have been exposed to these metals through foraging at sites contaminated by industrial sources unrelated to mining (O'Shea et al., 2000).

Powell (1983) demonstrated that aquatic nymphs of flying insects from a Virginia river polluted by mercury from industrial sources had elevated mercury. Insectivorous eastern pipistrelles (*Pipistrellus subflavus*) collected while foraging over such areas contained mercury in liver and muscle tissues. However, bats were not examined from reference areas for comparison. Massa and Grippo (2000) found that, in comparison with reference areas, mercury was elevated in muscle, kidney, liver, brain, and fur of bats collected over or near streams in areas of Arkansas with fish consumption advisories for mercury. In northern Florida, Clark et al. (1986) reported concentrations of cadmium, chromium, copper, lead and zinc in southeastern bats (*Myotis austroriparius*). In comparison with a distant reference colony, concentrations of cadmium were higher in guano, kidneys and livers of southeastern bats exposed to metals that had been released into local streams from a battery salvage plant. However, these metals were not judged to have reached pathological levels in the bats. Other studies of metal concentrations in bats (Table 2) provide less comparative information to link with exposure.

Foraging on Contaminated Insects

Several species of terrestrial plants are known to concentrate certain heavy metals and make them bioavailable to herbivorous animals (Eisler 1985a,b). Larison et al. (2000) demonstrated that cadmium biovailability may be higher in abandoned mine sites than previously believed. Cadmium may follow a terrestrial plant-to-consumer pathway. Elevated contamination of terrestrial insects by metals ingested from feeding on plants in mining areas is thus likely, resulting in possible exposure of foraging bats. In addition to the possibility of localized foraging on contaminated terrestrial insects that occur in the immediate vicinity of mining operations, bats may be exposed to metals that enter aquatic systems in runoff and drainage and are taken up by insects that emerge from water as flying adults. Such contamination can occur over considerable distances downstream from mines. Contamination of a number of groups of emergent aquatic insects by metals has been demonstrated in different geographic regions impacted by mines of many categories (Axtman et al. 1997, Cain et al. 1992, 2000, Saiki et al. 1995, Wickham et al. 1987).

The potential for bats to be exposed to metal pollution from feeding on such insects is evident by a coarse classification of U.S. mainland species of bats by the degree to which they are known to forage over water and/or include emergent aquatic insects (e.g. chironomid midges, stoneflies, mayflies, dragonflies, caddisflies and mosquitoes) in the diet. We reviewed general accounts for 42 species of bats of the continental U.S. for evidence of foraging over water or for such prey in the diet. Bats were categorized in three groups (Table 3). Group I includes species that are described as usually or frequently observed foraging over water and typically including a large proportion of emergent aquatic insects in the diet. Group II consists of species referred to as sometimes or occasionally foraging over water and/or sometimes including emergent aquatic insects in the diet. Group III includes those species of bats that were not reported to forage over water or include emergent aquatic insects in their prey. These include frugivores, nectarivores,

and some insectivores so little studied that there is scant information on diet or foraging.

More than half of all the species fall in Groups I and II, primarily or occasionally feeding on emergent aquatic insects or over water. Thus, contamination of aquatic systems by toxic elements from mining has potential to impact a large number of species of bats. The population status of some of these species is of direct management interest to Federal agencies, as well to individual States. All four in Group I are species of concern (former Category 2 candidates for listing under the U.S. Endangered Species Act), have subspecies that are so designated, or are listed as endangered, as are six species in Group II (Table 2).

Radiation Exposure

Natural sources of radiation can result in high levels of radioactivity in underground cavities. Abandoned mines can have such radioactive emissions, particularly those from old hard rock uranium, radium, and vanadium mining, although radioactivity can also be associated with other ores. Burghardt (1996) provides a fundamental overview of the physics and health hazards of radioactivity at abandoned mines, their geologic history, and abundance on some of the Federal lands. It has not been determined if bats roosting in such situations suffer any harmful genetic, developmental, pathological, or population-level effects.

Other Associated Toxic Effects

Extraction of resources by mining in areas once considered remote can bring rapid development and influxes of large numbers of laborers, families and supporting businesses. This can bring associated loss or conversion of habitat, air pollution, various water pollution sources unrelated to those directly stemming from mining activities, lowering of water tables, and use of insecticides for control of disease vectors such as malaria-bearing mosquitoes. The latter can occur in developing countries where organochlorine insecticides such as DDT may still be in use. These neurotoxic chemicals are lipophilic and thus magnify in food chains. They are well known to cause delayed mortality in insectivorous bats when lipid reserves are utilized and the compounds or toxic metabolites are mobilized into the bloodstream. Young bats nourished by lipid-rich milk can be particularly vulnerable (see reviews by Clark 1981, 1988). Direct poisoning by other classes of insecticides such as carbamates and organophosphates is also possible (e.g., Clark et al. 1996).

Oil shale mining and drilling activities in northwestern Colorado resulted in the creation of impounded pools of spilled oil and drilling fluids called sludge pits. Bats attracted to the smooth surface of sludge pits can mistake them for water, attempt to drink, and become mired in the pits or slicked with oil. Finley et al. (1983) reported several observations of dead or oiled bats at these sites. Mortality included individuals of at least six species, including hoary bats (*Lasiurus cinereus*), long-eared myotis (*Myotis evotis*), small-footed myotis (*M. ciliolabrum*), California myotis (*M. californicus*), western pipistrelles (*Pipistrellus hesperus*), and silver-haired bats (*Lasionycteris noctivagans*).

Indirect Toxic Effects

Accidental spills and discharges of cyanide solutions can kill all aquatic organisms in long stretches of rivers (Eisler et al., 1999), temporarily decimating emergent aquatic insects as food for bats. Alkaline or acid drainages from mines can severely impact abundance and species composition of emergent aquatic insects (Malmqvist and Hoffsten 1999). Other mine-associated chemical spills or breaching of impoundments of contaminated mine waste water can have similar community effects. Indirect impacts on bats through alterations in prey communities may be significant because a large number of species of bats forage directly over aquatic systems or within associated highly productive riparian vegetation communities. Brown et al. (1993) noted major declines in wintering populations of California leaf-nosed bats (*Macrotus californicus*) in areas where their foraging habitat of desert-wash vegetation was destroyed when mining activities reduced subsurface water tables. Rivers enriched by various human effluents may also show reduced diversity and abundance of insects and thus constitute loss of habitat for bats. Echolocation activity of some species of bats can be significantly lower below such inputs (Vaughan et al. 1996).

Future Research

Bat conservation has become of great interest globally and to U.S. wildlife agencies and the mining industry. However, there has been little effort expended towards determining impacts of mine-related toxic contaminants on bats. For many mining areas, basic inventories of the local bat fauna need to be carried out to determine what species may occur at the site, and if foraging or drinking activity takes place at sources of contamination. The feasibility of developing mine-related risk indicators, using insect communities bats depend on for food, should also be investigated. Future research should include regular and detailed surveys for direct mortality of bats at cyanide pools and other sites with major potential for exposure to toxic chemicals. These surveys should strive to identify bats to species and attempt to find local bat roosts to search for delayed deaths. Once management measures are taken, follow-up studies should be designed to document success. Surveys of bats in areas where metal exposure is suspected should be undertaken to examine for concentrations in target organs. These surveys should include interdisciplinary research on histopathology, physiological biomarkers of exposure, and other approaches that will assist in interpreting health effects associated with concentrations of metals in tissues. Initial steps can be taken to assess the degree of direct exposure of colonial bats to metals in the food chain through analysis of guano collected under local roosts (Clark et al. 1982). Guano from reference sites, where colonies of bats that are unexposed to mine-related metals can be found, should also be examined for comparisons. In cases where locations of bat colonies are unknown, radio tracking of bats captured foraging near sources of contamination can reveal roosting sites (O'Shea et al., 2000). Should elevated metal concentrations be discovered in guano then: (1) individual bats can be collected at future times to determine concentrations in target organs and health effects; and (2) the colonies can be monitored for mortality or other population impacts. Radiation exposure should be determined in bats living in abandoned mines with high radioactivity. Individual bats should be sampled to determine possible genetic, somatic, lethal or reproductive effects of this exposure. The most effective research on all of

these topics will involve multidisciplinary teams of bat biologists, environmental chemists, toxicologists, and health effects specialists. Additional topics and approaches to research in environmental toxicology and bats in general are discussed in a recent major review by Clark and Shore (2001).

Conclusion

Environmental contamination from mining activities has been shown to cause direct mortality of bats in cyanide-based gold extraction operations. Formation of sludge pits in oil drilling and mining operations has also been shown to cause direct mortality when bats become mired after attempting to drink at their surfaces. Research has not been carried out to determine other effects, however, accumulation of toxic elements is likely. This potential for impact is based on the demonstration that (1) bats can accumulate such elements in contaminated areas; (2) aquatic insects with emergent phases in the life cycle can accumulate toxic elements in streams with mine drainages, and (3) many bats feed on such prey. Bats roosting in abandoned mines in areas of high radioactivity may be exposed to potentially dangerous radiation. Impacts on health or population dynamics of bats has not been studied. Habitat alteration, introduction of other toxic chemicals, and various other forms of pollution that accompany development associated with mining activities also have potential to impact bats. Future, well-designed multidisciplinary approaches will be necessary to determine the extent of exposure and impacts of mine-related toxics on bats.

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Table 1. Some mine-associated toxic elements and their potential for direct and indirect effects on bats. Sources: Eisler (1985a,b, 1986, 1987, 1988a,b, 1989a,b, 1990, 1991, 1994, 1996, 1997a, b), Larison et al. 2000, Ripley at al. 1996, Sheuhammer, 1987.

Contaminant	**Source**	**Bioaccumulate/magnifies**	**Potential for Direct Effect on Bats**	**Indirect effects on prey communities**
Aluminum	Mine waste/smelter emissions	No	Unlikely	Toxic to aquatic organisms
Arsenic	Mine waste/smelters and coal burning emissions	No	Teratogenic, carcinogenic, acute and chronic toxicity	Toxic to a variety of aquatic and terrestrial organisms
Boron	Rare in mine waste	No	Unlikely	Phytotoxic
Cadmium	Common in mine/smelter wastes and emissions	Yes, passes through and accumulates in aquatic and terrestrial-based food chains	Teratogenic, mutagenic, high acute and chronic toxicity	Toxic to invertebrates
Chromium	Mainly in smelter emissions	No	Unlikely	Highly toxic to aquatic life
Copper	Mine waste, smelter emissions	No	Unknown	Highly toxic to aquatic life
Lead	Mine waste and smelter emissions	Uncommon	Inhalation and through food and water; high acute and chronic toxicity	Highly toxic to all life
Mercury	Old mine wastes and smelters	Yes	Teratogenic, mutagenic, high acute and chronic toxicity	Highly toxic to all life
Molybdenum	Mine waste and milling	No	Unlikely	Some phytotoxicity
Nickel	Mine waste and smelter emissions	No	Unlikely	Toxic to some invertebrates
Silver	Mine waste and smelter emissions	Unknown	Unlikely	Highly toxic to aquatic life
Selenium	Mine waste and smelter emissions	Bioconcentrates in plants	Teratogenic, mutagenic, Acute and chronic toxicity	Low toxicity to most organisms unless concentrated in food

Tin	Some smelting sources	No	Unlikely	Low toxicity
Zinc	Mine waste and smelter emissions	No	Low toxicity to mammals	Highly toxic to aquatic life and terrestrial plants

Table 2. Summary of studies demonstrating metals in organs, tissues, carcasses, or guano of bats.

Species	**Region**	**Metal**	**Material Sampled**	**Reference**
Antrozous pallidus	Arizona	Hg	Liver, muscle	Reidinger 1972
Eptesicus fuscus	Arizona	Hg	Liver, muscle	Reidinger 1972
Eptesicus fuscus	Maryland	Pb	Carcass, guano	Clark 1979
Eptesicus fuscus	Colorado	As, Hg	Carcass, guano	O'Shea et al. 2000
Eptesicus serotinus	Germany	Cd, Cr, Cu, Ni, Pb	Whole body, carcass, hair, lung, muscle, liver, kidney, femur, nails	Streit and Nagel 1993a
Miniopterus schreibersi	Japan	Hg	Hair, kidney, liver, muscle	Miura et al. 1978
Myotis austroriparius	Florida	Cd, Cr, Pb, Zn	Liver, kidney, guano	Clark et al. 1986
Myotis daubentoni	Germany	Cd, Cu, Cr, Ni, Pb	Whole body, carcass, hair, lung, muscle, liver, kidney, femur, nails	Streit and Nagel 1993a
Myotis lucifugus	Maryland	Pb	Carcass, guano	Clark 1979
Myotis mystacinus	Germany	Cd, Cu, Cr, Ni, Pb	Whole body, carcass, hair, lung, muscle, liver, kidney, femur, nails	Streit and Nagel 1993a
Myotis sodalis	Florida	Cd, Cr, Pb, Zn	Liver, kidney, guano	Clark et al. 1986
Nyctalus noctula	Germany	Cd, Cu, Cr, Ni, Pb	Whole body, carcass, hair, lung, muscle, liver, kidney, femur, nails	Streit and Nagel 1993a
Pipistrellus abramus	Japan	Hg	Hair, kidney, liver, muscle	Miura et al. 1978
Pipistrellus hesperus	Arizona	Hg	Liver, muscle	Reidinger 1972
Pipistrellus pipistrellus	Sweden	Cd, Hg	Liver, kidney	Gerell and Lundberg 1993

Pipistrellus pipistrellus	Germany	Cd, Cu, Cr, Ni, Pb	Whole body, carcass, hair, lung, muscle, liver, kidney, femur, nails	Streit and Nagel 1993a
Pipistrellus pipistrellus	Germany	Cd, Cu, Cr, Ni, Pb	carcass, liver, kidney, spleen, lung, milk, gut contents	Streit and Nagel 1993b
Pipistrellus subflavus	Virginia	Hg	Liver, muscle	Powell 1983
Plecotus auritus	Germany	Cd, Cu, Cr, Ni, Pb	Whole body, carcass, hair, lung, muscle, liver, kidney, femur, nails	Streit and Nagel 1993a
Rhinolophus cornutus	Japan	Hg	Hair kidney, liver, muscle	Miura et al. 1978
Rhinolophus ferrumequinum	Japan	Hg	Hair kidney, liver, muscle	Miura et al. 1978
Tadarida brasiliensis	Arizona	Hg	Guano	Petit and Altenbach 1973
Tadarida brasiliensis	Arizona	Hg	Liver, muscle	Reidinger 1972
Tadarida brasiliensis	Oklahoma	As, Cd, Pb	liver	Thies and Gregory 1994
Tadarida brasiliensis	Texas	As, Cd, Pb	liver	Thies and Gregory 1994
Vespertilio superans	Japan	Hg	Hair, kidney, liver, muscle	Miura et al. 1978

Table 3. Coarse categorization of U.S. species of bats based on proclivity to forage over water and/or on insects with aquatic life-history stages. Foraging information is based on accounts in the American Society of Mammalogists' *Mammalian Species* series, Wilson and Ruff (2000), Barbour and Davis (1969), and Whitaker and Hamilton (1998). Abbreviations: E = endangered under U.S. Endangered Species Act (ESA); SC = species of concern (former category C-2 candidate for listing under the ESA). Status categories provided only for Groups I and II.

Group I. Regularly forage over water and on emergent aquatic insects	
Myotis austroriparius (SC)	
Myotis grisescens (E)	
Myotis lucifugus (SC subspecies)	
Myotis yumanensis (SC)	
Group II. At least occasionally forage over water and on emergent aquatic insects	
Eptesicus fuscus	Myotis ciliolabrum (SC)
Eumops perotis (SC)	Myotis evotis (SC)
Lasionycteris noctivagans	Myotis leibii (SC)
Lasiurus borealis	Myotis septentrionalis
Lasiurus cinereus	Myotis sodalis (E)
Lasiurus ega	Myotis volans (SC)
Lasiurus intermedius	Nycticeius humeralis
Lasiurus seminolus	Pipistrellus hesperus
Mormoops megalophylla	Pipistrellus subflavus
Myotis californicus	Tadarida brasiliensis
Group III. Not reported to forage over water or on emergent aquatic insects, or information insufficient	

Antrozous pallidus	Leptonycteris curasoae
Artibeus jamaicensis	Leptonycteris nivalis
Choeronycteris mexicana	Macrotus californicus
Corynorhinus rafinesquii	Molossus molossus
Corynorhinus townsendii	Myotis auriculus
Euderma maculatum	Myotis keenii
Eumops glaucinus	Myotis thysanodes
Eumops underwoodi	Nyctinomops femorosaccus
Idionycteris phyllotis	Nyctinomops macrotis

SURFACE HABITAT DISTURBANCE, PROTECTION, AND ENHANCEMENT ASSOCIATED WITH ACTIVE SURFACE MINING AND RECLAMATION

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Abstract

Montana established a coal mining regulatory program in 1973. A requirement of the program has been comprehensive wildlife surveys throughout the life of the mine, from prior to the permitting stage through final bond release. Until the mid-1990's, only limited bat surveys were conducted and minimal data concerning the presence of bats at the coal mines had been collected. Casual observations and limited collections were the only sources of data on bat presence and distribution at the coal mines. During the mid-1990's, the Department issued Fish and Wildlife Guidelines changing the focus of the wildlife survey efforts, placing more emphasis on amphibians, reptiles, landbirds and small mammals – including bats. The Department considers these species groups as better indicators of habitat conditions then the omnipresent big game species. Additionally, several species within these groups are of special concern and potential candidates for listing as threatened and endangered species.

Currently five bat species are listed as species of special concern in Montana. They are fringed myotis (*Myotis thysanodes*), northern long-eared myotis (*Myotis septentrionalis*), spotted bat (*Euderma maculatum*), Townsend's big-eared bat, (*Corynorhinus townsendii*), and the pallid bat (*Antrozous pallidus*). Another species, Yuma myotis (*Myotis yumanensis*) is on the "Watch List," indicating a potential to be listed as a species of special concern in the future. Three of the bat species of special concern have been observed at coal mines in Montana and are considered to be residents of the areas.

Annual wildlife monitoring at each of the six active coal mines provides data on species occurrence, distribution and habitat use. This information is used to develop mitigation plans for implementation during the mining and reclamation phases. The information is also used to determine special habitats, habitat conditions and habitat features which need to be incorporated into reclamation, ensuring they are part of the post-mine vegetation community and landscape. Additionally, by conducting regular wildlife surveys, including those for bats, the Montana coal program has been able to address issues such as threatened and endangered species in an expedient manner prior to mining disturbance.

Introduction

In Montana, large-scale surface mining has replaced underground mining and smaller open-pit operations. Currently, six surface mines are permitted for coal mining

operations in Montana. The six surface mine permits encompass a total of 55,279 acres. Of this total, approximately 28,047 acres are disturbed by mining operations. Annually, approximately 900 acres are disturbed, with approximately 900 acres reclaimed. Because of the extensive surface disturbance, there is a definite potential for impacts to the wildlife communities, including several bat species, inhabiting the areas of the coal mines. In addition to the active surface mines, three small (<15 acres) surface mines have been reclaimed by the operator and are waiting for final bond release. Another small surface mine is in bond forfeiture and is being reclaimed by the Department. The last active underground coal mine in Montana, Bull Mountains Mine #1, is also under bond forfeiture and being reclaimed by the Department.

With the establishment of Montana's coal regulatory program in 1973, coal mine operators have been required to conduct pre-mine wildlife inventories, as well as, annual wildlife monitoring. Until the mid-1990's, wildlife surveys focused on big game, upland game birds, raptors and threatened and endangered species. Surveys of bat communities occupying the mine areas were confined to incidental observations and limited collections. An example of the type of collections that were made is the pre-mine surveys at the Spring Creek Mine. Roosting bats were collected from abandoned buildings, while shotguns were used to collect bats as they flew over selected ponds (NERCO, 1977). Similar surveys were conducted at other mine sites. These limited, pre-mine surveys provided rough baseline information on the presence of certain bat species within the wildlife study area. After the mines were permitted, only incidental observations of bats, such as observations of bats roosting on or in mine facilities, were recorded. In 1994, the Montana Department of State Lands (now Department of Environmental Quality) issued a comprehensive Wildlife Guideline. With this guideline, the Department redirected some of the wildlife survey efforts from seasonal big game surveys to surveys for wildlife species/species groups comprising a majority of the wildlife community found on the mine sites. This change redirected the focus of the wildlife surveys from the omnipresent big game species (mule deer, white-tailed deer and pronghorn) placing more emphasis on amphibians, reptiles, landbirds, waterfowl, shorebirds, raptors, and small mammals – including bats. The Department considers these species as better indicators of habitat conditions then the readily observable big game animals.

During the early 1990's, it became apparent that several wildlife species, possibly found on Montana coal mines, were potential candidates for listing as threatened or endangered species. Little information was available concerning the distribution and habitat use of these species, including several bat species, on coal mines in Montana. In the mid-1990's, several coal companies began collecting information on bat distribution. To date, four of the six active surface mines and one underground mine (now in closure) have collected more than incidental bat observations. In addition to incidental observations, bat surveys conducted at these mines include observations in the vicinity of foraging areas (ponds and in lighted parking lots), observations of roosting sites, mist netting, and use of electronic detectors.

Results

To date, surveys have not been as intensive or extensive as necessary to determine a complete picture of bat use at the various mines. However, presence of several species has been documented. Since the mines conducting more intensive surveys are located in the three geographical regions containing active coal mines, distribution information can be extrapolated to adjacent mines. A summary of the bat species observed to date is found in Table 1. This information was taken from the pre-mine and annual wildlife reports for the respective mines.

Of the fifteen bat species known to occur in Montana, ten species have been observed at or near the active coal mines. Survey intensity varies greatly from mine to mine as indicated by the results presented in Table 1. Bats have not been documented at the Big Sky Mine where no organized surveys have been conducted. The Bull Mountains Mine #1, an underground mine, was permitted in 1992. As a stipulation to the permit, bat surveys were to be conducted every summer. Surveys were conducted in association with permanent water sources and included mist nets and electronic detectors. During the surveys, nine species were confirmed while the pallid bat was potentially observed. The observation of the suspected pallid bat was in the headlights of a vehicle and could not be confirmed before the individual flew off. Surveys at the Western Energy and Westmoreland mines are considered intermediate between the surveys at the Big Sky and Bull Mountains #1 mines. In addition to organized surveys, incidental observations of bats using mine facilities have also been included to augment the bat distribution information.

Currently five bat species are listed as species of special concern in Montana (Montana Natural Heritage Program, 1999): fringed myotis, northern long-eared myotis, spotted bat, Townsend's big-eared bat, and the pallid bat. Additionally, the Yuma myotis is on the "Watch List", indicating a potential for the species to be listed as a species of special concern. Three of these species - spotted bat, Townsend's big-eared bat and pallid bat - have been observed at one or more of the coal mines.

Table 1. Bat species observed at the active coal mines in Montana.

Bat Species	Coal Mine						
	Big Sky[1]	Bull Mts.[2]	Decker[3]	Savage[4]	Spring Creek	Western Energy	Westmoreland
Pallid *Antrozous pallidus*		?[5]				YES	
Big Brown *Eptesicus fuscus*		YES				YES	YES
Spotted *Euderma maculatum*		YES					
Silver-haired *Lasionycteris noctivagans*		YES					
Hoary *Lasiurus cinereus*		YES				YES	?[6]
Western Small-footed *Myotis ciliolabrum*		YES			YES	YES	
Western Long-eared *Myotis evotis*		YES			YES	YES	YES
Little Brown *Myotis lucifugus*		YES	YES		YES	YES	YES
Long-legged *Myotis volans*		YES			YES		
Townsend's Big-eared *Corynorhinus townsendii*		YES			YES		

[1] No organized bat surveys have been conducted at this mine.
[2] The Bull Mountains Mine #1 was an active underground mine until 1998. The bat observations were made within or adjacent to the permit area.
[3] Only incidental observations of bats have been made at this mine.
[4] No organized bat surveys have been conducted at this mine.
[5] An unconfirmed observation was made in the vicinity of the mine.
[6] An unconfirmed observation was made on the mine site.

Discussion

Active coal mines in Montana encompass a variety of vegetation communities. These vary from grassland, to grassland with interspersed woody draws, to sagebrush grasslands, to mixed shrub, to conifer draws and uplands. Inter-mixed within these habitats are special features, such as gumbo knobs, gumbo and scoria ridges, sandstone outcrops, clay banks, springs and seeps, stock ponds, etc. The combination of diverse vegetation and special features provides habitats suitable of supporting a variety of bat species.

Montana's coal program recognizes the importance of reclaiming mined lands in a manner closely approximating pre-mine conditions. Gathering more information on bat distribution and habitat use provides additional support for quality reclamation of all vegetation types, as well as, for including special habitat features in final reclamation.

Some habitats important to several bat species, such as the woody draws and ponderosa pine, require a much longer time period to become established and mature to a stage at which bats will begin to utilize them. Other habitats, such as stock ponds, seeps, rock piles, and reshaped highwalls (bluffs) are suitable for use by bats shortly after their creation. When developing wildlife criteria for final (Phase IV) bond release, this disparity in colonizing reclaimed habitats will be considered. In order to maintain bat populations in areas of extensive pine plantings and woody draws, mitigation measures (e.g. bat houses) may need to be implemented.

In order to maintain some of the presence of historical homesteads located on mined lands, one company (Western Energy) has moved old homestead buildings from areas to be disturbed onto reclaimed areas. While this was done from a cultural and historical standpoint, these abandoned buildings provide suitable roost sites for bats using the mine site. While not currently used, coal mining companies have discussed the use of bat houses to maintain and promote bat use of the mine areas during mining and reclamation.

Bats have created problems at some mines, occupying facilities, including shop and office buildings. Initially, eradication programs were the normal course of action. With education about bats and their importance, companies have become more tolerant of bats. Where safety and human health standards were considered impacted by the presence of bats, exclusion has been implemented. Often, exclusion does not result in total elimination of bats, particularly in facility buildings such as shops with large overhead doors. In these cases, the company and the employees have become more tolerant of the reduced presence of bats.

Fairly extensive bat inventories were conducted within the permit area for the Bull Mountains # 1 Mine (Table 1). For numerous reasons, the Montana Department of Environmental Quality forfeited the bond for this mine, the last underground coal mine in the State, in 1998. Prior to the closure, nine species of bats were confirmed within the permit area. An unconfirmed observation of the pallid was also noted. During inventories of the underground equipment, Department personnel surveyed the workings for bats and bat sign; none were observed. Additionally, the author spent time during

evening hours monitoring the portals for exiting bats. No bats were observed exiting the mine. Therefore, due to safety considerations, e.g. unstable roof and flooding of the workings, it was decided to seal the mine. Bat gates were considered, however, due to the lack of bats and bat sign it was deemed total closure was appropriate. A partially collapsed adit into historical underground workings still exists on adjacent private lands, with no plans for permanent closure.

Summary

Several bat species listed as species of special concern and potential candidate species for listing as threatened or endangered species have been documented using active coal mines in Montana. Because of the known presence of these species, the Montana Department of Environmental Quality, Industrial and Energy Minerals Bureau, has encouraged coal companies to conduct more extensive, as well as intensive, surveys for bats on their respective properties. This proactive approach is beneficial during the permitting of expansions of existing mines (currently the Department is processing two amendment applications for mine expansions) or new areas within the vicinity of active mines. By gathering information on the distribution and habitat use of bats prior to the submittal of a mining application, the company can take a proactive role in addressing methods to maintain these populations during mining and reclamation. Furthermore, by addressing bats in conjunction with other pre-mine wildlife surveys, companies gain a better understanding of the entire wildlife community inhabiting a particular area.

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ENDANGERED SPECIES HABITAT REPLACEMENT

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Abstract

Ordinary reclamation and revegetation methods used at the Koehler Abandoned Mine Reclamation Project, a priority 1, dangerous highwall, would adversely affect critical habitat of a Federally and State listed endangered species, the Myotis grisescens (Gray bat). For reclamation to proceed, the Kansas Surface Mining Section (SMS), had to comply with the Kansas Department of Wildlife and Parks (KDWP) regulations to protect the Gray bat.

Critical habitat for the Gray bat is defined by the Kansas Department of Wildlife and Parks (KDWP) as any area within five miles of the City of Pittsburg, Kansas, that includes a tree lined, corridor shaped, body of water with quality suitable to support aquatic insects. The Koehler site contained such a habitat.

To accomplish the goals of the SMS, protection of public health and safety from hazards associated with abandoned coal mined lands and to comply with the National Environmental Protection Act (NEPA) requirements, consultation with KDWP began in the first stages of project planning. After several meetings, field visits, and other consultations, a list of design and construction criteria was agreed upon by both agencies. The criteria included relocating the strip pit lake and planting a woody buffer zone around the lake's shoreline. The lake was designed to maximize fish and insect reproduction. A 100 foot buffer of native trees and shrubs was planted around the shoreline to eventually help protect foraging bats from predators and enhance feeding opportunities. At the end of the fourth growing season, "Anabat" bat detectors were placed at both ends of the strip pit lake. Over 200 bat calls, including the Gray bat, were recorded over a 12 hour period.

Interagency cooperation and careful planning resulted in meeting the goals of both agencies which were elimination of a serious public safety hazard and maintenance of critical habitat for the gray bat.

Introduction

For the past five years the Kansas Department of Health and Environment, Surface Mining Section (SMS) has had to acquire at least eight T & E Species permits from the Kansas Department of Wildlife and Parks (KDWP). A routine check with State and Federal wildlife agencies determined that some inventoried AML projects were in Critical Gray bat habitat. The Koehler Abandoned Mine Land (AML) Project was the first project to require a T & E Permit and mitigation associated with Gray bats (Myotis grisescens).

The Koehler Abandoned Mine Reclamation Project is located in Crawford County Kansas, in the SE corner of the state. 1100 feet of dangerous highwall lay adjacent to a well traveled North/South gravel county road. The end of the strip pit lake lay adjacent to an East/West paved county road called, Country Club Road. Along the gravel road, erosion of the dangerous highwall had cut into the road bed in several places, while the rest of the highwall was within ten feet of the road. The highwall plunged approximately 12 feet to the water. The average depth of the water was six feet. The end of the strip pit lake was within 20 feet of Country Club Road which connects State Highway 7 with US Highway 69. People from the local communities use the paved road to commute to and from the town of Pittsburg, Kansas. School buses use both roads to transport children, from kindergarten through highschool, to Cherokee Grade school, middle school (3 miles) and the Unified District High School (5 miles).

Normally a strip pit in this condition and this close to two busy roads would have been filled in, graded to contour, and seeded. However, because the Koehler project is located in designated critical habitat for the Myotis grisescens (Gray bat), a Federal and State Endangered Species, an alternative approach to reclamation was implemented.

Critical Habitat

A nursery colony of Gray bats was found to exist in the City of Pittsburg storm sewers in 1961(Choate, 1989). Since its discovery studies have produced data that show the Gray bats use the linear shaped, tree lined, strip pit lakes left from past mining, for cover and forage. Formal consultations with the KDWP and the U.S. Fish and Wildlife Service (FWS) concluded with a determination that the project was not likely to jeopardize the continued existence of the gray bat if, as required by Kansas Statue and Administrative Regulation, the SMS obtained and implemented a Threatened and Endangered Species Action Permit from the Kansas Department of Wildlife and Parks (KDWP).

Female Gray bats start arriving in the Pittsburg area around the first part of April. The storm sewers provide excellent habitat for a nursery colony and it is the only maternity roost of this species thus far discovered in Kansas. The Gray bat breeds in the autumn before or after entering a hibernation cave. The spermatozoa are stored in the female's reproductive tract. Fertilization takes place in the spring when the females ovulate (Choate, 1989). Females then migrate to warmer summer caves, between 57^0 and 77° F where they produce a single young in May or June (Collins et.al, 1995). The more natural range of the Myotis grisescens are the limestone caves of Missouri and Arkansas. However, human disturbance to caves, conversion of forest to cropland, and reservoir construction, has destroyed much of the Gray bat's habitat. Because of habitat destruction, there was a great decline in the number of Gray bats (Collins et.al, 1995). Habitat destruction in the normal range of the Gray bat may have forced them to move to new maternity roosts like the Pittsburg storm sewer. The combination of storm sewers, linear wooded strip pit lakes, and the wooded streams of Cow Creek and Brush Creek, provide the Gray bat with an extended habitat in southeast Kansas. They use the wooded strip pit lakes not only for forage but for a safety cover while in flight from owls which are their main predator. Gray bats feed on flying insects over bodies of water, with Mayflies making up the major part of their diet.

Other non-breeding Gray bats, arrive later in the summer, around July, to use the habitat for shelter and forage. All of the bats then return to the caves in Missouri and Arkansas sometime in late September for hibernation (Choate, 1989). Hibernation caves must be very cold, between 42^0 and 52° F, and most hibernation caves are deep with vertical walls (website: ifw2es.fws.gov).

Interests

Considering the interests of the landowners, of the SMS, and the KDWP, coupled with a few engineering problems encountered while designing the project, the following list of objectives was derived.

- There existed a large watershed west of the gravel county road with inadequate drainage and inadequate culverts which caused erosion of the dangerous highwall, and flooding the county roads. The flooding subsequently carried much valuable topsoil from the landowners farm ground into the strip pit lake. The objective of the farm ground landowner was to rechannel the surface water flow and stop erosion of his farm ground.

- A major telephone fiber optic cable traverses a portion of the project area scheduled for excavation. The objective of the telephone company was to maintain continuous service to customers.

- The objective of the SMS was to abate the hazards associated with the abandoned mine land and protect the health and safety of the general public

- The objective of the Kansas Department of Wildlife and Parks (KDWP) was to prevent incidental take of the Gray bat, preserve Gray bat habitat to the greatest extent possible and mitigate any habitat loss.

- Initially the strip pit lake landowner did not want his land disturbed. He finally consented and his objective was to minimize disturbance to his land.

Consultation with KDWP began in the first stages of the project planning. Landowners were also consulted and informed of developments throughout the project. After several meetings between KDWP, the Office of Surface Mining, the United States Fish and Wildlife Service (FWS), and the SMS, field visits to the site, and other extensive consultations, Permit No. 95-14 was issued by KDWP with the following mitigation requirements:

- Any disturbance of the strip pit lake must take place from October 1 thru April 1.

- Any strip pit lakes that are backfilled, or sidefilled, must be mitigated. Relocated or enlarged pits should be linear in shape, have a shoreline of equal distance (linear feet) to the body filled, an equal amount of surface acres, and contain variations in depth.

- Construction of mitigation lakes or enlarged strip pit lakes, including all tree plantings, must be completed within one year of filling existing strip pit lakes.

- A 30' buffer of native trees species was to be planted around relocated strip pit lakes.

- The planted tree buffer would be maintained to provide a minimum of 80 percent survival after three years following planting.

- All areas planted or left as woody buffer areas would be fenced to exclude livestock.

Project Construction

As specified in Permit 95-14, for mitigation requirements, the contractor started reclamation activities first on the strip pit lake in early October. As he leveled the minespoil ridges and pushed the dirt into the strip pit lake, it became apparent that there was a large amount of mud to contend with. Years of having inadequate drainage of the large watershed had caused much erosion of the adjacent crop field and the highwall into the strip pit lake. The water depth was six feet, but the depth of the mud was up to ten feet. Simultaneously, the contractor began digging the replacement pond, and another problem arose, a high water table. The contractor had to excavate the new pond to an elevation below the existing water table. In both cases, the contractor innovatively used coffer dams. Using coffer dams in the existing pit helped the contractor to contain the mud so it could be covered. In the excavated pit, coffer dams helped the contractor get his equipment in position to build the relocated strip pit lake.

As required by Permit 95-14, the replacement lake was to have surface acres equal to or greater than that of the backfilled pit. This ended up being approximately 2.6 surface acres. The linear shoreline was increased from 2,360 feet on the original lake to 2,596 feet on the relocated lake, and slope to the water's edge on the new lake was a safe minimum of 6V:1H. The original strip pit lake discharged into a tributary of Brush Creek and the relocated pit discharges into the same tributary, through a rock spillway channel. To deter erosion, where water enters the pit at the south end, another rock spillway was constructed. The rock provides additional habitat for fish, amphibians, and insects. Mitigation item #6 requires the new pit to have varying depths of approximately two to ten feet. This variation provides the depth necessary for fish to survive over the winter, and supplies the fish with better habitat to spawn. The variation also provides habitat for other aquatic life, including amphibians, crustaceans, and insects.

Two new culvert installations were designed to correct the flooding and erosion caused from the surface runoff of the large watershed. In the right of way along the crop field was located a high traffic fiber optic telephone cable. Caution had to be taken when removing the existing culverts due to its presence. A 300 foot portion of the cable was relocated for the installation of the large 245 linear foot, 5' x 8' box culvert at the north end of the project area. Twelve sections of the 5' x 8' box culvert were placed at an angle under the north/south county road, joining the farmer's field to the channel on the north end of the new strip pit lake. The sections were brought in on semi trailers and a crane had to pick the sections up and put them in position. When completed, it looked like a small cave, and we have been observing it since for bat roosts.

A smaller culvert at the south end of the county road, carried the rest of the watershed to the inlet at the south end of the new strip pit lake. Installation of this culvert required the contractor to

hand dig a portion of the excavation to assure that no damage occurred to the fiber optic cable.

With the dangerous highwall eliminated, culverts replaced, the new pond completed, erosion control blankets installed, and drainage channels rip rapped, the final contours were finished according to the plans and the site was ready to be revegetated.

Revegetation

The first step in the revegetating process was placement of a temporary mulch. The temporary mulch adds organics to the root growth medium. Experience has led the SMS to strive for spreading a temporary mulch at least six months before seeding so it has time to break down and be beneficial to the vegetation planted. Final seedbed preparation took place in March.

Grass species had to be carefully selected so that the grass would not compete with tree seedling growth. KDWP, the SMS, and the landowner all agreed to plant native grasses on the site. Following is the list of native species chosen to plant with the trees:

Species	PLS/Acre
Little blue stem	2.0
Birdsfoot trefoil	5.0
Sideoats grama	1.8
Illinois bundle flower	0.5

As an erosion control factor, annual rye grass was planted along with the native species to provide quick ground cover. The herbaceous cover was planted and then the rows were trenched to prepare for the tree planting.

Discussions among the SMS staff, and consultation with KDWP and Kansas State Foresters helped to determine if bare root seedlings or container grown trees should be planted. In the end, price and availability dictated that bare root seedlings would be planted. Also, it has been demonstrated that bare root stock is often more successful than containerized trees on a project of this magnitude. Research, plus further consultation between KDWP and the SMS staff produced a recommended list of trees to plant along with the type of seedlings best suited for our mitigation pursuit. The list of trees is as follows: Hackberry; Sycamore; Bur oak; Green ash; *Black locust; >* Redbud; * Autumn olive; Choke cherry; >* Shrub lespedeza; and >American plum.

* Indicates legume tree
> Indicates understory tree.

A list of other stipulations regarding seedling trees are as follows:

- Bare root stock will be one to two years old and at least 12" tall.

- Trees planted will be native or adapted to the climate of the region

Although KDWP specified a 30 foot buffer to be planted around the strip pit lake, the SMS decided to plant a 100 foot buffer. Consensus was that a project of this size would obtain a 50 percent survival rate if planted on an undisturbed site with in situ soils. Permit 95-14 specified planting 430 trees/acre, and an 80 percent survival after three years (344 trees/acre). In order to achieve the numbers specified for survival on spoil, the SMS decided to plant 890 trees/acre, in 7x7 foot rows to increase the odds of achieving the required 344 live trees as stated in the permit.

To further increase survival odds, the SMS wanted to give the trees every advantage possible. The SMS required the contractor to properly handle the seedlings between delivery and planting. The seedlings were to be planted within 24 hours of delivery and be kept in a cool and moist environment until planted. The SMS chose to use tree protectors, mulch mats, root gel and fertilizer. By no means, would the roots be allowed to dry out. Seedlings were placed in a bucket, with root gel containing mycorrhizal fungus, while waiting to be planted. The root gel kept the roots from drying out, the mycorrhizal fungus gave the seedlings a head start in the necessary symbiotic relationship between specific fungus and tree roots. The contractor used a tree planter to rip the rows at least 12" deep. As the tree planter ripped the rows a person on the back placed the seedlings in the trench, and placed a packet of fertilizer in the trench along side the seedling. An additional person, walking behind the tree planter, made sure the roots of each seedling were spread out properly and then tamp the soil around the seedling to minimize air pockets. Three x three foot mulch mats were placed around each tree to keep grass and weed competition down. These were fastened with ground staples. A tree protector made of translucent plastic polymer was placed on each seedling. The tree protectors were three feet tall with a 3.13" opening. Tree protectors were fastened to bamboo stakes driven into the ground. The trees were watered after planting.

The next week and a half was dry. Just when the SMS decided to have the contractor water the trees, the rain came. We had sufficient rain the rest of the summer to keep the trees from becoming droughty. The protector tubes helped to conserve water by acting as miniature green houses. As the seedling transpired, the water condensed on the sides of the tube and then dripped back to the ground to rewater the seedling. The tube also helped regulate the temperature around the seedlings, keeping them warmer at night and cooler in the day. One problem we had with the protector tubes was their length. The Kansas wind blew them around badly. By the end of the summer half of them were blown off. We learned many things from our first tree planting projects, a few of those things are:

- Two foot tree protectors have replaced the three foot protectors.
- One inch square wooden stakes are used in place of the inadequate and flimsy bamboo stakes, to anchor tube protectors.
- The Black locust, which grew prolifically, have been replaced with other canopy tree species.
- The rows are spaced at least 10 feet apart for mowing purposes.

The Koehler project began Oct.1 , 1995, and was completed near the end of April 1996, with the completion of the tree plantings. The total number of trees planted around the new impoundment was 3,767. The SMS counted the number of live trees the next fall and again the next spring and once more the following fall. As the tree protectors either blew off or the bamboo stake gave way, they were removed. There was a difference in the overall health of the trees where protectors remained. Trees without protectors were badly damaged by rabbits and deer.

In May of 1997, the survival rate was over 60 percent of the original 890/acre of trees planted and 148 percent of the amount required by KDWP. At the end of the second growing season, some of the trees doubled their size and some tripled in size. The Black locust and Shrub lespedeza grew phenomenally, with the Sycamore and Bur oak slightly behind. The native grasses and legumes at the end of the second growing season had established enough vegetative ground cover to provide more than adequate erosion control.

Mitigation Results

In September of 1999, Scott Robinson, graduate student of Southwest Missouri State University, placed two Anabat detectors on the north and south ends of the Koehler strip pit lake, leaving them there over night to record bat sounds. After retrieving the bat detectors the next morning, Scott reported that there were over 200 recordings collected, and many of the recordings detected the Gray bat. We will continue to monitor this project and several other projects where the SMS has also mitigated for the Gray bat. Cooperation and planning have successfully attained the goals set forth by each agency and have given the landowners more productive land.

Since the construction of the Koehler Reclamation Project, there has been no flooding at the intersection of the county roads, no erosion of the road shoulders, and no consequential erosion on any of the disturbed areas. The site continues to be monitored regularly for tree survival and growth, grass coverage, and animal use of the area, although it has now been released from the formal maintenance program. The Kansas Department of Wildlife and Parks in July of 1999, evaluated the Koehler project and notified the SMS that the mitigation goal had been met. In April of 1999 the trees were once again counted. Although at this count the survival rate was only 47%, or 1776 trees, after three growing seasons, this still exceeded the KDWP requirement of 344 trees/acre trees. Many of the trees had been cut down by beaver and still more were used as rubs by deer (proof of wildlife use).

Discussion

Even though there were many problems encountered in the design work, and unforseen problems encountered in the construction work, the Koehler Reclamation project was finished in a timely manner. The presence of the vast number of tree protectors attracted more attention to the project than the actual construction work. Many spectators were impressed by the extra steps that were taken to mitigate for the Gray bat and other wildlife. The initially uncooperative landowner became one of the programs best advocates. He expressed amazement at how fast the trees had grown and how the impoundment in only its second year had insects, frogs, ducks, and other wildlife utilizing it. The other landowner has been pleased with the drainage

improvements. What was once a problem area for county road crews is now stable, not eroding, and not flooding. KDWP personnel have voiced their satisfaction with the reclamation and progress of the habitat mitigation and reestablishment. And, the general public is safer with the hazards removed.

Since the end of the Koehler project, we have had to acquire several other T & E permits concerning the Gray bat. At each of these projects the SMS has planted many more trees than were removed, has replaced equal or greater amounts of both surface acres and linear feet of shoreline of strip pit lake, and has improved the aquatic habitat by varying water depths in the reconstructed lakes. In addition, the frequent use of rock fill has also aided fish spawning, increased places for insects to lay eggs, and provides cover for overall benthic survival. Each project is different, and as we have learned more about habitat requirements the projects have become more innovative in their design.

Conclusion

Monitoring of the Koehler project has shown that Gray bats have returned to the project site. This demonstrates that strip mine pits can be backfilled to eliminate safety hazards without having a detrimental effect on the local bat population so long as proper mitigation is performed.

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SURFACE MINING CASE STUDY FROM KENTUCKY

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Abstract

The Kentucky Department for Surface Mining Reclamation and Enforcement (DSMRE) has required protection and enhancement measures for the Indiana bat (*Myotis sodalis*), on or near coal permit areas, for more than 6 years. Because of the inflexibility of some of the guidelines proposed by State and Federal fish and wildlife agencies and the need to better address unique mining permit areas, the DSMRE initiated discussions with the Kentucky Department of Fish and Wildlife Resources and the U.S. Fish and Wildlife Service to design a more effective Protection and Enhancement Plan (PEP). This Plan outlines: (1) the parameters that define when a PEP is needed, (2) mist netting and portal analysis/closure procedures, (3) short-term and long-term enhancements, and (4) a specific revegetation recipe for reclamation. With a fish and wildlife or forestland post mining land use, coal applicants may elect to forego the time and expense of bat surveys and assume presence of this endangered species.

Introduction

Since 1995, the Kentucky Department for Surface Mining Reclamation and Enforcement (DSMRE) has assisted coal mining applicants with protection and enhancement measures for the Indiana bat (*Myotis sodalis*), a Federally-listed endangered species. Originally, these plans concentrated on a post mining land use of fish and wildlife and associated enhancements with suggested tree species that would become suitable bat habitat. In 1997, the Kentucky Department of Fish and Wildlife Resources (KDFWR) and the Ecological Services Field Office in Cookeville, Tennessee of the U.S. Fish and Wildlife Service (USFWS) authored a set of guidelines to aid the coal industry in developing Indiana bat protection and enhancement plans bat in their applications. In July 1999, Commissioner Carl Campbell of DSMRE convened a working group of representatives from USFWS, KDFWR, and DSMRE to write a revised set of guidelines that would better utilize updated biological information, methodologies and protocols that would allow innovative measures for site specificities.

Guidelines

This revised document, now titled "Guidelines for the Development of Protection and Enhancement Plans for the Indiana bat (*Myotis sodalis*) November 1, 2000," was sent to the coal industry, Federal and State fish and wildlife agencies, and the academic community for comment in January 2000. The following May, reviewers from these entities attended a comment discussion and resolution meeting, hosted by DSMRE.

As a mining application is received (preliminary and/or original), the Critical Resources Section (CRRS) of the Division of Permits accesses the Kentucky State Nature Preserves Commission's database for the proximity of high value habitat or records of threatened/endangered species on or near the proposed permit area. An Indiana bat protection and enhancement plan may be required if a hibernaculum is within 10 miles or summer mist net capture is within 5 miles of the permit area. A site visit is conducted by the CRRS biologists and invited consulting agencies to determine if suitable bat habitat exists, such as potential roost trees, nearby water sources, corridors and abandoned mine portals. On some permits with previous disturbances, a protection and enhancement plan may not be required, although reclamation with potential roost tree species is always encouraged.

If an Indiana bat (IB) record is found within the specified radius and potential IB habitat exists within the permit area, the applicant options are: (1) to assume of presence with/without abandoned mine portals, or (2) to conduct a survey to demonstrate presence or probable absence with/without abandoned mine portals on the proposed permit area. By assuming presence, the applicant foregoes the time constraints and costs of mist netting and elects to abide by the winter tree clearing schedule and specific revegetation requirements. In these cases, a post mining land use of "fish and wildlife" or "forestland" is chosen. Even with the assumption of presence, any abandoned mine portals with appropriate ceiling, air flow and temeprature characteristics on the permit area must be assessed for winter use. If Indiana bats are caught or if the applicant wishes to assume summer portal use, a portal closure plan must be instituted. Portal closure involves closing portals after the first night's emergence, re-opening the portal on the second night and then permanently closing it after emergence. Mist netting methodologies are used according to the USFWS Indiana Bat Recovery Plan. The capture of bats confirms their presence. Although failure to catch bats does not confirm absence, negative data acquired during a survey conducted in accordance with approved protocol will be accepted as confirmation of the absence of the Indiana bat for the duration of the mine operation. If only a single male or non-lactating female is captured, it may be a transient or migratory individual. Capture of lactating females or juveniles during the summer likely indicates a maternity colony. Multiple captures at a cave or portal during the fall sampling period probably indicate the presence of a hibernaculum.

Certain objectives should be met when designing a protection and enhancement plan. The first objective is to minimize a taking of the Indiana bat. This is accomplished by the removal of potential roost trees during the winter months and assessing, surveying and possibly closing, abandoned mine portals. USFWS recommends a 100- ft. stream buffer zone around all intermittent and perennial streams and wetlands. The second objective is to provide short-term replacement of the bat habitat lost during the mining operation. This can be addressed by girdling suitable trees around the perimeter of the permit area supplemented with the installation of "rocket" design bat houses. The third objective is to restore and enhance bat habitat that previously existed on the mine site. A majority of the reclaimed area should be planted with exfoliating bark tree species supplemented with herbaceous ground cover compatible with tree growth. Such revegetation would provide

benefits to other wildlife species as well. Watering areas need to be created if permanent water sources are not in the vicinity of the permit area.

During the development and revision of our "Guidelines…November 1, 2000" document, DSMRE, KDFWR, USFWS and outside reviewers often disagreed or contributed diverse opinions regarding the following topics:

- Specification of critical distance that would trigger an Indiana bat protection and enhancement plan. In the 1997 Guidelines, a plan would be required if an Indiana bat record (hibernaculum or mist net capture) occurred within 10 miles of the proposed permit area. The coal industry asked DSMRE to relax that requirement to a 5 mile distance. Other reviewers requested the distance to be county (and adjacent county) wide. The Indiana Bat (Draft) Recovery Plan (1996) states, based on the literature and observations of Indiana bat consultants, that the Indiana bat forages 1.5-10 miles from their fall and spring roosts and 1.8-4.2 miles from their summer habitat. However, this is not an automatic requirement. After consultation with fish and wildlife agencies several proposed permit areas within these distances have not been found to contain suitable bat habitat and the PEP requirement has been waived.

- Minimizing the potential taking: stream buffer zones. The 1997 Guidelines state that a 100-ft. buffer zone around intermittent and/or perennial streams is mandatory. Very often Kentucky mining operations build head of hollow fills with accompanying sediment ponds in the natural drainways. If these operations are in the vicinity of these streams, the applicant must request a buffer zone variance. Variances, or encroachments to the buffer zone may be requested because of near-stream disturbances (access roads) or in-stream disturbances (road crossing, re-mining, temporary or permanent ponds, placement of fill). Based on DSMRE regulations, variances can be granted if the operations do not cause or contribute to the violation of applicable State or Federal water quality standards and if operations will not cause significant detrimental effects on other valuable environmental resources of the stream. USFWS has historically stated that in-stream disturbances qualifies as a potential taking of the Indiana bat, for any stream impact will affect the bat's food and water source. It is questionable whether the usually first order streams on permit areas are always intermittent/perennial. It is questionable whether the steep topography, usually low flow and lack of a clear stream corridor with a good amount of understory allow the bat to use these streams as a water source. It is questionable as to whether the streams provide a food source, since the literature states varying or conflicting "diets" of the Indiana bat according to Brack and LeVal (1985) and Kurta and Whitaker (1998). On all potential Indiana bat permits, DSMRE biologists will perform a site inspection of the streams and assess if an aquatic survey is necessary to identify high value habitats. The placement of temporary or permanent ponds in the stream, thereby changing a lotic to a lentic environment and possibly the macroinvertebrate composition may benefit the bat by providing a watering area and add to its adaptable diet. If mining operations involve stream loss, such as the placement of fill in an intermittent stream, DSMRE can require a permanent diversion that will replace the characteristics of the lost segment.

- Short-term enhancement: girdling of trees. As part of former protection and enhancement plans, the girdling of one 9" diameter (dbh) or larger suitable Indiana bat roost tree every 500 feet along the permit perimeter served as a quick, but temporary, bat habitat replacement measure. DSMRE believes that enough dead or dying trees exist in the vicinity of the permit area to deem this enhancement unnecessary. Roost adaptibility has been observed and recorded in the literature as stated in the Indiana Bat Recovery Plan (draft, 1996). Trees on the perimeter are often "girdled" or suffer extensive root damage by the heavy mining equipment. Girdled trees may remain standing for several years but not long enough to extend habitat to the planted trees during reclamation. The new Guidelines allow the applicant the option of girdling depending on the presence or absence of dead trees nearby at the time of bond release.

- Long-term enhancement: watering areas. The creation of permanent watering areas is an excellent bat and fish and wildlife enhancement. However, these permanent structures carry a large liability cost and must be sanctioned by the landowner once mining operations have ceased. Though USFWS highly recommends the building of these structures, DSMRE must acquiesce to the landowners' wishes. Nonetheless, shallow water depressions are encouraged and usually included in the reclamation plan.

In Kentucky, the coal industry has generally cooperated with the regulatory and fish and wildlife agencies and implemented protection and enhancement measures in their operations. When the Indiana bat has been recorded near proposed permit areas, most applicants assume presence (over 100 permits) and schedule tree removal between November 15 and March 31. In the past 6 years, 24 permit areas have been surveyed for the Indiana bat with 2 upland forest sites and 2 abandoned mine portal sites resulting in captures of 6 individuals. It would seem that, by surveying, the coal applicant might easily determine the absence of the Indiana bat and not be required to fulfill the obligations of a protection and enhancement plan.

However, with a fish and wildlife (requires 30 percent of the permit area to be reclaimed in trees) or forestland post mining land use, the cost of the additional trees to be planted (70 percent of the permit area) is less than the expense of surveys. In addition, assumption of presence would not subject the applicant to the time constraints of mist net surveys.

Conclusion

In conclusion, more research is needed before the coal industry and agencies can reach a common ground on the above mentioned issues. However, through a cooperative effort, the November 1, 2000 Guidelines have been developed based upon the literature that is presently available and provides the coal industry a set of workable options to protect and enhance this endangered species.

Copies of the "Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat (*Myotis sodalis*) November 1, 2000"can be obtained from the Critical Resources Review Section, Division of Permits, Department for Surface Mining Reclamation and Enforcement, # 2 Hudson Hollow, Frankfort, Kentucky 40601.

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Session 5

Program Development

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State Program/Colorado
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The McLaughlin Mine Bat Program: New Ideas in an Old Mining District
Dean Enderlin, Homestake Mining Co., Lower Lake, California

Implementation of a Recovery Plan for the Endangered Indiana Bat
Richard Clawson, Missouri Department of Conservation, Columbia, Missouri

THE COLORADO BATS/INACTIVE MINES PROJECT

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Introduction

The Colorado Bats/Inactive Mine Project is a cooperative effort between two sister agencies; the Colorado Division of Minerals and Geology and the Colorado Division of Wildlife. The Colorado Division of Minerals and Geology, Inactive Mine Reclamation Program (IMP) has the responsibility for safeguarding hazardous mine openings in the State. The Colorado Division of Wildlife (DOW) manages and protects the State's wildlife.

Colorado's history is mining. Mining attracted people to the State in 1859 and it was the most important economic activity in Colorado for many years. Mining is still important to Colorado's economy today although it is now oriented more towards coal and aggregate. There are over 23,000 hazardous abandoned mines and 1,300 miles of stream impacted by mining in the State of Colorado. To date, seventeen people have died in abandoned mines and twenty-four people have been injured.

While these abandoned mine openings represent a hazard to the public; they can be important habitat for bat species. Colorado is home to 18 different bat species, 13 of which are known to use caves and mines to some extent. Bat populations have been decreasing in Colorado and elsewhere in North America due to pesticide use and destruction of habitat. As bats lose their traditional roost sites, man-made structures, such as abandoned mines, have become increasingly important to bats.

History of the Colorado Bats/Inactive Mine Reclamation Program

The Inactive Mine Reclamation Program (IMP) in Colorado began in 1980 and the first mine closures were installed in 1982. Presently the IMP has installed over 5,000 mine closures in the State. The first three years of the program were spent exclusively on coal sites. The IMP has safeguarded about 900 coal openings since 1982. Initially most of the openings were safeguarded by backfilling or installing concrete caps. In 1985 the IMP began work on hardrock mines and in 1987 the first bat gate was installed on an uranium mine adit just west of Denver. In 1988, the IMP installed safeguards at the Orient Mine in southern Colorado. The Orient mine contains a bachelor colony of over 250,000 bats. Over 320 bat gates have been installed or are scheduled to be installed by DMG on abandoned mine openings. Over 300 of these gates are protecting Corynorhinus Townsendii roosts.

In 1990, the Division of Wildlife (DOW) began actively pursuing a bat conservation program. Neither the DOW nor the IMP had adequate funding to provide bat gates for all mine closures. Consequently, after a series of meetings, the two agencies outlined major goals to guide the Bats/Inactive Mines Project.

Goals

The goals of this cooperative venture are:

1. Develop a cost effective inter-agency project to evaluate and identify mines with significant populations of bats, particularly Corynorhinus Townsendii populations. The system that was developed requires close cooperation between IMP project managers and DOW coordinators.

2. Protect mines that are important bat habitat with bat gates. Bat gates allow bats to continue to use mines while providing for public safety. Gates also lessen the amount of human disturbance to bats. Several factors influence the decision concerning the installation of bat gates, particularly available funding. Other factors include: (1) species use, (2) opening characteristics, (2) degree of visitation to the site, and (4) susceptibility to vandalism.

3. Increase awareness about bat conservation and the hazards associated with abandoned mines.

Funding

The Federal Office of Surface Mining funds most of the IMP activity in Colorado. The money for this work comes from fees paid by current coal mine operations. The fees are placed into a trust fund by the Federal Office of Surface Mining. Fifty percent of these funds can be returned to the State for reclamation purposes. The program budget is approximately $2.5 million per year with the majority of the funds allocated to construction. The IMP safeguard mines by cost sharing with the National Park Service, the Bureau of Land Management, the United States Forest Service, and private landowners. The priorities of the program fall into four categories: (1) emergencies (coal only), (2) extreme hazards, (3) dangerous hazards, and (4) environmental degradation). Preference continues to be given to coal problems since the funding is derived from active coal mines. The IMP can safeguard extreme hazards at non-coal/hard rock mines with a letter from Governor and approval from the Secretary of Interior. Collection of fees is currently set to expire in 2004 and consequently it is imperative that the mines be safeguarded as soon as possible. The IMP continues to pay for the majority of the costs associated with special bat closures. Currently, only one third of one percent of construction dollars comes from DOW. DOW usually pays the incremental costs between the standard closure and the bat gate on lands where there is no other funding source other than the Office of Surface Mining.

Process

The following is the process used to initiate an Inactive Mine Project:

1. The IMP, with a citizen's advisory council, selects general candidate areas (geography, watersheds, part of a mine district, etc.) in order to target a reclamation project. A 1980 inventory of sites is used to locate mine openings as well as citizen requests.

2. IMP project managers visit sites and complete a mine site field form for each opening. Project managers may note the presence of bats on the field form. However, in most cases, no formal bat assessment is made.

3. The IMP gives copies of mine site field forms to DOW and begins a realty search to determine ownership.

4. The IMP identifies the owner and begins attempts to obtain consent for safeguarding work. Ownership information is given to DOW. DOW procures consent for bat surveys directly from the landowners of the mine sites.

5. DOW reviews IMP mine site field forms and, along with site inspections, determines which sites warrant further investigation.

6. DOW conducts site surveys where trapping and internal surveys are involved at some sites.

7. DOW makes recommendations to IMP on the desirability of installing bat gates. IMP reviews DOW recommendation as to:

    A. Feasibility (competency of surrounding material, "constructability," access for necessary equipment)

    B. Cost (size, accessibility for equipment, specific/special design needed)

    C. Landowner requirements.

    D. Effectiveness of the proposed closure with respect to eliminating the hazard.

    E. Future maintenance requirements/susceptibility to vandalism.

    F. Compatibility with possible competing interests such as historical preservation requirements.

Conclusion

The Bats/Inactive Mines Project is a great example of how two sister agencies can cooperate to accomplish related, though sometimes divergent, goals. The success of the project is due to the efforts of the coordinators of the DOW Bats/Inactive Mines Project, hundreds of volunteers, DMG project managers and the contractors who install the gates.

THE MCLAUGHLIN MINE BAT PROGRAM: NEW IDEAS IN AN OLD MINING DISTRICT

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Introduction

Homestake Mining Company's McLaughlin gold mine (located in northern California about 70 miles north of San Francisco) has distinguished itself by its adaptive approach to wildlife management. Homestake's strategy at McLaughlin has been one of open review and adaptation as new information becomes available. This approach is clearly exemplified in the management of bat populations at the site. Of sixteen species predicted to occur at the site, ten have been confirmed thus far.

Bat Colony Relocation

A pioneering effort to understand and provide for the needs of a sensitive bat population at the McLaughlin mine was initiated by Homestake in 1987. Under the guidance of Drs. Elizabeth "Dixie" Pierson and William Rainey, mine staff undertook the relocation of a colony of Townsend's big-eared bat (*Corynorhinus* (=*Plecotus*) *townsendii*). The colony resided in legacy mine workings from historic mercury mining in the district. Seventy females were identified as using nearby tunnels as a summer roost. Winter monitoring revealed that other workings in the vicinity were used as hibernacula. Excavation in the vicinity of these roosts was postponed until alternative roosting habitat could be found, and until additional behavioral/ecological data could be gathered to understand the needs of the colony.

In May 1988, once sufficient information had been gathered to proceed, the colony was relocated to safe alternative habitat sites. The new sites are protected within the boundaries of Homestake's lands, are stable, and have been gated to prevent human intrusion. Since relocation, the maternity colony has more than doubled in size, recently numbering in excess of 200 individuals. The methodology and habitat considerations used during the course of this effort were novel and unprecedented at the time. Little was known of the roosting requirements for this species. The success of this program is attributable to careful observation of the roosting patterns in the district to determine the preferences of the species. Once these needs had been identified, suitable alternative sites were selected for stabilization and occupation.

Creation of Artificial Habitat

Ongoing habitat innovation at the McLaughlin mine led to the installation of an artificial tunnel habitat for bats in 1996. This experimental structure was constructed of used heavy equipment tires, placed side-wall to side-wall, extending outwards in an X shape from a central concrete hub. The structure was built in an area where mine overburden "waste rock" was being placed.

Once filled over with clay and soil, the habitat consisted of 445 feet of tunnel, two gated entrances, and two ventilation risers. Although no bat occupation of the structure has been documented, its interior conditions are favorable for roosting. It is thought that occupancy may occur when suitable woody cover has been established across the exterior landscape, which now consists of recently reclaimed expansive grasslands.

Summary

In summary, the McLaughlin mine bat protection program is a highly successful model. Using the decision-making processes described above, an effective habitat management program (with minimal budgetary consequences) is established and is self-sufficient. Ongoing monitoring continues to confirm the effectiveness of this approach.

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IMPLEMENTATION OF A RECOVERY PLAN FOR THE ENDANGERED INDIANA BAT

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Abstract

The Indiana bat (*Myotis sodalis*) has been listed officially as endangered since 1967. The species was listed because it was and remains exceptionally vulnerable to disturbance and destruction during the winter hibernation season. This is because a high proportion of its population congregates during winter in a small number of caves and mines. Despite protection of many of these hibernacula, the overall population has continued to decline. Declines are not universal, however, throughout the species' range. The population in the southern portion of the Indiana bat's range has suffered disproportionately and lost numbers while that in the northern Midwest and northeast it has maintained or increased numbers during the same time period. At this time, the *Indiana Bat Recovery Plan* is being revised. The foremost need identified in the plan is research into the cause or causes of the observed declines and the reasons for the disparity in population trends in the different parts of the species' range. It still is important, however, for Indiana bat colonies in caves and mines to be protected during hibernation, and for management authorities to attempt to restore colonies that have declined in or been excluded from historic hibernacula. It also is possible to manage for summer colonies of Indiana bats by enhancing or restoring surface habitat to conditions favorable for the species. Mining concerns and regulatory agencies can participate in the recovery of the endangered Indiana bat in both winter and summer by: (1) identifying mines that are occupied by the species and protecting them, and (2) restoring surface mine landscapes to forested conditions.

Introduction

Land managers, including managers of mine lands, may be concerned about a number of bat species and their habitat needs. One bat species that has attracted attention in the eastern U.S. is the endangered Indiana bat (*Myotis sodalis*). The *Indiana Bat Recovery Plan* contains information and recommendations that may be used to manage underground and surface habitat for this species. Management for the Indiana bat not only would provide habitat for an endangered species, but also would provide habitat for a variety of other cave-dwelling and forest bats.

Current Status and Population Trends

Indiana bat populations first were surveyed in the late 1950s (Hall, 1962). In the decades since then, additional colonies of hibernating Indiana bats were discovered and our knowledge of the distribution and status of the species has expanded. Regular surveys have been conducted since the 1970s. Based on censuses taken at hibernacula, the total, known Indiana bat population in 1999 was estimated to number about 350,000 bats. More than half of the current population of

the Indiana bat hibernates in the nine Priority One hibernacula. Eight of the nine have been surveyed every two years from 1983 to the present (one is unsafe to enter). The populations in these caves are presented in Table 1. During the period 1983 through 1999, the populations in these caves have declined by 39 percent.

Table 1. Populations of Indiana bats in the eight surveyed Priority One hibernacula, 1983-1999.

Year	1983	1985	1987	1989	1991	1993	1995	1997	1999
Population	288225	246600	239200	213050	228675	208875	189000	178525	176125
Survey to survey % change		-14.4	-3.0	-10.9	+7.3	-8.7	-9.5	-5.5	-1.3
% change since 1983		-14.4	-17.0	-26.1	-20.7	-27.5	-34.4	-38.1	-38.9

The three States with the highest numbers of Indiana bats in winter are, in descending order, Indiana, Kentucky, and Missouri. The known population in Indiana appeared to drop from the earliest surveys through 1980, but has been growing almost steadily in recent years. Indiana now contains about 183,000 of its namesake bats, which is half of all the Indiana bats in existence.

Between 1960 and 1975, Kentucky had the greatest Indiana bat population decline among the States, an estimated 145,000 bats. Losses were attributable to exclusion and changes in microclimate at two of the three most important hibernation sites. Most of these were caused by poorly designed cave gates (Humphrey 1978) and by construction of a building over the upper entrance to one of the hibernacula (J. MacGregor, personal communication.). Although not as dramatic as earlier losses, many of the most important remaining hibernating populations have declined steadily during the past 15 years. During this period, populations in west-central, northeastern, and extreme southeastern Kentucky have declined, while the populations in east-central Kentucky and those in western Kentucky have increased.

Populations of hibernating Indiana bats in Missouri have declined steadily and drastically since 1980, despite efforts such as the construction of bat friendly gates at cave entrances. The colonies of Indiana bats in both of the Priority One caves that can be surveyed and 12 of the 13 Priority Two hibernacula in the State have declined during this period. Since 1983, the overall Missouri population has shown a cumulative estimated decline of over 130,000 bats, a loss of more than 85 percent of the population.

Among the other States with regularly occurring hibernating populations of Indiana bats, recent trends are mixed. For five States, trends either are not known or are not well documented. One southern State (Arkansas) has seen its population decline while two northeastern States (New York and Pennsylvania) and one eastern State (West Virginia) have seen population increases.

Reasons for Decline

Not all of the causes of Indiana bat population declines have been determined; nor do we know why the species is declining at its current rate. Although several known human-related factors have caused declines in the past, they do not appear to account for the declines we are now witnessing.

A serious cause of Indiana bat decline was human disturbance of hibernating bats during the decades of the 1960s through the 1980s. Bats enter hibernation with only enough fat reserves to last until spring. When a bat is aroused, it uses a portion of these reserves, as much as 68 days of fat supply in a single disturbance (Thomas *et al.*, 1990). Humans, including recreational use of caves and researchers, passing near hibernating Indiana bats cause arousal (Humphrey, 1978; Thomas, 1995). If this happens too often, the bats' fat reserves may be exhausted before spring and insect prey again are available. Direct mortality due to human vandalism has also been documented.

Some hibernacula have been rendered unavailable to Indiana bats by the erection of solid gates in the entrances (Humphrey, 1978). Other cave gates have so modified the climate of hibernacula that Indiana bats were unable to survive the winter on their fat reserves (Richter *et al.*, 1993).

Indiana bats are subject to a number of natural hazards. River flooding, internal cave flooding, and flash flooding have drowned Indiana bats during hibernation in several caves throughout the range of the species (Hall, 1962: DeBlase *et al*., 1965, J. MacGregor, and T. Wethington, personal communications.).

Bats hibernating in mines are vulnerable to ceiling collapse (Hall, 1962; R. Myers, pers. communication.). To a lesser extent, ceiling collapse in caves also is possible.

Another hazard exists because Indiana bats hibernate in cool portions of caves that tend to be near hibernacula entrances, or where cold air is trapped. Some bats may freeze to death during severe winters (Humphrey, 1978; Richter *et al.*, 1993).

Possible Causes of Decline

Caves and mines change far more than is generally recognized. Entrances and internal passages essential to air flow may become larger or smaller, or close altogether, resulting in increases or decreases in air flow. Blockage of entry points, even ones too small to be recognized, can be extremely important in hibernacula that require chimney-effect air flow to function.

Hibernacula in the southern portions of the Indiana bat's range may be either near the warm edge of the bat's hibernating tolerance or have relatively less stable temperatures, while hibernacula in the North may have passages that become too cold. In the South, bats may be forced to roost near entrances or floors to find low enough temperatures, thus increasing their vulnerability to freezing or predation. In the North, bats must be able to escape particularly cold temperatures.

In Missouri's hibernacula, average mid-winter temperatures appear to have risen from the mid 1980s through the present, compared to temperatures in the 1970s and early 1980s. During this period, major population losses have occurred. Preliminary analysis of fall and winter temperature data suggests that a similar trend has occurred in ambient temperature outside the cave, and thus appears to have played a role in these population losses (R. Clawson, pers. observation.). A much more detailed analysis is underway, with detailed temperature profiles of important hibernacula throughout the range of the species, to better understand the relationship(s)

between climate, air flow, and hibernation microclimates within hibernacula.

During summer, when Indiana bats are roosting under exfoliating bark, they are vulnerable to the effects of severe weather such as thunderstorms stripping the bark from their roost (J. Gardner, personal communication).

The Indiana bats' maternity range has been changed dramatically from pre-settlement conditions. The forests has been fragmented in the upper Midwest, fire has been suppressed, and prairie has been supplanted with agricultural systems. Native plants, especially grasses, have been replaced with exotics in large portions of the maternity range, and diverse plant communities have been replaced with simple ones or monocultures. Simplification of the habitat could have profound effects through factors such as availability and abundance of insects on which the bats prey. Conversely, regions surrounding hibernacula in the Missouri Ozarks and elsewhere may be more densely forested than they were historically. In the eastern U. S., the area of land covered by forest has been increasing in recent years. Whether this is beneficial, neutral, or negative for the Indiana bat is an open question, however. The age, composition, and size class distribution of the woodlands will have a bearing on their suitability as habitat for the species.

Pesticides have been implicated in the declines of a number of insectivorous bats in North America (Mohr, 1972; Reidinger, 1972, 1976; Clark and Prouty, 1976; Clark *et al*., 1978; Geluso *et al*., 1976; Clark, 1981). The effects of pesticides on Indiana bats have yet to be studied, but a study of closely-related species in Missouri suggests that Indiana bats may be exposed to organophosphate pesticides as well as persistent residues of organochlorine pesticides (McFarland, 1998).

Habitat Requirements

Winter Habitat

For hibernation, Indiana bats require specific roost sites in caves or mines that attain appropriate temperatures. Specific cave configurations determine temperature and humidity microclimates, and thus suitability for Indiana bats (Tuttle and Stevenson, 1978; LaVal and LaVal, 1980). In southern parts of the bat's range, hibernacula trap large volumes of cold air and the bats hibernate where resulting rock temperatures drop. In the northern parts of the range, however, the bats avoid the coldest sites. In both cases, the bats choose roosts with a low risk of freezing. Ideal sites are 50ºF (10ºC) or lower when the bats arrive in October and November, and a mid-winter temperature range of 37-43ºF (3-6ºC) appears to be best for the species. Only a small percentage of available caves provide for this specialized requirement. Stable low temperatures allow the bats to maintain a low rate of metabolism and conserve fat reserves through the winter until spring arrives (Humphrey, 1978; Richter *et al*., 1993).

Relative humidity at roost sites during hibernation usually is above 74 percent but below saturation (Hall, 1962; Humphrey, 1978; LaVal *et al*., 1976), although relative humidity as low as 54 percent has been observed (Myers, 1964). Humidity may be an important factor in successful hibernation (Thomas and Cloutier, 1992).

Summer Habitat

A full understanding of the summer needs of the Indiana bat is yet to be attained, but progress is being made. Flood-plain and riparian forest were considered by early researchers to be the primary roosting and foraging habitats used in the summer by the Indiana bat (Humphrey *et al*., 1977) and these forest types unquestionably are important. More recently, upland forest has been shown to be used by Indiana bats for roosting (Clark *et al*., 1987; Gardner *et al*., 1991*b*; Callahan *et al*., 1997; MacGregor, personal communication). Upland forest, old fields, and other upland habitats have been shown to provide foraging habitat (Gardner *et al*., 1991*b*; J. MacGregor, personal communication).

Indiana bats live in highly altered landscapes and use an ephemeral resource (dead and dying trees) as roost sites. There is evidence, in fact, that suggests that the Indiana bat may, in fact, respond positively to habitat disturbance.

Within the range of the species, the existence of Indiana bats in a particular area may be governed by the availability of natural roost structures, primarily standing dead trees with loose bark. The suitability of any tree as a roost site is determined by: (1) its condition (dead or alive), (2) the quantity of loose bark, (3) the tree's solar exposure and location in relation to other trees, and (4) the tree's spatial relationship to water sources and foraging areas. The most important characteristics of trees that provide roosts are not species but structure, specifically, exfoliating bark with space for bats to roost between the bark and the bole of the tree. To a very limited extent, tree cavities and splintered, broken tree tops also have been used as roosts (Gardner *et al*., 1991*a*; Kurta *et al*., 1993; J. MacGregor, personal communication).

Indiana bat maternity colonies use multiple roosts in both dead and living trees. Exposure of roost trees to sunlight and location relative to other trees are important factors in suitability and use (Humphrey *et al*., 1977). Miller (1996) found that sites in north Missouri at which Indiana bat maternity colonies had been located had significantly more large (> 30 cm [12 in] diameter) trees than sites at which Indiana bats were not captured.

Most of the roost trees used by a maternity colony are close together. The spatial extent and configuration of a colony's regular use area is probably determined by the availability of suitable roosts. The distances between roosts occupied by bats within a single maternity colony have ranged from just a few meters to as much as several kilometers (A. Kurta, personal communication; Callahan *et al*., 1997).

Maternity colonies have at least one primary roost that is used by the majority of the bats throughout the summer. Colonies also use multiple alternate roosts that are used by small numbers of bats intermittently throughout the summer. Primary roosts are located in openings or at the edge of forest stands, while alternate roosts can be in the open or the interior of forest stands. Primary roosts are not surrounded by a closed canopy and can be warmed by solar radiation, thus providing a favorable microclimate for growth and development of young during normal weather. Alternate roosts tend to be more shaded, frequently are within forest stands, and are selected when temperatures are above normal or during periods of precipitation. Shagbark hickories seem to be particularly good alternate roosts because they provide cooler roost

conditions during periods of high heat and their tight bark shields bats from water during rain events (Callahan *et al*., 1997; Kurta *et al.*, 1996).

Trees that provide Indiana bat roosts are ephemeral. It is not possible to generalize or estimate roost longevity due to the many factors that could affect it. Bark may slough off completely or the tree may fall over. Roosts in oaks (*Quercus spp.*), hickories (*Carya spp.*), and ashes (*Fraxinus spp.*) may be habitable for six to eight years, but roosts in some tree species such as elm (*Ulmus spp.*) and cottonwood (*Populus deltoides*) may be available for a much shorter time - only one to two years (Humphrey *et al*., 1977; Gardner *et al*., 1991*a*; Callahan *et al*., 1997; A. Kurta, personal communication).

Indiana bats have strong site fidelity to summer colony areas, roosts, and foraging habitat. Females have been documented returning to the same roosts from one year to the next and males have been recaptured when foraging in habitat occupied during prior summers (Humphrey *et al*., 1977; Gardner *et al*., 1991*a*,*b*; Callahan *et al*., 1997).

During the fall, when Indiana bats swarm and mate at their hibernacula, male bats roost in trees nearby during the day and fly to the cave during the night. These roosts are similar to roost sites selected during the summer, are primarily on upper slopes and ridge tops not far from hibernacula, and often tend to be exposed to sunshine rather than being shaded (Kiser and Elliott, 1996; J. MacGregor, pers. communication.;C. Stihler, pers. communication.)

Indiana bats forage in and around tree canopy of flood-plain, riparian, and upland forest. In riparian areas, Indiana bats primarily forage around and near riparian and flood-plain trees, as well as solitary trees and forest edge on the flood-plain (Belwood, 1979; Cope *et al*., 1974; Humphrey *et al*., 1977; Clark *et al*., 1987; Gardner *et al*., 1991*b*). Indiana bats, however, also forage within the canopy of upland forests, over clearings with early successional vegetation (e.g., old fields), along the borders of crop lands, along wooded fence rows, and over farm ponds in pastures (Clark *et al*., 1987; Gardner *et al*., 1991*b*).

The extent of foraging area used by an Indiana bat maternity colony has been reported to range from a linear strip of creek vegetation 0.5 mile (0.8 km) in length (Belwood, 1979; Cope *et al*., 1974; Humphrey *et al*., 1977), to a foraging area 0.75 miles (1.2 km) in length, within which bats flew over the wooded river or around the riverside trees (Cope *et al*., 1978). Indiana bats return nightly to their foraging areas (Gardner *et al*., 1991*b*).

During summer, male Indiana bats that remain near their hibernacula forage at the edges of small flood-plain pastures, within dense forest, and on hillsides and ridge tops (LaVal *et al*., 1976; LaVal *et al.* 1977; LaVal and LaVal, 1980). In the fall, male Indiana bats tend to roost and forage in upland and ridge top forests, but also may forage in valley and riparian forest (Kiser and Elliott, 1996; 3D/International, 1996). Upon emergence from hibernation in the spring, some males remain within the vicinity of their hibernacula, where they roost and forage in mature forest, however, other males leave the area entirely upon emergence in the spring (Hobson and Holland, 1995; 3D/International, 1996).

The Recovery Plan

History

A *Recovery Plan for the Indiana Bat* was first drafted in 1976. At that time, only limited data on populations and the distribution of the species were available. In addition, a lack of knowledge of life history made it difficult to write an extensive or comprehensive plan. The *Recovery Plan* was redrafted in the early 1980s and was approved on 14 October 1983. A *Technical Draft* of the *Indiana Bat Revised Recovery Plan* was completed in October 1996. An *Agency Draft* of the *Recovery Plan* was prepared and comments were received in 1999, but these comments have yet to be incorporated into the *Plan*.

Emphasis of the Plan

Given the concern about the cause or causes of the continued population decline, it should be no surprise that the highest priority identified in the *Recovery Plan* is research to answer this question. The *Plan* also, however emphasizes the need to continue to monitor the population status and trends, as well as the distribution of the species; and the need to protect Indiana bats during the hibernation period. Management of summer habitat is addressed, but the *Plan* at present does not spell out specific standards or guidelines. Instead, the Recovery Team recommends that land managers apply guidelines similar to those developed by the Daniel Boone National Forest or the Missouri Department of Conservation.

Management Strategies

The Hibernation Period

Current hibernacula should be protected and abandoned hibernacula should be restored, if it is feasible to do so. Preventing unwarranted entry by humans is the best way to curtail disturbance at these sites. Entry to hibernacula should be prohibited during the period of September 1 - April 30 in most of the species' range, and September 1 - May 31 in the northern portion of the range.

Signs may be used at caves to discourage entry, and should be used in conjunction with gates to inform the public. Signs should be placed inside cave entrances so as not to attract potential violators to the cave, but not block bat movement or air flow.

A structure, such as an angle-iron gate or fence, may be placed at the roost cave entrance to prevent unauthorized human access. The structure must permit Indiana bats to pass without danger and must not alter air flow. Plans and descriptions of proper gate designs are available from the American Cave Conservation Association and were reported by Tuttle and Taylor (1994). Caves that receive flash flooding should be carefully evaluated before barriers are constructed, especially if the bats roost where water may be impounded by a gate. Special care must be taken where detritus can accumulate against a gate over time, causing high water levels with flooding events, or blocking air flow.

Because of the vulnerability of Indiana bats to disturbance during hibernation, monitoring should be conducted every other year. This frequency should be sufficient to determine population trends, but not put additional pressure on the species.

Hibernacula are vulnerable to changes made to the surface areas above them. Some have other entrances, well away from the main entrance, that are crucial to chimney-effect air flow. Activities such as road construction, urban development, the conversion of forest to pasture or crop land, surface mining, or logging should be planned carefully or excluded within a $^{1}/_{4}$ mi (0.4 km) buffer zone around a hibernaculum. Forested buffer zones should be designed to conform to the surrounding topography on a case by case basis.

The maintenance of forest cover in the vicinity of hibernacula is important because male Indiana bats forage nearby and use snags and loose-barked trees as daytime roosts prior to entering hibernation (Kiser and Elliott, 1996). Forest management activities should incorporate standards and guidelines that protect and enhance Indiana bat roosting and foraging habitat.

The Summer Maternity Period

Forest management practices should incorporate standards that protect and enhance roost trees for Indiana bats. Silvicultural practices should favor the creation and retention of suitable roost trees, including the development of multiple age classes so that a sustainable supply of large diameter, mature and over-mature trees is assured through the foreseeable future. Uneven-aged management or even-aged management that includes provisions for snag retention may be used. Large diameter, standing dead trees, especially those at forest edges or in the open, should be retained. Snag retention guidelines developed by the USFS Daniel Boone National Forest and Missouri Department of Conservation are considered to be adequate and should be consulted by land managers. Managers are encouraged to use information on the life history and ecology of the Indiana bat in concert with their own experience to tailor management strategies to their own particular circumstances and situations.

For a real-world example, the following is a synopsis of the recommendations designed to provide Indiana bat roosting and foraging habitat on State-managed forest lands throughout Missouri: Within a management compartment, management should preserve or create a diversity of age and size classes, with mature and over-mature trees well represented. These trees, as they die and become snags, will provide a continuing supply of potential roost sites for Indiana bats. The goal should be to develop patchiness, vertical height diversity, and dead and dying trees to provide potential roosts and foraging habitat for bats.

In bottomland forest, management should perpetuate hardwoods with a diversity of tree species and age classes. Uneven-aged management should be used to create a mixture of mature and over-mature trees in groups within stands and small openings in the canopy.

In riparian corridors, management should perpetuate a diversity of tree species and age classes, and maintain a minimum forested buffer strip of 100 feet on each side of streams. This corridor should be wider if it is possible. Reforestation should occur on lands lacking minimum forest corridors.

Forested acres should be managed for optimum numbers of snags using the following recommendations:

	Number of Snags per Acre		
	>19" dbh	10-19" dbh	<10" dbh
Heavily Forested	0.5	4	2
Open/Semi Open	1	4	2
Riparian Corridor	1	7	4
Bottom land Hardwood	1	4	2

Where choices are possible, oaks, hickories, and ashes should be favored for retention or snag creation. During harvest, snags should be left wherever they are found except where they pose a safety hazard or are part of a salvage harvest. Some snags should be retained in groups with live trees to prevent wind-throw.

In regions with large areas of contiguous, mature canopy, forest management practices that open the canopy and reduce understory may enhance Indiana bat roosting and foraging habitat. Reducing the canopy from a solid, 100 percent coverage into the range of <80 percent but >30 percent would create openings and edges where snags would receive sunlight, thus improving them for roosting. Reduced canopy also would create foraging areas because Indiana bats preferentially forage around and adjacent to tree crowns. Reducing the understory would make snags more accessible by removing obstacles to flight, allow sunlight to strike the trunks of the snags, and allow the bats to forage beneath the tree canopy. Savanna management may supply some or all of these conditions and should be applied on appropriate sites within the landscape. Providing water sources such as ponds, ephemeral pools, seasonal depressions, and road ruts may enhance Indiana bat habitat. These should be sited along ridge tops, approximately ½ mile apart. Snag retention and development should be targeted at upper slopes and ridge tops.

Old growth forest should be designated around Indiana bat hibernation caves. Twenty acres is recommended, but topography, watershed, and other considerations should be factored into the old growth design, size, and configuration to protect the integrity of the cave system. In addition, the site should be managed to provide corridors of tree canopy from the cave to foraging areas.

- Within 5 miles of known Priority 1 and Priority 2 hibernation caves:
- A minimum of 10 percent of total forest should be designated as old growth.
- Forest conditions, including numbers of snags and cavities, should be inventoried regularly - at least every 15 years. Managers should attempt to inventory and manage at near uniform intervals around a given cave (e. g., if there were 5 forested compartments around a cave, one compartment should be inventoried and treated every three years rather than all being done during a single year).
- A balanced age and size class distribution should be maintained through forest management methods.
- The recommended number of snags should be retained or created in any stand that is treated, whether it be by clear cut, timber stand improvement, or intermediate cut. Leave stands or old growth should not be treated, because these will provide snags in the future.

Challenges and Opportunities

By law, managers have to deal with an endangered species, the Indiana bat. It is an animal whose life history and habitat needs were not well known until recent times and about which there still is much to learn. Even so, managers should make a good faith effort to apply what is known. Mining concerns and regulatory agencies can participate in the recovery of the Indiana bat in both winter and summer. During the winter, mines that are occupied by the species can be identified, assessed for needed protective measures, and made off-limits to humans during the hibernation season. Summer habitat can be provided for the Indiana bat by managing surface mine landscapes to restore or create forested conditions and managing the forest as outlined above. Forums such as this can bring together Federal and State agencies, private landowners, and professional organizations to work together rather than at cross purposes to one another.

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Session 6

Interest Group Recommendations to Enhance Bat Conservation Associated with Mining

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NATIONAL ASSOCIATION OF ABANDONED MINE LAND PROGRAMS RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

Mark Mesch
Utah Division of Oil, Gas, and Mining
Salt Lake City, Utah

In 1994, Merlin Tuttle of Bat Conservation International (BCI) came to the annual meeting of the National Association of Abandoned Mine Lands (AML) with a display featuring the work of BCI. Since then, BCI has been at every one of our annual AML conferences. This has allowed for an steady increase in technology transfer concerning bat conservation at abandoned mine sites. So now we have numerous AML programs around the country actively installing bat gates.

Although we have made great progress in installing bat gates, there are still many unanswered questions in terms of the effectiveness of the gates to actually be beneficial to the bats. One of my main concerns is that we need more research into the effect of gate design on bat behavior. Then we need to find a better way to transfer information on the best available bat gate designs to all of the people and programs working in this area including the information presented at this forum. I would encourage programs installing and working with bat gates to incorporate into their program a monitoring system that would evaluate the effectiveness of the gates and then communicate this information so that it is usable by other programs.

When you talk about AML related work you can not avoid the subject of where AML funds come from. They come from a tax on coal that is specifically earmarked for AML work. Congress has held back $1.6 billion of these funds and not allowed the States to use these funds for the purpose they were intended. These funds should be used by State AML programs to do reclamation of abandoned mines including the construction of bat gates. Utah's share of these funds is about $10.5 million. Everyone involved with or concerned about restoring lands affected by mining should be telling Congress to release those funds.

INTERSTATE MINING COMPACT COMMISSION/ EASTERN REGULATORY AUTHORITY STATES' RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

Dr. Richard Wahrer
Kentucky Department for Surface Mining Reclamation and Enforcement
Frankfort, Kentucky

I have two underlying themes to my talk. First, everyone wants their way and everyone needs a job. I represent the regulators of the Interstate Mining Compact Commission (IMCC) and we need to get an education on bat protection and come up to speed on current issues. At a minimum, we need to attend forums like this. We need to discuss problems and solutions and talk with the other affected agencies that you find at forums like this. I know there is going to be a symposium on the Indiana Bat in Lexington Kentucky in April of 2001 and I would encourage people to attend.

Since many of the IMCC members are not represented at this meeting, their attitudes on the subject are unknown. The bat protection movement is not going to go away. As regulators we need to deal with this issue. However, regulators live and die by the regulations. Woe be it to the regulator that bends or reinterprets the regulations and then has to answer to a superior.

Each agency has its own charge supported by law. OSM. and primacy States have the authority to issue mining permits. The USFWS has the endangered species act, a powerful piece of legislation that needs to be followed and enforced. Once all of the parties understand this, then rational discussions can start. It is imperative that each State mining program develop a close working relationship with the USFWS. Although consultation with the USFWS could be interpreted as "thank you for your comments now lets move on." Consultation could and probably should be questioning, arguing, challenging, and then resolving specific problems.

At this forum, most of the comments I have received from the regulators and coal industry representatives has centered around the USFWS. A unanimous concern has been the status of the Indiana Bat recovery plan. Most States do not know what to do about bat protection and are looking for clear direction from USFWS. Another major concern is about individual USFWS offices. They need to provide specific information about bat protection in terms of minimizing impacts to bat species supplemented with how to enhance and restore bat habitat. It has been reported to me that significant inconsistencies with these issues exist between different USFWS field offices as well as with a certain specific office. This could be due to changing policies or staffs within an office. I would encourage the USFWS to enter into discussions with the State mining regulatory agencies. Perhaps someone like Bob Currie who is an Indiana Bat expert could educate the staff at different USFWS field offices and State mining regulatory authorities.

Concerning the need for published research, perhaps OSM could facilitate the collection and review of existing research and make it available to all stake holders.

WESTERN INTERSTATE ENERGY BOARD/ WESTERN REGULATORY AUTHORITY STATES RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

Homer Milford
New Mexico Mining and Minerals Division
Sante Fe, New Mexico

The Western Interstate Energy Board (WIEB) represents the Western U.S. coal mining States. They are very interested in the economy of those States. They would view the $1.6 billion in AML funds held by Congress to be a significant amount of funding. The problem is how to get Congress to stop trying to balance the budget with these funds and delegate them back to the State for the reclamation work for which they were intended. This, however, may be a dream. Things that we may be able to affect are education. The education provided by BCI has made a dramatic difference. If, however, you had said 10 years ago that we would have being doing what we are doing now to protect bats, I would have said that was a dream. So perhaps we should be going after the dream after all.

But, putting aside the dreams, lets look at what we can do now. By setting up this forum, OSM has undertaken on a new role and responsibility. Hopefully this will reflect well on OSM in the future. There are many other things that OSM can do. We should encourage OSM in every way to keep this issue going. All of the States have done their own thing with bat gates and bat gate design. OSM has the chance to act as a clearing house for all of the information that has been brought out by this forum including research and bat gate information. All of the information being collected by State AML programs are under OSM jurisdiction. No other agency is set up to perform this database and clearing house function. OSM needs to do it, other wise it will not get done.

There is a constant turnover in the staffs of both Federal and State agencies resulting in a continuing need for education on these issues. OSM needs to put together, in an electronic format or any other way, all of the information presented at the forum so that new staff could be easily brought up to speed. This would make a dramatic difference.

OSM could also do more to place more emphasis on bat habitat evaluation by its AML programs. They could include this in their annual oversight function. By looking more specifically at the environmental result of State AML activities, OSM could have a great affect on how the State AML programs view themselves. Currently most State AML programs focus on revegetation because it is easy to measure.

In summary, I am asking everyone to take on a harder job because that is the way we improve the world.

THE U.S. FISH AND WILDLIFE SERVICE RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

Bob Currie
U.S. Fish and Wildlife Service
Asheville, North Carolina

The discussions that we have had for the last three days have been extremely beneficial. I especially appreciated the comments from Kentucky that we all have our separate responsibilities. Sometimes our goals seem to be in contradiction to each other. What I would like to see is that even though we have differences, we need to realize that we are all making a good faith effort to do our jobs. When we have disagreements at meetings we need to not let that effect our mutual respect for the importance of each of us doing our jobs to the best of our abilities.

The U.S. Fish and Wildlife Service (USFWS) got involved with bat protection because of the Endangered Species Act. When we are dealing with a listed species where we have the lead on that protection effort then things are very straight forward. Next we need to address how we deal with species that are in decline that are not protected under the Endangered Species Act. We all need to learn how to prevent a species from declining to the point of being considered a candidate species for the Endangered Species Act. Many agencies have a greater ability to deal with these types of species that USFWS does. We need to work to ensure that common species continue to be common.

We need to use the same standards for species protection in every part of the country. We need to have the same set of responsibilities that are imposed upon any agency who is working with that species. This doesn't mean that you are not going to have geography based differences in distinctly different areas of the country. Although there will be regional differences based on different environments, the approach to species protection should be the same. You should not be in doubt as to what will happen when you need to contact a USFWS office. Because of this, we have been working for several years to develop a set of guidelines with how to deal with the Indiana Bat.

Regardless of what Congress intended, what they said in the Endangered Species Act was that we should protect the ecosystems upon which threatened and endangered species depend. Until they change the law, we need to be concerned with all threatened and endangered species. Hopefully, the appreciation for these listed species and the biological diversity in the world will increase over the years. We need to work for a balance between making sure that more species do not become extinct while not stopping the normal activity of the world.

I would especially like to thank the pioneers in this field that have educated the rest of us as to the importance of protecting bats and helping to bring us all to this point of working together for bat conservation today.

NATIONAL PARK SERVICE RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

John Burghardt
National Park Service
Denver, Colorado

The National Park Service (NPS) has its own AML database in paper form. The structure for that database includes mine features, need for reclamation, environmental issues (i.e. acid mine drainage, habitat, etc.). My job is to get our database into shape and then plug it into OSM's effort to develop a national database so that we can all get a better understanding of what is going across the nation. We need to do some catching up in this area. We need to start doing better post gate surveys of how the bat gates are working.

In my earlier talk, I mentioned two research papers that are being done for the National Park Service that will be written up soon. I think that the technical information transfer that all of us are doing related to bat conservation is very important. We have already posted several technical papers on areas related to bat conservation on our office Website and I think this is a very important way to get new information to people who need it. I have already had people contact me who have read this information on our Website and have questions. This is a very good way to promote communication about these issues. NPS will have an article soon in its monthly magazine on what the NPS is doing for bats. We definitely need to explore new ways to get exposure for our ideas on bat conservation.

People have asked questions about how we get funding for our projects. We have attended the annual conferences of the National Abandoned Mine Lands Association for years and pursued funding from State AML programs there. We have contacted industry about funds for working on cooperative projects. There are opportunities out there to get funds for bat protection projects.

Concerning education and outreach, I get invitations regularly to speak to Boy Scout groups, school groups, and other public groups. These are very charismatic little animals and people love to learn about them. A lot is happening like this just on an individual level.

The Western Bat Working Groups have started to have their annual conference in Reno Nevada. They have started trying to coordinate the Western State activities. They have been trying to put together State Bat Conservation Summaries (basically a State specific conservation plan) that can be used by the State wildlife agencies.

INTERNATIONAL ASSOCIATION OF FISH AND WILDLIFE AGENCIES RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

Terry Johnson
Arizona Department of Game and Fish
Phoenix, Arizona

From a State Fish and Wildlife agency perspective, I can not overstate how important it is that all of the appropriate State and Federal agencies take a very close look at how they can become involved in bat conservation. For example, the North American Bat Conservation Partnership Program outlines strategies that are being undertaken by the regional bat working groups. I believe that within the next 20 years, agencies that are really committed to bat conservation will have found a way to be connected with these regional working groups. It is from this very organized structure of partnerships between agencies that funding will be provided and work done that will benefit bat conservation.

What are the three specific things that can be done by individuals leaving this workshop that will change how the Indiana Bat Conservation Program is organized and conducted? I would like to suggest that nothing will happen in the next few months that will bring about a change. Is there anyone here that knows what has been done with the Copperbelly Watersnake Conservation Agreement? I would suggest that those of you who are interested in improving Indiana Bat Conservation should contact Roy Grimes from the Kentucky Department of Fish and Game and ask how the Copperbelly Watersnake Conservation Team has been so successful in protecting a species in decline without being listed as an Endangered Species. If you handle the Indiana Bat like the Copperbelly Watersnake has been handled, you will make more progress in the next 3 years than has been made in the last 10. If we are going to actually accomplish things for bat conservation, we are going to have to think outside the box and be creative about building partnerships and seeking funding.

In an earlier talk, the subject was brought up as to who the lead was on a particular effort. I would submit to you that it really doesn't matter who the official lead is. What matters is that you find people who really want to do something and find someone who will lead and can lead. Whether the real lead is a Federal agency or a State agency does not matter, the question is do they want to do something or are they just interested in protecting their "turf." Find someone who is willing to share the credit, take the blame, and will be aggressive in pursue funds by whatever means it takes.

REGIONAL BAT WORKING GROUPS RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

Mary Kay Clark
North Carolina State Museum of Natural Sciences
Raleigh, North Carolina

I am going to talk to you today about all of the regional bat working groups. First I would like to discuss with you the concept of working groups. About 5 years ago the people who were working on a specific bat species got together and decided they needed to make a formal group. This became the Western Bat Working Group.

A similar group was developed about the same time in the East in 1995 at the National Bat meeting in Boston. One of the things that is of importance to these groups is the issue of keeping common species common. For this reason we chose the name the Southeastern Bat Diversity Network. The Southeastern Bat Diversity Network has annual meetings, a newsletter, and a Website at www.batworkinggroups.org. The Website has notices about our projects, meetings, and agenda. We have not addressed bats and mines as an issue yet but need to. We have learned a lot from other States at this meeting that we will try to incorporate into our program.

In the Western Bat Working Group, each State within the region has its own working group. Each of these groups is usually chaired by someone in the State Fish and Wildlife agency because we have found that State people can usually accomplish more than Federal people. Concerning the Townsend's Big Eared Bat, it began in 1993. It began when Idaho developed a very comprehensive strategy for managing Townsend's Big Eared Bat in the West. After numerous revisions over the last few years it is now out in a draft format circulating among the State and Federal Wildlife agencies. Now we must give some serious thought to how we are actually going to implement the plan. In 1998, we had our first Western Bat Working Group meeting. The goal was to develop a species priority matrix that would show for each species the greatest threats to their populations. We also evaluated the status of the management for each species. We had experts discuss the biology and life history of the 34 Western Species and develop range maps for each. This matrix has been published and is also available on the Website, so that others can see the status of each of these species. A lot of this information is starting to find its way into State strategic plans for species management.

The Northeast Bat Working Group is the last working group to be formed. We had our first meeting in 1997. One of the things we are trying to do is to develop a species priority matrix similar to that developed by the Western Bat Working Group. We have a committee that deals with research and management. We are trying to standardize research and data collection protocols. We have representative from 22 States and northeastern Canada. We have an education committee that focuses on State agency and public education. Many of our sites are literally in peoples back yards and we need to educate these people on the importance of bat conservation.

Mary Kay Clark joined the staff of the N. C. State Museum of Natural Sciences (Raleigh, NC) in 1979 and is the Curator of Mammals in the Mammal Collection. Clark was one of the founders of the Southeastern Bat Diversity Network (SBDN) (a regional group dedicated to the conservation of bat diversity in the southeastern U. S.) and has served as chairperson since its inception in 1995. Clark's recent field studies of bats have focused on the roosting and foraging requirements of two species, *Myotis austroriparius* and *Corynorhinus rafinesquii*. Both of these species are closely linked to bottomland hardwood forest communities, areas of concern due to habitat decline and alteration.

WHERE DO WE GO FROM HERE?
PARTICIPANT RECOMMENDATIONS

The following are recommendations for future action made by the Participants at the conclusion of the forum.

1. The Office of Surface Mining (OSM) should consider becoming a clearing house for Abandoned Mine Land (AML) bat conservation information.

2. There needs to be an inventory, tracking, and monitoring of Bat friendly closures. This should include the development or adaptation and maintenance of a database.

3. Need Safety Training for individual States concerning habitat assessment for underground mines.

4. Return to sites closed with bat **unfriendly** closures and evaluate occupation or exclusion by bats.

5. Need to investigate additional or alternative Funding for non coal AML for the west from the Natural Resources Conservation Service, the Highway Department, and State "Fish and Game" agencies.

6. Need to convince OSM leadership that appropriate and needed bat friendly closures are a high priority in addition to the primary mission of Health and Safety.

7. Need to expand partnerships to include active mining operations.

8. OSM should explore a partnership with existing Federal Agency safety training programs that would make this training more available for OSM and coal State program staff.

9. States need to investigate their schedules and timing of closures to minimize potential conflicts with efforts to protect bats and their habitats.

10. Need more information on the strengths and weakness of working with volunteers and how to develop or expand on these programs.

11. Need better information on ventilation requirements (flow, temp inside and outside mines, etc.).

12. Investigate how to bring the U.S. Environmental Protection Agency in as a participants of bat conservation efforts, especially on Superfund sites.

13. Need an evaluation of alternatives for bat protection on re-mined areas. Does the potential exist to require bat friendly closures after mining is finished.

SURVEY RESULTS
BAT CONSERVATION AND MINING: A TECHNICAL INTERACTIVE FORUM
PARTICIPANT COMMENTS AND RECOMMENDATIONS

CATEGORY OF PARTICIPANTS	# OF REGISTRANTS	% OF REGISTRANTS
TOTAL REGISTRATION	118	100
TOTAL COMPLETING THE SURVEY	42	36
LEVEL OF SATISFACTION WITH THE FORUM		
EXTREMELY SATISFIED	22	52
VERY SATISFIED	16	38
SATISFIED	3	7
DISSATISFIED	1	2
VERY DISSATISFIED	0	0

COMPLIMENTS:

1. **Great forum! Both the level of information covered and the quality of people involved was greatly beneficial.**
2. **Rousing Success!**
3. **I have been to four technical meetings in the past year and this was by far the best one.**
4. **Great Job! I learned some do's and don'ts. I received good information, met knowledgeable people, and made some good contacts.**
5. **Very good job! I was afraid this would just be a repeat of similar conferences held in the past by other groups, but it was very interesting with great speakers and many new topics.**
6. **Great Job! A very good job of bringing people from a wide range of occupations and geographic locations.**
7. **Forum format was set up very well.**
8. **My time was well spent at this conference.**
9. **I liked the participant interactive discussion sessions.**
10. **Good collection of people and the informal exchanges were very worthwhile.**
11. **I really liked the interactive discussion of the last session, it was an excellent way to end the forum. Good discussions.**
12. **Nice to see such a diverse group come together to share information and find common goals towards bat conservation. Many thanks.**

WHERE DID THE PARTICIPANTS COME FROM AND WHO DID THEY REPRESENT?

PARTICIPANT AFFILIATION	# OF REGISTRANTS	% OF REGISTRANTS
STATE REGULATORY	23	20
OSM	22	19
OTHER FEDERAL	21	18
WILDLIFE AGENCY	13	11
UNIVERSITY	12	10
CONSULTANT	11	10
MINING	5	4
CONSERVATION GROUP	3	3

REGIONAL REPRESENTATION	# OF REGISTRANTS	% OF REGISTRANTS
WEST	42	37
MID-CONTINENT	37	32
APPALACHIAN	36	31

PARTICIPANTS RESIDE IN THE FOLLOWING 29 STATES

AK	**IN**	**NM**	**TX**
AR	**KS**	**NV**	**UT**
AZ	**KY**	**OH**	**VA**
CA	**MI**	**OK**	**WA**
CO	**MO**	**OR**	**WV**
DC	**MS**	**PA**	
GA	**MT**	**SD**	
IL	**NC**	**TN**	

PARTICIPANT RATING ON USEFULNESS OF TALKS
4.0=EXCELLENT
3.0=GOOD
2.0=FAIR
1.0=POOR

SESSION 1 WHY BATS?

PRESENTER	AVERAGE RATING	RATING RANGE
Sheryl Ducummon	**3.3**	**4-2**
Len Meier	**3.3**	**4-2**
Homer Milford	**3.1**	**4-2**
Dr. Michael Harvey	**3.6**	**4-2**
Dr. Mike Bogan	**3.4**	**4-2**
Robert Currie	**3.2**	**4-2**

SESSION 2 INTEREST GROUP PERSPECTIVES

PRESENTER	AVERAGE RATING	RATING RANGE
Mark Mesch	**3.0**	**4-1**
Dr. Richard Wahrer	**2.9**	**4-1**
Homer Milford	**2.6**	**4-1**
Stephen Cawood	**2.1**	**4-1**
Bob Currie	**2.4**	**4-1**
John Burghardt	**2.9**	**4-2**
Laurie Fenwood	**3.5**	**4-2**
Mike Herder	**2.6**	**3-1**
Terry Johnson	**3.6**	**4-1**

SESSION 3 METHODS FOR PROTECTING BATS/UNDERGROUND MINES

PRESENTER	AVERAGE RATING	RATING RANGE
Dr. Scott Altenbach	**3.8**	**4-3**
Richard Sherwin	**3.7**	**4-2**
Robert Currie	**3.5**	**4-2**
John Kretzmann	**3.4**	**4-2**
Kirk Navo	**3.3**	**4-2**
Tom Posluszny	**2.5**	**4-1**
Robert Currie	**3.2**	**4-2**
Dr. Patricia Brown	**3.5**	**4-2**
Dr. Kate Grandison	**3.5**	**4-2**

SESSION 4 PROTECTING BAT HABITATS/SURFACE MINING

PRESENTER	AVERAGE RATING	RATING RANGE
Dr. Alan Kurta	**3.6**	**4-2**
Dr. Tom O'Shea	**3.1**	**4-1**
Chris Yde	**3.2**	**4-1**
Sally Imhof	**2.9**	**4-2**
Dr. Richard Wahrer	**3.2**	**4-2**

SESSION 5 PROGRAM DEVELOPMENT

PRESENTER	AVERAGE RATING	RATING RANGE
Dave Bucknam	**3.0**	**4-2**
Dean Enderlin	**3.4**	**4-1**
John Burghardt	**3.3**	**4-2**
Richard Clawson	**2.9**	**4-2**

SUGGESTIONS FOR IMPROVEMENT

FUTURE DETAILED WORKSHOP

- on safety concerns related to mine assessment and installation of bat friendly closures
- on techniques for conducting bat surveys
- on gate designs and information for managers on costs
- on mitigation of bat habitat other than caves and mines
- on protection of streams and riparian vegetation useful to bats
- on NEPA permitting related to bats
- a consistent protocol on survey methods and data collection when doing fall and winter bat surveys at mines and caves
- in depth discussions of specific aspects of bats and mining with summary and recommendations by a working group

FORUM IMPROVEMENTS

- more industry participation
- a talk from Roy Powers on bat gate construction
- more time for participant interaction
- more case studies, exhibits, and displays
- more discussion on long term maintenance of AML installed bat gates on private property
- more discussion on issues from the Eastern U.S.
- more information on funding options for program implementation.
- more involvement with MSHA
- More information on successes and failures of surveying and monitoring techniques
- better representation from more States with reports on their status and needs related to protecting bat habitat
- a field trip
- what is the mining industry doing to plan for mitigation of bat habitat

APPENDIX 1: RECORDED DISCUSSIONS

Edited by
Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

The following are the edited discussions that took place at the end of each speaker presentation and at the end of each topic session. The actual comments have been edited to translate the verbal discussion into a format that more effectively and efficiently communicates the information exchange into a written format. The organization of the discussion follows the same progression as that which took place at the forum. A topical outline has been developed to aid in accessing the information brought out in the discussions.

The topic of each question is shown in alphabetical order in **bold.** The individual speaker questions are listed in outline format under the appropriate topic session and presentation title. Questions during the twenty minute interactive discussion are listed at the end of the session in the following format:

SESSION # AND TOPIC AREA

1. Presentation Title
   - **Subject of Question or Comment**

SESSION # INTERACTIVE DISCUSSION

Subject of Question or Comment

OUTLINE OF DISCUSSION TOPICS

SESSION 1: WHY BATS?

1. Ecological and Economic Importance of Bats
   - **Presence of Bats in Each State**
2. Importance of Mines for Bat Conservation
   - **Extent of Survey**
   - **OSM Oversight Responsibility**
   - **OSM Protection of Bat Species**
   - **Rates of Reclamation**
3. Challenges in Protecting Bats
   - **Consequences of Settling Out of Court**
   - **Monitoring of Subsidence at Backfilled Mine Openings**
   - **The Purpose of Bat Gate Warning Signs**
4. Eastern Bat Species of Concern to Mining
5. Western Bats and Mining
6. Federally Listed Threatened and Endangered Species of Concern to Mining

SESSION 1 INTERACTIVE DISCUSSION

Effect of Remining on Bat Habitat Loss
Effect of Toxic Gases
Post Installation Monitoring of Gates
The Importance of Air Movement
What is the Relationship of Western Bats to Open Water Sources

SESSION 2: INTEREST GROUP PERSPECTIVES ON CONSTRAINTS, EXPERIENCES, TRENDS, AND NEEDS (No Questions after speakers due to lack of time)

1. National Association of Abandoned Mine Land Programs
2. Perspective of the Interstate Mining Compact Commission/Eastern Regulatory Authority States on Bat Conservation and Mining
3. Bat Conservation in Mine Reclamation in Eleven Western States and the Western Interstate Energy Board Perspective on Habitat Preservation
4. Kentucky Coal Industry Perspective on Bat Conservation and Mining
5. The U.S. Fish and Wildlife Service's Perspective on Bats and Mining
6. Bat-Compatible Closures of Abandoned Underground Mines in National Park System Units
7. Sex, Lies, and Videotape: My Views on the Evolution of Federal Policy and Practice to Conserve Bats on Lands Managed by the Forest Service
8. The Role of the Bureau of Land Management in Bat Conservation
9. International Association of Fish and Wildlife Agencies

SESSION 2 INTERACTIVE DISCUSSION

Cross Boundary Species Protection Planning for Indiana Bat
Department of Defense Activity with Bat Gates
Interagency Cooperation between OSM and USFWS on Bats
Lead Agency of Bat Conservation on Mines
Positive Benefits of Litigation
Protection of non listed Species

SESSION 3: METHODS FOR PROTECTING BAT HABITAT ASSOCIATED WITH UNDERGROUND MINES

1. Methods for Determining Local Mine Characteristics of Importance to Bats
   - **Rate at which Bats Occupy Mines**
2. Pre-Mine Closure Bat Survey and Inventory Techniques
   - **Underground Mine Safety Training**
3. An Evaluation of Alternative Methods for Constructing Bat Gates at Mine Closures
   - **Merits of Manganal Steel Gates**
   - **Predators at Gates**
4. New Mexico Experience with Bat Grates at Abandoned Mines
5. A Colorado Case Study to Secure an Underground Mine for Bat Habitat
   - **Volunteer Access to Private Property**

6. Pennsylvania Case Studies to Secure Underground Mine Workings for Bat Habitat
7. A Midwestern Case Study to Secure an Underground Mine for Bat Habitat: The Unimin A Magazine Mine in Alexander County, Illinois
8. An Overview of the Response of Bats to Protection Efforts
9. Evicting Bats when Gates will not work: Unstable Mines and Renewed Mining
10. Monitoring and Evaluating Results of Bat Protection Efforts

SESSION 3 INTERACTIVE DISCUSSION

Highest Elevation for Bat Hibernation
Life Expectancy of Gates
Prioritizing Bat Closures due to Time Constraints
Protecting Gates from Clutter
Quiet Bats not Detectable by Anabat
Volunteer Program

SESSION 4: PROTECTING BAT HABITAT ASSOCIATED WITH SURFACE MINING AND RECLAMATION

1. Bats at the Surface: The Need for Shelter, Food, and Water
2. Impacts of Mine Related Contaminants on Bats
3. Surface Habitat Disturbance, Protection, and Enhancement Associated with Active Surface Mining and Reclamation
4. Endangered Species Habitat Replacement
5. Surface Mining Case Study from Kentucky

SESSION 4 INTERACTIVE DISCUSSION

- **Acceptance of KY Bat Management Plan**
- **Bat Box Use by Indiana Bats**

SESSION 5: PROGRAM DEVELOPMENT

1. State Program/Colorado
   - **Mine Closure without Bat Surveys**
2. The McLaughlin Mine Bat Program: New Ideas in an Old Mining District
   - **Constraints to Bat Use of Tire Tunnel**
   - **Management Approval for Bat Structure**
3. Implementation of a Recovery Plan for the Endangered Indiana Bat
   - **Migratory pattern of Indiana Bats in Missouri**

SESSION 5 INTERACTIVE DISCUSSION

Define Riparian Area for Indiana Bats
Double Standard of Safety during Bat Surveys
How Safe are Coal Mines for Bats
The Value of Bat Habitat at a Superfund Site

SESSION 6: INTEREST GROUP RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

1. National Association of Abandoned Mine Land Programs
   - **National Bat Gate Information Database**
   - **Use of Additional AML Funds for Bat Gates**
2. Interstate Mining Compact Commission/Eastern Regulatory Authority States
3. Western Interstate Energy Board/Western Regulatory Authority States
4. The U.S. Fish and Wildlife Service
5. National Park Service
   Safety Training Courses for Underground Mines
   Training for Abandoned Underground Mines
6. International Association of Fish and Wildlife Agencies
7. Regional Bat Working Groups

SESSION 6 INTERACTIVE DISCUSSION

Are Conservation Agreements limited to non listed Species
Convincing Managers to Install Bat Gates
Funding for non coal States
Use of AML Funds for non coal

DISCUSSION BY SESSION

SESSION 1: WHY BATS?

1. Ecological and Economic Importance of Bats Sheryl Ducummon, Bat Conservation International, Austin, Texas

Question: **(Presence of Bats in Each State)** Are there bats present in every State in the U.S.?

Answer: Yes. Some have more species than others but they are found in every State.

2. Importance of Mines for Bat Conservation Len Meier, Office of Surface Mining, Alton, Illinois

Question: **(Extent of Survey)**Was your survey sent to all Federal and State agencies? I was surprised that there was only one bat closure reported in Arkansas.

Answer: It was sent to State Reclamation programs. When I could not get any answers there, I went to the State Fish and Wildlife agencies. Arkansas was a hard State to find information. These numbers probably do not reflect what the National Park Service or the Corp of Engineers have done in Arkansas. The paper provides documentation of the sources of all of my information.

Comment: Concerning what has been happening in Arkansas, at least for the National Park Service, at Buffalo National River we put 12 bat friendly closures up on three mine sites to date.

Question: **(OSM Oversight Responsibility)** In how many States does OSM have oversight responsibility?

Answer: 26 States. OSM has contacts in additional States where we promote technology transfer.

Question: **(OSM Protection of Bat Species)** Does OSM insure, in its review of documents, that all bats are protected or only Endangered Species?

Answer: I think that OSM is not consistent concerning the protection of all bats, but it is consistent with the protection of Endangered Species. This is definitely an area where OSM can improve the education of State programs on the protection of bats. OSM has very limited powers to protect species that are not threatened or endangered.

Question: **(Rates of Reclamation)** In terms of annual acres of land disturbed and reclaimed, why does the rate of reclamation lag so far behind the rate of disturbance?

Answer: First, let me clarify that the figure I provided of 9,000 acres or reclamation is strictly abandoned mine reclamation. These were lands mined before the passage of the Federal Surface

Mining Control and Reclamation Act (SMCRA) and are being reclaimed with funds from a tax on post SMCRA mined coal. After the passage of SMCRA, mines must, for the most part, reclaim their land contemporaneously with lands being mined. Eventually all of the 86,000 acres of SMCRA mined lands will have to be reclaimed consistent with the standards of SMCRA. Concerning the 6.6 billion tons of non coal minerals mined, those lands are not covered by Federal reclamation law but there are numerous State and local laws that govern the mining and reclamation. For lands not regulated under SMCRA, the final reclamation will be quite variable due to different requirements locally.

3. Challenges in Protecting Bats Homer Milford, New Mexico Mining and Minerals Division, Sante Fe, New Mexico

Question: **(Consequences of Settling Out of Court)** When an agency settles out of court, what will keep that same type of lawsuit from continually reappearing?

Answer: The fact is that they do just keep reappearing. Lawyers realize that, by adding a government agency to the lawsuit, they will find a "deep pocket." The lawyers in the State are concerned about loss control and must make a determination of which cases are cost effective to fight and which are not. In New Mexico, at least, the State agency has no say in what the legal department decides concerning loss control.

Question: **(Monitoring of Subsidence at Backfilled Mine Openings)**A number of the mines we have observed in Nevada have been backfilled but the backfill has experienced significant subsidence. This may have created hazards that didn't exist prior to backfilling. Do you monitor areas that have been backfilled for subsidence as well as those openings that are gated?

Answer: Yes. It is a requirement of most SMCRA programs. Nevada does not have a SMCRA program and has no requirement for monitoring. The Nevada State agency, however, does nothing but fencing so that the backfilled areas you observed must have been done by the mine or the landowner.

Question: **(The Purpose of Bat Gate Warning Signs)** Oklahoma is in the process of designing a gate and warning sign. Since you should be eliminating the danger of entering a mine with the gate, what should your warning sign say?

Answer: You should warn about any dangers associated with the mine. The National Park Service worked with Bat Conservation International to put out bat gate warning signs. In it they tried to explain the importance of bats and the dangers of abandoned mines in case someone breached the gate. It is basically designed to discourage vandalism. In addition, if the gate is breached, you have the legal concern that you have warned the vandals about the dangers of the mine in case someone gets hurt and the penalties involved with harming the bats, especially endangered species.

4. Eastern Bat Species of Concern to Mining Dr. Michael Harvey, Tennessee Technological University, Cookeville, Tennessee

5. Western Bats and Mining Dr. Michael A. Bogan, USGS Biological Research Division, Albuquerque, New Mexico

6. Federally Listed Threatened and Endangered Species of Concern to Mining Robert Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

SESSION 1 INTERACTIVE DISCUSSION

Question: **(Effect of Remining on Bat Habitat Loss)** What is the potential for habitat loss from renewed surface mining over abandoned mines?

Answer: With the movement of colonies of bats into abandoned underground mines, these sites have become critical to some bat populations. With the change of mining methods that now favors open pit mining, I have seen situations where an abandoned underground mine that was being extensively used by bats was destroyed because the area was remined. In this type of situation, we want to ensure that appropriate surveys are conducted to identify existing bat habitat and then apply appropriate exclusion techniques to ensure that the bats are not trapped and killed by the remining activity.

Question: **(Effect of Toxic Gases)** What is the effect of methane and carbon dioxide coming out of coal mines on bats?

Answer: An atmosphere that has high levels of gases that are toxic for other mammals will also affect bats. We have no evidence that bats can tolerate the presence of toxic gases but we do have evidence of bats being killed by carbon monoxide that has been drawn into an area where they are present.

Question: **(Post Installation Monitoring of Gates)** Is anyone monitoring the bats reaction to the installation of gates in addition to whether or not the gate has been breached?

Answer: Not all gates are being monitored. OSM does not have a requirement for annual gate monitoring. Monitoring of gates will vary across the country. Also many gates that have been installed at mines are not involved with OSM oversight. Most of the Western States have some type of monitoring program.

Question: **(The Importance of Air Movement)** In underground abandoned coal mines how important is air movement?

Answer: Air movement is critical in underground mines in terms of temperature control. If there is no significant air movement underground and air is not being exchanged with surface air the resulting temperatures will be the mean annual temperature which is too cold for maternity use and too warm for hibernation. In general, I have found that better site have some type of air exchange.

Answer: In Michigan, if we have a mine with an upper and lower entrance, this will produce a chimney effect in winter and there will be no bats hibernating in this mine because the air temperature will be too cold. It is important to keep in mind that concerning air flow, different parts of the country may have a different physical environment that yields different effects on bats.

Question: **(What is the Relationship of Western Bats to Open Water Sources)** In many mine surveys that I have been involved with in the arid southwest, bats were not looked at because of the lack of water nearby. During radiotelemetry studies of some western species, I have found that some species will bypass water sources and have also found bat roosts that were over 25 miles from surface water. Dr. Bogan have you found similar situations in your telemetry studies?

Answer: I probably do not work in as arid areas as you do Dr. Brown and do not have significant observations in that area. A lot of the bats we have been tracking in New Mexico and Utah are bats from montane areas. I have not seen them fly past a water area but we know from the literature that many bats are capable of quite long distance flights. There are examples of spotted bats that roost in a day roost in the Grand Canyon and fly into the Kayabab plateau at night to forage. We have frequently observed these bats to fly 20 kilometers one way to get to a particular site. I do not think that they fly these distances for water but rather for a particularly productive foraging site. I do agree with you that some bats can exist a great distance from surface water sites.

Answer: Bats definitely need water. In the Arkansas Ozarks, there are many small wildlife ponds and road ruts with water. We have captured large numbers of bats over these small bodies of water. I have come up with an estimate of 400,000 northern long eared bats in a 400 square mile area using these small bodies of water. I don't think these bats were in this area prior to the construction of the small water bodies. What I am alluding to is that in a mining situation, the creation of small water bodies promotes bats as well as other wildlife.

For those working in the arid southwest, the lack of open water sources should not be used as an indicator of the lack of bats.

SESSION 2: INTEREST GROUP PERSPECTIVES ON CONSTRAINTS, EXPERIENCES, TRENDS, AND NEEDS

1. National Association of Abandoned Mine Land Programs Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

2. Perspective of the Interstate Mining Compact Commission/Eastern Regulatory Authority States on Bat Conservation and Mining Dr. Richard Wahrer, Kentucky Department for Surface Mining Reclamation and Enforcement, Frankfort, Kentucky

3. Bat Conservation in Mine Reclamation in Eleven Western States and the Western Interstate Energy Board Perspective on Habitat Preservation Homer Milford, New Mexico Mining and Minerals Division, Sante Fe, New Mexico

4. Kentucky Coal Industry Perspective on Bat Conservation and Mining Stephen Cawood, McBrayer, McGinnis, Leslie, and Kirkland, PLLC, Lexington, Kentucky

5. The U.S. Fish and Wildlife Service's Perspective on Bats and Mining Dave Flemming, U.S. Fish and Wildlife Service, Atlanta, Georgia

6. Bat-Compatible Closures of Abandoned Underground Mines in National Park System Units John Burghardt, National Park Service, Denver, Colorado

7. Sex, Lies, and Videotape: My Views on the Evolution of Federal Policy and Practice to Conserve Bats on Lands Managed by the Forest Service Laurie Fenwood, U.S. Forest Service, Vallejo, California

8. The Role of the Bureau of Land Management in Bat Conservation Fred Stabler, Bureau of Land Management, Washington, D.C.

9. International Association of Fish and Wildlife Agencies Terry Johnson, Arizona Department of Game and Fish, Phoenix, Arizona

SESSION 2 INTERACTIVE DISCUSSION

Question: **(Cross Boundary Species Protection Planning for Indiana Bat)** Three of the speakers mentioned the need for some cross boundary issues, in particular with the Indiana Bat. Is the U.S. Fish and Wildlife Service considering species wide decision making for how to do management plans for Indiana Bats?

Answer: The U.S. Fish and Wildlife Service (USFWS) has raised the issue of consistency in the handling of the Indiana Bat within the three USFWS regions that deal with it but no decision has been reached.

Question: **(Department of Defense Activity with Bat Gates)** Mr. Milford, in you table listing States and agencies that had constructed bat gates, the Department of Defense was not included. I am aware of a number of bat gates that have been installed on installations in the West. Were they not included in your sample or did they not respond?

Answer: I included the Department of Defense under other because I could not get any good information except for Arizona.

Question: **(Interagency Cooperation between OSM and USFWS on Bats)**In thinking about a species wide conservation plan, because this is an issue in Mid-western mining, how can the mining regulatory agency like OSM work with the USFWS in beginning this process?

Answer: One of the difficulties that OSM may face in this situation is that the SMCRA function has been delegated to the States and the oversight that OSM has USFWS is concerned with exactly how oversight would take place on an annual basis particularly if there were any

problems or difficult situations that needed to be dealt with across the nation in a consistent fashion when you are dealing with so many individual State programs that actually implement SMCRA. Although this means there is so clear up front answer, it is actually a process of good communication between all of the agencies involved.

Question: **(Lead Agency of Bat Conservation on Mines)**Could you comment on the concept of who is the lead agency concerning bat conservation associated with mines?

Answer: (Laughter) I think that answers your question.

Answer: From the perspective of the National Association of Abandoned Mine programs, with Utah as an example, we are the only agency in the State authorized to undertake reclamation at abandoned mine sites whether it is private, State, or Federal lands. Through memorandum of understandings with each of these agencies we do the National Environmental Policy Act evaluations and seek appropriate comment from these agencies with final approval by the Office of Surface Mining.

Answer: The Park Service has about a dozen cooperative agreements with about a dozen State abandoned mine programs that includes States covered by SMCRA and some that aren't. It is very much a collaborative effort. But if you asked who was in charge of a park service program is would be the superintendent of the individual park involved.

Question: **(Positive Benefits of Litigation)** Concerning the positive benefits of litigation, do you think we have reached the limit of those positive benefits?

Answer: I don't think we have seen all of the positive benefits because within my agency we are still saying that we are committed to conservation yet we are not doing what we need to do. Generally, these lawsuits are about the fact that we are saying one thing and getting caught not doing it. In some cases litigation may have gone overboard but those are the exceptions.

Question: **(Protection of non listed Species)** One thing that bats and mines in the East don't have that bats and mines in the West do, is the lack of bats listed under the Endangered Species Act which directly involves the USFWS. Those of us who have worked with Townsend's Big Eared Bat realize that it is hit and miss as to whether or not they receive protection. Is there an other alternative for dealing with species before they become listed especially when dealing with private land owners?

Answer: We do have the opportunity to address that with a candidate conservation agreement. We have done a few in our region in the Southeast and it usually involves developing something similar to a habitat recovery plan. When you deal with private land owners we developed a safe harbor program that has worked well in this area. Another option would be through section 6 of the Endangered Species Act where you have a listed species and you can acquire land for protection of the species. We have the private landowner "sign up program." This is were corporate land owners can provide the funds for protection of a species.

SESSION 3: METHODS FOR PROTECTING BAT HABITAT ASSOCIATED WITH UNDERGROUND MINES

1. Methods for Determining Local Mine Characteristics of Importance to Bats Richard Sherwin, University of New Mexico, Albuquerque, New Mexico

Question: **(Rate at which Bats Occupy Mines)**Do you have any idea of the amount of time it would take before bats start to occupy a mine after it is abandoned?

Answer: I believe many species are going through a range expansion currently because of the opportunity to occupy abandoned mines. I have no idea of the population dynamics of any individual species. It may be that some of the low densities of individuals we see in many mines is due to the abundance of mines to choose from. There are many reports of bats moving into a mine while they are still being worked. In some abandoned mines the bats continue to use the mine even after it has been reopened.

Answer: I have done about 6 to 7 thousand underground surveys and less than 5 percent contained no bats.

2. Pre-Mine Closure Bat Survey and Inventory Techniques Dr. J. Scott Altenbach, University of New Mexico, Albuquerque, New Mexico

Question: **(Underground Mine Safety Training)** Have you developed a mine safety protocol that is available?

Answer: No. The reason I haven't is because I am afraid that "Grindstone and Flint Attorneys at Law" will pursue me. I am a little too afraid of a lawsuit to attempt that. There are programs that are available through the Forest Service and BLM. You need to be cautions about what that type of training will prepare you for. It is better than no training, but you can't get a certificate in that course and then pretend that you are prepared to enter an underground abandoned mine.

3. An Evaluation of Alternative Methods for Constructing Bat Gates at Mine Closures Robert Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

Question: **(Merits of Manganal Steel Gates)** Concerning the Manganal gates being used in Utah, you have mentioned that the material is much more expensive than the angle iron but they require less material. Can you address relative costs including the ease of installation?

Answer: I have some 2 year old data that compares the costs of using angle iron with one and one half inch Manganal. The Manganal cost was $12.00/foot compared to $12.57 for angle iron with stiffeners. Concerning strength, the angle iron with stiffeners is a little less than twice as strong as the Manganal.

Answer: In Utah, our experience has been that when we used the angle iron gates they are soon vandalized. Then we applied stainless steel facing on the gates and the vandals attacked the lock

box. With the Manganal gates the more a person tries to use a hack saw on the steel the harder it becomes. It will actually break the saw blades.

Question: **(Predators at Gates)** How do predators respond to these gates? I have noticed that two days after installation of a gate, I started finding half eaten bat carcasses around the gate.

Answer: Predation is a problem around any bat closures especially if it is a domestic predator like a cat. Then you need to deal with that problem. House cats belong in the house.

4. New Mexico Experience with Bat Grates at Abandoned Mines John Kretzmann, New Mexico Mining and Minerals Division, Sante Fe, New Mexico

5. A Colorado Case Study to Secure an Underground Mine for Bat Habitat Kirk Navo, Colorado Division of Wildlife, Monte Vista, Colorado

Question: **(Volunteer Access to Private Property)** How do you deal volunteers making multiple visits on private property to make the assessments?

Answer: We seek land owner permission on private property. Most private owners have no problem with our conducting the surveys.

6. Pennsylvania Case Studies to Secure Underground Mine Workings for Bat Habitat Tom Posluszny, Office of Surface Mining, Wilkes-Barre, Pennsylvania

7. A Midwestern Case Study to Secure an Underground Mine for Bat Habitat: The Unimin A Magazine Mine in Alexander County, Illinois Joseph Kath, Illinois Department of Natural Resources, Division of Natural Heritage, Springfield, Illinois

8. An Overview of the Response of Bats to Protection Efforts Robert Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

9. Evicting Bats when Gates will not work: Unstable Mines and Renewed Mining Dr. Patricia Brown, University of California, Los Angeles, California

10. Monitoring and Evaluating Results of Bat Protection Efforts Dr. Kate Grandison, Southern Utah University, Cedar City, Utah

SESSION 3 INTERACTIVE DISCUSSION

Question: **(Highest Elevation for Bat Hibernation)** Kirk what is the highest elevation you have found with bats in hibernation and with what species?

Answer: There is documentation of bats hibernating at 9,500 feet. There is a cave at 10,000 feet that we suspect has bats hibernating.

Question: **(Life Expectancy of Gates)** What is the life expectancy of a typical bat gate? Who will maintain the gate on private land after the State AML program withdraws its maintenance? Are there any other long term maintenance programs for gates on private lands?

Answer: This is a concern for both private and public lands and we don't have an answer.

Question: **(Prioritizing Bat Closures due to Time Constraints)**I work for the Navajo nation and we have primarily uranium mines that we are closing. We have been using exclusion process to remove the bats from the mine prior to closure. Since I am the only biologist, I can not get to all of the sites prior to closure.

Answer: I assume that all of the mines are not created equal and some may be more beneficial to bats than others. Given the lack of time for survey and exclusion, the first thing I would try to do is prioritize the mines in terms of their danger from a health and safety aspect and work on those first. I would not do any exclusion of bats during the winter or maternity season unless you had clear evidence that the mines were not being used during those times. For less than $1,000 you can get a video camera and set it up and observe the mine opening which will give you an actual record of bat usage. Then after dark to put up your mosquito netting for a couple of nights and then do something more opaque before sealing the opening.

Question: **(Protecting Gates from Clutter)** In the East where you may find bats in a mine with multiple openings and you are trying to protect some of the shafts for the purpose of air flow, how do you design a gate that will not collect a lot of clutter over time?

Answer: At a mine in Wisconsin, they did a standard cupola closure on a shaft of a large iron mine with horizontal bars across the top that the bats can fly though and they have had no problem.

Question: **(Quiet Bats not Detectable by Anabat)** What types of bat are quiet as they enter the opening so that they are not detectable by the Anabat?

Answer: The Townsend's Big Eared Bat emit very faint echo location signals so that you have to be less than 10 feet from the bat and lined up just right to hear their signals. They also have a variable signal that is very difficult to pick up on an Anabat. We have a new Sonabat program that uses a Peterson detector that shows all of the harmonics and amplitude information which gives you a lot more predictability as to the species involved. In the arid west, we have California Leaf Nose Bat and Pallid Bats that emit very faint or no signals. They are big eared species that do not need to echo locate and can not be picked up with an Anabat.

Question: **(Volunteer Program)** Concerning a volunteer program, how do you advertise for the volunteers, where do they come from, and how do you keep them?

Answer: Getting volunteers is the easy part. We began our program with advertisements in the newspaper. We received and overwhelming response with people who were interested. In Colorado, we have a volunteer program that handles volunteers for a wide variety of jobs. We

have a wide variety of volunteers from college students through retirees. There is a core of 20 - 30 people who have stayed with us since we began the program who work with us every year. This group does the lions share of volunteer work. There is a big turnover of people who come in and try it for awhile but then the excitement wears off and then leave.

SESSION 4: PROTECTING BAT HABITAT ASSOCIATED WITH SURFACE MINING AND RECLAMATION

1. Bats at the Surface: The Need for Shelter, Food, and Water Dr. Alan Kurta, Department of Biology, Eastern Michigan University, Ypilianti, Michigan

2. Impacts of Mine Related Contaminants on Bats Dr. Thomas J. O'Shea, U.S. Geological Survey, Biological Resources Division, Fort Collins, Colorado

3. Surface Habitat Disturbance, Protection, and Enhancement Associated with Active Surface Mining and Reclamation Chris Yde, Montana Department of Environmental Quality, Helena, Montana

4. Endangered Species Habitat Replacement Sally Imhof, Kansas Surface Mining Section, Frontenac, Kansas

5. Surface Mining Case Study from Kentucky Dr. Richard Wahrer, Kentucky Department for Surface Mining Reclamation and Enforcement, Frankfort, Kentucky

SESSION 4 INTERACTIVE DISCUSSION

Question: **(Acceptance of KY Bat Management Plan)** Is the Kentucky Indiana Bat management plan fully accepted and in use by the State and the USFWS?

Answer: Not to my knowledge. There is no mechanism for approval at this point.

Answer: You should be cautious in trying to apply what Kentucky has done to other States.

Comment: **(Bat Box Use by Indiana Bats)** Concerning artificial bat boxes, it is my understanding that there is no evidence to suggest that the Indiana Bat uses artificial bat boxes. This may not work for mitigation as a substitute for trees.

SESSION 5: PROGRAM DEVELOPMENT

1. State Program/Colorado Julie Annear, Colorado Division of Minerals and Geology, Denver, Colorado

Question: **(Mine Closure without Bat Surveys)** Do you ever have to put a non bat friendly closure on a mine before a bat survey has been done?

Answer: We try to give Colorado Division of Wildlife adequate time to do their surveys.

2. The McLaughlin Mine Bat Program: New Ideas in an Old Mining District Dean Enderlin, Homestake Mining Co., Lower Lake, California

Question: **(Constraints to Bat Use of Tire Tunnel)** It seems to me that the temperatures recorded inside the artificial bat habitat may be to high to attract bats and there may be better materials to use that would be more bat friendly than old tires.

Answer: It is certainly unknown how well the tire tunnel will work at attracting bats. Because the average temperature is around 15 to 20 degrees Celsius and you need around 10 degrees in order for bats to hibernate, we feel the tire tunnel would only be used for summer roosts.

Question: **(Management Approval for Bat Structure)** How difficult was it to get management approval to build the artificial tunnel for bat habitat?

Answer: The tunnel did not really cost a lot and the approval process was fairly easy. It would have been much more difficult if we did not already have staff and equipment on the site.

3. Implementation of a Recovery Plan for the Endangered Indiana Bat Richard Clawson, Missouri Department of Conservation, Columbia, Missouri

Question: **(Migratory pattern of Indiana Bats in Missouri)** Could you give us some information on the relationship of where the Indiana Bats spend their summer versus where they hibernate?

Answer: The bats in that hibernate in southern Missouri are going to North Missouri and southern Iowa and will range into western Illinois. Most of the populations seem to have a north/south migratory pattern.

SESSION 5 INTERACTIVE DISCUSSION

Question: **(Define Riparian Area for Indiana Bats)** We have had some discussions about what constitutes a riparian area of use to bats. Could you elaborate on what makes a desirable riparian area for Indiana bats?

Answer: It is a complex issue. Riparian areas are the first area were we found Indiana Bat use. The early studies of Indiana Bats in northern Indiana, Illinois, southern Iowa, and north Missouri indicated that riparian bat use meant perennial streams, year round pools of water, and well established riparian corridors with some large diameter trees of at least 12 inches diameter were a tree canopy overhangs the stream. Now with the advent of radio telemetry, we are looking farther and wider. In Kentucky they have found that the bats use the ridge tops of large contiguous forested areas where they will take advantage of ephemeral water sources. I think that they are actually using a lot more areas than we originally thought.

Question: **(Double Standard of Safety during Bat Surveys)** I have a concern about your statement that "if one bat surveyor gets killed, that will be end of the internal bat survey program." This points out a serious double standard. Bird surveyors looking for Peregrine falcons fall off cliffs and are killed. When I do internal bat surveys, the most dangerous thing I do is get in my truck and drive on the freeway. Airplanes are not safe to fly in and cars are not safe to drive in yet we do it all the time. If a volunteer falls down a shaft on a bat survey, then you say that would end the program, but if he gets killed driving to the site it wouldn't. I think that is a double standard. Who is going to shut the program down?

Answer: This is an issue that needs to be dealt with. We certainly need to make sure that both professionals and volunteers involved with bat surveys in mines are properly trained.

Answer: It is my opinion that a specially trained and experienced miner should be the safety officer that should accompany every biologist that does an internal mine bat survey. I think the BLM and Forest Service mine safety courses are good but they are not adequate for the amount of experience needed to go into abandoned underground mines. You need to have someone in charge who's sole responsibility is the safety of the people conducting the survey.

Answer: We need to think about developing some type of release that documents that those doing internal surveys accept the responsibility for their actions while doing the survey.

Answer: Having been involved with the rock climbing industry, that industry has developed a similar release. Releases for dangerous activities have been developed and do work.

Question: **(How Safe are Coal Mines for Bats)** Considering the inherent instability of many coal mines in the East, are we setting up biological sinks by encouraging bats to inhabit mines that may be unsafe for them when the entire system may collapse and kill the bats?

Answer: Although mine workings are inherently unstable, we need to keep in mind that bats are using mines because they are being forced out of natural caves and their populations have suffered because of their loss of natural habitat. Although the mines offer only a temporary habitat over an unknown life span, they are allowing the bats to expand their territory until a better solution is provided.

Question: **(The Value of Bat Habitat at a Superfund Site)** In the northwest, we have a copper mine on forest service land. It is a superfund site. Has anyone dealt with bats at superfund sites? The contractor working on the site wants to plug the openings because they feel that oxidation of the rock produces acid mine drainage. We have done summer surveys but have not found bats. There are about 15 miles of internal working with about one third that is flooded. There are 90 acres of tailings that contaminate water runoff. Will plugging improve or degrade the site?

Answer: I am not aware of anyone trying to tackle a similar situation where you are trying to balance the needs of wildlife with issues like acid mine drainage. If you have an acid mine drainage problem, you need to stop the oxidation in order to control the production of acidity. Although this is a natural process, it happens at an accelerated rate at a mine site. I suspect that

sealing the openings would be of benefit but would have no way of knowing how much of the problem it will solve. Given the toxic metals at the site, I would be more concerned about the exposure of wildlife to those toxic materials than the potential loss of habitat.

SESSION 6: INTEREST GROUP RECOMMENDATIONS TO ENHANCE BAT CONSERVATION ASSOCIATED WITH MINING

1. National Association of Abandoned Mine Land Programs Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

Question: **(National Bat Gate Information Database)** What would be the value of a national database on research and other information related to the effectiveness of bat gates?

Answer: I do not want to see a clearing house that would govern the direction of bat research. However, I think that something similar to the National Abandoned Mine Land Database that would monitor the work being done of bat gates and the effectiveness of those gates for bat conservation would be very useful. The States are collecting a lot of data in this area and I think that if it were collected on a national bases in a user friendly way that trends in effectiveness of bat gate design and effectiveness would become apparent and advance the field much more quickly and effectively. Right now we do not have any systematic way to manage that data from a national perspective. The type of information I am referring to would include: gate design, habitat location and characteristics, bat behavior, etc. Without this data, we are going to miss the opportunity to develop more effective bat gate designs. Utah has been developing a database that could be modified so that it could be used a basis for this national database.

Answer: Concerning the problem of Congress not releasing the funds for AML programs, I would like to encourage you to write a letter to your congressman and senator or to the Secretary of Interior requesting Congress to put the funds to the use for which they were intended. OSM has just recently received an increase in AML funding because about a year and half earlier we had a big influx of letters requesting their release.

Question: **(Use of Additional AML Funds for Bat Gates)** Assuming the Congress did give the AML funds to the States, how do we know that any of it would be spent on bat conservation?

Answer: Each State AML program has already established a priority system for identifying reclamation problems, including the need to either close or gate abandoned mine openings, that need to be addressed by these funds. An increase in funds would not change these priorities it would only increase the rate at which they could be addressed. It would mean that we could do more inventories, more surveys, more reclamation, and install more bat gates. Instead of needing 20 years to address these problems we could do it in 10 years.

2. Interstate Mining Compact Commission/Eastern Regulatory Authority States Dr. Richard Wahrer, Kentucky Department for Surface Mining Reclamation and Enforcement, Frankfort, Kentucky

3. Western Interstate Energy Board/Western Regulatory Authority States Homer Milford, New Mexico Mining and Minerals Division, Sante Fe, New Mexico

4. The U.S. Fish and Wildlife Service Bob Currie, U.S. Fish and Wildlife Service, Asheville, North Carolina

5. National Park Service John Burghardt, National Park Service, Denver, Colorado

Question: **(Safety Training Courses for Underground Mines)** Could you tell us about the underground mining safety training program sponsored by BLM and Forest Service?

Answer: The tuition is waved for Forest Service and BLM staff. There is a tuition charge for others. You need to get in touch with the National BLM training center in Phoenix Arizona. You can find it on the BLM Website. There is a National Training Program page where the course is listed. The Forest Service does a class at the National Minerals Training Center in Missoula Montana coordinated through Tuti Smith. I think they have a course coming up in May or June of 2001.

Question: **(Training for Abandoned Underground Mines)** Do any of these training programs focus specifically on the hazards of abandoned underground mines?

Answer: Yes. In these classes we address aging roof control, lack of ventilation systems, decay of wooden timbers, chemicals that were used at historic mill sites, training on contaminants used in ore processing in different time periods, and historic mining methods.

6. International Association of Fish and Wildlife Agencies Terry Johnson, Arizona Department of Game and Fish, Phoenix, Arizona

7. Regional Bat Working Groups Mary Kay Clark, North Carolina State Museum of Natural Sciences, Raleigh, North Carolina

SESSION 6 INTERACTIVE DISCUSSION

Question: **(Are Conservation Agreements limited to non listed Species)**Do conservation agreements work for both listed and non listed species?

Answer: The Conservation agreement is specifically for unlisted species. The candidate conservation agreement would apply if it were going to be treated as a candidate species. We are currently trying to develop a national model for the development of conservation agreements.

Comment: **(Convincing Managers to Install Bat Gates)**Some of the State people have said that their managers have discouraged installing bat gates. We have seen what the Utah and New Mexico AML have done in terms of being leaders in the installation of bat gates at mine sites to promote bat conservation. This is while other State AML staff are having problems convincing their management to fund bat gates rather than just closing the mine opening. To these States,

you need to go back to your management and remind them that OSM has sponsored this forum and we heard about the hundreds of bat gates being installed by the Utah and New Mexico AML programs and OSM has not written any bad reports on these States for wasting AML funds on bat gates. The Director of OSM spoke at the forum and two the OSM regional directors attended the forum. This is good evidence that OSM is strongly supporting the Bat Conservation effort.

Question: **(Funding for non coal States)**How can non coal States get funds to put bate gates in mine openings?

Answer: A good question that we don't have and answer for.

Answer: In the East, you could approach the State Game agency for section 6 funds or the non game program.

Answer: On Forest Service lands funds from the clean water action plan and abandoned mine land funds could be used for these closures.

Answer: I have discovered that the Natural Resources Conservation Service has actually provided funding for some bat friendly closures.

Question: **(Use of AML Funds for non coal)**Could you use AML funds to put up a bat gate on an old salt peter mine?

Answer: I don't think Utah could provide the funds but we could provide gate designs and technical assistance.

Answer: New Mexico would disagree with that. We could fund it.

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