

Assessing Mines for Bats

THERE ARE TWO PRIMARY TECHNIQUES for surveying mines for bats: internal and external surveys. As implied, internal surveys involve a thorough search of a mine's interior for bats or bat sign, while external surveys involve observing or capturing bats from outside a mine entrance as they exit or enter. For both methods, it is critical that surveys be conducted at the proper time of year, since the types of use and seasons of use differ widely. While an internal mine survey is generally the more thorough and accurate method for determining bat use, it is also more hazardous and requires the most training and experience.

The exploration of abandoned underground mines may be regulated in some states by the federal Office of Safety and Health Administration (OSHA), Mine Safety and Health Administration (MSHA), or the state mine inspector's office. Appropriate authorities in each state or region should be contacted before conducting or contracting for underground abandoned mine surveys. Underground surveys should not be attempted without appropriate training and experience. Human and financial resources, and the

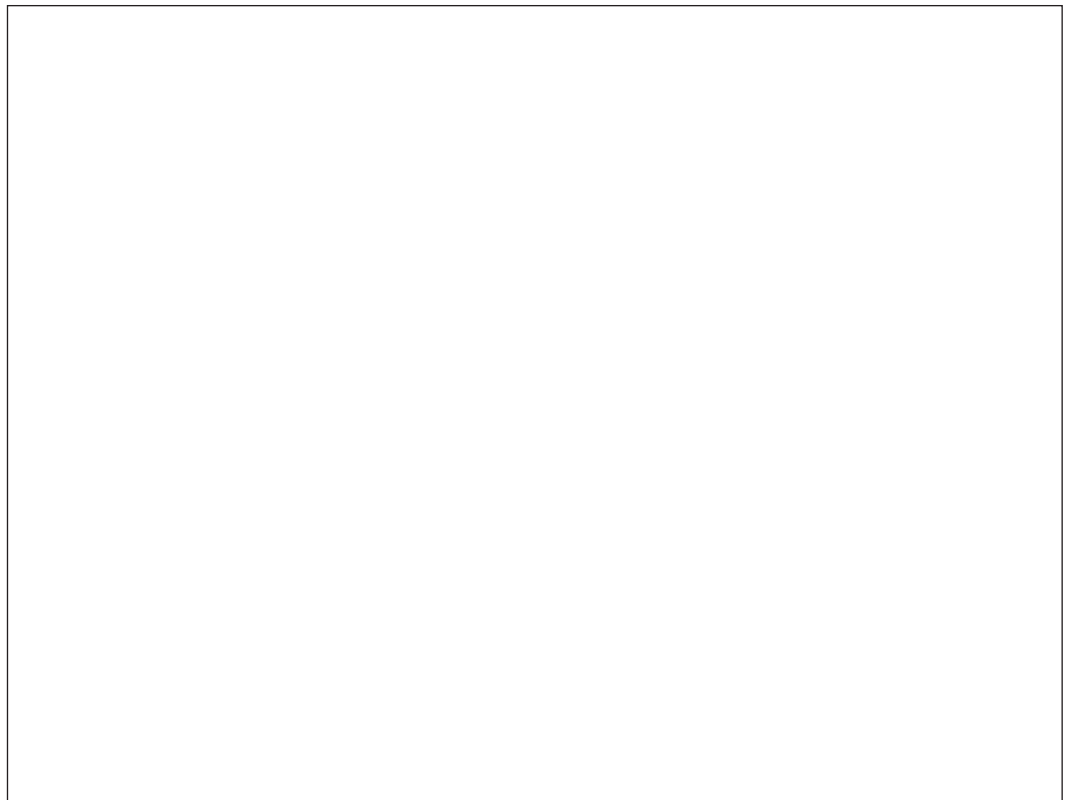
level of expertise available to natural resource managers, will likely play a major role in determining the method of survey used.

When time permits, an external presurvey of abandoned mine sites should first be conducted to determine if mines have potential as bat roosts. An initial site visit, and knowledge of how mine environments determine bat use, will help determine if additional surveys are necessary and if so, how and when surveys should be conducted. Sample survey forms are provided on pages 47 through 50.

External presurveys

Safety training is recommended even for those conducting external mine surveys. There are several safety issues to be aware of when conducting external surveys. Mine openings are often the most dangerous part of an old mine. The rock around entrances is often weakened by weathering and fractured from explosives. Care should be taken to approach the edges of shafts and other vertical openings with great caution, as edges can break away unexpectedly.

An internal survey of a mine is the most thorough and accurate method of determining whether bats use a site and in which season they are present. This method, however, requires training and experience.



Furthermore, sudden collapse and falling rocks represent potential hazards even at horizontal openings.

Presurveys can be conducted anytime the site is accessible, but should be planned well before scheduling of mine closures, providing adequate time if additional internal or external surveys are warranted. Information to be collected during presurveys should include: (1) number, dimension, location, and description of all entrances; (2) airflow direction, if any, through entrances; (3) outside air temperature; (4) the presence of any restrictions at or near entrances (vegetation, old timbers, trash, loose piles of rock, etc.); (5) the presence of standing water or evidence of prior flooding; (6) internal features that can be safely determined from outside, such as depth, side passages, ventilation shafts; and (7) visual signs of bats, such as droppings, roosting bats, carcasses, or piles of insect parts.

The information from the presurvey should then be evaluated by a person experienced in working with bats and mines. If all mine entrances are completely blocked by debris, rock, soil, or dense vegetation, the site is unlikely to be used by bats. *However, in some cases, especially where mine or cave habitat may be limited, these sites could be further evaluated for their potential value as habitat if the entrances were to be cleared and secured.* If the mine is shallow (generally less than 50 feet for adits and shafts) and all sides are visible when viewed from outside, confirming there are no drifts, internal shafts, etc., it probably has low potential as a roost site. Mine adits flooded to the ceiling or within a foot of the ceiling, or vertical shafts that fill with water can also be eliminated, unless there is a drift above the waterline. If there is a possibility of bat use, a more detailed evaluation should be considered.

Mines that can be entered

An internal survey is often the quickest and least time-intensive survey method. Winter surveys typically can detect summer use, since guano piles from active bats remain visible. However, summer surveys cannot detect winter use, since hibernating bats leave very little guano. Paying close attention to airflow patterns and a mine's temperature can save much time by focusing searches for bats in places where they are most likely to be during the season of inspection.

Abandoned mines can be dangerous, with cave-ins and falling rock, rattlesnakes, deadly gases, oxygen deficiency, hidden shafts, and old explosives all posing potentially serious threats to human safety. Thus, internal mine surveys should be conducted only by individuals trained in bat biology and mine

safety. As an additional safety precaution, a minimum of two people should participate in all surveys. For information on mine safety and training, contact the state mine inspector's office.

When internal surveys fail to reach all potential areas where bats might live, they should be backed up by entrance observations made in the appropriate seasons (see "Mines that cannot be entered"). Since bats usually emerge nightly to feed, warm-season surveys do not typically require mine entry to detect bat use. Furthermore, entrance observations avoid the risk of disturbing nursery colonies, which can cause loss of young.

When conducting warm-season internal surveys, listen for the sounds of bat squeaks and chatter, and when approaching a roost area, move quietly along a wall, staying as low as possible. Make counts and collect data as quickly as possible, reducing talking and other sounds to a minimum. Speak softly in low tones if talking is necessary. A red light may help, but if clustered bats begin to take flight, immediately back away. Do not attempt to capture active bats at their roost. Identification and reproductive status can be checked through trapping or netting at entrances.

Most non-hibernating bat colonies deposit piles of droppings beneath their roosts. These are easily observed in any season, though they can be missed in complex mines. The droppings of insectivorous bat species are simple to distinguish from those of rodents. Bat guano is easily crushed and is composed mostly of shiny bits of insect exoskeleton. By comparison, rodent fecal pellets are usually hard to crush and are composed mostly of plant matter. Furthermore, bat droppings are typically deposited near the middle of passages where ceilings are highest and where the bats have stained the rock surfaces. In contrast, rodent droppings are more likely to be concentrated along walls or in low places too small for bats to use. With experience, some species identification of insectivorous bats is possible from the size, color, odor, inclusion of insect parts (such as wings, carapace, or legs), and deposit pattern of the guano. Nectar-feeding long-nosed and long-tongued bats may produce formed droppings, but characteristically leave yellow or reddish "splat" marks on mine floors and walls, colored by pollen or cactus fruit.

Since even large numbers of hibernating bats often leave very few droppings or other evidence, internal surveys for hibernating bats must be conducted in the winter, preferably between December and February. Because mines with deep vertical shafts often provide the best cold air traps and protection from disturbance by humans and predators, these can be especially important resources for hibernating bats.

Such sites may attract many thousands, or even millions, of bats from thousands of square miles around. Those too dangerous to enter require entrance sampling in late summer or early fall (see “Mines that cannot be entered”).

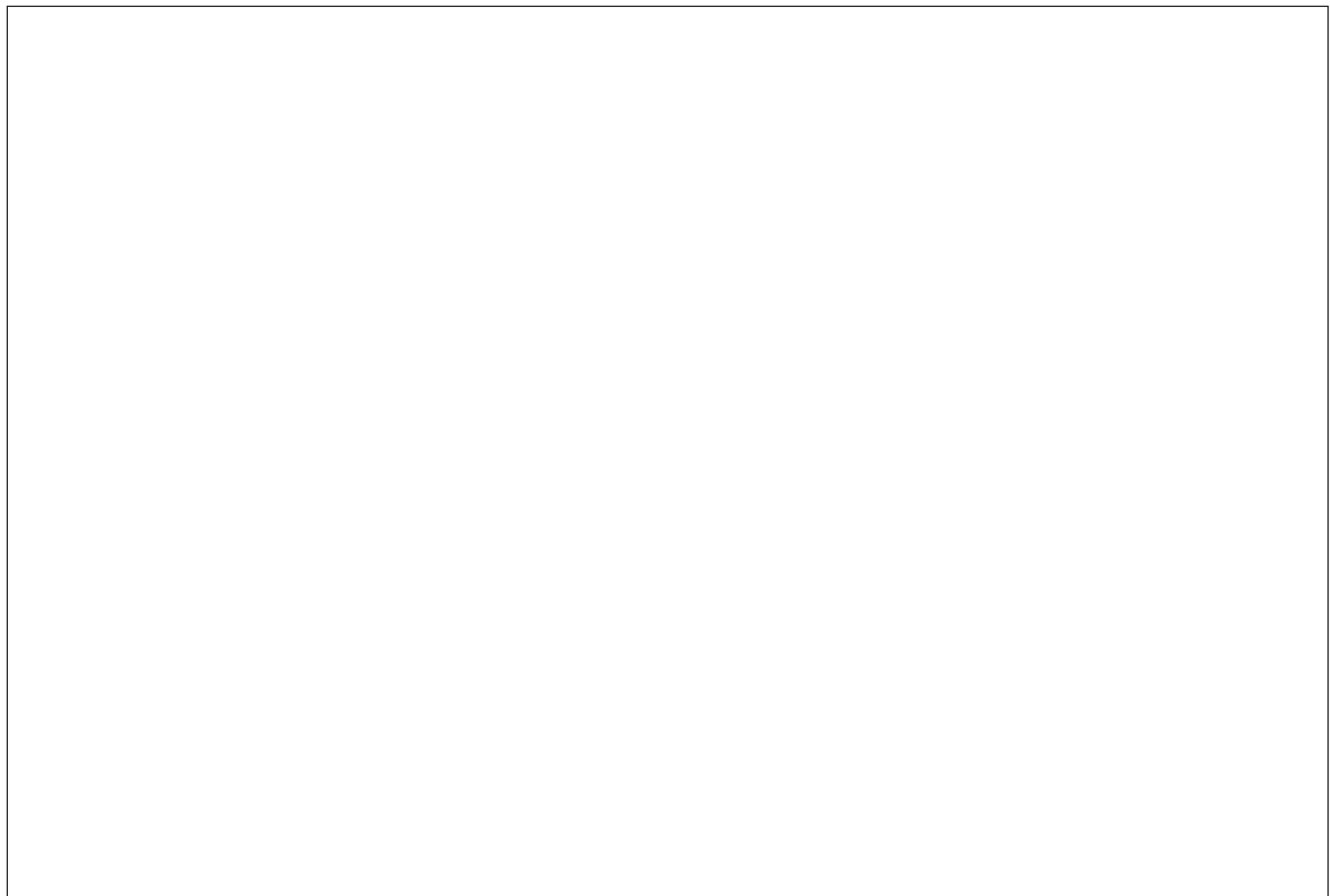
It is extremely important to minimize disturbance when inspecting the interior of a bat hibernation site. Once in hibernation, each arousal forces a bat to burn from 10 to 60 days’ worth of its limited fat, which must last until spring. Repeated arousal can easily kill bats. Visits into hibernation areas should be brief and never repeated more than once in the same winter.

Mines that cannot be entered

Many mines will be too dangerous for humans to enter. However, because these receive the least disturbance, they often shelter the largest bat populations. *In fact, some such mines are so predictably ideal for bats that they should be assumed crucial bat sites unless proven otherwise.*

Entrance observations, made between mid-June and early August, are often the best method for verifying summer use of mines. Since bats usually emerge each night to feed, determining their presence at dusk is reasonably simple. Surveys should be conducted for at least two hours after dark, beginning at sundown on nights that are free of rain and excessive wind or low temperatures. Observers should be ready at least 30 minutes before sunset and should keep noise to a minimum. Noise may alter or inhibit emergence behavior.

Observers should be seated at least 15 feet away to one side of the entrance, ideally positioned so that emerging bats are silhouetted against the evening sky. All entrances associated with the mine (if known) should be surveyed at the same time, if possible. A night-vision device with an infra-red light source will provide the most accurate observations, but if unavailable, a dim red light (aimed across, not into, the entrance) can be used to assess the approximate



In mines that cannot be entered, external surveys at appropriate times of year can determine whether bats are using the site and may also aid in assessing the approximate population size. A bat trap placed over the entrance is a reliable method.

colony size. Flights of even relatively small colonies typically can be detected by an observer positioned low enough to both listen and watch the skyline. Even after dark, listening for wingbeat sounds of emerging bats normally can aid in assessment. An ultrasonic bat detector may be used to help detect emerging bats. Night-vision devices are especially helpful for detecting some bats, such as big-eared bats, which are difficult to hear on a bat detector and which may exit after dark and at slow rates.

The best time to check mines for winter use is usually when bats begin arriving to inspect a site for hibernation. This is typically in August and September in the eastern and northern United States or Canada, extending into October in the Southeast. In warmer southwestern areas, arrivals are more likely to peak in October or November. Spring emergence also can be observed, but is less reliable, since activity then is often less predictable or detectable. Entrance observations at potential hibernation sites are best made between a half hour after sunset and midnight. Bats entering a hibernation site may arrive all night long each night for a month or more. Within that period, arrival rates vary considerably, but a flow of even a few dozen bats per hour on a given night could suggest a hibernating population of thousands or more. Sometimes, large groups of bats arrive together within just a few minutes.

Bats at many important hibernating sites exhibit "swarming" behavior, which is believed to be related to breeding and selection of hibernation sites. Swarming consists of many bats flying in and out and around the entrance of a mine or cave, with peak activity occurring between two to three hours after sunset. In the eastern United States, north into Canada, this behavior is intense in August and September and is easily used to detect hibernation sites. Such behavior sometimes occurs in the West, but can be more difficult to detect since greater numbers of mines are used for hibernation and are occupied by smaller numbers of bats. Swarming activities in the West, therefore, may be missed during early winter surveys.

Bat traps or mist nets can be used to capture and identify bats at mine entrances. Persons conducting capture surveys must have appropriate state and federal permits and have previous experience handling bats or be accompanied by someone who does. Although bats bite only in self-defense if handled, people who plan to handle bats should receive rabies pre-exposure vaccine, now relatively painless and highly effective.

A bat trap is effective in checking horizontal mine entrances for emerging or arriving bats. These traps, weighing as little as five pounds, can be made with capture areas as small as four feet high and three feet wide. If a mine entrance is considerably larger than the area covered by the trap, inexpensive cloth, plastic, or netting can be used to block alternate access. Removing bats with gloved hands is quick and efficient. Traps can rapidly capture hundreds of bats without entangling them, but they must never be left unattended, since traps can quickly fill with bats that may then suffocate. Also, traps containing bats readily attract predators.

Mist nets also can be used to capture bats and may be useful in checking difficult-to-reach locations. The disadvantage is that each bat must be individually disentangled from the net, which is time consuming and requires experience. Never set a net across an unfamiliar mine entrance before first observing the level of bat activity. A net over a busy entrance will quickly catch more bats than can be removed effectively, destroying the net and needlessly injuring severely tangled bats.

Neither nets nor traps should be used over vertical shafts. However, by observing the flight paths of emerging bats, they may be set effectively nearby. For some such sites, combined use of bat detectors and dim red lights or night-vision devices may be required. Since western big-eared bats are often active periodically throughout the winter, electronic counting devices may be helpful in documenting their use at sites that cannot be entered by people.

Protection of Bats in Mines

BATS THAT LIVE IN MINES face three primary human threats: closure of mine entrances for reclamation or safety reasons, human disturbance due to recreational entry, and loss of old mines and surrounding habitat if mining is renewed. Since mines are now essential habitats for many of America's most important remaining bat populations, they always should be assessed for bat use prior to any of these activities.

Reclamation and safety closures

If a biological survey reveals bat use of a mine, there are alternatives to total closure that provide for public safety and allow bats to continue using the site. Often the most effective solution is a steel gate placed over or across the entrance, which can include a small, lockable door or removable horizontal cross member for official access. Many bat species respond well to such structures. Bat gates must meet the land manager's objective of protecting the public from a hazardous situation, while ensuring safe access to bats. In areas where favorable roost temperatures require cold or warm-air traps (see "How Mine Structure, Location, and Human Disturbance Affect Bat

Use"), it is essential that gates not obstruct normal airflow through entrances. Proper design and placement is extremely important; bat colonies have often been driven from a site because of an inappropriate gate.

Modern gate designs are both difficult for vandals to breach and often less costly than traditional closure methods, such as capping mines with concrete or bulldozing entrances shut. A primary purpose of a gate is obviously to keep unauthorized visitors out. This requirement results in further limitations on the type of materials used, as well as the spacing of horizontal and vertical members of the gate. The *minimum* distance between vertical gate supports should be 24 inches (anything less may restrict bat movement). The ideal spacing for vertical gate supports is between 4 and 10 feet, depending upon the design and strength of material used.

The widest vertical and horizontal spacings are always preferred by bats, but in no case should human safety be compromised. Horizontal members should normally be spaced no less than 5³/₄ inches apart. Near heavily populated areas or recreation sites where small

Siebert Cowley (Unimin Corp.), Ray Smith (US Forest Service), and Sheryl Ducummon (Bat Conservation International) demonstrate the removable bar on this angle-iron gate at Unimin Corporation's Magazine Mine, an abandoned silica mine on the Shawnee National Forest in Southern Illinois. The gate protects humans as well as a growing population of endangered Indiana bats. This design has proven highly successful and difficult to breach.





This protective cage at the Neda Mine in Dodge County, Wisconsin, ensures human safety while also protecting one of North America's largest hibernating bat populations. It cost less than alternative methods of closure and was built through collaboration of the Wisconsin Department of Natural Resources, the University of Wisconsin at Milwaukee, and the Friends of the Neda Mine—a private group led by Bat Conservation International Chairman Emeritus Verne (pictured) and Marion Read.

children might attempt to gain entry, expanded metal grating can be used on the bottom third of the gate, or the spacing of the horizontal members on the bottom third can be reduced slightly. Spacing horizontal gate members less than $5\frac{3}{4}$ inches apart can severely restrict bat movement, while distances greater than $5\frac{3}{4}$ inches may permit small children to squeeze through.

Gates constructed of $4 \times 4 \times \frac{3}{8}$ -inch angle iron, reinforced by stiffeners (see Appendix III, Design A, for plans), have been successfully used to protect bats in caves and mines throughout North America. This design is extremely strong; hundreds of these gates have been installed thus far, and very few have been breached. When located properly, the gate has mini-

mal effect upon airflow because of the orientation of the angle iron.

Gates should not constrict mine openings more than absolutely necessary, especially along floors and ceilings. Whenever possible, construction should occur during the time of year when bats are not using a mine, in order to avoid disturbance. If construction must take place while bats are present, it should not occur within two hours of dusk or dawn. Furthermore, care must be taken so that welding fumes are not drawn into areas where bats are roosting.

Where either horizontal or vertical mine entrances are unstable, they often can be secured by use of galvanized or concrete sections of highway culvert. Vertical shafts further require specially designed

cage-type gates, since horizontal gates over shaft entrances can easily become blocked by debris and also force bats to slow down or land, greatly increasing mortality from predation. All cage-type closures should be high and wide enough to provide adequate flight space (minimally 6 to 10 feet square) for bats to maneuver safely through the bars without being caught by predators. Cage-type closures have been used successfully at many sites across the country. Because cage-type gates and vertical shafts entail special bat and engineering considerations, individuals or agencies familiar with their construction, such as Bat Conservation International or the American Cave Conservation Association, should be consulted (see Appendix II).

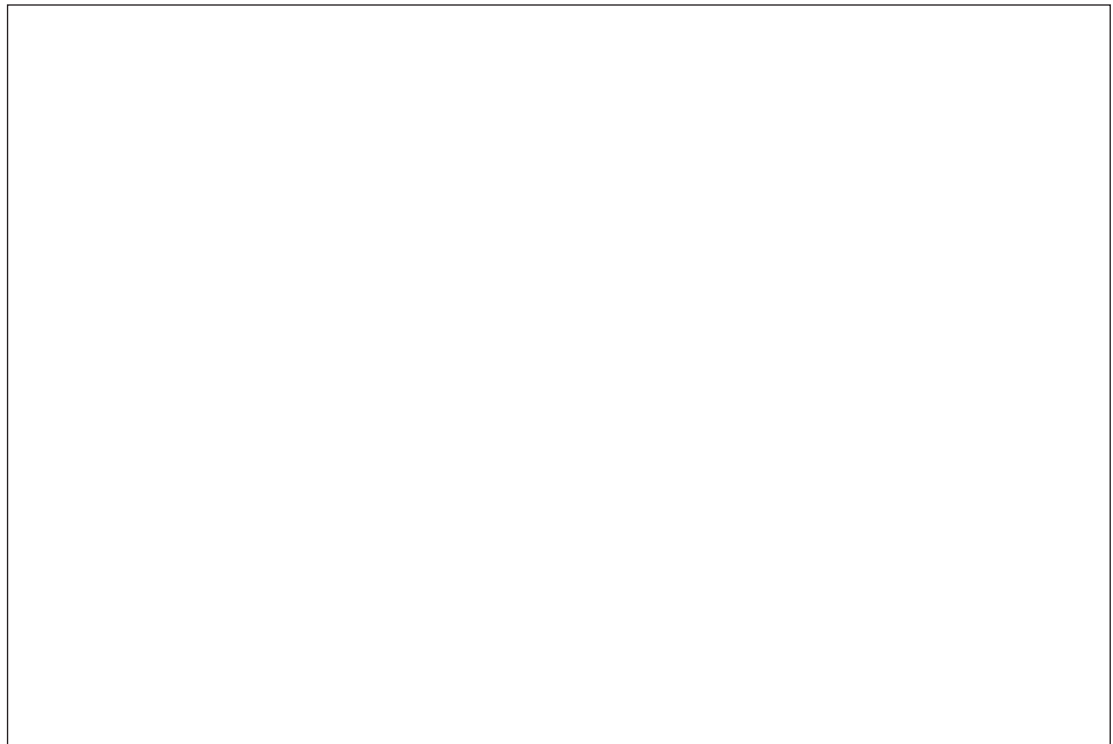
A cage-type design was built over a vertical entrance at the Neda Mine in Dodge County, Wisconsin. The foundation was constructed of poured concrete reinforced with steel. The cage was constructed from 4 x 4 x 3/8-inch steel angle iron, with a roof of expanded metal grating (see Appendix III, Design B, for plans). An expanded metal collar can be used at the base of cage closures to prevent small children from climbing up to the bars. A solid steel collar can be used in lieu of expanded metal where the entry of surface water is a concern, but should be avoided where cold-air trapping is especially important, as it

may inhibit airflow.

When carefully installed to avoid alterations of roost temperatures, bat-friendly angle-iron gates have proven highly successful in ensuring both human and bat safety at numerous locations throughout North America. Available evidence suggests that all hibernating North American bat species will accept gates at overwintering sites. Big-eared bats have accepted gates at both hibernation and nursery sites and California leaf-nosed bats accept gates during all seasons. However, gates often are not suitable for protecting nursery colonies of more than 1,000 individuals of other bat species, and are not tolerated at all by some. Bat tolerance of gates is roughly proportional to gate size, larger gates allowing more bats to exit through a larger area with less risk of being caught by predators. Gray bat nursery colonies rarely tolerate gates, and this is probably due to the fact that they typically number in excess of 10,000 individuals. Small to medium-sized nursery colonies of several species of the genus *Myotis* have accepted gates. Gates are never acceptable to Mexican free-tailed bats, and little is known regarding gate tolerance of long-nosed or long-tongued bats, ghost-faced (*Mormoops megalophylla*), Allen's lappet-browed (*Idionycteris phyllotis*), or pallid bats (*Antrozous pallidus*).

Experimentation has shown that at nursery sites,

Galvanized highway culvert can be used to stabilize vertical mine entrances.





This horizontal entrance was stabilized with a concrete culvert. Attachment of the gate to the inner end of a culvert reduced predation risk to the bats. The Homestake Mining Company in northern California reopened and gated this previously closed adit to provide an alternate home for a colony of western big-eared bats, which would otherwise have been displaced when mining was renewed nearby. The bats successfully moved into their new roost.

myotis bats may more readily tolerate gates located inside an entrance, beyond the twilight zone. Such positioning reduces the danger from visually orienting predators, but in some cases may not meet human safety needs or may make gate inspection and monitoring more difficult. This approach warrants further testing. When using culverts to stabilize entrances, gate attachment to the inner end of the culvert can also help bats avoid predation.

Other options exist for summer sites that cannot be protected by gates. Cyclone fences can be placed at least 12 feet back from an entrance to provide adequate space for bats to fly over, and half-gates have been used successfully in unusually large entrances, where sufficient space can be left for bats to fly over. Silent alarm systems can provide suitable backup.

Gates located in small entrances can greatly increase predation, especially where large nursery colonies are involved. They also are the most likely to restrict airflow, forcing bats to abandon even a protected mine if inside temperatures are raised or lowered beyond those they require (see "How Mine Structure, Location, and Human Disturbance Affect Bat Use"). When entrances are smaller than four feet

in diameter, consideration should be given to use of cage-type designs that do not further restrict either airflow or the bats' space for negotiating the gate.

The largest nursery colonies attract the most predators which may be one reason they are least tolerant of gates. In these cases, fences or silent alarm systems may be the only option. All signs of access for gate or fence construction should be eliminated, or access blocked, so that additional human activity is not attracted.

It is impossible to predict how untested species will react to gates constructed at their roost sites. Therefore, it is essential that any gates used in unusual situations, or to protect untested species, be carefully monitored after they are installed. Consultation should be sought when questions arise (see Appendix II). At a minimum, the following steps should be taken before and after gate construction:

(1) If possible, estimate the number of emerging bats, and make observations of their emergence and return behavior before constructing a gate (include times that emergence begins and ends, location of flight paths through the entrance, and the amount of circling at the entrance).

(2) Repeat the preliminary observations immediately after construction is completed. Periodically repeat these observations through the first season of use, and once again a year later, to ensure that the bats are not suffering adverse effects from the gate.

(3) Utilize the information gained in the post-construction observations to modify future gate designs and correct any mistakes revealed during monitoring, if necessary.

All protective barriers require appropriate signage and periodic monitoring to ensure structural integrity. Signs should be clearly visible and attached to mine walls, not to gates, where they might obstruct airflow or bat movement and be accessible to vandals. Once a site is protected, no one should be allowed to enter during periods when bats are present, except to perform official surveys or for clearly justified research. Hibernation site surveys should not be repeated more than once every two to five years.

Federal, state, or private assistance is often available to help plan and fund gate construction or other protective measures at key sites that must be saved. Federal and state governments also can assist immeasurably through passage of legislation limiting owner liability. When mining companies or private-land owners are asked to cooperate in conservation-relevant activities involving inactive mines, every possible effort should be made to protect them from increased liability exposure.

Renewed mining

Contemporary mining operations usually occur in historic mining districts and can have major impact on bats, either positive or negative. New sampling methods, such as drilling, often detect ore deposits missed by previous miners and the ore is typically extracted with open-pit mining techniques. When this happens existing adits and shafts are often destroyed. Exploratory operations can have a major impact on bats due to disturbance from mine personnel entering bat roosts for ore samples or bulldozers burying historic mine openings during road construction for drilling equipment. Today, underground mining methods are seldom employed, except where high-quality ore is located deep beneath the surface.

In addition to roost destruction, other aspects of renewed mining can have adverse impact on bats, even bats not living in mines. Destruction of riparian vegetation and other foraging habitat can threaten the survival of bat species that rely on this habitat for feeding. Open cyanide leaching ponds, or other water in which toxic chemicals accumulate, can poison large numbers of bats. New roads may lead to increased recreational visitation, and nearby blasting associated

with mine construction and operation can disturb roosting bats. When current mining operations cease, reclamation requirements and liability often require a company to close any remaining historic workings.

Mitigation for bats during mining or mine reclamation fall into two major categories: safe exclusion of bats from the mine, and the identification and protection of replacement roosting and foraging habitat. If a bat roost must be destroyed, this should be done during a season when bats are not present or only after exclusion of bats. Where large colonies of bats are at risk, a bat biologist with the necessary experience and equipment should be consulted. As already noted, many bats use mines only in certain seasons. If there is a maternity colony occupying a mine, then no closure should be made between late April and August. Closures should not be scheduled for the winter months at mines that may contain hibernating bats. If bats live in a mine year-round, then exclusion should occur in spring or fall to reduce harm, which would be most intense during summer nursery or winter hibernation use. Exclusions should not be attempted during severe weather, as bats may not emerge to forage or may die before finding alternate roosts.

Exclusion is best achieved by covering the mine entrance with one-inch chicken wire soon after most of the bats have exited to feed on a warm evening. Chicken wire can be molded to create a funnel shaped one-way escape door so that bats inside the mine detect a window, while those on the outside of the mine perceive a barrier. Bats still trapped inside can be allowed to escape by partially removing the chicken wire just before sundown on the following evening, then re-closing it after sundown once any remaining bats have left. One or two repetitions on warm evenings should successfully exclude most members of any summer colony. Other bat species may enter a mine to night roost before, during, and after the emergence of the resident bat colony. In these cases the creation of funnels as one-way escape valves in the chicken wire closure is especially important. If a mine contains multiple entrances that connect or could potentially connect, then all of the openings should be systematically closed as above. If the covered mine is not destroyed or permanently sealed within a few weeks of the bat exclusion, then chicken wire closures should be checked periodically to ensure that they are still effective.

It is sometimes possible to mitigate for the loss of evicted bats, either by protecting nearby mines or, in some cases, by reopening ones already closed. Abandoned mines within a radius of approximately five miles of the mine to be destroyed should be surveyed.