Session 4

Protecting Bat Habitat Associated with Surface Mining and Reclamation

Session Chairperson:
Len Meier
USDI Office of Surface Mining
Alton, Illinois

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Dr. Alan Kurta, Department of Biology, Eastern Michigan University, Ypilianti, Michigan

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

Allen Kurta
Department of Biology, Eastern Michigan University
Ypsilanti, MI

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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Dr. Allen Kurta is Professor of Biology at Eastern Michigan University. He holds a B.S. and M.S. from Michigan State University and a Ph.D. from Boston University. He has worked with bats for 23 years and published 46 articles in scientific journals on the ecology and natural history of bats. In addition, he has written one book, Mammals of the Great Lakes Region, and currently is co-authoring a new book on bats of Puerto Rico. He is a past Associate Editor of the Journal of Mammalogy, current Feature Editor of Bat Research News, and a member of the Indiana Bat Recovery Team for the U.S. Fish and Wildlife Service.

IMPACTS OF MINE-RELATED CONTAMINANTS ON BATS

Thomas J. O'Shea
USGS Mid-continent Ecological Science Center
Fort Collins, Colorado

Donald R. Clark, Jr. (USGS retired)
Columbia Environmental Research Center
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas
and
Terence P. Boyle
USGS Mid-continent Ecological Science Center
Colorado State University
Fort Collins, Colorado

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

Chris Yde
Industrial and Energy Minerals Bureau
Montana Department of Environmental Quality
Helena, Montana

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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Chris Yde is a wildlife biologist with the Coal Program, Industrial and Energy Minerals Bureau, Montana Department of Environmental Quality. This work has included establishing annual bat surveys at the surface coal mines in Montana, as well as participation on Montana's bat working group. He holds a B.S. and a M.S. from Montana State University in Fish and Wildlife Management.

ENDANGERED SPECIES HABITAT REPLACEMENT

Sally A. Imhof
Kansas Surface Mining Section
Frontenac, Kansas

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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Sally A. Imhof is an Environmental Technician with the Kansas Department of Health and Environment, Surface Mining Section. She holds a B.S. ED. and a Masters in Biology from Pittsburg State University in Kansas.

SURFACE MINING CASE STUDY FROM KENTUCKY

Richard J. Wahrer, Ph.D.
Kentucky Department for Surface Mining Reclamation and Enforcement
Lexington, KY

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