LOW DISTURBANCE TECHNIQUES FOR MONITORING BATS

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ABSTRACT

Human disturbance through recreational caving and research has been a factor in the decline in bat populations in the United States. In recent years there has been an increased effort on the part of land management agencies to preserve the unique features and biologic contents of caves. This process has been accelerated with the passage of the Federal Cave Resources Protection Act. The federal agencies have frequently depended upon volunteers to perform many of the cave monitoring tasks needed to make sound management decisions. Unfortunately, this monitoring may lead to additional disturbance of bat roosts. It is imperative that the cave monitoring process not contribute to the decline of bats.

The low disturbance techniques used at Kartchner Caverns State Park in Arizona were developed to monitor a maternity colony of Cave Bats (Myotis velifer). These techniques are particularly suited for use by volunteers. Because bats may abandon a roost if disturbed, as much information as possible should be collected when the bats are not occupying the cave. With proper scheduling of cave visits before the bats seasonally return to the roost, information such as species identification, and favored roost locations can frequently be determined. Once the bats are using the cave, the size of the colony can be monitored by counting bats at the entrance when they exit in the evening. Agencies managing caves should develop monitoring programs that will provide management information while protecting bat roosts and educating volunteers in low disturbance techniques.

INTRODUCTION

Since 1990, when the Federal Cave Resources Protection Act was enacted, federal agencies have been mandated to address the management of their caves and karst resources. In order to do this, the cave managers have suddenly needed to know what caves they have on their lands. Many times the agencies have turned to cavers and speleologists to help them locate and inventory the caves. It appears to be a reasonable partnership with the overall goal of all parties to protect the cave resources. Unfortunately this inventory process, with added visitation, has increased the impact to many caves and the cave inhabitants. The information needed by the cave managers is important to future management plans but there are a number of methods that can be used, particularly in caves used by bats, that minimize this impact. It would be counterproductive to adversely disturb the bats that you plan to protect.

In Arizona a non-profit organization performed a thorough baseline study of Kartchner Caverns, a well decorated cave, for Arizona State Parks prior to its planned development as a show cave. The cave houses a maternity colony of the Cave Bat (Myotis velifer) and a number of inventory techniques were utilized that minimized the disturbance to the bats in the roost while still getting data. These techniques minimized but did not eliminate disturbance to the bats. Bats are aware of human visitation in their roosts. Although we greatly reduced our presence by these procedures, we could not totally eliminate the disturbance. It may take a bit longer to acquire some of the data using "low disturbance" techniques, but the intolerance of many bats to human intrusion in their roosts (Smidley, 1991; Fenton, 1992) makes it worth the extra time. In many cases the inventory process is not on a tight schedule anyway, so timing is not the critical element.

This paper will only address those bats that utilize caves and mines. It has been suggested that bats' ancestors began to use caves to avoid predation, conserve moisture and provide a stable temperature (Kunz, 1982). Such roosts provide protection from many predators, particularly since bats can hang from the ceiling above danger on the floor. Unfortunately, this in not sufficient to protect bats from human intrusion into their roosts. As early as 1953, Charles Mohr, biologist and caver, was warning that man was playing a major role in the bats' decline. In 1972, at a symposium on cave bats held at the American Association for the Advancement of Science, scientists and cavers reported rapid declines in bat populations and confirmed that man contributed to the mortality of bats (Mohr, 1972). Even well-meaning humans performing cave inventories will cause disturbance. Therefore, it is imperative that this process of inventorying and monitoring bat roosts proceed with caution.

Some of the specific questions to be addressed regarding a bat roost include: a) what time of year do the bats live in the cave, b) what areas of the cave do the bats use, c) how many bats are in the roost, d) what species of bat uses the cave? At Kartchner Caverns State Park in southern Arizona, a number of low disturbance techniques were applied to answer these questions.

One of the first tasks of an inventory is to assess if and when bats are using the cave. There are a few caves that are used by bats year-round but many caves have conditions that are only favorable to the bats during a particular season (Kunz, 1982). A search through historical records and cavers' reports are the first place to look for any references to bats and their seasonal use of a particular cave. Bat excrement (guano) on the floor and formations will indicate that bats have roosted in the cave. The guano will also indicate which rooms in the cave are favored by the bats.
If a cave receives a lot of human traffic the guano may have become so compact that it is hard to identify. In addition to guano on the floor, staining on the ceiling can also be a good indication of bat use. The white or brown stains from urine and the body oils of bats may leave evidence of a bat roost on the walls and ceiling. Bat skeletons will also be evidence that bats have used the cave in the past. The temperature of the cave may indicate whether the site would be preferred by bats in the summer or the winter, since the temperature requirements of bats during these two seasons are so different (Kunz, 1982; Hill and Smith, 1984). If it is concluded that bats still use the cave, a low disturbance monitoring program can be established to answer the many questions about bat use of the site.

A number of inventory tasks can be performed during the season that the bats are not using the cave. The existing guano piles can be inventoried and photographed as baseline data. A complete photomonitoring of the roost when the bats are gone is an excellent basis for monitoring the site over time. Sometimes there are a number of guano piles throughout a bat cave in varying degrees of decay. Some piles will look like a dark soil, some will have complete pellets, and others will fall somewhere in-between. Noting the condition and location of the guano piles during the initial inventory will help later when assessing changes. Notes about mold and its condition on the guano should be recorded as mold is usually an indication of more recent deposition. Another such indication of recent deposition is any evidence of invertebrates living in the guano. Without at least a seasonal boost to their food supply, the numbers of invertebrates will diminish (Welbourn, 1992).

Another task that can be done during the time the bats are not in residence is an inventory of the bone material in the roost. A trained mammalogist will be able to tell what species of bat is using the cave from the bone material and may be able to determine whether it is a maternity colony if juvenile bone material is present (Anthony, 1988). Macro photographs, with a ruler for scale, will aid in identification of the species. Careful measurements with a sketch will also help, but care must be taken as bat bones are *extremely* fragile and may break apart if touched. If specimens will be removed from the site, the biologist who will do the identification should be contacted before material is removed as they may have the necessary permits and possible recommendations on the collecting procedure. Care must be taken to precisely record what bone material is taken and from what location. A plastic sign and inventory number can be left in place to facilitate the return of the bones after identification. Not *every* bone should be removed from the cave during this process. Indiscriminate collecting should be discouraged because once material has been removed, important information could be lost. Any bone material that is left in place should be clearly flagged to prevent damage from foot traffic.

Just before the bats are expected to return to the roost, guano sheets can be placed over existing guano piles and below ceiling stains. The first year or two, until it is determined where the bats prefer to roost , most areas indicating past use by the bats should be covered by a guano sheet. Care must be taken, however, that guano sheets be a material that does not suffocate living mold and invertebrates, impair the natural decay of the guano, nor introduce into the food chain new food by its own decay. A synthetic (non-cotton) netting like bridal veiling has been found to work quite well. To minimize disturbance in the roost, any trip into the cave to check the guano sheets should occur after the evening bat flight. This inventory may show what areas are currently being used by the bats. But these use areas may change during the season as the temperature and humidity requirements of the bats change. The guano sheets should be cleaned off each time before a deposit forms which "cements" the sheet to the guano pile. The invertebrates live on the top 1"-2" of the guano, and if the guano sheet becomes part of the pile, more damage will be done to the inhabitants when the cloth is removed (Welbourn, pers. comm).

Once the bats have returned to the site in spring, the task of figuring out how many bats use the roost may begin. In the past, researchers have entered the cave and used a white light to estimate how many bats were clustered on the ceiling. With this disturbance, bats would begin to drop off the ceiling into flight and soon if would be impossible to count the bats. To be sure all the bats were counted, a cave trip would have to include all the passages - which for some caves could be quite extensive. In addition to the confusion that flying bats would contribute, the researchers' estimates might vary greatly between individuals. This method of counting bats is particularly detrimental when using volunteer help because their lack of experience or knowledge will cause them to disturb the bats without getting much accurate data (Thomas and LaVal, 1988). Perhaps worse, it suggests to volunteers that it is acceptable to enter bat roosts and the practice of disturbance is applied to other sites.

At Kartchner Caverns, techniques suggested in *Ecological and Behavioral Methods for the Study of Bats* (Kunz, 1988) for observing and counting bats while minimizing disturbance to the bats were very successfully used. Volunteers would sit quietly outside the entrance with the sky backlighting the exiting bats (Thomas and LaVal, 1988). The conditions at Kartchner Caverns were ideal for this process because small constricting passages near the entrance caused the bats to leave in small groups. Although the entrance area at Kartchner lent itself to this technique, the same procedure has been successfully used at other caves with larger entrances and more bats. For this method to work with little or no disturbance, the volunteers must arrive with enough time so that they are seated before the first bat begins light testing. It is important that observers find a comfortable position to sit quietly for a long time because the flight can last an hour (or hours) depending on the number of bats in the roost. Only a small group (1-3 people) should sit near the entrance because the bats are aware of human presence and this can affect the exit pattern. The volunteer(s) should sit out of the flight path of the bats, preferably with the evening sky backlighting the bat flight. Sometimes, due to the orientation of the entrance, backlighting is not possible and it is then preferable to sit to one side of the entrance and allow the bats to exit in front of the viewer. A light should not be used unless absolutely necessary, but if used, a red filter should cover the headlamp (Thomas and LaVal, 1988). Many bats see red light but experience has shown us that they panic less, as determined by alterations to their flight behavior, with filtered light. It is also better to use an electric light with a rheostat so that a very dim light can be produced. Observers should not whisper to each other because whispering is very noisy in the ultrasonic range and certain sounds (like 's', 'p' and 't') are very audible to the bats. Thus, while talking is not recommended, if it is necessary, it should only be spoken in low tones. The volunteers should sit quietly until the flight is over. The number of bats leaving may fluctuate during the flight and care should be taken to allow enough time after the last bat to be assured that it isn't merely a lull in the flight.

Different equipment can be used to count the exiting bats. The most inexpensive is an inventory counter, which records one event (individual) each time a button is pressed. The disadvantage of this method is that when bats are milling about in the entrance early in the flight, the volunteer must keep track of returning bats and not add another count when this bat exits a second time (Thomas and LaVal, 1988). This can be very confusing, especially in inclement weather when the bats fly repeatedly in and out of the cave. This method produces a total number of bats exiting the site but tells nothing about the dynamics of the exit flight itself.

A more informative count can be made with a handheld calculator or lap top computer that is programmable and has an internal clock. Once the keys have been programmed, a particular key adds an additional count and records the time of that count and another key can be used to subtract a bat. Keys can be programmed to increase the count by 10 and/or 100 depending on the size of the colony. This technique may not work at large roosts (i.e. Carlsbad Caverns, New Mexico with 3/4 million bats or Bracken Cave, Texas with 20 million bats); however, many bat caves on federal lands have so few bats that they are easy to count, particularly with practice. It is recommended that the same volunteer(s) count at a particular cave as precision improves with practice. Constantly changing observers will introduce additional error into the results.

A piece of equipment that helps the accuracy of the count is a bat detector (Thomas and LaVal, 1988). As available light dims during the latter part of the exit flight, it becomes more and more difficult to see individual bats leave. A bat detector alerts the observer that a bat is exiting. In addition, if a site has more than one species of bat roosting in it, a bat detector might help the volunteers distinguish between the species if the bats echolocate on different frequencies. Some species of bat leave to forage later in the evening than other species. If the bat species being monitored leaves well after dark it may be necessary to use a night vision scope or infrared goggles (Barclay, 1988) with an infrared filter over an electric light. In the past such equipment has been very expensive but recently a number of models have become available at a more reasonable price.

Species identification of bats is not always correct when made by untrained observers. For this reason an experienced bat biologist may be necessary when the inventory requires species identification. At Kartchner Caverns the project mammalogist, a trained bat biologist, not only provided correct identification of bats, but was also instrumental in performing the technical work that required the necessary permits to net and handle wild bats in the field. Certain species of bats may be identified from a distance in the site. This is best accomplished by a bat biologist so that additional trips are not required to confirm the observations made by non-biologists. Identification should be accomplished using the low disturbance light techniques already discussed. However, some species of bats, for example, the bats of the genus Myotis, must be examined in the hand for correct identification.

One method to confirm the species of bat(s) using the cave is by netting them in the site. This can be very disturbing to the bats and may cause the animals to abandon the site (Kunz and Kurta, 1988). Because of this risk, at Kartchner Caverns we decided to net first at a water tank close to the cave. While bats netted there were disturbed, they would not necessarily associate the experience with the cave roost.

Over two summers, the dates of critical reproductive events for the (Myotis velifer) that used the cave were learned by netting at the water tank (Kunz and Kurta, 1988). Netting for at least a two year period allowed for annual variation in the dates of these events. By netting away from the cave, the bat biologist was able to decipher the period of pregnancy, parturition, lactation, and fledging of juveniles (Racey, 1988) without disturbing the bats in the roost and potentially driving then away. Confirmation of species identification in the roost itself was made in several ways. The bones and carcasses of bats found in the active roost area after bats had departed were all those of Myotis velifer. Two isolated individual bats were plucked off the wall away from the roost and identified. During the maternity season, fourteen bats netted at the water tank were banded with reflective tape on their bands (Barclay, 1988). A few nights later, a light was shone across the cave entrance and 5 reflective bands were seen on exiting bats. This confirmed that the (Myotis velifer) that had been banded at the water tank, where reproductive information was learned, were indeed the bats using the cave. Finally, late in the season, just before the bats left naturally for hibernation, exiting bats were netted outside the entrance and identified by species.

To confirm the presence of non-volant juvenile bats in the cave, a bat biologist made a trip into the roost ***after the evening bat flight*** to take a quick photograph of the juvenile bats on the ceiling. By using a telephoto lens the resulting photograph can be projected on a wall and the number of young and their different stages of development can be ascertained with less disturbance to the bats than observing them at length in the roost. On one such trip, the photo showed an adult female in the cluster of juveniles and this female was wearing a reflective bat band on her wing - again confirming the identity of these bats as those netted and studied away from the cave. It should be noted however, that even though the trip was made by a small party familiar with the cave and using red filtered light, the one or two adult females left in the roost were disturbed and attempted to move their young. After counting bats at the entrance of Kartchner Caverns for six years some very interesting patterns begin to emerge. By not using a white light to estimate the surface area of the cave ceiling covered by bats to calculate their numbers in the roost, the disturbance in the site was minimal. Also, since the bats were counted as they exited, some interesting fluctuations in the out-flight can be observed which may be worth additional study. If volunteers had entered the roost on a weekly basis (instead of making weekly counts at the entrance), it is possible that the female bats would have abandoned the site for a safer roost. They may have had to choose less favorable conditions in which to raise their young. This in turn would reduce the chances for survival of the young. It has been shown that maternity roost selection is one of the most important determinants in the survival of the juvenile bats (Tuttle and Stevenson, 1982). It is therefore imperative that any bat roost suspected to be a maternity colony be aggressively protected from human disturbance (Kunz, 1982; Fenton, 1992) whether it is by sport cavers or volunteers performing cave inventories.

A different type of roost is the cave or mine where bats hibernate. This type of roost is more difficult to monitor because the bats don't leave every evening and allow time to enter the roost to find out what part of the cave is being used. Guano sheets have limited value because when bats are in hibernation they are not defecating. However, they are still extremely critical sites to protect. As with maternity sites that have the best environmental conditions to assure the survival of the young, a hibernaculum also provides a particularly stable temperature and humidity for the species of bat that uses it (Hill and Smith, 1984; Smidley, 1991). Suitable hibernacula are in limited supply and once the bats have settled in for the winter - the site should be closed to sport caving.

A bat accumulates fat in the late summer for metabolic use during hibernation (McNab, 1982). It has been calculated that if disturbed, whether by cavers or monitoring personnel, a bat that awakens will burn the equivalent of 17 days of uninterrupted sleep (Harvey, 1992). If disturbed a number of times during the winter, a bat could literally starve to death before spring when it could again forage for food (Smidley, 1991). This is especially critical for juvenile bats because they potentially stored less fat by fall than the adults (McNab, 1982). It is therefore important for a hibernaculum to have a different monitoring program than a summer roost. The U.S. Fish and Wildlife Service census schedule is once every two years for endangered species and any researcher wishing to disturb a roost more often than once a winter should be required to submit a detailed proposal outlining the need for such a study before it is approved by the controlling agency.

After six years of monitoring the bat colony at Kartchner Caverns, an incredible amount of data have been collected that are still being analyzed. Because the low impact techniques have worked so successfully at this and other sites in Arizona, we recommend their use for any caves on federal land that will no doubt become part of the inventory process of the Federal Cave Resources Protection Act. Many notable researchers have stated that the decline in the numbers of bats is primarily due to human disturbance. If cave locations will be tabulated by the federal agencies, as required by the Federal Cave Resources Protection Act, then an aggressive management plan will need to be initiated to protect bat roosts from additional traffic.

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