Section B—Developing Cave Management Programs

On Cave Gates

Jim Kennedy

Cave gates. There are hardly two words that polarize cavers as much as these. Even the most vocal anti-gate cavers admit that gates serve an important function in protecting irreplaceable cave assets, and in reducing the liability of cave owners. Yet all too often land managers turn to gates as quick and easy solutions to complex cave management problems.

Cave gates can be an important part of a comprehensive cave management plan, but there is much more to gating a cave that just welding steel. This chapter will *not* tell you everything you need to know about gates and gating, but it will give you an overview of the planning, design, building, and monitoring process and will direct you to additional expert resources.

Is a Gate Needed?

First, determine if a gate is truly necessary. Since a gate is a somewhat permanent structure that requires great expenditures of resources and may negatively impact the cave environment, it should be installed only after careful planning and design. Other protective methods may be more efficient or effective and should be explored first.

Other protective measures for cave habitats include but are not limited to the items in the following list.

- Administrative closures
- Signage
- Fencing
- Redirecting trails
- Public education
- Protective stewardship
- Electronic surveillance

While carefully designed and constructed gates have minimum effect on the cave environment, poorly placed gates can be very detrimental to the cave and its resources. If a gate is needed, it should have minimum impact on the cave.

If a gate is needed, it should have minimum negative impact on the cave.

Types of Protective Closures

Next decide on an appropriate gate design. In this section, the term *cave gate* is used for any type of lockable barricade that prevents human access to the cave, including fences, doors, and bars. Some types of closures, such as a simple chain across a passage restriction, are less secure than others.

The majority of this chapter focuses on various types of *bat-friendly* horizontal bar gates, which are suitable for most situations and are very secure. In rare instances that require an environmental seal, such as a newly opened cave or section of cave with no natural entrance, bat-friendly gates would be inappropriate. In those cases, *air lock gates* may be necessary to prevent drying air currents and contamination by outside organisms or materials such as mud.

Units of Measurement

Editors' Note: In this chapter, dimensions for materials deviate from the standard metric/English format used elsewhere in this volume because construction materials are usually sold in English units in the United States.

Editor's Note: If a cave gate will change air currents that originally flowed through breakdown or small openings, then measure the natural airflow before the gate installation begins. Design and construct the gate to mimic the original airflow. (See virgin digs, page X265.)

Bat Friendly Gates

Most cave gating scenarios call for a bat-friendly gate. Fortunately, there are many types of gates that incorporate bat-friendly features. Standard bat-friendly gates are designed with widely spaced uprights and 5 3/4-inch (146-millimeter) spacing between horizontal bars. The actual design depends on the amount of human vandalism pressure, the bat species present, and the way the bats use the cave. For instance, we must be aware that some species of bats do not tolerate cave gates at all, and others only at certain times in their life-cycle. The size and angle of the cave entrance may also dictate innovative adaptations of the *standard bat gate* designs. (See drawings for the horizontal bar gate, figure 3.)

After carefully choosing a location and initiating the actual construction, observe the effectiveness and impact of the gate over time. If the gate is creating negative impacts, quickly modify or remove it. *Routine maintenance tasks* should be planned before commencing the actual construction. Maintenance schedules may be required to repaint the gate if necessary, remove sticks and leaves or flood debris, change locks before they stop working, and remove rocky debris that accumulates around the gate. Signs, fences, and gates are also susceptible to vandalism, and repairs or replacement may be necessary.

Selection of Protection Method

Before installing a gate at a cave entrance, many factors must be considered. Issues to examine can be divided into two broad categories.

- Evaluate the cave resources themselves.
- Assess the level of threat to the cave resources.

Obviously, an easily accessible cave is more in need of protection than a rarely visited cave in a remote wilderness area. Likewise, a cave with a wealth of speleothems, important biota, or archeological and paleontological remains, is more in need of protection than a small, featureless, relatively sterile cave. We believe that all caves have value. But how do we determine what is significant and threatened?

Ideally, a complete resource inventory is done for the cave in question, with periodic monitoring up to the time of the actual gating. In reality, this rarely happens. Even caves that have been known and visited for decades hardly ever have simple baseline data, like temperature and invertebrate studies.

Often a gate is planned because the cave owner or manager is reacting to a crisis—the discovery of a rare and threatened resource, advanced loss of cave resources, sharply increased visitation, or liability concerns. No matter what the impetus for protection, we should consider all users and resources when designing a gate or other type of protective closure.

Five Possible Scenarios

This process can be illustrated by a hypothetical example. Assume that we have five caves on a 1,000-acre (405-hectare) parcel of land.

Cave 1. This cave is located on a remote back corner of the property, accessible only by fording a shallow river. It is backed by several hundred contiguous acres of forest under other ownership. It has a few thousand feet of passage, some fun climbs, and ancient bear den sites.

Cave 2. This is a shallow, 25-foot (8-meter) pit leading to 300 feet (90 meters) of easy canyon and crawlway. This cave is very near a road, and an obvious trail leads to its entrance. No bats or other obvious wildlife have been noted, but the temperatures are very cold, even in the summer.

Cave 3. This cave is on a distant hillside and has a small obscure opening that leads through breakdown and crawls to a fairly large room. Endangered bats hibernate in this cave during the winter.

Cave 4. This is a large, well-known system with several horizontal entrances. Several entrances have obvious trails leading to them, and one entryway is small, torturous, and rarely used. There are many delicate and unusual speleothems in this cave, and damage has been steadily increasing for many years.

Cave 5. This is a small crawl cave with records of endangered invertebrates. Because it is near the fourth cave, it is often mistaken as an entrance to Cave 4 and receives unnecessary traffic.

What to do with these? Gating all the entrances would be time-consuming and expensive, would likely aggravate those people currently visiting them, and might cause overflow problems in neighboring caves. We already have some resource information on the five caves, so we can prioritize their significance. We also have information on the level of disturbance and threats to these caves, so we can determine the level of urgency for protecting each one. Now we have to determine exactly how we will protect each cave.

Gating all entrances would be time-consuming and expensive, would likely aggravate those people currently visiting them, and might cause overflow problems in neighboring caves.

Cave	Significance	Threats
1	paleontology, recreation, pristine	few due to difficult access
2	possible bats in winter, recreation	highly visible, liability (pit)
3	bats in winter	small, hard to find, rarely visited
4	recreation, speleothems, possible invertebrates	heavy traffic, increasing damage
5	invertebrates	unintentional traffic from Cave D

Set Up a Table to Prioritize Actions

Cave 5. This cave appears to have an urgent need for protection because of its endangered fauna and the unintentional traffic. This reality would need to be weighed against the population size of the invertebrates, and the numbers of those species in other caves. Since this is a relatively small cave with a well-known entrance and no bats, a gate could be appropriate.

Cave 4. This cave needs a more thorough resource inventory. Its proximity to Cave 5 indicates a likely connection. Although it is viewed primarily as a recreational cave, the possibility of finding endangered invertebrates there is high. There are too many unknowns at this time to make a good decision. Perhaps the entrances can be gated. A small internal gate might allow access to only part of the cave. Signs and a permit system might reduce the number of visitors to a sustainable level. We need to know more.

Cave 3. This cave might be categorized toward the opposite end of the spectrum. Rarely visited and obscure, it faces no immediate threats. The only critical time of year is winter when the bats are hibernating. Winter visits could be curtailed simply by doing public education through the local grottos. Because the entrance is obscure, a gate or signs might draw unnecessary, detrimental attention to the cave.

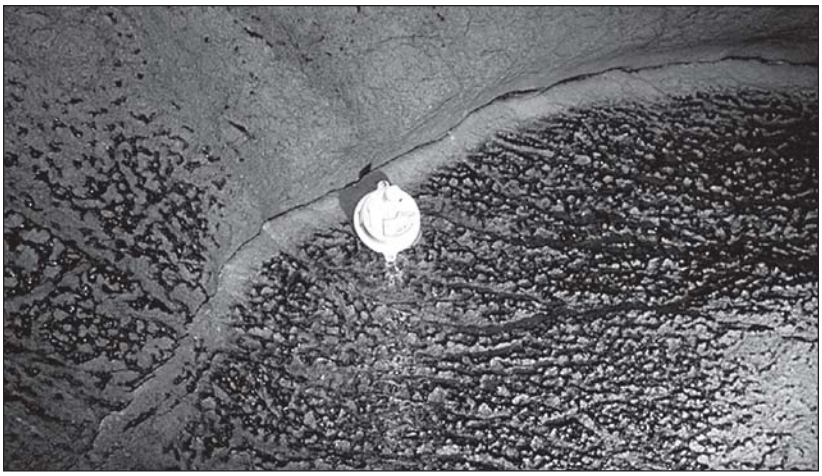


Figure 1. Bat roost stains on cave walls provide evidence of bat population even when bats are not present. In the image, a 3-inch (80-millimeter) HOBO® Pro data logger is used for scale. (See page 5 of color section.)

Cave 2. This cave presents a different challenge. It is easily accessible and well known, so rerouting the trail would make little difference. A combination of educational signage and a bat-friendly fence could prove beneficial, and would not detract from the aesthetics of the pit. If the fence is repeatedly damaged, and if the cave is suitable for bats, a cupola-style bat gate could be installed over the entrance (Figure 4). Since temperatures are suitable for hibernating bats, we might conclude that bats are no longer in that cave due to disturbance, so fencing or gating should allow for their eventual recolonization. A thorough in-cave survey for old guano or roost stains would help with this decision (Figure 1). As with any site where there is a strong history of visitation, the reputation for open access must be broken, even if it means patrolling the site and arresting violators.

Cave 1. This is a relatively pristine wild cave. However, traffic may increase if other nearby caves are gated. The paleontological resources are very vulnerable. A permit system, combined with increased caver education, might work here if the location is protected by the terrain and the remoteness of the site. If natural site protection is not adequate, the cave might need a gate. Since the threats are not immediate, protective efforts for this cave are not as urgent.

Careful assessment of a cave's resources and threats is necessary before installing any protective device on a cave.

Summary of Assessment

Careful assessment of a cave's resources and threats is necessary before installing any protective device on a cave—particularly more permanent structures like gates. Public input from concerned user groups should be solicited, especially if those groups oppose closure and may damage or destroy protection efforts.

It is essential that gates and other protective structures be continually monitored, not only for structural damage, but also for their impact on the cave ecosystem. Gates, culverts, or fences that cause a negative effect should be modified or removed. Cave gating is not a quick Band-Aid approach to cave management. Gating is merely one tool a cave manager can use. Maintenance schedules should be established because gates need attention and review after installation.

Certain types of protective efforts may have an opposite effect than that intended. For instance, several species of North American cave-dwelling bats do not tolerate any type of gate at all. Some species only tolerate gates during one part of their life cycle and not at other times of the year.

Always consult experts early in the planning stages of any gating project and be sure to get the most current gate design recommendations through Bat Conservation International, the National Speleological Society, and the American Cave Conservation Association.

Location and Design

Placement of a fence or gate is as critical as the actual design of the structure. Poorly located gates may increase flood damage to the cave, accumulate debris and restrict airflow, and restrict movement of bats or other wildlife. Poorly placed gates may also be more susceptible to natural damage or vandalism, and may increase predation at the cave. Much depends on the size, shape, and orientation of the opening, but in general, bat gates should not be situated in natural passage constrictions, and fences should not interfere with the flight path at the entrance.

It must be stressed that cave gating is not a cookie-cutter management technique. Simply because a cave has bats does not mean that one can dust off a gate design and build it in the cave mouth. But even if a cave does not have bats, the cave may need a bat-friendly gate. The approach to protecting each cave should be based on the configuration of the cave itself, the species using it, the season bats occupy it, the proximity to civilization, and so on.

It must be stressed that cave gating is not a cookie-cutter management technique.

There is not a one-size-fits-all solution to cave protection. Poor gate design or placement can render the cave unsuitable for bats. Consult the experts listed in the resources section at the end of this chapter.

Gate Location

As mentioned above, cave gates should not interfere with the natural flow of air, water, nutrients, or wildlife to and from the cave. Gates should never be in a constricted part of the passage. The bottom of an entrance slope should also be avoided since it will catch debris that will pile up against the gate. In cave entrances that have inflowing streams this can be a very serious problem. The gate on the North Entrance of Bat Cave (Carter County, Kentucky) failed in the spring of 1996 as flood debris lodged against the gate, backing up water until the increased pressure finally collapsed the gate. The resultant flood pulse destroyed many low-roosting Indiana bats, a federally listed endangered species. (See Indiana bats, page X57.)

Predation Dangers

Predation can also increase dramatically because of badly located gates. Most bat predators rely on vision when hunting, so gates in the daylight or twilight zone may enhance the predators' foraging success. When bats slow down to negotiate the gate bars, or back up behind the gate waiting their turn to pass through, they are easily captured by enterprising raccoons, ringtails, and feral cats.

Gates installed beyond the twilight zone eliminate the predators' advantage. The old gate to the lower entrance of Sinnett–Thorn Mountain Cave (Pendleton County, West Virginia) had piles of Virginia big-eared bat wings around it from the nightly predations of local house cats. The gate was removed in October 1998 and a new gate was built in a tall area approximately 75 feet (23 meters) further in, despite having to maneuver the steel and equipment through a crawlway. The new gate, in the dark zone, has eliminated the predator problems.

Cupola or Cage Gates for Vertical Entrances

Vertical or near-vertical entrances pose their own set of problems. A horizontal gate at such an entrance accumulates debris, makes a perfect feeding platform for predators, and is very difficult for most bats to negotiate.

To solve these problems, a raised gate called a *cupola gate* or *cage gate* can be used. Generally, the longer and narrower the

Figure 2. This is a poorly designed gate, constructed of 1-inch (25-millimeter) round bars. It is not very secure—the bars may be easily bent and the welds are small. The small rectangular openings in the narrow vertical entrance make the gate difficult for bats to fly through. On this type of platform gate constructed in a vertical entrance, branches and leaves can collect to restrict airflow and light.

Figure 3. Idealized Sequence of Horizonal Bar Gate Construction Front and Side Views

Figure 3a. Measurements of the gate location, taken at regular intervals from a horizontal (level) line.

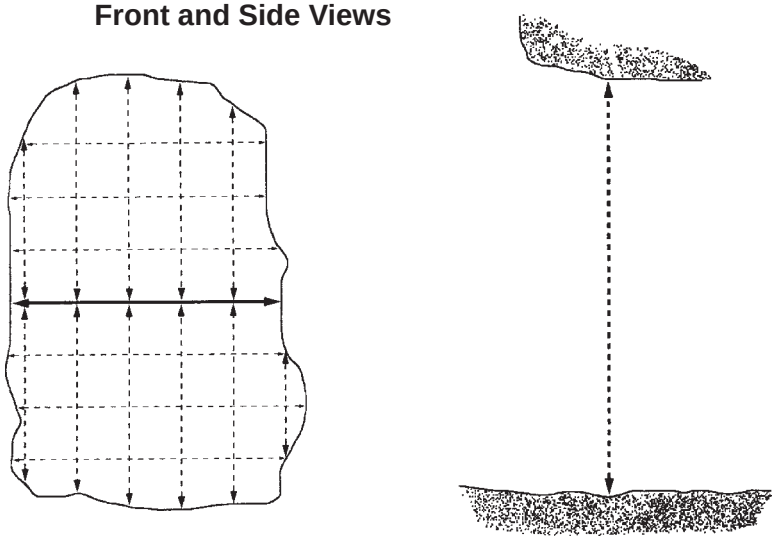


Figure 3b. Scale drawing of finished gate, used to estimate materials.

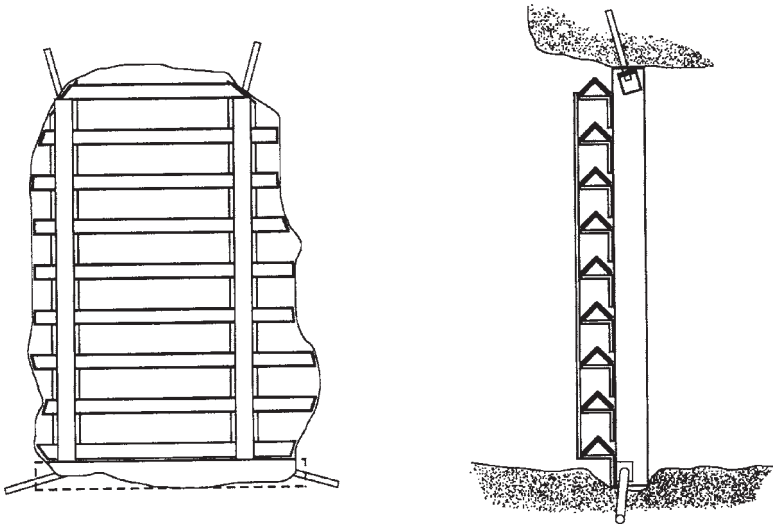
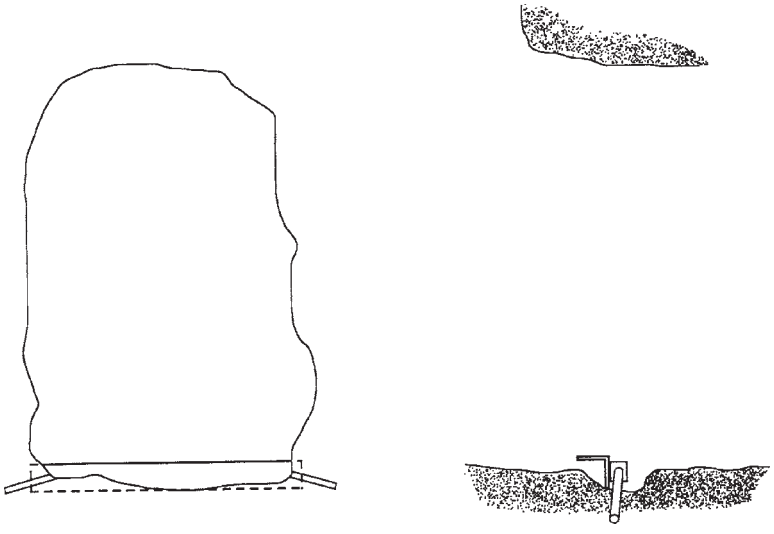
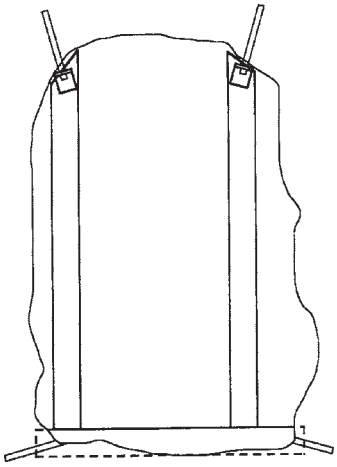


Figure 3c. Trenching and securing of sill.





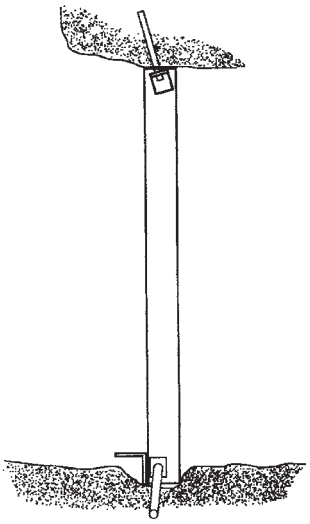
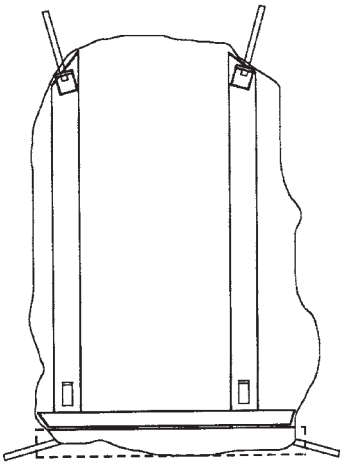


Figure 3d. Installation and securing of uprights.



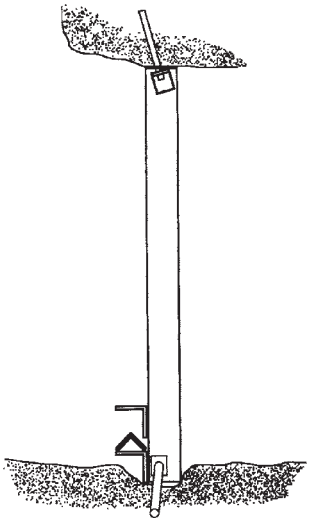
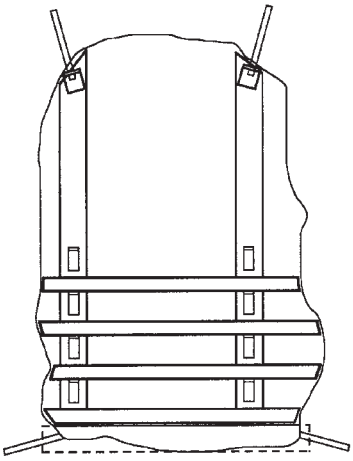


Figure 3e. Installation of bottom bar and hangers for second bar.



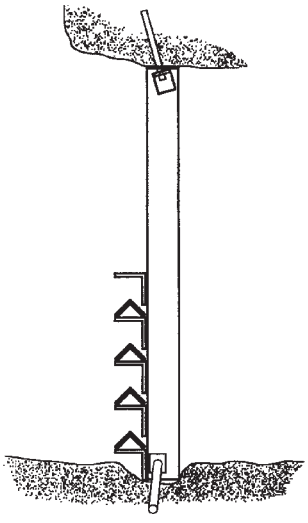


Figure 3f. Continuation of hangers and horizontal bars (for clarity, removable bar is not shown).

Figure 3g. Completion of horizontals.

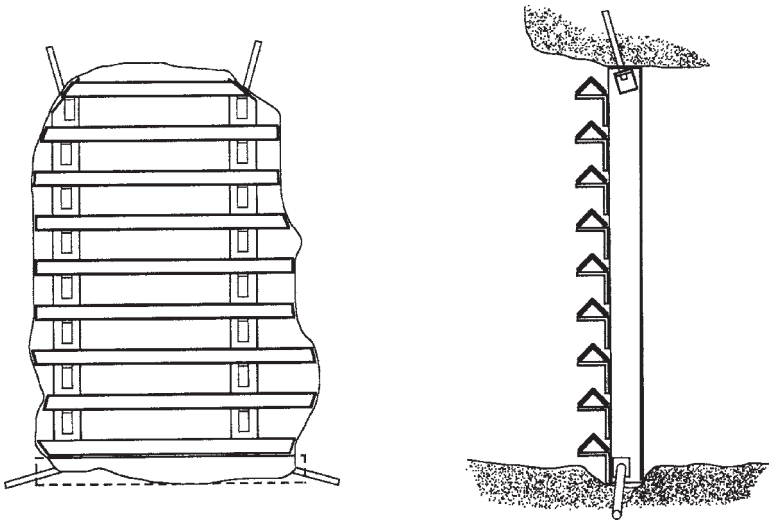


Figure 3h. Placement of bat guards.

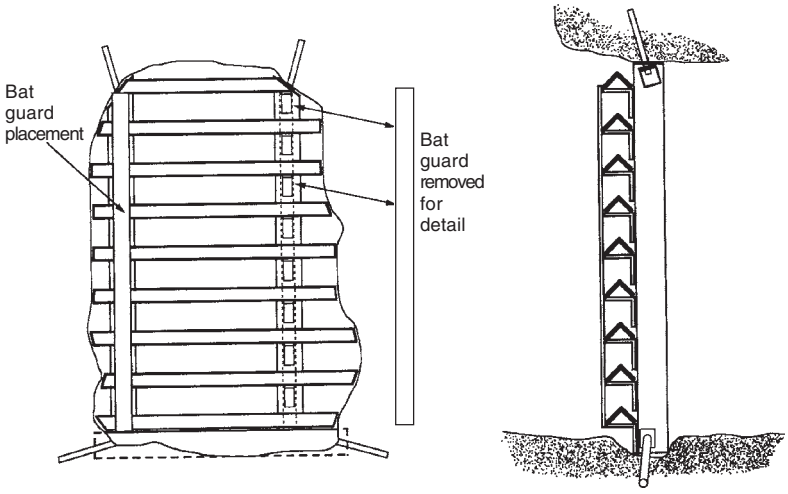
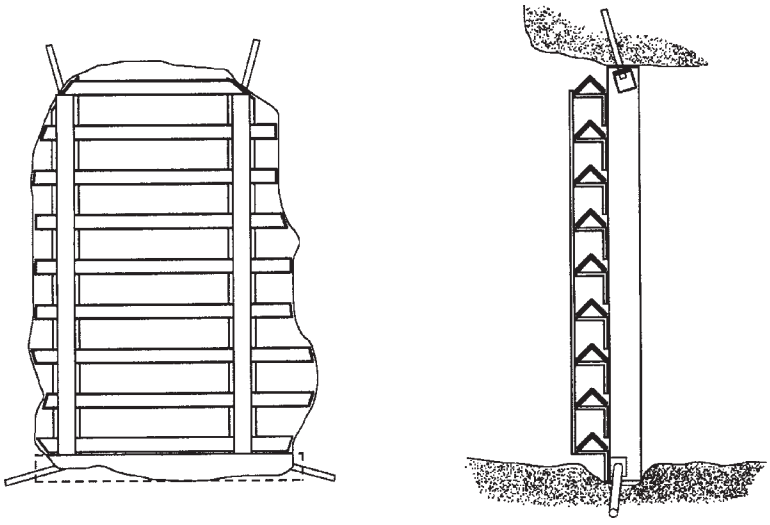
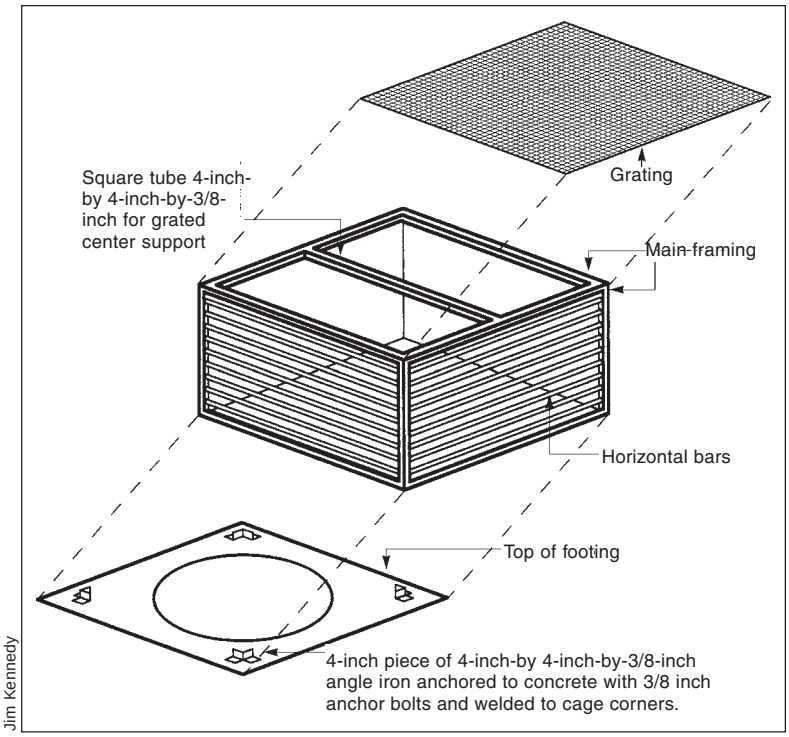


Figure 3i. Completed gate.



opening, the larger and taller the cupola gate should be in order to give the bats adequate space to gain altitude and avoid predators. Cupola gates are not practical for very large openings, and fencing may be the only option.

For vertical entrances with very short drops, a standard gate may be installed deeper within the cave where the passage begins to be more horizontal (when the vertical entrance itself is not a liability concern).



Jim Kennedy

Figure 4. A cupola or cage gate is often used in vertical or near vertical-entrances.

Chute or "Window" Gates

A recent innovation, since the late 1990s, is the chute gate, sometimes called a window gate. An otherwise standard horizontal gate is modified with a rectangular opening boxed in with additional angle iron and expanded metal mesh. This design allows sufficient opening for emerging bats and makes it very difficult for trespassers to breach the opening. The chute is usually angled to make it more difficult for humans to enter. This particular gate design is especially useful in caves with large bat populations, such as gray bat maternity colonies, which have entrances that are too small for traditional half gates or flyover gates. Because of the weight extending out from the main (standard) part of the gate and the resulting mechanical stresses, extra attention is needed in the design and construction to prevent future cracked welds and gate failure. Chute gates have been used successfully on numerous Alabama, Kentucky, Missouri , and Tennessee caves, and are well accepted by bats.

Figure 5. Chute gate at McDowell Cave, Missouri.

Nonstandard Gates

Caves that are entirely unsuitable for bats (as opposed to sites where bats are not currently found) may be candidates for gates that are not bat-friendly. However, the bat-friendly design is the preferred solution for most caves, except those that have no natural entrance and require some sort of environmental seal. Sometimes the availability of materials and volunteer labor, or the lack of adequate funds will dictate construction of a nonstandard (not bat-friendly) gate. Nonstandard gates are almost always poor substitutions.

Educational Signage

All finished gates require signs stating the purpose of the gate and contact numbers for more information. The penalty for entering the cave or vandalizing the gate can be written in small print, but this should not be the focus of the sign because it is often taken as a dare by would-be vandals.

Figure 6. Typical bat gate (not to scale).

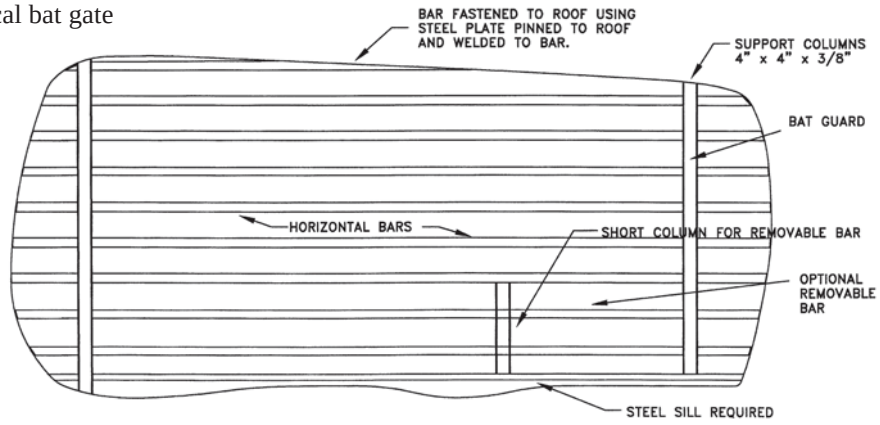


Figure 7. Horizontal bar spacing, typical detail (not to scale).

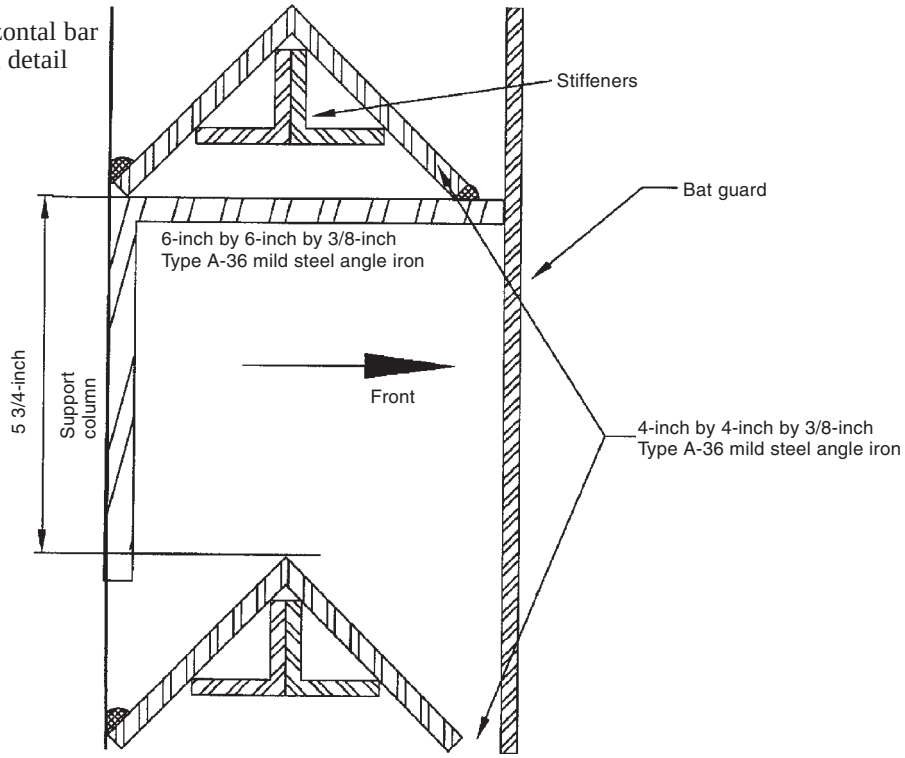
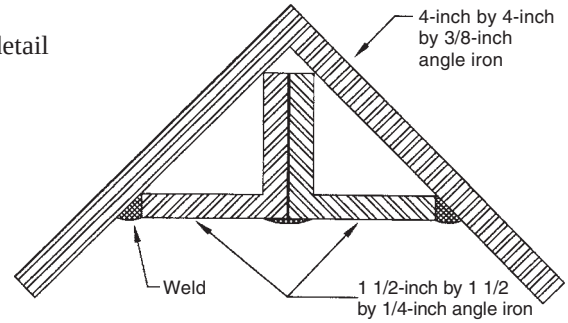


Figure 8. Stiffener detail horizontal bars (not to scale).



Stiffeners run the full length of the the horizontal bar, except for being 2-inch shorter on each end

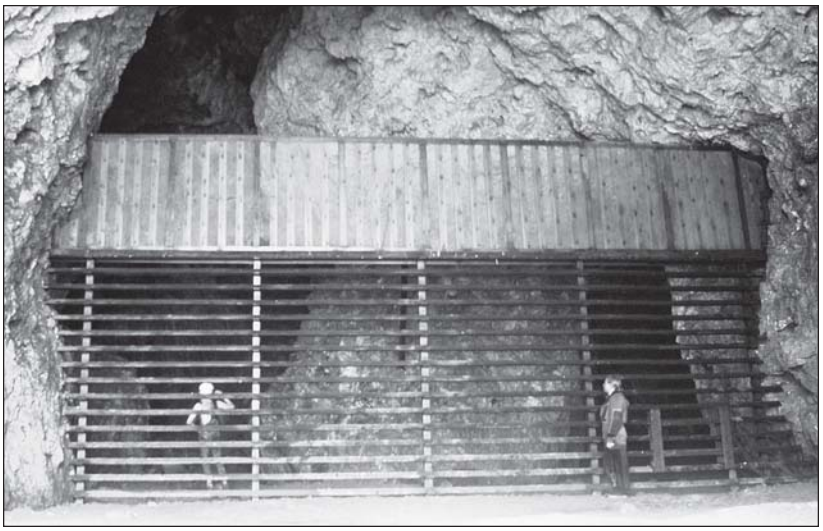


Figure 9. Half or "flyover" gate. Note the removable bar at bottom right. Expanded metal mesh covers the overhanging top portion, making it extremely difficult to climb over. Coating the overhang with grease also helps repel trespassers.

Educational material is less antagonistic.

Signs themselves sometimes become collectors' items, or are needlessly damaged by thwarted cave visitors. Permanent signs mounted inside the gate where they can be read, but are out of harms way, will last longer. Paper and wooden signs are highly susceptible to weather, decomposition, and the gnawing teeth of rodents. Metal or plastic signs are preferred. (See protective signs in caves, page X187.)

Permanent signs mounted inside the gate where they can be read but are out of harms way will last longer.

Construction Logistics

This cave gating chapter is no substitute for a more complete cave gating manual or training workshop. While it covers the rudiments of cave gating to assist resource managers in making better informed decisions, it is too brief to help with actual design and installation. Nevertheless, here we provide information for better planning of gating projects. Further assistance is readily available on request. (See cave gating resources, page X168.)

Timing

Construction should take place during seasons when human activity is least disturbing to the cave resources. For bat caves, this means the work must be done when the bats are absent. Some caves may be used as both summer and winter roosts, which leaves only short periods in the spring and fall for construction. Seasonal temperature variations may also cause reversals in the cave's airflow. If the cave is drawing in air, it may be necessary to install temporary plastic curtains inside the construction site to keep smoke and noxious welding fumes out of the cave. (See toxic fumes, page X49.)

Construction should take place during seasons when human activity is least disturbing to the cave resources.

Materials

Ordering adequate materials depends on accurate estimates of the area to be covered. Gate construction projects require accurate measurements and scale drawings of the finished gate. Materials should be ordered well in advance of the actual gating and may need to be stored off-site in a secured area before being transported to the cave. Always order a little extra for emergencies.

Supplies

To help ensure completion of the project, carefully calculate welding

gases, welding rods, grinding wheels, and other expendables. It is much easier to return unused supplies, or save them for the next project, than to run out before the new gate is finished.

Tools

The remoteness of the site will dictate the type of tools needed, but almost every gating project requires an electric generator or two to run the welders, grinders, and lights. Most projects need the following equipment.

- Electric generator(s)
- Extension cords
- Oxy-acetylene torches (with spare tips and regulators)
- Chipping hammers and wire brushes
- Tape measures, levels, and squares
- Ladders (for tall gates)
- C-clamps
- Portable work lights
- Hammer drills and hand-held grinders
- Digging and rock breaking tools to prepare the site

Every cave gating work plan needs to address the protection of the cave and surrounding site as well as the safety of the workers involved.

Also, provide the following safety equipment at cave gating sites.

- Rakes and water for fire control
- Buckets
- Welding vest, hood, and gloves
- Cutting goggles, and so on

Always plan for things to break, so have backups on site or readily available. Other equipment such as come-alongs, pulleys, chainsaws, all terrain vehicles, or in extreme cases, a helicopter may be needed to move materials to the site.

Short, 8-foot (2.5-meter) lengths of 1-inch (25-millimeter) tubular nylon webbing tied in loops make excellent carry handles for moving lengths of steel. Tools should be color-coded or labeled so they get back to their proper owners. Be careful to keep track of tools and equipment. Tools are especially easy to lose in or around the cave area.

Transportation of Materials

Many ingenious methods have been developed for moving materials to cave sites. Rarely can the delivery truck drive to the cave mouth. For long hauls, caver power may suffice, given a large enough workforce. Animal power (horses, mules, and burros) is sometimes used. All-terrain vehicles are sometimes used in nonwilderness areas with adequate trails. Boats or rafts may be necessary along rivers or lakes.

Materials may even need to be airlifted in extremely rugged terrain. Airlifts are sometimes accomplished with the cooperation of a local military reserve unit (the project may be used as a training mission). But during the course of most projects, all materials must be carried by hand. Keep in mind that a 20-foot (6-meter) length of 4-inch (10-centimeter) angle iron, 3/8-inch (9.5-millimeter) thick, weighs about 196 pounds (89 kilograms). Avoid pinched fingers and crushed toes by keeping safety in mind.

Personnel

The gate designer should oversee construction—this person is most important in any gating project. Currently, there are very few people in North America with the experience needed for all but the simplest jobs. (See contact list, page X170.)

Next comes the welder, who may be an agency employee, a volunteer, or a person hired specifically for the project. Depending on the size of the gate and the amount of work necessary, it is usually good to have several welders (people and machines) available to make the work go faster and to offer rest breaks.

Gating projects also need one or more welding assistants, anticipating the next piece to be cut, handing tools, taking measurements, and generally facilitating the workflow so that no one is standing around idle.

Finally, a project needs sufficient labor to prepare the site, carry items from the cutting area to the gate location, carry the steel from the drop point to the work area, and clean up afterwards. These workers can be hired with the welder, be provided by the responsible agency or organization, or be volunteers such as local cavers.

In several gating projects, prison labor was arranged for much of the heavy work. Using volunteers is beneficial because it involves the cave's user groups, educates them about purposes for the gate, and lessens potential for opposition and future vandalism to the gate.

Don't forget to take care of the safety and well-being of your workers. Provide plenty of food and drinks, and give adequate recognition after the project is finished.

Safety

Every cave gating work plan needs to address the protection of the cave and surrounding site as well as the safety of the workers involved. Prevent ground fires from starting at the work site. It may be necessary to temporarily remove dead leaves or grasses in the areas where cutting, welding, and grinding occur. As a precaution, have plenty of water and fire fighting tools (rakes and shovels) on hand. An Indian Pump or chemical fire extinguisher is also handy.

All workers should wear leather work boots, preferably steel-toed, as well as leather gloves, hardhats (caving helmets are fine), long pants, long-sleeved shirts or coveralls, protective eyewear, as well as hearing protection, especially when working around the welders, torches, and grinders. Caution all workers not to look directly at the torch flame or welding arc. Brief the crew on hot metal, heavy objects, potential dangers from the tanks of welding gases, and any other hazards specific to the site (loose rock, steep slopes, poison ivy, and the like). Keep a well-stocked first-aid kit on site. Also, be aware of the dangers of exhaustion, dehydration, hypothermia, and heat-related illnesses. Be sure the team takes breaks, eats during the day, and keeps hydrated.

Site Restoration

It may be difficult, but try to minimize disturbance of rocks, vegetation, and ground cover during steel hauling and other work. Natural contours should be restored after the gating is completed, unless the work on the cave entrance includes retuning it to a former historic configuration in an attempt to restore internal conditions. Sites may need revegetation, and trails may need to be blocked to divert casual hikers from the cave. All trash should be picked up and removed, including all scrap metal and as much welding waste as possible, including welding rod stubs. Cave gates, after painting (if necessary), should blend in rather than attract attention.

If an entrance was previously modified or enlarged, gating processes may provide a perfect time to restore the entrance to a former ecological state. Keep in mind that, relatively speaking, caves are short-lived geologic features that constantly change.

Entrances open and close naturally during the life of some caves, sometimes repeatedly. Choosing the historic baseline configuration is sometimes a judgement call based on the special resources for which the

site is actively managed. For declining populations of endangered Indiana bats, for instance, we would aim for restoration to a time frame of pre-European settlement, but post-Pleistocene.

Locks and Removable Locking Bars

Many modern gates now dispense with hinged doors entirely, and use removable locking bars.

Since the main purpose of a cave gate is to secure the site from intrusion, the choice of locking mechanism is critical. Many modern gates now dispense with hinged doors entirely and use removable locking bars. The removable bars can be secured with standard padlocks or with specially keyed bolts, similar to automotive locking lugnuts. Removable bars have several advantages.

- Removable bars are easy to construct.
- They disguise the obvious entry point.
- They eliminate the use of moving parts.
- They reduce maintenance tasks.

All padlock mechanisms must be designed to protect the lock from damage. Locks should be inspected regularly and replaced at the first sign of trouble or failure. No gate is completely vandal proof, but the idea of building a strong gate secured by a weak lock is ridiculous. If the cave is worth gating, make it as secure as possible.

Monitoring and Maintenance

So, you have finished building the gate and restored the entrance zone to a natural appearance. Job well done, right? More like job half done. There are no guarantees that the gate will accomplish your objectives despite your most careful planning.

Instead of helping maintain or restore the cave's ecosystem, a gate may cause further problems. Only long-term monitoring and assessment will tell. For bat caves this entails nightly and seasonal observations to monitor and ensure the bats' behavior is unchanged and uninterrupted. For other critters, monitoring might involve population estimates via specific sampling techniques. Monitoring requirements also point out the need to establish good baseline data before gate installation so comparisons can be made with postgating data. At the minimum, temperature and airflow should be recorded, but observations of moisture and humidity, animal distribution, and nutrient flow are also useful.

If the gate is not doing its job, then it should be modified or even removed.

If the gate is not doing its job, then it should be modified or removed. Many bat caves gated in the 1970s and early 1980s were thought to be protected and were largely ignored thereafter. Continuing bat population declines puzzled researchers, who *believed* the caves were protected and looked for other reasons to explain decreases.

Recent advances in gating knowledge show that the gates themselves were causing negative impacts on the caves because they were poorly designed or placed, or because the entrance was modified during the gating process. In an extreme case, the temperature of the cave was raised by as much as 5°F (2.8°C). Temperatures were restored and the population began to increase when the original gate was replaced with a better-positioned and better-designed closure. Monitoring programs are now initiated early in gating projects to identify and correct bad situations before human modification results in tragedy.

Gates must also be monitored for the inevitable breaching attempts. Certain segments of our society delight in trying to break into places where access is denied. Proper signage will go a long way toward educating most of the public about the reasons the cave was gated. Signs should point

visitors to more information and contacts for access. Gaining the trust and cooperation of user groups and local cavers during the planning and construction processes will also alleviate potential animosity and break-in attempts.

Repairing Damage

Any damage to the gate should be repaired immediately—otherwise, you will be repairing more damage and dealing with illegal entries. When design flaws and weaknesses are discovered, you have the obvious opportunity to modify the gate and make it stronger. As noted gate expert Roy Powers says, "We have to keep one step ahead of the vandals." Be careful not to negatively impact the cave environment with security modifications.

Recurring vandalism may require increased security measures, such as surveillance. Sometimes trustworthy local cavers can be named as volunteer cave stewards who can provide much-needed manpower for patrolling the site. A well-publicized arrest of trespassers vandalizing a posted cave gate makes a wonderful deterrent to other would-be lawbreakers. Many other clever techniques have been utilized to deter vandalism, including fake monitors and signs announcing (usually nonexistent) alarm systems. Real alarms can also be used, triggering a dispatch to the agency office or local law-enforcement authorities.

To get hands-on training, participate in one of the Cave Gating Seminars co-sponsored by the American Cave Conservation Association, Bat Conservation International, the US Fish and Wildlife Service, and the USDA Forest Service.

Cave Gating Resources

If, after reading this, you feel overwhelmed and want to stay as far away from cave gating issues as possible, RELAX! There are several sources of excellent assistance available to help you. Modern, bat-friendly cave gates (also called zero-airflow-reduction bat gates) are the result of many years of experimentation and development, supplemented by field observation, strength testing, and wind tunnel testing.

The design presented in this chapter is the standard accepted by most federal and state agencies that manage caves, and by organizations such as The Nature Conservancy and Bat Conservation International. The leading force behind bat-friendly gate development has been the American Cave Conservation Association, particularly Roy Powers. Detailed drawings may be requested from them. Across the country, there are examples of many adaptations showing varying degrees of success. Successful gate designs provide entrance security and avoid the blockage of airflow, water, nutrients, and animals.

Current Books on Cave Gate Design

Bat-friendly gate designs are also widely used for closing abandoned mines. Mines and caves are similar, but not equivalent management concerns. Mines usually lack the complex ecosystems and recreational values that caves offer, and mines often pose bigger liability problems. Mines are extremely short-lived in comparison to caves. Stabilizing or closing mine entrances to achieve desired conditions does not have the ramifications that such actions cause in undisturbed caves. Bat Conservation International (BCI) has produced a free booklet, *Bats and Mines*, that discusses in detail the suitability of mines as habitat, addresses the dangers associated with them, and includes full plans for both standard and cupola gates. The booklet also offers excellent template forms for conducting external and internal summer and winter bat site assessments. (In the additional reading list for this chapter, see Tuttle and Taylor 1998.)

The authors and editors know of no modern, comprehensive, published gate plans for caves that have no bats or other vertebrates. *Trap door gates*

and *air lock gates* are common in several parts of the United States but are usually built by local experts.

A detailed book on cave gating has been developed by the US Fish and Wildlife Service, the USDOI Office of Surface Mining, Bat Conservation International, the American Cave Conservation Association, the National Speleological Society, and numerous other sponsors. It includes the entire proceedings from the groundbreaking conference on cave and mine protection options held in Austin, Texas, in March 2002. It is available through the National Speleological Society and covers the entire gating process in detail. (In the additional reading list for this chapter, see Vories and others 2004.)

Modern, bat-friendly cave gates (also called zero-airflow-reduction bat gates) are the result of many years of experimentation and development, supplemented by field observation, strength testing, and wind tunnel testing.

Cave Gating Seminars

To get hands-on training, participate in one of the Cave Gating Seminars cosponsored by the American Cave Conservation Association, Bat Conservation International, the US Fish and Wildlife Service, and the USDA Forest Service. These workshops combine evening slide lectures and discussions with hands-on gate building experience. The small group residential setting teaches design and placement philosophy, covers design options and case studies, and offers an opportunity to interact with some of the most knowledgeable cave gaters in the country. Contact the American Cave Conservation Association or Bat Conservation International for dates and locations of upcoming workshops.

Cave Gate Contractors

There are also several private individuals and firms that will contract gate-building projects. The best of these have many years experience or are graduates of the Cave Gating Seminar. Names of those known to be knowledgeable and reliable can also be obtained from Bat Conservation International or the American Cave Conservation Association. (See the contact list at the end of this chapter, page 170.)

Summary

Cave gating is only one form of cave protection. It should not be undertaken without sufficient study and planning. There are many types of gates and the manager should choose the type that best protects the resources within the cave and best fits the cave configuration.

Planning, construction, and follow-up activities are time and resource intensive. Gating projects may require a lot of manpower and other resources, including volunteers as well as specialized equipment. There are several sources of expertise and possible funding assistance for gating projects. Gating experts should always be contacted before any work begins.

There are several sources of expertise and possible funding assistance for gating projects.

Additional Reading

Anon. 1985. Volunteers protect Tennessee bats. *American Caves* 1(2):8-9.

Anon. 1993. James Cave receives new gates for bats. *Bats* 11(3):4.

Anon. 1993. BCI helps protect Pennsylvania mine for bats. *Bats* 11(4):16-17.

Anon. 1995. New ACCA gates protect Kentucky and Tennessee caves. *American Caves* 8(1):10-11.

Anon. 1997. Gates, gates, and more gates! *American Caves* 10(1):6-7.

Bat Conservation International (BCI). BCI home page. <http://www.batcon.org>. Direct link to full articles from *Bats Online*. <http://www.batcon.org/batsmag/batindex.html>. Accessed 2004 March 30.

Bobo K, Greene J. The gating of Wolf River Cave. *NSS News* 58(10):283, 286, 294.
Brady JT. 1985. Cave management for the endangered Indiana bat (Myotis sodalis) and gray bat (Myotis grisescens). In: Thornton H, Thornton J, editors. *1982 Cave Management Symposia Proceedings*. Richmond (VA): American Cave Conservation Association. p 86-95.
Brown CB. 1996. Bat habitat in caves: What are the caver's responsibilities? *NSS News* 54(2-3):52-53.
Burghardt JE. 1997. Bat-compatible closures of abandoned underground mines in National Park System units. In: Brandt JE, editor. *1997 Proceedings of the American Society for Surface Mining and Reclamation*. Lexington (KY): American Society for Surface Mining and Reclamation. p 184-195.
Currie RR. 2002. Response to gates at hibernacula. In: Kurta A, Kennedy J, editors. *The Indiana Bat: Biology and Management of an Endangered Species*. Austin (TX): Bat Conservation International. p 86-99.
Dutko R. 1994. Protected at last, the Hibernia Mine. *Bats* 12(3):3-5.
Elliott WR. 1996. The evolution of cave gating. *American Caves* 9(2):9-15.
Elliott WR. 2001. Project reports 2000: Missouri caves. *American Caves* 14(3):6-9.
Elliott WR. 2001. *Cave Gating Criteria*. Unpublished document for the Missouri Department of Conservation. 5 p.
Fletcher MR. 1985. Endangered bat protection at Buffalo National River, Arkansas. In: Vandyke JE, editor. *1984 National Cave Management Symposium Proceedings. Missouri Speleology* 25(1-4):147-150.
Forbis S, Haskins V, Foster DG. 1996. Protecting the ancient history of Crumps Cave. In: Rea GT, editor. *1995 National Cave Management Symposium Proceedings: Spring Mill State Park, Mitchell, Indiana, October 25-28, 1995*. Indianapolis (IN): Indiana Karst Conservancy. p 88-92.
Hathorn J, Thornton J. 1987. The common sense guide to cave gates. In: *ACCA Cave Management Series* 1(3):23-45. Horse Cave (KY): American Cave Conservation Association, Inc.
Hathorn J, Thornton J. 1993. Cave gates: design and construction considerations. In: Foster DL, Foster DG, Snow MN, Snow RK, editors. *1991 National Cave Management Symposium Proceedings: Bowling Green, Kentucky, October 23-26, 1991*. Horse Cave (KY): American Cave Conservation Association, Inc. p 359-363.
Hopper HL. 1999. Cave gating: three success stories. *American Caves* 12(3):6-9.
Hunt G, Stitt RR. 1975. *Cave Gating*. Huntsville (AL): National Speleological Society. 60 p. [Editors' note: Cave Gating (2nd edition). 1981. Huntsville (AL): National Speleological Society. [Use these books for historical reference only—gate designs are outdated.]
Ludlow ME, Gore JA. 2000. Effects of a cave gate on emergence patterns of colonial bats. *Wildlife Society Bulletin* 28(1):191-196.
MacGregor J. 1993. Responses of winter populations of the federal endangered Indiana bat (Myotis sodalis) to cave gating in Kentucky. In: Foster DL, Foster DG, Snow MN, Snow RK, editors. *1991 National Cave Management Symposium Proceedings: Bowling Green, Kentucky, October 23-26, 1991*. Horse Cave (KY): American Cave Conservation Association. p 364-370.
Martin KW, Puckette WL, Hensley SL, Leslie DM Jr. 2000. *Proceedings of the Oklahoma Academy of Science* 80:133-137.
Murphy M. 1993. Restoring Coach Cave. *Bats* 11(3):3-5.
Nieland J. 1996. Washington's Christmas Tree Cave gated–Bats protected. *American Caves* 9(2):16-17.

Olson R. 1996. This old cave–The ecological restoration of the Historic Entrance ecotone of Mammoth Cave, and mitigation of visitor impact. In: *Proceedings of the Fifth Annual Mammoth Cave Science Conference*. Mammoth Cave (KY): National Park Service and Cave Research Foundation. p 87-95.

Powers RD. 1985. General cave gate considerations. In: Thornton H, Thornton J, editors. *1982 National Cave Management Symposium Proceedings*. Richmond (VA): American Cave Conservation Association. p 77-79.

Powers RD. 1993. Design improvements for gating bat caves. In: Foster DL, Foster DG, Snow MN, Snow RK, editors. *1991 National Cave Management Symposium Proceedings: Bowling Green, Kentucky, October 23-26, 1991*. Horse Cave (KY): American Cave Conservation Association. p 356-358.

Powers RD. 1996. A study of acoustical confusion. In: Rea GT, editor. *1995 National Cave Management Symposium Proceedings: Spring Mill State Park, Mitchell, Indiana, October 25-28, 1995*. Indianapolis (IN): Indiana Karst Conservancy. p 274-276.

Quinn M, Petterson J. 1997. A grand effort in the Grand Canyon. *Bats* 15(3):4-7.

Raesly RL, Gates JE. 1986. Winter habitat selection by north temperate cave bats. *American Midland Naturalist* 118(1):15-31.

Richter AR, Humphrey SR, Cope JB, Brack V Jr. 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). *Conservation Biology* 7(2):407-415.

Roebuck BE, Vakili A, Roebuck L. 2001. Cave gate airflow disturbance: a qualitative study. In: Rea GT, editor. *Proceedings of the 14th National Cave and Karst Management Symposium: Chattanooga, Tennessee, October 19-22, 1999*. Chattanooga (TN): Southeastern Cave Conservancy. p 169-175.

Roebuck L. 2000. Gating in Tennessee: a plethora of summer bat protection projects. *American Caves* 14(1):6-8.

Stihler CW. 2000. Gates constructed to protect bats in West Virginia caves. *American Caves* 13(2):15-16.

Toomey, RS III, Coburn ML, Olson RA. 2002. Paleontological evaluation of past use of caves by the Indiana bat: a significant tool for restoration of hibernacula. In: Kurta A, Kennedy J, editors. *The Indiana Bat: Biology and Management of an Endangered Species*. Austin (TX): Bat Conservation International. p 79-85.

Tuttle MD. 1977. Gating as a means of protecting cave-dwelling bats. In: Aley T, Rhodes D, editors. *National Cave Management Symposium Proceedings: Albuquerque, New Mexico, October 6-10, 1975*. Albuquerque (NM): Speleobooks. p 77-82

Tuttle MD, Stevenson DE. 1978. Variation in the cave environment and its biological implications. In: Zuber R, Chester J, Gilbert S, Rhodes D, editors. *1997 National Cave Management Symposium Proceedings: Big Sky, Montana, October 3-7, 1977*. Albuquerque (NM): Adobe Press. p 108-121.

Tuttle MD. 1985. Joint effort saves vital bat cave. *Bats* 2(4):3-4.

Tuttle MD. 1997. A Mammoth discovery. *Bats* 15(4):3-5.

Tuttle MD, Taylor DAR. 1998. *Bats and Mines*. Resource Publication (Bat Conservation International) No 3. Revised edition. Austin (TX): Bat Conservation International.

Tuttle MD. 2000. Where the bats are, Part III: caves, cliffs, and rock crevices. *Bats* 18(1):6-11.

Tuttle MD, Kennedy J. 2002. Thermal requirements during hibernation. In: Kurta A, Kennedy J, editors. *The Indiana Bat: Biology and Manage-*

ment of an Endangered Species. Austin (TX): Bat Conservation International. p 68-78.
Twente JW Jr. 1955. Some aspects of habitat selection and other behavior of cavern-dwelling bats. *Ecology* 36(4):706-732.
Vories KC, Throgmorton D, Harrington A, editors. 2004. *Proceedings of Bat Gate Design: A Technical Interactive Forum held in Austin, Texas, March 4-6, 2002*. Carbondale (IL): USDOI Office of Surface Mining, Alton, Illinois and the Coal Research Center, Southern Illinois University at Carbondale. 434 p. Proceedings available on the internet <http://www.mcrcc.osmre.gov/bats/>. Accessed 2004 March 30.
Werker JC. 2005. Materials considerations for cave installations. In: Hildreth-Werker V, Werker JC, editors. *Cave Conservation and Restoration*. Huntsville (AL): National Speleological Society. p 171-178.
White DH, Seginak JT. 1987. Cave gate designs for use in protecting endangered bats. *Wildlife Society Bulletin* 15:445-449.

Contacts for Additional Information

American Cave Conservation Association (Roy Powers or Dave Foster)
PO Box 409
Horse Cave, KY 42749-0409
502.786.1466
<acca@caveland.net>
<http://www.cavern.org/>

ACCA Northwest Chapter (Jim Nieland)
12178 Lewis River Rd
Ariel, WA 98603-9745
360.247.3946
360.247.3901 fax
<jnieland@fs.fed.us>

Bat Conservation International (Jim Kennedy)
PO Box 162603
Austin, TX 78716-2603
512.327.9721, extension 17
512.327.9724 fax
<jkennedy@batcon.org>
<http://www.batcon.org/>

US Fish and Wildlife Service (Bob Currie)
160 Zillicoa Street
Asheville, NC 28801-1038
828.258.3939, extension 224
828.258.5330 fax
<robert_currie@fws.gov/>