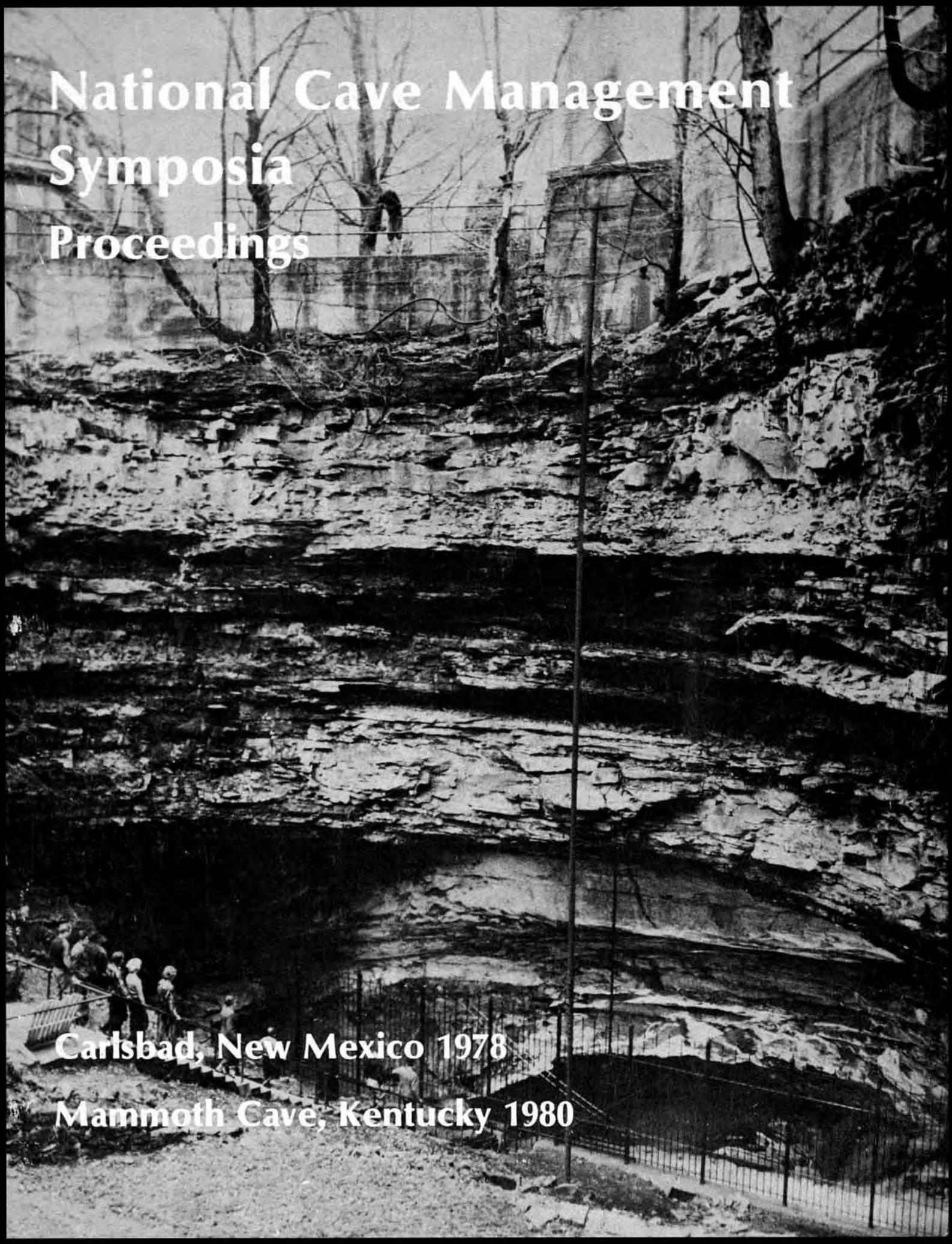
National Cave Management Symposia

Proceedings



Carlsbad, New Mexico 1978

Mammoth Cave, Kentucky 1980

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CARLSBAD, NEW MEXICO
OCTOBER 16 - 20, 1978

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MAMMOTH CAVE NATIONAL PARK, KENTUCKY
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Edited by Ronald C. Wilson and Julian J. Lewis

Front cover: A popular show cave until it was forced by domestic and industrial pollution to close in the 1940's, Hidden River Cave, Horse Cave, Kentucky has come to symbolize the problems of poor land use planning and lack of watershed management in the Mammoth Cave region of Kentucky. Circa 1940 photo courtesy of W. T. Austin.

Back cover: The explorer makes his way on untrodden earth, and he carries light to a realm that has been forever dark. New Discovery, Mammoth CAve, Kentucky, circa 1938. Ray Scott photo courtesy of Mammoth Cave National Park.

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PREFACE

This volume contains papers from both the Fourth National Cave Management Symposium held in Carlsbad, New Mexico on October 16-20, 1978 and the Fifth National Cave Management Symposium held in Mammoth Cave National Park, Kentucky on October 14-17, 1980.

The 1978 Symposium was composed largely of workshops and field trips, while the 1980 meeting emphasized formal presentations. Both formats were productive, but the formal presentations provided more written statements that can be used by people who were unable to attend the meetings. The consensus among participants of these symposia is that the meetings provide a much-needed forum for exchange of ideas from many agencies and diverse academic disciplines. We are grateful to the organizations and individuals whose support made the National Cave Management Symposia possible.

The Organizing Committee of the 1978 Symposium at Carlsbad was chaired by Ron Kerbo of the National Park Service. Other organizers included Cal Welbourn, Cave Research Foundation; Milford Fletcher, National Park Service; Joe "Buzz" Hummel, Bureau of Land Management; Katherine Rohde, National Park Service; Jerry Trout, U. S. Forest Service; Tim Anderson, National Caves Association; and Doug Rhodes, National Speleological Society.

The 1980 Symposium at Mammoth Cave was planned by two committees. Members of the Steering Committee were Bob Deskins, National Park Service; Joe "Buzz" Hummel, Bureau of Land Management; Jack Steiner, National Caves Association; Robert Stitt, National Speleological Society; and Cal Welbourn, Cave Research Foundation. Organizing Committee workers included Bill Austin, National Caves Association; Tricia Fink, Tennessee Valley Authority; Jim Goodbar, Green River Grotto; John Mylroie, National Speleological Society; Jim Wiggins, National Park Service; and Ron Wilson, Cave Research Foundation. Addresses for these individuals can be found in the list of participants at the end of this volume. Special thanks to Diane Karpoff of the University of Louisville for typing these proceedings. The next National Cave Management Sympoisum is planned for 1982 at a site not yet selected at this writing.

Ronald C. Wilson

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

SELECTED CAVE MANAGEMENT SITUATIONS IN NEW YORK STATE

*John E. Mylroie

Introduction

The Helderberg Plateau of central New York State contains the best area for cave exploration in the northeastern United States. This plateau extends westward from the Hudson River in the eastern part of the state and ends in the vicinity of Syracuse. The formation of caves has been especially pronounced in Albany and Schoharie counties (Figure 1) at the eastern end of the plateau.

The Northeastern United States is one of the most densely populated regions of the country. This large population and the limited amount of good areas for caves in the region results in a very high caver to cave ratio. Until recently, cave management was almost non-existent in New York but, due to the high traffic levels, it had become more and more essential with time. Commercial cave operators were about the only people who made an attempt to assess, inventory, and manage caves, and this was done in an exploitative manner, using caves as a resource. Still, commercial operations are preservational to a certain extent. The best example of this preservation is at Howe Caverns (Figure 1), which would have been almost entirely destroyed by the quarrying activities of a cement company, if the upstream part of the cave hadn't been a tourist operation. Twenty-five hundred feet of cave is estimated to have been quarried away, but about 8000 feet of cave were saved.

Cave management on public lands has either been non-existent, or a very basic plan of total exclusion. Recent activities by the State Parks and Recreation Division at the Clark Reservation in Jamestown, New York has resulted in one of the first attempts at cave management on public lands in the state. While still rudimentary, the management activity includes resource evaluation, preservation, and access control. This program was initiated in part by local cavers who are now assisting in its implementation.

Cave management by cavers and cave-oriented groups was primitive and haphazard until the 1970's. An increase in the number of cavers, plus the closing of a few important caves led to a sudden awareness in the caving community of the need for the management of caves. There is now a wide variety of individual and group cave management activities in New York State. Most of these have a strong inclination to access control and little else, but the other aspects of cave management, such as preservation and inventory, are beginning to be developed. From 1975 to 1977, the author had the opportunity to manage four separate cave properties in very different manners in Albany and Schoharie counties, New York. These four caves (Figure 1) were Knox Cave, Knox; Single X Cave, Gallupville; Caboose Cave, Gallupville; and McFails Cave, Carlisle Center.

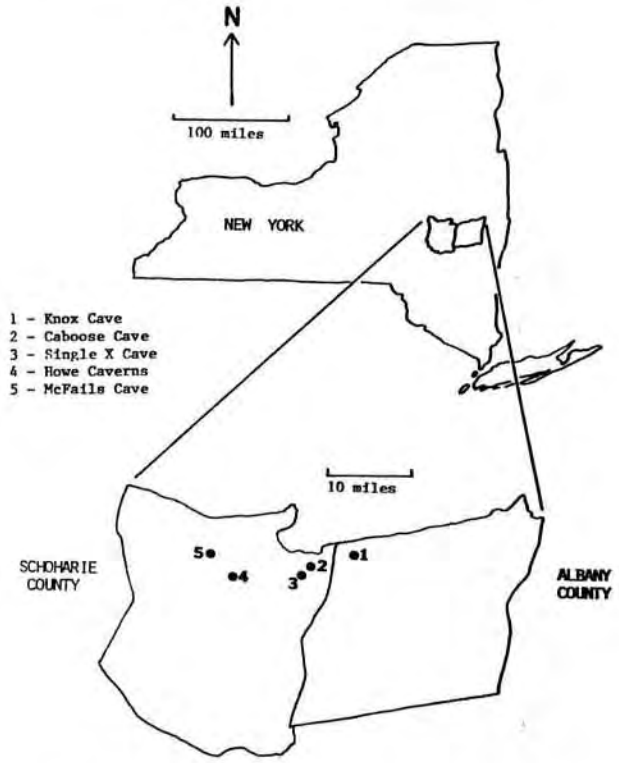

Figure 1: Location map of Albany and Schoharie Counties, New York showing placement of the caves discussed in the text.

These four caves represent a wide variety of conditions and options. They demonstrate not only that it is impossible to manage all caves in the same way, but also that it is best for each cave to be studied and handled in a different manner.

The Caves

Knox Cave: Knox Cave, a former commercial cave, located in Knox, NY (Figure 1), is well known and heavily trafficked. The commerical operation lasted from 1933 to 1958, and road signs and highway map locations persisted well into the 1960's. One oil company still had Knox Cave on its highway map as late as 1972. The commercial operation and its advertising carry-over into the 1970's resulted in very high visitation rates. Many minor accidents

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occurred over the years, mostly to novice caves, but in May, 1975, a large piece of ice fell from the vertical wall of the sinkhole entrance, killing one person and crippling another just as they were entering the cave. The owner, who had been trying to give the cave to the NSS for a tax write-off since the spring of 1974, was sued. He discussed control of traffic at Knox Cave with the author until both lawsuit and property transfer issues were resolved. At the owner's direction, the cave was fenced and the access road gated. The land was posted by the author, and he was appointed caretaker of the property. All visitors, whether novices or experienced cavers, were denied access. Notices of closure were placed in all area caving publications as well as at the cave site. Despite this, many people were caught trying to use the cave. If caught by the caretaker, they were warned and escorted from the property. If caught by local authorities, who were patrolling the area, arrests were made. Some well known and experienced cavers were among those apprehended, and re-inforced the concept that strict controls were necessary. Without strict access control, there was a serious threat that the cave would be permanently sealed, either by the owner, to remove the problem, or by the local residents, to end the nuisance. The cave had to be closed in order to save it.

Knox Cave has 3010 feet of accessible passage, and a variety of caving techniques must be used to traverse it. This diversity, coupled with the past publicity and the absence of water passages (rare in New York), made the cave very popular among a wide variety of individuals. This put intense traffic pressure on the cave, and closing the cave to save it was a very difficult task. Since the out-of-court settlement of the lawsuit, plans to transfer the cave to the NSS, or a similar group, have been moving along. The non-access policy is still in force, but does not require the extreme effort needed when first established. A complete discussion of the cave and its management can be found in Stitt and Addis (1975).

Single X Cave: Single X Cave is located on the south side of Barton Hill just west of Gallupville in Schoharie County, New York (Figure 1). The cave was discovered after an intense digging campaign conducted by the author and others in the spring of 1974. The circumstances surrounding the cave are somewhat unique. The cave is 3000 feet long and contains a tremendous room with 2000 feet of the finest passage in the state. Entry, however, requires a 750 foot crawl in water 42°F. The entrance is located at a spot described in an earlier publication (Gurnee, 1961) as having been checked and no accessible cave found. The management plan developed by the author (really just an access plan) called for successively decreasing secrecy about the cave.

The management problem presented by the cave was basically two-fold: (1) protection of the inexperienced caver from the hazards of the cave, and vice versa, and (2) maintain access through the development and maintenance of good landowner relations.

Item number 1 was not a real problem, since the entrance crawl is in cold water, is very long, and generally forbidding. This tended to inhibit entry by untrained and/or ill-equipped people. The primary hazard of the cave is in the entrance area where it can test and deter the unready without really endangering them.

Item number 2 was of real concern. The landowners were very friendly individuals and glad to see their cave enjoyed. Past experience had shown that such excellent landowner relations deteriorated quickly in uncontrolled situations. Since the cave was basically self-protecting as regards novices, and located where no cave was supposed to be, a secrecy approach was used. This method involved taking leading cavers from the region to the cave over a two-year period. The cavers were given a tour of the cave, and introduced to the landowners. As the level of secrecy decreased, the number of cavers in the area who had seen the cave and met the landowners increased. This gradual approach avoided a sudden, heavy traffic surge for the cave and the landowners. As stories about the grandeur of the cave spread, so did horror tales about the entrance crawl, and this also helped attenuate any mad dash by region cavers to see the cave. A more public approach was taken in 1976, as knowledge of the existence of the cave became widespread. A coordinator for Single X Cave was appointed, and a simple but reasonable access policy established and published in the regional caving magazines. Access has been based on asking permission and demonstrating adequate knowledge and equipment for caving. By approaching the access coordinator, the landowners were spared the necessity of dealing with strange people at unusual times of the day or night. The policy was very flexible and, since most of the applicants were known to the author, access decisions were easier to make.

The management plan for Single X Cave was not a complete program. A classic resource inventory was never done, but a complete survey, geologic description and photographic survey of the original features of the cave were accomplished before general knowledge about the cave was made public. The major concern of the author was to avoid any of the many problems associated with the discovery of new caves. Total secrecy for an indefinite period of time would eventually lead to alienation among the caving community because the secret would eventually get out. In regions where caves are more plentiful this is not the problem it is in New York. A new cave also poses problems in terms of safety, preservation and landowner relations. Gradual disclosure of the cave helped control a sudden surge in cave visitation, and so helped avoid many problems. This was especially important in this case, since the cave could not be gated.

Caboose Cave: Caboose Cave is located just north of Gallupville in Schoharie County, New York (Figure 1). The cave was discovered by the author in the fall of 1974 and was quickly dug into. While only 800 feet long, the cave contains a variety of interesting and sporting passages, as well as an excellent display of speleothems.

In order to protect the cave, an access plan was developed. The landowner did not live in the immediate vicinity of the cave, but was perfectly

willing to let the author manage the cave. This had two advantages: first, it gave complete authority to the cave manager; and second, it made by-passing the cave manager difficult, since the whereabouts of the owner was not obvious. Secrecy was used here as an early part of the management program, as at Single X Cave, and in a similar, planned-deterioration manner. This again prevented a sudden surge in traffice into the cave.

Physical access to the cave was relatively easy, so a gate was constructed. It was built of steel and concrete, with an obvious weak point to keep vandals from destroying the entire structure when attempting to break-in (no break-ins occurred in the two-year period the author managed the cave). The gate was a triangular-shaped piece of steel plate, covering a similarly shaped hole in the concrete platform covering the entrance. Each apex of the triangle gate was a locking point. This allowed access to the cave by opening any one of the three locks, and letting the other two act as hinges. With this arrangement, one lock was for the owner, one lock was for the regional cave rescue organization, and one lock for routine access. Each lock was different and had its own key and combination.

With access now secure, the actual program was set in motion. The cave was surveyed, photographed and inventoried in great detail. The cave was presented to the caving community in a comprehensive article published in the regional newsletter (Mylroie, 1975), complete with description, geology, hydrology, maps, and photographs. The purpose of this was to blunt curiosity about the cave by providing full disclosure in an open and frank way. Area cavers did not feel anything was being hidden from them, or that they were missing out on anything. As a result, actual requests to see the cave were slow in coming, and never reached a high level. Requests for access were made to the cave manager, and evaluated based on the manager's knowledge of the people involved, and the supporting material presented. To avoid key problems, a changeable combination lock was initially used. Keys did not have to be mailed out, and thus were not lost or duplicated. The combination could be given over the phone to avoid mailing delays, and the combination changed weekly to maintain security. The lock itself, unfortunately, failed repeatedly due to inadequate construction, and was eventually replaced with a key-type lock. Even this lock was unusual though, as it was a magnetic lock requiring a special magnetic key to open it. While this had all the handling and mailing difficulties of normal keys, it could not be duplicated. These locks are expensive, however, and if vandalized would cost a high amount to replace.

The purpose in managing Caboose Cave was to allow use of the cave, while controlling traffic levels to lower the negative effects of traffic on the cave, the property, and the cavers. In this respect it was successful, and deliberate vandalism is not known to have occurred. A steady, though low, level of deterioration took place through accident and carelessness. In spite of this, the cave was a morale booster for area caving, and took pressure off other nearby, hard-pressed caves.

McFails Cave: McFails Cave, five miles long, is the largest surveyed cave in the northeastern United States. The cave is located just north of the crossroads of Carlisle Center in Schoharie County, New York (Figure 1). The entrance area has been known since the mid-1800's but the bulk of the cave was discovered in the early 1960's by Fred Stone and others. The cave is currently entered from a 90-foot vertical shaft. Many pits and sinkholes exist on the surface near the entrance, some being former entrances to the cave, but now blocked. A complete description of the cave can be found in Mylroie (1977) and Palmer (1976).

After its discovery in the early 1960's, Fred Stone gave the NSS approximately one acre of land around the entrance in 1965. Since that time, the NSS has managed the cave, using as a guide a set of rules developed by the Board of Governors of the NSS. The actual management of the cave is done by a committee, the McFails Cave Committee, which initially reported directly to the Secretary-Treasurer of the NSS, but which now also reports to the NSS Cave Ownership and Management Committee. While the NSS rules have a few specific items, such as requiring an NSS member on each trip into the cave, actual access policy is determined and carried out by the Chairman of the McFails Cave Committee. In 1976, the author was appointed chairman of the committee. The cave was in need of some new management policies. The property was re-surveyed, the sinks and pits fenced, and the land posted. Work was done to stabilize the entrance pit and crawlway. A gate already existed on the cave entrance pit, but had been unlocked for many years. The gate had been installed after a trespassing, inexperienced caver died from exposure in the entrance pit in March, 1968. Following the legal proceedings at Knox Cave resulting from the accident there in May, 1975, the gate was again locked at McFails. By 1976, the cave had been well explored, surveyed and photographed. A classic resource inventory, similar to those done in Federal caves in the western United States, has never been done but should be completed in order to further understand this significant cave. In 1976, cave management in New York still meant access control and property upkeep.

From the viewpoint of access control, McFails Cave presented many problems. Unlike the three previously discussed caves, McFails Cave is a dangerous cave with many severe obstacles. Two deaths have occurred here, and the cave is such that a wrong step deep inside could be fatal, where in another cave it would only be an inconvenience. The dangers are varied: the entrance complex requires a 90-foot vertical descent in a tight fissure, followed by a 150-foot-long crawlway, the first 100 feet of which are eight to nine inches high. After about 500 feet of walking, stooping, and crawling, the explorer must pass a near-sump with three to eight inches of air space, requiring almost total immersion in water that is 42°F. Following this are 4½ miles of cave, mostly walking. Route finding is occasionally difficult, and sections of water waist deep must be traversed. The real threats in this cave are exhaustion and exposure. The length of the cave, coupled with immersion and tight passages that must be passed to exit the cave, have brought many cavers to their limits.

In granting access, the cave manager has to assess the abilities of the applicant, both in mental and physical terms. Advance permission is required to enter the cave, and this policy has been well publicized in the regional caving magazines. The rigors of the cave have been well publicized, but the exceptional quality of the cave has led to questionable groups trying to enter the cave. At least one break-in occurred in the period 1976-1977, but fortunately, no accidents occurred.

Conclusions

The cave management programs conducted by the author in New York state from 1975-1977 were not cave management as the term is understood today, but really were just access control. Each of the four examples given was controlled differently based on the purpose of the access control and the condition of the cave and its ownership. Despite the disparity in the way the caves were managed, the experience resulted in some persistent, recurring factors: (1) Cave management is labor intensive. Trying to control access to caves takes time and effort to accept, evaluate, and respond to access requests. This is above and beyond the labor necessary to build gates, string fences, place articles and signs, and general property up-keep. (2) The most difficult cave management (i.e., access control) task is accurate assessment of the caver applicant. Deciding who is qualified is the most grueling aspect, even with people well known to the manager. The potential for alienation and breakdown of the entire program exists if standards are too rigid, but accidents and vandalism follow a loose policy. (3) Cave management is most effective when the cave manager has full authority. When a difficult job like access control has to be done, it is much easier if you are the boss. This is best illustrated by the situations at Caboose Cave and McFails Cave. At Caboose Cave, not only was the manager given full authority, but the true landowner was difficult to locate, making "going over the manager's head" unlikely. At McFails Cave, there was a vague and difficult NSS policy to apply, and disgruntled cavers could (and did) go the NSS officers and/or Directors, causing many problems.

One aspect of access control by a cave manager is his dubious legal standing and vulnerability. In case of an accident, is he responsible? Can a disgruntled caver gain access to a cave by a lawsuit? These ramifications did not occur to the author until after he had left New York State, but without a clearer understanding of the implications, the author would hesitate to be a cave manager in the future.

Cave management, actually access control, did prove valuable to the caves and cavers in New York. It is impossible to satisfy all people who would like to go caving, just as it is impossible to totally protect any utilized cave. As least most individuals appreciated and supported this effort, and the rate of cave deterioration was dramatically reduced compared to non-regulated situations. The only sure way to protect caves is to close them. That way, no access decisions have to be made, and the caves undergo no degradation. But as individuals involved in caves and caving this is not the goal of our efforts, except in special circumstances.

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THE MANAGEMENT OF CAVES WITHIN THE NATIONAL PARK SYSTEM

*Roland H. Wauer

I grew up in a middle-sized town in southeastern Idaho, where my earliest memories of caves were of a nearby ice cave on a Sunday afternoon and a lava tube one Saturday in summer. I remember little more about those trips.

My next cave experience was some 15 years later in Oregon, where, as a naive buck ranger, I reported for duty at Oregon Caves National Monument. That beautiful cavern, tucked away in the bowels of the Siskiyu Mountains, had an annual visitation of only 85 thousand then, little fame, and even less environmental impact.

The Chief Ranger handed me a guidebook and told me to memorize the facts within, and that my first tour would be two days hence. I found the booklet full of myths and semi-historical highlights that were witty and cute. There was one about fat man's squeeze and another about Mollies' nipple. Then there were five pages of anecdote to "keep the folks entertained." The one I still remember is about the visitor that asked the guide, "how many miles of undiscovered passageways are there in this cave?"

The last five or six pages of the guidebook included "Facts that you should know." That was the section that I thought most important. It included measurements of the main passageways and rooms. It told the story of the cave's formation; the one about the sea coming in and the sea going out, and after millions of years the mountains pushed their way above the surrounding lowlands and the resultant, massive movements provided fractures that eventually were enlarged by water to form the fascinating features of Oregon Cave. There was but one page that addressed the cave's biology, and another that discussed the known history of man in the vicinity. In other words, the guidebook was only one notch above being worthless.

The morning of my first tour I accompanied the ranger-in-charge on his tour, and was encouraged to ask questions. I heard the same spiel as I had read in the guidebook, with a few homelies thrown in to complete my education. When my first two questions remained unanswered, I decided not to embarass my boss any further.

That afternoon I led my first cave tour, with so little information about a place that I suddenly was the acknowledged expert, that I pretended not to see most of the raised hands. The one really memorable event of that day was when a lady, standing near the edge of a deep hole, turned to her friend and said, "Wow, it sure looks like the further down it goes the deeper it gets."

In those days, interpretation and management of cave resources were little more than I just described — mostly folktales and necessary maintanance. In 21 years we have come a long way, but I am convinced that we have at least an equal distance to go to provide even adequate preservation of the magnificient natural and cultural resources that exist within the numerous cave systems within the National Park System. The immediate goal must be a complete inventory and full protection of our cave resources in as short a time frame as possible.

It was Aldo Leopold that said, "The first rule of intelligent tinkering is to save all the pieces." We plan to save all the pieces and to develop a cave management program that is second to none.

The National Park Service currently manages eight areas which were specifically authorized for caves or cave related values. Among these are world famous caves such as Carlsbad Caverns and Mammoth, the largest known cave in the world. The other six include Jewell, Lehman, Oregon, Russell, Timpanogas and Wind. At least 22 other national parks possess significant cave resources which are secondary to the reasons for the establishment of the areas. In addition, until 1978 the Service had responsibility for a Natural Landmark Program that includes approximately 50 caves outside national parks distributed throughout the United States.

Cave resources within the National Park System vary as much as the public that enjoy them. Their uses range from recreation to re-creation. Some provide great national refugiums of rare and unique flora and fauna. Other more sturdy ones can withstand controlled visitation with minimal impact on the resources.

Several areas of the Service contain underwater caves. Amistad Recreation Area in Texas, for example, and Devil's Hole in California, that contains the endangered Devil's Hole Pupfish. It is said that this fish has the smallest distribution of any vertebrate in America.

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*Acting Chief, Division of Natural Resources, National Park Service

Researchers have identified three endangered bat species in caves at Buffalo National River in Arkansas. Two new species of arthropods were recently discovered at Craters of the Moon National Monument in Idaho. Rampart Cave in Grand Canyon National Park contains droppings of the extinct Shasta Ground Sloth, as do several caves in Guadalupe Mountains National Park. Studies of the droppings have led to a much better understanding of the vegetation and climate present there during the Pleistocene. And Musk Ox Cave, also in the Guadalupes, has so far yielded even more information about the vertebrates that lived during the Pleistocene. That cave has produced fauna from shrew to bush oxen size, and includes a whole range of species that, according to Lloyd Logan, "may prove to be the most significant deposit of vertebrate fossils ever found in the Guadalupe Mountains." Only five to ten percent of the paleontological potential of that cave has yet been utilized.

A 1970, National Park Service guideline states, "Every activity of the Service is subordinate to the duties imposed upon it to faithfully preserve the parks for posterity in essentially their natural state." This is not just a management objective or policy statement, but a mandate by Congress and the people of the United States.

From that mandate has evoloved a cave management statement that I quote:

"The National Park Service will manage caves for the perpetuation of their natural, geological and ecological conditions, and historic associations.

"Developments such as artificial entrances, enlargement of natural entrances, pathways, lighting, interpretive devices, ventilation systems and excavation of elevator shafts are permissible only where necessary for general public use when such development will not significantly alter any conditions perpetuating the natural cave environment or harm historic resources. General public access by tours of suitable duration and interest will be limited to a representative sample of a cave.

"No development above or adjacent to caves will be undertaken which could significantly alter natural cave conditions including subsurface water movements.

"Caves, or portions of caves, may be closed to public use or restricted to access by conducted tours when such actions are required for human safety and protection of the cave resources. Caves, or portions of caves, may be managed exclusively for research and access limited to approved research personnel."

How is the National Park Service fulfilling those objectives?

Initial emphasis must be placed on protection of the known resources, while at the same time we must learn more about what additional resources exist. It is virtually impossible to provide protection to a resource that is unknown.

Although "no management" is often the best strategy when it comes to preserving resources in an unaltered state, it can be catastrophic in a natural system that is receiving heavy impact.

It is vitally essential that we inventory our resources and understand how they work. We must preserve wild, unaltered cave systems if we are to comprehend the essence of a natural cave. The information base for our caves is far behind most of our terrestrial resources, but a number of areas of the National Park System are currently in the process of inventorying caves and their associated resources. Each resource is being classified, and that activity leads to a scientifically-oriented management strategy.

Insofar as possible, the dual classification system, devised by the U. S. Forest Service, B.L.M., and the National Park Service, is being used with a value for significant content and a hazard rating for each cave. For example, more than 40 caves at Buffalo National River have already been inventoried, and the classification, mapping and monitoring is continuing.

A Cave Management Plan is necessary for every national park containing significant caves. These action plans, in conjunction with the area's Resources Management Plans (the umbrella documents) must contain a statement on how each cave is being managed and what research is required for better management and interpretation. That document includes details of such actions as gating to preserve a hyberniculum or a maternity colony of bats, or for the purpose of protecting special features from vandals, etc. It may describe a monitoring program required to protect aquatic organisms, or the protection of an essential habitat for an endangered or unique form of animal, plant or natural formation.

It may describe the recreational use of a cave system when that type of use has been determined to be acceptable. The National Park Service recognizes that recreation caving, like mountain climbing and river running, is a legitimate recreational pursuit. Within the framework of the management policies and the enabling legislation, certain caves may be opened to the public, either for guided tours or on a self-guided basis. Carlsbad Caverns and Mammoth Cave National Parks have legislation (Code of Federal Regulations, Title 36, Sections 7-36 and 7-47) which, in the case of Carlsbad state, "with the exception of the regular trips into Carlsbad Caverns under the guidance or supervision of employees of the National Park Service, no person shall enter any cave or undeveloped part or passageway of any cave without a written permit from the Superintendent."

The Federal regulations go on to state that entrance to caves by permit must be for scientific or educational investigations and shall be approved by the Superintendent. At Carlsbad there are two other caves into which guided tours are available. New Cave has regularly scheduled tours during at least a part of the year, and Spider Cave is occasionally used as a "spelunker" tour cave. In some areas, the regulations may be less stringent. For example, at Buffalo National River, more than 20 caves have been determined to be suitable for the

public to visit with minimal hazard and no significant damage to the resources. In some cases, permits will not be required.

There undoubtedly will be caves that must be totally preserved for their scientific values, and entry will be restricted to that pursuit. These areas will be most useful as baselines for other cave systems.

This may sound like grand rhetoric; a good part of it has been said before. Is the National Park Service really going to monitor and control the external and internal threats to our caves? The answer is that we must!

What makes the next decade different from the last? For the first time we have an organization that combines the functions of science and resources management. The Service's recent reorganization not only provides the recognition of science and its implementation, but the catalyst to get it done. The ingredients for success are good information and its proper use.

Land managing agencies can fund the world's best scientist who can provide the most succient solution to a specific problem, but unless that report and the recommendations are read, understood and utilized it is worthless to the area. In numerous cases that is exactly what has taken place.

Knowledge of an area's resource base can already be available. The understanding of how the significant parts of the system function can be known. And the knowledge of the best management strategy can also be available. But the lack of communications between the scientist, manager and interpreter can negate the whole process.

It has previously been the sole responsibility of the scientist and the manager. The scientist usually has had a predetermined set of obligations, many not related to the park's needs, and the manager usually has had a million daily tasks from personnel problems to past due reports. The roles of the park manager and ranger are far more complex and demanding than ever before. Today's bureaucracy rarely permits the convenience of full communications between the scientists and the user. And there is where the system has failed.

The key is the liaison. It must be performed by one trained in the art of resources management and possessing a basic background in science. There lies the major goal for the new Division of Natural Resources of the National Park Service.

Although a few parks already have implemented the idea, the new thrust for the Service will provide more and better trained Resource Managers. These individuals will report to the area Superintendent and serve as liaison officer between the scientists, interpreters and managers.

Let me use an example from Carlsbad Caverns as the way the system should work. The problem of an 80% decline in the area's bat population was identified by the park staff in 1973, and listed as the park's highest research priority within their Resources Management Plan. It was necessary to know what caused the decline before anything could be done about it. The Regional Office assisted the park staff in selecting researchers, and contracted for a three-year study. The project was jointly funded by the National Park Service and the U. S. Fish and Wildlife Service, and the selected scientists were located at the University of New Mexico and the National Museum of Natural History. Daily communications between the scientists and park management was retained at the park level through a representative of the Superintendent. From the beginning, the park and the researchers were able to talk to each other. The park resources manager was able to freely interface with the researchers, and so as new data became available it was readily available to the managers and interpreters. The scientists provided the park staff with occasional seminars on their work, and were able to respond to staff questions and suggestions. The scientists became so management/interpretive oriented that their status and final reports were directly related to the needs of the park. They also prepared several valuable technical reports that were accepted and published in scientific journals. But the principal value of their work was valid usable information everyone shared. The recommendations had already been partially implemented when the final report was received. Everyone involved had been part of the process.

THOUGHTS ON TRAINING

*William R. Reeves

The purpose of this workshop is to provide persons interested in cave management with tools and ideas that they can take back and use in their operations.

A manager of a cave has the primary responsibility of the total operation of the services and facilities provided to the visitors. To most managers, this responsibility has several aspects, such as the quality of services, the appearance of the resource, operational budget, etc. The manager must decide what is to be accomplished and develop a plan of action to follow. The area that will be addressed by this workshop is "Employee Training."

Employee training is a rather expensive and time consuming process. However, depending upon the desires or objectives of a particular manager, the expense and time can be of great value.

Facility Functions

Let's first look at the different activities that may be present at a facility. First, the tour. The tour may be of a self-guided nature, in which visitors investigate the secrets of the cave, via specially marked trails. These trails may have marked areas for interpretation using signs, displays, or a recorded message as the method of distributing information to the visiting public. Guides may be stationed throughout the tour for safety reasons and to assist the visitor when asked. This type of tour is quite beneficial to the visitor, basically for the reason that the pace at which the visitor investigates is the choice of the visitor.

Another type of tour that is very well received by visitors that are a bit more adventurous is the spelunker's tour. Many times this type of tour also allows the visitor to proceed at his own pace, but with one exception. The visitors are accompanied by a guide who is responsible for the visitors as they travel through a pre-determined section of the cave. This particular type of tour is most exciting and provides a free association with the cave that persons do not forget. Probably, the most important factors that are provided by a spelunking tour are the close contact with nature, the sensation of being an explorer, and the development of an appreciation of the beauty and mystery of this subterranean world. To the spelunker, this unique world is more than something to look at — it is something to be admired and respected.

*Blanchard Springs Caverns, Mountain View, AR 72550

A third method of presenting a cave to the visiting public is the guided tour. The guided tour can be used to give the visitor a chance to see and experience the cave, via the talents and enthusiasm of the guide. This type of tour is most often used, due to the delicate balance of nature that is present in the cave. A guided tour can be just as informative as a self-guided tour and just as exciting and mysterious as a spelunking tour. The important aspect is the attitude and desires of the tour guide. It is true that the guide is not the star of the tour, the cave is. But the guide can provoke or entice the visitor to want to know more about caves and educate the visitor to some extent in the importance of and respect for caves.

Second, the facility. The facility may be as simple as a small building that serves as a gathering point or as elaborate as a large visitor center. The size of the facility is of very little importance. The attitude of the employees stationed at the facility is most important.

Third, the advertisement materials or information. The most common method used is a souvenir shop. The visitor usually will be very responsive to individuals that are attentive and helpful.

Aims of Training

The three services that have been mentioned have one thing in common. The performance of the services depends upon people performing their duties. If the duties are performed with a professional and humanistic attitude, the results will usually be favorable for the facility and will provide educational rewards to the public, and, in some instances, will prove much more profitable for the operations. The question may have arisen in your minds, "How does one accomplish this utopia?" Well, part of the answer is the training that is provided to all employees.

Training is an expensive and time consuming method of reaching objectives set by management. However, training with professionalism as the focal point will always help the operation to be a success.

What kind of training is necessary for this professionalism? The answer is not easy, but part of the answer comes from the experience that an employee has had. New employees usually need more attention and returning employees need only a refresher course.

Some of the following suggestions may be considered before deciding the types of training that are set up for each employee. The suggestions are basically aimed at individuals that are working

at a facility that performs its services with a guided tour, but these suggestions can be useful to all employees.

The purpose of training is presumably to help the guides discharge their responsibility effectively. A moment's reflection, however, discloses that guides are, in fact, required to fulfill a surprising diversity of roles:

1. A guide is a COMMUNICATOR OF ENTHUSIASM.

He/she needs to be really excited about caves, and that excitement should be contagious.

By his/her own attitude and interest, a guide should awaken and nurture in others a sense of wonder, curiosity, and appreciation.

2. A guide is, at least to some degree, an EXPERT ON SPELEOLOGY.

He/she needs to have a basic mastery, though perhaps only at an elementary level, of the relevant aspects of geology, hydrology, biology, caving skills and techniques, and the history of the particular cave and its environs. It is not objectionable to have more than a basic knowledge of speleology and in many cases knowing more is necessary.

3. A guide is an ORAL COMMUNICATOR AND ENTERTAINER.

A guide is a public speaker and needs the abilities and skills involved in speaking clearly and projecting the voice.

He/she is an instructor, who must impart information in an effective manner.

A guide is an entertainer. The guide's performance should be subordinate to the cave itself and should help people appreciate the cave, but he/she is a performer. And visitors should enjoy the performance.

In addition to being interested in caves and having accurate information to impart, the best guides generally have a considerable bit of the ham in them and really enjoy performing in front of an audience.

We all know the canned spiel is deadly. But the alternative is that each guide—as an oral communicator—must be an imaginative and disciplined creative artist.

4. A guide is a GROUP LEADER

For a brief period, a guide is a commanding officer and must be able to direct and control a group of people.

He/she is something of a social director, helping people to have a good time and actively involving as many as possible in the tour so that they become more than passive spectators.

A guide must be, in some sense, a counselor and friend when those relationships are appropirate. He/she must be sensitive to the interests, feelings, fears, hostilities, etc., of the visitors and must encourage, instill confidence, accept, calm, etc.

5. A guide is a PROTECTOR AND GUARDIAN.

He/she protects the cave. A guide is a law enforcement officer.

He/she protects persons from whatever dangers may be present in the cave.

A guide should be able to administer first aid when necessary.

6. A guide is a PERSON.

This is not an additional role. This item in the list is intended to call attention to the importance, not just of what the guide does, but of who the guide is.

There is more to being a good guide than just acquiring information and mastering skills. Effectiveness in fulfilling at least some of the guide's responsibilities requires a considerable measure of maturity, emotional security, and comfortableness in the roles which are his/hers.

Thus, there is a place for a type of guide training that need not have an obvious and direct relation to "the job" but which facilitates personal growth and increases depth and sensitivity in interpersonal relations.

Effective guide training will aim at cultivating a sense of professionalism with respect to the fulfillment of all the above-mentioned roles.

Types of Training

What types of training have been used to attain the goals set by a manager? The following list is by no means complete, but offers suggestions that may be used with new ideas and variations to answer training requirements:

I. The first area of training can be classified as Human Relations and Personal Attitudes.

A. Interpersonal Skills and Human Relations. This part of training is most important when dealing with the visiting public; as well as fellow employees. Employees attending this type of training should gain awareness in the following areas:

1. Self analysis (values clarification). When dealing with the public, one can communicate much more efficiently if he knows what makes him react certain ways to certain situations. The theory of 'I'm OK, You're OK' helps one to relate much better to people of all ages.

2. Human Potential Development. Training in this area helps give one a positive approach to new and different situations.

3. Improving Interpersonal Relations. If there is conflict within the organizational structure, it will cause conflict in the entire work force. Interpersonal relations is designed to head off internal flare-ups before they occur.

B. Transactional Analysis. This type of training is a reinforcement of the "I'm OK, You're OK" theory. A major area that is covered in this training topic is the relations that an employee has with a visitor. Training in this area helps the employee recognize signals that show irritation, rejection, etc.

C. Communications. The major tool that an employee has to commnicate with a visitor is the ability to speak. Speaking must be done in a clear and understandable manner. Colloquialism is not objectionable, but must be done in good taste and with a proper method of explanation prepared in the event a visitor indicates signs of not understanding the terms that were used. Speaking words properly is not enough, however, for to speak and to be heard are two different things. An employee must speak loudly enough to be heard and yet not distract from the atmosphere that the cave creates.

D. Interpretation. Interpretation is closely related to communication, but this is an art that requires a great deal of self-determination by the employee. All employees must speak clearly and understandably, but to interpret is to incorporate these items with provocation, which stimulates the visitor and causes the visitor to listen to the information that the employee is providing. Interpretation is more than repeating a memorized talk. Certain methods and techniques are used to create the desire in the visitor to know and comprehend a subject. It should be mentioned that the reason for a visitor being at a cave is because he/she wants to be there for fun, but if their educational background is expanded, this helps meet the desire of management to make more people aware of the uniqueness and importance of the cave, while still providing the recreational experience.

Areas that can be covered are:

1. Overview of interpretation and interpretive principles.
2. Writing interpretive objectives.
3. Role of objectives in organizing interpretive presentations.
4. Structuring techniques
   a. Introductions
   b. Transitions
   c. Conclusions.
5. Questioning and responding to establish dialogue, rapport, and to better understand a visitor.
6. Understanding an audience and modifying a program to meet visitor needs.

E. Social Activities. This is free time that the employees can use to relax and enjoy, as well as learn about the job that they will be required to perform.

F. Image that is desired. This is the specific area that the management must decide upon. Usually, the host attitude is most successful for having the end result (the experience that the visitor takes with him) be that which is intended.

I. The second area that training can be beneficial n is facility operations. This part of training ives the employee the background that is necessary n performing quickly and efficiently routinely performed duties.

A. Orientation. Orientation provides the employees with the first glimpse of the duties and responsibilities that they will be required to perform and accept. This early step is the most appropriate time to let the employees know some of the important aspects of their job and some of the desires of management.

B. The Functional Operation of the Facility. Knowledge of the functions that are provided at a facility is essential to an employee. If an employee knows what a visitor has as options while visiting a facility, assistance can be provided with higher quality. Also, this type of training helps the employee become a dependable and functional part of a staff.

C. Area Information. Providing area information is a part of an employee's job that is seldom covered in a training session. However, a large percentage of work time is taken up by a visitor asking questions about other places to visit, where food services are located, and numerous other questions that require the employee to know about the area. Many times, the employee is a member of the immediate community and would know a great deal about the area, but a quick refresher or an in depth session for old and new employees will help them discharge their duties more efficiently.

D. On the Job Training. This segment of training is most often used when preparing an employee for his duties. Training of this nature is vital when presented as a part of the learning experience, but there is a pitfall that can develop, imitation. Imitation does have a value, but when an employee begins to imitate another employee, the new employee can start to sound just like the model.

Imitation is not the most desirable method of communication because a particular method of explanation can be performed by one employee in a most acceptable manner, but if another employee tries the same method, the results are often less than acceptable.

Imitation does have a long range effect — boredom. A suggested article for reading and analyzing by management is, "Boredom in Paradise" by W. T. Austin and Tom Chaney. The article is in the 1976 Cave Management Symposium Proceedings, on page 54.

E. Emergency Procedures and Regulations. In any public facility it is essential that an emergency plan of action be established for those emergencies that could occur. All staff members should know what to do in the event an emergency arises. Some common emergencies are power failures, equipment failures, threatening natural conditions, physical violence or threats, injuries, etc. The procedures should be well known and practiced to lessen the dangers that could result. In most facilities, there are regulations that a visitor is required to follow. Also, an employee can better demonstrate and uphold regulations if the employee understands why the regulations have been developed.

F. Logistics. Logistics provide the employees the working knowledge that is necessary to perform properly their duties within the limitations that are present. Specifically, logistics show the employee where switches are, which direction to travel, what is supposed to happen in a particular lighting sequence, how to watch certain areas that would be susceptable to damage, timing, order, and safety aspects that must be observed. Also, if the operation of the facility requires a large staff, the schedules of operation, work days, number of tours to be taken and requirements that the employee must be aware of can be incorporated.

III. A final section of training that has significance is special knowledge and requirements.

Special knowledge of requirements are those that are more than general observation of a specific topic, but a more comprehensive understanding of the topic. Some of the topics that deal with a cave and its operations are: the safety aspects such as first aid and cardio-pulmonary resuscitation, history, hydrology, geology, cave biota, how animals of the cave relate to each other and their surroundings, archeology, and even special emergency procedures that would apply to very unlikely situations. The special knowledge and requirements are the crowning touches to give an employee the confidence that is displayed to a visitor and in the fulfillment of duties that are assigned. By no means are these topics the only ones that an employee could use in the performance of his duties, but they are the basis for building a quality tour guide.

Training Resources

Before a training session can be conducted, the manager must find qualified individuals to present the information. The following information may be of use if a decision to train employees is reached.

Several sources are available to the manager to draw upon. The most available is the staff that is presently working. A manager can incorporate some or all of the primary staff. This group of people can provide past experiences to new employees as well as add to the knowledge of returning employees. Also, these people can be of great assistance in training sessions dealing with facility operations.

The primary staff is the group that can help the manager decide the types of training that are necessary to reach objectives that have been set.

The special training session is often done more efficiently by individuals that have expertise in a desired area of training.

The following list of possible sources of information or assistance is a small portion of the resources that can be tapped when formulating training sessions:

I. Private enterprises

A. Tom Aley - Hydrologist, Biologist, Geologist
Ozark Underground Laboratory
Protem, Missouri

B. Hanna & Silvy - Interpretation
RR 5, Box 1107
Bryan, Texas, 77081

C. Emmett Burkeen - Human Relations
Department of Guidance
Western Kentucky University
Bowling Green, Kentucky

D. Communications Skills Co.
Huntsville, Alabama

E. Andy Kardos - Interpretive Specialist
National Park Service
North Carolina

F. Dr. Tate Page - Human Relations
Russellville, Arkansas 72801

These people or companies will usually perform the training for a fee, and the results are always of high quality.

II. Governmental Agencies

A. U. S. Geological Survey

B. National Park Service
Mather Training Center
Harpers Ferry, West Virginia

C. U. S. Forest Service
P. O. Box 1
Mountain View, Arkansas, 72560

D. Carl Davis - Geologist
U. S. Forest Service
1720 Peachtree Road, NW
Atlanta, Georgia 30309

E. Don Williams - Geologist
U. S. Forest Service
Washington Office
Box 2417
Washington, D. C. 20013

F. U. S. Forest Service
Supervisor's Office
P. O. Box 1008
Russellville, Arkansas, 72801

G. State Geological Commission

H. Mining Safety and Health Administration (MSHA)
Denver, Colorado

I. Army Corps of Engineers
District Office nearest you.

III. Public Service Organizations or Interested Groups

A. American Red Cross

B. National Speological Society

IV. Private Individuals

A. David A. Saugey - Biologist
Hot Springs, Arkansas

B. Anyone interested in Speleology

C. Dr. Michael Harvey - Biologist
Memphis, Tennessee

D. Fire department members with rescue team experience.

INTERPRETIVE DEVELOPMENT OF CARLSBAD CAVERNS

*Clifford Stroud

> Only recently has man been able to extend himself, physically, beyond the limits of his own existence. Man's technology has opened new frontiers. The exploration of the ocean's depths and the vast regions of space will undoubtedly provide man with a new way to look at himself. Man will begin to explore himself as an entity, free from the cyclical regulatory functions that have governed him from the beginning. Unfortunately, the regions of space and the depths of the ocean are limited to a privileged few. However, one other environment can effectively take man from his state of perpetual repetition — the underground cave.

A legend was told of an Apache Indian medicine man who was lowered into the twilight zone of the cavern, late in the evening, as the sun was settling beneath the western horizon. In his hand he carried a drum, which he slowly patted. This man was observed with awe by other Indians, watching from the ledge above. The sounds of the drum carried to their anxious ears. With a determined facial expression, the drum-carrying medicine man walked from the twilight zone — into the darkness beyond. After disappearing from sight, sounds from the drum were still audible for several minutes, to the Indians gathered on the ledge. The medicine man never returned. Interpretation of that which would later be known as Carlsbad Caverns had begun.

The history of man in the Park began more than a thousand years ago, with prehistoric hunting and gathering Indians roaming the region. Evidence of these Indians has been left in the forms of paintings on the entrance wall of the Caverns and large rock pits used to cook the desert plants. It is believed that they were attracted to the Caverns because of the shelter that they provided, but it is doubtful that the Indians wandered into the dark and eerie lower portions of the Caverns not reached by natural light. In the late 1500's there are records of Spanish explorers encountering fierce Apache Indians, the true masters of the rugged hills, in the region where the Guadalupe Mountains served as a sanctuary for the tribe.

It wasn't until after the Civil War and the Indian wars had been fought that ranching finally arrived in the area. In the late 1880's it is believed that the first cowboys discovered the large opening in the earth leading to the Caverns. With the discovery of the caves and their large population of bats also came interest in the large deposits of guano located in the caves. Guano, being a natural fertilizer rich in nitrate, was a valuable commodity and mining operations to extract the guano from the cave began shortly thereafter. Although a number of companies were involved in the mining process, high transportation costs made financial success difficult. Even with all of the financial failures, over 100,000 tons of guano were extracted from the caves over the 20 years of mining operations.

Although the mining meant considerable activity around the caves, very few of the miners had any interest beyond the area near the entrance known as the "Bat Cave". However, one young cowboy named James Larkin White, who also served as a foreman for several of the guano mining companies, was fascinated by the Caverns and spent much of his spare time probing the deeper and darker portions of the caves. As he continued to explore the Caverns and find more and more interesting features, he slowly began to convince others to accompany him. In 1922, stories of Jim White's endeavors and the wonders he was discovering reached the General Land Office. The Office then initiated an investigation to determine if the cave was worthy of being set aside as a national monument. After a six-month exploratory expedition, conducted by the National Geographic Society, national monument status was designated in 1923, by presidental proclamation, to preserve "a limestone cavern....of extraordinary proportions and of unusual beauty and variety...." and containing "...stalactites, stalagmites, and other formations in such unusual number, size, beauty of form, and variety of figure as to make this a cavern equal, if not superior in both scientific and popular interest to the better known caves...."

In 1923 the National Park Service assumed interpretive responsibilities for the cavern. The fragile nature of the underground wilderness was recognized to some extent, as was the potential danger to the unwary visitor. The question: how to interpret? As the Indians had in legends? As Jim White had during his days of guano mining? Or were there other alternatives? In 1923 guided tours began at Carlsbad Caverns and were continued through 1971.

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*Carlsbad Caverns National Park, Carlsbad, New Mexico 88220

Through a series of executive orders and legislative acts, highlighted by the establishing act of May 14, 1930, the former national monument and surrounding lands, which contain numerous other caves and other outstanding natural features, were made a national park "...for the benefit and enjoyment of the people...." Carlsbad Caverns, largest of the park's caves, is one of the world's largest, by volume, and one of the world's richest in speleothems. Described by National Geographic Society expedition leader and United States Geological Surveyor geologist Willis T. Lee as 'King of its Kind', Carlsbad Caverns attributes remain unrivaled.

During the period 1930 through 1971 interpretation at Carlsbad Caverns remained largely unchanged, and consisted primarily of guided tours which were regulated as to frequency, stops, length of talks, etc. Topics covered were normally history, geologic development, bats, and guano mining. The potential was present for the development of "canned" talks. New employees learned their talks by listening to the "old timers", making suppression of creativity a distinct possibility. Photography was not permitted on the regular tours but special photographic tours were scheduled at regular intervals. Blackouts were a regular part of the guided tour. Throughout the 1930's and until 1944 blackouts were held at the Rock of Ages in the Big Room. These programs consisted of an interpretive talk followed by total darkness, singing of the hymn "Rock of Ages" and gradual illumination afterwards. Eventually this program was discontinued.

In the 1960's scheduled guided tours continued to provide the primary means of interpretation. However, increased visitation greatly limited the effectiveness of this guided mode. At one point as many as 1,000 people were recorded on a single tour. The quality of the visitor experience was lowered as the quantity of people on a single tour increased. Congestion along the trails and in the underground lunchroom necessitated a change. Consideration was given to establishment of a reservation system thus controlling the size of any given tour. Also discussed were non-regimented, self-paced trips. In January of 1972 self-guided trips with interpretive signs spaced throughout the trail system were initiated. Employees were on roving assignments in the cave to provide additional interpretive information, protect the resource, and respond to visitor emergencies.

In 1974 hand-held electronic receivers were added to the self-paced trip. This audio system provides the visitor with 43 interpretive messages. These messages are transmitted on one of three channels in either adult English, children's English, or in Spanish. The system explains the cavern and its features, and conveys environmental and safety messages.

Today the park visitor has two options for a self-guided tour of the cavern. The visitor may take an elevator from the visitor center to the Big Room for a 1- to 1½-hour self-guided walking tour. Or, the visitor may choose to take the three mile 2½- to 3-hour walk that begins at the cave entrance and enables the visitor to walk through all developed portions of the cave. From either walk, the visitor returns to the surface by elevators that are situated near the underground lunchroom facility.

While the park's primary significance lies in its superlative cave resources, and in the segment of the Permian-age Capitan barrier reef and associated geological formations preserved within its boundaries that gave rise to and contain these cave resources, the interpretation is not confined solely to caves. Rather the environment as a whole is considered with the feeling that complete awareness of the cave requires some understanding of surface conditions both today and millions of years ago.

The entrance to Carlsbad Caverns is situated 4 miles west of White City. The 7-mile Walnut Canyon Road provides access from White City to the visitor center. Four interpretive pulloffs are situated along the Walnut Canyon Road. The interpretive topics present information units relating to the regional geology, the Chihuahuan Desert, and the Apache Indian culture.

At the visitor center, parking space for 900 cars is within easy walking distance of the cavern entrance. The visitor center has a variety of functions including a fee collection station, an interpretive exhibit room, the elevator/lobby, a waiting lounge, distribution and collection centers for electronic receivers, and concession operations that include a restaurant, a gift shop, a nursery, and a kennel. In the visitor center, the roof of the elevator tower functions as an overlook from which the visitor can view the Chihuahuan Desert and the southwestern trend of the Capitan Reef face. Adjacent to the cave entrance is a surfaced, self-guided, nature trail. Throughout the main visitor season, guided nature walks are provided by the ranger staff every afternoon on another trail near the visitor center location.

Second in popularity to the cavern tours is the evening bat flight program. This is presented in the amphitheater at the cave entrance by a member of the ranger staff every summer evening. The ranger gives an interpretive presentation, the visitor asks questions, and, if the bats are cooperative, the program ends with a mass exodus of bats from the cave mouth.

Visitor interest in primitive lantern trips and spelunking tours is increasing. The National Park Service has offered an additional cave experience. Carlsbad Caverns's newest attraction is a guided, lantern tour of an undeveloped cave in Slaughter Canyon — New Cave. The opening of New Cave offers the more curious visitor an intensive exposure to spelunking and a "wild cave experience". This undeveloped cave is now limited to small groups and provides a totally new experience in cave "exploration". New Cave is much smaller than the main cavern, but has many beautiful features that are illuminated by the visitor's light rather than a formal static lighting system. New Cave offers an opportunity to interpret subjects lacking or inaccessible in Carlsbad Caverns such as the history and methods of guano mining, prehistoric human use of cave resources, and paleontological details demonstrating extinction of certain mammalian species including some bat species.

Sadly, extensive vandalism has occurred in some backcountry caves in the past due to lack of regular protection patrols and the absence of cave entrance gates. As backcountry use continues to increase, visitor safety and protection of delicate cave features, irreplaceable pictographs and other archaeological remains are of increasing concern. The caves of Carlsbad Caverns National Park will be managed to assure the perpetuation of a natural cave environment for future generations. No development or use will be allowed which will destroy or seriously impair the biological and geological processes normal to the cave system. Subject to this constraint, the National Park Service will offer to the public the greatest possible variety of cave experiences.

SEVENTY - FIVE YEARS AT WIND CAVE

*Larry W. Frederick

Located in the bottom of a limestone draw on the southeastern flank of the Black Hills is a 10-inch-diameter opening which has attracted the attention of numerous fascinating personalities, and has been the cause of countless exciting events during the past 100 years.

The Sioux word for the Black Hills is Pahasapa. The Hills were so named because from a distance the pine covered slopes appeared black in contrast to the golden, windswept prairie grass that surrounds this dome-shaped mountain range. The Black Hills are located in western South Dakota and extend a short distance into eastern Wyoming.

There are many Indian legends concerning Wind Cave. Sitting Bull's nephew is quoted as saying that "Wind Cave in the Black Hills was the cave from which Wakan Tanka, the Great Mystery, sent buffalo out into the Sioux hunting grounds." Because wind was one of the four sacred deities, the small opening from which the wind blew was very sacred to them. Their belief that the prairie winds and buffalo emanated from this opening is said to have been one of the reasons that the Sioux fought so hard to keep the Black Hills.

A gold rush in 1876 led to the settlement and development of the Black Hills by whites. Until then the Sioux dominated the territory and few whites had ever ventured into the interior of the Hills.

Pre-Park Era — 1881-1900

The first recorded discovery of Wind Cave occurred in the spring of 1881. The legend states that two brothers, Tom and Jesse Bingham, were riding through a draw when they heard a whistling noise. They dismounted and approached a small opening where wind blew out quite strongly. When they bent over the opening, one of their hats was blown off. Later, they returned with friends to show them the hat trick. The wind had changed direction and when a hat was placed over the opening it was sucked inside.

In the fall of 1881, Charlie Crary, of Custer, is reported to have told pioneer Frank Herbert that he had been in Wind Cave and explored it, leaving a ball of twine behind as evidence. Crary told about a hole in the ground where the wind "came out screeching".

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*Assistant Chief of Information & Interpretation, Wind Cave National Park, Hot Springs, South Dakota, 57747

Another early account states that we "explored the walls as we went and saw places that were scalloped and looked like post office boxes". This is what we believe to be the first mention of boxwork, the most highly developed, best known formation at Wind Cave.

Explorations continued during 1884 by curious townsfolk. In July, 1886, the largest group to visit Wind Cave arrived. Thirty to forty folks from Custer, 20 miles away, "supplied with tents, camping utensils and everything essential to comfort, left for the Cave of the Wind, on Tuesday, where they remained for a day or two exploring the labyrinthine mazes of that attractive wonder and enjoying the refreshing winds that make that place especially enjoyable when the mercury is seeking the upper levels."

"By September 23, 1887, the Hot Springs Star was reporting that Wind Cave had been explored for three miles and no bottom found. The wind blows a perfect gale from the mouth of the infernal pit." Another entrance had been opened next to the original hole by 1887 and a log house, 8 by 10 feet square stood over it.

In 1889 the McDonald family moved to Hot Springs, 10 miles south of the Cave. In a recently-donated letter, we have learned that it was the father, Jesse D. McDonald, who first filed a mining claim in 1890 on a portion of the land over the cave. Later, in 1890, Jesse sold all interest in the Wind Cave mining claim to the South Dakota Mining Company, whose President was J. D. Moss. During a portion of the time between 1891 and 1894, the company hired Jesse as "agent and employee of said company and received compensation for his services as such employee and agent."

In the June 20th, 1890, Hot Springs Star there is a report that "Mr. J. D. McDonald was at Hot Springs on Monday. Mr. McDonald is located at Wind Cave, a natural curiousity of great beauty, about 10 miles north of Hot Springs. He deposited on our desk an elegant specimen from the cave and the curiousity excites the wonder and admiration of all visitors at the office."

Jesse brought with him two of his sons, Alvin and Elmer. Both were to play an important role in the drama and excitement that soon would unfold.

Elmer's wife wrote about her recollection of the first days at the cave. "J. D. and sons located in an old blacksmith shop with a view of prospecting gold. A small log house was erected over the

FIGURE 1. A group of visitors in IOOF HALL (International Order of Odd Fellows). Photo taken sometime after April 1902. In the lower right hand corner you can see part of a survey station (U.S.). The station reads: "U.S.W.C.S. 52". We believe this stands for United States Wind Cave Survey. This room is sometimes referred to as the Model Room on present-day tours. (Photo courtesy National Park Service)

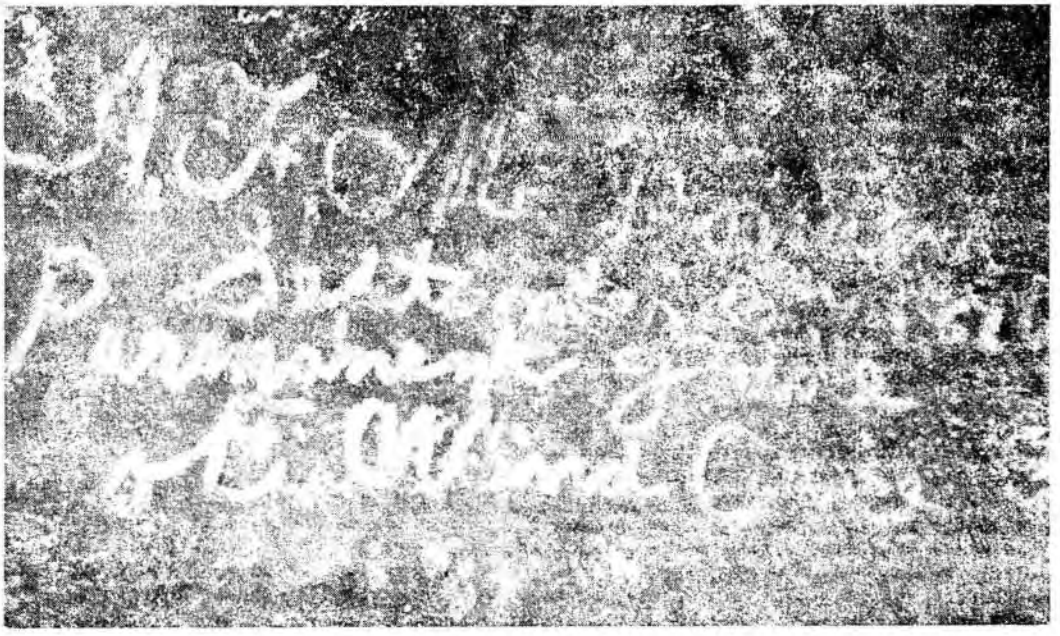

FIGURE 2. One of the earliest Alvin McDonald signatures. Reads: "A. F. McDonald, September 6th, 1890, Permanent Guide of Wind Cave. (Photo courtesy National Park Service)

opening and some little work done toward an entrance to the cave. No minerals were found. The McDonalds had to furnish their own supplies. Mr. Moss of the South Dakota Mining Company, finally discharging J. D. McDonald as agent."

"J. D. McDonald then changed the entrance a little, built a log house over the new opening and settled on the land as a 'squatter'. Work was going steadily forward in opening up the cave, new rooms were discovered and opened up by blasting through intervening rock walls...much exploring was done. Elmer and Alvin McDonald would take balls of twine, fasten one end on a snag near the main route and steer off in a side opening and go, and crawl, as far as the twine lasted, then turn back marking the route..."

In later years Katie Stabler recalls that the front room of the log house built over the cave entrance had a trap door in it. To enter the cave one climbed down 155 feet. Katie said "the wind blew so strong at times it took two of us to raise or lower this door according to which way the wind blew."

Accounts in those days of cave trips were embellished with the dangerous and mysterious aspects of travel. "...touching our toes to the wall for a little rest, now swinging clear from everything until at last we were rewarded by arriving save and sound at the bottom of the cave? No, for the bottom of the cave has never been found."

On January 1, 1891, Alvin McDonald started a diary which is a lasting tribute to the early explorations of brave young explorers like himself, Elmer, and friends, who by now had joined in this new adventure. It is Alvin's diary that gives us a clue as to how much exploration was done and where in the cave the early explorers and visitors had gone.

In 1892 Alvin finally wrote an introduction to his diary. It reads: "On the first of January 1891 I saw fit to keep a record of the inside workings at Wind Cave, and, acting with the thought, I started a daily record which I called The Private Account of A. F. McDonald, Permanent Guide of Wind Cave. My intention this year is to keep a correct account of the development and explorations of Wind Cave or any other caverns that fortune favors me to be exploring in. By the word exploring I mean 'finding cavities that no human beings have yet discovered'. Respectfully yours, Z.U.Q. P. S. For the meaning of these initials or any other initials used in the pages of this book, inquire of the guide of any of the Celebrated Caverns of America." Strange as it may seem, to this day we have never discovered what the initials Z.U.Q. stand for or mean even though Alvin commonly left them on the cave walls.

The diary makes for fascinating reading. At one point Alvin writes: "am getting homesick after staying out of the cave so long." He had not been in the cave for two days. In April he wrote: "I now have 209 different kinds of rock in my geological collection". The diary lists rooms and routes, described discoveries, and shows what inscriptions were left. During the four short years that Alvin explored in Wind Cave, he and others had named almost 400 rooms or objects, had found 13 series of passages or routes and estimated the cave at 81 miles in length.

Visitors wonder how the McDonalds knew the length of their cave. Luella Owens in her book, Cave Regions of the Ozarks and Black Hills, published in 1898, explains: "The measure of distances in the cave is not by the usual guesswork method which has established the short measure reputation for cave miles, but is done with a fair degree of accuracy by means of the twine used to mark the trail in exploring new passages. A careful measurement of the twine has shown it to run nine balls to the mile with a close average of regularity, so it is the custom to add another mile to the cave record as often as a ninth ball becomes exhausted." As accurate as this method is claimed to be, we think the early explorers knew of eight miles of the cave, not 81.

The year 1891 proved to be the start of new developments at the cave. Jesse boasted that more than $1,000 had been spent in improving the interior of the cave "in the way of widening passages, putting in ladders and otherwise making the cave accessible to visitors". He also talked of organizing a "company having for its object the more perfect opening up the cave...(and) to light the cave with electricity and make other improvements". However, the first lighting system was not to be installed until 40 years later.

In July 1891, the Hot Springs Star reported that Wind Cave "is now claimed to be the largest and deepest cave in the United States. There are more miles of underground passageways than the Mammoth Cave in Kentucky can boast. A free hack (buggy) from Hot Springs to Wind Cave has just been put on, and all that is lacking to make the Wind Cave a popular resort is a good hotel. Here is a chance for a good investment". By this time, it was not unusual to have 8 to 10 persons per day visiting the cave during the summer.

In the summer of 1891, John Stabler arrived to manage the Hotel Parrot in Hot Springs. He saw Wind Cave as a wise investment and decided to buy part interest in the operation. The claim to the cave was held by the South Dakota Mining Company, not the McDonalds. This would be a major point of contention in coming years. Nevertheless, the McDonalds sold part interest in the cave operation to the Stablers. The Stablers were also given permission to build and operate a hotel at the cave.

Somehow, the McDonalds were persuaded to hand over the bookkeeping and accounting to the Stablers. John's son, George, assumed responsibility. Unbeknownst to the McDonalds, the Stablers transferred money to their own pockets and removed large quantities of specimens from the cave which they sold. This, too, was to cause serious problems in the near future.

In the summer of 1892, the long talked about hotel was opened and managed by George Stabler.

A year later, the best known publicity stunt was conceived. Alexander Johnstone, a famous mind reader, agreed to find a hidden hat pin within Wind Cave. To start with, Johnstone was locked in a Hot Springs hotel room while a group of citizens guarded him. "A committee of citizens

and scientists" went to Wind Cave where they carefully hid the hat pin. The committee returned to Hot Springs where they joined Johnstone in the wagon ride back to Wind Cave. Reports are that Johnstone, while blindfolded, drove the wagon like a mad man and arrived at the cave in an amazing 52 minutes. A piece of twine was connected to the wrist of Johnstone and a member of the committee. This would not allow a muscle twitch or a squeeze of the hand to tip the mind reader off as to where the pin might be. Still blindfolded, Johnstone and others entered the cave. The search began while Johnstone was supposedly busy reading the minds of the committee of citizens who had hidden the pin. Finally, after stumbling around in the cave for nearly three days, they entered Standing Rock Chamber where Johnstone, still blindfolded, pointed to the hidden hat pin. They emerged successfully soon after, where Johnstone's magnificent feat was spread across the country as an unbelievable mind reading event. This action alone pushed Wind Cave into the headlines.

Early In November, 1893, Alvin and J. D. McDonald left Wind Cave to attend the Columbian Exposition, also known as the Chicago Worlds Fair. Their purpose was to promote Wind Cave by selling specimens and bragging of the safe travel through their magnificent cave. Unfortunately, Alvin, who was now 20, returned to Wind Cave rather ill. Soon after he died of typhoid fever. His family, knowing his love for Wind Cave, buried him on the hillside above the cave entrance. Today one may visit Alvin's grave where a granite boulder and bronze plaque lay in tribute to this adventurous young explorer.

During July, 1893, the first of many lawsuits and court proceedings took place. At this time the Moss family owed Peter Folsom $700 for assay work that he had done on various Moss claims. The courts ordered Moss to pay Folsom or the mining claims would be auctioned. With payment still outstanding, the claims were auctioned and Folsom bought them. Folsom became the new owner of the Wind Cave claims. Meanwhile, the South Dakota Mining Company filed suit asking that the McDonalds and Stablers pay for their use of the area by paying $2700 for rents and profits on the cave and $1000 in damages and for restitution of the land and premises. To our knowledge, the Mining Company never collected and the families stayed on to operate the cave as a tourist attraction.

In 1894, the McDonalds, Stablers and others filed on the acreage surrounding the cave and previous mining claims. The Wonderful Wind Cave Improvement Company was formed with John Stabler, J. D. McDonald, Charles Stabler and two other men. This same year the Deadwood Times reported that "ladies can (now) go through the cave without being subjected to the ordeal of wearing coveralls and jumpers". One busy day in August had 75 visitors to the cave.

In 1895, J. D. McDonald apparently proved his homestead claim and was awarded a "receivers receipt". McDonald had successfully claimed agricultural rights while the Stabler and Folsom forces were claiming mineral rights.

The story grew even more confusing as the turn of the century approached. In the spring of 1896, J. D. asked to see the books which the Stabler family had been keeping for about five years. The McDonalds learned that the Stablers had overdrawn their share. The books were taken by Jesse and Elmer was put in charge. The Stablers were given a chance to pay back what was shown they had overdrawn by making small reasonable payments to the McDonalds. The Stablers became quite angry over the affair. This was the first serious conflict that rose between the two families but it was not to be the last.

During the winter of 1896-97, Peter Folsom and the Stablers broke into the McDonald's house, which rested over the cave entrance. When Elmer and Jesse returned they were met with guns. The Stablers claimed they were there to protect their property and no McDonald could enter. The Stablers kept control of the cave entrance from then on. The McDonalds, not satisfied with the outcome of the encounter, filed against the Stablers in county court in March of 1897, claiming legal ownership of the land. The court upheld the Stablers' possession. However, they were not permitted to dig, excavate or blast on the property and possibly deface the cave in case the property should revert to the McDonalds.

During this period of litigation and conflict between the two families and Folsom, we have little knowledge of what, if anything, was changing in the cave. The newspapers turned from writing about the magnificent wonders of the cave to reporting the outcome of the feud and each court ruling or suit filed. Jesse fell out of favor with the Hot Springs Star and John Stabler, probably a more articulate spokesman, gained considerable support. Honest John Stabler became known by the local press as Jolly John.

In April of 1898, the McDonalds and Stablers sought to end the conflict and seek a legal and binding opinion on exact ownership of the land. Both parties submitted all the evidence they could to the General Land Office in Rapid City and pressed the U. S. Government for a decision on ownership of the land. This move was to bring Wind Cave to the attention of important government officials and spell the demise of private ownership of the cave and adjacent lands.

In September of 1898, without any decision on ownership, Stabler started the Black Hills Wind Cave Company with Peter Folsom as president and shares of stock went on sale at $1.00 each.

Meanwhile, the Department of Interior, one of its agencies being the General Land Office, started to investigate the Wind Cave claims. Lucius Boyod, Vice Dean of South Dakota School of Mines, studied Wind Cave at the request of the Interior Department. His nineteen-page report contained basic scientific data upon whith the Park was later established. The report claimed that Wind Cave was "one of the most extensive...in the Union."

C. W. Greene, special agent of the General Land Office, write the GLO Commissioner in Washington

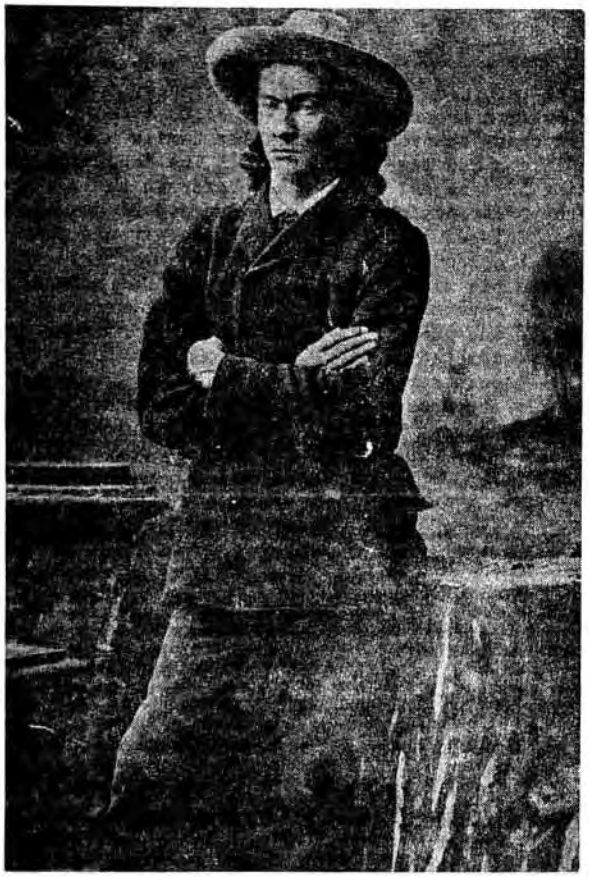

FIGURE 3. Alvin McDonald, early explorer at Wind Cave. Died in 1893 at age 20. His diary describes his explorations of Wind Cave during the early 1890's. (Photo courtesy National Park Service)

FIGURE 4. View of the McDonald house and the cave house (right), constructed of logs. Photograph probably dates back to the mid-1890's. (Photo courtesy National Park Service)

concerning his findings at Wind Cave in 1899. Since there were still mining and agricultural claims pending, he examined the surface extensively and concluded that "there is nothing upon the surface that I deam worthy of consideration. I am of the opinion that none of the claimants, either the agricultural or mineral who have fought through the various hearings ordered by your office, would spend a day's time or a dollar in money, if the cave were not there..." Unfortunately for the McDonalds and Stablers this astute observation was quite true.

Park Establishment and Early Years — 1900-1914

In January, 1900, the Department of Interior withdrew lands around the cave from agricultural or mining settlement. This was "Pending determination of the question of the advisability of recommending the setting of said lands apart as a National Park for the purpose of preserving the beauties of the natural curiosities of what is known as Wind Cave."

In December of 1900, the Secretary of Interior became personally involved. From the reports that had been submitted and recommendations made by those who had seen the cave, he "declares that neither party is entitled to it, that in the first place it is not mineral land and the plaintiff (Stablers) therefore has no claim to it, and in the second place, McDonald did not comply with the law relating to the cultivation, and his entry is held for cancelation. The Secretary also directs that the land be held in reserve until Congress shall have had an opportunity to create a permanent reservation there." A National Park was on its way.

After this, J. D. and Elmer made one last desperate attempt to regain control of the cave entrance. They entered the cave house where they had been evicted about three years earlier. Folsom and Stabler were away at the time. When Stabler learned of this he returned with a gang of neighbors and chased J. D. and Elmer into the cave, where they stayed for 24 hours before returning to the trap door and begging to be released. They were released unharmed, but, while they had been trapped in the cave, Jesse's nearby cabin mysteriously burned to the ground and his specimen collection was destroyed. No blame was ever established for this occurrence.

In 1901, Agent Green took charge of the cave for the U. S. Government and posted new warning signs in conspicuous places. They read, "each underground tourist is expected to shake the dust from his feet on making his exit (from the cave)...."

In February the Government officially cancelled J. D. and Elmer's homestead entries on lands surrounding the cave.

In Washington, legislation was introduced to establish Wind Cave National Park. A series of Congressional reports gives us some idea on what information the House and Senate were basing their votes.

A June 17, 1902, Senate Report (#1944) reprinted a statement made by GLO agent Meyendoriffs: "To do justice to the wonderful evolution of nature which c ted this cavern, to describe its grandeur, grotesqueness, and beauty would require the researchful mind of a profound student of geology and pen of the poet. Bereaved of both and limited in space and time, I will simply say that it is one of the greatest wonders of the world. The box work crystallization of lime and gypsum formed, undoubtedly, by the action of hot water — representing geometrical figures, is the feature of the chamber knows as Post Office, from which it took its name. This box work is the prevalent character of the roof of most of the chambers."

The House of Representatives Report of June 20, 1902 (#2606) described the first cave survey. The Secretary of Interior had asked for the survey to determine the probable extent of the cave. A partial survey was made in April, 1902, and a report submitted to the Department in May. "It appears therefrom that the survey was extended as far as it was found practicable to do so under the conditions existing at present in the cave, the want of adequate openings and of suitable stairs having barred progress in certain directions in which further extensive chambers are known to exist."

In June of 1902, the Senate approved the bill establishing Wind Cave National Park. The House of Representatives followed suit in December.

After 13 years of strife between families, court cases, lawsuits, restraining orders and confusion over ownership, Wind Cave National Park was established on January 9, 1903, with President Roosevelt signing the legislation. The fact remains that from 1890 to 1903 some of the most colorful and interesting events that have ever occurred at Wind Cave took place. That period in history lends many stories that are woven into our interpretive message on present-day tours.

Whatever happened to that cast of characters? Elmer's wife gives us some clue. In later years she reported that "J. D. McDonald, after many hardships, left for Montana. Elmer McDonald, after working two years as guide for the government and after 12 years residency at the cave, left with his family for Hot Springs. Neither received one penny in recompense from the government for all the time, labor, and expense contributed by them in exploring and developing the cave." John Stabler passed away in 1901 from a disease caused by an infected prairie dog bite at age 53.

Now that the Government had its ninth National Park to administer, a superintendent had to be appointed. The man for the job was William A. Rankin, who entered on duty August 1, 1903. He was paid $75.00 per month for his efforts and was the only park employee. The next six years were lean. There was little money and few people around to help build the new park.

In 1905, Superintendent Rankin reported that the "walks and stairways leading to the cave have been completed as has also the stairways on the three main traveled routes in the cave." Blasting was used to level up and widen out areas along all three routes. The total cost for this

was $291.00.

The next superintendent, Joseph Pilcher, had the opportunity to take General Pershing through the cave. The General took an aneroid barometer with him and checked depths along the route. He proved, to Pilcher's satisfaction, that the cave was not as deep as the guides were reporting. The guides, however, refused the evidence and stuck with their own figures.

One problem that plagued many of the early superintendents was rotting wood steps in the cave. In March, 1911, a temporary solution was found by using creosote-treated wood for steps and bridges.

Difficult Years — 1914-1931

In 1915, lard bucket candle lanterns were used by guides and visitors. This clever device consisted of a lard bucket turned on its side with a hole punched up through the bottom where the candle was stuck. The bucket acted as a reflector and worked very well. Even though electrical lighting was desired, one report stated that, "it would be impossible or nearly so, to wire the cave. The atmosphere is destructive to all organic material and the walls on which the cable or wire should be fastened are almost impenetrable. The wire would also be an unsightly object."

Though it was only four years since the creosoted wood had been used, the Superintendent advised the Director of the National Park Service in 1915 that the wood was rotting too quickly. He advised stone for steps and stairways. One problem with the wood was that the maximum length board that could be carried through the cave was 12 feet and longer pieced were needed in many places.

Tour operations have changed dramatically over the years. In 1898 we know that the fee was $1.00 for the short tour and $2.00 for the long tour, which lasted 4 to 6 hours. The fees dropped to 25¢ at one point, but have come back to the 1898 price today.

It is not surprising to learn that there has been a gradual increase in the number of tours offered each day. In 1915 there were only 2 tours per day, but since there were only 1 or 2 people in the park, the tours lasted 3 hours. It rose to 38 tours per day in 1963. Today 4 types of tours are offered for a total of 43 tours per day.

Cave-ins and earthquakes are always a concern to the visitor. Wind Cave is no exception since there has been minor damage in the past. The first recorded cave-in was in February, 1916, when 2 tons of rock fell during an extremely cold day. Several other falls occurred over the years. Until 1957, most of the problems occurred off-season, while the cave was closed. But, on August 12 that year, 10 to 14 tons of rock caved in 75 feet from the entrance between two tours. No one was injured. Nevertheless, this was at least the fourth time that a cave-in had occurred at this point, so cement pillars were installed to support the ceiling. Earthquake tremors or shocks have been felt, but only the Alaska quake of April, 1964, resulted in damage. Two rocks were removed from the trail and the cave thoroughly inspected.

Up until 1920, there had always been long discussions as to what caused the wind at the cave entrance. The belief was that the differences in atmospheric air pressure caused the air to rush into or out of the cave as the air pressure changed. This, along with minor temperature influences, is what we know to be true today. However, in 1920 another theory was advanced that the wind "is caused by subterranean passages of water down in the lower levels of the cave beyond any of those yet explored, and that the rise and fall of these waters creates the pressure of suction to force it out or draw it in, as the case may be." Logical as this later theory seemed in 1920, there is no supporting evidence.

On October 10, 1926, Superintendent Roy Brazell and others entered the cave to experiment with radio reception. In Odd Fellows Hall, about 208 feet below the surface, they were able to pick up KOA radio station in Denver and WRR from Dallas.

A surprising turn of events took place between 1925 and 1931. The Secretary of Agriculture and the local congressional representatives made several attempts to make Wind Cave National Park a National Monument, transfer it to the Agricultural Department, or make it a part of Custer State Park. The reasons for this are unclear, but their efforts were unsuccessful.

In 1928, an article, written by Ranger Anton J. Snyder, who later became Park Superintendent, appeared in the publication The Black Hills Engineer. He wrote that the cave was formed by hot water and contained 108 miles of passages. Needless to say, both of these "facts" have been disproven.

In 1929, the staff started experimenting with concrete and masonry for foundations, bridges, and stairs and found the results "very satisfactory from the standpoint of looks and utility".

In April, 1931, work on the first lighting system started. The main cables were carefully concealed. Wires running to individual lights were hidden where possible or strapped to the rock walls. The project was finished on June 30. In July the lights were first turned on by Senator Peter Norbeck, who was the invited guest of honor. It is not known how much of the cave was illuminated, but it matters little since this system lasted only two seasons before moisture deteriorated the cables. Some experimentation was done at this time with colored lights. Fortunately, the idea was dropped.

Years of Growth — 1931-1946

It is interesting to note that throughout the early years at Wind Cave most every superindendent felt the cave trails were finished and safe for the public. Then the next superintendent would disagree. Each wrote that more work was needed. This was the case in 1934 when the need was identified for more cement or stone stairs, iron handrails, trail widening, smoothing and trail surfacing. A large task at best. In February, 1934, more improvements were made on the short tour route, but it still did not put

FIGURE 5. Civilian Conservation Corps workers carry concrete in tire innertubes theough Wind Cave to where another step will be poured. (Photo courtesy National Park Service)

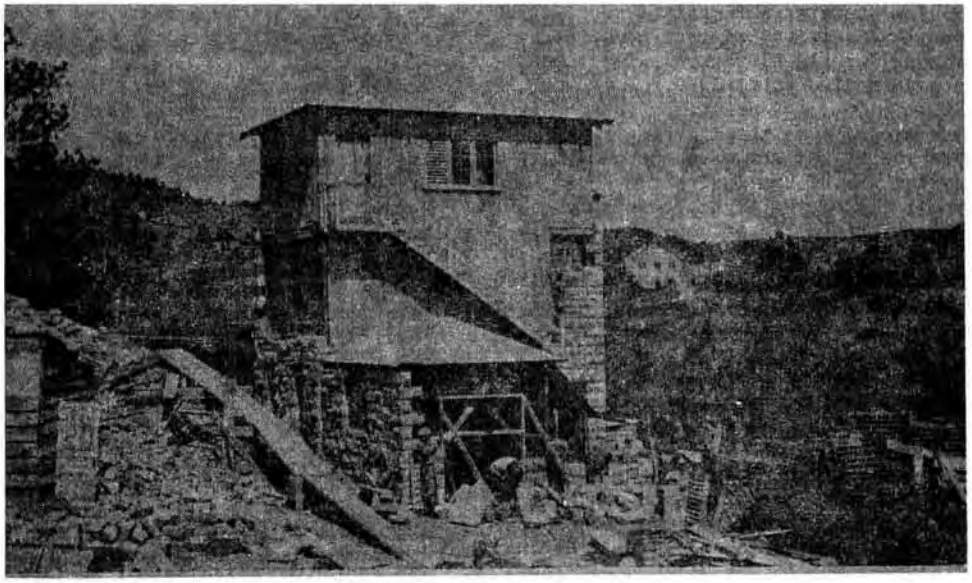

FIGURE 6. Construction of the Elevator Building at Wind Cave National Park by the Civilian Conservation Corps, 1938. The Park Visitor Center and Headquarters is visible in the background and to the right of the Elevator Building. (Photo courtesy National Park Service)

the trail in first class condition. The trail had been surfaced with screened gravel which made walking easier and cut the tour from 1½ hours down to 1 hour.

The saving grace came when President Roosevelt formed the Civilian Conservation Corps as part of the New Deal package to put jobless men to work after the depression years. On July 16, 1934, the Wind Cave Civilian Conservation Corps Camp was officially established. During the next eight years they would accomplish more in the cave and on the surface than any eight years before or since. The first chore was to establish a camp large enough to house, feed and care for the 240 men that were expected. By October 5, 1934, fifteen buildings had been erected. Several important projects were started soon after.

The first was the construction of the elevator shaft and elevator building. Early in 1934 a survey of the cave and surface was completed to determine the shaft location. On August 20, 1934, work began on the construction of a shaft that would penetrate the cave 212 feet, stop at two levels, and provide room for two 13-passenger elevators. In November, 1934, the Otis Elevator Company bid $19,481 to install the first elevator. By February, 1935, the digging of the shaft and tunnel were completed.

In September, 1935, a 120-HP diesel plant was installed to supply power for the new elevator. Tours could now enter the cave a quarter mile away, drop two hundred feet below the surface and for the first time ride an elevator out of the cave without having to walk back up and out the way they had come in. This was one of the most influential changes affecting where the tours could go and how long they would last.

Preliminary drawings were completed in June, 1937, for the new stone elevator building. The building was started in January, 1938, and completed in December. It stands as a tribute to the fine craftsmanship of the CCC labor force. The stone blocks were hand-carved from rock quarried in or near the park. The building contains a first aid room, lobby, restrooms, and a two-story vent house to house the machinery for the elevators. The second elevator was not installed until 1959.

The second major project was the lighting system, cave trail improvement, and new cave entrance. The lighting system was of the indirect method with most, if not all, of the lights carefully concealed, sometimes with the aid of cement and stonework. A 2300-volt armored cable was required as a primary line for this system. Sometimes it required as many as 50 men to carry the next section of cable into the cave.

Cement stairs were determined to be the safest and most durable way to develop the steeper areas along the trail. It is not known for sure how many of the 1033 satirs now in the cave were constructed by the CCC. With an abundance of laborers available, manpower was no problem. They mixed the concrete on the surface and poured it into tire innertubes, which they slung over a worker's shoulders. He entered the cave by elevator or the walk-in entrance to reach the point where the stairs were being built along the one and a half mile trail.

Finally, the cave entrance was reconstructed and finished in the fall of 1936. In front of the old cave house a new walk-in entrance was made and a false ceiling built which was covered with dirt to make the entrance appear natural. Today, very few visitors suspect that the hill one walks into is more man-made than natural. In 1940, a wood door was installed over the cave gate. A 10-inch-diameter opening was made on the door "restoring the natural whistling effect to the entrance which led to the discovery of Wind Cave".

The year 1942 brought increased American involvement in World War II and also the abolishment of most CCC camps (including Wind Cave's) since the young men were drafted.

Post War Years — 1946-1960

After the war was over, visitation jumped dramatically from 3,784 in 1944 to 10,298 in 1945, and 43,608 in 1946. In 1955 the 1 millionth visitor finally arrived. It had taken 74 years to take a million visitors through Wind Cave. Since 1955, 2½ million more have been taken through the cave.

During 1955 and 1956, the third electrical lighting system was installed. This system consisted of 421 fixtures using direct and indirect light. Switches were installed along the route so the ranger could turn the lights on in front of him and off behind him. Even though that was twenty-two years ago, the system has proved a real energy saver in this day and age of high energy costs and energy conservation. In addition to normal 100-watt bulbs, a band of photofloods were installed in the Temple in 1956. The effect of showing the room by regular cave light and then by photoflood is quite dramatic and it is one of the most photographed rooms on the tour. A third type of light was installed in the Fairgrounds, the largest room open to the public. A black light (short wave ultra-violet) is used during the black-out to demonstrate the property of florescence and phosphorescence which the calcite exhibits.

Active exploration of Wind Cave had been nonexistant for many years. It is believed that some of the CCC workers took an interest in caving but maps and survey records are scant. In December, 1958, the Colorado Grotto started preparing for weekend trips to Wind Cave to map and explore. Their efforts over the next few years were the start of a new era of exploration.

The National Speleological Society hosted an expedition to Wind Cave during August, 1959. During one week, 22 cavers completed more work than had ever been done. Three miles of cave were mapped; a faunal study was conducted; a meteorological study started; a report made on the geology and mineralogy of the cave and park; and a surface topographic survey completed.

1960-1978

The National Speleological Society held their 1962 National Convention in Custer, South Dakota, 20 miles from Wind Cave. As part of the convention,

on-trail and off-trail tours were led by rangers and members of the Colorado Grotto.

Probably one of the most bizzare proposals for the use of a cave appeared in 1963. In a copy of the Congressional Record there is a report that Senator Karl Mundt of South Dakota addressed the Senate concerning a proposal that Wind Cave be considered as one of three possible sites for the Strategic Air Command (SAC) headquarters if it was moved from Omaha. This suggestion was originally made by Secretary of Defense Robert McNamara. Mundt urged the Senate to "make careful consideration" of this proposal. Upon hearing of this, Superintendent Jess Lombard wrote the Regional Director not to be alarmed that "we are not actually preparing for turning over the keys to Wind Cave to the Air Force". The idea has not been heard of since.

Exploration continued during 1965 with other cavers becoming interested. Seasonal Ranger Dave Schnute, along with Herb and Jan Conn, explored for several months, mapping 7,298 feet of passage.

As of March, 1966, the recorded length of Wind Cave was 10.53 miles. This seems a far cry from the reported 108 miles that appeared in 1928.

On January 8, 1967, an experimental spelunking tour was conducted by Dave Schnute. He outfitted 15 junior and senior high school students and sponsors and conducted a very successful trip. He recommended that this activity be made available to the public. In 1968, Wind Cave offered its first public spelunking tour.

Presently, the tour is one of our most successful, though now limited to 10 visitors. The four-hour experience allows the novice a chance to see the wild section of Wind Cave in a safe and careful manner. Hardhats, kneepads, electric lights and two other sources of light are provided. Cave conservation and safety are stressed both on the surface before the tour and throughout the trip. We find that we have fewer injuries on this tour than on any other we offer. One of the highlights of the trip is the opportunity for the visitor to explore on his/her own in groups of at least three. They are given a handful of plastic ribbon and careful instruction on how to mark their way from the Muddle Room, where the ranger gives advice on where to explore and waits for their return. This portion of the cave is well known by our staff and was chosen because there are very few dropoffs, pits, wet areas, and fragile formations and many passages loop back into the room where they started. The sense of exploring is thus achieved with relative safety. We have been very pleased with the response by the public and now offer this tour 10 times per week. Often the tour is booked well in advance.

In 1967, over one inch of rain fell in one hour and a small flash flood entered the cave. Most of the tour that was entering the cave escaped unharmed but the tour leader and 6 visitors could not escape. They climbed a ledge to safety and waited. The water soon receded and they too left the cave unharmed. A rock ledge was constructed around the blowhole and an iron plate was attached to the bottom of the cave gate to prevent this from happening in the future.

In 1970, the last major exploration project was undertaken. This time it was a four-year effort by Windy City Grotto from Chicago. During their first summer at the park they mapped 9,806 feet of passage and established a base camp deep in the Calcite Jungle portion of the cave, where medical and emergency supplies were kept. A field phone was installed to base camp, where communication with the surface kept everyone informed of what was happening several thousand feet away in the cave. During the first summer the crews pushed beyong Calcite Lake, discovered by the Conns and others in the 1960's, and discovered Wind City Lake. This, the largest evidence of water table found so far, is a lake 220 feet long and 50 feet wide at one point. Another discovery was the largest helictite bush found in Wind Cave, which measures nearly 6 feet in height.

In 1971, the Grotto mapped 20,415 feet and pushed a series of maze passages into what is now the largest room in Wind Cave. The room measures 2800 feet and is called Half Mile Hall (or Haul). Extensive surface topographic mapping was done and an 8-mm movie was made using the phone line as an electrical conductor to power flood lamps to illuminate the cave.

During 1974, a five-week exploration project was undertaken by Windy City involving at least 65 cavers. Five three-man teams were established. These teams stayed in the cave three days and two nights, living and working out of Base Camp #2. This base camp was equipped with sleeping and cooking gear and sanitation facilities. Base Camp, located 7,000 feet into the cave, was occupied by one or another of the teams continuously for four weeks. By the end of their third year, the Grotto had mapped a total of 75,000 feet.

During their last summer at the Park, the Grotto brought back a small group of dedicated cavers. The Base Camp, telephone communication system, and large numbers of cavers were replaced with small teams moving rapidly without the cumbersome logistics of camps, meals, telephones, and the like. In two weeks an amazing amount of work was accomplished, including the mapping of 31,000 feet of passage. By the end of the summer Wind Cave was officially 26 miles long and the fourth longest cave in the country.

Last fall, after compiling all the survey data from work done by the seasonal rangers and others, the total length of Wind Cave was found to be 30.55 miles. According to the most recent compilation the cave is still rated fourth largest. Occasionally visitors ask when we will open up new sections for tours. Our answer is, probably never. Besides the cost of such an undertaking, there is the potential and unknown impact that such a project would have on the cave. Finally, we feel that the section that is open is a representative sample of Wind Cave and this corridor through a true wilderness environment is sufficient to satisfy the curiosity of most.

Nevertheless, changes are coming. This is the 75th anniversary of the establishment of Wind Cave National Park. Funds have been appropriated for two long-overdue projects, which will directly affect the quality of the visitor experience.

Hopefully, before Christmas, construction of an addition to the Visitor Center will begin. This addition will enlarge the exhibit area tremendously. New exhibits are now being planned by our Harpers Ferry Design Center. We hope that the new interpretive exhibits will demonstrate such things as the air speed and direction at the cave entrance, the early history of Wind Cave and exploration efforts. We are cramped in our present facilities; the interpretive staff is housed in the basement of the headquarters with no room for expansion. The new facility will provide us with a new library, museum collection storage, dark room, more office and storage space, new information counter and plenty of elbow room to better assist and inform the visitor. We are extremely excited about the unlimited possibilities for our new facility.

Finally, this winter we will begin the task of removing the present lighting system, which is over 10 years old, and replacing it with an all-florescent lighting system. We estimate that we will install 600 fixtures along one and a half miles of passages. We plan on indirect lighting in every spot possible. During experiments last winter we were amazed at the brightness of the florescent lights and the color which it brings out. We saw thing along the tour route we have never seen before. The project may be an inconvenience to some during the installation but the results will be outstanding. Again, we are extremely excited about this project and only hope that within the next year or so we will see the results of our efforts.

I think one of the greatest rewards of working at Wind Cave will be to be part of the change and growth we are now experiencing. And, by 1981, when the discovery of Wind Cave will be 100 years old, I will be able to look back at the turmoil and problems we are about to go through with this construction and say what a thrill and challenge it was to be part of history in the making.

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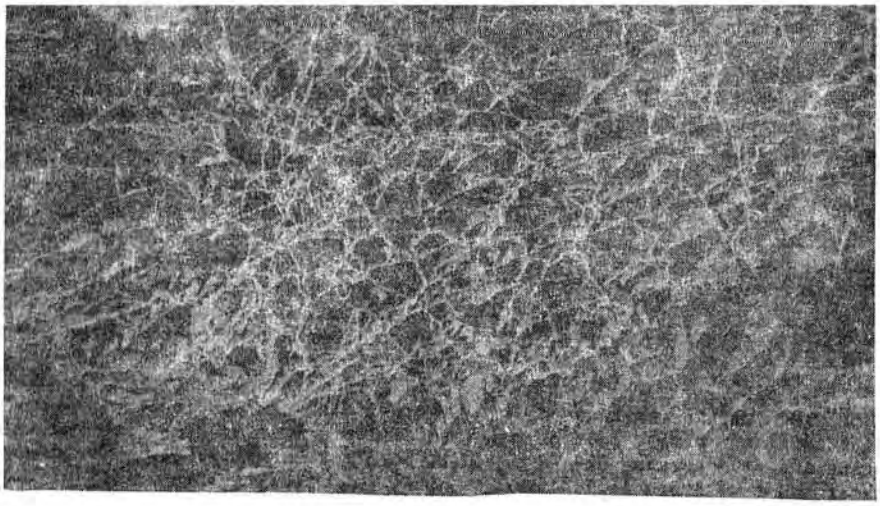

FIGURE 7. Boxwork formation. In the early days at Wind Cave they thought this formation reminded them of post office boxes. It is the one formation that Wind Cave is well known for. (Photo courtesy National Park Service)

THE NATIONAL PARK SERVICE CAVE RADIATION RESEARCH AND MONITORING PROGRAM

*Keith A. Yarborough

The first measurements in the United States of airborne alpha radiation in caves were made in 1954 and in 1962 and 1963 in New York and Alabama (5, 14). Later work at Carlsbad Caverns National Park and other southern New Mexico caves in 1974 and 1975 (13, 15), indicated that a possible health hazard might exist for personnel who spent considerable time underground leading tours or doing maintenance work. As a result, the National Park Service initiated a program of research and monitoring in September 1975 at Carlsbad Caverns to evaluate the situation (1, 2). Subsequent measurements of alpha radiation were made in 1976 and 1977 in many National Park Service administered caves (16-24). These findings have led to weekly monitoring being carried out routinely since May 1976, at a number of National Park Service caves: Mammoth in Kentucky; Wind and Jewel in South Dakota; Oregon Cave; Crystal in Sequoia National Park, California; Cumberland Gap in Kentucky/Tennessee/Virginia; Lehman in Nevada; Round Spring Cave in Ozark Scenic Riverway, Missouri; as well as Carlsbad. National Park Service employees have been equipped and trained to make the radiation measurements, including radon gas and daughter concentrations, Tsivoglou and free ion concentrations, and airflow determinations; and to compute personnel exposure accumulations (4, 7, 12). This work continues to the present time under the National Park Service Cave Radiation Research and Monitoring Program. Table 1 summarizes the entire cave radiation program's work, both existing and projected.

The research phase of this program established the relationship between the alpha radiation in caves and the natural airflows by a working hypothesis which the data have substantiated (23). This is that all caves in which the primary cause of airflow is due to temperature/(density) gravity-gradients and also having minimal man-made disturbances (such as tunnels, elevator shafts, bore holes, sealed and closed portals, etc., which would alter the natural airflows) experience seasonal variations in airborne alpha radiation. The radiation levels increase in summer but decrease in winter, based upon seasonal air movements through each cave system which occur naturally. Two general types of physical cave configurations were identified which act to control the airflows seasonally:

1. Those which go up into a hillside or mountainside: Type I ("Upside-down" = USD).
2. Those which go down into the earth; Type II ("Right-side-up" = RSU)

The summer increase in Type I caves is due to increased airflows, whereas in Type II caves it results from stagnation or reduced airflows. This seeming paradox is explained by the physics of the airflow regime in each cave type and whether or not its natural airflow patterns have been altered by human activities. All of this has been reported in detail elsewhere (20, 22, 25, 26); particularly at the 1976 and 1977 National Cave Management Symposia. It is true in general that airflow decreases airborne radiation in the immediate vicinity in which it occurs. Any paradox results from how the air moves through a cave system with respect to time and space.

In more humid areas, water inflows from variable rates of percolation resulting from fall, winter and spring precipitation may mobilize more influxes of radiation materials than summer thunderstorms. Such action might contribute to the summer increases in radiation. This is being studied by Dr. James Quinlan in the Mammoth Cave area. In arid and semi-arid areas the sparse annual precipitation occurs as snows and rains during the winter, or as intense, but very localized, summer thunderstorms. While the former could mobilize some radiation materials, the latter will do so only if they occur in the immediate vicinity of the cave system. In any case, for arid and semi-arid areas, the amount of percolating water usually is small, so that airflows play the major role in the alpha radiation distribution in cave systems. An example is Carlsbad Caverns in southern New Mexico. Furthermore, in humid areas the volumes of air which move through cave systems are much greater than the volumes of water, so that the airflows probably play the major role there, too.

Therefore, because air can move more freely and quickly throughout cave systems, airflows are much more significant in the mobilization of the alpha radiation materials. These airflows are the main means by which radiation is dissipated or concentrated. Thus, this integral link between airflow and cave alpha radiation has been studied closely because it affects employee exposure accumulations in unaltered, natural caves.

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Alterations of the natural airflow patterns by man's "developments" and management practices also can have marked effects. For example, at Mammoth Cave in Kentucky, an immense Type I system, the summer outflows cause elevated radiation levels. However, to minimize uncomfortable inflows of cold, outside air in winter, metal covers are placed over the natural entrance. This causes considerable increases in the radiation levels which moderate with greater distance from the entrance (see Tables 3A and 3B). This artificial radiation increase causes winter levels to approach summer levels (when the covers are not in place) at times.

The use of forced air ventilation, as is done in mines, is unthinkable for caves because of the disastrous adverse effects on the microclimates of caves which would result. For example, air movements in the unsealed elevator shafts at Carlsbad Caverns led to an unfortunate and substantial drying of the cave and its formations over several years until these were finally sealed. Detailed studies by Mr. John McLean of the U. S. Geological Survey showed this (6).

Table 1 shows a summary of annual personnel exposure accumulations at those National Park Service administered caves which are regularly toured and which also have the highest levels of radiation. The extreme and mean values are presented. Comparing means, Mammoth Cave (USD type) is seen to have the greatest exposures, both because its size generates relatively high radiation levels and because it has the largest staff. Cave air was used for year-round air conditioning here until late April 1976. Carlsbad Caverns (RSU type), having the second largest staff, is also of great size and has comparable exposure means to Mammoth Cave, though its levels are lower. Table 2 summarizes representative radiation level extremes selected from the overall data record obtained for several National Park Service caves.

Table 3A also shows the effects of the management practice of putting up sealing covers in the winter, as previously described for Mammoth. To investigate these management activities more fully, a series of observations were made in the fall of 1977. The results, as summarized in Table 3A, have been grouped in general as to whether the airflow was incast into the natural ("Historic") entrance or outcast from it. The work entailed alternately putting up and taking down the sheetmetal covers at this entrance. When the air was outcast, the entrance configuration (i.e., covers up or down) caused little difference in the alpha radiation levels because the air had mobilized its radiation load from farther back within the cave. The cover down condition promotes somewhat higher radiation levels, as would be expected for a Type I (USD) cave. However, for the incast airflows, a great deal of difference was observed. This was most pronounced for those areas closest to the entrance, but was attenuated for areas farther into the cave. When the covers were up, the diluting effect of the incast air was precluded and the radiation levels rose, as occurred during previous winters when these covers were in place from October to April. Conversely, with the covers down, the incast air depressed the radiation levels significantly. The "unaltered" airflow conditions (no covers) of summer, when the natural airflow patterns of this vast USD cavern network have been well established in the cyclic unsteady "breathing", resulted in the radiation levels shown in Table 4. There is a reasonable good consistency from year to year for most of the tour routes and during the same months. (This table extends data previously reported at the 1977 National Symposium; see ref. 23).

Oregon Cave, in southwestern Oregon, shows other effects of management practices. In the early 1930's, an exit tunnel was driven into the central areas of the cave to produce an easier tour route. This altered the natural airflow patterns in the cave. Table 3B shows the average seasonal WL values for the central parts of Oregon Cave, outside air temperatures, and generally-prevailing airflow conditions. As is expected, the warm season cave radiation level (0.30 WL) exceeds the cool season level (0.12 WL) average. Sometimes during the spring and fall, or at times in midsummer, when there is little airflow or an oscillating flow which continually shifts directions and with cave and surface air at about the same temperatures, the radiation levels increase in the central parts of the cave to well above "seasonal" averages. These increases indicate what the undisturbed nature of this USD cave may have been. In this case, in contrast with the situation at Mammoth Cave in Kentucky, the man-made tunnel, which is unsealed, has enhanced airflows through the cave and, therefore, has caused depressed radiation levels for the altered conditions of this USD cave system. This emphasizes that when airborne radiation materials are mobilized by USD cave airflows, and that motion subsequently stagnates in the typical, unsteady ("breathing") cyclic form of Type I cave configurations, the radiation levels can rise above the more prevalent, usual values of the altered, more steady-state airflow seasonal situations, which may have been caused in a USD cave modified by human activities. Therefore, the vital role of understanding the airflow, the cave's physical configuration, and the cave's management procedures is vital in understanding its radiation fluctuations and seasonal behavior. These all affect personnel exposure accumulations. Furthermore, we must be very careful in our cave management actions to avoid changes which may be subtle but of considerable adverse effect on cave microclimate and general "well being".

All data which have been or are being collected from the NPS Cave Radiation Research and Monitoring Program are being placed in a computerized data base. This Cave Radiation Information Systme (CRIS) has been developed over the past year. The radiation monitoring personnel, from each NPS cave which is regularly monitored, were trained in the use of CRIS in June 1978. This system will permit much easier access to the data from all NPS caves and will expedite exposure record keeping and timely reporting of results. All data are reported by cave monitors on special coding forms to the NPS-WASO Division of Natural Resources Management. These data, which are placed into CRIS, are of four main types:

1. Radon and thoron daughter measurements along all tour routes and in all occupied areas;

2. Employee exposure times and cave locations;

3. Measurements of radon gas concentration, the concentrations of the individual radon daughters and free ions, and small particulate concentrations;

4. Cave meteorological measurements; both inside and outside for pressure, temperature, relative humidity and evaporation rate, and air speed and direction inside the cave.

The NPS Program has been aided by a number of other agencies which have been consulted: Environmental Protection Agency, Occupational Safety and Health Administration, National Institute for Occupational Safety and Health, U. S. Bureau of Mines and especially Mining Safety and Health Administration's Denver Technical Support Center, Radiation Branch (formerly Mining Enforcement and Safety Administration) and the National Caves Association (NCA). From this interaction, the National Park Service Program has evolved. The findings have led to interim precautionary health standards for cave radiation exposure of personnel, drafted by both the National Park Service and the National Caves Association. Measurements of alpha cave radiation also have been made by private consultants and by agencies of a few states.

In 1977, NCA funded a study by speleological and groundwater specialist/consultant, Mr. Tom Aley, who reported on "Cave Radiation and the Commerical Caves of the United States" (3). His results from 218 questionnaires returned from private cave employees have been compared with 41 responses from National Park Service personnel at Mammoth Cave, Kentucky (see details elsewhere in these 1978 Proceedings). They show that private cave employees spend less time underground than do National Park Service personnel, in general. This is to be expected because of differences in methods of operation. Private caves are usually smaller in size with shorter tours which move through the cave more quickly. Also, their tours usually do not penetrate as deeply into the cave but stay in outer areas which are better ventilated, often by multiple access portals, where the radiation levels are lower. Mammoth Cave and other National Park Service caves usually have much greater visitation in proportion to numbers of personnel so that NPS spend more time underground, usually. Also, the means of conducting tours is important. At most private caves tours are led so that personnel alternate their shorter periods of underground exposure with time above ground throughout the day; even in busy times. Many NPS caves (e.g., Lehman, Nevada; Round Spring, Missouri; Wind and Jewel, South Dakota; etc.) are operated this way. A few, however, which have the greatest visitations, operate differently. For example, tours are conducted at Mammoth Cave during times of lower visitation, but at busy times personnel are stationed along some tour routes which are then "self-guided". This keeps personnel underground more continuously. Carlsbad Caverns has used this self-guided method for several years now on a year-round basis. Because the radiation levels at Carlsbad are lower, the exposures have been lower (refer to Tables 1 and 2).

Measurements by private consultant, Mr. William Austin, (9) in certain private caves in Kentucky show "no appreciably high levels" and range from "very low to well below the highest levels found in NPS-administered caves." Checks by the Kentucky Bureau of Health Services, Radiation Control Branch (10), show values usually of a few hundredths of a WL, with all levels below 0.3 WL for one privately operated cave. A total of eight such caves were sampled in March through April 1977; three of which were man-made by drilling and blasting. The findings showed a range of 0.045 to 0.49 WL, with an average for all of 0.20 WL. These radiation levels are two to five times lower than those measured in various parts of Mammoth Cave, Kentucky, during the same time period.

In Missouri, a few private caves were checked in 1977 by the State Mine Inspector's Office (11). Results for winter (early February) measurements in five caves, four to five samples at each, varied from zero to 0.14 WL for all these caves, with averages in each of the five caves of 0.04, 0.07, 0.06, 0.02 and 0.02 WL. A mid-summer (mid-August) measurement series at one cave showed a range for three samples of 0.01 to 0.28 WL with an average of 0.18 WL. This was in a large cave system having strongly outcast airflows.

The National Park Service arranged with the National Institute for Occupational Safety and Health to conduct a health hazard survey at each of its routinely-monitored caves in 1976. This was determined by the National Institute for Occupational Safety and Health to be only a sputum cytology investigation which was conducted during the summer 1976 for NPS cave personnel, on a voluntary basis.

The report (8) of May 1978 (No. TA 76-54), was prepared by: Eileen Philbin Gunter, R.N., MPH, Nurse Officer and by: Channing R. Meyer, M.D., Chief, both formerly in the Medical Section, Hazard Evaluations and Technical Assistance Branch, U. S. Department of Health, Education, and Welfare, Center for Disease Control; National Instutute for Occupational Safety and Health, Cincinnati, Ohio, 45226.

This report has been excerpted to provide the following summary of the most pertinent parts (see also, Table 4, for detailed sputum cytology results for each cave area sampled).

"In March of 1976 the National Institute for Occupational Safety and Health received a request from the Department of the Interior for medical evaluation of employees working in several of the caves in the National Park System. The request was made because elevated levels of radon 'daughters' radiation were found in several caves tested.

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"...samples for pulmonary cytological analysis were taken from long term employees at Carlsbad Caverns in December of 1975. The results of the analysis of those specimens showed many mild atypical cells present in non-smokers as well as

smokers, and two of the individuals tested showed marked cellular atypia. These preliminary results prompted the Assistant Director for Safety Management, Office of Management Services, Office of the Secretary, Department of the Interior, to contact Dr. Finklea, the Director of NIOSH. In this communication he requested that NIOSH conduct a survey of the workers in not only Carlsbad Caverns, but long term employees at the other National Park Service Caves. After the available sampling results were reviewed, it was felt that a NIOSH evaluation was justified.

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"Subsequently, NIOSH studied each individual cave's employees (eight caves total). Employees were given a questionnaire and asked to provide two first morning sputum specimens on successive days. Because the NIOSH contract laboratory did not report the sputum findings in a manner satisfactory to NIOSH, all specimens had to be reevaluated using new criteria. Because of this a substantial delay in the reports occurred.

"The results are now available and based on the sputum findings as well as the results of the questionnaire, it is apparent that no evidence of a measurable respiratory effect on the cave workers was present at the time of these studies. Recommendations for long term surveillance and other pertinent suggestions are included in the recommendations of this report.

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"The project was undertaken in late May of 1976 and sputum samples as well as a detailed questionnaire were thoutht to be appropriate. The employees to be studied were employed at the following caves:

A. Carlsbad Caverns, Carlsbad, New Mexico
B. Mammoth Cave, Mammoth Cave, Kentucky
C. Lehman Cave, Baker, Nevada
D. Oregon Cave, Cave Junction, Oregon
E. Round Spring Cave, Van Buren, Missouri
F. Wind Cave, Hot Spring, South Dakota
G. Jewel Cave, Custer, South Dakota
H. Crystal Cave, Three Rivers, California

"EVALUATION METHODS

Employees at the caves mentioned were evaluated by two means. The first was a detailed questionnaire eliciting past occupational exposure as well as past pulmonary history and a history of tobacco consumption. The second was collection and analysis of two separate sputum specimens obtained from each worker.

"The questionnaire elicited occupational history, pulmonary symptomatology, smoking history, family history of malignancies, and a variety of demographic data (i.e., age, sex, years at present job, etc.).

"Each worker was requested to arrive before he or she reported for work on two consecutive mornings. Sputum samples were induced by use of an ultra sonic nebulizer with a propylene glycol-sodium chloride solution. Specimens were collected in solutions of 50% ethyl alcohol, properly labeled and analyzed by Medical Diagnostic Services Laboratory (MDS), a GSA contract laboratory in Cincinnati, Ohio.

Original results were reported in terminology unacceptable to NIOSH. As a result, the pathologists at MDS were asked to reevaluate each specimen after having adopted the criteria (developed by Saccamano, et al.)[1] felt to be acceptable to NIOSH.

"In addition to the workers who were tested a group of volunteers from within NIOSH were asked to participate in the study as a control group. The group of controls included males, females, blacks, whites, smokers, and non-smokers. They were evaluated in a similar manner as the cave workers. Each participant was asked to provide two sputum specimens and occupational as well as smoking history.

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"RESULTS

All of the caves studied during this investigation had results that were similar so the general discussion will cover all the caves as a group. (Each cave is reported in Table 10).

NIOSH controls were a significant part of this investigation. Thirty-five individuals participated. They had a mean age of 30.9 years. There were 22 males and 13 females; 14 were smokers, 17 were non-smokers, and 4 were ex-smokers. Although each individual participating in the study was requested to provide two first morning sputum specimens, 13 individuals provided only one specimen. The remaining individuals provided two specimens each for a total of 57 specimens. Of these 57 specimens 11 were judged to be poor samples not representative of sputum. Of the remaining sepcimens 5 were interpreted as metaplasia, and 3 were read as mild atypia. The 3 specimens that were judged to show mild atypia were all from smokers or ex-smokers. Those who had one sputum reported as metaplasia also had another sputum that was read as normal. (Note: NIOSH feels that these results are comparable to those found for Mammoth Cave. See Table 10).

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"DISCUSSION AND CONCLUSIONS

The sputum samples were analyzed and placed into one of five categories by the examining pathologist. The sample might be marked as normal meaning that only normally occurring cells were present in the specimen. The second category was metaplasia which indicates that the cell is not normal but neither can it be classified as abnormal. Third, fourth, and fifth categories were all judged to be abnormal. These were classi fied as mild, moderate, or marked atypia, reflecting an increasing degree of severity as one moved from the mild to the marked atypia. Marked atypia

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[1]Saccamano, Geno, Ph.D., M.D., et al. "Development of Carcinoma of the Lung as Reflected in Exfoliated Cells," Cancer, January 1974, Vol. 33, pgs. 256-270.

would be suggestive of potential malignancy, with detailed medical follow-up suggested.

Based on the results of the eight caves studied as well as the NIOSH control population, it is apparent that there are only a few individuals out of the large group studied that showed any significant consistent abnormalities. Again, based on the results of these samples, it does not appear that there were widespread pulmonary cytological abnormalities in any of the groups tested.

Based on the data that have been collected, it appears that only certain high risk individuals should be monitored on a routine basis. Cave workers who are greater than 40 to 46 years of age, who are cigarette smokers, and who have worked in the caves for more than 5 years are those individuals who should be most closely observed. In addition workers who are greater than 45 years of age and who have worked in the caves greater than 5 years despite the fact that they are not smokers or ex-smokers whould also be high priority for surveillance procedures.

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"RECOMMENDATIONS

Based on the results of this study, the following recommendations are made. They in no way are mandatory and may be judged to be too conservative by some and too liberal by others, but based on the data available they would provide adequate surveillance in those high risk populations without adding tremendous expense that is encountered in massive medical screening.

1. All employees of the cave system be encouraged to cease consumption of tobacco.

2. Each permanent full-time employee should be given a complete history and physical including occupational history, history of tobacco consumption, as well as a general physical examination baseline chest x-ray and baseline sputum cytology for those individuals who are over 30 years of age.

3. A yearly physical examination with laboratory studies should be performed on smokers who are greater than 40 years of age and have had greater than five years of service in the caves and on workers who are greater than 45 years of age who are non-smokers who have had greater than 5 years of exposure in the caves. This examination should consist of the routine history and physical examination as well as chest x-ray and sputum cytology done at alternating 6-month intervals.

4. Workers who are less than 40 years of age with 5 or more years in the caves may also be considered for study.

5. If the screening studies begin to detect increased abnormalities, then the program should be re-evaluated and extended.

6. If on the screening program any abnormalities are discovered, that is x-ray or sputum examinations, then these abnormalities should be referred to a consulting physician and appropriate medical follow-up be instituted.

7. All use of cave air for air conditioning and other uses should be suspended if it has not already been done."

These recommendations have been incorporated into the second draft revision of the National Park Service "Interim Precautionary Cave Radiation Health Standards and Management Guidance for Natural Caves Open to Visitation by the Public."

This has been concurred with by Mr. John Hast, Chief of the Division of Safety Management, Office of Administrative and Management Policy, Department of Interior, who stated"

"I have reviewed each of these recommendations (to safeguard employees who work in the caves) and feel that each is prudent and necessary to protect these employees. I suggest that you (NPS) consider these recommendations and incorporate them into your present safety and health program. I might add that, aside from humanistic considerations of a medical surveillance program, the costs for conducting such a program can be relatively small in comparison to losses resulting from a lack of the periodic physical examinations."

As reported in the 1978 Proceedings by Mr. Tom Aley, the NCA has unanimously approved standards similar to those being considered at present by NPS. The NCA has adopted them for use at privately operated caves among their membership. Therefore, the National Park Service is in compliance with the precautionary cave radiation health standards and management guidances prevalent for the cave management industry in considering standards and guidances which are essentially similar. The main differences between the adopted NCA and the draft, interim NPS standards and guidances are:

1. NPS will inform all cave personnel of the potential health hazard due to cave radiation whereas NCA will be selective in what cave personnel be informed in order to minimize possible confusion and/or panic due to misunderstandings.

2. NPS no longer permits cave air to be used for any kind of air conditioning (summer or winter) in any surface buildings, whether regularly occupied or not.

3. The NPS has incorporated the NIOSH recommendations into its draft, interim standards, as discussed above.

4. NPS is considering the inclusion of the following at this time:

   A. NPS-WASO will provide the funding support which may be needed for each of the following:

      i) Payment for the medical exams and/or compensation (including possible travel expenses and per diem) to workers for any and all medical exams and testing which NPS may require.

ii) Compensation (including possible travel expenses, per diem and charges for any medical expenses) which may be incurred when further medical follow-up to the testing in i) may be necessary.

iii) Compensation (including possible travel expenses, per diem and charges for any medical expenses) for any treatment, lost work time, and even disability, which may have resulted in cases of illness attributable directly to cave air radiation.

B. NPS-WASO will make all necessary arrangements for this medical testing and will communicate the procedure to be followed to the field areas through the appropriate channels.

5. NPS will use its computerized CRIS data base to store, retrieve and report all data on cave radiation and employee exposures.

The NPS Cave Radiation Research and Monitoring Program completed its research phase at the end of January 1978, and has entered its long-term management phase. The latter phase will extend over the next several years, at least, in order to gather both cave radiation and employee exposure data and to obtain such epidemiological information as may be possible using the interim standards and guidances which have been based on the research data of NPS and the recommendations of NIOSH.

Of particular significance in both the NCA and NPS statements on standards is the following:

"PART III - SCIENTIFIC INFORMATION

Interim Guidance for Data Collection for Natural Caves Open to Visitation by the Public

In order to make the most effective resource management decisions for caves which will be both prudent and proper in the long term phase of the radiation program, it is important to continue to develop the data base. This is to be done by continued routine monitoring, where applicable, using the above standards (Part I) and Management Guidelines (Park II), at caves not being monitored - especially those administered by the NPS.

In addition, managers should recognize the importance of continuing cooperation with scientific professionals. This will insure that appropriate skills will be mustered which can assist in developing the quantitative basis for establishing sound management plans and actions, by implementing pertinent applied research efforts. Conversely, managers, can provide questions, ideas and facts useful in shaping such research so that it can produce management oriented results."

These concepts have been redrafted subsequently into an overall set of Precautionary Cave Health Management Guidelines which are a part of general draft Cave Management Guidelines. All of this, especially those parts dealing with medical surveillance and possible compensation is undergoing extensive review by the Washington Office of the National Park Service. Henceforth, the Division of Safety Management of the National Park Service, WASO, will coordinate the long-term management phase of the Cave Radiation Health Monitoring Program.

In general, it is the consensus of alpha radiation health experts that the National Park Service must continue the routine monitoring activities (including use of the CRIS - Cave Radiation Information System - computerized data base managed in Washington) at the caves which it administers and must add the medical surveillance which the National Institute for Occupational Safety and Health has recommended. It is naive to look for an easy, clean "solution" to the alpha radiation situation in caves, because real-world problems do not have such crisp, analytical solutions. The closest resolution of the situation is what has been done: the evolution which has been undertaken by "scoping" the National Park Service (and private) cave radiation conditions and employee exposure amounts by research; establishment of the monitoring system of people, equipment and training; and continuous, active management in the future using the system established and adding medical surveillance to it. Managers will have to manage, as the cave radiation situation will not magically vanish! To complain that more problems have been created than solved, or that greater hazards and problems exist elsewhere for the National Park Service to work on, or that the reports from the study work are too extensive is to beg the question and to shirk responsibility. Such pettifoggery must be discarded. This is a problem "past" only insofar as it has been defined in extent by the National Park Service work to date and that "the system - of continued monitoring and medical surveillance - is the solution." If we considerably curtail or drop the entire effort at this point in order to conserve resources, it may well come back to hanut us in the future on a much greater scale with much more expensive tort claims and/or adverse publicity, as Mr. Hast of the Department of Interior has noted.

An alternative to the routine monitoring may be the use of predictive computer modeling. While this may work acceptably for caves such as Carlsbad Caverns for which the natural airflows are little altered and in which our extended (over three years) research shows repeatability of radiation levels, it will not work at others such as Mammoth Cave or Oregon Caves where the airflows are considerably altered. The extension of radiation level prediction to employee exposure prediction could be even less reliable due to the inherent uncertainties of time averaging and weighting for underground areas. Nevertheless, this seems like an alternative worthy of trying in some National Park Service caves, such as Carlsbad Caverns. Another way of doing this, or of complementing it is to use continuous, automated monitors. These have given results comparable to those found by the present methods when tried in a few places at Mammoth Cave, Carlsbad Caverns, Lehman Caves, and Jewel Cave.

The hope of personal dosimeters for employees is still unfeasible. The U. S. Bureau of Mines (Mr. Droullard) has reported that after seven years development research, these dosimeters (both TLD with air pump and tract-etch types) are just now ready for actual field testing in mines. In moist

and/or dusty conditions serious errors still can result (± 20% to ± 100% in each type, respectively). In any case, the present National Park Service type monitoring system would have to be carried out as a check. Mine Safety and Health Administration feels that it has insufficient data at present to promulgate personal dosimeter standards for the uranium mining industry.

An "instant" WL device has been developed by several different workers, but these are expensive and error prone. Mine Safety and Health Administration (Mr. Beckman) has tested and reported on them.

The perennial question will continue to be raised as to whether cave workers are "radiation workers" subject to the same economic benefit vs. health risk considerations implicit in mining, especially uranium mining. It has been noted that with the alpha radiation levels formed in some National Park Service caves they would be closed according to mining health standards. Continuously, we have sought to differentiate between cave management and mining operations. The National Park Service - WASO is shaping a policy decision on this at the same time it decides upon the alpha radiation monitoring/medical surveillance issues for the National Park Service cave management purposes. Some medical experts believe that if lung disease could be attributable to cave radiation exposures, then it should be compensatable, as the National Park Service draft health standards and management guidances proposes. Mr. Tom Aley, consultant to the National Cave Association, has expressed considerable concern that the National Park Service will be opening a "Pandora's Box" in the form of claims from the general population, if it should adopt the medical responsibility commitments now drafted into the second interim standards statements. He sees this as an admission that cave exposures do cause lung cancers. He estimates, using the National Institute for Occupational Safety and Health (NIOSH) uranium miner data, that there are about two lung cancers among the five million cave visitors (and workers, who are a very small part of this total) per year. Therefore, the National Park Service will proceed cautiously. Health experts reject this viewpoint as being implausible and unrealistic in both a legal and practical sense.

The Environmental Protection Agency has presented data indicating that the natural alpha radiation found planet-wide may be one of our greatest environmental hazards, causing 5 to 10% of all lung cancers. This is now a great health debate: as to whether low alpha (and other) radiation levels are statistically related to cancers in the general populace. The linkage has been shown for radiation workers, such as uranium miners. Canadian estimates are 5 to 20% of all cancer from natural sources. Dr. Neal Nelson of the Environmental Protection Agency has reported increasing lung cancer risk for lower exposure accumulations (in WLM) based on WLM vs. percent increase in lung cancer risk per WLM. Canadian findings agree with this. United Nations data show 2 to 4.5 lung cancers per 10,000 WLM in uranium miners, while International Council on Radiation Protection data (unpublished) show 1 to 4 lung cancers per 10,000 WLM.

Dr. Victor Archer of NIOSH has recently found that intermittent exposure to "higher" alpha radiation levels may be less damaging than continuous exposure to "lower" levels, even when the total accumulated exposures are the same. This is significant for cave management.

However, previously Dr. Archer had found no exposure rate (WL) dependence with respect to lung cancer incidence. Now he reports that for "low" accumulated exposures (about 30 or 40 WLM or less), the effects of a given exposure rate (in WL) may be greater than that for "high" accumulated exposures. There is a linear response, which Canadian data confirm. All of these data are for uranium miners. Other recent health data show 110,000 new lung cancers annually, with a 200% increase in the last 25 years. This may be due in part to more accurate health monitoring and data reporting and in part to more anthropogenic pollutants in the overall planet-wide atmosphere.

It seems, when all is considered, that any agency planning medical surveillance would be well advised to contract with Dr. Saccamanno's laboratory to have this testing done as part of its medical surveillance program for its cave employees. At $20 per test per year (though perhaps less could be arranged for a "bulk" package) the cost of this preventive health check seems acceptable.

Finally, to reject all of this mining evidence and the National Park Service research and monitoring results to date -though certainly no epidemiological link between cave worker airborne alpha radiation exposure and lung disease has been established - seems like the king killing the messenger who bears bad tidings. As in the contemporary movie, THE WIZ, when Evilene advises her cohorts in badness: "Don't nobody bring me no bad news!", the cave radiation situation has been treated similarly by some cave managers. By contrast, of course, there may be those among us who may have some deep psychic need for bad news - whether it be that cave radiation may cause lung cancer or that the research and monitoring system established to define the situation has not as yet been as effective as desired since no clear link has been determined as yet.

Between both of these extreme views, it seems most prudent to get on with cave management responsibilities now, without dwelling upon whatever setback, oversights or omissions may have occurred, and moving on from this point. Part of these cave management responsibilities must be to make policy on cave worker health. We must be positive in our actions, not negative and reactive.

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TABLE 1. ANNUAL NATIONAL PARK SERVICE PERSONNEL EXPOSURES TO CAVE AIRBORNE ALPHA RADIATION

Cave Area	Time Interval Year & Dates	Annual Personnel Exposure, WLM						Remarks
		Visitor Services			Maintenance			
		Max	Min	Ave. (No.)	Max	Min	Ave. (No.)	
Carlsbad Caverns, N.M.	Sep 1975 thru Dec 1975	0.86	0.06	0.511 (19)	0.74	0.02	0.278 (17)	Open all year.
		0.81 Concessioner	0.12 Concessioner	0.569 (12) Concessioner	—	—	—	
	Jan thru Dec 1976	2.17	0.22	1.287 (18)	1.79	0.04	0.574 (16)	Tours not guided
	Jan thru Dec 1977	2.09	0.41	1.23 (18)	1.70	0.02	0.548 (17)	All data are for permanent personnel only in 1975-1978
	Jan 1 thru Aug 31, 1978	2.70	0.90	1.66 (9)	1.78	0.01	0.53 (18)	
Lehman Cave, Nevada	Jan thru Dec 1977 Permanent Personnel	0.54	0.04	0.243 (6)	0.15	0.03	0.083 (3)	Open all year
	Mar thru Dec 1977 Seasonal Personnel	1.36	0.13	0.849 (10)	0.08	0.02	0.053 (2)	Tours are guided
	Construction work on lighting system May thru Dec 1977	—	—	—	0.73	0.005	0.436 (6)	
	Jan 1 thru Aug 31, 1978 Permanent Personnel	0.286	0.01	0.107 (4)	0.14	0.051	0.085 (3)	
	-- thru -- 1978 Seasonal Personnel	1.05	0.24	0.857 (9)	0.017	0.071	0.017 (1)	
Mammoth Cave, Ky.	May 1, 1976 to Apr 30, 1977	3.06	0.03	1.237 (85)	3.45	0.37	2.077 (15)	Data are for all personnel. Open all year. Tours guided only in fall, winter and spring.
	Jan 1, 1977 thru Dec 31, 1977	2.87	0.04	1.202 (84)	3.82	0.006	1.474 (17)	
		3.98 Concessioner	0.002 Concessioner	0.427 (49 Concessioner	—	—	—	
	Jan 1 thru Aug 31, 1978	1.77	0.03	0.825 (74)	1.96	0.004	1.201 (9)	
		1.87 Concessioner	0.001 Concessioner	0.301 (23) Concessioner				
		YACC 1.17	YACC 0.02	YACC 0.31				
Caves in Sink Hole Plain, Ky (south of MACA)	May thru Aug 1975	9.32 Researchers	1.94 Researchers	5.61 (9) Researchers	—	—	—	Hydrologic studies have been conducted in these caves during the last 4 years to trace water pollution movements which may enter MACA from the south.
	May thru Aug 1977	3.69	0.74	2.51 (8)	—	—	—	
Round Spring Cave, Ozark, MO	Jan 1, 1977 thru Nov 22, 1977	1.13	0.10	0.518 (8)	—	—	—	Open only in summer
Crystal Cave Sequoia, Calif.	Apr thru Sep 1977	0.985 (Apr-Dec 1977)	0.03	0.264 (7)	(included in "Visitor Services")			Open only in summer.
	Jun thru Sep 1977	0.29	0.05	0.140 (17)	(included in "Visitor Services"			

TABLE 2. SUMMARY OF REPRESENTATIVE CAVE RADIATION RADON SAUGHTER WL VALUES AT SELECTED CAVES HAVING HIGH RADIATION.

Cave Name Area	Weighted Average of all Tour Route Sampling Sets with one or more values ≥ 1.00WL (NO.)				Weighted average of all Sample Values ≥ 1.00WL in each sampling set having at least one value ≥ 1.00WL (NO.)			
LECA Lehman Cave, Nevada	0.68 (115) (Based on 13 sampling sets)				1.12 (22)			
SECA Crystal Cave, Sequoia, CA.	0.79 (82) (Based on 21 sampling sets)				1.37 (24)			
CUGA Indian Cave Cumberland Gap Va./Ky./Tenn.	1.01 (17) (Based on 5 sampling sets)				1.18 (10)			
ROSP Round Spring Cave Ozark, MO	1. Overall Cave: 1.50 (146) (Based on 19 sample sets)				1.93 (98)			
	2. North Passage: 1.00 (52) (Based on 14 Sample Sets)				1.35 (22)			
	3. South Passage: 1.86 (70) (Based on 19 Sample Sets)				2.04 (64)			
	1976 - 1977		1977 - 1978		1976 - 1977		1977 - 1978	
	Covers Up	Covers Down	Covers Up	Covers Down	Covers Up	Covers Down	Covers Up	Covers Down
MACA Mammoth Cave	0.89 (246)	0.91 (152)	1.07 (454)	1.03 (263)	1.20 (87)	1.10 (67)	1.35 (252)	1.21 (148)
Other Caves at Mammoth Cave National Park, KY:								
Floyd Collins Crystal Cave	1.13 (12)	1.17 (25)	0.81 (7)	1.07 (14)	1.18 (10)	1.32 (10)	1.02 (3)	1.42 (8)
White's Cave	None	1.03 (12)	None	1.59 (20)	None	1.25 (7)	None	1.63 (19)
Great Onyx Cave	1.00 (8)	1.03 (8)	0.81 (8)	1.26 (10)	1.09 (4)	1.13 (4)	1.25 (4)	1.26 (10)
New Discovery Entrance Area	0.86 (7)	1.00 (16)	None	1.02 (5)	1.09 (4)	1.06 (10)	None	1.15 (4)

TABLE 3-A. EFFECTS OF MANAGEMENT ACTIVITIES AT NATURAL ENTRANCE OF MAMMOTH CAVE ON AIRBORNE ALPHA RADIATION LEVELS - (October 10 through November 22, 1977).

Cave Area Sampled	Average Radon Daughter WL	Gate Cover Configuration	Airflow Direction	For Same Air-Flow Direction, % Change When Covers Put Up	Remarks
Historic Tour Route	1.46	Up	Incast	+54%	Average is for entire Tour Route.
	0.67	Down(off)	Incast	—	
Historic Tour Route	1.33	Up	Outcast	-5%	Average is for entire Tour Route
	1.40	Down	Outcast	—	
Natural Entrance to Methodist Church (closer to natural entrance)	1.21	Up	Incast	+65%	Average is for that part of the Historic Tour Route nearest the entrance. This is most changeable sample (walking). Difference: Up/In vs. Up/Out = .17 WL Difference: Down/In vs. Down/Out - -1.09 WL
	0.42	Down	Incast	—	
	1.38	Up	Outcast	-9%	
	1.51	Down	Outcast	—	
Stairway before Fat Man's Misery to River Hall (farther from the natural entrance)	1.54	Up	Incast	+16%	Average is for that part of the Historic Tour Route farthest from the entrance. This is least changeable sample (walking). Difference: Up/In vs. Up/Out = +.32 WL. Difference: Down/In vs. Down/Out = -.05 WL
	1.29	Down	Incast	—	
	1.22	Up	Outcast	-9%	
	1.34	Down	Outcast	—	

TABLE 3-B. MANAGEMENT EFFECTS AT OREGON CAVE, OREGON. (Note: In the early 1930's a tunnel was driven into the central areas of this Type I (USD) cave to serve as a tour route exit. This greatly altered the natural airflow patterns. The average cave air temperature is between 44° to 48° F. Highest WL. tour route rate segment includes: Joaquin Miller's Chappel, Paradise Lost, Wedding Cake Room and Ghost Room in the central part of the cave.)

SEASON	DATE	RANGE	AVERAGE	AVERAGE OUTSIDE AIR TEMPERATURE	AIRFLOW CONDITION
1. Warm-Seasonal Average	April thru November 1977, April & May 1978	0.12-0.57	0.03(for 9 months) no data for 10/77	50.9° (for 9 months) no data for 10/77	From man-made exit and "110" portal down and out at natural entrance. This is not expected for a USD cave; though Oregon Cave is altered by human activities. This airflow is more steady-state in nature.
2. Cool-Seasonal Average	December 1976 thru March 1977, & December 1977 thru March 1978	0.045-0.30	0.12 (for 7 months) no data for 2/78	39.3° (for 7 months) no data for 2/78	From natural entrance and "110" partal up and out at man-made exit. This is not expected for a USD cave, though altered. The airflow is more steady-state in nature
3. Cool	Nov. 10, 1977 (1358-1413 hours)	0.32-0.35	0.33 (of 3 samples)	45°	Down toward entrance in general, but with oscillating flows, alternating directions. These tend to keep the cave air somewhat stable in the center portions of the cave; a net stagnation effect since the cave and outside air temperatures were about the same. Airflow as expected

(continued)

TABLE 3-B. (continued)

SEASON	DATE	RANGE	AVERAGE	AVERAGE OUTSIDE AIR TEMPERATURE	REMARKS
4. Cool	Nov. 10, 1977 (1944-1959 hours)	0.36-0.44	0.39 (of 3)	45°	Airflow as expected for a USD cave, though altered as before but with reduced airflows.
5. Cool	Nov. 11, 1977 (1015-1030 hours)	0.52-0.55	0.56 (of 3)	45°	As before, but with airflow between the mid-day and afternoon sample sets on November 11, as expected for a USD cave, though altered.
6. Cool (end)	Mar. 16, 1978 (1430-1442 hours)	0.15-0.30	0.21 (of 3)	43°	Down toward entrance in general, but with oscillating flows, alternating directions. Cave and outside temperatures are about the same. Airflow as expected for a USD cave.
7. Cool (end)	Mar. 17, 1978 (0837-0851 hours)	0.26-0.52	0.40 (of 3)	43°	As before, about the same. Airflow as expected for a USD cave, though altered.
8. Warm	Aug. 17, 1978 (2026-2041 hours)	0.31-0.36	0.34 (of 3)	approximately 47° - 48° F. (estimated)	Very little airflow, with oscillations, as expected.
9. Warm	Aug. 18, 1978 (0716-0732 hours)	0.44-0.52	0.48 (of 3)	48°	Very little airflow, as expected.
10. Warm	Sep. 21, 1968 (1953-2006 hours)	0.60-0.73	0.66 (of 3)	43°	Stagnation of air. (Cave temperature = 45°F) These are the highest levels as yet measured.
11. Warm	(Sep. 22, 1978)	0.51-0.69	0.57 (of 3)	42°	Very little airflow; condition as expected for USD caves, even though altered. (Cave temperature = 46°F)

TABLE 4. COMPARISON OF SUMMER MONTHLY RADIATION LEVELS AT MAMMOTH CAVE ("UNALTERED" AIRFLOWS). AVERAGE WL → (Number of Samples Averaged are in ( )'s).

Cave Tour	July 1978	July 1977	July 1976	August 1978	August 1977	August 1976	Sept 1978	Sept 1977	Sept 1976	Number of Samples Routinely Taken on Tour
Historic Tour(MACA)	.59(34)	.68(33)	.80(26)	.61(50)	.81(40)	.76(17)	0.76(49)	.88(35)	.79(33)	8
Half Day Tour(MACA) (Scenic)	.42(56)	.44(44)	.43(19)	.46(67)	.47(45)	.57(49)	0.56(66)	.62(43)	.67(55)	14
Lantern Tour(MACA)	.83(36)	.93(35)	.82(16)	.85(43)	.90(27)	.96(23)	0.83(41)	.90(31)	.80(24)	9
Wild Cave Tour(MACA)	.35(64)	.46(28)	.44(9)	.40(59)	.45(42)	.44(24)	0.48(63)	.50(45)	.59(46)	12
White's Cave Tour	1.55(8)	1.63(7)	1.23(4)	1.37(9)	1.69(7)	.96(4)	1.41(8)	—	—	3
Snowball Lunchroom (MACA)	.38(13)	.49(6)	.49(4)	.43(13)	.46(10)	.52(4)	0.50(13)	.53(7)	.58(4)	1
Great Onyx Cave Tour	.62(12)	.72(12)	.80(7)	.72(21)	.89(13)	.83(10)	0.64(12)	.77(11)	—	4

(continued)

TABLE 4. (continued)

Cave Tour	July 1978	July 1977	July 1976	August 1978	August 1977	August 1976	Sept. 1978	Sept. 1977	Sept. 1976	Number of Samples Routinely Taken on Tour
Frozen Niagara Tour(MACA)	.39(16)	.36(6)	.40(4)	.38(16)	.41(14)	.39(8)	0.49(20)	.45(14)	.50(16)	2

TABLE 4. HEALTH HAZARD SURVEY RESULTS BY NIOSH OF SUMMER 1976 SPUTUM CYTOLOGY TESTING OF NPS CAVE PERSONNEL VOLUNTEERS.

	Employees Sampled			Employee Age Date,yrs				Employment Length→Yrs,Wk,Mos.				Employee Smoking Habits		
Cave Location	Total No.	Male	Female	Low	High	Mean	Median	Low	High	Mean	% of Employees Sampled Working at Cave 1-5 yrs	Smokers	Non-Smokers	Ex-Smokers
1. Carlsbad Caverns, N.M.	35	23	12	19	63	38.8	34	4 mo	27 yr	6.2 yr	>50%	19	11	5
2. Mammoth Cave,Ky	(68*) 51	38	13	18	64	36.5	32	5 wk	35 yr	6.4 yr	Approx. 35%	23	19	9
3. Lehman Cave,Nev.	7	3	4	21	38	28.3	26	2 mo	6 yr	1.7 yr	2 of 7 = 28.5%	4	3	–
4. Oregon Cave,Ore.	4*	3*	1	27	43	34.5	34	4 mo	11 yr	3.2 yr	1 of 4 = 25%	2	1	1
5. Round Spring Cave, Oxard Riverway, Mo.	4	4	—	20	29	23.5	24	3 mo	11 mo	4.5 mo	—	—	4	–
6. Wind Cave, S.D.	(11*) 9	5	4	22	47	27.5	24	9 mo	11 yr	4.4 yr	7 of 9 = 77.8%	3	5	1
7. Jewel Cave, S.D.	(13*) 9	8	1	—	—	29.4	28	8 mo	7 yr	2.1 yr	>50%	2	7	–
8. Crystal Cave, Sequoia, Calif.	5	5	—	22	62	36.2	33	3 mo	2 yr	9 mo	2 of 5 = 40%	1	3	1
NIOSH Control Group	35	22	13	—	—	30.9	—	—	—	—	—	14	17	4

TABLE 4. (continued)

EMPLOYEE HISTORIES			
Employees with former respiratory hazardous occupations	Employees with former positive respiratory disease history	Number with a positive family history of malignant disease	Sputum Cytology Results
1. 5	11	4	All specimens within normal limits, except 2. No significant problems. Both of these showed mild atypia. One was a cigarette smoker, one a non-smoker. All but 2 employees provided 2 specimens. These 2 gave 1 specimen each.
2. 12	22	17	*17 employees were unable to produce any sputum whatsoever. 13 employees produced only one specimen, the other 38 provided 2 specimens. 2 of 13 with only one specimen were mild atypia - one a cigar smoker, one a non-smoker, 1 of 28 with two specimens had both abnormal: one of these mild atypia, the other moderate atypia - a heavy cigarette smoker. 3 of 38 had one specimen abnormal, the other normal: mild atypias for these 3. One was a smoker, one a non-smoker and one an ex-smoker. 5 of 38 had one specimen showing moderate atypia, the other normal. 3 of these were smokers, 2 were non-smokers. One non-smoker with 30 years exposure in caves, of these 38 showed metaplasia, 28 of the 38 had both samples within normal limits. Surveillance of this situation should continue even though these results indicate any significant problems are unlikely.
3. 1	4	1	All 7 employees provided 2 specimens. All were within normal limits. No problems.
4. 1	2	—	2 of 4 employees gave 2 specimens. The other 2 gave only 1. *Dr. Yarborough, NPS Program Coordinator was included here. All specimens were normal. No problem.
5. 1	—	—	All 4 employees collected first morning sputum samples on 3 consecutive mornings, self-administered. All specimens were within normal limits. No problem. Cave open only in summers.
6. 3	5	7	4 of 11 employees gave only one specimen. *2 employees could not produce any sputum. All specimens were within normal limits. No problem.
7. 3	4	5	1 of 13 employees gave only one specimen and *4 could not produce any sputum. All specimens were normal. No problem.
8. 1	1	—	4 employees produced 3 consecutive first morning samples, but one was lost. 1 employee produced 2 consecutive forst morning samples. No significant epithelial cells were found; therefore, no determination was possible. Cave open only in summers.
NIOSH	—	—	13 of 35 provided only one specimen, the other 22 produced 2 specimens each, but 11 of these were poor samples not representative of sputum. Of the 46 good specimens 5 were read as metaplasia and 3 were mild atypia - the latter were all from smokers or ex-smokers. Of the metaplasia specimens, each other sample was read as normal.

BAT MANAGEMENT IN THE UNITED STATES

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Introduction

Between the years 1600 and 1850, five American animal species vanished. In startling contrast, fifty-seven additional mammal, fish, and bird species have been forced into extinction just since the year 1850 (120 Cong. Rec., 1974). The basic reason for this dramatic increase in species extinction is the rapid, and in some cased uncontrolled, development and advancement of our modern industrial and technological society (115 Cong. Rec., 1969). In an attempt to counter this ongoing and potentially disastrous process, Congress passed, during the years 1969-1973, three major legislative acts which were designed to encompass and provide impetus to the concept of protection to any and all endangered species.

Congressional Action

The first formal involvement by Congress in endangered species legislation began with the Endangered Species Preservation Act of October 15, 1966. This law acknowledged a national responsibility to act on behalf of all native species of wildlife which were threatened with extinction by requiring the Secretary of the Interior to implement a comprehensive program to conserve, restore, and where necessary, bolster wild populations found threatened with extinction.

Its amended version, the Endangered Species Conservation Act, was enacted on December 5, 1969. It expanded the scope of the previous act by including all vertebrates, mollusks and crustaceans on a world-wide basis, by including subspecies as well as species, by ensuring that the United States would not contribute to the extinction of other nation's wildlife, and by authorizing funds to acquire lands for the purpose of conserving, protecting, restoring, and propagating any endangered species.

In the early 1970's Congress discovered that the existing Endangered Species Conservation Act simply did not provide the kind of management tool needed to act early enough to save a vanishing species. It had determined that the inadequacy of an existing regulatory mechanism was a major factor contributing enormously to the continuing problem of animal extinction.

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Endangered Species Act of 1973

After Congressional study and Presidential urging, the Endangered Species Act was passed on December 28, 1973, hereinafter referred to as the "1973 Act." It totally replaced the previous two acts except for the provisions relating to the National Wildlife Refuge System.

The emphasis of the 1973 Act is the conservation of endangered and threatened species. It empowers the Secretary of the Interior to compile and maintain separate official lists of threatened and endangered species on the basis of the best scientific and commercial data available. The Secretary may also issue regulations as he deems necessary and advisable for the conservation of such species. This action provides the Department of the Interior with the power to act to protect species before they actually become endangered.

The 1973 Act also commits all federal agencies to utilize their authorities in furtherance of the purpose of the law by taking such action necessary to ensure that actions authorized, funded, or carried out by them, do not jeopardize the continued existence of such endangered and threatened species which is determined by the Secretary to be critical. Federal agencies are required to consult and obtain the assistance of the Secretary before any actions are taken which may affect any endangered species or their critical habitat.

Although Congress had recognized that hunting and destruction of natural habitat were two causes of extinction, the 1973 Act addressed another cause of extinction — over-utilization for commercial, sporting, scientific, and/or educational purposes. Taking was defined to include harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, and/or collect. Protection was also offered for the first time to endangered species of plants.

Finally, the 1973 Act authorized legal suits by private citizens seeking injunction relief for an alleged violation.

Department of the Interior Actions

In accordance with Congressional directions, the Department of the Interior has taken specific action towards protection and restoration of populations of bats (Table 1 outlines the actions taken regarding bats).

TABLE 1

Department of the Interior Actions.

Action	Law	Source
Indiana bat (*Myotis sodalis*) - E*	1966 Act	32 Fed. Reg. 4001 (1967)
Hawaiian hoary bat (*Lasiurus cinereus semotus*) - E	1969 Act	35 Fed. Reg. 16047 (1970)
Indiana bat critical habitat	1973 Act	41 Fed. Reg. 41914 (1976)
Gray bat (*Myotis grisescens*) - E	1973 Act	41 Fed. Reg. 47180 (1976)
Indiana bat recovery plan	1973 Act	Dept. of the Interior (1976)
Ozark big-eared bat (*Plecotus townsendii ingens*) and the Virginia big-eared bat (*Plecotus townsendii virginianus*) - P**	1973 Act	42 Fed. Reg. 61290 (1977)

*E = Endangered, **P = Proposed as endangered

Court Decisions

In recent years court decisions concerning endangered species have increased in frequency and have proven to be of major significance in that they have embodied individual and governmental attempts to make difficult, and yet practical, decisions concerning the preservation of species in an increasingly technological and urbanized environment which often casts aside the fate of animals. Since the passage of the 1973 Act, there have been several "landmark" federal court decisions which have greatly affected application of the 1973 Act and which have established a burden of "proof of responsibility" upon those wishing to utilize the 1973 Act as a deterrent against further habitat and/or species destruction.

The primary issue in the Sierra Club v. Froehlke (1976) became whether the Army Corps of Engineers had adequately considered the fate of the Indiana bat (*Myotis sodalis*) in its environmental impact statement regarding the construction of the Meramac Dam near St. Louis, Mo. The Circuit Court of Appeals ruled that the Sierra Club failed to meet its burden of proof, which was to show that the actions taken or considered by the Army Corps of Engineers had or would jeopardize the continual existence of the Indiana bat.

In the National Wildlife Federation v. Coleman (1976), the issue centered upon construction of a highway through a critical habitat of the Mississippi sandhill crane (*Grus canadensis pulla*). The court ruled that secondary impacts must be evaluated in order to ensure the continued existence of an endangered species and to ensure that the critical habitat will not be modified or destroyed.

In probably the most publicized and controversial decision regarding the 1973 Act, the Circuit Court of Appeals, in Hiram G. Hill v. Tennessee Valley Authority (TVA) (1977), enjoined TVA from completion of the construction of the Tellico Dam. The Appeals Court stated in its opinion that once a living species has been eradicated, in this case the Snail darter (*Percina imostoma tanasi*), discretion loses its significance. Whether the project is 50 percent or 90 percent completed is irrelevant in calculating the social and scientific costs attributable to the disappearance of a unique form of life. Enforcement of the 1973 Act must be taken to its logical extreme. The welfare of the snail darter and its critical habitat along the Little Tennessee River, weighed more heavily on the Court's conscience than the write-off of millions of dollars already expended on the Tellico Dam.

In the United States v. Capparet (1974), the United States sought a declaratory judgement of its rights to the use of water adjacent to land in Death Valley Monument necessary to maintain a pool of water for the Devil's Hole pupfish (*Cyprinodon diabolis*). The court enjoined the defendants so as to limit their pumping to achieve and maintain a stated daily mean water level in the pool. The court determined that the protection of an endangered species is more important than private property rights.

Survey Procedure

In order to determine how the federal government interpreted and implemented the 1973 Act, four questions were directed toward each department and/or agency. These questions were:

1. What Federal laws, regulations and guidelines govern your agency's actions regarding endangered species, especially bats?
2. How has your agency interpreted these laws, regulations and guidelines in the formation of its internal policies?
3. What do your protection policies include?

4. If eradication is necessary, what methods and recommendations are followed? What chemicals, and what dosages, are allowed?

Agency Response

Upon receiving responses from twenty-six departments and/or agencies, they were categorized into three groups — no responsibility, secondary responsibility, and primary responsibility.

There were eleven departments and/or agencies which had no responsibility in bat management. Those agencies were the Animal and Plant Inspection Service, Department of Commerce, Department of Housing and Urban Development, Bureau of the Mines, Geological Survey, Department of Justice, Department of Labor, Department of the State, Federal Aviation Administration, Office of Science and Technology Policy, and the National Oceanic and Atmospheric Administration.

Nine departments and/or agencies stated that they had secondary responsibilities regarding bat management. By secondary responsibility, it is meant that there are policies and procedures to be followed if bats are encountered during an action taken by either the department, agency or employee. The departments and/or agencies with secondary responsibility are: Forest Service, Soil Conservation Service, Department of Defense, Army Corps of Engineers, Coast Guard, Federal Highway Administration, Tennessee Valley Authority, Council on Environmental Quality, and the Bureau of Reclamation.

Six departments and/or agencies stated that they have primary responsibility regarding bat management.

The Department of Health, Education and Welfare — Center for Disease Control (CDC) was registered by the Environmental Protection Agency on May 28, 1976, to release DDT for the control of bats in man-made structures where they constitute human health hazards as potential rabies vectors. CDC has prepared a document entitled "Guidelines for the Use of DDT in the Control of Bats." This document outlines stringent criteria for the correct procedure as to requests, application, use, techniques, and reporting. CDC is reluctant to release DDT for bat control because of the benefits derived from bats and will not approve any requests for the use of DDT to kill bats in caves. The applicant must show that an abnormal rabies risk of human exposure exists and that other methods of repelling or physically excluding bats have failed before CDC will release DDT. CDC recognizes that total elimination of rabies is seldom a practicable goal and that the reduction to a normal level of risk is a more realistic goal. CDC will not approve programs simply to control nuisance animals.

The Department of the Interior is a land managing agency and has four agencies which have primary responsibility for bat management. These agencies are: Bureau of Land Management (BLM), Endangered Species Scientific Authority (ESSA), National Park Service (NPS), and the Fish and Wildlife Service (FWS). BLM and NPS have objectives which are to maintain diversity and natural abundance of all endemic species. Both manage cave systems as total systems and have management policies for threatened and endangered species, pesticides and caves. The Endangered Species Scientific Authority (ESSA) is primarily concerned about international trade of animal species. Trade includes the movements of specimens for commercial, scientific, exhibition, or other reasons. There are five species of bats (four from Tunisia and one from Uruguay) to which ESSA procedures are applied.

The Fish and Wildlife Service has direct responsibility for bat protection and management authorized through the 1973 Act and the Fish and Wildlife Coordination Act of 1956. The Fish and Wildlife Service has issued "Guidelines to Assist Federal Agencies in Complying with Section 7 of the 1973 Act." These guidelines are intended to furnish a broad framework within which federal agencies may prepare internal procedures to guide their activities and may be used at their discretion. The Fish and Wildlife Service has several policies depending upon the state of the individual species and are dictated by a recovery plan. They include cave management, land acquisition, cave fencing, critical habitat preservation, and a moratorium on bat banding. They recommend "bat-proofing" as an alternative to DDT spraying. The indiscriminate killing of bats under the guise of public health is not acceptable to the FWS.

The Environmental Protection Agency (EPA) stated that it was primarily a regulatory agency and did not have any formal bat management policies. They have responsibility for enforcing the Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (FIFRA), which regulates the marketing of pesticides and requires that such products be registeres on the basis of proven effectiveness and safety to humans, livestock, wildlife, and the environment. A crisis exemption (Section 18 of FIFRA) can be used to obtain DDT if an emergency condition exists. The governing factor in applying for a crisis exemption is time and that no readily available pesticide registered for that particular use to eradicate or control the pest can be found. Before EPA allows a crisis exemption, consultation takes place with the Secretary of Agriculture and the Governor of the State. There are four products registered with EPA that can be used for control and/or eradication of bats. These products are DDT, rozol tracking powder, naphthalene flakes, and chlorophacinone.

Conclusion

The response to the questions indicate that there exists several federal policies relative to bats, all of which are basically uniform and consistent. Ultimately, the Department of the Interior, Department of Health, Education and Welfare, and the Environmental Protection Agency have the primary responsibility for decisions regarding bat management. Judging from these agencies' responses, it is apparent that the actual eradication of bats, when proven to be of human danger, is a decision not taken lightly. It is, in fact, one subjected to careful scrutiny, preparation, and inter-agency coordination.

It can be concluded that a more concerted effort should be made to educate the general public about

this tiny fragile creature which is unique in the animal kingdom. Such a programmed effort would, undoubtedly, be an up-hill struggle given the awesome power of the media, but nevertheless it should be attempted.

Another result of the survey was that the existing endangered species legislation provides a basic tempering tool — one which must be applied judiciously, yet forcefully. Through application of the 1973 Act, the courts are engaged in ecological tinkering, getting species through the bottlenecks until management of entire ecosystems (including habitats), can be realized and accomplished. The existing 1973 Act is capable of coping with the potential problems of future species extinction. The 1973 Act does not necessarily ensure protection for many species either now endangered or now threatened. This responsibility of protection remains a burden which we must bear. It remains our responsibility to see that this pattern of extinction is not repeated in future generations. Because one day we may discover that our own survival has become the matter of primary global concern and is contingent upon some form of legislative dictate. And who will be there to ensure our survival?

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STATE LEGISLATION CONCERNING THE PROTECTION OF CAVES

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There have been many changes in the list of state laws protecting caves since the publication of Rob Stitt's article on state legislation in the Proceedings of the First National Cave Management Symposium - 1975. This paper is an update of that list incorporating essentially the same tabular format used by Stitt. In the past three years, seven states have instituted cave protection laws. Those of particular note have been passed by the legislatures of Georgia, Maryland, Texas and West Virginia. Unfortunately, one state, Indiana, repealed its already inadequate law on October 1, 1977. Several additional cave protection laws, unreported by Stitt, have been included in Table 1, which is a listing of known cave protection laws and their characteristics.

Important items to take note of in several of the more recent laws are provisions to protect landowners from liability and to stop speleothem sales. Both are very critical measures toward preserving caves.

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TABLE 1
STATE CAVE PROTECTION LAWS IN FORCE

State and Citation	Penalties	Features Protected: Speleothem Sales	Speleothem Damage	Pollution and Litter	Forcible Entry	Cultural Remains	Biota	Comments
Arizona Arizona Revised Statutes 1977 Title 13-3702 Effective 1978	6 months		X	X	X		X	
California California Penal Code 1977 Title 14-523 Effective 1975	1 year $500		X		X	X	X	
Colorado Colorado Revised Statutes 1963 Article 18 40-18-14 Effective 1883	3 months $500		X		X			Law must be posted at cave entrance to be effective.
Florida Florida Statutes Ann. 1975 Title 17-267.061 Title 17-267.13 Effective 1973	6 months $500		X			X		Effective on state land. State permitted to buy caves.
Georgia Code of Georgia Ann. 1977 Title 43-25 Title 43-9916 Effective 1977	12 months $1,000	X	X	X	X		X	Owner protected from liability.
Illinois Illinois Ann. Statutes 1977 Chapter 56-2.2 Chapter 56-3.11 Effective 1971, 1972	$25-$300						X	Cave protection falls under criminal mischief.
Kentucky Kentucky Revised Stat. 1975 Title 41-13-1601 Effective 1948	5-30 days $500		X					Applies only to commercial caves.
Louisiana Louisiana Revised Stat. 1977 Title 41-13-1601 Effective 1970	30 days $500		X					Applies to caves on public land.
Maryland Annotated Code of Maryland 1974 Chapter 314-14 Effective 1978	10 days-6 mo. $500	X	X	X	X	X	X	Gates must allow free access to bats, water, and air. Owner protected from liability.
Missouri Missouri Revised Stat. 1956 Title 18-293.620 Effective 1959								Deals only with the safety and inspection of commercial caves.
Nevada Nevada Revised Statutes 1977 Title 33-381-195 Title 33-381-225 Effective 1959	6 months $500		X			X		Caves preserved as prehistoric or speleologic sites. Applies to public land only.

TABLE 1 — continued

State and Citation	Penalties	Features Protected: Speleothem Sales	Speleothem Damage	Pollution and Litter	Forcible Entry	Cultural Remains	Biota	Comments
Oklahoma								
Oklahoma Statutes Ann. 1977								Specifically protects cave biota found outside caves. Guano mining, predator hunting is permitted
Title 21-69-1789								
Title 21-69-1790	1 year							
Effective 1967	$500		X	X	X		X	
South Dakota								
South Dakota Compiled Laws 1967								
Title 22-34-9								
Title 22-34-20	misdemeanor							
Effective 1939, 1965	30 days $100		X			X		
Tennessee								
Tennessee Code Annotated 1955								Confused wording due to partial omission of one sentence.
Title 39-4535	1 year							
Effectivd 1967	$10-$100		X	X	X		X	
Virginia								
Code of Virginia 1975								
Title 18-2-142								
Effective 1966	$500		X	X	X		X	
West Virginia								Cave gates must allow free access to air and biota, Owner protected from liability.
West Virginia Code 1978								
Chapter 20-7A	$100-$500							
Effective 1978	10 days-6 months	X	X	X	X	X	X	
Wyoming								
Wyoming Statutes Ann. 1957								
Title 6-10-107								Hot springs and geysers included.
Effective 1909	$100, 60 days		X					

Overleaf: Carl Hanson (left) and Leo Hunt (right) catching blind fish in Roaring River during the 1930's. Roaring River is one of the large base level streams in Mammoth Cave that is threatened with deteriorating water quality. Concern over this problem was a central theme of the Fifth National Cave Management Symposium at Mammoth Cave National Park, October 17-20, 1980. (Ray Scott photo courtesy of Mammoth Cave National Park)

1980

WELCOMING REMARKS

Robert Deskins

Good Morning — On behalf of the Director, it is indeed a pleasure for me this morning to welcome you to Mammoth Cave. It's only appropriate that Mammoth Cave was selected for the site of the Fifth National Cave Management Symposium, its being the longest cave system in the world and our recent nomination to the World Heritage List. In reviewing the program and a list of the participants, I am amazed with the talent, knowledge, and expertise of those that are here for this session.

I want to especially thank Jim Wiggins of my staff for all the hard work he has done in preparing for the Symposium. Jim has spent countless hours in working out all the fine details. Other participants on the Organizing Committee are Bill Austin from the National Caves Association, Tricia Fink of the Tennessee Valley Authority, Jim Goodbar of the Green River Grotto, John Mylroie with the National Speleological Society, and Ron Wilson of the Cave Research Foundation.

STEERING COMMITTEE — Joe "Buzz" Hummel with the Bureau of Land Management, Jack Steiner (my good friend from Chattanooga - Ruby Falls, Lookout Mountain), Bob Stitt of the National Speleological Society, and Cal Welbourn with the Cave Research Foundation.

In reviewing the programs from the previous Symposia, I would like to think that what's planned here this week will be extremely stimulating, informative, and interesting. Today we face more serious problems in managing our resources than in any other period of history. I would like to believe that we are moving in a positive direction.

As a manager, I always feel comfortable knowing that we have competent people such as the Cave Research Foundation, the National Speleological Society, and other scientific groups working for the benefit of the National Park Service.

As all of you know, research dollars for the National Park Service have been skimpy and at times non-existent at Mammoth Cave. If it had not been for the work of organizations such as yours, then it is difficult to state the decisions we would be facing today. We are now getting the attention of our local citizenry — more attention is being paid to our problems — or their problems. This is definitely an attitudinal change that has been brought about by research and knowledge.

For those of you making your first visit to Mammoth Cave, be sure to get out around the Park and see more than the headquarters area. If we can be of assistance to you during your visit, please call on us. If you have any particular matter you would like to discuss on a personal basis, I'll be around all week.

THEIRS NOT TO REASON WHY

*G. Jay Gogue

ABSTRACT

Three areas are discussed, i.e., need for information in cave management, acquisition of information, and use of information. The need for resource identification and description is emphasized. The importance of broad-based input into information collection is discussed. Proper use of information in decision making is encouraged.

Let me first echo Superintentent Deskin's comments concerning our pleasure in hosting your symposium this year. We are most excited to have this opportunity and we are hopeful that you will consider Mammoth Cave or other national parks in future years. Let me also follow-up on Bob's comments on the science budget. This year the research proposal by Dr. Quinlin, Research Hydrologist here at Mammoth Cave, was a top priority in the Southeast Region. His proposal received very high consideration at our Washington office and it made the "cut" by the Department of Interior. We are very optimistic that this necessary project will receive funding.

It is a pleasure for me to participate in the 1980 National Cave Management Symposium. I want to thank Bob Deskins and all the members of the steering and the organizing committees for their excellent work in putting this symposium together. I know what is involved. About a year ago the National Park Service held a major conference on Science and Research in National Parks. I was the conference chairman, and I learned a great deal about conferences. 1) I have great respect for anyone who ever trys to plan one, 2) I am much more tolerant than I ever used to be of small things such as whether or not the coffee will arrive on time, and 3) Finally, I learned that occasionally you have to literally disconnect the microphone to get some speakers to sit down. I promise that I will not stay up here long enough for you to disconnect me.

In preparing my remarks today I had the opportunity to go back to your first symposium in October, 1975, and to begin to trace your progress through the last 5 or 6 years. Let me say that the wealth of information that has been generated and consolidated because of your efforts is really noteworthy. I was quite impressed. I also noticed that certain individuals seem to contribute frequently. I won't call their names but their repeated involvement tells me that the quality of their contribution is withstanding professional scrutiny and review from their peers. If this were not the case they would not be repeat performers. Quality information that is legally defensible is indespensible. I encourage you to continue in the fine tradition you have started, that is, making the National Cave Management Symposium as professional as possible.

This morning, in representing the Director of the National Park Service, Mr. Russell Dickenson, I would like to briefly discuss three areas with you:

1. The need for information in cave management.
2. Acquiring the necessary information, and
3. The use of that information.

The informational needs to properly manage any complex natural system are enormous. It appears that this need increases almost daily with no real end in sight. As we learn answers to certain questions, we become enlightened enough to ask other questions.

In an attempt to understand our informational needs in the National Park Service, last November we surveyed our parks concerning potential threats and the need for information to address these threats. Of the eight areas that the National Park Service manages specifically for their cave resources, 126 threats were identified. This figure does not take into account that there are at least 22 other national parks that possess significant cave resources. Servicewide, approximately 7,000 threats to resources of the approximately 340 national parks were identified. So what I am trying to say is that we have a large number of threatened resources on which we need information. I am confident that whether you are a federal cave manager or a private one, that you have a great need for information to address threats or concerns or problems.

Many of the threats that our parks identified were not even perceived as problems a few years ago, i.e., acid rain, endangered species, development of energy resources, air quality deterioration, and radioactivity. In the future some of these threats will be adequately addressed, but new threats very likely will replace them. Speaking of future threats, I read an interesting excerpt from a book entitled, "Secrets of the Ice Age" by Evan Hadingham, that I want to share with you:

> "A cave, he explains, is a "confined and delicately poised world"; a person entering that world "is a drastic intrusion... The average visitor, for example, breathes out enough carbon dioxide during a single

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> hour to produce...20 liters of carbonic gas, the agent which dissolves limestone. In the same period of time, the visitor will generate 60 calories of body heat and 40 grams of water vapor, so the temperature and absolute humidity of the cave will rise.... The entire nature of the cave system can be altered in unforeseeable ways."

The concept dealing with the interaction between visitors and cave resources is certainly not new, but for me the fragilness of the system and the magnitude of impact that cumulative visitation might pose were brought into focus in this excerpt.

So where are we? We obviously need information, the need is growing, and we will need information in the future in areas that are not known to us today. How do we approach this need? It is usually not cost-effective or economical to deal with threats or problems as they haphazardly occur. Threats occur randomly and often with little advance notice.

For those of us in the federal system, you know that we are often under extremely tight deadlines to take action or to do something.

I feel that it is the systematic gathering of information that describes and defines the resource; that is the first step. Unfortunately, it is this first step that we are still trying to take in many, if not most, of our cave systems.

Let's not be like a late president reflecting on his administration, "I spent most of my time on urgent issues, so I often did not get to work on the important ones." So let's not just be opportunisitc and work on issues as they occur — let's be systematic!

The second area that I want to discuss with you today is that of acquiring necessary information. In a single word I feel that this is accomplished through a partnership. I will try to emphasize what I mean through a short scenario that I recently heard from one of the leading funding institutes.

1. Late 1940's
   Individual Researchers
2. Early 1950's
   2 faculty members in the same department
3. Early 1960's
   Several departments
4. Late 1960's
   Several colleges within the same university
5. 1970's
   Several universities
6. 1980's
   Universities plus foundation plus state and federal agencies plus private enterprise plus the public.

In the 1980's I think we will see this type of partnership in the gathering of information. I personally applaud this direction that has evolved. No longer can a biologits "do his thing" individually and expect major support. We must "do our thing" in concert with others.

One of the most elementary ecological concepts is that diversity equals stability. In essence, a natural system which is composed of a great species diversity is able to withstand external pressures over time much better than a less diverse system. For example, in agriculture the non-diverse or the monocultural model is used primarily in this country. The threats to such a non-diverse (low species diversity) system are very significant. Frost that occurs too early or too late, seasons that are too wet or too dry, pests, diseases, and a host of other pressures. All threaten the stability of a given crop. Obviously the objectives of such a system are different than those of a natural system. (But as a side point, American agriculture is beginning to apply this basic concept of diversity equals stability.)

My point in this discussion is to emphasize that only through diversity in our information gathering will we have stability in our decision making. The biological scientist, the physical scientist, and the behavioral scientists must work together. The economists, and attorneys, federal and state agencies, managers, foundations, private citizens, special interest groups, and elected officials must work together, not just in the decision-making, but in the information gathering process. Ultimately, broad based input means better decisions.

So far, we have mentioned the need for information that describes and defines resources and the acquisition of information from a broad perspective. My final point deals with the use of information. I recently read in the "Smithsonian" that the new Library of Congress that is being built in Washington, D. C., will have nine floors and more space than 35 football fields. It will be large enough to contain only two-thirds of its current 18-million-book collection and virtually none of the periodicals.

My question is, how well do you think we use the information that is available to us today? How well is the information that was generated from your previous conferences being used in the management of caves systems? I do not know the answer to these questions, but I suspect that most of us know of pieces of information that are not being used. The pieces, however, must be translated into some form that is useful to the manager. It is often this translation that is lacking. I encourage you this week to make sure that the translation is made.

I think that in general, information is used and that it is used well. Obviously, there are cases when we do not use information that is available and something happens such that we receive adverse publicity and rightly so. To be fair, however, there are times in which we manage resources poorly in spite of the fact that we are trying. A good example would be the improper gating of some of our caves that contain endangered bat populations.

Also, there are times when information is available, but we don't understand what it means. The concept of carrying capacity is a good example:

1. Engineers/Architects
   Carrying Capacity
   Physical carrying capacity, parking lots, roads, trails, visitor center capacities, etc.

2. Biologist
   Carrying Capacity
   Fragilness of the natural resources; how many people use the resource prior to damage.

3. Social Scientist
   Carrying Capacity
   Perceptions of crowding; social conflicts, etc.

You may have wondered about the title of my comments today, "Theirs not to Reason Why." It is a line from the poem entitled, "Charge of the Light Brigade" by Alfred Tennyson. It reflects the common managerial style during the 1800's. "Theirs not to reason why, theirs but to do and die." The cavalry charged an in-place artillery unit. This form of blind obedience to power obviously does not exist today. Decisions are tempered with judgement—and rightly so. Likewise, information must be used in an objective, unbiased manner. We need diverse inputs to insure that the outputs are proper. Nearly 400 years ago when modern science was just beginning, Sir Frances Bacon wrote that "knowledge is power". It is this power that is available to us all that we must use more wisely.

In conclusion, your work here this week is a forecast of the issues and challenges facing cave managers. The list of topics in your program is most impressive. I know that these topics will be stimulating and informative, but that is not enough. The key question is, "How will this information be used?"

I appreciate the opportunity, on behalf of the Director, to speak with you today, and I look forward to your teaching me more about caves in the coming days.

AN OVERVIEW OF CAVE MANAGEMENT

*Robert R. Stitt

ABSTRACT

Cave management in the United States undoubtedly began in the last century, as cave owners began showing their caves to the public. Formal management probably began as caves were added to the National Park System in the early part of this century, but it was not until the rise of organized recreational and scientific cave exploration in mid-century that a signficiant concerned group of users began to foster cave conservation — wise use, on the part of themselves and of the cave managers. This user interest led to the first National Cave Management Symposium in 1975. Three national symposia and several regional symposia in the five ensuing years have resulted in the publication of a large body of information and an increasing awareness on the part of cave managers, cavers, and even the general public that caves are a valuable resource requiring careful management so that they will continue to be available for future generations to enjoy.

Formal cave management in the United States probably began with the opening of the first commerical caves in the early part of the nineteenth century. The establishment of cave national parks and monuments in the early twentieth century led to the assumption of cave management techniques by agencies of the federal government, as well as some state and local governmental bodies. By the time of the advent of organized speleology in the United States (in the 1940's), however, there was little communication among the various agencies, corporations, and individuals managing caves. Each group managed caves for their own goals and purposes, and there was a general lack of information transfer and coordination. Although a sizable body of information on speleology began to appear in the literature, there were few written materials dealing with the subject of cave management per se.

Members of the National Speleological Society became interested in the problems of cave conservation (as opposed to strict preservation) in the early 1950's, and began working with landowners and agencies to further their goals of wise use. By the late 1960's cavers had discovered that if they did the work, and actively involved themselves in cave management, that they could have a significant influence on the cave management policies of various federal agencies, especially on the local level. New Mexico cavers, in particular, began working with local officials in the Bureau of Land Management (BLM), National Park Service (NPS) and Forest Service (USFS) to actively manage caves in southeastern New Mexico. It soon became clear to many cavers that there was a need for communication among cavers and agencies engaged in cave management.

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I believe that the idea for a cave management symposium began when a group of New Mexico cavers, of whom I was one, pondered the question of how to encourage communication among cave managers over a few beers in Bill Bishop's living room in Albuquerque in the fall of 1973. How, we asked, could we get various cave managers talking to one another, as well as to us? The answer seemed to be: get them together in the same room to discuss the problems of cave management and to share their solutions with one another. A Symposium! Mammoth Cave seemed like a good place to have one—or perhaps Carlsbad?

I was in the process of moving to New York. To my surprise, several months later I received a phone call from Don Sawyer of the BLM's Roswell District, probably the federal employee most concerned with cave management at the time. Don reported to me that his agency, with active support from the state office, was preparing to set up a cave management symposium for the fall of 1975. Would I be willing to help out? During the ensuing months we burned up the phone lines for many hours. Don unfortunately had to retire due to medical problems before the symposium actually occurred, but other BLM people carried on. In concert with representatives from other federal agencies in New Mexico, cavers, and commercial cave owners, finally, in October of 1975, the first symposium was produced in Albuquerque.

Sponsored by the National Speleological Society, the Cave Research Foundation, the Bureau of Land Management, the U. S. Forest Service, the National Park Service, and the National Caves Association, the Albuquerque symposium concentrated on providing a basic overview of cave science and management methods to about 100 participants. The program was broken up into the categories of Cave Resources; Resource Management; Visitor Management, Safety and Rescue; Cave Management Aids; and Objectives,

Policies and Plans of Agencies. The proceedings, published by Speleobooks, provided a general overview of the field and became a basic reference source on cave management.

Participants in the Albuquerque symposium felt strongly that another symposium should be held in the following year, and an invitation was extended from the USFS management of Blanchard Springs Caverns in Arkansas to hold the 1976 Symposium near there. So it was that we gathered again in the fall of that year at nearby Mountian View for what was turning out to be the second annual symposium. Based on suggestions from Albuquerque participants, the program here concentrated on cave management approaches and techniques in four areas; Carrying Capacity of Caves; Cave Inventory, Valuation, and Assessment; Subsurface Management as a Component of General Land Management in Soluble Rock Landscapes; and the Management of Commerical and High Value Caves.

The third annual symposium, held at Big Sky, Montana in October 1977, concentrated on the development of cave management tools and techniques—a how-to session, as it were. Particular emphasis was given to the management of non-limestone caves: lava tubes, ice caves, and glacier caves.

The cave management symposia have proved their value in several ways. They have provided a forum for cave managers to meet and discuss their mutual problems. They have enabled the publication, in concise form, of a large body of works on cave management. They have encouraged an ongoing interest in cave management on the part of a large number of land managers, cavers, and cave owners. There are some significant improvements that should be made, however. In particular, the participation of private landowners and commercial cave operators should be encouraged more. More prompt publication of proceedings would put information into the user's hands sooner. The participation of the academic community should be encouraged to a greater degree.

Because agency personnel working with caves seem to change frequently, there will continue to be a need for education and information exchange. There are pressing problems of cave management which remain. These factors should lead to a long series of successful symposia in the future.

CURRENT PROBLEMS IN CAVE MANAGEMENT

*Roger W. Brucker

ABSTRACT

The years 1970 to 1980 marked the beginning and maturity of cave management as a resource management activity with a specialized methodology. Early in the period managers were preoccupied with problems centered around individual caves, and sought counsel from their peers on how to remove graffiti, how to rate hazards, and how to build cave gates. By the mid-1970's a class of management problems was recognized that plague most cave managers. These functional problems included how to conduct a cave inventory, how to set cave management policy, and how to use cave rescue capabilities. In the 1980's managers will face mega-problems that will demand extraordinary skills and levels of effort. Three such mega-problems are: 1) Groundwater pollution on a regional scale, 2) Cave access, and 3) Education of public officials about the political and natural problems of caves. Strategies such as watershed management, alliance building, and benchmarking are proposed to solve these problems.

In 1975 in Albuquerque, NM, I addressed the opening of the first Cave Management Symposium. We were plowing new ground. Now as I look around the room I see veterans of nearly 10 years of struggles with cave management problems. To the survivors I say: Congratulations, and get ready for more work. To the victims: Thanks for your eforst. We will remember you.

It is not possible to view current management problems without some perspective. In the early 1970's most of the problems seemed to focus on a specific cave. How could we remove graffiti and unwanted moss? How could we evaluate and rate hazards of our particular cave? How might we construct a gate to deter entry, optimizing expense and environmental damage?

One function of the first symposium, and subsequent sessions, was to provide a forum of peers for solving common problems. Discussions after hours were sometimes more fruitful than formal presentations. Your presence today indicates the importance of this subject. Such deliberations have continuing value.

By the mid-1970's we began to see interrelated sets of functional problems. What is the best way to conduct a cave and karst resource inventory? How can we set cave management policy and make it work? What are the pitfalls? How can we organize or use cave rescue capabilities?

As one example, the subject of cave carrying capacity was approached in innovative ways. Every manager today understands there is a limit to the number of people who can occupy a given cave at a given time, but the issues of resource vulnerability, experience values, and reliable feedback are widely recognized—if not completely understood—elements of the subject.

Presentations will deal with specific as well as functional problems this week. Future symposia will undoubtedly deal with the same issues because new people enter our field all the time. Old hands receive new jobs, promotions, and sometimes retirements. Perhaps if we solve current problems creatively more of us will be promoted and fewer retired!

MEGA-PROBLEMS OF THE 1980's

A mega-problem is a large cave management problem. The scope of a mega-problem goes beyond any local cave. Parts of the problem may be dimly understood or, like the caves themselves, hidden from view. A mega-problem, at first recognition, may seem unique, unprecedented, and certainly unwelcome.

My orientation is that of a past-president and a director of the Cave Research Foundation. CRF has been involved in specific, functional, and mega-problems (and we may have caused some). CRF has worked closely with the National Park Service, Forest Service, Bureau of Land Management, and with the park services of other countries. As outsiders we were sometimes able to tell cave managers what they needed to know. As scientists we have been able to provide the factual data or evidence to help solve a variety of problems.

GROUNDWATER POLLUTION ON A REGIONAL BASIS

The first mega-problem is groundwater pollution on a regional scale. You will see and hear a lot about that during this conference.

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In 1979 we demonstrated that Mammoth Cave's underground drainage basin extends beyond the limits of National Park boundaries. Perhaps the NPS can control the purity of groundwater that enters the caves from lands within the park, but most of the groundwater at the base level of this 217-mile-long cave originates from sources outside the park.

The NPS has no way to control what is dumped into Mammoth Cave by accidental spills or deliberate discharge from outside the park. This fact was dramatically proven in the summer of 1979 when CRF explorers found Hawkins River beneath Proctor Cave. It is a very large 25 cfs stream. When we found it, it smelled of gasoline. We found on its banks over a hundred dead and dying cave crawfish. It may be the first underground fish kill reported. We also smelled a petroleum product miles away in the same stream several weeks later. It now appears that there were two separate origins. The first may have been a 30,000-gallon buried gasoline tank leak at the Texaco station in Cave City. The second appears to have been an upset diesel fuel bulk transport about a quarter of a mile away from the Texaco station on I-65.

Dr. Jim Quinlan has been dye tracing to find the exact area of the Mammoth Cave drainage basin. CRF survey teams are probing toward the limits that Quinlan has found.

What is remarkable is that the basin geometry and dymanics have been inferred from Quinlan's indirect evidence for years. When finally a significant new portion of the flowline was discovered in the ground, the potential pollution problem loomed larger than ever.

We now see that as water levels rise, as after a hard rain, the subsurface drainage literally spills over into higher level and presumably older trunk passage drains.

Dr. Quinlan's discovery that Echo River in Mammoth Cave is polluted at times is now understood by examining the "plumbing" *in situ*. Park boundaries indeed encompass only parts of the upstream basin. Pollution may yet destroy the aquatic biota of Mammoth Cave. An even worse scenario is that Mammoth Cave might become another Hidden River Cave (Horse Cave, KY), whose sewage stench and poisons have made it a desert to all life—including man.

Here are some of the interlocked problems:

1. The Master Plan for Mammoth Cave National Park (MCNP), begun in 1967, rests on an obsolete understanding of the cave system that has little relevance for protecting the caves today.

2. The NPS is currently powerless to protect the park from outside threat.

3. The local initiative EPA 201 sewage study is stalled because of Kentucky's inability to provide underground discharge standards.

4. The EPA, Kentucky water quality agencies, and CRF, among others, are seeking Outstanding Resource Waters protection for the basin and the section of the Green River that drains the area.

5. A regional sewage system, while protecting the basin in some ways, will encourage development which will add silt and other untreated pollutants to the cave. It is a Catch 22.

6. Spills continue to occur. In July 1980, a truck carrying cyanide compounds wrecked near Cave City, and threatened the basin for a time. We may not be so lucky next time.

What can be done? Currently two strategies are being employed. CRF and the NPS are trying to encourage watershed management as a basic concept. That phrase connotes a host of desirable practices ranging from soil conservation to enforcement of existing laws against pollution. CRF is also trying to bring together an informal alliance of organizations and people who can speak up as courageously and effectively for watershed protection as the citizens' 201 committee has spoken up for regional wastewater treatment.

The outcome is in doubt. CRF feels the frustration of wondering if the NPS understands the problem. Does the NPS have the resources and will to act? A recent article in the Atlanta Constitution about the five most problem-ridden parks in the NPS Southeast Region failed to mention Mammoth Cave. On balance, however, the NPS highest priority research project, as we have heard, is the proposal by Dr. Quinlan to study what is necessary to protect the underground basin. As an aside, I want you to know that Quinlan's work has not always been popular even within the NPS, but if Mammoth Cave National Park is saved, those people who funded Dr. Quinlan's research deserve the credit.

For the mega-problem of regional drainage basin pollution, the strategy is: 1) Develop the facts and the scientific analysis. 2) Build a case for watershed management. 3) Seek alliances to help in the work.

CAVE ACCESS

As Mammoth Cave becomes longer and more famous, more and more cavers press the managers for access to undeveloped parts of the cave. This is not a new problem. What will make it a mega-problem is the changing climate of civil rights.

Following in the wake of the Freedom of Information Act, I predict that we will see a Freedom of Assess Act. Cavers, like rock climbers and hang-glider pilots, will certainly go to court to sue when denied access to the caves.

Any protectionist effort, such as inspecting equipment and checking cavers' qualifications will move increasingly into conflict with areas of the law such as invasion of privacy, unauthorized search, discrimination, and assumption of liability by the inspecting agency or manager.

Is the cave manager powerless to protect the

caves? Must we set up "sacrifice caves" to be used by all and presumably to be despoiled? The answer is that cavers will not allow themselves to be restricted to "tame" caves (scarifice or not). A second part of the answer is that in our opinion managers need not write off an open cave as a sacrifice.

Strategies relating to access are two-fold: 1) Build a stewardship toward the cave by cavers—especially local cavers.

CRF has performed contract inventory studies for both the NPS and Forest Service in Arkansas. Local cavers saw CRF workers as outsiders. To them, it was bad enough to be shut out of caves on federal lands, but when CRF "carpetbaggers" were admitted, local caver feelings ran to high anger. CRF deliberately recruited local cavers to help in the work and to take leadership roles. We reasoned that this would help build a local caver stewardship to the cave resources. Also it would bring local cavers and cave managers into contact on a constructive basis rather than as adversaries.

One day Lorraine Mintzmier, the Superintendent of Buffalo National River, called me as president of CRF to complain of the slowness of the study. I explained this strategy to her and told of the delays we had encountered in getting the local caver support we felt was vital to the park's best interest in the future. Without that support, we said, it would be war between cavers who could be the park's most important ally in cave protection, and the NPS. She understood, and was patient.

Has this strategy worked? We believe it has. One caver who felt he was *persona non grata* to park officials reported that the Ranger in Charge saw him in a store and called his name. They exchanged friendly words. One swallow does not a summer make, and it remains to be seen how successful a changed role will prove to be.

The second strategy dealing with assess is: 2) Build an accountability chain. Get the cavers who want access involved in the policy discussion to get accountability. For example, benchmarking might be set up in a program to photograph the cave at predetermined points at regular intervals. The photo record would show if damage is taking place. Other accountability techniques are well known: cave registers that tell you who has visited the cave, a trip report file that reinforces the caver's sense that others are exploring the cave and that there is a responsibility to those yet to come and to the cave itself.

Still another access strategy is to encourage the NSS to buy and hold caves. Nearly every issue of the NSS News describes a new cave closing due to abuse and misuse. Caves placed out of bounds by landowners create pressures on the remaining caves. "Cult cavers", with a six-pack of beer, exuberant shouts of four-letter words, and a trail of litter will continue to be problem. There are also the legal problems of whether the NSS is risking too much financially in owning caves. Perhaps "holding companies" can be established, but whatever the difficulty, one partial solution to the access problem is to have more caves administrated by cavers for cavers.

EDUCATION OF PUBLIC OFFICIALS

Most public officials do not care about caves, do not understand caves, and do not want to know about caves. Areas of their ignorance include the politics of caves and the natural processes of caves.

To be fair, however, I acknowledge that there is a parallel problem of an ignorance of politics by cavers who care.

At Mammoth Cave National Park the NPS spent several years in paralysis over opposition to the Master Plan. That opposition was amplified and orchestrated by a few who did understand the politics of the situation.

One strategy is to ask for help from organizations and individuals who may be familiar with the problem and may have some idea for approaching the political problems. When the NPS asked CRF for counsel on how to deal with political opposition to the Master Plan, other groups responded as well. The National Parks and Conservation Association sued under the Freedom of Information Act and obtained release of the financial statements of the National Park Concessions, Inc. This was the group widely believed to have promoted the most vociferous opposition to the Master Plan. The financial reports revealed that the concessioner, who had maintained a position as a non-profit corporation and in the same boat as other local businessmen, was in fact enjoying a lucrative government-protected monopoly. The concessioner was revealed to have $1.7 million in cash, a fact that caused local business people to realize that the opposition motives stemmed from a desire to protect the monopoly more than anything else.

What is illustrated here is the tactic called networking—the building of lines of communication outward from the managers to organizations and individuals that may have many resources and skills at their disposal. We in this room form a network; the address list of attenders makes it a formal network. I believe we can call on each other when mega-problems arise.

Public officials need facts to place issues in proper perspective. That is why cave inventories are a good beginning. But to be most useful to officials, suggestions about policy and objectives are usually welcome. Objectives are an absolutely essential first step before undertaking information gathering and planning.

Once information, objectives, and proposed policies are in hand, it helps to go see the officials rather than just write them. Many officials are not "paper oriented" and will not read. You might be able to prevail without facts IF you have a mob of 300 ready to break down the door, but don't count on it.

One example of the importance of a personal visit will suffice. CRF once greeted an incoming park

superintendent by sending him a great pile of reports and studies through the mail. A few weeks later he called and professed ignorance about why we were in the park at all, and maybe our permit should be terminated. We hastily set up a personal visit with the new superintendent. With an invitation like that, how could we refuse?

When we arrived in his office, he said, "now you people in CFR have to understand that our mission is to protect the caves."

Something clicked in my mind; nobody had ever called CRF by the name of CFR. Such a mixup was typical of a person with dyslexia. A dyslexic person is usually very bright, an extremely good listener, but not a reader. If the new superintendent was dyslexic, probably he had not read a word of the ton of paper we had dumped on him. After we explained our research program and methods, things went more smoothly. This experience underscored the need to pay personal visits on officials wherever possible.

That is why CRF has been seeking audiences with Congressman Natcher of this district, and why we no longer take for granted that everyone reads.

In summary, we have examined three mega-problems. All are characterized by being complicated, perhaps unprecedented. When you tackle them you need the advice and support of allies in many places. Ask for help. Counsel together. Analyze the dynamics of the situation. If you articulate your own objectives you may find common ground, and you may clarify the problems that face the caves. Mega-problems call for all the resourcefulness and help you can get. Like the caves, their solutions may take a great deal of time and patience.

SINKS, STINKS, AND SPRINGS: A SUMMARY OF THE HYDROGEOLOGY OF THE MAMMOTH CAVE REGION - WITH EMPHASIS ON RESULTS AND APPLICATIONS OF NATIONAL PARK SERVICE-SPONSORED RESEARCH

*James F. Quinlan

The Pennyroyal Plateau in central Kentucky consists of the Sinkhole Plain, a 2- to 10-mile wide streamless area, and the Glasgow Upland — each of which is underlain by Mississippian limestones that gently dip in directions ranging from north to west. More than 50 streams drain the Glasgow Upland and sink into the ground at its north and west margin with the Sinkhole Plain. This sinkhole-pocked area is flanked on the north by the Chester Escarpment and the sandstone-capped Chester Cuesta. All of the Mammoth Cave National Park south of Green River is in part of the Chester Cuesta.

The occurrence and movement of groundwater in the St. Louis and Ste. Genevieve limestones (the principal aquifer) has been traced from the highest recharge area, just beyond the south and east margin of the Sinkhole Plain, where water slowly drains from numerous small swamps of the Glasgow Upland which feed perennial springs that feed streams that sink at this margin. Water from the swallets flows to cave streams. These low-order underground tributary streams join intermediate-order tributaries and finally a high-order trunk stream that discharges at a major spring along Green River, Barren River, or Little Barren River. The streams that flow beneath the Sinkhole Plain are also fed by runoff into sinkholes and direct infiltration through the soil. The streams that drain beneath the Chester Cuesta may be fed not only from the Sinkhole Plain, but also by runoff from ridge tops, infiltration from karst valleys, and by spring discharge from two perched aquifers above the Big Clifty Sandstone.

Water from numerous sinking streams has been traced as much as 15 miles via as many as 3 caves and streams that cross the bottom of certain sinkholes. Most flow is through a dendritic system of conduits that feed trunk streams that are commonly 50 feet wide and in which water levels may rise as much as 100 feet in response to heavy rains. Flow velocities range from 30 to 1300 ft/hr. Most groundwater basins are also characterized by discharge from springs fed by caves with a distributary flow pattern that is 150 feet to 6.8 miles wide. One of these distributaries, in the Hidden River sub-basin (several miles east of the park), is 1.8 miles wide and it discharges heavy metal-rich water at as many as 46 springs at 16 locations along a 5-mile reach of Green River. One of these springs was excavated and more than 18 miles of distributary and floodwater-maze cave passage has been mapped. The heavy-metal-rich water is mixed with waste from a cheese plant and discharged into the ground at a municipal sewage treatment plant. The effluent flows to Hidden River Cave, beneath the city of Horse Cave. This formerly commercial cave is now, unfortunately, a fetic sewer that is a malodorous civic embarrassment and nuisance.

The following have been successfully used as tracers: 1) heavy metals in industrial effluent discharged into a sinkhole, 2) optical brightener, both introduced and in sewage plant effluent, 3) Direct Yellow No. 96 (a newly-discovered dye), 4) fluorescein, and 5) Rhodamine WT. As many as 9 dye tests have been run simultaneously in various groundwater basins.

A potentiometric map, constructed with measurements of water levels in 1500 wells during baseflow conditions, complements much of the dye tracing data and is being used to plan additional dye tests.

Twenty-seven groundwater basins have been delineated within the St. Louis-Ste. Genevieve limestone aquifer in 740 miles^2 area south of Green River. Data used are from more than 300 dye tests, 1500 water-level measurements and 45 miles of cave mapping. The three larger basins are: Bear Wallow (190 miles^2), Graham Springs (120 miles^2), and Turnhole

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Bend (90 miles^2). The Bear Wallow basin includes the second largest underground distributary in the world — 6.8 miles wide over an 11 mile reach of Green River! It includes discharge from the 1.8 mile-wide distributary of the Hidden River sub-basin and discharge from the 2.4 mile-wide distributary of the Three Springs sub-basin.

Wells have been drilled 100 to 180 feet into 5 different cave streams. Stage recorders have been installed in them, at several springs, and along Green River. Temperature, conductivity, and flow velocity instrumentation will be installed at some of these sites. These data, in conjunction with data from a proposed network of recording precipitation gages and stage recorders on wells, will be used to discover the relations between precipitation, chemical hydrology, and aquifer properties. They will facilitate prediction of flow rates and computer simulation of aquifer behavior.

The most extensive recent mapping has been done in Whigpistle Cave (total length: 16.2 miles but it is much longer). Whigpistle has trunk passage at several levels and it extends under 3 ridges — so far — and crosses the park boundary.

Delineation of groundwater basins is useful and, indeed, essential in karst areas when planning for regional sewage disposal, protection of cave resources, industrial development, protection and development of water supplies, reaction to accidental spills of toxic materials, and water budget studies; it also aids interpretation of both geomorphic history and processes of karst development. The most recent application of the research described herein is the determination of the boundaries of a "Rural Clean Water Project" area — as proposed by the Agricultural Stabilization and Conservation Service. This watershed management district will include all of the Turnhole Bend groundwater basin outside of Mammoth Cave National Park plus the 100 square mile portion of the Hidden River sub-basin that is upstream from Hidden River Cave.

HYDROLOGIC IMPACTS OF URBANIZATION IN THE SOLUBLE ROCK LANDS OF GREEN COUNTY, MISSOURI

*Tom Aley

INTRODUCTION

We recently conducted a contract study on sinkhole flooding and groundwater contamination associated with urbanization in Greene County, Missouri (Aley and Thomson, 1980). This investigation was conducted for the Greene County Planning and Zoning Commission. Greene County (which includes the city of Springfield) is experiencing rapid urbanization. Much of the county is immediately underlain by soluble rocks of Mississippian and Ordovician age, and there are many caves, springs, and sinkholes in these areas.

Our investigation was designed to provide county officials and others with a workable understanding of the sinkhole flooding and water quality impacts which should be anticipated with urbanization. Since these impacts vary dramatically from area to area within the county, we prepared a set of large multi-colored maps which depicted various hydrolocig characteristics and/or assessed the severity of anticipated hydrologic problems. We cannot reproduce these maps with this paper; we can, however, describe what they depict, and we believe this will be adequate for most readers. For those who wish to see the maps, information can be obtained from the author.

We believe this investigation will help protect water resources in Greene County. We also believe that our approach could be useful in other soluble rock areas.

SINKHOLE FLOODING

Sinkholes are surface components of the natural subsurface conduit drainage network existing in Greene County. Intense or prolonged rainfall can result in water flows which exceed the capacity of the natural conduit system. When this occurs, sinkholes rapidly flood. In some cases, sinkhole flooding may persist for days or even weeks after a major storm.

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Providing effective stormwater drainage in sinkhole areas after urbanization is difficult and often extremely expensive. In areas prone to sinkhole flooding, the cost of publicly constructed storm drainage can exceed the value of nearby undeveloped land where sinkhole flooding is not a problem.

Sinkhole systems consist of both the surface features which we can readily see (the sinkholes themselves) plus the subsurface conduit systems which drain the sinks. Based upon exploration of accessible sinkhole drainage conduits, the conduit systems are comprised of two components.

The first component is steeply inclined to nearly vertical. This component transports water from the surface into the groundwater system. Except during runoff periods, these conduits do not commonly transport appreciable quantities of water. This component of the drainage system will be called sinkhole drainage conduits: the surface expressions of such conduits are sinkhole drainage points.

The second component of the sinkhole drainage system is a lateral component which transports water from the base of sinkhole drainage conduits to the spring or springs which drain the area. This component of the drainage system will be called lateral transport conduits. Underground streams and most of the cave passages in Greene County represent present or former lateral transport conduits.

There are two basic causes of sinkhole flooding. The first is flow rates in excess of the transport capacity of sinkhole drainage conduits. Sinkhole flooding caused by water volumes in excess of the transport capacity of sinkhole drainage conduits is a common problem in the sinkhole plain areas of Green County. Much of the sinkhole flooding which has been experienced to date within the City of Springfield is due to this mechanism.

The second basic cause of sinkhole flooding is

flow rates which exceed the transport capacity of the lateral transport conduit systems to which sinkholes discharge. Such systems have finite capacities; if the capacity of the conduit system is exceeded, then sinkhole flooding can result. The transport capacity of lateral transport conduits can vary dramatically from point to point within the conduit system. A constriction within a conduit system can cause dramatic increases in water level elevations in areas upstream of the constriction.

Under near-natural conditions, some sinkholes will pond water for a few hours to a few days after a heavy or intense rainstorm. Many sinkholes which formerly flooded only occasionally, and only for short periods of time under near-natural conditions will flood more frequently, deeper, and for a longer period of time after urbanization has occurred. These changes in sinkhole flooding are due to three primary factors:

1) Increased clogging of sinkhole drainage points, sinkhole drainage conduits, and lateral transport conduits.

2) Increased runoff rates.

3) Increased runoff volumes.

Each of these factors is discussed in the following sections.

Increased clogging of sinkhole drainage points, sinkhole drainage conduits, and lateral transport conduits.

Clogging of sinkhole drainage points and sinkhole drainage conduits has been a major cause of sinkhole flooding problems within the city of Springfield (Hayes, 1977). Water transport through sinkhole drainage points and drainage conduits can be significantly reduced by sediment and debris washed or dumped into such areas. In some cases, sinkholes and sinkhole drainage points have been partially or completely filled with dirt and rock to make more useful land for urban development. Such sinkhole modification is not in the long-range interest of the people of Greene County. If only the drainage points or a portion of the sinkhole is filled, then flooding within the remainder of the sinkhole is likely to become a more serious problem. If the sinkhole is completely filled and waters are diverted to adjacent sinkholes, then flooding problems in the adjacent sinkholes are likely to become more severe. Furthermore, subsidence and sinkhole collapse are more likely to occur in sinkhole areas which have been subjected to filling than in undisturbed areas.

Sediment and debris can also reduce the capacity of the lateral conduit system. Rapid sediment filling of a conduit draining the Cherry Street Industrial Park in Springfield near the Highway 65 Bypass occurred after a major rainstorm. Particularly when significant amounts of debris are present in runoff waters, partial or nearly complete plugging of constrictions can occur.

Land development will essentially always increase the amount of sediment washed into sinkhole drainage points, sinkhole drainage conduits, and lateral transport conduits. Clearing of vegetation, construction of roads, construction of utility lines and ditches, and construction of homes and other buildings all increase sediment production from the land. In sinkhole areas, much of this sediment is flushed into sinkhole drainage points during runoff periods.

To date, most land development in Greene County has given inadequate attention to erosion prevention during and immediately after development. Trees and brush are too often removed and piled in areas where they will contribute organic debris and soils to sinkhole drainage points. Undesirable vegetation is commonly removed without promptly establishing replacement vegetation which will minimize erosion. Replacement vegetation (such as grasses) need to be seeded, and the sites typically need lime and fertilizer to insure good vegetative growth. Filter strips of well established vegetation need to be left undisturbed around important sinkhole drainage points, and construction needs to avoid these locations. Unless such steps are taken, clogging or plugging of sinkhole drainage points will continue to be a significant problem in Greene County.

Increased runoff rates

When land development occurs, the rate at which water runs off the landscape is dramatically increased. This increase in runoff rates occurs for a variety of reasons. Among the more important reasons are: 1) the vastly increased amount of impervious areas and semi-impervious areas which rapidly yield runoff water, and 2) the straightening and clearing of natural drainage routes.

An indication of the magnitude of the increases which can occur in runoff rates due to land use changes is provided by Kittredge (1948). He states that peak flows from forested areas rarely exceed 60 cfs (cubic feet per second) per square mile whereas runoff rates from denuded lands may be 500 to 1,000 cfs or more per square mile. Peak runoff rates from agricultural and permanent pasture lands are typically greater than peak runoff rates from forested lands. Most suburban developments in unincorporated Greene County would not have runoff rates as rapid as those which characterize denuded areas. Therefore, the changes in runoff rates which should be anticipated when typical Greene County areas are converted from agricultural and wildland uses to typical suburban housing developments are not as extreme as those discussed by Kittredge (1948). The changes, however, are still substantial and significant, and must be comprehended if we are to minimize sinkhole flooding problems associated with future land development activities in Greene County.

Increased runoff rates can result in temporary sinkhole ponding. Such temporary ponding has a secondary adverst impact: it results in the deposition of sediment and debris in the vicinity of sinkhole drainage points, which increases the likelihood of sinkhole plugging.

Increased runoff volumes

When land development occurs, the quantity of water

which runs off the land is dramatically increased. This increase in quantity is due to a number of factors which include: 1) major increases in impervious areas, 2) decreases in infiltration rates through soils due to compaction and vegetative changes, and 3) removal of native vegetation which consumed more water than does replacement vegetation.

Jens and McPherson (1964) present data showing the amount of directly connected impervious areas associated with various categories of land use. Directly connected impervious areas include building roofs, roads, sidewalks, and other areas where very little water can enter the soils or the subsurface. These values, with an additional value which we calculated for undeveloped sinkhole plain areas in the county, are shown in Table 1.

In Greene County, mean annual runoff is approximately 12.0 inches per year. This runoff results from a mean annual precipitation of 39.51 inches.

Using the above values and the values in Table 1 we have estimated the increases in annual water runoff which should be anticipated from selected land use categories in Greene County. Our estimates assume that 90% of the mean annual precipitation will run off from directly connected impervious areas (as shown in Table 1). A second assumption is that any fully-developed housing, commerical, or industrial development will result in a 20% increase in runoff from unpaved areas. This increase is due to reduced infiltration and reduced vegetative water use in these areas.

Based upon the mean annual precipitation and runoff volumes which characterize the area and the two assumptions discussed above, we have estimated the mean annual runoff which should be anticipated under various categories of land use. These values are shown in Table 2. These values are generally applicable to all of Greene County, but we have specifically calculated them for use in evaluating problems of sinkhole flooding.

The data in Table 2 clearly show major increases in the volume of runoff when land development occurs. Suburban housing will increase annual runoff by an average of about 59% while industrial and commercial development will increase annual runoff by an average of about 140%. In areas where sinkhole flooding can occur, such dramatic increases in water volumes can create the major flooding proglems which have been experienced in the past in Greene County.

Development of a sinkhole flooding hazard map for Greene County.

Three sinkhole flooding hazard categories were recognized in our mapping:

1. High Sinkhole Flooding Hazards — Areas within this category typically have over 25% of the land in sinkholes. Many of the sinkholes are large, shallow, and have large drainage areas. Even under near-natural conditions, sinkhole ponding after major rains is common. Included within these identified areas are lands which contribute water to some of the large sinkholes. Sinkhole flooding is a serious problem in high sinkhole flooding hazard areas.

2. Moderate Sinkhole Flooding Hazards — Areas within this category typically have between 5 and 25% of the land area within sinkholes. Sinkholes in these areas are typically smaller than those found in the high sinkhole flooding hazard category. Sinkhole flooding can be a significant problem in moderate sinkhole flooding hazard areas.

3. Low Sinkhole Flooding Hazards — Areas within this category typically have less than 5% of the land area within sinkholes. Sinkholes are typically small and steep, and have small drainage areas. It is generally unlikely that houses would be built in these sorts of sinkholes. Under present land use conditions, sinkhole flooding is not a significant problem in these areas. With development, these areas are not likely to present significant sinkhole flooding problems.

TABLE 1

Percentage of land area in directly connected impervious areas in Greene County, Missouri. Includes roads, building roofs, sidewalks, and other paved or otherwise impervious areas.

Land Use Description	Directly connected impervious areas Percent of total land area
Typical undeveloped sinkhole plain areas in Greene County, Missouri	0.1 to 0.4%
Suburban housing (single family)	16 to 28%
City housing (single family)	28 to 40%
Apartments with business	40 to 60%
Industrial and commercial	60 to 80%, and sometimes higher

Approximately 2.5% of the unincorporated portion of Greene County is classed as high sinkhole flooding hazard areas. An additional 3.4% of the unincorporated land is classed as moderate sinkhole flooding hazard areas. The balance, 94.1%, is classed as low sinkhole flooding hazard areas.

Hydrologic strategy for minimizing sinkhole flooding problems in Green County.

With good planning, sinkhole flooding problems in Greene County can be minimized without the necessity of prohibiting land development activities in high and moderate sinkhole flooding hazard areas. Based on hydrologic considerations, we developed approaches to minimize sinkhole flooding problems.

Our hydrologic strategy has two objectives. First, to minimize the severity of the flooding problems. Second, to keep flooding problems which may develop from significantly affecting the people of the county.

There are four hydrologic steps which must be taken to minimize the severity of sinkhole flooding in Greene County. We must: 1) Minimize erosion and sedimentation. Sediment reduces the capacity of sinkhole drainage points and of the underground conduit system which transports floodwaters away from the sinkhole areas. 2) Minimize filling of sinkhole drainage points with dirt and debris. Such activities reduce the capacity of sinkhole drainage points and the capacity of the underground conduit system. 3) Minimize increases in water runoff rates. Rapid runoff can exceed the capacity of sinkhole drainage points and the capacity of the underlying conduit systems, and thereby produce rapid surface flooding. 4) Minimize increases in water runoff volumes. Increases in the total volume of runoff water can obviously increase sinkhole flooding problems.

We have identified seven specific actions to minimize the severity of sinkhole flooding problems. These are listed and discussed below.

1. Major erosion and sedimentation commonly occurs during land development. Erosion and sedimentation could be significantly reduced if developers were required to immediately revegetate cleared areas with grass or other desirable vegetation. Such vegetation should require adequate application of seed, fertilizer, and lime. Land clearing for development should not be permitted at those times of the year when vegetation cannot be quickly reestablished.

2. A filter strip of suitable vegetation should be established and maintained around each identified sinkhole drainage point. At a minimum, the low point in each sinkhole plus all subsidiary low points should be identified as sinkhole drainage points and should be surrounded with a vegetative filter strip. The filter strip could be woods or native vegetation; if it were grass, it should not be closely mowed. The filter strip would significantly reduce sediment and debris deposition in sinkhole drainage points.

3. Filling of sinkholes with fill dirt and rock should be strongly discouraged and generally prohibited. Filling activities increase sediment loads in runoff waters and block existing sinkhole drainage points.

4. The amount of impervious surface area in developments in sinkhole flooding hazard areas must be kept low to minimize increases in runoff rates and runoff volumes. This can best be done in insuring that all lots are large.

5. Impervious areas should be as disconnected as possible, and should be as far from sinkhole drainage points as possible. This is important in

TABLE 2

Estimated mean annual runoff for sinkhole plane areas in Greene County under varying land uses.

Land Use Description	Mean annual runoff (inches/year)	Increase over natural conditions
Undeveloped sinkhole plain	12.0	0%
Suburban housing (single family)	17.8 to 20.3	48% to 69%
Mean	19.1	59%
City housing (single family)	20.3 to 22.8	69% to 90%
Mean	21.6	80%
Apartments with business	22.8 to 27.2	90% to 127%
Mean	25.0	108%
Industrial and commercial	27.1 to 30.4 or more	127% to 153% or more
Mean	28.8	140%

minimizing increases in runoff rates and runoff volumes. Good architectural and engineering design work can accomplish this if the architects and engineers realize at the outset that the location and connection of impervious areas is of major importance in areas subject to sinkhole flooding.

6. Runoff from impervious areas must be dispersed rather than channeled. This will reduce erosion rates, and will also reduce sediment and debris loading in runoff waters. Again, good architectural and engineering design work can accomplish this if the architects and engineers realize at the outset that the dispersion of runoff waters is of major importance in developments in areas subject to sinkhole flooding.

7. Areas subject to high or moderate sinkhole flooding hazards should be zoned either for agricultural use or single family residential use only. More intensive development increases runoff rates and volumes, which in turn will result in sinkhole flooding problems. Areas subject to high or moderate sinkhole flooding hazards are not appropriate areas for the more intensive types of land development.

Even if the above actions are taken, some sinkhole flooding will still occur. Two specific actions could be taken to keep sinkhole flooding problems from seriously affecting the people of Greene County. These are listed and discussed below.

1. Buildings must not be located in portions of sinkholes where they are likely to be inundated by sinkhole flood waters. Many, but unfortunately not all, problems could be avoided if the lowest point in any building foundation were more than 2.0 feet higher in elevation than the inferred maximum flood pool of the sinkhole. We recommend that the inferred maximum flood pool elevation of a sinkhole be defined as the elevation to which water would stand in a sinkhole after a 100 year recurrence interval 24 hour rainstorm. Calculation of this level should assume that the 100 year recurrence interval 24 hour rainstorm in Greene County equals 8.0 inches, that there is 100% runoff of all this rainfall from the area topographically tributary to the sinkhole drainage points, and that there is no infiltration or drainage of any of this water out of the sinkhole. Using detailed topographic maps, it is not difficult to determine the total volume of runoff which would be generated by such a storm and the elevation in the sinkhole to which this volume of water would rise.

2. Road surfaces should not be located in portions of sinkholes where they are likely to be inundated by sinkhole flood waters. We recommend that no road surface be constructed at an elevation lower than the inferred maximum flood pool of the sinkhole. The same calculation approach discussed above should be used in determining the inferred maximum flood pool of the sinkhole for road purposes.

Development constraints in high sinkhole flooding hazard areas.

Based upon hydrologic considerations, we recommend the following development contraints for high sinkhole flooding hazard areas:

1. Prompt revegetation with fertilization and lime application to bring the soils to optimum fertility should be required and stringently enforced. Land clearing should be restricted to those periods of the year when prompt revegetation can occur.

2. A filter strip at least 300 feet wide should be established and maintained around each identified sinkhole drainage point.

3. Filling of sinkholes and sinkhole areas with dirt and rock should be prohibited.

4. Lot size should be no less than 3 acres; it would be preferable if the minimum were 5 acres or more.

5. Land development at an intensity of greater than single family occupancy should not be permitted.

6. The total impervious area within developments should be less than 10% of the land area. This includes roads, other paved surfaces, and buildings.

7. Good architectural and engineering design should be required to insure that impervious areas are as disconnected as possible.

8. Good architectural and engineering design should be required to insure that runoff from impervious areas is dispersed rather than channeled.

9. Developers should be required to map the inferred maximum flood pool for every sinkhole in the area they plan to develop. Based upon this mapping, the lowest point in any building foundation should be at least two feet higher in elevation than the inferred maximum flood pool of the sinkhole. Furthermore, no road surface should be located at an elevation lower than the inferred maximum flood pool elevation of any sinkhole.

Development constraints in moderate sinkhole flooding hazard areas.

Based upon hydrologic considerations, we recommend the following development constraints for moderate sinkhole flooding hazard areas:

1. Prompt revegetation with fertilization and lime application to bring the soils to optimum fertility should be required and stringently enforced. Land clearing should be restricted to those periods of the year when prompt revegetation can occur.

2. A filter strip at least 200 feet wide should be established and maintained around each identified sinkhole drainage point.

3. Filling of sinkholes and sinkhole areas with dirt and rock should be discouraged and generally prohibited.

4. Lot size should be no less than 1 acre; it would be preferable if the minimum size were larger.

5. Land development at an intensity of greater than single family occupancy should not be permitted.

6. The total impervious area within developments should be less than 15% of the land area. This includes roads, other paved surfaces, and buildings.

7. Good architectural and engineering design should be encouraged to insure that impervious areas are as disconnected as possible.

8. Good architectural and engineering design should be encouraged to insure that runoff from impervious areas is dispersed rather than channeled.

9. Developers should be required to map the inferred maximum flood pool for every sinkhole in the area they plan to develop. Based upon this mapping, the lowest point in any building foundation should be at least two feet higher in elevation than the inferred flood pool of the sinkhole. Furthermore, no road surface should be located at an elevation lower than the inferred maximum flood pool elevation of any sinkhole.

Development constraints in low sinkhole flooding hazard areas.

No constraints relative to sinkhole flooding problems are required for these areas. Land developers must be aware that isolated sinkholes may exist in some of these areas, and that such sinkholes may be subject to flooding. If sinkholes exist, development should be guided by our recommendations for constraints in moderate sinkhole flooding hazard areas.

WATER CONTAMINATION AND POLLUTION PROBLEMS RESULTING FROM LAND DEVELOPMENT

Contamination and pollution of water supplies are serious problems in Greene County. Water quality problems can occur with either surface or groundwater supplies. In the case of groundwater supplies, the problems are uniquely serious because the subsurface does not provide effective natural cleansing for much of the water which enters and passes through the subsurface. Furthermore, much of the water contributing to spring systems in the country moves rapidly into and through these systems. As a result, there is typically insufficient time to insure that all bacteria and viruses entering subsurface waters will die before the water again appears on the surface.

Sinkholes are a reflection of a close and direct connection between the surface and the spring systems which drain the area. This was discussed in conjunction with our earlier section on sinkhole flooding problems. Where a close and direct connection exists between water on the surface and water in the groundwater system, the potential for groundwater contamination is particularly high. It has been our experience and the experience of other hydrologists working in karst landscapes that sinkhole areas are particularly prone to groundwater quality problems.

For the purposes of our water quality hazard mapping, we concluded that sinkhole areas warrant special attention. For this reason we prepared a map delineating all sinkhole areas in Greene County.

Our second map showed lineaments, fracture traces, and faults. Lineaments are natural linear features consisting of topographic, vegetational or soil tonal alignments which are expressed continuously for over one mile. Fracture traces are similar features expressed continuously for less than a mile. Lineaments and fracture traces are apparently surface expressions of vertical or near-vertical zones of fracturing.

Lineaments, fracture traces, and faults are all zones where substantial groundwater movement typically takes place. Furthermore, these areas are also highly favorable sites for water movement from the surface into the subsurface. As a result, areas along lineaments, fracture traces, and faults present contamination hazards similar to the hazards associated with sinkhole areas. For this reason our lineament, fracture trace, and fault map is a component of our water quality hazard mapping.

Our third map was based upon soil mapping conducted by the U. S. Soil Conservation Service. Soils are mapped by soil series, and a data sheet is published for each soil series. Each soil series is rated by the Soil Conservation Service for its suitability for septic field systems; the three categories are: 1) slight limitations, 2) moderate limitations, and 3) severe limitations. Our soil map displayed these three categories of soil limitations. Within Greene County, 2.55% of the land is within the slight limitations category, 27.50% is within the moderate limitations category, and 69.95% is within the severe limitations category.

On our fourth map, we delineated watershed areas for municipal water supplies and recharge areas for springs determined to be of importance to Greene County. Municipal water supplies warrant special attention to insure protection of water quality. Important springs fit one or more of the following requirements: 1) they are used as municipal water supplies, 2) they are major features in parks, or 3) they provide habitat for rare, threatened, or endangered species.

The final map (Map 5) which we developed is a water quality hazard rating map. It incorporates data from the four maps we have already discussed, and represents a mapping of the potential of lands in Greene County to create serious water quality problems. This map identifies four hazard categories, which are defined as follows:

Extremely high water contamination hazards. These lands include: 1) Sinkhole areas within the recharge areas of important springs. 2) Areas within 400 feet of fracture traces, lineaments, mapped faults, or sinkholes in areas lying within the recharge areas of important springs.

High water contamination hazards. These lands include: 1) Sinkhole areas not within the recharge

areas of important springs. 2) Areas within 400 feet of fracture traces, lineaments, mapped faults, or sinkholes in areas which are not within the recharge areas of important springs. 3) Recharge areas for important springs regardless of the mapped suitability of the soil for septic system use. 4) Areas within the surface basins for municipal water supplies where soils have severe limitations for septic field use.

Moderate water contamination hazards. These lands include: 1) Areas with soils which have severe limitations for septic field use, except where such areas are within the recharge areas of important springs or within the surface basins for municipal water supplies. 2) Areas within the surface basins for municipal water supplies where soils have slight to moderate limitations for septic field use.

Low water contamination hazards. These lands include: 1) Areas with soils which have slight to moderate limitations for septic field use. However, to be rated as a low hazard, such areas must be more than 400 feet from lineaments, fracture traces, faults, and sinkholes; must not be located in sinkhole areas; must not lie within the recharge area of an important spring; and must not lie within the surface basin for a municipal water supply.

Hydrologic strategy for minimizing water contamination problems associated with land development in Greene County

The soluble rock lands of Greene County frequently provide ineffective natural cleansing for contaminated waters which enter the subsurface. Serious groundwater contamination and pollution problems have already occurred at numerous points in Greene County, and increasing problems will undoubtedly occur as Greene County continues to develop. However, the number and severity of groundwater contamination and pollution problems can be significantly reduced if we match land use with the hydrologic suitability of the land for the proposed use. This matching of land suitability with land use is the basis for our hydrologic strategy for minimizing water contamination problems associated with land development in Greene County.

The objective of our hydrologic strategy is to insure adequate protection of water quality for the people of Greene County. We are concerned with both groundwater and surface water. Protection of water quality at important springs and in areas used as municipal watersheds receives particular attention; we believe this is appropriate.

There are four basic hydrologic steps which need to be taken to minimize water contamination and pollution problems in Greene County. We must: 1) Identify major problem areas. These are the areas identified in our mapping as extremely high water contamination hazard areas and high water contamination hazard areas. For this identification to be of any significance in minimizing water contamination and pollution problems in the County, the information must be incorporated in land development planning and in land use decisions.

2) Insure that waste water will be adequately handled in the extremely high and high water contamination hazard areas. Furthermore, we must discourage sewage or sewage effluent discharges within these areas.

3) Insure that storm water runoff does not create water quality problems. This will require that the intensity of development be minimized in the extremely high and high water contamination hazard areas.

4) Recognize that leaks, spills, and waste discharges from commerical and industrial sites can create very serious water quality problems. Such land uses are best suited to low and moderate groundwater contamination hazard areas.

We have identified five specific actions which need to be taken to minimize problems of water contamination and pollution. These are listed and discussed below:

1) Regulation of the intensity and nature of land development will be necessary in some areas to insure that water quality in Greene County will be adequately protected. Such regulation of the intensity and nature of land development should focus the majority of its attention on the higher contamination hazard areas (the extremely high and high hazard categories).

2) In areas where sewage and sewage effluent disposal is expected to cause significant water quality impacts, we need to develop a policy that sewage from developments should be exported from these areas. It must be recognized that there are areas where even waste treatment cannot be expected to insure the protection of water quality. An example of this is presently offered by the waste disposal facilities at Litton Industries, located in a sinkhole area near the Springfield Regional Airport.

3) The use of septic tank systems and similar on-lot systems in developments should be restricted to sites where significant water quality problems will not result from the use of such systems. The cost per residence of sewage collection systems increases as lot size increases, thus making on-lot disposal systems financially attractive for large lot developments. However, it must be recognized that protection of groundwater quality in extremely high and high water contamination hazard areas needs both large lot sizes and good sewage treatment.

4) Effective actions need to be taken to minimize water quantity and water quality problems from urban runoff in areas where runoff waters are likely to cause water quality problems. The areas where these problems are most severe are sinkhole areas subject to high or moderate sinkhole flooding hazards. Sound planning and control over developments in sinkhole areas will minimize both sinkhole flooding and water quality problems.

5) We need to encourage the location of commercial and industrial sites in areas where leaks, spills, and discharges will not significantly affect water quality. In particular, we must protect important water supplies. Water quality problems which would result from industrial and commercial development

have generally been ignored in the past when such facilities were being planned and located. As a result, such development in high and extremely high hazard category areas regularly create water quality problems in Greene County. As an example, in the past year industrial wastes have discharged from at least two, and probably three, of the eleven spring systems in Greene County which we identified as important.

Development constraints for protecting water quality

Based upon hydrologic considerations, we have developed a list of land development constraints appropriate for each of the four water quality contamination hazard area categories. The rationale for these actions has already been discussed; the reason for our listing is to give the reader a specific outline of the intensity of constraints which we believe, from a hydrologic standpoint, to be needed to protect water quality.

Development constraints for extremely high water contamination hazard areas

1) Septic field and related on-lot disposal systems should not be used for land developments in these areas. Regardless of lot size, residential development should not rely on septic field systems for waste waters. Some advanced on-lot systems may be appropriate for use in these areas.

2) All liquid wastes should be exported from areas within this category. No land application of effluents should occur on lands in this category.

3) Increases in water quantity associated with land development should be minimized in sinkhole areas. It should be remembered that a number of the areas within this category also have high or moderate sinkhole flooding hazards.

4) Groundwater quality would be best protected by perpetuating agricultural land use in these areas. If land development does occur, lots should be no smaller than three acres, and preferrably greater than five acres. Developed areas should be zoned for single family occupancy.

5) Commerical and industrial activities in lands of this category can create major groundwater quality problems. Furthermore, this type of land use typically involves large areas of impervious surfaces. Runoff from these areas adversely affects groundwater quality. Hydrologically, commercial and industrial development is unsuited to lands in this category.

Development constraints for high water contamination hazard areas

1) Septic field and related on-lot disposal systems should not be used for land developments in these areas. Regardless of lot size, residential development should not rely on septic field systems for waste waters. Some advanced on-lot systems may be appropriate for use in these areas.

2) In general, liquid wastes should be exported from areas within this category. No land application of effluents should occur on lands in this category, except possibly for areas within the surface basins of municipal water supplies. The reason for this exception is it is possible that some soils with severe limitations for septic field use might be adequate for effluent irrigation purposes; this will seldom be the case.

3) Increases in water quantity associated with land development should be minimized in sinkhole areas.

4) Residential land development on these areas can generally be conducted if adequate sewage treatment is provided and lot sizes are generally large. From a hydrologic standpoint, we would like to see lots no smaller than one acre. In some places larger lots are needed due to sinkhole flooding problems.

5) Commercial and industrial activities in lands of this category can create significant water quality problems, and particularly significant groundwater quality problems. Hydrologically, commercial and industrial development is poorly suited to lands in this category.

Development constraints for moderate water contamination hazard areas

1) Septic systems and related on-lot disposal systems should not be used for land developments in these areas. Lands in this category because of their location in watersheds for municipal water supplies could use septic field and related on-lot disposal systems if lots were large and the associated soils had slight limitations for septic field use.

2) Land application of effluents could occur on lands in this category if suitable soils are present and if appropriate irrigation techniques are used. Sprinkle irrigation may create fewer problems than overland runoff irrigation, but site-specific questions need to be considered.

3) In general, increases in water quantity associated with land development will not create serious water quality problems in lands of this category.

4) Residential land development on these areas can generally be conducted if adequate sewage treatment is provided. Based upon hydrologic considerations, we have no minimum lot size recommendation.

5) Commercial and industrial activities on lands of this category could create significant water quality problems. Site-specific investigations should be made for each commercial or industrial site proposed for an area within the moderate water contamination hazard category.

Development constraints for low water contamination hazard areas

1) Septic systems and related on-lot disposal systems could be used for land developments in these areas.

2) Land application of effluents could occur on lands in this category if suitable soils were present.

3) Certain commercial and industrial activities on lands of this category could create water quality problems. Site-specific investigations should be made for each commercial or industrial site proposed for an area within the low water contamination hazard category.

SUMMARY AND OUTLOOK

In a soluble rock area, surface waters and groundwaters are integrally connected. Because of this, land use changes can have dramatic consequences on groundwater quality and groundwater resources. However, this does not mean that all development will create groundwater problems; there are two reasons for this. First, some groundwater systems are more sensitive to damage or have greater values than other groundwater systems. Secondly, the hazards of groundwater contamination and pollution vary widely from point to point. Even with very careful land development, one site could create serious groundwater problems while another nearby site creates only negligible groundwater impacts.

In certain areas, land development will either create or magnify sinkhole flooding and/or groundwater contamination and pollution problems. In other areas, land development is not likely to create appreciable sinkhole flooding problems.

Regardless of whether one considers groundwater contamination or sinkhole flooding problems, it is obvious that there is a wide range of conditions present within Greene County. Because of this, land developments must be tailored to the characteristics of the land. We believe that implementation of guidelines such as we have outlined in this paper would represent a prudent tailoring of land development to the characteristics of the land.

As yet, we do not know the extent to which our hydrologic strategies and recommended land development constraints will be adopted by Greene County. However, our mapping has received a great deal of public attention. The maps were heavily used by the county in a series of township by township public hearings on county land use planning. A portion of the water contamination hazard map was reproduced on the front page of the Springfield newspaper, and the maps were featured in a 20 minute prime-time television documentary on the future of Springfield. In addition, the state of Missouri and the U. S. Environmental Protection Agency are expected to fund color printing of several hundred sets of the maps for public distribution; a substantial demand for copies of the maps has already developed. We hope that this attention will encourage the adoption of our hydrologic strategies and most of our recommended development constraints. If this occurs, we believe it will result in a much improved level of protection for water resources in Greene County.

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KARST MANAGEMENT IN URBAN AREAS: SINKHOLE FLOODING IN BOWLING GREEN, KENTUCKY

*Nicholas Crawford

ABSTRACT

Sinkhole flooding is a serious problem for urban areas located upon sinkhole plains. Pollution of subsurface streams by urban stormwater runoff is also a problem. Storm sewers are often prohibitively expensive because of the karst terrain. Good karst management can reduce sinkhole flooding while at the same time help to protect the caves and water quality of the aquifer under the city. Restricting development in sinkholes which flood by zoning combined with stormwater retention basins appears to be the most effective method of dealing with both sinkhole flooding and stormwater pollution of karst aquifers in urban areas.

Introduction

One of the most serious karst-related problems for urban areas located upon sinkhole plains is periodic flooding of karst depressions. Perhaps the most severe problems occur in Bowling Green, Kentucky, where homes, streets, businesses, apartment complexes, and even a shopping center are affected. Flooding occurs: 1) during periods of intense rainfall of short duration when the quantity of stormwater runoff exceeds sinkhole outlet capacities, and 2) during periods of prolonged rainfall when the Barren River at flood stage has a backwater effect on subsurface streams and/or subsurface streams at high discharge have a backwater effect on surface runoff attempting to flow underground at sinkholes.

Almost all of the stormwater runoff in the Bowling Green area flows into sinkholes or drainage wells (over three hundred have been drilled) and thereby into the very complex system of solutionally enlarged conduits in the limestone. It is believed that the great majority of the small subsurface streams flowing through these conduits are tributaries of the Lost River, a major subsurface stream which collects much of the karst drainage from southern Warren County before flowing under Bowling Green to a rising near the Barren River. Unfortunately, Bowling Green is rapidly growing in a direction that is upstream in terms of the subsurface Lost River; this may greatly aggravate the situation in the future unless wise decisions are made concerning the problem of karst flooding.

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Sinkhole Zoning Restrictions

The City-County Planning Commission is attempting to prevent future flooding problems by restricting land use in sinkholes to the contour which correlates with the capacity of the sinkhole to hold the volume of runoff from a one hundred year probability, three-hour, rainfall event. This will greatly reduce the majority of future flooding problems, but it is not the most conservative estimate of the depth to which karst depressions will flood. Many sinks have springs, often ephemeral, which deliver water to them from areas beyond the topographic divide. Also, many sinkholes are interconnected by a common subsurface conduit into which they normally drain, but during floods water may back up behind a constriction (such as a breakdown collapse area) until it has sufficient head to force the floodwater through. This will result in the flooding of those interconnected sinkholes upstream from the constriction but not those downstream. They may drain within impoundment even during the largest of floods. The water level in the flooding sinkholes upstream will reach a common level which has nothing to do with the size of each sink. Some sinks may fill completely and overflow, thus creating flooding problems for other areas.

If two or more sinks are connected by a common conduit, urban development or other land use which increases runoff into one sink may result in flooding of the other sink some distance away as water is impounded and flows out of the swallet at the distant sink. Water may or may not flood the sink where the development takes place, depending on its elevation.

As the city grows toward the southeast, hopefully most potential flooding problems will be avoided by zoning, thereby preventing development in

sinkhole areas which flood. However, urban expansion in that direction will increase the flood crest of the Lost River which flows under Bowling Green as more runoff water is directed underground faster. This will increase the depth of flooding in sinkholes downstream, and I fear that sinkholes which have not flooded in the past will flood in the future.

Flood Retention Reservoirs

Before approving drainage plans for changes of land use, the City-County Planning Commission is requiring stormwater retention reservoirs capable of holding the volume of additional runoff directly resulting from the change in land use which will occur during a three-hour, 100-year rainfall event. The flood retention reservoirs should reduce the rate at which stormwater runoff gets underground at swallets, thus reducing flooding pressure on the subsurface streams. Unfortunately, it is standard procedure for developers to drill one or more drainage wells inside the retention basins. Thus the reservoirs do not hold the water until it sinks slowly into the soil, instead they collect stormwater runoff and direct it down drainage wells into the karst drainage system and into subsurface streams.

The placement of drainage wells inside the reservoir defeats the purpose of the flood retention basin, the purpose being to retain runoff on site and thus withhold it from the stream so as not to increase the flood stage downstream. Flood retention reservoirs with drainage wells do not withhold runoff water from subsurface streams, instead they deliver more water to subsurface streams faster. This may result in flooding of sinkholes which are lower in elevation. If the retention reservoirs did not have drainage wells, stormwater runoff would sink slowly into the soil, thus filtering out sediment, trash and some other pollutants associated with urban stormwater runoff.

Stormwater Drainage Wells

Another area of concern is the numerous stormwater drainage wells in the Bowling Green area. Both the city and individual property owners have drilled wells to direct stormwater into the karst aquifer. Does water directed into these wells at higher elevations resurge at sinkholes at lower elevations, thus contributing to sinkhole flooding? There is direct evidence that several drainage wells have caused subsidence and sinkhole collapse. As the city expands toward the southeast into areas of the sinkhole plain where the depth to bedrock is greater, the danger of sinkhole collapse will probably increase. Also, there is some evidence that soil erosion from agricultural land use, urban stormwater runoff, and construction sites is clogging many of the sinks and drainage wells. Sediment forty to fifty feet deep is often found stacked up in drainage wells. What about the sediment that reaches the karst aquifer under Bowling Green? Is it being deposited in the small conduits of the underlying limestone, clogging them, and thus contributing to the sinkhole flooding problems of this karst landscape?

Research Objectives

A major objective of this investigation is to understand the complex groundwater system under the Bowling Green area in order to facilitate stormwater management and thereby reduce future flooding. The first step in understanding the karst-related flooding problems of the sinkhole plain upon which Bowling Green is located, is to delimit the underground drainage divides and subsurface flow routes by dye tracing. Numerous dye traces using automatic water samplers and fluorometer have delimited the general boundaries of the Lost River Groundwater Basin. The process of identifying drainage divides and locating the smaller subsurface streams under Bowling Green is now in progress.

In order to identify possible correlations between precipitation intensity and duration, stage height of the Barren River, stage height of the subsurface Lost River, elevation of the water table, and the depth of flooding in various karst depressions, continuously recording instrumentation is being installed. Nine recording stream gages and four recording rain gages have been installed to date. Monitoring will continue for at least three years.

An inventory and investigation of drainage wells is in progress. The investigation includes: 1) elevation of the water surface, 2) geochemical analysis of water samples taken from the wells, 3) siltation, 4) sinkhole collapse in relation to the wells.

A second objective of this research is to investigate non-point pollution of karst aquifers in the Bowling Green area resulting from stormwater runoff. This research is part of a 208 study funded by the Kentucky Division of Water through the Barren River Area Development District. Trailers with continuous monitoring instrumentation for water quality have been placed at the Lost River Karst Window (before the stream flows under the city) and at the Lost River Rise (where the subsurface stream resurges after flowing under Bowling Green.

Conclusions and Management Recommendations

It would be financially prohibitive for Bowling Green to run storm sewers throughout the city due to the karst terrain. Even with storm sewers, much of the stormwater runoff would still flow into the caves under the city. However, some things can be done which would reduce sinkhole flooding while at the same time help to protect the caves and the water quality of the aquifer under the city.

Restricting development in flood prone areas by zoning, combined with stormwater retention basins (without drainage wells), appears to be the most effective method of dealing with stormwater flooding in karst areas. Retention basins: 1) prevent stormwater flooding in the local area; 2) retain stormwater on the surface thereby relieving pressure on the already overloaded subsurface drainage

system; 3) provide a means of filtering stormwater through the soil thereby protecting the subsurface drainage system from silt, trans and some other pollutants; 4) are far less expensive to construct and maintain than storm sewers which are often prohibitively expensive in karst regions.

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AQUATIC ECOSYSTEMS AND MANAGEMENT PROBLEMS IN THE MAMMOTH CAVE AREA

* Julian J. Lewis

ABSTRACT

Aquatic troglobites exist in stable environments with low food input and have developed specializations which allow them to utilize the unusual habitats found in caves. Fifteen species of aquatic troglobites are known from the Flint-Mammoth Cave System, of which 13 are invertebrates and 2 are fish. In Mammoth Cave these species develop communities which exist in both upper level and base level habitats.

Many aquatic troglobites are highly specialized in their habitat utilization. Evidence from distribution studies conducted in Mammoth Cave indicates that the troglobitic isopod, Caecidotea sp., and its predator, Orconectes pellucidus, have declined in Styx and Echo rivers due to the effects of backflooding caused by Green River Dam #6. Other habitat disturbances are caused by the use of sinkholes on the sinkhole plain adjacent to Mammoth Cave National Park as dumps or sewers. Water from the sinkhole plain flows to the Green River via subterranean streams in Mammoth Cave National Park.

I would like to start by discussing a few general aspects of aquatic invertebrate cavernicoles, and then the kinds of invertebrates which occur in aquatic cave habitats, and the habitats available for community development. Several management problems inherent to the Mammoth Cave region, which also are applicable to other areas, are interspersed in the discussion.

A readily observable and often striking characteristic of aquatic troglobites is their specialized morphology. In comparing an epigean isopod, *Caecidotea brevicauda*, with a subterranena species, *Caecidotea antricola*, several differences are readily apparent. In *Caecidotea brevicauda*, eyes and pigmentation are present, the body is stout in relation to the length, the appendages are similarly short and stout, and the uropods are especially short, about one half the length of the pleotelson. In *Caecidotea antricola*, both eyes and pigmentation are absent, the body is relatively long and narrow, the appendages are elongate, and the uropods are over twice the length of the pleotelson.

In eastern Missouri cave streams these two species often co-occur (Lewis, 1974; Peck and Lewis, 1977), but *Caecidotea antricola* is dominant. An interesting exception to this is found in a section of stream passage in Tom Moore Cave, in Perry County, Missouri, which lies under a septic field. In this passage, the opportunistic *Caecidotea brevicauda* has apparently taken advantage of the unusually large food supply and has virtually displaced *Caecidotea antricola*, because the troglobite's feeding and reproductive strategies have not evolved to allow rapid utilization of such ephemeral occurrences, giving the epigean species the advantage in this particular situation.

A more detailed report on the effects of septic field pollution on an underlying cave ecosystem has been given by Holsinger (1966).

In any ecosystem the basis of the food web is ultimately green plants, which derive energy from the sun to photosynthesize organic compounds from inorganic raw materials. Cave ecosystems are not an exception to this, but plants will not grow past the twilight zone of caves, so food must be imported by indirect means. Floods carry in large amounts of materials ranging in size from tree trunks down to dissolved organic matter, and as such, are a major source of food to the cave's aquatic inhabitants. Unfortunately, pollutants are equally vagile. Unlike terrestrial troglobites, which can avoid localized disturbances by moving elsewhere, aquatic troglobites are less able to find refuge from a pollutant which has been spread over a wide area by stream flow. The "broken back syndrome" of the fish *Amblyopsis spelaea* in the Donaldson Cave System, in Lawrence County, Indiana, is apparently caused by the spread of an unidentified chlorinated hydrocarbon from the

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surface into the cave system, as a case in point. The damage caused by even a single introduction of a toxic material to a cave stream can be long-lived due to the relative low fecundity and long lifespan of some aquatic troglobites.

A second source of food is provided by trogloxenes, notably bats, cave crickets, and raccoons, which feed on the surface and import food into the cave in the form of guano. Ultimately, these animals may also donate their bodies as food sources if death occurs within the cave.

The aquatic troglobitic invertebrate fauna of Mammoth Cave is a good example of the types of invertebrates found in caves of the eastern United States, although the species diversity and degree of syntopy is unusually great. Three species of non-arthropod troglobites occur in the waters of Mammoth Cave: two species of flatworms, *Sphalloplana percoeca* and *Sphalloplana buchanani*; and one species of snail, *Antroselates spiralis*.

The majority of aquatic invertebrates in many caves are often arthropods, notably crustaceans, and this is the case in Mammoth Cave. These include: two species of isopods, *Caecidotea stygia* and an undescribed species, *Caecidotea* sp. (Lewis and Bowman, in press); three species of amphipods, *Crangonyx packardi*, *Stygobromus vitreus* and *Stygobromus exilis*; and two species of decapods, the crayfish *Orconectes pellucidus* and the shrimp *Palaemonias ganteri*. The final additions are a copepod, *Cyclops donnaldsoni* (known in Mammoth Cave from a single specimen taken in Roaring River), and two ectocommensal ostracods, *Sagittocythere barri* and *Sagittocythere stygia*, which have been taken from the crayfish *Orconectes pellucidus*. A general summary of the fauna of Mammoth Cave, including many species of aquatic troglophiles and trogloxenes, has been presented by Barr (1968).

It is relevant to point out that some of these species are more susceptible to localized disturbances than others. If a widespread species such as *Caecidotea stygia* is destroyed at one locality, the possibility of re-invasion of the habitat from other populations is probably good if the habitat is restored to its original condition. However, if a species such as *Palaemonias ganteri*, which is known from a single cave system, is subjected to an environmental disturbance, the species may be entirely extirpated, since the habitat can not be resupplied from other populations.

Many parts of the upper levels of Mammoth Cave are extremely dry, but two general types of habitats (Table 1) occur which support aquatic communities

TABLE 1

Generalized troglobitic aquatic communities in the Flint-Mammoth Cave System

Upper Level Habitats (shaft drains, terminal breakdowns)	Base Level Habitats (cave rivers)
Flatworms:	
Sphalloplana percoeca	?
Sphalloplana buchanani	?
	Snails:
	Antroselates spiralis
	Copepods:
	Cyclops donnaldsoni
	Ostracods:
	Sagittocythere stygia
	Sagittocythere barri
Isopods (water slaters):	
Caecidotea stygia	*Caecidotea* sp. (undescribed)
Amphipods (scuds):	
Crangonyx packardi	*Crangonyx packardi*
Stygobromus vitreus	*Stygobromus vitreus*
Stygobromus exilis	*Stygobromus exilis*
	Crayfish:
	Orconectes pellucidus
	Shrimp:
	Palaemonias ganteri
	Fish:
	Typhlichthys subterraneus
	Amblyopsis spelaea

when perennial water is available. The more common of these two types are small streams associated with vertical shafts. Shaler's Brook, which originates from a waterfall coming from Annette's Dome, flows across Gratz Avenue, and then ends by falling into another pit, Lee's Cistern, is typical. In Shaler's Brook, the dominant species is *Caecidotea stygia*, with population densities ranging from 70 individuals per 15 cm^2 in gravel riffle areas to nearly 0 in sand bottomed parts of the stream. In the riffle areas amphipods occur in densities of 1 to 2 individuals per 15 cm^2, and flatworms occur 2 to 3 per 15 cm^2. Smaller pools such as the Devil's Cooling Tub in Gratz Avenue are also supplied by water flowing through shaft complexes, and contain small communities of invertebrates. This type of pool habitat is similar to the rimstone pool habitats which are common in other caves.

A second type of upper level aquatic habitat can be found where a valley has intersected a cave passage, creating a terminal breakdown. In some areas, such as the breakdown at the end of Rafinesque Hall, enough water flows down the breakdown to support a community similar to that described for Shaler's Brook. Pumphouses drawing water from springs which normally supply water to upper level cave passages has threatened the existence of some of these localized aquatic communities by depleting their water sources, but this problem is being rectified by bringing in water from other sources for human needs, allowing the springs to supply the underlying caves.

At some point, e.g., Charon's Cascade, the water from the upper levels finds its way to the base level streams, which in Historic Mammoth are the Styx and Echo rivers. In these streams, which offer a wider variety of aquatic microhabitats, communities are more diverse than those allowed by the semi-perennial upper level streams. Different species are present, most notably the snail *Antroselates spiralis*, an undescribed isopod of the genus *Caecidotea*, the crayfish *Orconectes pellucidus*, the shrimp *Palaemonias ganteri*, and the fish *Typhlichthys subterraneus* and *Amblyopsis spelaea*.

Much of the Echo and Styx rivers consists of deep ponded water, due to backflooding from the Green River Dam #6. This structure was built in 1906 to allow navigation on the Green River, but was deactivated in 1951 due to a lack of river traffic. In 1965 Green River Dam #4 collapsed, and navigation upstream of this point is no longer possible, except in localized situations. The lock at dam #6 has been concreted shut and is totally non-functional at this point. Studies are presently underway to evaluate the possibility of eliminating the Green River Lock and Dam #6.

The downstream parts of Styx and Echo rivers have become heavily silted due to backflooding from the Green River, and some areas which were once dry are now permanently flooded. Hay (1903) reported that the crayfish *Orconectes pellucidus* was abundant in the River Styx. However, now the sand bottom of the river supports an isopod population of nearly zero population density (similar to that found in the sandy areas of Shaler's Brook), which in turn will not support the crayfish predacious on the isopods. The backflooding has, in essence, created an aquatic desert.

As discussed above, two subterranean species of *Caecidotea* occur in the Flint-Mammoth Cave System, a situation which is found in only a few other caves in the United States. In Mammoth Cave, these two species of isopods are interesting as ecological indicators. *Caecidotea stygia*, which was first described by Packard (1871) from a collection probably made at Richardson's Spring, is in the Mammoth Cave area generally restricted to habitats in the upper levels of the cave. However, *Caecidotea stygia* also occurs in the ponded, heavily-silted, downstream parts of Echo and Styx rivers. As one travels upstream an interface is found between the populations of *Caecidotea stygia* and the undescribed species of *Caecidotea*, with the undescribed species becoming more abundant in relation to the numbers of *Caecidotea stygia* present the further upstream one travels. Extremely deep water in Roaring River, the upstream continuation of Echo River, makes sampling difficult, but the upstream portions of other streams have been found by dye tracing (Quinlan and Rowe, 1977; 1978) so that a more continuous examination from downstream to upstream can be conducted. Moving from Hawkin's River (in Mammoth Cave National Park) upstream to Mill Hole (a karst window outside of the park) to the subterranean headwaters under the sinkhole plain at Parker Cave, only the undescribed species of *Caecidotea* has been found.

Apparently the undescribed *Caecidotea* is a habitat specialist, living only in base level stream passages where rock or gravel is available. *Caecidotea stygia* is more of a habitat generalist, which through its range inhabits a number of different habitats, including base level streams.

In Mammoth Cave, *Caecidotea stygia* is excluded from the base level stream habitat by the undescribed *Caecidotea*, except in the disturbed lower reaches of Styx and Echo rivers, where the undescribed species preferred habitat is not available due to the siltation accompanying the backflooding disturbance caused by the nearby dam on the Green River.

I would like to close by pointing out some of the real and potential problems presented by the fact that the water flowing through Mammoth Cave National Park comes from outside of the bounds of the park from the adjacent sinkhole plain. Perhaps the most simplistic of these problems is that sinkholes continue to be used as dumps for trash, although the dumping of digested sludge from the Horse Cave sewage treatment plant containing, mong other things, chromium, nickel, lead, and cadmium, gives a new perspective on this age old problem. Pollution of the groundwater from an oil field located on the sinkhole plain also presents occasional problems. However, a more serious problem is caused by the discharge of the Horse Cave sewage treatment plant's effluent into disposal wells which flow into Hidden River Cave. This problem is compounded by the discharge of industrial waste from a local metal plating plant and creamery into the treatment plant. The high concentrations of metals present are toxic to the bacteria necessary to degrade the sewage, so treatment is less than effective. After leaving the

Horse Cave treatment plant, the effluent travels to the Green River via Hidden River Cave. This cave was at one time a commercial attraction, but the discharge of sewage into the cave has transformed the passages into sewers, with a large, odorous entrance in downtown Horse Cave.

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A CONCEPTUAL CHARACTERIZATION OF THE SUBSURFACE MOVEMENT OF TOXIC CHEMICALS IN SOLUBLE ROCK LANDS

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In the past few years we have seen a dramatic increase in the number of soluble and fractured rock groundwater problems which were associated with toxic chemicals. These have included chemicals such as polychlorinated biphenols (PBC's), 2,3,7,8-tetrachlorodibenzo-p-dioxin (commonly called TCDD or dioxin), heavy metals (including chromium, copper, and other plating wastes), and radioactive isotopes.

Soluble rock landscapes, and to some extent certain fractured rock landscapes, have some unique groundwater features not typical of other regions. As a result, the subsurface movement of toxic chemicals in soluble rock areas can be dramatically different from what would be anticipated in a more hydrologically homogeneous environment. It has been our experience that these differences are seldom appreciated by the management-oriented people who are responsible for dealing with toxic chemical problems. As a result, thousands of dollars have been wasted in poorly conceived study programs, monitoring plans, and pollution control strategies.

The purpose of this paper is to provide the reader with a general characterization and workable understanding of how toxic wastes move through the subsurface in soluble rock areas. To some extent, this characterization is also applicable to some fractured rock landscapes, and the reader should keep this in mind even though fractured rock landscapes will receive no specific attention in this paper. Furthermore, we urge that our conceptual characterization not be used in lieu of chemical-specific and site-specific investigations.

There are three factors of critical importance in determining the susceptibility of toxic chemicals to subsurface movement in soluble rock lands. These factors are: 1) the nature of the chemical, 2) the nature of the groundwater recharge system, and 3) the nature of the groundwater system.

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THE NATURE OF THE CHEMICAL

Toxic chemicals are commonly associated with industrial and municipal wastes. Their properties are as varied as their sources, and understanding the nature of these chemicals and their interactions is essential to predicting their behavior in groundwater systems.

There are tremendous differences in the water solubility of toxic chemicals. Toxic chemicals which we have encountered can range in water solubility from less than 2 parts per billion to totally soluble. People often tacitly assume that toxic chemicals with low water solubilities will not cause adverse impacts in groundwater systems because of the assumed dilution which occurs within these systems. In soluble rock landscapes, this assumption is commonly invalid. At a minimum, the assumption is less valid in soluble rock areas underlain by a more uniform porous media (such as alluvium or sandstone).

In cases involving toxic chemicals included in landfills, dumps, or industrial discharges, one must consider not only the solubility of the chemical in water, but also its solubility in other liquids present at the site. It sometimes occurs that a toxic chemical has a very low solubility in water, but a high solubility in certain solvents. These solvents, in turn, can have a high solubility in water.

There are also great differences in the adsorptive properties of toxic chemicals with respect to soils. Chemicals with low adsorptive tendencies are likely to remain available for transport in solution through a groundwater system. Conversely, other toxic chemicals have high adsorption tendencies and readily adhere to soil and clay particles. If they encounter suitable soil particles with suitable and available adsorbing surfaces, they can be rather rapidly removed from waters moving through the subsurface.

The chemical stability of toxic chemicals in groundwater systems is also important. The stability of a compound may be influenced by a range

of conditions found in the environment. Assessment of stability based upon conditions encountered on the surface, however, do not necessarily reflect conditions encountered in the subsurface. In underground conditions, for instance, ultra-violet irradiation (from the sun) is absent; sunlight irradiation of chlorinated hydrocarbons can be an important destructive mechanism.

The stable temperature of the subsurface environment is another condition enhancing stability of compounds that would otherwise deteriorate in the temperature extremes of the surface.

Bacterial degradation of some compounds is yet another important destructive mechanism. Bacterial abundance decreases by orders of magnitude as one progresses deeper into the ground. Bacteria are most abundant in the leaf litter and uppermost few inches of the soil. It has been our experience that toxic chemicals tend to be significantly more stable in deeper subsurface environments than in surface and near-surface environments.

Other properties and characteristics of toxic chemicals are also important in assessing their potential for subsurface migration and creation of harmful impacts in soluble rock areas. However, most of these differences do not vary between soluble and insoluble rock areas, or between surface and subsurface conditions. For this reason we will not discuss these properties and characteristics in this paper.

NATURE OF THE GROUNDWATER RECHARGE SYSTEM

In soluble rock landscapes, the movement of water into the groundwater system is typically non-uniform. As a result, the subsurface movement of toxic chemicals will also be non-uniform.

Groundwater recharge is the movement of water from the surface toward the groundwater system which underlies the land. In most soluble rock lands, it is our opinion that groundwater recharge can be divided into two classes: 1) discrete recharge, and 2) diffuse recharge. The distinctions between discrete and diffuse recharge is discussed in detail by Aley (1977).

Discrete recharge, which could also be called concentrated recharge, is the concentrated and relatively rapid movement of recharge water toward the groundwater system. Descrete recharge is localized; it occurs in discrete areas. Substantially greater quantities of water per unit area enter the groundwater system through discrete recharge zones than through diffuse recharge.

Diffuse recharge refers to the general and relatively slow seepage and percolation of recharge water toward the groundwater system. Diffuse recharge, by definition, is not concentrated flow.

Discrete recharge zones have a much greater potential for transporting toxic chemicals in solution toward the groundwater system than do diffuse recharge areas. The primary reason for this is that discrete recharge zones provide less effective adsorption than do diffuse recharge areas. There are three explanations for this difference.

The first explanation for the difference is that flow rates through discrete recharge zones are typically much more rapid than through diffuse recharge areas. As an example, surface rainfall in the Ozarks recharging through discrete recharge zones causes major flow increases in nearby springs within a few hours of the precipitation; the diffuse flow component is delayed and greatly attenuated (Aley, 1977). The rapid transit times which characterize discrete recharge waters provide less time for adsorption by soil particles than is the case with diffuse recharge zones.

The second explanation is that discrete recharge zones commonly have been flushed of much of the fine textured materials which could potentially adsorb toxic chemicals from contaminated water; diffuse recharge areas have not been flushed. It appears likely that water velocities through discrete recharge zones occasionally are rapid enough and consist of enough water to present turbulent flow conditions capable of transporting substantial quantities of sediment through and out of the discrete recharge zones.

The third explanation is that adsorption of toxic chemicals by soils increases with increases in the amount of potential adsorbing surface area encountered. Contaminated water will encounter a much smaller area of adsorbing surfaces in discrete recharge zones (which are composed primarily of conduits) than in diffuse recharge areas (where intergranular water movement predominates). No data have been assembled to quantify the difference in adsorbing surface areas between discrete and diffuse recharge zones, but it is our belief that the differences could commonly be ten to one hundred fold.

An mentioned earlier, discrete recharge zones are capable of transporting materials in suspension; diffuse recharge areas are not. Because of this distinction, toxic chemicals adsorbed on clay particles can be transported through discrete recharge zones to the groundwater system. This represents a subsurface transport system which generally does not exist except in soluble rock landscapes. In our experience, this transport mechanism has seldom received any attention.

Clay particles, which are typically smaller than four microns in diameter, can be transported into and through groundwater systems in soluble rock areas. We believe that toxic chemical adsorption on suspended clay particles is commonly an important mechanism of toxic chemical transport in soluble rock lands. *Lycopodium* spores are a groundwater tracing agent which the senior author has used on a number of occasions (Aley and Fletcher, 1976). These spores have a mean diameter of 33 microns, thus they are substantially larger than the less than four micron diameter clay particles onto which toxic chemicals can be adsorbed. Both spores and clay particles will travel in suspension toward and through groundwater systems; if anything, the clay particles will tend to remain in suspension for longer periods of time in calm waters than will the spores.

The senior author has traced *Lycopodium* spores from sinkholes and sinking streams to springs as

far as 39.5 miles distant from the injection site. In addition, spores have been successfully traced from a septic field to a domestic water supply well, and from two wells which penetrated shallow caves to a major cave stream half a mile away.

Toxic chemicals with moderate to high water solubility and low to moderate adsorption tendency, will most commonly receive the majority of their subsurface transport in solution. Toxic chemicals with low water solubility and moderate to high adsorption tendency, will most commonly receive the majority of their subsurface transport in suspension if local subsurface conditions are conducive to sediment transport.

NATURE OF THE GROUNDWATER SYSTEM

Groundwater recharge contributes water to the groundwater system. It is the movement of water through the groundwater system which is the topic for this section of the paper.

A good conceptual model for dealing with groundwater in soluble rock areas should recognize that there are two components of the groundwater system. The terms "water in storage" and "water in transit" have been used to characterize these two components (Aley, 1977).

Water in storage generally fits the conventional view of groundwater. Water in storage is characterized by slow lateral movement. In distinct contrast, water in transit is characterized by rapid lateral movement, commonly at rates of from several feet per hour to several hundred feet per hour. It would be illogical to label water moving at these rates through a groundwater system as water in storage. This rapidly moving water is in transit, not storage. Obviously, the two classes (water in storage and water in transit) are a continuum, for even the water in storage has some movement. Rather than hang ourselves with semantics, which is totally unnecessary for the purposes of this discussion, we propose that flow rates equal to or in excess of one foot per hour indicate water in transit, and rates less than one foot per hour represent water in storage.

Based on Missouri studies (Aley, 1977), discrete recharge zones tend to contribute most of their waters to water in transit. Diffuse recharge zones contribute water both to water in transit and water in storage.

In general, water in transit is underground for a shorter period of time than is water in storage. In addition, contaminants introduced into water in transit tend to move as pulses through the groundwater system. In general, contaminants receive less dilution in waters in transit than they do in waters in storage. These distinctions between water in storage and water in transit are of vital importance in assessing the potential for subsurface movement of toxic chemicals.

Within most soluble rock groundwater systems one does not generally encounter abundant soil particles capable of adsorption, although some exceptions to this generalization undoubtedly occur. If there is a difference in contaminant exposure to adsorbing particles within soluble rock groundwater systems, we anticipate that water in storage would be exposed to more adsorption than would water in transit. In general, most adsorption will occur above the groundwater system (in other words, within the groundwater recharge system).

If toxic chemicals in solution reach the soluble rock groundwater system, we should expect them to move widely through the groundwater system. Toxic chemicals entering through discrete recharge zones will contribute primarily to the water in transit component of the groundwater system; most of the toxic chemicals introduced will discharge as pulses from springs draining the area. Toxic chemicals in solution entering through diffuse recharge zones will typically have low to moderate adsorption characteristics, and will contribute both to water in transit and to water in storage; they will typically be detectable in springs before they are detectable in wells, although they will ultimately be found both in springs and wells. Concentrations in springs and wells will be a function of the flow system; we cannot develop a generalization as to whether concentrations should be greater in springs or in wells since this is a site-specific question.

Toxic chemicals adsorbed on soil particles can reach the groundwater system through discrete recharge zones. Discrete recharge zones tend to contribute most of their waters to the water in transit component of the groundwater system. As we have demonstrated through the use of *Lycopodium* spores, water in transit can transport suspended materials. As a result, toxic chemicals adsorbed on soil particles which enter the groundwater system should be expected to discharge from springs. They will settle and not be transported through the water in storage system. Since wells normally are extracting water in storage, toxic chemicals adsorbed on soil particles will seldom be recovered from such wells.

SUMMARY

We have characterized the likely movement of toxic chemicals in subsurface waters in soluble rock landscapes in an attempt to develop as many general conclusions about toxic chemical movement in such landscapes as we could. Numerical verification for our conceptual characterization is generally lacking, yet the characterization fits our field experience in cases involving subsurface movement of toxic chemicals in soluble rock areas.

We believe that our conceptual characterization will provide management oriented people with a better general characterization of subsurface toxic chemical movement in soluble rock lands than presently exists. However, general characterizations can only provide general help in dealing with problems of subsurface movement of toxic chemicals in soluble rock lands. Our conceptual characterizations should not be used in lieu of chemical-specific and site-specific investigations. We believe, however, that this conceptual characterization can be of substantial value in guiding the design of investigation programs; it has been our experience that such guidance for soluble rock

landscapes is urgently needed.

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APPLICATION OF KENTUCKY WATER QUALITY REGULATIONS TO KARST WATERS

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ABSTRACT

On May 7, 1980, the U. S. Environmental Protection Agengy approved Kentucky's Surface Water Quality Standards which were adopted by Kentucky's Department for Natural Resources and Environmental Protection on December 5, 1979. Revisions to the previous regulations included expansion of use designations to include all uses for all waters, specific requirements to accompany applications for designated use adjustments and variances, numeric toxic limits for aquatic life protection for eleven constituents in addition to general bioassay criteria, bacteriological criteria for primary and secondary contact recreation waters, and a new use classification of Outstanding Resource Waters.

The Department recently received a formal request from the Cave Research Foundation to redesignate all underground streams in the Mammoth Cave area as Outstanding Resource Waters. Kentucky's surface water regulations apply in this area according to the definition of surface waters which expressly includes "...any subterranean waters flowing in well defined channels and having a clear hydrological connection with the surface." In general consideration is given to any proposal for Outstanding Resource Waters classification accompanied by substantial documentation to support the designated use and associated criteria. However, certain subsurface streams in the Mammoth Cave area may qualify for automatic inclusion pending the addition of the Kentucky Cave Shrimp to the Endangered Species List.

Closely related to this activity is the finalization of EPA's Environmental Impact Statement on the Mammoth Cave area. The Department and EPA have generated wasteload allocations for effluents from publicly-owned treatment works in this area. These wasteload allocations are based on criteria associated with the current Warmwater Aquatic Habitat classification. An Outstanding Resource Water classification will assign more stringent criteria to protect the use. In turn, more stringent wasteload allocations will be required to insure associated in-stream criteria are not violated. The selection of the most cost-effective treatment alternative for the area is dependent upon the final wasteload allocations and their associated treatment costs.

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ENVIRONMENTAL REGULATIONS, ASSISTANCE AND A STATUS REPORT ON THE MAMMOTH CAVE ENVIRONMENTAL IMPACT STATEMENT

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I. INTRODUCTION

The purpose of this paper is to discuss EPA's involvement in environmental programs from two perspectives. First, and very generally, an overview of several environmental programs that EPA has been authorized by Congress to administer and implement will be presented. Six pieces of Federal legislation — the Clean Water Act, Clean Air Act, Toxic Substances Control Act, Resource Conservation and Recovery Act, Safe Drinking Water Act, and the National Environmental Policy Act — will be reviewed. The legislative history and the highlights of these laws as they relate to environmental regulation and assistance will be covered.

Secondly, the experiences of EPA's efforts in the practical application of the Clean Water Act and the National Environmental Policy Act in the Mammoth Cave area will be discussed. This effort — the Mammoth Cave Area Environmental Impact Statement (EIS) involves a program of Federal assistance in addressing this area's wastewater management problems. The progress and difficulties that have been encountered thus far in efforts to resolve existing and avoid future wastewater management problems will be the focus of this discussion.

II. ENVIRONMENTAL REGULATION AND ASSISTANCE

In the continuing and often heated discussion of pollution and environmental issues, the United States Environmental Protection Agency (EPA) is frequently in the public eye.

EPA was created because of increasing public and governmental concern about the dangers to the health and welfare of Americans caused by pollution. Clearly, immediate and positive action was necessary to cope with the deterioration of the natural environment. Grounds for deep concern were not difficult to find: on all sides, noxious air, foul water, and other serious threats to the health and well-being of all Americans were abundantly evident.

EPA was given the main Federal responsibility for coming to grips with these complex problems and at the same time, striking a balance between the protection of the natural environment and securing for our citizens the benefits of economic and technological progress.

On July 9, 1970, President Nixon sent to Congress a reorganization plan removing 15 units from existing departments and agencies, and relocating them in a new independent agency. When the reorganization plan became effective on December 2, 1970, the United States Environmental Protection Agency opened its doors for business with William D. Ruckelshaus as Administrator.

EPA brings under one organizational roof Federal activities in controlling air and water pollution, drinking water quality, solid wastes, pesticides, environmental radiation and noise. It is an independent regulatory agency that has no obligation to promote agriculture, commerce or industry. It has only one mission — to protect and enhance the environment. In general, the agency is responsible for establishing and enforcing standards, conducting research and demonstrations for monitoring pollution in the environment, and perhaps most importantly, for assisting State and local governments in their own efforts. The purpose is to mount an integrated attack on pollution and at the same time, to make orderly progress toward understanding the environment as a single system of independent, but interrelated parts.

The following discussion of EPA's major environmental programs will relate the six previously listed laws to four major areas of concern: air, water, solid waste, and toxic substances.

AIR - The average person breathes 35 pounds of air each day — six times as much as the food and drink normally consumed in the same period of time.

By 1970 over 200 million tons of waste products were being released into the air annually. Slightly over half of the pollution came from the internal-combustion engines of cars and other motor vehicles. Roughly 22 percent came from fuel burned at stationary sources such as power generating plants, and another 15 percent was emitted from industrial processes

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Air pollution is associated with the increasing number of cases of emphysema, bronchitis, asthma, lung cancer, and numerous other respiratory disorders, with diseases of the heart, and with certain incidences of impaired mental performance. Illness caused or aggravated by air pollution cost the American people an estimated $4.6 billion yearly in medical treatment, lost wages, and reduced productivity.

Air pollution also corrodes buildings, damages personal property, and harms forest and crops, causing an additional $12.5 billion in destruction and decay each year.

The Federal air pollution control effort began modestly in 1955 when the U. S. Public Health Service implemented an air pollution research program and offered technical assistance to State and local governments concerned about the problem. Congress stepped up the tempo in 1963 with the Clean Air Act, providing for Federal-State action to cut down on industrial smokestack gases. In 1965, the first set of amendments to the Clean Air Act gave the Federal government authority to reduce motor vehicle emissions. The Air Quality Act of 1967 called for a new air quality management approach to the problem. The Federal government designated air quality regions with problems and published information on the effects of air pollutants on health and welfare, and on control techniques for air pollutants. The States were then obliged to develop air quality standards and plans for implementing those standards in the designated regions. Perhaps more significantly, the 1967 legislation paved the way for enactment of the historic Clean Air Act Amendments of 1970.

Under these Amendments, EPA has established national air quality standards which specify maximum allowable levels for the major pollutants. These pollutants include sulfur oxides, particulate matter (such as dust, smoke, and fly ash), carbon monoxide, hydrocarbons, and nitrogen oxides. Another major pollutant, formed when nitrogen oxides combine with hydrocarbons in the presence of sunlight, is called smog — the eye-stinging haze which hangs over most major American cities. The technical name for smog is photochemical oxidants.

The Amendments further required that the States, in order to meet the national standards set by EPA, develop detailed plans to control air pollution coming from such sources as automobile traffic, manufacturing plants, and power plants. The Amendments directed that hearings be held, allowing citizens to participate in the formulation of such control plans.

The standards which EPA set for new cars beginning with 1975 models required significant auto emission reductions from models produced before 1968.

EPA also establishes performance standards limiting pollution emissions from new or substantially modified plants in certain industries and requires these plants to use the best pollution control equipment and procedures available. Standards have been set for fossil-fuel powered electric generators, cement plants, oil refineries, steel mills, and a number of other industrial operations. EPA also regulates such extremely hazardous air pollutants as asbestos, beryllium, mercury, and vinyl chloride.

Before the States and EPA develop specific programs to achieve clean air standards, they conduct extensive technical research and monitoring to determine the levels of air pollution that exist in each area. While the standards for all areas of the country are uniformly established by Congress to protect health and welfare, specific strategies for individual States and localities must depend on existing and projected levels of air pollution. The more severe the levels of pollution are, the more stringent the pollution abatement programs will be to achieve the standards. Hundreds of monitoring stations around the country continually sample the air and analyze its quality as a basis for establishing these specific pollution reduction programs.

Air quality in the United States is now showing definite signs of improvement. Nationally, sulfur dioxide concentrations have been reduced by roughly 30 percent since 1970. The national average for particulate matter, such as dust and soot has dropped about 17 percent in that same time, and this downward trend is continuing. Carbon monoxide levels have decreased by roughly 10 percent and modest reductions in hydrocarbons have also been recorded.

WATER - For centuries, natural processes have helped to keep many lakes and rivers clean. Eutrophication, the natural aging of lakes, causes some deterioration of water over geologic periods of time, but this cannot compare with man-made pollution, which has placed more of a strain on many of our waterways than nature can accomodate.

By the early 1970's, pollution had made many of our rivers, estuaries, and lakes unfit for recreation, and adjacent wetlands were being choked with silt or ruined by chemical effluents. Analyses of drinking water revealed signs of potentially dangerous contamination in many parts of the country.

Even the vast oceans are jeopardized by the wastes that eventually reached them through the rivers, by oil spills, and the dumping of wastes and hazardous materials.

Prior to 1948, the main thrust of the Federal water pollution control program was to ensure unhampered navigation and prevent the spread of communicable disease. In 1948, clean water efforts were first launched on a trial basis as Congress authorized funds for research, State and local planning, and manpower training. A permanent program was initiated under the Water Pollution Control Act of 1956.

In 1965 the water pollution control program was strengthened by legislation which called for establishment of water quality standards and implementation plans for cleanup of all interstate and coastal waters. The Clean Water Restoration Act

of 1966 provided more Federal money for building treatment facilities.

The far-reaching Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) include strict deadlines for cleaning up the Nation's waterways. Rigorous effluent standards are set by EPA and are enforced by the States and municipalities in cooperation with EPA. Industries discharging into navigable waters must install needed pollution control equipment and must obtain permits which limit the kinds and quantities of pollutants that can be discharged. More than 41,000 industrial, agricultural, and Federal facility sources of pollution and 20,000 municipal sewage plants are to be regulated under the permit program.

The 1972 law also authorized Federal grants of up to 75 percent of the cost of planning, designing, and building municipal sewage treatment facilities. This effort is one of the largest public works programs in America, and since 1972 EPA has been authorized to commit over $25 billion in construction grants through September 1982.

The Federal Water Pollution Control Amendments of 1972 also provide for public participation in developing and enforcing water pollution control programs. EPA and the States have published regulations specifying minimum guidelines for public participation in the process. Therefore, no Federal water pollution control program can go forward without the opportunity being provided for active participation by the interested public.

In 1977, the FWPCA of 1972 was amended to create the Clean Water Act of 1977. Congress has periodically improved the Federal Water Pollution Control Act. Indeed, even as it adopted P.L. 92-500, Congress clearly anticipated that review, course-correction, and fine tuning would be required soon after 1972. EPA was directed to report to Congress annually on the measures taken toward implementing the objectives of the Act. In short, Congress well recognizes that the water quality field is changing rapidly; new problems emerge, new technology is developed, overall knowledge improves apace. And the law must be adjusted in response.

A practical but especially compelling motivation for the 1977 amendments lay in the fact that the financial authorizations of P.L. 92-500 applied only until June 30, 1975, with short term funding extensions voted after that date. The 1977 amendments provide long-term authorizations, generally to September 30, 1982, generally at $5 billion annually.

The 1977 amendments were shaped in part by what might be described as "institutional forces". For instance, priority and program decisions by state agencies in response to the 1972 law tended understandably to focus on urban areas, where problems loomed largest and needs were found greatest — an emphasis which aroused frustrations in some rural communities. At the same time, agricultural interests began to voice concern about difficulties potentially inherent in the Act's language governing nonpoint source pollution and disposition of dredge-and-fill materials. Accordingly, several of the 1977 amendments deal directly with the needs and problems of small communities, rural areas, and agriculture.

Another "institutional force" stemmed from findings that lack of compliance with the 1972 law could in a great many cases be traced to failures of the Federal Government to adhere to its own policies or to follow through on promised actions. Major industry, it was noted in the Congressional hearings to amend the Act, was better than 85% in compliance; municipalities were complying at only 33% level.

Probably the most important of the 1977 amendments, however, are those which might be described as based upon "technological forces" — emerging public philosophies and expressed concerns about chemical pollution, materials recycling, and environmentally compatible technical systems.

The 1977 amendments reflect Congressional recognition that dangerous toxic pollution was going unabated while much attention was focused on less serious forms of pollution. Major oil spills on the open seas, carbon tetrachloride contamination of the Ohio River, the Kepone disaster in Virginia, PCB's in the Great Lakes, and growing concern about the chemical contamination of drinking water supplies nationwide, have driven home the fact that there are different kinds of pollution, and that some kinds pose a greater threat to public health than others. This recognition, combined with emerging questions about the cost effectiveness of applying our more stringent technology-based limitations on "ordinary" wastes, led in 1977 to a new classification of pollutant types, with different requirements specified for each category. These changes result in a much greater emphasis on the control of toxic pollutants.

Finally, a number of the 1977 amendments reflect a strong Congressional desire to encourage deployment of new "innovative and alternative" waste treatment technology — in part because it may in some cases cost less than conventional technology, and in part because it offers substantial environmental benefits. Beyond that, the 1977 legislation promotes recycling and reuse of pollution control by-products (effluent, sludge, nutrients), energy conservation, and multiple use of lands and waters which are components of wastewater treatment systems.

But the cleaning up of our waterways in not our only concern. The quality of the water which comes out of our taps strikes even closer to home. Most of us assume that the water we drink is safe, and it usually is. But approximately 4,000 cases of waterborne illnesses are known to occur each year in this country, and the actual total may be far greater.

Under the Safe Drinking Water Act, EPA is responsible for establishing national regulations to protect public health. The Act also authorizes EPA to provide technical assistance to the States and grants for demonstration projects involving

improved treatment technology or methods for providing a dependable, safe supply of water.

Under the Act, water suppliers are obligated to notify the public when the quality of their product fails to meet Federal regulations.

A second major thrust of the Safe Drinking Water Act concerns the protection of water that comes to us from underground sources. In many parts of the country, certain industries dispose of their waste materials by injecting them into wells that penetrate deep into the ground. These and other waste disposal practices may contaminate our groundwater with a variety of toxic materials. EPA, working with the States, will regulate such practices to ensure the quality and safety of this essential source of drinking water.

SOLID WASTE - Under solid waste legislation, EPA seeks to reduce the amounts of solid waste produced, to recover materials and energy from wastes wherever possible, and to ultimately dispose of wastes in ways that will not endanger public health or the environment.

National figures show that Americans generate a staggering amount of solid waste — an estimated 4.5 billion tons a year from household, commercial, agricultural, animal, industrial, and mining activities. Furthermore, the volume of waste increases, year by year.

This country has been blessed with what was considered to be an abundance of natural resources. We have reached unprecedented heights of production and consumption.

While accounting for only six percent of the Earth's population, Americans consume at least one-third of its industrial raw materials. But we are now faced with the prospect of paying the price for our past activities. Many of our resources appear to be reaching their limits, and accumulating solid waste poses significant hazards to health and to the environment. The management of the waste we produce is already an extremely difficult task, and the situation threatens to worsen.

Our annual "throw-away" includes 48 billion cans, 26 billion bottles and jars, 4 million tons of plastic, 7.6 million television sets, 7 million cars and trucks, and 30 million tons of paper. It is estimated that by 1980 waste collection may amount to over 340 million tons per year, or nearly twice the amount picked up by collection agencies and hauled away for disposal in 1977. The 1977 cost of waste disposal was $4.5 billion per year.

In this vast country, the most convenient waste disposal system has long seemed to be open dumping. However, burning at most dumps contributed to air pollution, and approximately half of all dumps are so situated that their drainage aggravates the pollution of groundwater, rivers, and streams. Dumps also attract rodents, flies, and other pests.

To remedy this situation, many communities have progressed over the past decade from open dumps to sanitary landfills. In this system, a layer of dirt applied daily over the trash keeps pests away, cuts off water pollutants from surface runoff, does away with the need to burn the wastes, and prevents wind scattering of litter. When filled, the site can be reclaimed for use as a park or playground.

However, very few of the approximately 15,000 to 20,000 municipal disposal sites completed or in current use were designed to prevent waste materials from seeping through the soil and contaminating surface or groundwater. The belated discovery that dumps and landfills may seriously threaten drinking water supplies — even years after the sites have been closed — suggests that all levels of government must select, design, and operate their sanitary landfills with great care.

Chemical, radioactive, biological, explosive, and flammable substances (referred to as hazardous wastes) require special disposal techniques. The Nation generates more than 10 million tons of such materials each year. In the past, much of the waste was incinerated or dumped into lakes and streams. As air and water pollution controls are implemented, more and more of these wastes — which are growing at a five to ten percent annual rate — are being diverted to the land where, again, they threaten human health. The technology for safe management is often available, but it is not being extensively used.

Historically the Solid Waste Disposal Act of 1965 marked the first significant interest of the Federal government in the management of solid waste. The Department of Health, Education, and Welfare was ordered to conduct research into improvement technology for collection and disposal of solid waste. HEW's responsibilities were later assigned to EPA when the Agency was created.

Then, the Resource Recovery Act of 1970 amended the legislation to provide a new focus on recycling and recovery of valuable waste materials.

The Resource Conservation and Recovery Act (RCRA) of 1976 (PL 94-580) provides for the development of Federal and State programs for otherwise unregulated land disposal of waste materials and for the development of resource recovery programs. The Act regulates creation, transportation, treatment and disposal of "hazardous waste"; regulates facilities for the disposal of all solid wastes; and phases out the use of open dumps for disposal of solid wastes in favor of the required utilization of sanitary landfills. Additionally, it makes funding available for the planning and construction of both waste disposal and recycling facilities by municipalities.

TOXIC SUBSTANCES - The Toxic Substances Control Act of 1976 gives the EPA authority to regulate the production and use of all chemicals harmful to public health or to the environment.

The Act requires the Agency to list all such chemicals (perhaps as many as 20,000) now on the market, to limit the use of those found to be harmful, and, if necessary, to ban their production.

As new chemical substances are produced, the law requires that they be tested for toxicity and environmental effects before they are marketed. It is estimated that several hundred and perhaps as many as 1,000 new chemicals are introduced into commerce each year. These now have to be tested for their possible effects on human health and on plant and animal life.

The Act does not apply to drugs, food additives, pesticides, radioactive materials, and other chemicals regulated by other Federal laws.

It does apply to chemicals that may escape into the environment and poison the air and water. It thus augments EPA's protective authority under air and water pollution control laws. It is particularly concerned with chemicals that may cause cancer, birth defects, and genetic mutations (hereditary changes in human cells).

The suspect chemicals include such widely used substances as polychlorinated biphenyls (PCB's), which accumulate and persist in the environment; raw material for plastics (vinyl chloride), once thought to be harmless; and certain propellant gases for spray cans, which may do long-term damage in the upper air.

Before a new chemical can be marketed, the manufacturer must notify EPA at least 90 days in advance, giving the amount of the chemical to be produced, the number of persons who would be exposed to it, and all available test data on its toxicity and environmental effects.

EPA must then evaluate the risk involved. If there is not enough information to make that judgment, the Agency may seek a court injunction to prohibit manufacture pending further testing.

If EPA believes the new chemical presents an unreasonable risk, it may make rules limiting the chemical's distribution and use, or requiring certain labeling and disposal methods, or both. A permanent ban on manufacture requires action by a Federal court.

In any rule making on toxic substances EPA must consider and publish its findings on the substances' expected benefits, the availability of substitutes, and the probable effects on the chemical industry and the national economy.

A special section of the law bans the manufacture of PCB's as of 1979. These chemicals are now used mainly as insulating fluids in electrical equipment but were formerly used in paints, inks, plastics, and many other products. They are poisonous to humans, accumulate in the fatty tissues of fish, and resist natural decay in the environment.

NATIONAL ENVIRONMENTAL POLICY ACT

On January 1, 1970, the President signed into law the National Environmental Policy Act (NEPA), which declared a national policy to encourage productive and enjoyable harmony between man and his environment.

In signing the bill, the President remarked that it was particularly fitting as his first official act of the new decade not only because it gave desparate Federal environmental efforts organization and direction, but because, "the 1970's absolutely must be the years when America pays its debt to the past by reclaiming the purity of its air, its waters and our living environment. It is literally now or never."

NEPA established in the Executive Office of the President a Council on Environmental Quality (CEQ), charged with responsibility to study the condition of the Nation's environment, to develop new environmental programs and policies, to coordinate the wide array of Federal environmental efforts, to see that all Federal activities take environmental considerations into account and to assist the President in assessing environmental problems and in determining ways to solve them.

To ensure that environmental amenities and values are given systematic consideration equal to economic and technical considerations in the Federal decision-making process, NEPA requires each Federal agency to prepare a statement of environmental impact in advance of each major action, recommendation or report on legislation that may signifciantly affect the quality of the human environment. Such actions may include new highway construction, harbor dredging or filling, nuclear power plant construction, large-scale aerial pesticide spraying, river channeling, new jet runways, munitions disposal, bridge construction and more.

An Environmental Impact Statement is the heart of a Federal administrative process designed to ensure achievement of national environmental goals. Each statement must assess in detail the potential environmental impact of a proposed action, and all Federal agencies are required to prepare statements for matters under their jurisdiction.

As early in the decision-making process as possible, and in all cases prior to agency decision, an agency prepares a draft statement for review by appropriate Federal, State and local environmental agencies as well as the public. After comment from the agencies and interested parties, the statement is prepared in final form incorporating all comments and objections received on the draft and indication how significant issues raised during the commenting process have been resolved. Both draft and final statement are made available to the public.

The statement's primary purpose is to disclose the environmental consequences of a proposed action, thus alerting the agency decision-maker, the public and ultimately Congress and the President to the environmental risks involved. An important and intended consequence of this is to build into a Federal agency's decision-making process a continuing consciousness of environmental considerations. This, in turn, ensures to the fullest extent possible that the agency directs its policies, plans, and programs so as to meet national environmental goals.

III. MAMMOTH CAVE AREA EIS BACKGROUND

The planning, design and construction of wastewater treatment facilities are guided by two pieces of Federal legislation: The Clean Water Act and the National Environmental Policy Act. As provided in Section 201 of the Clean Water Act, the Federal government will fund approximately 75% of the eligible costs for the planning, design and construction of wastewater treatment facilities. Under the provisions of the Act, the Kentucky Department for Natural Resources and Environmental Protection is responsible for the designation of wastewater facilities planning areas in Kentucky. In the case of this project, the planning area includes the municipalities of Munfordville, Horse Cave, Cave City and Park City as well as portions of Mammoth Cave National Park.

Because of the unique geologic conditions in the study area and potential environmental sensitivities and impacts associated with current and proposed wastewater facilities, EPA decided that the preparation of an EIS was necessary. The notice of intent to prepare the EIS was issued in October 1977.

The EIS study area occupies a considerable portion of the area widely known as the "Central Kentucky Karst". As is characteristic of the Central Kentucky Karst, the terrain of the study area is gently rolling and pitted with sinkholes while the subsurface contains a complex structure of limestone caves and free flowing groundwaters. The area's unique geological features are of national interest and provide the area with a strong tourist attraction at the National Park and other local private caves.

With regard to wastewater management, the unique topography and resources of the Mammoth Cave area demand special attention. The caves and passages along the Green River and under the Karst Plain are hydrologically complex. As resources, they are subject to pressures for use or potential misuse as is any surface terrain feature or watercourse. However, since there are no surface streams in or conveniently near existing population centers, the options for wastewater treatment and disposal in this area are already limited.

The identification and development of the most environmentally-sound and cost-effective wastewater management system is the central issue of this EIS. This effort, however, cannot be carried out independently of other interrelated issues that must all be considered.

ISSUES

1. Existing Wastewater Management - For the purpose of the EIS, there are 5 major population centers in the study area. These include the municipalities of Munfordville (1975 population of 1,233), Horse Cave (1975 population of 2,068), Cave City (1975 population of 1,818) and Park City (1975 population 576), and the proposed staging area of the Mammoth Cave National Park. With the exception of Park City, these population centers maintain and operate wastewater treatment facilities. The disposal technique practiced by Munfordville and Mammoth Cave National Park is surface water discharge to the Green River. Treated effluent is disposed of in Horse Cave and Cave City, however, by direct discharge to adjacent sinkholes. Additionally, several privately owned treatment plants are located throughout the study area. Most of these small wastewater treatment plants have either a direct or indirect discharge to groundwater. Those areas not serviced by municipal or private treatment and disposal facilities, including Park City, employ on-lot treatment and sub-surface disposal techniques.

Because the environment of the caves is somewhat naturally protected, the natural processes of oxidation, bacterial action and decay that serve to restore surface environments, operate very slowly or not at all. The Cave environment is therefore very sensitive to intrusion from surficial pollutants. Direct threats to the caves include: (1) loss of scenic value due to contamination of the cave environment by pollutants, (2) damage to rare and sensitive aquatic and terrestrial life forms, and (3) damage to mineral deposits and other special features. Existing wastewater disposal practices are currently impacting the area's extensive network of limestone cave passages and free flowing groundwaters and could pose a threat to the water quality in the cave systems of the National Park. These threats to the caves and the park are magnified because of the necessity to maintain the sensitive environmental balance that is required for the protection and preservation of these resources.

2. Cave Resources

The underlying theme that is basic to the conduct of the EIS is that the provision of wastewater management services should be compatible with efforts to preserve and protect the area's nationally significant cave system and physical, biological and historical resources. In this regard, the most important scenic, recreational and wilderness resources of the Central Kentucky Karst are the caves. The Flint Mammoth Cave System alone extends for over 230 miles and is the world's longest cave. Numerous other caves are a significant scenic and recreational resource.

3. Subsurface Hydrology

The link between existing wastewater disposal practices and the caves is best understood when the sub-surface water arrangement is explored. Other than the Green River, there are few surface streams in the study area because of the hydrologic conditions associated with the Karst geology. Surface runoff from the higher elevations flows north toward the Green River, sinks at the south and east margin of the sinkhole plain and then forms cave streams. As these subsurface streams continue to flow to the Green River, they are also fed by runoff into sinkholes and direct infiltration. Thus, in the study area there are no surface tributaries to the Green River. The Green River, in fact, is the hydrological base level for the region and receives all ground water discharges from the study area.

The underground drainage in the karst areas follows well-defined flow paths which could be considered underground streams. These streams of water can in some instances be followed for distances of miles and often appear on cave maps as "rivers". The continuity of these streams is documented by dye tracing which shows that there are distinct flow paths connecting the points where dye is injected and where it is detected. Extensive dye-tracing investigations by the National Park Service over the past 5 years has resulted in the production of maps detailing subsurface drainage basins.

Generally, these investigations have shown that two of the major basins, the Turnhole Spring Basin and a portion of the Bear Wallow Basin, the Hidden River Sub-basin, are of most relevance to the EIS.

Turnhole Spring Basin has its headwaters in the group of springs and sinking streams south of Park City, continues in a northwestern direction through the Park and results in a discharge to the Green River at Turnhole Spring. The eastern and northern divides of the boundary are complex and the actual definition of the boundary and flow or drainage patterns depends upon the flow stages of the underground stream network. The Hidden River Sub-basin occupies most of the remaining eastern portion of the study area. The headwaters of the basin are the sinking streams south of Cave City and Horse Cave. The discharge to the Green River is through a distributary system of approximately 39 springs at 14 locations over a 5 mile reach.

4. Financial Impacts

Efforts to develop wastewater management systems that are compatible with the area's sensitive natural resources must also consider the local economic condition and the ability of the community to pay for an environmentally sound management system.

The entire study area has for many years had an economy dominated by agriculture or agriculturally related employment. However, agriculture as a focal point of employment in the study area has given way to manufacturing as the major employer. Although the area has been changing its economic base from dependence upon agriculture to increasing dependence on manufacturing and tourism related services, the area continues to suffer from high unemployment and low per capita incomes. Unemployment data for 1975 and income data for 1969 for the 3 county study area reveals that the study area is sub-par with regard to both state or regional and national figures for both areas.

Income data is a good indicator of a community's economic status and reflects the income producing category of an area. The relatively low median family income of the study area is indicative of the capital producing ability of agriculture, manufacturing and tourism related services. Income data is also the yardstick against which a community's ability to fund a wastewater management system is compared.

5. Alternatives

As previously discussed, wastewater management in the study area is presently handled locally by each population center. Potential economic and/or environmental concerns may, however, encourage two or more population centers to combine wastewater for joint treatment and/or disposal. Through the development and evaluation of alternatives in the EIS process, eight management alternatives ranging from a regional management concept of joint treatment/disposal by all population centers except Munfordville to local treatment and disposal of wastewater at each population center have been generated.

The basis for the evaluation of these alternatives is the cost-effectiveness analysis. The cost-effectiveness analysis provides a method for gauging the overall resource costs of an alternative since factors other than monetary cost are considered. The criteria that are involved in the analysis include, net present worth costs, impacts on the natural and man-made environments and system operability.

6. Recent Issues

In August 1979, the range of EIS alternatives was presented to a local review committee.

It was the opinion of the majority of committee members that an alternative involving the removal of existing subsurface wastewater discharges would be most beneficial to the area and should be selected as the EIS proposed action. During the meeting, particular attention was given to a regional system which would involve wastewater treatment facilities at Park City, the Park Service's proposed Staging Area, Cave City and Horse Cave. Wastewater would be treated at these facilities, combined and discharged to the Green River. Although this alternative was the most expensive, it was considered to be an environmentally superior proposal.

Given the direction that was received from the committee, the attention of EPA was then focused on the regional system alternative. Two major problems immediately surfaced: (1) the higher cost, and (2) the lack of a management agency to implement the plan.

First, with respect to cost, the regional system alternative was considered to be the most costly alternative with a net present worth cost of approximately $10.6 million. (The least costly alternative which involved local disposal at each population center was estimated to result in a net present worth of $6.5 million.) In order to more properly describe and understand economic impacts of alternative systems, it is necessary to translate these costs into user charger — the monthly or annual cost to users of the system. In doing so, it became obvious that costs incurred to provide service to previously unsewered areas (Park City and along Route 70) were extremely high. These costs were so high, in fact, that the viability of a regional system was jeopardized. Even with the application of EPA 75-85% funding of eligible wastewater facilities, an annual user charge for the Park City area approximated $800. Annual user charges for residents of Horse Cave and Cave City were significantly less than the estimates for Park City, although user charges

were expected to almost double from current levels.

Several mechanisms to minimize the economic impact of a regional wastewater management system were explored. Questions concerning funding sources to supplement EPA and the local shares of the project cost and attempts to amend existing policies to fund facilities not previously funded through the EPA 201 Grant Program have not yet been resolved. The viability and successful implementation of a regional alternative may, however, rest upon the successful resolution of these issues.

The second problem associated with a regional system that was quickly identified was that of implementation and management. Several different management approaches are being looked at with application to this area. If necessary, these management approcahes will be discussed locally, following the selection of an alternative.

Another problem that was recognized during this time frame that has resulted in a substantial delay involves the very difficult task of developing wasteload allocations for subsurface discharges in the area. A wasteload allocation is the determination of the pollutant load that a wastewater discharge may contain that would ensure that the receiving waters would meet instream water quality standards. In Kentucky, it is the responsibility of the Department for Natural Resources and Environmental Protection, to develop wasteload allocations for waters of the Commonwealth. At the time of the EIS evaluation of alternatives, wasteload allocations for subsurface discharges in the area had not been developed. For the purposes of the EIS, it was necessary to independently establish treatment levels for the various proposed facilities in order to evaluate cost, etc. The EIS evaluation of alternatives did, therefore, contain various treatment levels based on rough assimilative capacity estimates. These estimates, however, cannot be substituted for the wasteload allocations which are to be developed by DNREP. The consequence of this situation is that EPA is unable to select an EIS proposed action because the basis for any decision has not been completely developed. Stated differently, the problem is this: wasteload allocations for subsurface discharges need to be developed to determine the level of treatment required to meet in-stream water quality standards. The level of treatment that is required is needed to determine the cost of wastewater management alternatives. The cost of the various alternatives is the major factor in the cost-effectiveness analysis of alternatives. The cost-effectiveness analysis, in turn, is usually given a great deal of weight in the decision process. The key, at this point in time, to the EIS decision process is therefore the development of wasteload allocations for subsurface process discharges. As of this date, preliminary wasteload allocations have been developed and are in the process of being refined and finalized.

Additionally, two recent developments that are peripherally related to the EIS may eventually become important in the EIS and decisions to be made. These developments include: (1) a request to list the Kentucky cave shrimp on the U. S. Department of the Interior's Endangered Species List, and (2) a request to designate subsurface waters in the study area as Kentucky Outstanding Resource Waters.

The Fish and Wildife Service, Department of the Interior issued an advanced notice of a proposal to list the Kentucky cave shrimp as an endangered or threatened species. The impact of this proposal and any subsequent listing on the EIS is unknown at this time. If, however, the species is listed as an endangered species other federal agencies must formally consult with the Fish and Wildlife Service on all actions taken that may affect the listed species or critical habitat that supports the species.

The request to the Kentucky DNREP to designate the subsurface waters of the area as outstanding resource waters is authorized under Section 8 of Kentucky's Surface water standards (401 KAR 5: 031). This section indicates that any person may present a proposal to classify certain waters as outstanding resource waters. The Kentucky DNREP will evaluate the proposal and consider: (1) existing water quality; (2) current use; (3) aesthetic, biological, morphological and habitat characteristics of the waters; (4) occurrence of individuals or populations, indices of diversity and well-being, and abundance of species of any unique biota; (5) economic and social consequences of the proposed classification; (5) other justification given for the proposed classification.

Two questions, with respect to any designation, are important to the EIA — (1) what will be the geographic scope of any designation? and (2) what use criteria will be established to supplement an outstanding resources water designation? Again, as of this date, these questions are unanswered and the impact of these actions upon the EIA selected action and EIS process in general is unknown.

WHAT HAPPENS NEXT?

As noted above, the key to the EIS decision at this point is the development of wasteload allocations for subsurface wastewater discharges. Without this information the EIS will not be able to proceed. The problem of developing wasteload allocations for these subsurface discharges is compounded by the endangered species and outstanding resource water actions. The outcome of these actions will undoubtedly affect any efforts or decisions concerning wasteload allocations.

Several possible courses of action appear to be available to resolve this problem — many of which will undoubtedly be time consuming. The actions which must necessarily be taken prior to EPA's selection of a wastewater management system are actions that are occurring outside of EPA's immediate control. EPA is in contact with the Federal and State agencies, organizations and individuals involved in the development of applicable wasteload allocations for subsurface discharges, the proposal to list the Kentucky cave shrimp as an endangered or threatened species and the request and action to designate subsurface waters of the area as Outstanding Resource Waters. The EIS will be affected by the outcome of one or all of these activities. Efforts will be made to encourage these activities to be completed expeditiously to allow EPA to fulfill its NEPA responsibilities and the EIS process to reach a successful conclusion.

It is evident that many of the decisions to be made in the Mammoth Cave Area EIS decision process may be beyond the purview of EPA to execute. Irrespective of decision responsibility, the objectives of a proposed action should not be lost. The issue at hand is wastewater management. Ultimately, however, the concern is for the protection and preservation of a national resource through prudent wastewater management planning and decision-making. In the spirit of preservation and environmental protection, a reasonable approach that affords the greatest degree of protection and yet is sensitive to local fiscal concerns should be pursued.

This area has already been victimized by poor wastewater management. Solutions to these problems will take both time and money. However, if the commitment to resolve these problems is not made, the potential exists for the unique resources of the area to be irreparable damaged with possible repercussions to be felt by the area's tourist industry and local economy.

The local communities, in concert with the State and Federal governments, must be able to make the commitment and investment that is required to protect and preserve the invaluable resources of this area.

INTERPRETIVE TRAINING FOR SHOW CAVE PERSONNEL

*Tom Aley and Cathy Aley

We need to convey ideas, not merely facts.

Facts are boring, sleep producing, and tend to not stick in our minds. Ideas, on the other hand, can be interesting and contagious. Why is it, then, that the typical show cave tour submerges the visitor in facts rather than ideas?

Part of the problem may be lack of time or inexperience on the part of the guide. The guide must tie together facts to develop and support his ideas, and this requires time, effort, and a good understanding of the cave. We can help overcome these problems through training; ideas can be developed for, and given to, the guide.

Many guides, even though they have been given interpretive ideas which they could use, are likely to be found spieling facts rather than giving ideas to visitors. An explanation for this is that many guides have a difficult time distinguishing between facts and ideas, and listings of facts predominate over the discussion of ideas. Ideas are illusive, and they slip away, leaving us with nothing but facts. If the management of a cave operation is convinced that their tours should focus on ideas rather than facts, then they need to periodically assure that this is being done.

We have run a series of training programs for returning guides at several show caves. We have found that a good technique to use in our "refresher course" is to go in the cave with a group of guides and ask each guide to show us at least one of his stops and to tell us what he talks about. If we get a recitation of facts, we will usually respond by asking the group what ideas, in addition to the facts that have been listed, could guides convey at this stop, and what facts could be used to develop these ideas. By the end of a half-day session in the cave, ideas rather than listings of facts, seem to predominate in everyone's answers. Discussions often get lively, and the guides are reintroduced to the concept of conveying ideas.

Two critical ideas to convey to visitors at show caves.

1. Visiting caves is a very worthwhile experience.

2. My, this cave is very nice; I'll have to come back sometime, and my friends really ought to visit here too.

If the majority of visitors to show caves took these ideas with them after their visit, we believe that show caves would do an outstanding business. However, visitors to most show caves leave with neither of these impressions. How, then can we implant these ideas in our visitors?

The first thing we need to do is insure that the entire staff recognizes that giving the visitors these two ideas is a major objective of the cave's management. Second, management needs to regularly reinforce this objective. Third, management of the show cave must give visitors an experience which is truly very worthwhile.

Why should visiting this cave, or caves in general, be a worthwhile experience? Visiting caves gives people a deeper look at the earth on which they live. Such a look is relevant to many of the water and environmental problems presently facing this nation. We are convinced that one of the greatest assets of caves is their display of natural features and natural processes which have significant impacts on our day to day activities on the surface. We are convinced that this asset is seldom effectively used at show caves. Both visitors and the show cave industry are hurt by the failure to use this resource.

Visiting caves is also a worthwhile experience because it is fun. It should be enjoyable, and we should work to make sure that it is. However, we believe there is a serious trap for show caves here; visitors to show caves should not leave with the idea that caves are worthwhile primarily because they are fun. When this occurs, the visitor is likely to equate show caves strictly with the amusement industry. The amusement industry is continually expanding and changing with myriads of new things to see, do, and experience. By comparison, caves are very static amusement attractions. The static features in a frenzied industry should be expected to hold an every-decreasing share of that total industry; it seems to us that this is exactly what is happening in the show cave industry.

Show caves have the potential for blending a learning experience relevant to our day to day lives with entertainment. A part of that relevant learning experience is finding out that once you have seen one cave you have not in effect seen them all. If show caves can achieve a blending of learning and entertainment, we are convinced that visiting

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caves will generally be viewed by the public as a very worthwhile experience. At present, we do not believe that this is the public attitude; if we are right, then a lot of work needs to be done.

Guide training

Much of the day to day burden of making show cave visitation a worthwhile experience rests with the guides. Training can make it possible for guides to make a show cave visit a worthwhile experience. It is a necessary and important first step, but we have no illusion that good training alone will insure that the guide does a good job.

The guide training programs which we conduct are designed to give the guide ideas which he can use on his tours. We show how specific facts can be used to support or fill-out the ideas. With returning or continuing guides, we try and make sure that his "facts" are technically accurate.

Most guides do not realize how important their job is. They tend to view guiding as just another job; a job with about the same status as selling Big Macs or pumping gas. In our training programs we impress upon the guide that guiding is not just another job. We emphasize that the information they give visitors is relevant to the visitors' day to day lives, and that well done tours can do a great deal of good. Guiding can also give people tremendous experience in communicating with others. Guiding is important work, and the guide needs to know it; he also needs to have other people recognize the importance of his work.

We also give guides some hlep in avoiding boredom. The article by Austin and Chaney (1977) is the crux of this facet of our training. The reader should consult this fine paper.

The old platitude that "everybody loves a lover" is applicable to cave guiding, and we convey this in our training program. If the guide thinks that the cave is very nice and the experience very worthwhile, chances are that most visitors will think the same thing after their trip. One of the best cave tours we have ever had was from an old woman who owned Round Spring Caverns. After chasing the geese out of the garden, she spent four hours in her cave with us. She went through the cave like most of us would go through a trunk full of familiar, but long-unseen, heirlooms. It was a totally marvellous experience.

We try to insure that the guide appreciates the cave in which he is working. We openly admire the features of the cave as we conduct the training, and we encourage the guides to do likewise when they are leading tours. Guides need to realize that most visitors need help in recognizing features worthy of admiration. We also encourage the guide to always be looking for cave features which he has never noticed before; discovery helps combat repetitiveness. And finally, we tell the guide to look at and admire a feature for a few moments before he begins to talk about it; this helps the guide appreciate the feature better.

The training dilema

Ultimately, the quality of the experience which a visitor to a show cave receives is largely a reflection of the interest, skill, and knowledge of his guide. Training programs can help provide the knowledge and skill, and can often improve a guide's interest in his job.

Unfortunately, the average guide at a private show cave will spend less than 1,100 hours working underground as a cave guide. Economic considerations are commonly the reason for providing only very fundamental guide training. Can the typical show cave afford to provide good training? The solution to this dilema is made annually by the management of show caves; it appears to us that improved guide training is the trend.

References

Austin, W. T. and T. Chaney. 1977. Boredom in paradise; a hard look at cave guide training. Nat'l. Cave Management Symp. Proc. from the Mountain View, Arkansas Symp., Oct., 1976. pp. 54-58.

GUIDE TRAINING AT MAMMOTH CAVE NATIONAL PARK

*Lewis D. Cutliff

Introduction

"How wonderful to be wise, to understand things, to be able to analyze them and interpret them. Wisdom lights up a man's face, softening its hardness" Ecclesiastes 8:1.

"When people are free to do as they please, they usually imitate each other." E. Hoffer

For years this is exactly what happened at Mammoth Cave. Sons and brothers, nephews and cousins followed in the footsteps of their ancestors into the cave, parroting the same stories, jokes and legends handed down from generation to generation. Training of new guides consisted of accompanying a seasoned guide on a particular route or section of the cave for three years before he was permitted to become a lead guide. This system of training prevailed until the mid-fifties with little attempt made to change the standard canned speeches of facts, figures, and stale jokes. Ray Nelson, who became assistant Chief Interpreter in 1957, should be credited with bringing about the first major change when he compiled a new guide manual and introduced the guides to Freeman Tilden's writings in the book, Interpreting Our Heritage. He also insisted on in-house training during slack periods with emphasis on Dramatic Interpretation, or "drammer" as he called it. This was the fetal stage at Mammoth Cave in formal interpretive training. From it has grown the intensive training courses which we now hold for our permanent and seasonal guides.

Every winter since 1977, Mammoth Cave has held Interpretive Skills or Basic Communication courses, in-park for all interpreters in the Park and from other parks as well. They are conducted by a professor in speech communications.

II. History Mammoth Cave Training

A. Early training

1. Families—legends—stories—jokes

2. Trailed 3 years before guiding

B. Introduction Formal Training

1. Ray Nelson - 1957

a. Winter training

b. Introduced to Freeman Tilden and reading.

c. New guide manual - examples, etc.

d. More updated information—Biology—Archaeology—Geology—History

C. Training today—how do we attain training

1. Through HFC or HOAL (SV. TR. CTR.) or through civil service training.

2. In-park (geared specifically to our needs, cave interpretation—using basic communication skills).

1977-Thematic Interpretation - Interpretive Skills

1978-Thematic Interpretation - Interpretive Skills

1979-Energy Interpretation - Interpretive Skills

1980-Thematic and Energy - Video Package

3. Format

a. Seasonal-Basic interpretation skills as well as area orientation and service orientation

b. Comm. Spec. in summer—continually working with seasonals

D. Seasonals

1. Who are they and how do we get them.

a. Changing raw recruit into a communicator (many disciplines-backgrounds) may be a walking book of knowledge but unless able to stimulate or provoke the visitor he is not an effective communicator. (3 weeks) A workable product.

2. Complex Hiring Procedure

*Mammoth Cave National Park, Mammoth Cave, Ky. 42259

Summary

We feel that we are on the right track in our training program but must also be aware that there is always room for improvement. I think Freeman Tilden's statement in the fifth essence should be constant reminder for those of us concerned with communicating with the visitor when he said, "Interpretation is a voyage of discovery in the field of human emotions and intellectual growth, and it is hard to foresee that time when the interpreter can confidently say, 'Now we are wholly adequate to our task.'"

INTERPRETATION AT MAMMOTH CAVE

*Joe Wagoner

Editor's Note: The following outline reflects the general theme of romantic interpretation currently being emphasized at Mammoth Cave National Park. In addition, interpretation at Mammoth Cave includes literature for foreign visitors and activities and programs for special populations such as the hearing impaired, the blind, and persons confined to wheelchairs. A special Environmental Education Team is also active both above and below ground interpreting park features to children and special groups. — RCW

I. The triadic configuration of interpretation.

   A. The underlying form: the basic facts as they are presumed to be and as set forth by a supposed authority.

   B. The classical form: understanding and relating basic facts in language(s) understandable when presented to the uninformed.

   C. The romantic form: relating to the uninformed the story intimated by one's understanding of the basic facts—and doing so in such a way as to be as interesting and entertaining as possible.

II. Classical versus romantic form.

   A. Classical form.

      1. A technologist for technology's sake.
      2. Uses technology to fullest.
      3. Understands technology.
      4. Can cope with technological breakdown.
      5. Knows that technology can and will solve our problems.
      6. Will not readily give up his/her technology.

   B. Romantic form.

      1. Non-technologist; leary of technology
      2. Uses technology because it is thrust on him/her.
      3. Has no understanding of technology.
      4. Cannot cope with technological breakdown.
      5. Believes technology might solve our problems.
      6. Might give up some forms of technology.

III. Classicist (occidental) versus romanticist (oriental).

   A. Occidental.

      1. All things are preordained.
      2. Purpose behind each thing.
      3. Mankind is the master of nature.
      4. All things placed on earth primarily for his use.

   B. Oriental.

      1. There is no reason.
      2. Things are, just because they are.
      3. Mankind is a partner in nature.
      4. Mankind is an integral part of his surroundings.

IV. Organization: "We trained hard—but it seemed that every time we were beginning to form up into teams we would be reorganized. I was to learn later in life that we tend to meet any new situation by reorganizing: and a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralization."—Petronius Arbiter 210 B.C.

V. Wagoner's hypothesis: In any given interpretive task, it is the goal of the interpreter to provide the visitor with one valid and important point which is relatable to the visitor's daily life. And, the interpreter should strive to do so in as interesting and as entertaining a way as is possible.

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PANEL DISCUSSION: MANAGEMENT PROBLEMS OF PRIVATE CAVES

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Editors' Note: Austin and Cale submitted written comments for inclusion here. The remainder of this discussion was edited from a transcript (by Donna K. Wilson) of a tape supplied by Harry Heidemann.—R.C.W. and J.J.L.

Moderator:

I'd like to introduce Bill Austin, of the National Cave Association, who will introduce the panel for the discussion we're going to have on Management Problems of Private Caves.

Austin:

We have a pretty good collection of private cave operators here. A few are so shy they are in the audience. I would like to identify Tom and Cathy Aley from the Ozark Underground Laboratory; Gordon Smith from Marengo Cave, Indiana; Vernon McDaniel from Diamond Caverns, Kentucky; Ron Burke, from Ruby Falls, Tennessee; Dick Bell from Seneca Caverns, Ohio; Steve Fairchild from Boydan, and many other caves, in California; Clara Heidemann from Natural Bridge Caverns, Texas; Joe Waggoner, Lost Sea, Tennessee; Tim Anderson, Lake Shasta Caverns, California; Wes Odle of Crystal Onyx Cave, Kentucky; and David Cale from Laurel Caverns, Pennsylvania.

The last member of the National Cave Organization, and the one with a short message for us, is Barbara Munson, the Sectetary/Treasurer. She is associated with Cumberland Caverns, Tennessee. Barbara, could you tell these folks about our meeting coming up in two weeks?

Munson:

As you see, we have representatives here from all over the United States. We are having our Annual National Cave Association Convention October 28, 29, and 30, in Tennessee. We will be in Sweetwater visiting the Lost Sea, in Chattanooga at Ruby Falls, in McMinnville for Cumberland Caverns. We would love to have any of you come join us for all or part of the meeting. We don't confine ourselves to just showcave problems and considerations, just as you don't seem to be confining yourselves just to wild caves. We have a great crossover of information. Any of you who would like more information, please see me and I'll give it to you. Thank you.

Austin:

My name is Bill Austin, and I am owner and operator of Mammoth Onyx Cave. I am also owner of Hidden River Cave, about which you have heard much, and the former manager of Floyd Collins Crystal Cave.

I am the fourth generation of a Kentucky cave-owning family and the third generation of commercial cave operation by that same family. We bought our first cave in 1889 and opened our first commercial tour in 1916. We have been involved in many of the cave-related happenings in the Kentucky cave area — happenings ranging in scope from the introduction of the knee-crawler to the sport, lifting the 150-year-old myth of 150 miles of cave at Mammoth to the reality of more than 200 miles of cave in the Flint-Mammoth Cave system, and other events all the way back to the development

of hydropower and hydroelectric production in Hidden River Cave in the early 1890's.

What does all this mean? How does it fit into a discussion of cave management? It means that I grew up in the cave business, and that cave management is a way of life for me — and for my wife, or wives, and for my children, and for my employees. My management of my cave also affects others in the cave area for it affects their income as well. If I screw up I don't have the privilege of preparing the three envelopes! I damn well have to stay here and work my way out of the mess! So I tend to think a lot about the management of my cave, and the management of my competing caves as well. I want to share some of these thoughts with you for possible discussion.

Buzz Hummel wrote me early in September asking for a copy of my management plan. This was my reply, "We really don't have a formal management plan — the name of the game in the private sector has always been 'survival'. Accomplishing this means that on the average you must spend less than you earn, or try to earn more than your expense of operation. It would be safe to say that in the private sector, management depends entirely on visitation and the resultant cash flow. The essential bills, including taxes, are paid, staffing levels adjusted, and any surplus goes into advertising —— all based on income or promise of income."

I believe that many of you who have visited private cave operations will think they have done a very worthwhile job of preserving the caves they show — the task that is central to management of the public-sector caves. You can look at the events before and after 1961 at Floyd Collins Crystal Cave, for instance, and get a direct comparison of cave protection under private and public management. Private cave operation must protect the resource — no resource, no income!

The points I wish to draw from this are these:

1. Private cave operations, through their management, have had a great deal to offer the public sector over the years. Private cave operations also preserve and protect caves.

2. Private cave management depends totally on cash flow which is derived by multiplying the number of visitors times the price of admission.

3. The public sector, without exception, had traditionally offered cave tours at admission prices ranging from well below the industry average of the private sector to absolutely ridiculous fees!

At the time Mammoth Cave was removed from private operation, the basic admission price was $2.00 per person. At that time you could buy a new Ford for 650 dollars. In 1980 you can get a tour for one dollar, the cave admission price for the Frozen Niagara tour. Those friends of the National Park Service, National Park Concessions, Inc., get another dollar for the ten-minute bus ride — a total of two dollars for the one and a half hour tour. This at a time when the private sector industry average is close to four dollars per tour.

(NOTE: A November, 1980, survey of cave admission prices at twenty-nine National Caves Association member caves indicates the average admission fee planned for the 1981 season is $4.36.)

Admission to the two-hour historic tour is a dollar and fifty cents.

Low admission fees constitute a subsidy from the Treasury to the affluent who can afford a vacation — a subsidy they probably deserve, but is not really fair to the rest of us who have to pay it. Why should all the people in this country, including those of us in the private cave sector, contribute to assist a few to see a public show cave operation? Those of us in the private sector have demonstrated that people will pay a reasonable, profitable admission fee.

It is my contention that the public sector should raise their admission fees to at least approximate the private sector industry levels. This is a necessary step to encourage and foster better cave management in this country. Without it you will soon be adding the private cave operator to the list of endangered species you discuss at these meetings!

Those of us who have been involved in cave ownership and cave management over a great many years are very protective of the cave. We have it before our eyes that we are "in charge of management" of this feature for only a fragment of time in its existence. This tends to make us very careful about the changes we inflict on it. I think we do a good job when you compare our record with that of the public sector. We need public sector support in the form of realistic admission prices in order to continue this effort.

I'll leave you with this thought which has been credited to a Nigerian cheiftan:

> "I conceive that land belongs
> to a vast family ....
> of which many are dead
> few are living
> and countless numbers are unborn."

Help us save our land, and the caves they contain, for the countless numbers unborn. Thank you.

Jim Goodbar:

What do you think a good fee would be? Five dollars, three dollars, two dollars and fifty cents, or is there a general consensus of what the fee would have to be to make it a lucrative business or something that would survive?

Cale:

I can speak to that. Some of you might receive something from Oregon Caves, I know I do. What they do is target different private operations (they are a state-owned cave) which they feel have about the same number of people and the same size facility. They then write every year, ask for your rates, and for the information on the things that you do. Then the State of Oregon structures the admission fee to that cave on the consensus of the private fees received. That's

how they approach the problem.

Goodbar(?):

Are there any kind of guidelines for the private cave owner for setting his fee, such as the development, beauty, or length of tour?

Austin:

I can only speak from personal experience. When we first got involved in the cave business we adopted the industry standard, which was two dollars. That applied not only here, but at Mammoth and other caves. This was fairly early on. Following that time we added various taxes that came along. At one time we had a fifty-four cent tax on a two dollar admission, so admission was two dollars and fifty-four cents. We maintained that fee from the very beginning through 1976. Economic necessity forced us to raise it. I have been in some of these discussions with other cave operators. I don't know any of them that are rich or lucrative. In fact, I told the group at the last meeting, if anybody that was there still had their first wife and a reasonably new car, he was probably doing pretty good. So, we think about this a lot.

Bell:

My opinion would be that unless you make a reasonable profit you are just not going to survive. My CPA just raises hell with me because I am reluctant to go any higher. With the economy, inflation, taxes, the whole ball of wax increasing every year 12 to 15%, whatever it is, I have not increased my fees commensurate with that. I just can't do it. Consequently, my profit margin has decreased considerably. I am kind of in a destination area with a lot of other attractions, which is part of it. Just at the base level, statistically, going back to my own operation, inflation that is occurring right now — and I just use it as an illustration I am not keeping up with inflation, which from a basic business sense is wrong. Yet I don't want to go any higher. I'm charging $3.75 for adults, at this time, which is not out of sight and there is almost no customer resistance at the window.

Speaker from audience:

I was under the impression that since commerical caves really had not been all that lucrative, strictly charging an admission fee, that the most successful ones had tried to add on supplemental businesses — restaurant business, various shops, antique cars, golf courses, motels, and that when they could do this the cave cave tour was an attraction and really didn't present most of the profit. That profit could be generated from these other businesses at the same location. Is this true or this just a narrow view from my part of the country where this has occurred.

Austin:

Help us save our land. Let's not cover it up with that sort of stuff.

Cale:

A lot of private caves, private owners, have a sense of wanting to maintain the atmosphere, the ambiance of the cave setting. We have to avoid recommending commercialization in the interest of that mortgage payment. So a private operation does not necessarily mean that you will start pulling in motels. Some do, some have a cave in a setting where it is compatible. I can think of many caves, and if Roy Davis was here right now he could certainly address that quickly. I think that a lot of commercial caves have avoided that very kind of development intentionally. That is what we don't want, although our image is that we do.

Speaker from the audience:

I wasn't talking about what you are doing. I was just talking about my idea that the most successful commercial caves had done some of it. I was talking about doing it in a very professional and high quality way.

Austin:

Did you ever hear the story about the guy that went up to the girl in a bar and asked her if she would go out with him for $500. She said yes. He went back and talked to his buddy, then went over and gave her $5. She screamed at him, slapped his face and said "What do you thing I am." He said, "We've already established that, we're just bickering over the price." Now if you get involved in these ancillary operations, you get further away from cave conservation with every step.

Steve Fairchild:

To answer your question, no I don't think that the successful businesses are the ones with the gift shops and car collections. We hope to be able to maintain the land in an absolutely natural condition. There are no buildings on it. We permit no gift shops. We don't have lights and trails. It costs $60 for that tour, and we just barely break even on it. If I had a government cave down the street taking people through for $1.50, my land would be a subdivision and the cave would be under a subdivision.

Speaker from the audience:

Does anybody have any information on the amount that people are prepared to pay to go into a cave? I mean, if your prices are going to go up, does your attendance go down? Or do the cheap government caves regularly get higher attendance?

Speaker from the audience:

Seems like to me the whole thing is location of a cave and the word-of-mouth type reaction that they get. When you look at Luray Caverns, they are up pretty high. I don't know what they charge, 7 or 8 dollars, but they have large visitorship.

Speaker from the audience:

I'd like to make a comment on prices, Joe. Social scientists will tell you that when people pay more for something, they tend to enjoy it more. At Mammoth Cave I'm surprised to see they have such a drop. This is probably a pretty radical idea, but if you're only paying $1.50, you may be "not appreciating" it as much as if you paid $4.25. Sounds like a crazy idea, but there might be something to it.

Austin:

At Mammoth Cave there is a $1.00 user fee charge for a cave tour that takes an hour and ten minutes, and you pay a buck for a 10-minute bus ride.

Speaker from the audience:

And the maximum limit on a tour is 200, in the summertime. In an hour's time you have 200 visitors that tour for an hour and a half. So how much money is that? It would be $200 in an hour and a half's time. The visitors pay more money in a government cave than they would in Bill Austin's cave. For the wild cave tour, we charge $4.00 for six hours.

Austin:

What does it cost you to run those trips?

Speaker from the audience:

Well, of course, there are other factors; we break even through the year, I imagine.

Austin:

You imagine? It is my information that you return about 60% to the Treasury. That was in a good year.

Speaker from the audience:

I'm not sure. There are other factors. That's the usual fee. Who knows if it's too high to too low. Depends on the way you look at it.

Speaker ?:

My question, though, is why is that fee $1.00 and what is the basis of that. Is that administrative?

Speaker ?:

The basic reason is that any government operation is not normally required to operate at a profit. That's the base line. If they do not make a profit, they are just rather incidental, because appropriation that has no relationship to the amount of money grossed on the property will take up the slack for the next year. We do not have that leeway.

Speaker ?:

You're actually encouraged to cut normal prices.

Speaker ?:

I would imagine that Jim will support me on this. The National Park Service and the Forest Service philosophy is to keep the price low enough to make it more available to greater numbers of people so that it wouldn't be prohibitively expensive for any stratum. Is that correct?

Wiggins:

That's correct.

Austin:

Any other questions?

Speaker ?:

I'd like to say, in the field of recreation there have been quite a few studies, and the situation is no different with caves, campgrounds, river running, mountain climbing — the whole subsidy situation. In some places they index the cost of the campground where you have the KOA outside the campground and it only costs a buck to camp in the campground, and $5 in the KOA. In some places they have already come to the indexing situation. Is that what you are saying you would like to see in terms of the National Cave Association?

Steve Fairchild:

The government recently seems to be into user fees for their services. As a light plane flyer, I get a big tax on my gasoline to pay for Laguardia Airport. They call it a user fee. I'm not allowed to go in there, but I have to pay a fee on it. The government is not at all afraid to make me pay for things I can't even use and call it a user fee, and here they have all these fantastic services that people are willing to pay. Bear in mind, my customers pay me $60 to go in my cave. They are willing to pay money to go in them. Why not let them pay for it and use some of that money for research on the floodplains, the sinkhole plains, the things out here. Why not let them pay for some of those services that they are getting the benefit of; after all they are using them.

Why should he have to pay the taxes to support this place so that this place can undercut him? That is exactly what is happening.

Speaker ?:

I'm asking the same question. Why don't you have a lobby or Congressional relief or something to have an index?

Speaker ?:

One comment here. TVA was accused, and again, that is a "government operation", of undercutting on campgrounds and so forth. They took it into consideration and I think revised their schedule to be sure that they don't undercut private campgrounds. They are a competitor in some cases, but not a low competitor. There are different approaches.

Speaker from the audience:

I've got one other comment. A lot of people in Cave City would love to see us charge nothing,

free. A lot of pressure from locals. Everything is free in the park. They make their living on accomodations and food. So you've got that aspect to worry about, too.

Speaker ?:

My guess is that your visitation would not fall off if your prices were higher.

Speaker from the audience:

You are probably right.

V. McDaniels:

How much is the half-day tour now?

Speaker from the audience:

I think it is $3.00.

McDaniels:

There are probably very few private caves in the country that are less than $3. They offer a four and a half hour tour and I'm almost certain that most of your private tours are one hour.

Speaker from the audience:

You are probably right. Most of the private tours are quality trips, with low numbers, right? How many do you take on a trip?

McDaniels:

Just as many as I can get. In the summertime, 25 or 30.

Munson:

NCA did a survey 4 years ago. It was right about $3.00. That was not a survey that was related to the length of time of the tour or the length of the tour. But in listening to this discussion, we also touch on a number of other problems that are mentioned here in the Management Problems of Private Caves. We're talking about admissions, but we want to talk about other problems.

(Note from Bill Austin, Nov. 25, 1980. A November 1980 survey of cave admission prices indicates the industry average is well above $4.00 per tour.)

Ramey:

I personally feel that it behooves the government Parks Service, Forest Service, or other agencies who manage the caves and present caves in such a manner, to be a credit to the others. Visitors come to Blanchard Caverns and go away enthusiastic enough to go to another cave. And that's really our objective — to make the American public aware of the resource and to develop appreciation for it. Not so much how much it costs, because the federal government is not going to make a profit, that's not the intent, but to do something right. I think that's our objective. I hope when a visitor leaves Blanchard that they do go away with an appreciation for caves, which is what show cave industry is all about.

Austin:

I would like to introduce David Cale who will take the next segment of the program.

Cale:

I. There has been a trend toward declining domestic tourism since 1974 due to four basic causes.

   A. The price of gasoline and, at times, availability concerns have lessened auto tourism.

   B. High inflation rates have gobbled up discretionary income.

   C. Vacations are no longer a prestige thing. A visit to a famous cave is no longer a "big deal".

   D. Travel has become more resort - bus tour - common carrier oriented, hurting caves, which tend to be in rural areas, and favoring cities and highly developed resort pockets.

II. Though the good old days were never really all that good, there has been a comparative decline in recent years in the American sense of individual responsibility which has created four basic problems for show caves.

   A. The old belief that caves should be "free" ("If God made it why should I pay to see it?") and government owned has been strengthened by a national decline in public support for the free enterprise ethic.

   B. There has been a comparative increase in park vandalism and abuse.

   C. A weakening of the work ethic has made the old problem of finding good help even worse, even with high unemployment.

   D. The advent of consumerism has led to higher operating costs, higher insurance costs, and an upsurge in lawsuits where big bucks are sought for little hurts.

III. Caves are having to compete with a great proliferation of leisure time opportunities since 1960, especially in the following three areas.

   A. The Home: The increase in home swimming pools, home games, and home and yard maintenance have worked with inflation to popularize the "back yard vacation".

   B. Sports: A five-fold increase since World War II in golf courses, the rise in tennis, basketball, and handball courts as well as other community recreation opportunities, the proliferation of leisure vehicles and boats, and televised spectator sports have absorbed much of the American leisure that used to go to week-end travel.

   C. The Tourist Industry: National awareness of the potential of the tourist dollar has

put everyone in the tourist business. Every state now promotes every building and piece of land it can as a tourist attraction, diluting the preeminence caves once had in tourism.

IV. National environmental concerns and big government have teamed up to increase cave regulation.

A. Highway signing, the most effective media for the highway market, has been greatly restricted.

B. Most caves are now state inspected and forced to comply to rules that sometimes greatly increase operating costs.

C. Caves by their very nature are usually not near public sewerage or in areas suitable for septic systems. Local zoning and sewerage regulations have hampered development and raised costs.

D. The threat of radon regulation now looms on the horizon.

Each one of these areas of concern must be met with some response from cave operators, either as individuals or as a group. My time allottment at the symposium allowed me to address only one problem. I chose II-A, the problem of public resistance to pay for a cave visit and resentment of private ownership.

First of all, the public should be made aware of what it costs to maintain a cave, a service building, a guide staff, and a promotion budget. It might not be inappropriate for caves to post their annual costs including capitalization on a small sign in the lobby. A typical sign might read:

Your admission fee
maintains the cave
and park grounds
and
preserves them for
future generations.
Last year's park
expenses were
$ 226,458.67

The cost will probably surprise your visitors. I have written a child's book titled "The Old Man's Cave". It will be full color when complete, very brief, and to the point that even an undeveloped cave costs money. The book makes the case for the private show caves and the kinds of problems their owners have, without being heavy about it.

The private caves close to National Park caves have the added problem of low user fees at the NPS caves. Of course, the NPS caves have their own problems with taxpayers who think NPS caves should be free. I suggest the private caves post, in their lobbies, the annual budget of the NPS cave divided by their paid attendance figures. The result will be the true cost per visitor. The NPS true cost will make the private cave fee look quite reasonable.

The 1960's nourished an anti-business attitude and that attitude is still around, though not as strong. How often have you heard: "How can anyone own a cave?" or "No one should be allowed to make a profit on nature." I think private caves have an image problem.

Part of the problem may be due to the way a number of caves were promoted in bygone decades. In the minds of many Americans the idea of a private show cave conjures up a shabby souvenir building and a plethora of gaudy "tourist" signs making ridiculous claims for the attraction. NCA member caves have standards far beyond those I am referring to, yet there still is much some of us might do. Here are some thoughts along that line:

1. Avoid the use of the word tourist. For many it conjures up a sucker image and no one likes to be called a tourist.

2. Refer to your cave property, no matter how small, as a park. For instance, let your brochure talk about park hours instead of cave hours, or refer to picnicing or camping in the park.

3. Make your on-premise instruction signs similar to those used by state parks. Buy a router and use earth colors for such signing. Try to make your highway signs look official by mimicking state letter style, bordering, and even color as much as legally possible.

4. Drop the work "Inc." from your cave name in all advertising. It serves no promotional purpose and is a turn-off to many.

5. Talk ecology, preservation, and nature in your promotion. Avoid the "tourist superlatives" typical of 1930's advertising. Don't tell your customers that they will be "amazed beyond belief!" Those flowery cave descriptions that have been in your literature since the year one should also be reviewed.

6. Use uniformed guides and service personnel as much as possible. Concentrate more on guide training.

7. Make your grounds park-like. Those old trailers at your entrance that you've been getting a hundred dollars a month rent for may be costing you ten times that in turn-around customers. Can that pile of old boards and salvaged block be put somewhere else? Customers will pre-judge your cave by the appearance of your grounds and buildings.

Private cave operators are in the business of education and preservation. Yes, we are also showmen, but only in the sense that a proper appreciation of nature's beauty is best achieved when presented in an interesting way. We are not a bunch of greedy locals out to make a fast buck off a hole in our backyard from sucker tourists. We know this. The question is: does the American public know this?"

Austin:

Any discussion?

Wes Odle:

There is a lot of truth in what he said. I started to ask a question a while ago on what Bill was saying and not to drag out the fact of money, but all these caves are in business, basically, to make a dollar. I'm a real estate broker by trade and somehow I got hooked into being a cave operator; I'm not sure I was such a good real estate investor! If you're going into a restaurant business you're automatically put out on the firing line to compete with everybody else. You try to do something a little different, better, or for a cheaper price, and then see if I've got something to take home and put in the bank. It's no different in the cave business and as a new cave owner in the area I expected to have competition. I'm the type of person who can usually meet competition head on and I'll battle for it. I've never been one to think much about these subsidy programs. I guess maybe I was brought up in southern Illinois the hard way, my Dad being coal miner. I learned to kind of grovel for existence and when you get into business for yourself you have to grovel just to survive. So just as much as a little restaurant man has to survive, so does a cave operator and there's no program that I know of set up for subsidy. In case we don't make it this year, we can't get subsidized to carry us over to the next year. So competition from within the government is something that is a little hard for me to understand. I don't suppose there is a place in town you can go and not pick up Mammoth Cave information. I know if you come to our cave we will tell you about every tour, give you a little brochure telling you what hours you can come, and how much you have to pay to go on a tour. But I've been very unsuccessful in getting my information to the public. So I have a problem that I brought up to some of the personnel out here at Mammoth Cave that I'd like to see us have free access to get all of our business advertised just as much as we hand out information on Mammoth Cave.

I'd like to address just a copule of minutes to the problem of fair competition. If we can't compete on today's market maybe our cave doesn't deserve to be open. If we don't have something to show the people, they certainly aren't going to keep coming back. I've been to every cave around here that's commercialized, even the man-made one. I think the natural caves are very beautiful and I'd recommend you see every one of them. If we put ourselves out on the open market and be promoted by the Mammoth Parks System I think we would stand as good a chance even competing price-wise. Mammoth Cave is a huge cave, it's a long cave, it's a historic cave, it's something that everybody should see once. But after you've walked the first hour on a 4-hour trip you're not going to see much different. The next 3 hours are going to be pretty close to the same. This cave's shown for its size. All your small caves are known for their beauty in the area. They are beautiful and just as someone said this morning, they are different. Just because you've seen one, you have not seen them all. You've still got something to see. So I think we should have the opportunity to compete in a fair and equitable manner and I've suggested to the parks that we be granted a bulletin board, a brochure rack, or some method where the pubilc has free access to our literature. You can go to the information center and ask for the literature on Vernon's cave and they will hand you a Diamond Caverns brochure. You can ask about Crystal Onyx Cave and they will hand you one of our brochures. But if you don't ask you're not going to get it. I think it would only be fair to offer as much information on us as they do on them. So I think our problems are competing not only with price but with the advertising in diseminating the information about our caves. I'm willing to stand with our cave and compete on the open market as any other business and I think it's only fair that we could have a reciprocating agreement with the National Park.

Austin:

The next gentleman is Tim Anderson from Lake Shasta.

Tim Anderson:

I really don't have too much to say either. I'm just going to bring up a completely new problem. We pay workman's compensation. I think everyone knows that, but for each of your employees you put so much into your insurance company to pay in case they have an accident on the job. The insurance companys have rate tables and depending on the type of job, you pay so much percent for these people, depending on what the insurance company considers to be the most dangerous type of job. About 4 or 5 years age, we got our insurance bill and there was a big difference. We immediately got on the phone and asked them what the deal was. They said they just realized that our employees were working in a mine, that we were employing mine workers and that happened to be the highest rate of any insurance you could pay. Well, to make a very long story short, eventually we got them reclassified as amusement park workers, which is still very high. The point of this whole discussion is that the radon question is not completely dead. I know we've been over this many times, but it keeps coming back. Its almost like a zombie. If caves are going to be classified as mines that will just be one problem and that problem has been addressed before, but I thought I would bring it back again.

Jim Goodbar:

If they were classified as mines would you all have to be responsible for buying radon monitoring equipment, being able to tell how many working hour level people you should have, and be under their restrictions also?

Anderson:

There are a lot of horror stories as to what would happen if caves were classified as mines, and that's not just private caves, but Mammoth, Carlsbad, or any of the public caves too.

Austin:

Any other questions on this workman's compensation problem? One of the extra expenses that we have in private cave operation is the overhead. It can

get pretty bad. I think of coal mining in Kentucky. Now 70 or 80 cents is sent to the insurance company every time a miner is paid a dollar.

Okay. The next gentleman around the table is Mr. Joe Waggoner from Lost Sea, Tennessee.

Waggoner:

The Lost Sea is owned by a corporation, and quite frankly, a number of people who own part of the cave went into it as an investment. If you bought stock in General Motors or AT&T or whatever else and it was worth less today than when you bought it, your attitude would be a little shaky. Without dividends, a privately-owned cave would go down because of lack of profit. It is hard to tell those people who own stock in it that the good Christian, American thing to do is to preserve it. I'm sorry, but there are a number of those people who would say sell that thing to a mining company or anything else to get money out of it. I'm not trying to tell a horror story, I'm just saying the way it is from a business standpoint.

We have a small operation, and we don't have experts. If I know we should have a water expert, I have to become that person. It bothers me sometimes to realize how many different areas I have to be an expert in. People who run small operations need all the help they can get.

We blame declining attendance on the economy, or inflation, or competition, or whatever, but I'm not sure that is it. It may be the fact that the private cave owners, in conjunction with the parks and everyone else, need to go on a major educational campaign. We do not give the experience that we should. A major campaign should be waged to put interest into this area. I am sorry I do not have the answer to it, but I would sure contribute.

Austin:

Clara would you care to comment on the problems of cave management?

Heidemann:

I probably don't belong up here on this panel because I don't have any gripes. I probably shouldn't say that, but it's the truth. We do own Natural Bridge Caverns and we developed the caverns. We try to employ people who are very enthusiastic and give them the same love for the cave that we have and at a reasonable price. We haven't gone up in our price in four years where most everybody in our area has gone up. I'd say in the future that we will have to go up to meet the rising cost of insurance, advertising, and wages, because even though we do not come under the minimum wage law, we've got to pay it in order to get good help. After you have the people a few months they want a raise. We all want to give them that raise. They've got to get it somewhere. But we have been giving an increase every year. We've just spent a lot of time trying to publicize our cave. We have kept it in its natural state. We do most of the work ourselves. It is a family operation, but we have repeat visitors. Some people say they've come 8 or 12 times. I think that speaks pretty well for Natural Bridge Caverns.

Any questions?

Austin:

I've got a question. What are you doing right?

Heidemann:

I think probably we owe what we have to the cave and the treatment we give our visitors, more than anything else, I believe.

Austin:

Steve Fairchild from Boyden Cave.

Fairchild:

They have already talked about everything I was going to talk about. I have a small town sitting above my cave system in California. I have all the problems that government cave managements have plus workman's compensation and insurance. I have to generate my own electricity and to be an expert on cities. It is interesting to know that there is a lot of information out there, but we have a very difficult time getting it sometimes.

For those curious about my cave trip, it is an experiment. For years I have advocated that not everyone wants trails and lights in a cave. We charge $60 for the tour, it is 14 hours. They keep coming back. Every weekend is packed. About a third of them are people who have been there before, so we hit an imaginary connection somewhere. We have had 16 or 20 newspaper articles and 4 or 5 TV shows. We have certainly turned on the people in California to the fact that there is something under the ground besides rock and oil.

Speaker ?:

Tom Aley, do you have a view on this topic?

Aley:

I would like to tie several points together here. One way of protecting some outstanding private caves is through some sort of economic return. I don't particularly care how it is you get the economic return as long as it's not destructive to the cave. But he has two beautiful caves there, or he had two beautiful caves, if you went back to 1849. Cave City Cave was also known as Mammoth Cave, and was visited by John Muir, Bret Hart, and others. It was a show cave for a number of years and went out of business. I think any of us who have ever gone caving have seen show caves that have gone out of business. There is hardly anything left in Cave City Cave. There is a lot left in Cave of the Bells, but there would be nothing left if you had the subdivision over it. I have the feeling if we really could total up the damages we might find that there have been more damages done to caves by land use than there has by people, beating and bashing, and mucking around in them. And yet, we put a lot of attention on this. I feel what is needed is some way to assure that some

good caves can be protected through commercial development or whatever. It's always a shaky thing. Anything can happen. But I think whatever it is in the question of pricing and the impacts of associated developments, it's a great catastrophe for caves and for sound cave management when a show cave goes out of operation. We lose a tremendous resource.

Austin:

Could we move on. We've got about 10 minutes and 3 people left! The next speaker will be Richard Bell from Seneca Caverns in Ohio.

Bell:

The main thing I would like to say is that I think this symposium is very healthy. There was a time when there was no intercommunication. The real benefit of this whole thing is that everybody is talking to everybody else. Constructive criticism is extremely healthy for anything, and when we need help we know who to call. I hope everybody remains interested and that we keep growing.

Austin:

Ron Burton from Ruby Falls.

Burton:

I don't have anything to add. Just if any of you are down for the NCA this month, we've been doing some work on our lower cave, which is the original cave. I'd be glad to take any of you through that.

Austin:

Our last contestant here is Vernon McDaniels from Diamond Caverns, Park City, Kentucky.

McDaniels:

To summarize just a bit. Bill may probably be doing this too, but I think what we primarily find is that to look at a private cave and see an owner is not to say that he is making a lot of money. We have tremendous overhead.

I was very interested in the things that Tom was talking about as far as interpretation, I also realize that interpretation is extremely important. If you have the most beautiful cave there is, whether it be in California, New Mexico, or whereever, you never forget the guide. It's very, very important. People see the little things about a guide and sometimes you have to give him the benefit of the doubt, but it's hard for us to hire the very best, and if we did, it's harder to keep them for very long for what we can pay them. As an example, they are opening up a factory on Bowling Green, starting people at $11 an hour. The same people that we hire as cave guides can go there and do the same thing, so we're really pinched by that. There are other things — signs for example. In this part of Kentucky, an interstate sign runs you from 10 to 13 thousand dollars.

Speaker from the audience:

I'd like to talk to you about these cave trips. I have been Region Chairman for about 10 years. You'd be surprised at the number of requests I get from people wanting to go into a semi-wild cave trip for a birthday party. They want their young ones to go on a "wild birthday party cave trip."

Austin:

Did you ever think of sending them to a show cave?

Speaker from the audience:

Well, really there are a lot of groups that want more of a wild trip. Yet you need people to lead them. I think there is some advent for something along this line. Perhaps something could be worked out with the commerical cave owners that we could provide something like this. I've been looking at it myself and I did take the birthday trip. We had a good party in the park and then had a pretty rough cave trip. Everyone really enjoyed it. There didn't seem to be qualms about even costing any money

Austin:

You've had a chance to get to know these cave operators and hear some of them talk. Vernon McDaniels from Diamond Caverns, also Wes Oldham from Crystal Onyx and myself are offering free tours for anybody that shows up with a nametag or a receipt from the symposium. The folks at Park Mammoth will also give you free tours, however, only on Firday and Saturday. With that, we're going to finish up 15 seconds ahead of the schedule.

THE SIZE AND LOCATION OF SALTPETRE MINING SITES IN TENNESSEE, ALABAMA, AND GEORGIA

*Merilyn Osterlund

ABSTRACT

During the Civil War saltpetre or niter, a major ingredient in gunpowder, was procured from limestone caves in the southern Appalachian Mountains. One of the more important niter producing areas of the Confederacy was east and middle Tennessee, north Alabama, and northwest Georgia. Many of the mining operations in this area were discovered and destroyed by the invading Federal armies, but many were not discovered and the mining of niter continued throughout the war. A number of these caves have been documented by either written records or oral traditions. The majority, however, were obscure, small-time operations whose historic roles have been forgotten. To support the hypothesis that the obscure locations and entrances of caves contributed to the success of the Confederate saltpetre operations the 'forgotten' caves have to be documented. To do this requires that specific features or artifacts are found in the cave, such as pick marks, cleared walkways, vats or casts of vats, tally marks, ladders, or tools.

During the Civil War saltpetre, or nitre, the major ingredient of gunpowder, was procured from limestone caves in the South. Throughout the war saltpetre was mined in Tennessee, Alabama, and Georgia, one of the more important saltpetre areas. This area provided twenty-nine percent of the Confederacy's domestic supply of the mineral.[1] The purpose of this paper is to show that Tennessee, Alabama, and Georgia's success in producing saltpetre for the Confederacy can be attributed to cave location and the nature of saltpetre mining.

Of the 160 or more saltpetre caves in the study area only eleven were discovered and the mining operations destroyed by the invading Federal armies.[2] Nearly all of these discovered caves were highly visible; that is, located near lines of attack or major transportation routes, and had large entrances. But the size of the entrance and the location of the majority of the caves were so obscure and remote that the chances of discovery by the enemy were slim.

Saltpetre mining was not very vulnerable to attack; conveniently hidden within the cave it could even take place behind enemy lines. Because the mining operation could be conducted with a small labor force, a few basic tools, and simple equipment, it could be restored easily after capture and destruction. Frequently, mining operations resumed as soon as the enemy left the area; in fact, several caves were captured more than once.[3]

Historically, from the fourteenth century to the end of the nineteenth century, saltpetre was used in gunpowder.[4] This gunpowder was a mixture of seventy-five percent saltpetre, twelve to fifteen percent sulphur, and twelve to fifteen percent charcoal. Saltpetre is a term usually applied to certain naturally-occurring nitrate minerals. Saltpetre leached from the earth of limestone caves is calcium nitrate that is converted to potassium nitrate by further processing.[5]. During the war the South not only procured saltpetre from the earth of caves but also from the earth under old houses, tobacco barns, and animal shelters.

At the beginning of the war the South was poorly prepared to supply its armies with gunpowder. There were only two small private powder mills in the South and these mills produced blasting powder not gunpowder.[6] The South had little recent experience in making powder, in extracting nitre from natural deposits, or in obtaining it by artificial means. The entire supply of gunpowder in the Confederacy was scarcely sufficient for one month of active warfare.[7] Thus plans were enacted quickly to improve the powder mills, to construct a large powder mill at Augusta, Georgia, and to obtain nitre from the caves of Tennessee, Alabama, and Georgia.[8] The Ordnance Department, with General Josiah Gorgas

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at the head, was established, and Colonel George W. Rains was appointed to take charge of the manufacture of gunpowder.[9]

One of the first actions taken by Rains was to initiate a campaign to promote the production of domestic saltpetre. He visited many of the caves in Tennessee, Alabama, and Georgia, sent agents to make contracts with cave owners, advertised for saltpetre in newspapers, and published a pamphlet, "Notes on the Making of Saltpetre from the Earth of the Caves."[10] This pamphlet was distributed widely and was reprinted several times.[11]

The production of nitre was slow in getting started and the Union blockade effectively was limiting imporations.[12] To meet this crisis the Confederate Congress in April, 1862, organized the Nitre and Mining Bureau and appointed Isaac St. John as chief.[13] This was a wise move because within six months the daily production of saltpetre increased from 200 pounds to 2,000 pounds, a level of production that St. John was able to maintain throughout the war.[14] After the autumn of 1862, the South was always adequately supplied with saltpetre and gunpowder.[15] The other ingredients of gunpowder, sulphur and charcoal, were obtained easily from the buring of iron pyrites and the burning of wood.[16]

Half of the Confederacy's supply of saltpetre came from domestic sources, the remainder was imported from Europe and Mexico.[17] At the close of the war more than 70,000 pounds of gunpowder and a supply of saltpetre were on hand at the Augusta Powder Mill.[18]

Through the efforts of St. John, the Nitre and Mining Bureau became known as the most efficient, well-organized and successful division of the War Department.[19] Some of the larger and richer caves were taken over by the government and mined by conscripts, other large caves were left in private ownership and mined by hired slaves,[20] but by far the most numerous were the small, two- or three-man mining operations. Everyone in the area was encouraged to mine saltpetre. The process of making saltpetre, as Colonel Rains stated,"...was so simple that anyone... can without any expense make at least a few pounds of the salt every day."[21]

The first step in the recovery of nitre is to test the cave earth for it. Nitre is present if the earth contains small, whitish, needle-like crystals that taste salty-bitter and feel cool to the tongue, and that sparkle and promote fire when thrown on glowing coals, or if a furrow scratched into a smooth surface of the earth is again smooth two to five days later. If the earth contains nitre, the next step is to fill vats or barrels with the earth and cover it with water; the water, after percolating through the earth becomes a leach-brine of calcium nitrate, and is drained from the vat and treated with potash (the ash of burned wood). The potash changes the calcium nitrate to potassium nitrate. This liquor is boiled to increase the concentration and then cooled. Cooling causes the potassium nitrate to precipitate out of the solution. The precipitate, called grough saltpetre, is sent to the powder mill for further refining and combining with sulphur and charcoal to make gunpowder. As Colonel Rains said, "The making of saltpetre is simple."[22]

The research of saltpetre production during the Civil War is hampered because the extant, contemporary documents are few and scattered. Most of the records of the Ordnance Department and the Nitre and Mining Bureau were destroyed by fire at the end of the war, and their chiefs, Gorgas and St. John, died before they could write histories of their operations. No contemporary record exists of the number, location, name, or owner of the caves mined. Only a few caves are mentioned in the Official Records of the Rebellion, mainly those that were captured. The cave locations shown on the maps (Fig. 1 and 2) in this paper were compiled from the published cave surveys, reports in the files of the National Speleological Society, and from the oral and written accounts of local historians and cave explorers. To verify that a cave was mined it is necessary to find in the cave evidence of the operation.

The most conclusive evidence that a cave was mined is the remains of a vat or other relics of the leaching process. Leaching vats, in various sizes and shapes, round, "V", and square were constructed simply. All vats were made so that the water poure over the dirt could percolate through the dirt and collect at the bottom. One method of construction was to make the bottom of the vat out of overlapping, lenth-wise halved logs. The sides of the vat were made without nails, the supports were dovetailed and the planks were not fastened to the supports so that they could be reused in another vat. Troughs to collect the leach-brine were hewn from large logs. Quite often all that remains of a vat are a few pieces of wood, a cast of the vat, or a pile of leached earth.

Another indication that a cave was mined is evidence of excavation, such as an obvious change in the color and texture of the passage walls about one or two feet above the floor; man-made tunnels, holes, or fossilized pick marks in the cave earth; logs propping up the ceiling of an excavated area; or a pile of rocks holding up a boulder from under which earth was removed.

Further evidence is improvement in the passageways of the cave: inclined walkways, rocks piled to the side of a smooth path, bridges, steps, ladders, and winches. Some of the ladders were put together with pegs probably because of a scarcity of nails or possible because of a need to make it convenient to assemble and disassemble for ease in transporting it through the cave. Bags of earth and workers were hauled up and down deep pits or crevices with wooden winches. Wooden tramways or tracks for carts were laid to facilitate the removal of dirt from the cave.

Other evidence of a mining operation are tally marks, possible recording the number of bags of earth removed, and names of workers with dates. Isaac Drake signed his name in 1862 in Hubbard Cave, as did W. R. Johnson and E. Grisson in W. R. Johnson Saltpetre Cave, and found on the wall of Piper Cave was the inscription, "James Piper worked this prong 1863."

And, if you are lucky, an abandoned mining tool is found, or a leaching kettle. Extant are four of seventeen large cast iron kettles from Sauta Cave,

SALTPETER CAVES

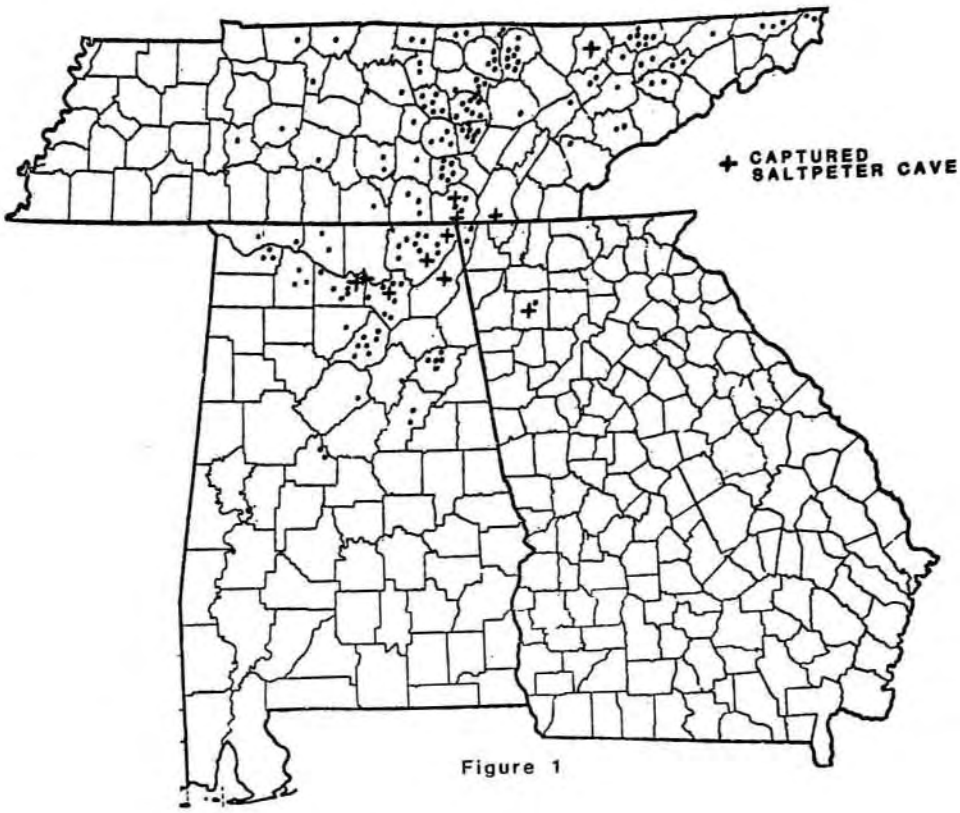

Figure 1

CAPTURED CAVES
RELATIVE TO TRANSPORTATION ROUTES

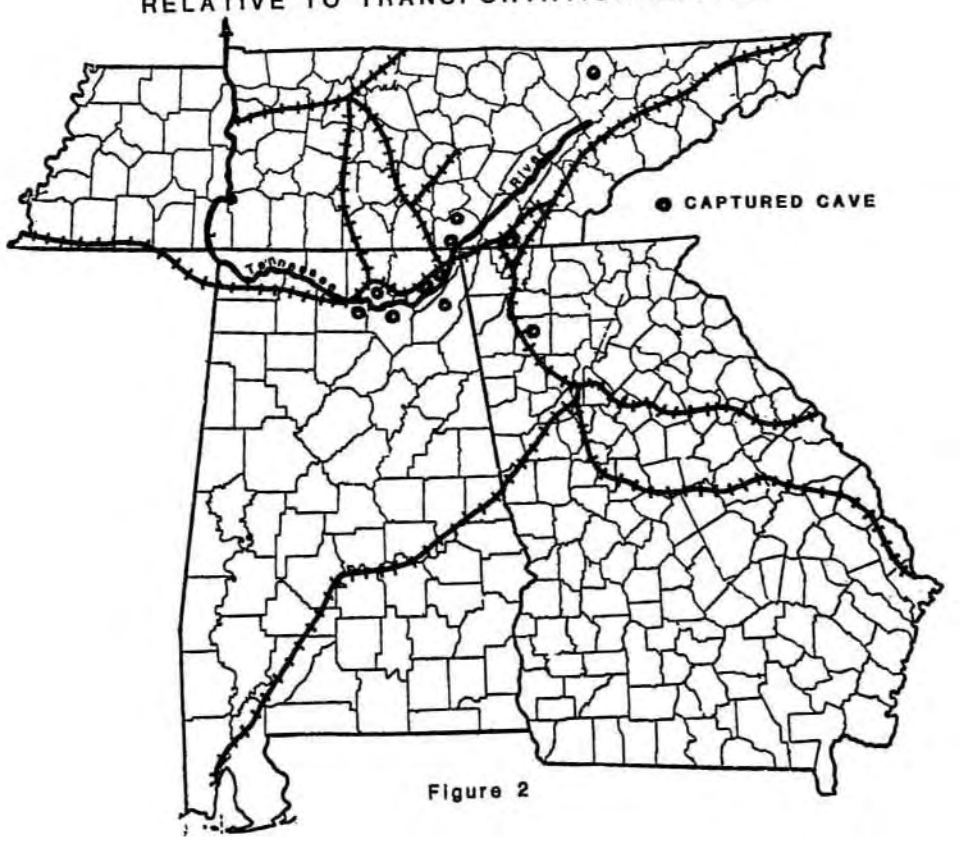

Figure 2

Jackson County, Alabama. The operation at Sauta was the largest in the area.

In Tennessee, Alabama, and Georgia more than 160 caves were mined for saltpetre during the Civil War. Most of these caves have entrances that are small and difficult to see or find, are located in rugged, remote, and isolated areas. These features made caves less vulnerable to enemy discovery and destruction. One saltpetre cave has a fairly visible entrance that is within a quarter mile of a road, but since it is near the top of a 300-foot hill in a sinkhole, it is not visible from the road. Another example is an extremely large entrance, but because it is more than a mile from a road, at the head of a narrow cove, and approximately 400 feet above the valley floor, it was not vulnerable to attack.

Of the eleven known captured caves nine were either visible from the Tennessee River, a railroad, or a major road; had a large entrance; or were very near where the Union army camped for a long time. The exceptions, Talucah Cave in Morgan County, Alabama, was accidentally discovered by a raiding party,[23] and Meredith Cave in Campbell County, Tennessee, is thought to have been reported to the Federals by a Union sympathizer.[24]

Typical of the captured caves is Kingston Saltpetre in Bartow County, Georgia. Captured by the Union army in May, 1864, it has a highly visible entrance that could be seen from the road that was used by the Union army. Two other captured caves, Lookout Mountain and Nickajack, were visible from the Tennessee River and the railroad which paralleled the river. A picture of the entrance to Nickajack Cave taken a few months after it was captured by the Union army shows an extremely large entrance, approximately 100 feet wide and 25 feet high; today it is inundated by the backwaters of a TVA dam. Lookout Mountain Cave now contains the widely advertised Ruby Falls.

The production of saltpetre was successful because nitre was easy to locate, mine, and refine and it could be a small or large operation. Mining nitre was profitable. The government paid thirty-five cents to one and a half dollars a pound for grough saltpetre, while the North paid thirteen cents a pound for imported nitre.[25]

Saltpetre miners were exempt from military duty.[26] This may explain why there are more known saltpetre caves in Tennessee. Tennessee's loyalities were divided and some men may have opted to mine saltpetre rather than leave their homes and move to the North. Of the almost two million pounds of domestically-produced saltpetre, over 500,000 pounds came from the caves of Tennessee, Alabama, and Georgia.[27]

FOOTNOTES

[1]The War of the Rebellion: A Compilation of the Official Records of the Union and Confederate Armies (70 vols. in 128 parts, Washington, D. C., 1880-1901), Ser. 4, III, 698.

[2]OR; passim.

[3]Nickajack Cave, Tennessee, and Manitou Cave, Alabama, were both raided twice by the Federals. OR, Ser. 1, X, Pt. II, 161: XXX, Pt. III, 354: XXXII, Pt. I, 129; Harper's Monthly, February 6, 1864.

[4]Burton Faust, Saltpetre Mining in Mammoth Cave, Ky. (Louisville, Filson Club, 1967), 2.

[5]P. Gary Eller, "Saltpetre Chemistry" Georgia Underground, XI (Fall, 1974), 88-89.

[6]A. P. Van Gelder and H. Schlatter, History of the Explosives Industry in America (New York, Columbis University Press, 1927), 107.

[7]George W. Rains, History of the Confederate Powder Works (Augusta, Chronicle and Constitutionalist Print, 1882), 3.

[8]Ibid. 4-7.

[9]Ibid., 4.

[10]Ibid.

[11]Rains' pamphlet was printed in the Clarksville (Tenn.) Jeffersonian, Mobile Advertiser and Register and Huntsville Democrat.

[12]OR, Ser. 4, II, 291

[13]Frank E. Vandiver, Ploughshares Into Swords: Josiah Gorgas and Confederate Ordnance (Austin, University of Texas Press, 1952), 106.

[14]OR, Ser. 4, II, 222.

[15]Ibid.; Rains, Confederate Powder Works, 26.

[16]James H. Brewer, The Confederate Negro (Durham, N. C., Duke University Press, 1969), 45: Rains Confederate Powder Works, 16.

[17]OR, Ser. 4, III, 698.

[18]Rains, Confederate Powder Works, 26.

[19]Ralph W. Donnelly, "Scientists of the Confederate Nitre and Mining Bureau," Civil War History, II (December, 1956), 70.

[20]OR, Ser. 4, I, 1, 115-16; II, 83, 222-24; Brewer, Confederate Negro, 44-46.

[21]George W. Rains, Notes on Making Saltpetre from the Earth of the Caves (Augusta, Steam Power Press Chronicle and Sentinel, 1861), 2.

[22]Ibid.

[23]OR, Ser. 1, XXXIX, Pt. I, 463-64.

[24]Ibid., Ser. 1, X, Pt. I, 20.

[25]Rains, Notes on Making Saltpetre, 11; Jonesboro (Tenn.) Telegraph, February, 1864; Alfred D. Chandler, Jr., "Bupont, Dahlgren, and the Civil War Nitre S hortage," Military Affairs, XIII (Fall, 1949), 143.

[26]Jonesboro (Tenn.) Express, January 20, 1863.

[27]OR, Ser. 4, III, 698.

MANAGEMENT OF PREHISTORIC CULTURAL RESOURCES AT MAMMOTH CAVE NATIONAL PARK

*Kenneth C. Carstens

ABSTRACT

In addition to containing the world's longest cave and having world renowned cave formations, the Flint Mammoth Cave System has received international acclaim also for its contents of unique prehistoric and historic cultural resources. This paper will focus on the history of cave resource management as it pertains to preserving the fragile remains of the prehistoric cultural past.

Introduction

The field of cultural resource management, like that of cave management, begins with the identification and assessment of the resource data base. Intended solely for the public good, cultural resource management persists for the protection and preservation of the non-renewable cultural resources. To archaeologists of North America, as well as cavers and private cave owners, the protection of caves containing cultural resources did not occur until the Federal government enacted the Antiquities Act of 1906. Unfortunately, that act, as well as several additional laws since passed by Congress, offers protection to those resources on federally-owned lands only. The management, protection, and preservation of cultural resources within Mammoth Cave National Park could not begin, therefore, until April of 1940—almost four decades after the 1906 Act.

Only recently has there been a concerted effort to systematically and scientifically identify and preserve the cultural resource data base in the Mammoth Cave area. Prior and subsequent to the Mammoth Cave region becoming a National Park in 1940, the quantity and quality of cultural resources within the Mammoth Cave area have dwindled through intentional and unintentional mismanagement. The following paragraphs trace the management of the cultural resource base in the Mammoth Cave area.

Early Investigations: 1800-1916 - The Age of Antiquarians

One of the earliest archaeological recordings pertaining to this research area was written by Constantine Sameul Rafinesque (1824). Rafinesque, a colleague of James Audubon, was deeply interested in recording information on prehistoric remains of the Ohio Valley. According to Young (1910:18), Rafinesque claims to have located one hundred and forty-eight ancient sites (settlements) and five hundred and five monuments (mounds and forts?) all from a 41-county area of Kentucky. His study area included portions of the Central Kentucky Karst. Rafinesque's entry for the Central Kentucky Karst area listed "shellmounds along the Green River and mummies in caves."

Following Rafinesque's initial inquiry into Kentucky's prehistory, there appears to be an absence of related literature about the antiquities of the area. This is not to say that interest in antiquities had died; it had not. According to Young (1910), increased farming activity, and in general, disruption of the land due to population growth, caused an increasing amount of destruction and looting of prehistoric sites. By 1870 the collecting, selling, and smuggling of antiquities was a major profession. This is also true for the Mammoth Cave area. Although known mostly for its large cave system, the archaeological contents of the Central Kentucky caves, e.g., a variety of artifacts as well as desiccated human remains, and their collection and selling was a topical pasttime. Such finds as Fawn Hoof in 1813, Scudder's mummy in 1814, Little Al(ice) in 1875, and Lost John in 1935, helped make the Mammoth Cave area famous (Meloy, 1968). During the mid-nineteenth and early 20th centuries, many individuals explored the cave systems looking only for such finds to sell (see Young, 1910). Unfortunately, this dilettantic pastime has stopped only in those caves which are constantly protected by the National Park Service (e.g., Salts, Mammoth, and Lee Caves).

The earliest date known from inside Salts Cave is 1809 (Watson, et al., 1969:7). Dates and names signed on various signature rocks in Mammoth and Salts caves, indicate that the majority of historic

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caving "dates from the last quarter or so of the 19th century to the first quarter of the 20th century...." The vegetal antiquities (e.g., textile, sandals, cordage) that could be found within the dry caves were not normally preserved in surface or "open" sites. Hence, these items were especially sought out for collecting, smuggling, and looting.

In 1874 or 1875 Louis Vial and some friends explored extensively in Salts Cave using a "new side entrance known only to themselves" (Watson, et al., 1969:7). During one of these cave trips they found the "Salts Cave Mummy", later nicknamed incorrectly "Little Alice". More recent examinations by Robbins (1971:200-206) has identified the sex and age of this individual to be that of a nine year old male, now called "Little Al".

During the 1890's such men as F. W. Putnam of the Peabody Museum as well as local Kentuckians such as Colonel Bennett Young, T. F. Hazen, and W. D. Cutliff, made extensive collections and/or purchased prehistoric materials from Salts and Mammoth Caves. Young (1910:300, 305) states:

> "In 1893 Mr. Theodore F. Hazen...opened a new entrance into Salts Cave..." (and) "we obtained many interesting relics..." about the present entrance (Salts Sink), numerous spalls, flakes of flint, pestles, axes, and awls, and other implements have been found..."

Young goes on to describe numerous artifacts taken from within Salts and Mammoth Caves, such as cords of bark, hemp, cattail leaves, and grass; basketwork; half-burned cane torches; corn cobs (possibly modern); an aboriginal ladder; wooden digging implements; cups, dishes, bowls and water bottles made from gourds and squash rinds; tobacco leaves and seed pods, as well as many chert implements. The large collection of Col. Bennett Young was eventually acquired by the Museum of the American Indian, Heye Foundation, New York (Schwartz, 1958e; Watson, ed., 1974:167). Later, John M. Nelson, who was a cave guide from 1894-1907, extensively collected antiquities both from the caves and from surrounding surface sites (Carey, 1942; Schwartz, 1958f:3; Watson, et al., 1969; ed., 1974). With the exception of the John M. Nelson collection, the other large private collections were either given or sold to: the American Museum of Natural History, New York; Smithsonian Institution, Washington, D. C.; or the Peabody Museum of Archaeology and Ethnology, Cambridge, Massachusetts.

Cultural Assessment and Reorganization: 1917-1960

It was the Mammoth Cave Estates collection, donated to the American Museum of Natural History in 1913, that prompted Nels C. Nelson (no relation to J. M. Nelson) to engage in the "only scientific archaeological investigations" of the Mammoth Cave area up to that time (Schwartz, 1958d). Nels C. Nelson worked in Mammoth Cave National Park during May and November of 1916 as an archaeological representative of the American Museum of Natural History.

Nels C. Nelson's 1917 report described the materials he found during his surface and subsurface reconnaissance and excavations within the Mammoth Cave area. Specifically, Nelson describes and compares his surface finds from the Mammoth Cave and Eaton Valley fields to similar bifacial chipped stone materials then being found in the French Paleolithic (Nelson, 1917:16-19). In total Nelson examined through excavation and/or other examination (it is unclear whether or not some sites were "test excavated") six of nine cave sites; six of seven open surface sites; and one of four rockshelters (Ibid:11). The later number refers to the category of site types he reported for the Mammoth Cave area. Schwartz (1958d:1-2) states that Nelson's main contribution was to "scientifically document the presence in the caves of some classes of material previously only reported by amateurs" but that Nelson did not make substantial conclusions about his materials due to the lack of published reports concerning the antiquities of the area. However, upon visiting Flint Dome, a section of Mammoth Cave, Nelson (Ibid:34) correctly stated:

> "...the sum of the evidence established beyond reasonable doubt that the Indian quarried chert in the recesses of the Mammoth Cave."

One of Nelson's excavations, (a rockshelter near Bone Cave), gave further evidence that the area was occupied prehistorically. In his 5' X 7' X 2½' excavation, Nelson uncovered a burial pit lined with 13 limestone slabs set on edge. Included within the burial detritus were four cord-marked, limestone-tempered sherds and several flint chips. Nelson was apparently struck by the mode of ceramic tempering, remarking that it was odd that they had not been tempered with shell as had been those recovered from the Fox Farm site (a Fort Ancient site in northern Kentucky). Nelson concluded that the people who had occupied this shelter were of the Middle Mississippian period. From what is known about the ceramics of the Green River drainage, it is more plausible that the burial's context was Late Woodland, although limestone sherds have been recovered from both Late Woodland and Middle Mississippian contexts (Hanson, 1960).

Nelson's other excavation, inside the vestibule of Mammoth Cave, is probably his major work in the Mammoth Cave area. Although Nelson's excavation of the vestibule was exploratory, it was extremely extensive and thorough. Nelson sank a series of 10 test trenches that revealed midden in two places. One was near the west wall of the entrance while the other, some 40 feet from the first, extended 50 feet back over the entire entrance area. Although Nelson's notes are at times ambiguous, he does demonstrate a strong concern for the temporal and spatial location or artifacts excavated (personel observation of Nelson's catalog record on file with the American Museum of Natural History, New York: April, 1975).

Nelson excavated almost all of the vestibule entrance, but the number of artifacts found was small. As Schwartz (1958d) points out, however, this was probably due to the extensive looting

that had occurred earlier. It may also be the result of Nelson's recovery methods (no screens were used) and/or extensive subsurface alterations as a result from cave commercialization or previous salt petre mining operations. Any of these reasons may help explain the paucity of artifacts recovered. In any case, Nelson did find and recognize evidence of prehistoric diet in the form of animal bone from such species as bear, opposum, porcupine, deer, dog, elk, bat, turtle, and possibly crane and turkey, as well as eleven different species of freshwater molluscs (unionids). He also found prehistoric tools such as bone awls, bone flakers, antler points, tubes, stone projectile points, scrapers, and ground stone implements, and items for personal adornment, such as pendants. From his findings, Nelson (1917:69) concluded:

> "...we have here evidence of a type of culture very similar to that of the Stone-grave and Mound-building tribes, but much more limited in its scope of development; in other words, essentially more primitive. The primitive group lived off the natural products of the land and the advanced group gained subsistence mainly through the practice of agriculture."

Nelson's reference to two different cultures were interpreted from two stratigraphically different middens. The lower, or more "primitive" group was identified by Nelson what archaeologists would define two decades later (e.g., Ritchie, 1933), as the Archaic culture (Schwartz, 1960:133).

Only one other mention of Mammoth Cave area prehistory appeared in print during the first two decades of the twentieth century. This was a fleeting mention of a series of rockshelter sites near what is now the western boundary of Mammoth Cave National Park. The reference was made by C. B. Moore who visited the Indian Hill rockshelter complex in 1915 (Moore, 1916). Shallow water conditions on the Green River forced Moore to terminate his Green River archaeological expedition near Indian Hill as his boat, the Gopher, was too large to continue the journey upstream.

Since the time of Nels C. Nelson's work until the formation of Mammoth Cave National Park during the early 1940's, competition among the various land and/or cave owners for the public dollar greatly increased. It was a period of great turmoil and rivalry (Sides, 1971). A newly discovered desiccated burial within Mammoth Cave, known as Lost John, brought about additional archaeological publicity (Pond, 1935; 1937). Pond's work and G. K. Neumann's analysis of Lost John (Neuman, 1938) constituted the only archaeological inquiry in the area between N. C. Nelson's work in 1916 and the formation of the Park in 1940, although several additional references to caves and rockshelter sites in and around the present boundary of Mammoth Cave National Park appeared intermittently (e.g., Fowke, 1922; Funkhouser and Webb, 1932). With the final acquisition of the lands by the government on April 25, 1940, it became a federal offense to remove materials from the cave interiors.

During the formation of the Mammoth Cave National Park, the Mammoth Cave National Park Association purchased from Mr. John M. Nelson a collection of prehistoric, historic, and geological specimens that were then donated to Mammoth Cave National Park on January 15, 1942 (Carey, 1942:1). Mr. Henry A. Carey of the Archaeology Department at the University of Kentucky was placed in charge of cataloging the Park's new acquisitions. Carey, assisted by two park employees, Mr. M. L. Cook and Mr. R. Skaggs, began the arduous task of categorizing, measuring, and cataloging the John M. Nelson collection. Some photographs were also taken by Mr. Fred Binnewies. Nelson's collection of archaeological and local cultural materials numbered over 25,000 specimens. Unfortunately, the majority of the Nelson archaeological collection was without specific provenience. That is, the materials comprised, for the most part, items collected and bought from the local area, but with no note made as to the exact collecting location. Furthermore, Nelson kept only "mental notes" for specimens of exceptional quality of unusual circumstance of discovery.

From the Nelson collection, Carey concludes that: (1) the Mammoth Cave National Park area was utilized for an extensive period of time by the aboriginal peoples; (2) a typological sequence could be worked out for the area using the collection, but that extreme caution should be used in drawing definitive conclusions due to the lack of controlled locational data; and (3) that scientific archaeological excavations should be started, both inside the caves and at selected surface sites within the Park area, by a trained archaeologist. Unfortunately, due to the "International Emergency" (World War II) occurring at the time of Carey's writing, the collections were not studied again until 1957 when Douglas W. Schwartz examined the John M. Nelson collection and attempted to relocate some of the surface sites from which Nelson had made his collections (Schwartz, 1958f). Schwartz also visited several of the major museums in the East to study the collections acquired from the Mammoth Cave area at the turn of the century.

A rebirth and interest in the surface and subsurface archaeological potential of the Mammoth Cave area began as part of the National Park Service's "Mission 66" program, which was designed to accomodate park visitors better by enriching, "their visits with more complete information on the natural and the human history" of the Mammoth Cave area. Douglas W. Schwartz, then with the Department of Anthropology, University of Kentucky, was engaged to "study all the available artifacts and remains, including materials scattered in several musuems", and "present the complete story of the cave in its relation to the life of prehistoric man" (Schwartz, 1960:135). Schwartz began work in 1957, thirteen years after Carey's initial plea for additional regional synthesis. Schwartz states that this program also called for radiocarbon dating, a thorough study of the remains of the prehistoric miner found in 1935 (Lost John), mapping activity areas utilized by the Indians within Mammoth Cave, and a surface survey of sites within Mammoth Cave National Park

In 1958, Douglas W. Schwartz produced seven different papers (1958a-g) in which he tried to accomplish the aforementioned responsibilities. The majority of his work, however, was simply a summary account of work accomplished by others before him (e.g., N. C. Nelson, J. M. Nelson, and H. Carey). Schwartz put this body of previous data, narrative discussions, and artifactual descriptions into an organized fashion. These seven unpublished reports were then used as his foundation for the writing of two popular accounts of Mammoth Cave area prehistory (1960; 1965). Three of Schwartz's reports (1958a, d, and f) and a later report by Schwartz and Sloan (1960) provide some useful discussion of archaeological site locations and probable site locations. After rechecking the majority of Schwartz's (1958f) and Schwartz and Sloan's (1960) site locations during my field research period (intermittent visits from fall, 1973, through fall, 1975), it became clear that many of Schwartz's site locations were dubious. Those sites which were accurately recorded were those reported by Schwartz and Sloan's predecessors. Schwartz and Sloan did give accurate interpretations of the materials in possession of the Mammoth Cave National Park library, although these interpretations appear to be drawn mainly from the archaeological surface collections stored at the Park's research center and were accomplished wholly on a typological basis. Schwartz should also be given credit for pulling together hitherto unorganized archaeological leaflets, letters, and documents.

In 1957 (Schwartz, 1958h) and in 1959 (Schwartz, 1960b; Schwartz, Sloan, and Hanson, 1960), Schwartz's group conducted additional archaeological surveys in Breckinridge, Grayson, Hardin, Hart, and Edmonson counties (adjacent counties to the north and west of Mammoth Cave National Park; a portion of Hart and Edmonson counties lies within the Park's boundaries). These surveys were part of the inter-agency archaeological and paleontological salvage program for the Rough and Nolin Rivers. Additional archaeological sites were located during the surveys. Archaeological test excavations, however, took place at 16 sites. With the exception of site 15 Gy 12, only two to four short descriptive paragraphs were written explaining the cultural content of these test excavated sites. Hence, the significance of this geographically similar data sample and its relationship to the Mammoth Cave area was minimal.

A New Era: 1960-1980 — Interpreting the Area's Prehistory.

Patty Jo Watson's archaeological work in Mammoth Cave National Park began in 1962 when, in conjunction with the Cave Research Foundation, the Illinois State Museum, and Mammoth Cave National Park, she initiated an archaeological reconnaissance of the large caves within the Flint Mammoth Cave system (Watson, et al., 1969). Watson's initial work was carried out primarily in Salts Cave but more recent research has expanded into other caves (Mammoth, Lee, and Bluff), and to archaeological surface reconnaissance. One reason for studying the archaeological deposits and artifacts within the recesses of the caves is that data derived from the paleofecal materials and vegetal fibers (cultural organic matter preserved by the dry cave environment) are highly relevant to discovery of dietary practices during the Late Archaic-Early Woodland period. Organic artifacts containing this information are not generally found at eastern U. S. archaeological sites. Research was expanded in April of 1969 to include, "excavation in the Salts Cave Vestibule, a search for and testing of possible surface sites near Salts Sink, and recording of prehistoric remains in other caves within the Park (Ibid.). In addition, comparative studies were made at a cave located outside the park (Wyandotte Cave, Indiana); a more complete radiocarbon sequence was obtained from Salts and Mammoth Caves; a stratigraphic column from Salts Cave Vestibule was floated; pollen and parasitological analyses from paleofecal specimens were undertaken; and pollen core studies from nearby sinkhole ponds initiated.

Aided in her research by scientists representing the biological, geological, philosophical, mathematical, social, physical, and chemical fields of study, Watson was able to approach the archaeological problems of the Mammoth Cave National Park area in a scientifically-integrated manner. This approach has led to some answers, and to many new questions, particularly with respect to environmental changes and their possible effect on the prehistoric inhabitants of the study area. Watson has been able to document that the prehistoric people were mining the cave for minerals (e.g., gypsum and mirabilite) and chert as well as simply exploring it. She has also noted similar patterns in portions of other caves located inside (Lee and Bluff) and outside the Park boundaries (Wyandotte Cave in Indiana and Jaguar Cave in northern Tennessee). Although Lee, Bluff, Wyandotte, and Jaguar Caves are not comparable in size to either Salts or Mammoth Cave, Watson's data clearly suggest that cave mining and exploration were widespread activities in this karstic region which probably began during the Late Archaic (Watson, ed., 1974:221-232; personal communication re: Jaguar Cave). The twenty-nine dates now available for the Mammoth Cave project clearly demonstrate the widespread prehistoric use of the caves over a very important and similar time horizon: that of the beginning of horticulture in the Late Archaic-Early Woodland period (ca., 4,000 to 2,000 B. P.). Human remains from the Green River Archaic Shellmounds as well as remains of individuals from the Mammoth Cave area are being studied (Robbins, 1971; 1974; 1976; Barnes, 1974; Molnar and Ward, 1974). These studies have emphasized the stature, diet, various osteological characteristics (e.g., muscle structure, bone pathology, and masticatory), and social treatment (e.g., burial practices and cannibalism) of the extinct Green River populations. Data concerning the social organization and general culture history of the people who ventured into the Flint Mammoth Cave System is much more speculative, but the data and the suggestions made (Watson, ed., 1974:231) are within the range of probability when supported by the various strands of information how available. Pollen analyses of paleofecal specimens by Schoenwetter (1974a: 57-58) have been interpreted as meaning that the people who left the feces were not members of a special work or elitist group. As Watson (op. cit.) states "The people who went into the caves were...simply

individuals who wanted or needed cave minerals for personal or family use." This hypothesis also fits information derived from human and non-human remains found in both Salts and Mammoth Caves, such as the presence of child-sized slippers in Salts Cave (Young, 1919:307), hanks of raw material that might be associated with female work and/or clothing repair, and the bodies of an adult male from Mammoth Cave (Lost John), and a preadolescent boy from Salts Cave (Little Al). Physical pathological evidence suggests that both individuals died while pursuing exploring and/or mining activities in the caves; neither seems to have been deliberately placed in the respective caves following their deaths.

Most importantly, dietary information suggests that the individuals who visited the caves not only relied heavily upon a steady plant-food diet (hickory nuts, sunflower, sumpweed, chenopod seeds, and occasional fruits; Watson, ed., 1974:234), but also utilized plants which were domesticated. Meat from deer, turkey, and small mammals was also consumed, but to a lesser degree than the vegetable materials. The nature of the food remains suggests that the people who ventured into the caves utilized food sources which were light weight, yet nutritious (e.g., sunflower seeds and/or hickory nuts in the whole, or pemmican when ground and dried).

Watson's research in the Mammoth Cave region is unique for two reasons: (1) it is the first time such scientifically-integrated archaeological cave research has been attempted in the eastern United States; and (2) it provides an aspect of cultural history which was, relatively speaking, short-lived yet extremely important (e.g., evidence of horticultural remains by our present archaeological recovery techniques would not be found in "open" surface sites, or would not be preserved). Watson's research continues in the Mammoth Cave region. As part of that continuation, my work is to document the cultural history of the Central Kentucky Karst so that Watson's synchronic studies may be fitted into the prehistoric cultural continuum of the Mammoth Cave area.

The initiation of the Green River Survey on January 26, 1974 by Watson, Janet Levy, and myself, marked the beginning of intensive, systematic surface survey in Mammoth Cave National Park and my commitment to this research project. In September of 1974 I synthesized the progress of this surface reconnaissance, analyzed surface collections, and discussed the cultural characteristics of several open and rockshelter sites (Carstens, 1974); GRS-12 (Blue Spring Hollow Rockshelter); GRS-11 (S-Curve Site); GRS-13 (Daniels Cemetary); GRS-25 (Nolin Rockshelter); and GRS-37 (Salts Sink Surface).

Surface reconnaissance and additional site excavation have continued since 1974 (Carstens, 1975, 1976, 1977; Watson and Carstens, 1975). Excavations took place at Three Springs Pumphouse (GRS-5) during January and March, 1975; Nolin Rockshelter during April, 1975; Blue Spring Hollow Rockshelter during March, June, and July, 1975; Patch Rockshelter (GRS-18) during July and November, 1975; Crumps Cave (GRS-21) during September, 1975; Owl Cave Vestibule (GRS-19) during October and November, 1975; and at Indian Cave Rockshelter (GRS-49) during November, 1976. Additional test excavations at the Elmore site (GRS-42) were started in October, 1975.

In addition to these excavations and surface collections, one week during April, 1975, was spent in the American Museum of Natural History, New York, examining material obtained during the surface collections and excavations conducted by Nels C. Nelson (1917; much of this material was unpublished). The interpretation of these excavations, surface survey and collections made by the Green River Survey personnel, as well as observations made on the John Nelson and Nels C. Nelson collections have proved sufficient in determining the cultural history of the Central Kentucky Karst (Carstens, 1980).

Since the time of Nels Nelson's work in the early twentieth century, it has taken archaeologists more than six decades to piece together the area's prehistoric culture history. Much of this delay is the result of significant prehistoric sites being destroyed by vandals. Stronger measures of resource protection are urgently needed if we are to continue to identify, interpret, and preserve the cultural resource base. Without adequate enforcement, resource protection by legislation is meaningless.

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CULTURAL RESOURCE MANAGEMENT AT RUSSEL CAVE NATIONAL MONUMENT

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ABSTRACT

Russell Cave is one of the most important archeological sites in the southeastern United States. It was declared a national monument in 1961 after a series of excavations, covering 25% of the cave interior, documented over 9,000 years of intense prehistoric human occupation and an artifact assemblage in excess of 250,000 specimens. Since that time, a comprehensive cultural resources management program has been developed at the site which is considered here in detail. Based on the information from Russell Cave, a number of suggestions are proposed regarding problems and the goals of cultural resource management at cave sites in the future.

Introduction

Russell Cave (1JA 181) is located in Jackson County, northeast Alabama. The site is situated approximately 40 miles west of Chattanooga, Tennessee and 6 miles west of Bridgeport, Alabama (Figure 1). The site is located in Doran Cove, a narrow valley 6 miles long and 0.5 miles wide. Physiographically, the valley is bounded by steep-sided mountains rising over 1,300 feet above the valley floor. To the southeast, Doran Cove valley forms a corridor to the Tennessee River valley and to the northwest, it extends into the uplands of southern Tennessee. Geologically, Russell Cave is situated on the southwest edge of the Cumberland Plateau of northern Alabama and is developed in an oolitic limestone of Mississippian age.

Russell Cave is an exposed part of a subterranean drainage system. Prior to 9,000 years ago, the roof of this cave system collapsed, forming a large "sink" and exposing a two-chambered cross section of the drainage system. The two chambers are separated by a substantial pillar of limestone. One chamber subsequently began filling with roof fall, sediments and eventually occupational debris. The adjacent chamber is fed by a perennial spring and has remained clear of rock fall and debris. The stream travels some 4.5 miles through Montague Mountain where it emerges and forms Widows Creek which eventually flows into the Tennessee River, 7 miles from the site.

The present occupation surface of Russell Cave is 625 feet above sea level and the floor is 33 feet above the stream at the base of the site deposits. The cave aperture is 100 feet wide and extends 150 feet to the backwall (Figure 2). The roof ranges from 17 to 25 feet above the present occupational surface. Large surface rockfalls are located on the southern portion of the cave interior and on the outer margin of the dripline (Figure 2).

The site is situated in dense woodlands dominated by oak, hickory and maple. The lower vegetation layers consist of shrubs and herbs that are sparsely distributed throughout the site area.

Russell Cave was initially recorded by amateur archeologists in 1951. Exploratory test excavations were conducted by the amateurs along the north wall of the site from 1953 to 1955. A description of the excavation procedures was published by Brown (1954). The resultant collection of materials was catalogued and a brief report was published by Broyles (1958). The amateurs reported this important site to Matthew W. Stirling, Director of the Bureau of American Ethnology at the Smithsonian Institution, in 1955. Carl F. Miller, a Bureau of American Ethnology archeologist, was dispatched to inspect the site and, based on his enthusiastic report, the Smithsonian solicited financial support from the National Geographic Society and jointly, under Miller's direction, conducted exploratory excavations at the site from 1956 to 1958. Miller's excavation grid superimposed and expanded the test trench opened by the amateurs (Figure 2). This research was designed as a preliminary endeavor and the excavations were based on one foot arbitrary levels. Miller's excavation unit measured approximately 20 feet by 20 feet and was stepped down toward the north backwall to a maximum depth of 32 feet. A series of brief notes and accounts of this research were published by Miller (1956, 1957, 1958, 1960, 1962, 1965). In addition, brief reports of the research were

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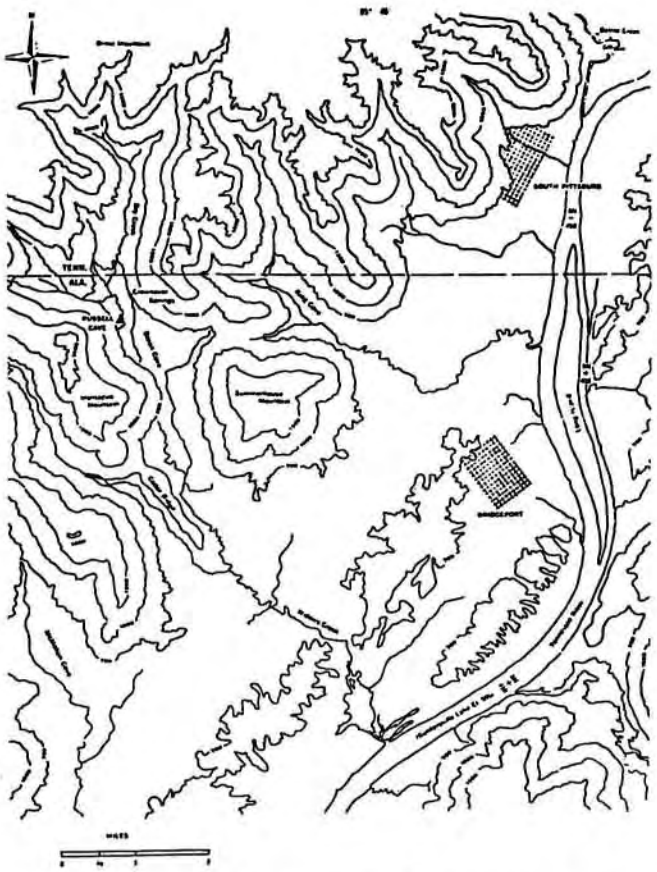

Figure 1. Russell Cave, Northeast Alabama, and adjacent South Central Tennessee (From Griffin 1974:2).

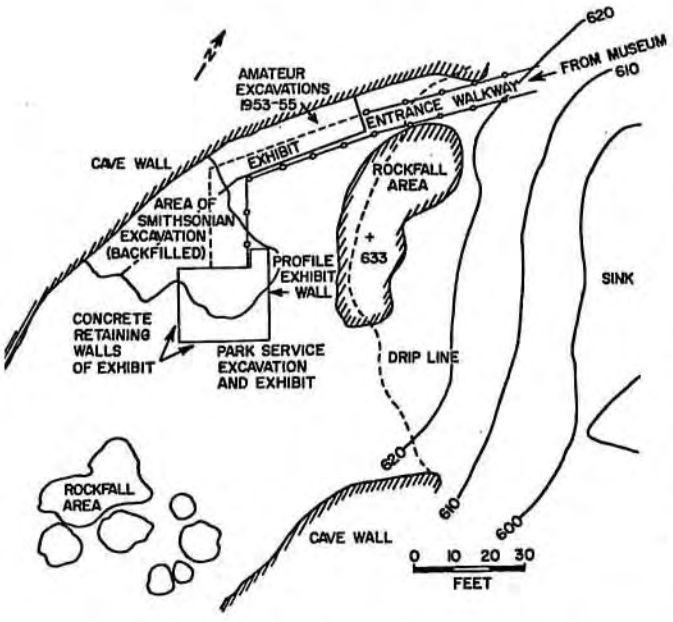

FIGURE 2—PLAN OF AREAS EXCAVATED AT RUSSELL CAVE AND "IN PLACE" EXHIBIT. (MODIFIED FROM GRIFFIN 1974)

published in the Bureau of American Ethnology Annual Reports (Stirling 1957, 1958; Roberts 1959, 1960). Unfortunately, a final report has not been published. However, radiocarbon dates from Miller's excavations document over 9000 years of prehistoric human occupation at Russell Cave. The deposits contain fantastically well-preserved artifacts numbering well over 200,000 specimens. They include stone tools and debris, ceramics, bone tools, faunal and floral remains, as well as burials and fire hearths and storage pits. The variety of cultural materials and features suggests that a wide range of activities were conducted by human inhabitants at the site.

Considering its archeological significance, the National Geographic Society wisely purchased Russell Cave and its contiguous areas (310 acres) in 1958. The site and land were donated to the "American people" and given to the National Park Service (Grosvenor 1958). In 1961, President John F. Kennedy officially established the "Russell Cave National Monument". In 1962 the National Park Service conducted excavations at Russell Cave under the direction of John W. Griffin. The purpose of this research was "primarily aimed at preparing for the development of an in-place exhibit of the stratified deposits within the rock shelter" (Griffin 1974:5). Griffin's excavations yielded another rich assemblage of cultural material which was comparable to that recovered by Miller.

In 1979, the author conducted a detailed analysis of some of the archeological materials recovered during the 1956-1958 excavations at Russell Cave. Of special interest is the faunal assemblage, which includes over 105,000 elements. The preservation of bone and shell materials is extraordinary. Over 50 vertebrate species and 27 invertebrates (11 mussels, 6 freshwater snails and 10 terrestrial snails) have been tentatively identified. Deer, turkey, raccoon, squirrel and box turtle were the species most important to human groups throughout the occupational sequence. After about 500 B.C., a variety of freshwater fauna, including fish, turtles, mussels and snails, was intensely exploited. Habitat characteristics of some of the freshwater species indicate they were (are) indigenous to the Tennessee River, documenting the economic importance of both local and non-local resources. Overall, the preliminary evidence indicates that riverine and midland hardwood forest biomes were the principal resource areas exploited by the inhabitants of Russell Cave.

The chipped stone assemblage consists of over 24,000 specimens. Of these, 16,400 are flakes (14,200) and blades (2,200) exhibiting distinct striking platforms. Other debitage (6,186) types include chunks and smaller fragments. There are 1,414 finished implements, including 58 types of projectile points (827 specimens), 14 other types of bifacial implements (472), and 7 types of unifacial tools (121). The high incidence of projectile points and other bifacial implements, in addition to the great size of the faunal assemblage, suggest that the site was used as a hunting and food processing locality. The large concentration of chipping debris implies that stone tools were manufactured at the site. A portion of the limestone

formation above the cave contains abundant chert nodules, which undoubtedly constituted an important source of raw material for stone tool manufacturing.

The ceramic assemblage from Russell Cave consists of plain and decorated wares. The earliest ceramics are plainware and "twine" impressed wares tempered with crushed limestone. Later, a wide variety of decorated types were introduced, including check-stamped, block-line and concentric-circle designs. Crushed limestone is the most common tempering agent. During the latest occupations, vessels tempered with pulverized shell were common.

Overall, the excavations conducted by Miller and the National Park Service have recovered over 500,000 artifacts and hundreds of cultural features including burials, fire pits and storage pits. In addition, over 60% of the site is undisturbed.

Russell Cave National Monument

Russell Cave has been preserved because it represents a valuable archeological resource. It represents one of the oldest sites in the eastern United States. The monument was created to protect the remaining prehistoric cultural deposits as well as the adjacent natural cave system. As noted above, the site has been maintained by the National Park Service since 1958. The site is administrated by Mr. John Mapel, director, and a number of highly competent Park Service personnel. A small museum houses an exhibit that includes diagnostic artifacts and a description of the prehistory of the site, as well as a history of excavations. From the museum, a path winds through the woods to the site. On the cave interior, an elevated wooden platform leads to Griffin's excavation unit, which has been converted to an open "pit" exhibit. Two concrete retaining walls form one corner of the exhibit (Figure 2). A third wall, parallel to the aperture of the cave, consists of a profile showing the occupational sequence at the site with corresponding C-14 dates. The fourth side of the exhibit consists of a set of wooden stairs leading down into the "pit". A tape recording explains the prehistory of the site as well as the history of excavations. According to Mr. Mapel, the site averages 25,000 visitors a year. The cave and the interior "excavation" exhibit are the main features at Russell Cave National Monument. The National Park Service has developed a number of protective measures for these resources. At any cave site, roof collapse is a potential problem. The interior of the site is constantly monitored for cracks, etc. Elevated walkways into the cave prevent disturbance and destruction of the existing cultural deposits (Figure 2). Lights and cameras are used periodically to monitor activities inside the cave.

A program has been developed to preserve and protect the natural environment at the site. A series of nature trails pass through the forest circumscribing the site. Signs are used along the trails to point out natural resources exploited by the prehistoric groups living at Russell Cave. These include water, animal, plant and stone resources. The monument museum provides additional information about the site through exhibits and taped explanations. A series of publications and slides about the site are also available.

Overall, the cultural resource management program at Russell Cave has been focused on protection, preservation and public information. The cave exhibit, resource trails, museum, literature, and park service personnel provide comprehensive information about the archeology and natural environment of the site. The cave system is also an important part of the management system. The cultural resource management system at the site is unique because the cave has substantial deposits, 60% of which are undisturbed, over 9000 years of human occupation, over 500,000 artifacts exhibiting extraordinary preservation, and is located within an undisturbed natural setting.

Cultural resource management at the site has provided the public with a better understanding of prehistoric archeology and the relationship between human groups and the environment. It also emphasizes the need for the protection and preservation of cave sites, excavations, and cultural deposits. Last, the preservation of the undisturbed cultural resources enhance the potential for future archeological research at the site.

Future Goals

The most important problem is recognition and subsequent evaluation of cultural deposits at cave sites. This requires increased collaboration among cave owners, speleological societies, and archeologists. Furthermore, archeologists are interested in both cultural and biological data which provide information on environmental and cultural reconstruction and thus, necessitates collaboration with biological researchers. Cave sites need protection via legislation or private ownership. At present, cave sites are being destroyed at an alarming rate. A cave site, such as Russell Cave, represents an educational device which provides the general public with information for understanding the necessity for cave preservation and thus education should be a major concern of any cave management program.

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THE RECOGNITION, EVALUATION, AND MANAGEMENT OF CAVE BONE DEPOSITS

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ABSTRACT

Most caves contain some type of bone deposit. Bone accumulations most frequently occur in caves due to natural pitfall traps, woodrat nests, raptor roosts, and carnivore dens. Cave bone deposits preserve an unduplicated record of prehistoric life and should be managed as the nonrenewable resources they are. Recognition of these deposits often requires techniques similar to those used by archeologists, but evaluation requires the skills of a vertebrate paleontologist. The National Speleological Society has recently formed a Vertebrate Paleontology Study Group to serve as a clearing house for reports of bone discoveries in caves. While bone deposits are most valuable for their record of extinct animals and of prehistoric ecology, they also provide information on the geologic history of the caves and their sediments. Information obtained from the study of cave bone deposits is an often overlooked interpretive resource.

Effective management requires recognition and evaluation of the resource being managed. Potentially important paleontological sites located in caves often are neither recognized nor evaluated. This results in mismanagement that may lead to destruction of the sites and loss of the associated paleoecological record that the sites contain. Most caves contain bone deposits. These can range from fossil vertebrates in the parent strata to remains of a recent explorer's lunch.

The most significant bone accumulations are those that represent a large number of species in stratigraphic context or unusually well preserved specimens of poorly known species. Such accumulations most frequently occur in cave fill as a result of natural pitfall traps, woodrat nests, roosts of raptorial birds, or carnivore dens. Each of these situations can produce large accumulations that may be several feet deep and may represent several thousand years of deposition. Long term preservation of such sites requires geologic stability that results from a lack of major environmental fluctuations in the local environment of the site. Caves act as buffers that shelter the interior from such fluctuations, making caves the most important paleontological sources in many areas. Sites most often are found near present or past cave entrances.

The same depositional and post-depositional processes that produce the bone sites may also serve to obscure them from the untrained observer. Recognition often requires techniques similar to those used by archeologists. Careful examination of cave fill is required to detect small or fragmentary remains. Mineral coatings may cause bones to resemble rocks. Teeth of small mammals and vertebrae of salamanders and snakes may be as small as the head of a pin. Screen washing or floatation may be required to detect such items, but it is small bones such as these that are most useful in reconstructing environmental conditions during the period of deposition. Discovery of all but the most obvious bone deposits requires careful observation. Areas in danger of disturbance should be carefully examined for any type of organic material: small bones, teeth, snail shells, seeds, or other fragments of plants or animals. If any organic remains are found, small test pits and screen washing are indicated to determine the extent and importance of the site.

Evaluation of any teeth or bones recovered usually requires the skills of a vertebrate paleontologist. Bones can sometimes be identified from photographs, but it is usually preferable to have the actual specimen in hand. Direct comparison with a comparative osteology collection is frequently required, especially if the item is incomplete or if it is from an animal with several closely related species of similar morphology. Collection of specimens for identification should be selective, choosing those that are most likely to be identifiable: skulls, jaws, teeth, and major limb bones. If you are dealing with a complete skeleton, a single jaw or major limb bone will probably be enough for identification. If the deposit is a jumble of bones, several of the most distinctive

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elements should be selected for referral to a specialist.

The National Speleological Society has recently formed a Vertebrate Paleontology Study Group to serve as a clearing house for reports of cave bone deposits. The addresses of founding members are available in Table 1. Any of these individuals may be consulted for advice on how to deal with specific discoveries, for identification of specimens, or for referral to the nearest specialist or institution.

Once a site has been recognized and evaluated, its management should be similar to that preferred for archeological sites. Excavation should be under the direction of a paleontologist. If a qualified supervisor is not immediately available, the management objective should be protection of the site from unauthorized collecting and from damage due to heavy traffic in the area of the site. The value of the site lies in the information it contains on past animals and their environments. Stratigraphic relationships as revealed by proper excavation and preserved in field notes and publications are therefore required in order to obtain the most information from the site. Fossil specimens and the information associated with them provide an often overlooked basis for interpretation of the geological history of the cave and of the ecological history of the region in which it occurs. The details will be different for each site. Assistance from the National Speleological Society Vertebrate Paleontology Study Group should aid cave managers in obtaining maximum benefits from the paleontological resources of their caves.

TABLE 1

Members of the National Speleological Society Vertebrate Paleontology Study Group

Name	Address
E. Ray Garton	P. O. Box 200, Barrackville, WV 26559
Frederick Grady	1201 South Scott, #123, Arlington, VA 22204
Oscar Hawksley	Department of Biology, Central Missouri State University, Warrensburg, MO 64093
Allen McCrady	Section of Vertebrate Fossils, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15213
H. Gregory McDonald	Department of Vertebrate Paleontology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, Canada M5S 2C6
Ronald C. Wilson	Department of Biology, University of Louisville, Louisville, KY 40292

THE ENDANGERED SPECIES ACT AND THE REGULATIONS DEVELOPED BY THE U.S. FISH AND WILDLIFE SERVICE TO PROTECT ENDANGERED SPECIES

*Robert R. Currie

ABSTRACT

The Endangered Species Act of 1972, as amended, provides for a National Program to identify, protect, and to recover species on the verge of extinction. The Fish and Wildlife Service has the responsibility of implementing the Act for terrestrial species, freshwater species, and certain marine species when on land. In response to the Congressional mandate to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved," and "to provide a program for the conservation of such endangered species and threatened species" the Fish and Wildlife Service has developed a series of regulations implementing the provisions of the Act. These regulations outline the procedures to be followed in determining what constitutes an endangered or threatened species; the procedures to be followed in protecting the species once they have been officially determined to be endangered or threatened; and, the mechanisms to be used to develop plans which will lead to the recovery of endangered and threatened species. When successfully implemented, these measures should ensure that in the United States no additional species are lost forever through extinction precipitated by man.

The Endangered Species Act, in approximately its present form, was enacted in 1973. It has been amended several times since then but, with the exception of those passed in 1978, these amendments have been minor. Congress states in Section 2 of the Act that its purposes are to "provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved," and "to provide a program for the conservation of" these species.

The Fish and Wildlife Service and the National Marine Fisheries Service are charged with the administration of the Act. The National Marine Fisheries Service is primarily responsible for the species found in the marine environment such as whales, while we are responsible for the species found in terrestrial or freshwater environments, such as the bald eagle, gray bat, and Alabama cave fish. There are a few species, like the threatened loggerhead turtle, which are the responsibility of both Services. While the sea turtle is in the water, it is under the jurisdiction of the National Marine Fisheries Service, but when it comes ashore to nest, it is under our jurisdiction.

There are five sections of the Act which are of special interest. These are:

1. Section 4 which establishes the mechanism used in determining which species are endangered or threatened;
2. Section 5 which authorizes the purchase of land expressly to protect or enhance the status of listed species;
3. Section 6 which sets up a program for cooperating with the states in meeting the purposes of the Act;
4. Section 7 which directs all Federal agencies to cooperate in the protection and conservation of listed species; and,
5. Section 9 which outlines activities that are

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prohibited when dealing with listed species.

I will now review each of these sections in a little more detail. But first we will need to define three important terms.

An endangered species is a species which is in danger of extinction throughout all or a significant portion of its range.

A threatened species is a species which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Critical habitat is a specific area within the geographical area occupied by the species on which are found those features which are essential to the conservation of the species and which may require special management or protection. Specific areas outside the present range of the species can be designated critical habitat if they are judged to be essential for the conservation of the species.

The listing responsibilities under Section 4 have, until fairly recently, been with the Office of Endangered Species in Washington. Within the recent past some of the duties have been delegated to our Regional and Area Offices, such as the Atlanta Regional Office and the Asheville Area Office.

This section and the regulations developed under it state that a species may be determined to be endangered or threatened for any of the following reasons:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;

2. Over utilization for commercial, sporting, scientific, or educational purposes;

3. Disease or predation;

4. The inadequacy of existing regulatory mechanisms; or

5. Other natural or man-made factors affecting its continued existence.

At the time a species is listed as endangered or threatened, the Service must also determine what constitutes critical habitat for the species. The only way a species can now be listed without designating critical habitat is when such a designation is judged not to be prudent. This exception would only be used in cases where publishing information about the exact location of a species would increase the threat or be of no benefit to the species. This was the case with the recently listed Green Pitcher Plant in Alabama. The Green Pitcher Plant is very popular as a novelty plant and as an unusual addition to home gardens. Since there is no restriction in the Act on taking or collecting listed plants, it was judged that it was not prudent to provide information about where the few remaining individuals were actually located.

The Act requires that the Service hold a public meeting in the Area to be designated critical habitat or if critical habitat is not designated, to hold a public meeting if one is requested by anyone. Basically this means that very few additional species will be listed without holding a public meeting.

As I am sure many of you are aware, adding a species to the list is not a simple task. The procedures which must be followed are time consuming and costly to carry out. The process includes:

1. A status review of the species based upon the best information currently available;

2. An environmental assessment of the impacts of listing the species;

3. A determination of what constitutes critical habitat;

4. An economic assessment of the impacts of designating critical habitat;

5. Consultation with local and state governments, Federal agencies, private individuals, and organizations which may be affected by the listing of the species;

6. Notice in the Federal Register of the proposals to list the species and determine critical habitat;

7. Distribution of copies of the Federal Register notice to local newspapers, scientific journals, local governments, state governments, and others if appropriate.

8. A public meeting to gather information, and if requested, a more formal public hearing on the proposals; and finally,

9. Notice in the Federal Register of the disposition of the proposals.

Section 4 also directs the Service to develop and implement plans designed to conserve and insure the survival of listed species. These are referred to as recovery plans. Dr. John Brady, team leader of the Indiana/Gray Bat Recovery Team, will give you some perspective on how these plans are developed in his presentation on the Indiana bat.

Section 5 of the Act authorizes the purchase of lands specifically for listed species. Examples of caves which have been or are in the process of being acquired for this purpose include Sauta Cave and Fern Cave in Alabama. Both caves are of utmost importance to the gray bat. The Morgue section of Fern Cave is a major hibernaculum and Sauta Cave is an extremely important maternity site. In addition to the summer use of Sauta Cave by the gray bat, several thousand Indiana bats also hibernate there.

Section 6 of the Act authorizes the Service to enter into Cooperative Agreements with qualifying states for the study, protection, and conservation of endangered or threatened plants and animals. This cooperation takes the form of at least two-thirds

Federal funding of most of the state's endangered species activities. At the present time, 36 states have entered into cooperative agreements with the Service for fish and wildlife while six states have agreements covering plants.

We now come to the extremely important and occasionally controversial section which requires other Federal agencies to cooperate in the protection and enhancement of listed species. Section 7 of the Act states in part that all Federal agencies shall:

1. Carry out programs for the conservation of listed species;

2. Insure that their actions do not jeopardize the continued existence of a listed species or destroy or adversely modify a species' critical habitat (unless of course the agency has been granted an exemption from Section 7 by the Endangered Species Committee); and

3. Consult with the Service on the effect of proposed actions on listed species or critical habitat if it is determined that an action "may affect" a listed species.

There are two broad categories of actions which may require consultation with the Service to determine their effect on listed species. The first of these are construction projects. A construction project is an action which is conducted, authorized, or permitted by a Federal agency which involves "construction" of some type, and which is a major Federal action. That is one requiring preparation of an environmental impact statement under the National Environmental Policy Act.

When a Federal agency is involved in a construction project, they must first ask the Service if there may be any listed species or species proposed for listing within the impact area of the project. These requests for lists come directly to the Area Offices in most regions. When such a request is received, the distributional information available is reviewed and the Federal agency is provided a list of species which may occur in the area. At the same time, the agency is informed of its responsibility to prepare a biological assessment of the effects of the proposal on these species and their critical habitat (if critical habitat has been designated within the project area).

After preparation of the biological assessment, the agency determines if the proposed action may affect in either a positive or negative manner a listed species. If the agency believes that a listed species may be affected, it must request a formal consultation with the Service. If it believes that the species will not be affected, consultation is not required unless requested by the Service. For species which have been proposed for listing but have not yet been formally added to the list, the Federal agency must confer with the Service if they determine that the proposed action may jeopardize the continued existence of the proposed species.

Federal actions which do not meet the criteria for construction projects are treated differently. Agencies are not required to formally request lists of species which may occur in the area, nor are they required to prepare a formal biological assessment. However, they must still determine if the proposed action will affect, again in a positive or negative way any listed species. Usually to get enough information to make this determination an agency must perform an analysis similar to that required for a biological assessment. If a listed species will be affected, consultation is required.

The formal consultation process is the procedure by which the Service issues a Biological Opinion on what effect the project will have on listed species. The conclusions which may be reached in a Biological Opinion include:

1. That the project will enhance the conservation of a species;

2. That the project is not likely to jeopardize the continued existence of a species;

3. That the project is likely to jeopardize the species continued existence; or

4. That the agency cannot insure that their actions will not jeopardize the continued existence of a species. This type of opinion would be issued in those cases where there is not enough information available to form a more explicit opinion and agreement cannot be reached on extending the consultation period.

The Act prohibits a Federal agency from doing anything which would jeopardize a species. Although the Service has no enforcement powers under Section 7, agencies which ignore this directive are subject to suit by private individuals or organizations in Federal court.

In 1978 Congress instituted a mechanism for resolving conflicts of this nature. This was accomplished by the establishment of an Endangered Species Committee. This committee can review the merits of a project and weigh them against the merits of project alternatives (including not completing the project) which would not be likely to jeopardize the continued existence of the species. They can either rule that the project as proposed or some alternative to the proposal is in the public interest.

It is only after the committee has issued an exemption from the Act that a project which is likely to jeopardize a species can legally be completed. It should be pointed out that this is the next to the last resort for the most difficult conflicts. In the past almost all controversies have been satisfactorily resolved well below the Endangered Species Committee level.

As I stated, the Endangered Species Committee is the next to the last resort. The last resort is Congress. Congress can specifically exempt a project from all provisions of the Act. This was done with the Tellico Dam project in eastern Tennessee.

Section 9 of the Act deals with the prohibition of certain activities which would adversely affect listed species. Plants and animals are treated differently under this section. There is no prohibition against taking or possessing a listed plant while these acts are prohibited when dealing with animals.

The following are prohibited unless specifically authorized by a permit from the Wildlife Permit Office in Washington:

1. Importing or exporting the species;

2. Possessing, selling, delivering, etc., the species;

3. Taking the species;

4. Selling or offering for sale in interstate commerce any listed species; and,

5. Violating any special regulation developed when the species is listed.

We should note that "take" is defined in the regulations to include harming or harassing a species.

Harass means "an intentional or negligent act or ommission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering."

Harm means "an act or ommission which actually injures or kills wildlife, including acts which annoy it to such an extent as to significantly disrupt essential behavior patterns, which include, but are not limited to, breeding, feeding, and sheltering; significant environmental modification or degradation which has such effects is included within the meaning of harm."

The penalties for violating any of these prohibitions are fines up to $20,000 and a year of imprisonment.

If the Endangered Species Act is conscientiously implemented, we as a Nation can fulfill the goal outlined by Congress of conserving endangered and threatened species as well as the ecosystems upon which they depend. If it is not, then we will continue to lose elements of our diverse fauna and flora at an alarming rate. It all depends upon us. We must support the goal of preserving these species if we are to succeed. We should also all be prepared to pay the costs which will be required to do so.

THE STATUS OF THE INDIANA BAT (Myotis sodalis)

*John T. Brady

Introduction

The Indiana bat has been designated an endangered species by the U. S. Fish and Wildlife Service, and is protected under the Endangered Species Act of 1973, as amended (U. S. Fish and Wildlife Service, 1978). A recovery plan was prepared in 1976 (Engel, et al., 1976), and the Indiana/Gray Bat Recovery Team is in the process of revising this plan.

Distribution and Numbers

The Indiana bat is found in the midwestern and eastern United States from northern Arkansas and eastern Oklahoma, north to Iowa and northern Michigan, to eastern Vermont and New Hampshire, southeast to northern Florida. The winter range is primarily in Missouri, Indiana, Kentucky, and Tennessee.

Table 1 shows hibernating population figures from the most recent available sources. Missouri has the largest hibernating population, accounting for 66.4 percent of the total. Indiana has the next largest hibernating population with 20.4 percent. Ninety-one percent of the known Indiana bat hibernating population is found in ten locations (nine caves and one mine) with eight in Missouri, one in Indiana, and one in Kentucky. There could be other major hibernating caves, especially in the southeast, that have not been located.

Habitat Requirements

1. Hibernating. — Depending on local weather conditions, Indiana bats are in hibernation from October to April (LaVal, et al., 1977). Indiana bats have specific requirements for hibernation, generally choosing roost sites within caves or mines which have stable temperatures of 4-8°C allowing the bats to maintain a low metabolism and conserve fat reserves until spring (Humphrey, 1978). The bats usually hibernate in large, dense clusters of about 300 bats per square foot (Hall, 1962; Engel, et al., 1976; Clawson, et al., 1980).

2. Maternity Period. — Very little was known of Indiana bat summer habits until recently. Current studies indicate that females form nursery colonies mostly in riparian and floodplain areas of small to medium sized streams (Humphrey, et al., 1977; Cope, et al., 1978; Sparling, et al., 1979; Gardner and Gardner, 1980), but sometimes even in tree-lined drainage ditches (Brack, 1979). The few nursery colonies found have ranged from 50 to 100 individuals including young, (Humphrey, et al., 1977; Cope, et al., 1978). Humphrey, et al. (1977 found a nursery colony under the loose bark of a dead butternut hickory tree (*Carya cordiformis*).

Table 1

Estimated hibernating population of Indiana bats (*Myotis sodalis*)

State	Population Size	Percent of Total	Date	Source
Missouri	342,100	66.4	1980	Clawson (1980
Indiana	104,824	20.4	1975	Humphrey (1978)
Kentucky	55,782	10.8	1975	Humphrey (1978)
Tennessee	7,554	1.5	1975	Humphrey (1978)
West Virginia	1,757	0.3	1975	Humphrey (1978)
Arkansas	1,700	0.3	1975	Humphrey (1978)
Virginia	580	0.1	1975	Humphrey (1978)
New York	500	0.1	1975	Humphrey (1978)
Illinois	194	0.0	1975	Humphrey (1978)
	514,991	99.9		

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The colony occasionally used a living shagbark hickory tree (*Carya ovata*) as an alternate roost. The bats were observed foraging in air space from 2 to 30 m above the ground under riparian and floodplain trees (Humphrey, 1977). Excellent foraging habitat has been described as mature trees that overhang rivers by more than 30 m on one or both sides; streams without riparian vegetation do not appear to be suitable (Cope, et al., 1978). Indiana bats were found to feed primarily on Lepidoptera in Missouri (LaVal and LaVal, 1980). Population estimates for nursery colonies ranged from 60 to 90 bats per km of suitable stream with an average figure of 75 per km. Riparian habitat was found to be occupied by Indiana bats from mid-May until mid-September (Humphrey, et al., 1977).

The location of males during the breeding period is not well known, although a few have been found in caves (LaVal, et al., 1977; Hall, 1962). They have been observed feeding in flood plain, hillside, and ridge forests in the Missouri Ozarks (LaVal, et al., 1977).

3. Mating. — Between early August and mid-September, Indiana bats arrive in the vicinity of their hibernacula and engage in swarming and copulation. Swarming is described as "...a phenomenon in which large numbers of bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in the caves during the day." (Cope and Humphrey, 1977). Swarming continues into October, and it is during this time that fat reserves are built up for hibernation.

Reasons for Decline

1. Natural Hazards. — Indiana bats are subject to a number of natural hazards. In Bat Cave in Mammoth Cave National Park, an estimated 300,000 skeletons were found, apparently victims of flooding from the nearby Green River. A few other cases of hibernacula being flooded have also been recorded (Hall, 1962).

Bats hibernating in mines are vulnerable to ceiling collapse. This has occurred in Illinois (Hall, 1962) and is presently a serious concern at a mine in Missouri that is the largest known Indiana bat hibernaculum. Another potential hazard exists because Indiana bats hibernate in cool portions of caves that tend to be near entrances. Some freeze to death during very severe winters (Humphrey, 1978).

2. Human Causes. — The most serious cause of Indiana bat decline is human disturbance of hibernating bats. The bats enter hibernation with only enough fat reserves to last until spring. When a bat is aroused, it uses a portion of these reserves, as much as 10 to 30 days of fat supply per average disturbance. Cavers or researchers passing near hibernating Indiana bats cause arousal (Humphrey, 1978). If this happens very often, the bats likely will die.

Vandalism also has been documented. In 1968, an estimated 10,000 Indiana bats were killed in Carter Caves State Park, Carter County, Kentucky, by 3 boys who tore masses of bats from the ceiling and trampled and stoned them to death (Engel, et al., 1976). There are many examples of such tragedies. Bats seem to have a bad reputation and are viewed by many people with fear and repugnance.

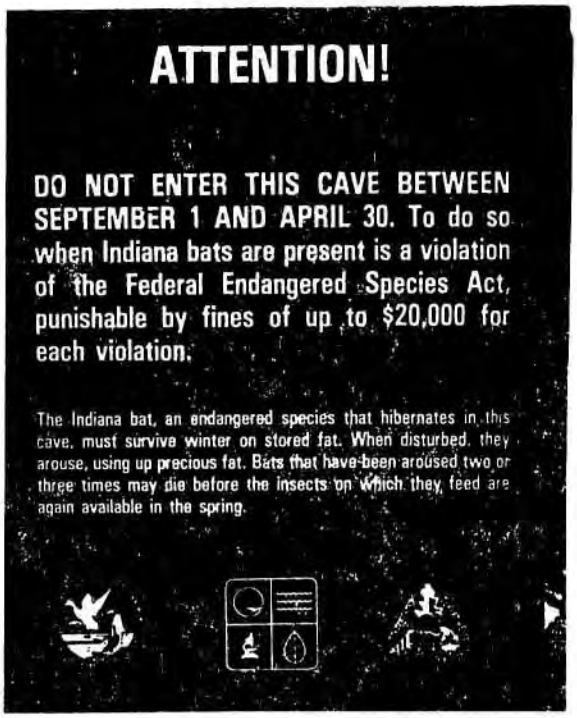

FIGURE 1. Warning sign for Indiana bat hibernacula by the Missouri Department of Conservation (Photo Credit, St. Louis District, Corps of Engineers).

Other sources of decline include indiscriminate handling of bats by biologists, especially in hibernacula; commercialization of hibernacula; exlucsion of bats from caves by poorly designed gates; changes in cave microclimate by opening of additional entrances or blocking of air flow by poorly designed gates; flooding of caves by reservoirs, butting of forests necessary for summer roosting; and pesticide poisoning.

Management

1. Protection of Hibernacula. — The U. S. Fish and Wildlife Service has designated 13 caves and 2 mines, which are used by about 453,600 hibernating Indiana bats, as critical habitat under the Endangered Species Act of 1973. Eight of these are in public ownership. This represents 88 percent of the total known population. There are a number of other hibernating caves which probably qualify as critical habitat. The Recovery Team needs cooperation from the caving community to locate hibernating caves which are not known. Protection of these caves does not exclude cavers since the caves can be entered during the summer months when the bats are not present.

A number of measures should be taken to protect these important hibernacula. Usually, the first recommendation is to purchase the cave and place it in public ownership. After purchase, a decision must be made on how best to protect the cave from human disturbance. If the cave is remote and never visited, the best course of action probably is to do nothing. The next level of protection is to erect a sign. An example of a sign from Missouri is shown in Figure 1. The most secure level of

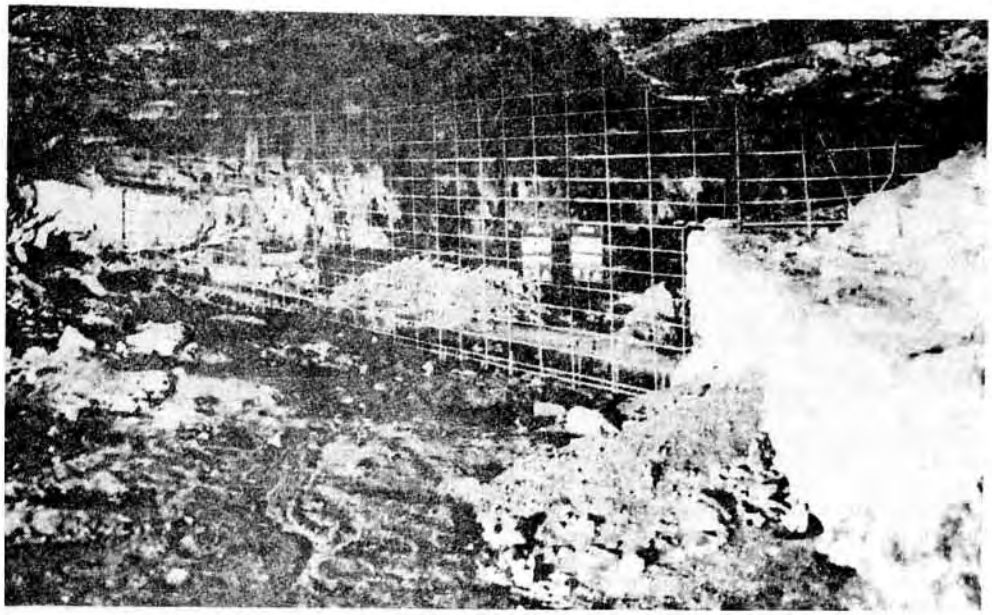

FIGURE 2. Photograph of a gate used on an Indiana bat hibernaculum by St. Louis District, Corps of Engineers (Photo Credit - St. Louis District, Corps of Engineers).

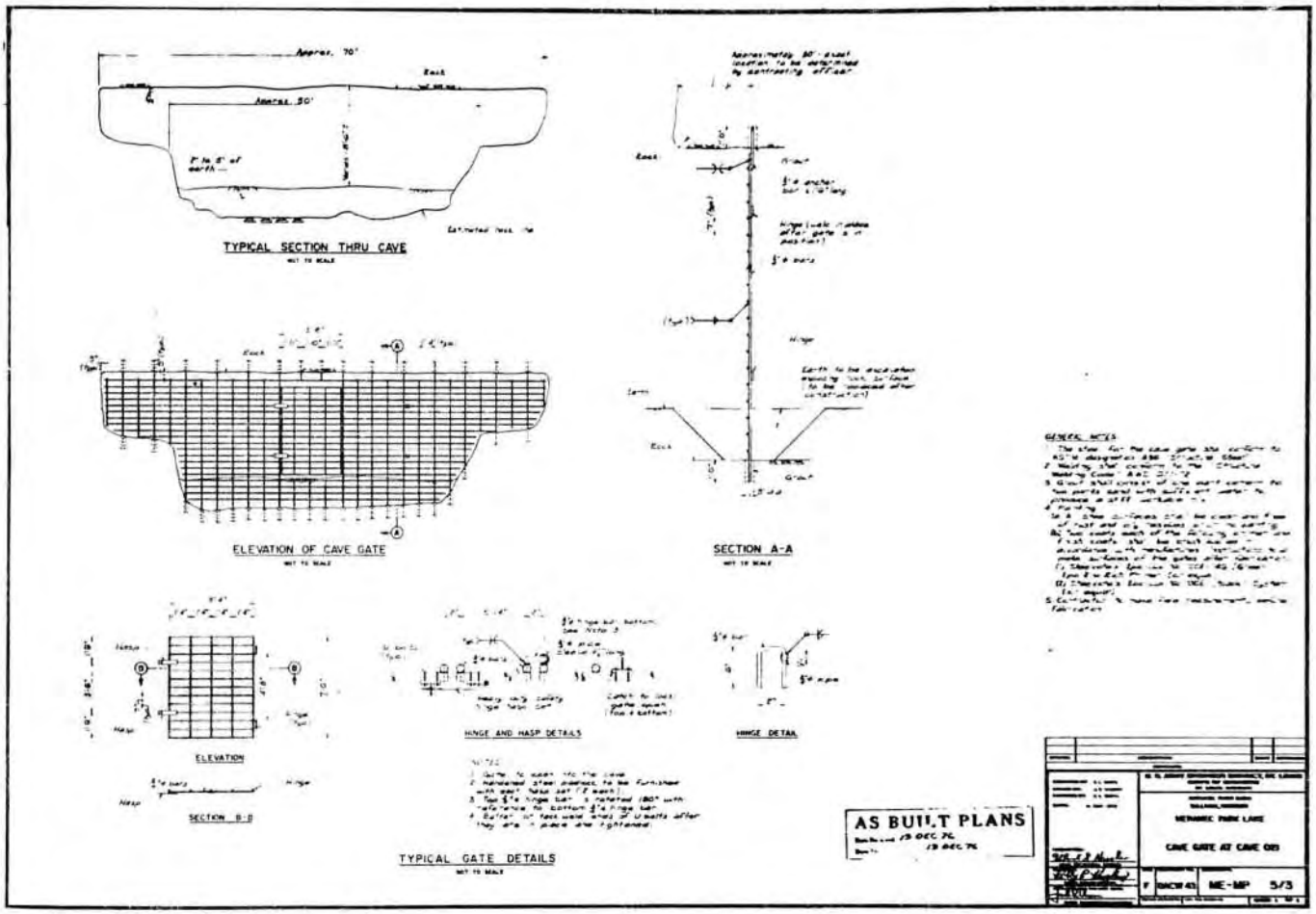

FIGURE 3. Drawing of a gate used on an Indiana bat hibernaculum by the St. Louis District, Corps of Engineers.

protection is to place a gate at the cave entrance, or a fence around the perimeter of the entrance. A gate is considered the most effective, but the choice may depend on the physical setting. Figure 2 shows a photograph of a cave gate constructed by the St. Louis District, Corps of Engineers, on a critical habitat hibernaculum in Missouri. This gate has proven to be effective in keeping most people out and has been acceptable to the bats over the last 3 years. Figure 3 is an engineering drawing of this gate. A gated cave should also have a sign explaining the purpose of the gate and penalties involved if the cave is entered.

Gates must be used only with extreme care to avoid detrimental effects. They should not be horizontal or used on entrances smaller than six feet in diameter. Gates on small entrances are most likely to restrict air flow or increase bat vulnerability to predators (Tuttle, 1977; Tuttle and Stevenson, 1978), leading to abandonment of the cave by the bats.

Welded steel bar gates provide the most secure means of preventing human entry into a cave. Even the best designed and well-built gate can be vandalized. Routine inspections will identify damage so that repairs can be made promptly.

Each gate must be designed specifically for the cave to be protected, considering numbers of bats, air flow, and entrance size and shape. In spite of the number of variables involved, certain generalizations about gate design can be made.

Gates should be constructed of steel bars, of sufficient size and hardness to be invulnerable to bolt cutters. Round steel bars 3/4 to 1 inch in diameter (American Society of Testing Materials A242) are recommended. All welds should be made carefully, using arc welding equipment.

Access openings in gates should be constructed to the same standards, with the most durable hinges, hasps, and locks. In a situation where vandalism seems likely, weak-link design may be employed. The lock, hasp, or some other easily replaceable portion of the gate should be relatively weak so that vandals will not try to breach the main body of the gate. Locks should be chosen with care, as many common types are extremely easy to force open.

Free ends of all bars should be grouted into solid rock. In some caves it may be necessary to pour a concrete footing (although it should not rise above original ground level), or to dig through a deep clay or gravel fill to reach the underlying floor.

Openings in gates through which bats are expected to fly should be approximately 6 inches vertically and at least 24 inches horizontally. Lengths greater than 24 inches between vertical bars increase the probability that the bars can be spread by use of hydraulic jacks.

Unfortunately, a simple vertical gate seldom can be constructed at a cave with a sinkhole entrance. Horizontal gates have two serious drawbacks: (1) bats are reluctant to fly up through such a gate; (2) a horizontal gate may become blocked with debris, preventing entry and exit by bats, as well as blocking normal air flow. A solution is provided by a "cage" gate, similar to that shown in Figure 4.

It is also important to restrict access to important Indiana bat caves. Few people find caves without the aid of trails and roads. Obliteration of jeep and foot trails may greatly reduce human traffic to the caves (Indiana/Gray Bat Recovery Team, in manuscript).

There are a number of caves with blocked entrances caused by poorly designed gates restricting air flow, which have caused Indiana bats to abandon them. These blocking structures should be removed so that the bat populations can recover (Humphrey, 1978)

After the important caves are protected, a periodic (not more than one per year) census should be made to monitor the hibernating populations. These will be indicative of the effectiveness of protective measures. Censuses should be done with a minimum of disturbance by a qualified biologist, and bats should not be handled. Recreational cavers need not be excluded from Indiana bat hibernacula during the period when bats are not present (1 May to 1 September) (Humphrey, 1978).

Cave gating recommendations presented here for the Indiana bat do not necessarily apply to the gray bat (*Myotis grisescens*). In general, gray bats are much less likely to use gated caves. A recovery plan should be released late in 1980 for the gray bat explaining cave gating procedures for this species. The U. S. Fish and Wildlife Service and the Indiana/Gray Bat Recovery Team should be contacted before attempting to gate either an Indiana or gray bat cave.

The following agencies have had the most experience in bat cave management and are recommended as sources of information:

(1) The Indiana/Gray Bat Recovery Team

(2) U. S. Fish and Wildlife Service, Region 4, Atlanta, GA

(3) Missouri Department of Conservation, Columbia, MO

(4) Tennessee Valley Authority, Norris, TN

(5) U. S. Army Corps of Engineers, St. Louis, MO

(6) U. S. Army Corps of Engineers, Kansas City, MO

2. Protection and Restoration of Riparian Habitat—Within the summer range of the Indiana bat, riparian and flood plain forest should be preserved wherever possible. It is especially important to preserve old large trees and recently dead trees which still have bark and may become a nursery tree. In cases where streams are diverted or channelized, riparian forest should be replaced. Trees planted along new drainage ditches could be used when they become mature.

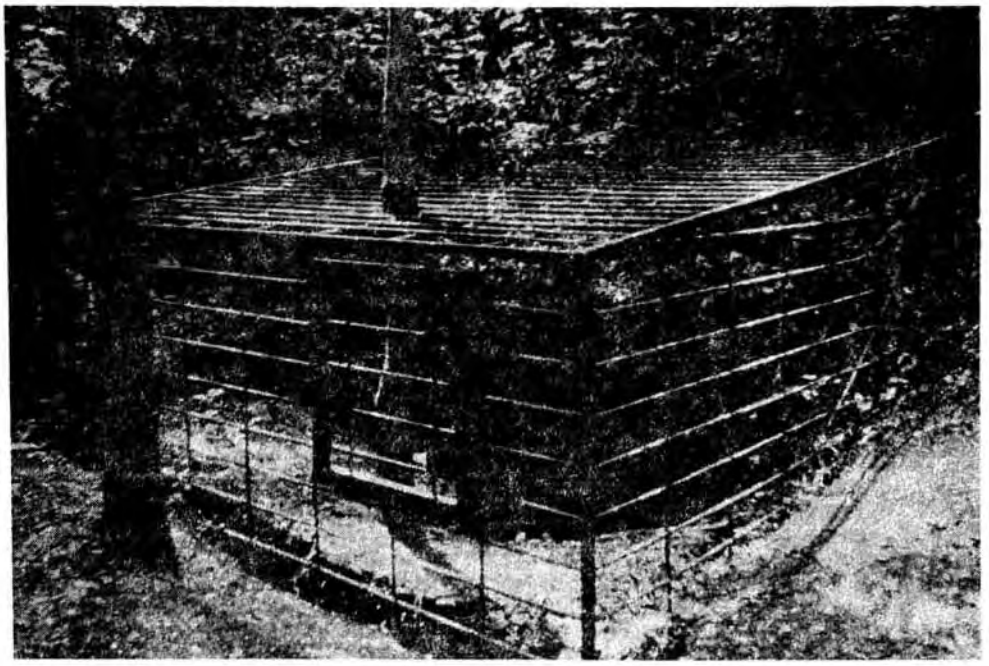

FIGURE 4. Photograph of a "cage" gate used on an Indiana bat hibernaculum with a horizontal entrance by the Missouri Department of Conservation (Photo Credit - R. Clawson).

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THE SURVIVAL OF THE ENDANGERED GRAY BAT (Myotis grisescens), A CONTINUING DRAMA

*Alan Rabinowitz

ABSTRACT

The gray bat is one of only a few bat species which uses caves year-round. Colonies will migrate seasonally between warm (14-25°C) maternity caves during summer months and cold (6-11°C) hibernating caves during winter months. Gray bats feed primarily over aquatic habitats and thus summer caves, particularly those used by maternity colonies, are nearly always located within 1-2 kilometers of rivers or reservoirs. Growth rates and survival of newly volant young are inversely proportional to the distance to the nearest over-water foraging habitat. In winter, colonies hibernate in deep, cold, vertical caves. Thermoregulatory and other habitat requirements necessitate large aggregations of gray bats in only a few hibernating caves throughout their range. Approximately 95 percent of the entire species hibernates in only 9 caves each winter with more than half in a single cave.

Drastic declines of gray bat populations probably began as early as the 19th century from intensive saltpeter mining and cave exploration and commercialization. Present rates of decline have been accelerated by additional factors such as use of pesticides, chemical siltation, pollution, and impoundment of waterways, natural calamities such as cave flooding, and increased popularity of spelunking. Of all of these factors, human disturbance within occupied caves appears to be the primary cause of decline of the gray bat. Close relationships have been demonstrated between rates of decline and frequence of disturbance. Studies in Tennessee - Alabama, Missouri, and Kentucky indicate declines of 76%, 72%, and 88%, respectively, when comparing present colony sizes to past maximum population estimates. Since gray bats require large colonies for successful rearing of young, these trends indicate that unless recovery action is taken immediately, by the year 2000 the total population may not be able to sustain itself. Clearly the primary objective concerning the recovery of gray bat populations entails the reduction of human disturbance in occupied caves. Although this burden has come to rest primarily with government agencies, cooperation among private cave owners and local conservation and caving groups could play a crucial role. Secondary objectives should include public education, protection of critical habitat for gray bat foraging activities, and monitoring of pesticide concentrations in gray bat populations. Recent progress by the U. S. Fish and Wildlife Service and the Indiana/Gray Bat Recovery Team makes the future hopeful. However, much more needs to be done.

The rapid expansion of man's recreational and commercial activities has seriously threatened many important cave faunas. Among these are numerous bat species that have shown marked declines over the past 20 years (Cockrum, 1970; Mohr, 1953, 1972). The gray bat, *Myotis grisescens*, a monotypic species which occupies a restricted range in the southeastern United States, is perhaps the most seriously threatened of all cave bats. Eleven years ago Barbour and and Davis (1969) predicted that the gray bat probably faces extinction unless protected, and recommended its inclusion on the U. S. Fish and Wildlife endangered species list. This protection finally came about in 1976 (Federal Register 28 April 1976) after drastic declines reduced the total population number to a dangerously low level. Since that time progress has been made towards recovery of the species, however, much more needs to be done before extinction no longer remains a possibility. Among the many actions that will have to be taken to protect this species, the foremost must include substantial and continuing effects towards public education. With this in mind

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the purpose of this paper is fourfold:

(1) To reiterate the causes of decline of the gray bat.

(2) To ascertain its current population status.

(3) To specify recovery actions that are underway or needed in the future.

(4) To make a public appeal to a group of individuals, in whose hands the future of a species lies.

The gray bat is one of the few bat species which is virtually restricted to cave environments year-round. However, due to its highly specific roost requirements, less than 5 percent of all available caves could ever be occupied by this species (Tuttle, 1979). Colonies of gray bats move seasonally between warm (14-25°C) caves in the summer and cold (6-11°C) caves during winter. Their specific thermoregulatory and other habitat requirements force them to seek only caves with definite structural configurations (Tuttle, 1976a; Tuttle and Stevenson, 1978). Thus, summer maternity caves are large warm air traps while winter hibernating caves are usually deep, vertical, voluminous cold air traps (Tuttle, 1975; Tuttle and Stevenson, 1978). During winter, large colonies of gray bats congregate in fewer hibernating caves than any other North American vespertilionid bat. Approximately 95 percent of the entire known species population hibernates in only nine caves each winter, with more than half in a single cave (Tuttle, 1979). This is one of the real threats to their survival (Mohr, 1972). Continued disturbance at these sites and subsequent arousal from hibernation depletes fat reserves that cannot be replaced before spring emergence. Calculations for similar species indicate that each arousal causes an expenditure of 20-30 days fat reserves. Clearly, repeated or prolonged visits to hibernacula within a single winter can result in high levels of mortality. During summer, disturbance at maternity sites can be equally detrimental. From late May through mid-July flightless young bats are present at the roosts and may be dropped upon a single disturbance. Any loss of young is serious since females do not reach sexual maturity until their second season and then bear only one young each year (Tuttle, 1976a).

In addition to their specific cave requirements, adult gray bats feed almost exclusively on insects over aquatic habitats (Tuttle, 1979; LaVal et al., 1977). This makes it necessary for summer caves, particularly maternity colonies, to be located near water and in fact the majority have been found within 1-2 km of rivers or reservoirs (Tuttle, 1976b). Unfortunately this type of foraging habitat and its associated insect fauna can be very susceptable to chemical pollution and siltation of waterways. These occurrences, particularly in areas of increased strip mining, are possible factors in the further decline of the gray bat. Additionally, deforestation of areas near cave entrances and between caves and over-water foraging habitat could affect gray bats detrimentally. Forest habitat is used by adult gray bats for foraging during inclement weather and for predator avoidance (Tuttle, 1979). It is also used by young gray bats during their first week of flight when they are weak and clumsy fliers.

Other factors that are known to cause declines of gray bat populations include increasing use of pesticides (Clark et al., 1977, 1980), cave commercialization, impoundment of waterways (Tuttle, Stevenson, and Rabinowitz, in manuscript), and natural calamities such as flooding. However, despite all of these threats to the existence of the gray bat, the primary cause of population declines has been the human disturbance at occupied cave sites. A close relationship has been demonstrated between overall population decline and frequency of human disturbance at cave sites (Tuttle, 1979).

Although estimations of gray bat colony sizes are difficult, techniques have been developed that cause minimal disturbance to colonies, yet give good comparisons between past maximum population numbers and present colony sizes. These techniques are based upon measurements of ceiling stains and guano accumulations at maternity sites, and are carried out only after the colony has vacated the cave (Tuttle, 1979). Using such methodology at caves throughout the species range, we are left with a gloomy picture concerning rates of decline and present population numbers. In three separate censuses carried out at maternity caves in Tennessee and Alabama (Tuttle, 1979), Missouri (LaVal, 1980), and Kentucky (Rabinowitz and Tuttle, 1980), there were reported declines from past maximum population levels of 76%, 72%, and 88%, respectively. In Tennessee and Alabama, 22 colonies surveyed in 1970 and again in 1976 showed a 54% reduction during the six-year period (Tuttle, 1979). In Missouri, 27 maternity colonies censused in the early 1960's and again in 1978 showed an 80% reduction over the 15-year period, with 16 of the original colonies totally abandoned (LaVal, 1980). In Kentucky, of 20 randomly chosen gray bat sites, 12 were totally abandoned (Rabinowitz and Tuttle, 1980). With these kinds of trends it can be speculated that if populations continue to decrease at the current rates of decline, serious problems could arise in the near future. Since gray bats require large colonies for the successful rearing of young (Tuttle, 1975), consistent declines in population numbers tend to have a snowballing effect. The total population number that would be scattered over six states by the year 2000 might not be able to sustain itself. However, there is hope for the future. Since the gray bat was listed on the Federal endangered species list in 1976, government agencies have been compelled to attempt the reversal of past population declines. So far, encouraging progress has been made. The Federal Indiana/Gray Bat Recovery Team has made major strides in the documentation of critical habitat for the species. As a result, several major caves have been purchased and/or protected, through the construction of proper gates or fences. In addition, the team has outlined future priorities for recovery of the gray bat. These include, among other things, the acquisition and protection of additional caves, the control of foraging habitat destruction, and public education. Although all of these actions will be needed to help curtail present rates of population decline, only a strong

public education program will solve the long term problems. The role of public education cannot be taken lightly. The time and money spent in protecting the gray bat could all be fruitless unless we seek to obtain cooperation and understanding between government agencies, private cave owners, caving clubs, conservation groups, and the general public (Rabinowitz, in press). An expensive, well-constructed gate designed to protect bats is worthless if subjected to vandalism by individuals who feel their rights are being infringed upon. We can never totally solve the problems caused by individuals who will vandalize caves for no reason, but we can minimize such occurrences. In some instances particular caves which harbor endangered gray bat populations could be open to the public during certain non-critical times of the year. Properly worded signs and naturalist talks could go far in giving the public a better understanding of a creature that has been maligned by so many for so long. Much of the future of the gray bat as well as all other cave bat species will be in the hands of many people at this symposium today. The strongest platform for bat conservation can come through the caving community. Cave owners, cavers, government officials, and naturalists can play a major role in disseminating information regarding the need to protect bat species as well as dispelling long standing rumors concerning bats (i.e., bats as major vector of rabies). As a biologist, I can study bats and pass on my information to you. The future of the species, however, is in your hands.

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THE FUTURE OF CAVE MANAGEMENT IN RELATION TO BAT CONSERVATION

*Alan Rabinowitz

Recent legislative action concerning endangered species has brought to light the rapid decline of many temperate cave bat populations in the United States. At the present time, 2 bat species and 2 subspecies are listed on the Federal endangered species list, the Gray bat (*Myotis grisescens*), the Indiana bat (*M. sodalis*), the Ozark Big-Eared bat (*Plecotus townsendii ingens*), and the Virginia Big-Eared bat (*P. t. virginianus*). Consequently, federal and state agencies have been willing to commit increasing sums of money for the purchase and gating of caves that harbor endangered populations. This is a worthwhile endeavor which is necessary for the important maternity and hibernating caves that have histories of human disturbance. However, this type of action should not be considered as the only means of bat conservation; it is unnecessary and unfeasible in many circumstances. A broader concept of bat cave management needs to be established by federal and state agencies which takes into account changing economic situations and low priority caves that harbor bat populations not yet endangered. In other words, proper cave bat conservation should involve "strategic management" as apposed to "crisis management" (Devereaux, 1977).

In addition to the increasing costs for caves and their associated lands, there are many difficulties involved with constructing proper gates or fences to protect the caves. The potentially disasterous effect that may result from improper gate design is well documented (Welbourn, 1975; Tuttle, 1977). Although this type of bat cave management has been shown to yield excellent results when carried out properly, its prohibitive cost makes it available to only the most important caves containing large numbers of endangered bats. Thus, we need to consider channelling additional time and money into alternative efforts that will protect other bat populations as well. Such protection efforts should include public education and the involvement of private cave owners and local conservation and caving groups. Experience has led me to believe that there is often immediate attitude and behavioral changes in many individuals with whom I have taken the time to discuss bat biology and the importance of bats. Furthermore, I have seen a willingness by many cave owners and caving clubs to protect many of their own bat caves once they realize their biological importance. This kind of protection can be more valuable than the strongest gate and is much less expensive. In a recent survey to establish the status of maternity colonies of the gray bat in Kentucky, I found that only one of the twenty caves surveyed was owned by individuals who willingly kept people out of the cave and did their best to protect the bats from harm. This cave showed a 74% decline in numbers of bats from past maximum population levels. Although this is a large decline, it was the third lowest of the caves surveyed. The only other caves showing lower declines were more structurally complex and better suited as gray bat maternity colonies (Rabinowitz and Tuttle, 1980).

Many landowners have indicated a willingness to protect their caves if there was some input from federal or state agencies. Another cave that was surveyed in Kentucky showed a past maximum population of 94,000 gray bats, perhaps one of the largest maternity colonies in the state at one time. However, the current population is 6,800 bats, a 93% decline. The owners of the cave were horrified to learn of such a decline and felt that if the government sent them a letter recognizing the importance of their cave, as well as a sign to post at the cave entrance, they would do their best to keep people away during critical seasons. Due to the caves's location it would be difficult for individuals to get into the cave without permission from the owners.

Minimum amounts of time and money spent on cooperating with local caving clubs in Tennessee and Kentucky have also been productive. My attendence at local cave club meetings to give slide presentations concerning bat biology has greatly bridged the gap between science and local cavers. The cavers were generally intelligent and eager to learn about cave biology and the general feeling seemed to be that we were working towards a common goal, the preservation of caves and cave fauna.

The education of the general public is not as easy to deal with as with people interested in caves or in conservation. Federal and state governments, however, have ideal outlets through which to accomplish this goal. Better and more numerous interpretive programs could be established in state and national parks, and the U. S. Fish and Wildlife agency could set up environmental education programs to provide lectures to schools and community groups. The impact of such work may not always be immediately obvious but it would be far reaching and long term.

Unfortunately, personal experience with government agencies has indicated an antipathy for this type of public relations. In the past, actions taken by many agencies have been aimed at curing symptoms,

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not establishing long range goals. The National Park Service and the U. S. Fish and Wildlife Service have been willing to spend large sums of money in complying with legislative guidelines for endangered species but they have done little or nothing in regards to establishing more and better interpretive programs concerning cave related fauna. Many caving groups have become frustrated and angry with government agencies because they feel they have been snubbed and cheated. Local cave clubs have been responsible for many important bat cave locations, only to find a favorite sport cave purchased and/or gated without their prior knowledge or input. Now, many cavers feel they must keep their caves secret so that it will not be taken away from them. Much of their frustration is warranted and could hurt future bat conservation efforts. Unless public education and cooperation accompanies the purchase, gating, or posting of caves, illegal entry and vandalism will continue. For example, despite the fact that Blowhole Cave, a major Indiana bat hibernaculum in the Great Smoky Mountains National Park, has a sign restricting entry this cave had the greatest number of known unauthorized visits of any of the eleven caves in the park (Rabinowitz and Nottingham, 1979). Recent designs for cave gates include a deliberate weak link so that forced entry does not destroy the entire gate (Hunt and Stitt, 1975). If enough antagonism among local cavers is aroused through the gating of certain caves, forced entry would be relatively simple and might result in the deliberate destruction of large bat populations. This action would make the land purchase and gate construction virtually worthless.

The view that public education and cooperation is crucial to the protection of any species is not a new idea. However, it has rarely been attempted due to the difficulties of implementing such programs as well as the lack of observable results. Despite these problems, the idea must be pursued particularly in regards to bat conservation. With increasing numbers of species being put on the endangered species list and critical habitat taking last place in many instances, sufficient money for protecting bat species and cave environments will become more difficult to obtain. Evidence of this can be seen in a 1980 letter to Tennessee state representative T. Wheeler by federal congressman John Duncan. Referring to the purchase of a cave considered to be critical habitat for both gray and Indiana bats, Duncan states:

> "First of all, Federal funds to purchase habitat for endangered species of wildlife are extremely limited, with most of the recent expenditures having been made for the benefit of species which have greater public recognition and appreciation. I am afraid that the elimination of a species of bat would cause much less of an outcry than would, say, the elimination of an eagle species."

With this kind of attitude prevailing in our society, public education and cooperation will be our only hope for long term protection of cave bats. Fortunately, the latest recovery plan for two endangered bat species, the Indiana and gray bats, have public education as their first priority. However, we must realize that public education does not solve the immediate problems. We need more extensive efforts by government agencies and recovery teams to involve bat cave owners and local cavers in protecting their own cave resources. Through such efforts it is my belief that we may not only remove many species from endangered or threatened status but we may curb the decline of other cave bat populations as well.

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THE ENDANGERED KENTUCKY BLIND CAVE SHRIMP

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ABSTRACT

First discovered in 1901, the Kentucky Blind Cave Shrimp, Palaemonias ganteri Hay, has been collected in only two baselevel areas of the Flint-Mammoth Cave System. Regularly observed in the Shrimp Pools from 1955 to 1967, the shrimp was not seen again for twelve years. In September, 1979, a single dead individual was found, demonstrating the P. ganteri is not extinct. Habitat modification caused by Lock and Dam Six and by early fall releases from the Nolin River Reservoir, as well as pollution from sewage and oil brine are implicated in the shrimp's near extinction. Relict populations of the shrimp remain in habitats which are not readily censused.

The Kentucky blind cave shrimp, *Palaemonias ganteri* Hay, was first observed by William Perry Hay in 1901. While searching a series of pools in the Roaring River passage of Mammoth Cave for crayfish, he noticed a small object swimming near the surface. Hay (1902) described his attempts to capture it:

> "After a most exasperating chase, during which my specimen seemed more than once to have eluded me, it was captured, and I saw immediately that another animal had been added to the fauna of the cave. I then set about finding others, and, knowing what to look for, they were found quite easily... All their movements were unmistakably shrimp-like and very different from those of any of the other crustaceans in the cave."

Resembling a small crayfish without pincers, the Mammoth Cave blind shrimp is delicate and transparent. Its antennae are about half again as long as the body, which ranges up to 25 mm, or about one inch, in mature shrimp. What little is known about the life history of the shrimp suggests that they live one or two years. Females carry eggs from late spring to fall. Although the young have not been found, they apparently hatch during the fall when the water is least turbulent and when the microorganisms on which the shrimp feed reach their peak abundance. The seasonal winter floods that wash the shrimp from the quiet pools into the large cave rivers also recharge nutrients in the pools. As the flood waters recede in the spring, the shrimp are again isolated in the pools until the following winter's floods.

Quiet, silt-bottomed pools associated with seasonal sediment deposition are the prime habitat for the Kentucky blind cave shrimp for two reasons. First, the thin organic veneer deposited on the bottom of the pools by winter floods provides a propitious nutrient source for microorganisms, which are a critical link between organic material that is washed into the cave and the shrimp and other aquatic cave animals. This veneer is less well developed in the cave rivers because the organic sediments are continually mixed with the inorganic sediments in the main river channel. Second, when isolated in pools, the shrimp are protectdd from their predators, the three species of cavefishes and the two species of cave crayfish.

The seasonally replenished pools near the base level rivers in Mammoth Cave have been a reliable locality for observing shrimp for over half a century whenever biologists visited the cave. Hay collected twelve specimens there in 1901. When the prominent European biospeleologists Candido Bolivar and Rene Jeannel (1931) visited Mammoth Cave in 1928, they observed 30 shrimp in a pool near Echo River. Giovannoli (in Bailey, 1933) reported another sighting in 1929. No biologists visited the cave rivers between 1930 and 1950, but cave guides reported occasionally seeing shrimp in a pool near Echo River (Barr, 1967). During the 1950's and until 1967 the Kentucky blind cave shrimp reliably could be found in the Shrimp Pools of the Roaring River passage. Also, in the early 1960's, the shrimp could be found in small pools near the Golden Triangle, a portion of the base level river under Flint Ridge. Since the shrimp were not seen again between 1967 and 1979 despite repeated searches in their prime habitat, they were feared extinct.

Many of the disturbances which have drastically reduced the population levels of the shrimp come from 20 to 50 miles away. To understand the nature of these impacts we need to review the hydrology of the Mammoth Cave Region (Figure 1). Five sources contribute water to the base level rivers of Mammoth Cave. At least 50 sinking creeks terminate in swallow holes, and water from some of these flows northwest underground 15 miles on a straight line to large springs on the Green River. Precipitation that

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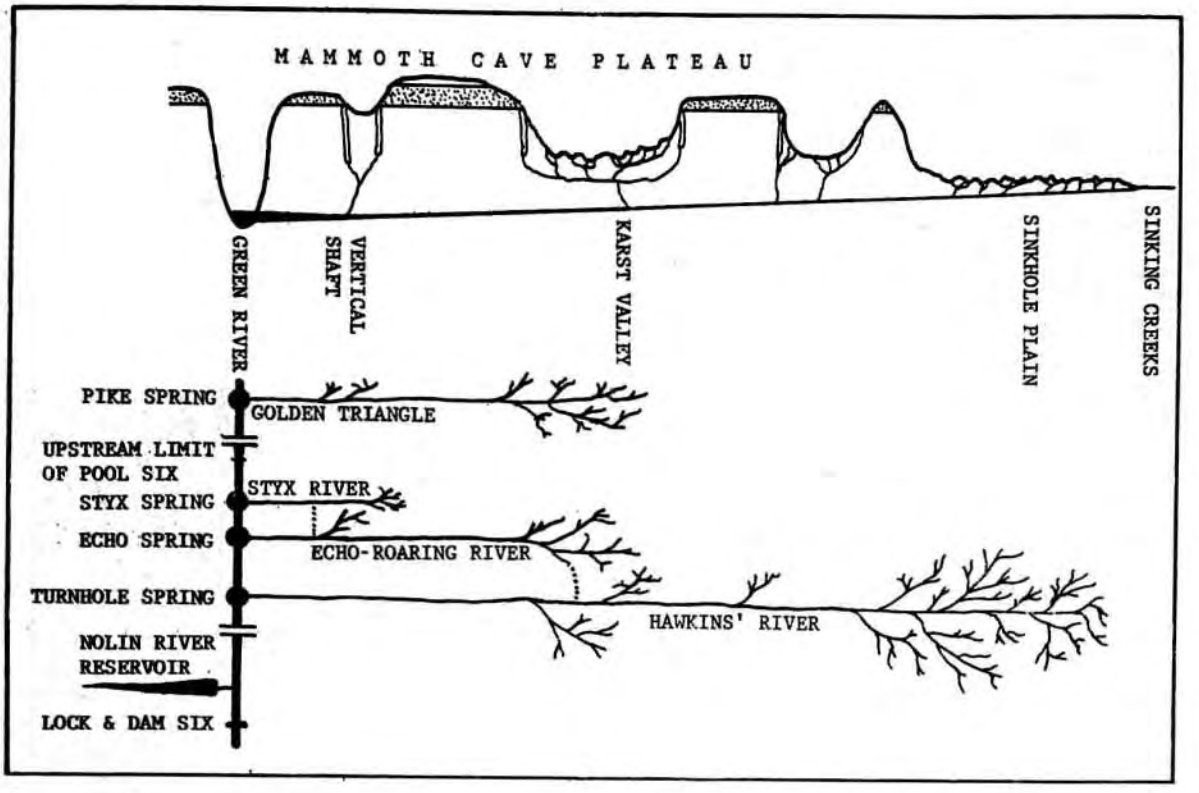

FIGURE 1. Sources of water in the base level rivers of Mammoth Cave. Five sources contribute water to the hydrologic system in the Mammoth Cave Region: sinking creeks, sinkholes on the Sinkhole Plain, karst valleys between the sandstone-capped ridges, vertical shafts which conduct water downward from the edges of the ridges and backflooding from the Green River. For clarity, only the Styx, Echo-Roaring and Hawkins rivers are shown. Hydrologic connections during high water are shown as dotted lines.

falls on the sinkhole plain sinks quickly underground to the base level cave streams as does the precipitation that falls on the karst valleys separating the three major ridges over Mammoth Cave. Precipitation that falls on these caprock protected ridges is conducted downward at the edges of the ridges to base level through a complex of vertical shafts. Finally, an immense amount of water is backflooded far into the base level cave passages during the seasonal winter flooding of the Green River, which has flood crests up to sixty feet.

Each of these sources of water, if polluted, can adversely affect the Kentucky blind cave shrimp. Hidden River Cave, in the nearby town of Horse Cave, is a prime example of the effects of pollution on cave biota. This cave, once a municipal water supply and a commercial show cave, was so polluted by residential, creamery, and industrial wastes, that it was closed and all the cave life in it was destroyed. Forty years later, many of the major sources of pollution have abated, but much of the pollution still persists and the cave animals have not recolonized Hidden River Cave.

Fortunately, none of this polluted water regularly flows through the shrimp's prime habitat in Mammoth Cave. However, during 1979, a massive crayfish kill occurred in Joppa Ridge's Hawkins River, a major underground stream that receives water from the sinkhole plain. Pollution, and in particular petroleum contamination, is the most likely cause of the crayfish kill, since large dollops of a petroleum-based sludge were seen floating on Hawkins River. Possible sources of this pollution are a fuel oil tanker-truck which overturned earlier that year near Cave City, gasoline spills that are hosed off service station driveways and flow in sinkholes, or a storage tank that was leaking large quantities of gasoline until the leak was discovered.

A similar disaster, larger in magnitude, was narrowly avoided in June 1980. A fiery collision between two trucks, one of which was carrying printers ink and cyanide, forced the evacuation of portions of Cave City for a day and a half. Only luck and immediate action by EPA and NPS officials prevented large quantities of cyanide from entering Hawkins River and killing all its aquatic life downstream to the Green River.

During high flow conditions, some Hawkins River water, which occasionally is contaminated by pollution, crosses underground drainage divides and flows into Roaring-Echo River. Fortunately for the shrimp, during low water conditions, Hawkins River water does not flow into Echo-Roaring River or Golden Triangle, the only two known localities for the Kentucky blind cave shrimp.

Since, during low flow conditions, the water at these two localities comes primarily from sources within Mammoth Cave National Park it is not heavily polluted. However, the Great Onyx Job Corps Conservation Center's sewage lagoon on Flint Ridge has contaminated cave streams. The shrimp were last seen in the Golden Triangle area of Flint Ridge just before the first of a series of overflows of the lagoon into the cave.

Under certain hydrologic conditions surface water from the Green River also enters the shrimp's known habitats. When the Green River is higher than the cave streams, the hydrostatic pressure forces surface water through the springs and far into the low-gradient base level passages. When polluted, this surface water can adversely affect aquatic cave ecosystem. Beginning in 1958, a considerable amount of brine pollution, high in chloride ion concentration, was discharged into the Green River from the Greensburg oilfield upstream from Mammoth Cave National Park. This brine pollution continued for several years until stopped by enforcement of disposal regulations. By monitoring the chloride ion concentrations, Hendrickson (1961) was able to trace the movement of water from the Green River into the Styx River Spring, through Styx and Echo rivers and finally out the Echo River Spring. He calculated that during the period 8-12 March 1960 "about 40 percent of the water discharged from Echo River at this time came from the Green River and about 50 percent came from local groundwater runoff." A reduction in sightings of cave fish, crayfish and shrimp occurred just after the contamination of the Green by these oilfield brines and related hydrocarbons.

Strict enforcement of environmental protection laws and implementation of a regional sewage treatment plan will improve the quality of both the surface and sub-surface water in the Mammoth Cave Region. The reduction in water pollution will enhance the chances of survival for the shrimp. However, another serious threat to its survival remains in the form of adverse modifications of the prime habitat by dams on the Green River.

Lock and Dam Six, completed in 1906, was constructed as part of a series of navigational improvements to the Green River. Its primary purposes were to encourage development of mineral resources along the Nolin River and to permit navigation on a year round basis as far upstream as Mammoth Cave Ferry, near Echo River Spring. A general decline of shipping on the upper Green began in the 1930's, and, in 1951, the U. S. Army Corps of Engineers, which constructed and administered the structures, deactivated Locks and Dams Five and Six due to a lack of traffic. Subsequently, Lock and Dam Four collapsed in 1965, ending all shipping upstream from that point.

The abandoned Lock and Dam Six is located immediately downstream from the boundaries of Mammoth Cave National Park. The impoundment artifically backponds water on the lower 17 miles of the Green's 26-mile course through the park. Although the lower cave streams of Flint Ridge (e.g., the Golden Triangle), upstream from the impoundment, remain free-flowing at low Green River flows, they are backflooded during high flows more frequently than before construction of the dam. The lower cave passages of Joppa and Mammoth Cave ridges that are within the impounded area are packponded at all times.

Backponding from Lock and Dam Six considerably reduces the available cave habitats in the base level passages. A comparison of pre-1906 and post-1906 maps of the lowest levels of the historic sections of Mammoth Cave reveals that several dry passages are now perennially flooded (Figure 2). Previously

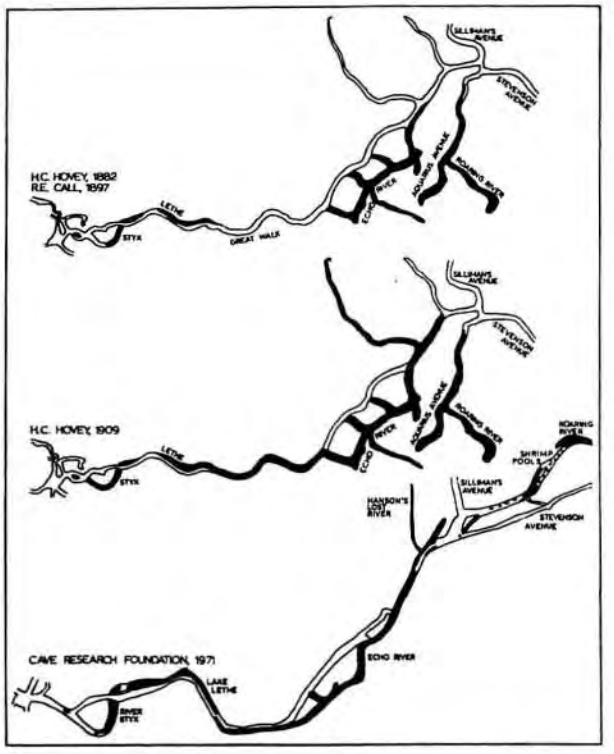

FIGURE 2. A comparison of pre- and post-Lock and Dam Six maps of the baselevel river passages of historic Mammoth Cave. The Hovey and Call maps are redrawn from sketches, and the Cave Research Foundation map is from a compass and tape survey.

dry areas such as Hanson's Lost River and a section of the Echo River passage between Echo River and Silliman's Avenue now contain four to five feet of water. Written accounts of early visitors and explorers are also revealing. Hovey, in 1897, wrote: "The Great Walk is only five feet above low water mark." Later in 1909, he stated: "The Great Walk for four hundred yards used to be admired, but now its beautiful yellow sand is covered by the back-water from the rivers." Also, free-flowing cave streams, with alternating riffles and pools, have become perennially backponded pools.

Perennial backponding increases siltation at the interface between the backponded waters and the free-flowing cave streams. These silt deposits act to retard the flow causing additional siltation immediately upstream. Thus, additional aquatic habitats become silted over as the interface between the perennially backponded cave waters and the free-flowing waters migrates upstream.

Because of siltation, the diverse stream habitat, with patches of silt, sand, gravel, rocks, and boulders, has become a nearly uniform habitat of silt-bottomed pools. In Echo and Styx rivers of Mammoth Cave, this simplification of the aquatic habitat has resulted in a documented reduction of the areas where aquatic cave animals, in particular, the cave fishes and crayfishes, are seen. It has also reduced the overall numbers of each species

According to the Corp's figures, the minimum water surface at Echo River Spring will be five feet

lower after removal of Lock and Dam Six. Furthermore, the Styx River Spring, which is almost continually flooded by the impoundment, will experience free-flow out of the cave 45 percent of the time. Removal of Lock and Dam Six will restore the free-flowing conditions in the lower levels of Mammoth Cave. This will flush out the silt as well as restore the diversity of the aquatic habitats and increase the population density of the cave species.

In addition to reducing the area of suitable habitat for the Kentucky blind cave shrimp, Lock and Dam Six is also altering the seasonal flooding regimes. Flooding normally occurs from early winter through late spring. A drier period, extending into the fall when the water table generally is at its lowest level, follows.

Lock and Dam Six increases the occurrence of unusual summer and fall flooding of the shrimp's prime habitat. Because of the increased Green River level, surface water now enters the River Styx Spring during the summer months, whereas this occurred rarely, if ever, before the construction of the dam. This adversely impacts the aquatic cave organisms in three ways. First, summer backflooding forces warm surface water into the cave streams. On 30 May 1960, Hendrickson (1961) observed an abrupt rise in temperature of Echo River from 54° to 70° F. Aquatic cave animals are physiologically less able to tolerate warm water than the cold water that is backflooded during normal winter floods. Second, organic pollution, with attendant algal blooms, gives a temporary competitive advantage to the non-troglobitic short-lived opportunists that occasionally enter caves at the expense of troglobitic long-lived specialists, which are adapted to the normally low food supply. This simplifies the community and is called the paradox of enrichment. Third, increased summer and fall backflooding increases the likelihood that toxins will be washed into the cave when they are concentrated due to low Green River flows. Summer and fall releases to increase winter storage capacity from the Nolin River Reservoir, starting in 1963, and from the Green River Reservoir, starting in 1969, aggravates these impacts.

Because Lock and Dam Six increases the water levels, on the average, the seasonal winter flooding of the shrimp's prime habitat occurs earlier in the shrimp's life cycle. The young shrimp hatch in the early fall when chances of flooding are minimal and prey density is maximal. Modifications of the timing of winter flooding affect the young shrimp by either diluting their food supply or washing them into unfavorable habitats before they can cope with the large rivers. Fall releases from the Nolin River and Green River reservoirs have a similar adverse impact (Figure 3).

The combination of habitat modification or destruction and unnatural floods during the critical fall hatching and growth period most assuredly keeps the population size of the shrimp at a very low level. The continued survival of the Kentucky blind cave shrimp depends on steps that will raise the population level so that the species will be able to withstand the uncertainties of its limited and food-poor environment and will restore the natural risk-spreading mechanisms.

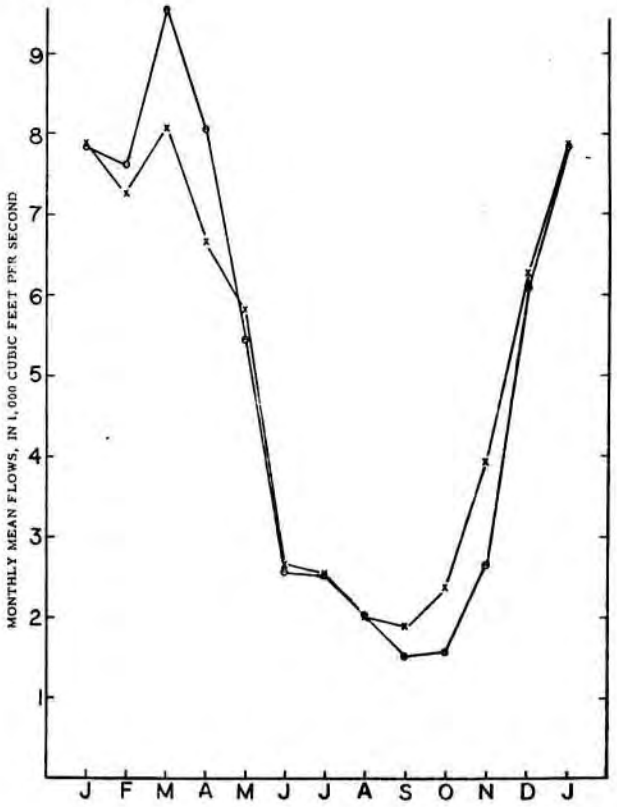

FIGURE 3. Altered Seasonal Flows. The monthly mean flows of the Green River at River Mile 181.7, 200 feet upstream from Lock and Dam Six, for the water years 1965 to 1978 (U.S.G.S. data), Monthly mean flows regulated by the Nolin and Green River Reservoirs are indicated by an "X". Monthly mean flows adjusted from the changes in contents of the reservoirs are indicated by an "0". Floods of short duration as well as extremely low flows can occur anytime during the year. Without releases from the two reservoirs, the average flows would be lower in the summer and fall and higher in the winter. For example, during November 1970, the natural flow of 2871 cfs was increased to 5661 cfs by releases of 1284 cfs from the Nolin River Reservoir and by releases of 1506 cfs from the Green River Reservoir. Removal of Lock and Dam Six will not alter these flows but will lower the elevation of the water during low flow by nine feet to the elevation of Pool Five at the site of Lock and Dam Six. The low water elevation at Echo River Spring will be lowered by five feet.

A species spreads its risk of total extinction when its individuals are in different patches of a habitat or in different types of habitat. A species that utilizes habitats that are both large in number and size is better able to survive major disturbances than a species that utilizes habitats that are small in either number or size (Figure 4). Not all populations will be equally vulnerable to a local disaster, so, some will survive. Once the surviving populations build up in size, some individuals may recolonize areas where the rest of the populations went extinct.

Because the shrimp have highly specialized habitat requirements, restricted geographic range, and poor powers of recolonization, all the adverse impacts discussed above are especially detrimental to the

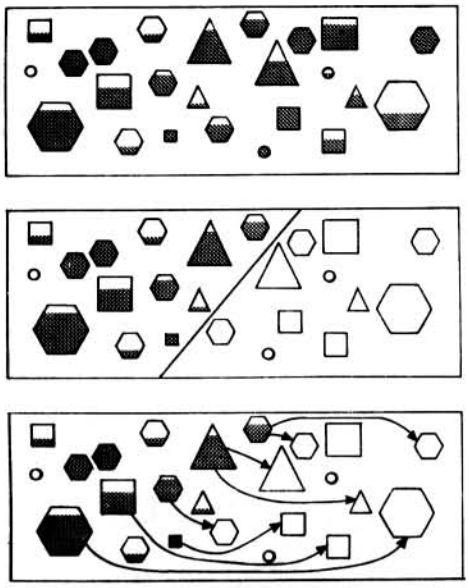

FIGURE 4. Spreading the Risk of Extinction. Each type of geometric figure represents a type of habitat for a different species, and the size of the figure represents the size of the patch. The area of the stippling is proportional to the number of individuals in the patch. If a disturbance eliminates populations in some of the patches, individuals from other patches can recolonize. The "circle" species has become extinct since all of its populations were eliminated by the disturbance.

Kentucky blind cave shrimp compared to the cave fishes and crayfishes in Mammoth Cave. Even in the absence of the man-made adverse impacts, the shrimp lead a precarious existence. A petition to nominate the shrimp for Endangered Species status was submitted to the U. S. Fish and Wildlife Service on 12 January 1977. To comply with the 1978 Endangered Species Act Amendments, the USFWS withdrew the petition on 10 December 1979.

Although many people were convinced that the shrimp was extinct since none were seen for twelve years, Cave Research Foundation investigators began an intensive search for it during 1979. On 1 September 1979, a single dead specimen was found in the Shrimp Pools. It was probably killed by an unusual summer flood, which occurred during the previous week. The discovery of the dead shrimp provided crucial evidence that the shrimp is not extinct and constituted sufficient new information to warrant a new petition to list the species. Dr. Raymond Couchard, Chairman, Freshwater Crustacean Specialist Group, International Union for Conservation of Nature and Natural Resources, submitted the petition on 12 December 1979. The USFWS agreed to repropose listing the Kentucky blind cave shrimp as an Endangered Species, and will conduct a public meeting on 10 December 1980 in Bowling Green, Kentucky.

In summary, removal of Lock and Dam Six and modifications in the summer and fall releases from Nolin River and Green River reservoirs are necessary for the survival of the Kentucky blind cave shrimp. this will prevent unnatural summer and fall backflooding when the newly hatched shrimp are most vulnerable. More importantly, removal of Lock and Dam Six will restore free flow out of the cave into the Green River. This free flow will flush out silt deposits, restore habitat diversity, and increase the size and numbers of optimum pool microhabitats, which will make the shrimp population more stable by restoring the natural risk-spreading mechanisms. The shrimp, as an indicator species, mirrors the condition of the entire base level aquatic ecosystem. To restore conditions needed by the shrimp is to restore overall habitat diversity and thus the biotic diversity of the ecosystem. This restoration is critical for the survival of the endangered Kentucky blind cave shrimp, *Palaemonias ganteri* Hay.

UPDATE; SCUBA divers observed six Kentucky blind cave shrimp near the Fourth Boat Landing on Echo River on 29 November 1980. The shrimp was examined, photographed, and released in its original habitat. On 10 January 1981, Cave Research Foundation biologists observed three shrimp in the Golden Triangle of Flint Ridge during a period of unusually favorable water conditions.

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THE HART'S TONGUE FERN - AN ENDANGERED PLANT IN CAVE ENTRANCES

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ABSTRACT

The American Hart's-tongue Fern (Phyllitis scolopendrium var. americanum) occurs in widely disjunct populations in northeastern and southeastern North America. In its northern distribution it occurs in scattered populations on calcerous outcrops in central New York State, the Bruce Peninsula region of Ontario and the Upper Peninsula of Michigan. In the southeastern United States it was known historically from two locations in Tennessee, one of which is now destroyed. Attempts by botanists to find new populations have not been productive, but in the last three years two new populations have been discovered by spelunkers in Alabama. The three extant populations are in pits, or sinks, with superficially quite differing ecological habitats, from relatively exposed and dry to extremely dark and humid. These southern populations are presumed to be Pleistocene relicts of then widespread boreal floras. The ecological adaptations of these ferns to these restricted environments need to be better understood. The taxon has been proposed for listing as Federally Endangered by the U. S. Fish and Wildlife Service and is under study and review. Alerting spelunkers and other interested cavers appears to be a significant way to help protect and study known populations, and to aid in locating new ones.

The current interest in our "rare plants" has provided us with opportunities to investigate certain aspects of the natural history of some of the critical organisms in our flora.

The early stages of our concern with protection of fragile elements of our flora inevitable revolved around the philosophical questions of what constitutes "rarity" and which of the various proposed categories should be applied to any given taxon. Categories have become relatively well-established, and we are not fitting these biota into convenient man-made categories of "endangered", "threatened", "extirpated", etc. — a novel, thought-provoking, and often amusing verbal and philosophical debate. We are also primarily in the inventory phase of this process. Individuals and agencies are putting considerable effort into attempting to inventory localities, describe habitats, search the literature for historical records and information, and provide management proposals for designated plants. This has provided an impetus for much-needed field studies into some very worthwhile fragile and unusual habitats and organisms, but one is constantly reminded that the next step in the process is research into the ultimately most important question of what makes particular types, or groups, of organisms "rare". What causes certain taxa to become restricted to particular scarce or fragile habitats? Is it because the habitat itself provides some positive environmental ingredient, or is it a more negative force in which the organism may actually be more broadly adaptive, but lacks aggressive qualities to compete successfully in more favorable sites. There is general agreement that our concerns with protecting "rare" organisms usually boil down to a question not of preserving the biota, but of preserving the appropriate habitats in which they naturally exist. Often the habitats themselves are unique and/or fragile and predictably we find that these localities harbor more than one, and sometimes several, of our designated rare organisms. For example, in the cedar barrens of middle Tennessee we have listed species in the genera *Petalostemum* and *Leavenworthia*. Along the narrow margins of the rough and tumble rivers of the Southern Appalachians we have *Conradina verticillata* (Cumberland Rosemary) and *Heterotheca ruthii* (Ruth's golden-aster) which be grown easily in cultivation, and on Roan Mountain and other high elevation outliers of the southern Appalachians we have *Lilium grayi* (Gray's Lily) and *Geum radiatum*, to name just a few ramdon examples. We can find these plants and we can make inferences as to why they might be where we find them. However, hard data on habitat adaptation is

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largely lacking. I expect that the next or eventual phase of search and recovery efforts will produce some quality research into the dynamics of the life cycles of the organisms involved and the organism-habitat interrelationships.

But in the present context, the discussion needs ultimately to relate to caves. To the spelunker and geologist, and even the zoologist, the interior of the cave is fair ground, if not the fertile ground; to the botanist the cave mouth may be of major interest as the interior is rather sterile. It would appear that the combination of geology and climate control produced by certain caves in this region have produced a situation which is of interest here.

The American Hart's-tongue fern (*Phyllitis scolopendrium* (L.) Newm. var. *americanum* Fernald) (Fig. 1) occurs in few widely disjunct populations in northeastern and southeastern North America. In its northern distribution it occurs in scattered populations on limestone and dolomite outcrops in central New York State near Syracuse, and along the Niagara escarpment of southern Ontario (Soper, 1954) and the Upper Peninsula of Michigan (Futyma, 1980). The plants occur primarily on moist cool talus slopes below cliffs usually shaded by forest and often associated with streams and waterfalls. On the Upper Peninsula of Michigan, the plants are more exposed, occurring on low-lying drier and less shaded limestone outcrops. In the southeast the situation is fascinatingly different. The plants have historically been known from two populations in Tennessee. It was first discovered at Post Oak Springs in Roane Co., TN in 1849 about a "dry cave" with a northwest exposure at the base of the escarpment of a large sinkhole basin (Maxon, 1900; McGilliard, 1936). There have been several reports in the literature since the turn of the century (Shaver, 1954) that this population has disappeared, and I also searched the locality about ten years ago without success. The extant Tennessee locality was first discovered in 1879 in a small pit just northwest of South Pittsburg, on the Alabama border, west of Chattanooga in Marion Co. (Maxon, 1900). This pit is about 25 m deep with a teardrop-shaped opening about 20 m long by 10 m wide. The walls are undercut so the interior is permanently shaded by the walls. A permanent stream enters from springs on the slope above the lip and spray from the waterfall into the pit keeps the humidity extremely high year around. The Hart's-tongue fern grows on the walls and ledges, but in very low numbers and with heavy competition from liverworts (*Conocephalum* sp.) which sometimes overgrow the plants. Over the past ten years, I have visited the locality during various seasons, and the number of plants have dwindled from 18 to 12. It was only this summer that I saw the first mature fertile plant — heretofore the plants have been perennial juveniles with leaves only up to ca. 5 cm long. As older reports have cited a gradual decline in numbers of plants from an early high of about 200, I believe that this population has been under severe stress and is probably in its last stages of decline and extinction.

I have sporadically searched the caves and sinks of Tennessee without success over the last decade

FIGURE 1. *Phyllitis scolopendrium* (L.) Newm. var. *americanum* Fern. Habit, X 1/8.

for new populations. There has been little doubt in my mind that this taxon existed in this one remaining known population as a distant outlier population of a once wide distribution during the glacial period. Whereas many examples of disjunct boreal plant populations have "hung on" to our southern Appalachian mountain tops, it would appear that the habitat requirement of cool moist shaded limestone has driven this particular species into the caves rather than to the mountain tops.

With the high number of cave systems in this region additional populations should turn up eventually, but the logistics of searching suitable caves have turned back much of the efforts of field botanists.

It was therefore delightful, and not altogether surprising, that two new populations of the Hart's-tongue have recently been found in pits in Alabama by botanically-inclined spelunkers, specifically Merilyn Osterlund. What is particularly interesting, however, is how different these two new populations appear to be from the Tennessee population and from each other.

In 1979, Short reported the first Alabama station in Jackson, County, in "The Morgue", part of the Fern Cave system on the west slope of Nat Mountain. The locality is quite different from the Marian County pit in Tennessee. The Morgue is an open, barrel-shaped pit with relatively straight sides, with two cavern entrances at opposite side and a high talus ridge across the middle bissecting the sink into two flat-sided funnels leading into the caverns. The pit is about 20 m deep at the two passage entrances but, from the low side of the

lip, only ca. 12 m deep at the top of the ridge across the middle. The ferns are not sheltered along the walls, but are on and about small boulders on the north-facing slope of the ridge bisecting the pit. They are quite exposed, growing with the Glade Fern (*Athyrium pycnocarpon*), the walking fern (*Asplenium rhizophyllum*) and several species of mosses carpeting the rocks. They are exposed to direct sunlight during mid-summer except for the tree cover surrounding the opening. The surrounding forest has recently been lumbered almost to the pit. Increased exposure to sunlight, drying in summer and probably increased wind flow caused by this logging may have some ecological effect on the microclimate within the pit and it will be interesting to follow this change over time. But the most visible difference between this and the Tennessee pit is that this one is dry, with no water flow except rainfall. Humidity is maintained by cool moist air flow out of the caverns keeping the temperature significantly below ambient outside the pit, and by fogs formed within the pit where the cool cavern air meets with warm air from above.

The fern population is also strikingly different from the Tennessee population. The plants are large, mature and vigorous, growing not as single individuals but as clumps of several connected by short branched rhizomes. There are only ten clumps, which are probably quite old. No small or juvenile plants occur, and no signs of reproduction were apparent.

Whereas the Tennessee population seems to be stuck in a relatively permanent juvenile stage with little or no mature reproductive foliage produced, the Jackson County, Alabama, population produces abundant, reproductively-mature leaves and abundant spores, but there is no sign of young spore-produced plants. The population seems to be stuck in an overmature state, with the plants increasing in size by forking of the rhizomes (stems) but not producing new individuals. During the interval between two visits in February, 1978 and August, 1980, several plants have disappeared, either by washout or possibly by human disturbance. The conspicuous losses are several plants which grew on one of the ledges where not only one very inaccessible plant remains.

Recently, a second Alabama population was found, again by Merilyn Osterlund, which I visited in August, 1980. This one is in Peterson Pit, Newsome Sinks, Morgan County, Alabama, and it has some striking departures from the other two. The habitat is intermediate between the previous two, at least in apparent ecological features. It is an open pit similar to The Morgue, with a sloping floor to a single cavern. The pit is ca. 25 m deep at the cavern mouth, and about 20 m in diameter, more or less round, and more or less straight-sided, but with a conspicuous ledge about half way down, in which the Hart's tongue ferns grow. This pit is open and exposed to, at least, shaded forest daylight. The ferns are on the northwest to southwest side, with an east exposure, but probably far enough into the pit that they rarely have direct sunlight. The wall above the ledge is undercut, providing a crawlspace shelter, and the ferns are growing under this overhang on a wet sheltered clay bank. There is a waterfall into the pit, so that this one is more moist than The Morgue. But here the most striking aspect of the situation is that the fern population is a very vigorous one. There are over 100 plants in all stages of development from tiny juvenile sporlings to substantial mature plants with leaves up to 40 cm long. This is the most vigorous population of the three in the southeastern United States, and is what one would expect to find in a healthy, well-adapted population of actively reproducing plants. This population suggests that this species is still adapted to appropriate environments in the southeast, and gives me substantial confidence that other populations exist in this region.

The major thrust of this paper is to bring this situation to the attention of cavers, perhaps stir some botanical curiosity, and hopefully come up with additional finds which can be compared to the three we know of so far. These three are so different in so many fascinating ways. Although they can be studied, and hopefully protected, additional localities can present us with better means of analysing and predicting what might be the norms for *Phyllitis scolopendrium* var. *americanum* in the southeastern United States.

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THE ECOLOGY OF HAWAIIAN LAVA TUBES

*Francis G. Howarth

ABSTRACT

The geologically young tropical Hawaiian archipelago is the most isolated group of high oceanic islands. Its native fauna reflects that isolation, as relatively few continental groups, particularly representatives of continental cave faunas, managed to colonize Hawaii. Yet in 1971, a diverse assemblage of highly specialized cave arthropods was discovered living in Hawaiian caves. These evolved from representatives of the speciating native fauna by the process of adaptive shifts. The deep cave zone, where the troglobites are found, is a rigorous or harsh environment that is perpetually dark, with a relatively constant temperature, with a water saturated atmosphere, and without many of the temporal cues used by surface species. The most critical environmental factor determining the distribution of troglobites within inhabitable caves is the stable saturated atmosphere. Young basaltic lava has numerous voids which allow intercave and interlava flow dispersal of troglobites. In fact the largest populations of troglobites are believed to inhabit these voids, and only where food and environment allow, do they enter and colonize the larger cave passages. The main energy source in the Hawaiian cave ecosystem is tree roots. Feeding on these roots are troglobitic cixiid planthoppers, noctuid moth larvae, and Dimerogonus millepedes. Six species of true crickets, Gryllidae, are omnivorous. A blind "terrestrial" water treader scavenges on dead arthropods. The blind predators include a thread-legged bug, a large earwig, and 2 remarkable wolf spiders. It is with some trepidation that I made the existence of this fauna known, for the increase in public curiosity means an increase in cave visitation. Caves are particularly sensitive to physical disturbance. Yet if the existence of these remarkable animals is not made public, then their habitats may be destroyed through ignorance during changes in land use.

The Hawaiian Archipelago is a string of young oceanic islands stretching more than 1500 miles across the northern tropical Pacific. They are isolated from other high islands and continents by more than 2000 miles, and relatively few terrestrial animals and plants managed to disperse to and colonize the islands naturally. However, many of those that won the dispersal sweepstakes evolved into many new species, giving Hawaii a bizarre and unique flora and fauna. Given the relative youth of the eastern high islands in general and the extreme youth of Hawaii's lava tubes in particular, it had long been assumed that specialized cave animals did not exist in Hawaii.

Thus it was quite surprising to discover in 1971 a relatively diverse community of native arthropods specialized to live in young Hawaiian lava tubes (Howarth, 1972). To date, more than 30 terrestrial troglobites have been discovered.

The cave ecosystem is rigidly defined by the geological setting. Thus, if we have an understanding of the geology of cavernous rock, we can better understand the adaptations of cave animals to their environment as well as the functioning of the cave ecosystem. Although some controversy concerning their formation still exists (see Ollier and Brown, 1965; Greeley, 1971; and Ollier and Zarriello, 1979), I follow Peterson and Swanson (1974) who vividly described the formation of lave tubes from actual observations in Hawaii.

Basaltic lava flows, the main building material of oceanic volcanoes, generally flow in 2 forms called the a'a and pahoehoe, differing mainly only in heat and gas content. A'a is cooler, contains less gas, and flows more sluggishly than pahoehoe. A'a flows advance much like a caterpillar tractor tread with a molten interior and a solid but irregularly broken surface crust that moves forward, breaks, tumbles in front of the flow, and is buried by the advancing flow. Pahoehoe, on the other hand, is hotter, has a highe. gas content, is more fluid, and flows as a river. These rivers tend to crust over by crystallization as the surface cools. The crystals grow along the leading upstream edge and also inward from the sides. This crust may grow quite fast over the flow. Eventually, if the flow is continuous, the crust may thicken enough to support itself and become a roof. Overflows of lava through

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skylights also may thicken and strengthen the roof. When the lava level subsides, secondary roofs often form below skylights. This natural healing of breaks keeps the pahoehoe moving, since the roof of basalt acts as a good insulator for the flowing lava beneath. This roofing and healing process is actually responsible for carrying pahoehoe great distances from the vent. The formation of lava tubes is one of the main factors in the formation of oceanic shield volcanoes, in contrast to the cone-shaped volcanoes of the continents, which are largely composed of andesitic lavas. Andesitic flows are more sluggish than a'a and generally pile up around the vent, thus the cone shape.

Other voids sometimes large enough to be considered caves may also form in lava. Overflows of pahoehoe spread out as thin layers. Degassing can swell the still plastic upper crust and form large gas bubbles. Also shrinkage during cooling may separate layers of lava, or cause extensive systems of cracks, creating voids. Gas vesicles form in the cooling lava from trapped bubbles. These may form extensive porous layers of vesicular basalt within a flow. Other voids, such as tumuli and buried tree molds also occur.

The cave ecosystem can be divided into 4 environmental zones. These are (1) an entrance zone where the surface and underground environments meet; (2) a twilight zone where light progressively diminishes; (3) a transition zone that is in complete darkness but where some outside environmental effects are still felt; and (4) a deep cave zone where the specialized terrestrial cave animals are found. The extent of the different zones depends on the size, shape, and location of the entrance(s), on the configuration of the cave passages, and on the subterranean moisture supply. The most critical environmental factor determining the distribution of troglobites within habitable caves appears to be the saturated atmosphere (Howarth, 1980). In order to confirm this observation I have been studying the microclimate of selected Hawaiian caves and correlating the data with the distribution of cave animals (Howarth, in press).

Charcoal Cave near Hilina Pali in Hawaii Volcanoes National Park at ca 800 m elevation is a large passage lava tube which trends downslope from its single large entrance. Kempe and Ketz-Kempe (1979) mapped and described the cave. Charcoal Cave appears to fit the type 1 category of Tuttle and Stevenson (1977) since its greatest volume is below the elevation of its large main entrance. However, the environmental data indicate that the passage has a small downslope entrance (Howarth, in prep.).

Preliminary reconnaissance indicated that Charcoal Cave had a very long transition zone and would be ideal for determining the climatic factors defining the transition/deep cave zone boundary. For 15 consecutive days from 21 August to 5 September, 1979, I gathered climatic data simultaneously from the twilight, transition, and deep cave zones. The stations were approximately 45, 110, and 185 meters, respectively, from the entrance. The maximum penetration of light into the cave is 70 m. A Weather Measure H311 hygrothermograph and 2 piche atmometers were set at each station. The piche atmometers were modified by using a larger filter paper disc, 5.5 cm diameter, in order to increase sensitivity, and a small plastic disc as an umbrella to divert the almost constant ceiling drip. An analysis of these data will be published elsewhere, but the results of the evaporation study are meaningful here.

When mean potential evaporation rate for the 4-day period from 28-31 August, as measured by the piche atmometers, is plotted against distance from the entrance of Charcoal Cave, the evaporation rate follows a nearly hyperbolic curve on its way into the deep cave. The rate of evaporation at the deep cave zone station was 0.15 cc per day or only 36% of the rate at the transition zone station and only 8% of the rate at the twilight zone station. Compared to the surface environment outside of the cave entrance, the twilight zone was still quite humid. Although not measured during the same period, the comparable evaporation rate outside of the cave was certainly over 9.0 cm^3 per day or over 5 times the rate of the twilight zone station. On 31 August 1979, specialized cave animals were found only beyond 165 m from the entrance. Thus, the boundary between the transition zone and the deep cave zone has a calculated evaporation rate of 0.16 cm^3 per day.

The rate of evaporation at each station varied during the study. However, there was a constant pattern of decreasing evaporation deeper within the cave. During the study the mean evaporation rates were 1.88 cm^3, 0.35 cm^3, and 0.11 cm^3 at the twilight, transition, and deep cave zones, respectively. The cave animals vary somewhat in their response to evaporation rate among different species. Significantly, some cave animals, notably the wolf spider, *Lycosa howarthi*, the rock cricket *Caconemobius varius*, the centipede, *Lithobius* sp., and the cave planthopper, *Oliarus polyphemus*, migrated towards the entrance during the periods of less evaporation. There was a good correlation between the measured evaporation rate and the distribution of specialized cave animals. These measurements were made about 25 cm from the wall and 1.5 m above the floor. The evaporation rate, of course, would be much lower next to the moist substrate where the animals are living.

Food Webs:

The main energy source in Hawaiian caves is tree roots which penetrate the young lava to a depth of 10 m or more. The 2 other energy sources are cave oozes, i.e., organic and mineral colloids deposited by percolating ground water, and accidentals, i.e., surface and soil animals that blunder into the cave but cannot survive there (Howarth, 1973).

Feeding directly on the roots are 2 species of blind cixiid planthoppers. All stages are found only underground. The adult is the dispersal stage and is quite distinct from its surface relatives which also feed on roots as nymphs, but their adults live and disperse above ground.

Several species of apparently troglobitic moth larvae also feed on tree roots. The best known of these is an undescribed noctuid which has a blind caterpillar, flightless female, and weakly-flying

male. A cave millepede and a remarkable blind terrestrial amphipod feed on both living and dead roots and occasionally other organic matter.

A blind terrestrial water treader scavenges on dead arthropods in the cave. Six species of omnivorous crickets are restricted to Hawaiian caves. These are true crickets, Gryllidae, and are not at all related to the continental cave crickets. One group, which is closely related to the native Hawaiian tree crickets, prefer to walk upside down on the ceiling. The other group belongs to the ground or rock crickets. These prefered thefloor, and have close surface relatives which scavenge on wet rocky substrate, such as unvegetated lava flows (Howarth, 1979), and sea coasts.

The predators include a thread-legged bug which prefers to sit and wait for prey on the ceiling, and a large blind earwig which prefers to remain in cracks and smaller voids in the lava and only rarely is found in cave passages. It is quite closely related to native surface species.

At the top of the food chain and perhaps the most exciting Hawaiian cave animals are the blind wolf spiders. The members of the family Lycosidae are characterized by the large, headlight-like front eyes and are called the big-eyed hunting spiders. Hawaii has a large and interesting surface lycosid fauna. It seems axiomatic that no member would become cave-adapted. However, on the Island of Hawaii there lives the cave-adapted, small-eyed big-eyed hunting spider. This species is common in low to mid-elevation lava tubes. But, even more remarkable, there exists in a small area on the older Island of Kauai another cave-adapted lycosid. This is the rare and endangered, no-eyed big-eyed hunting spider. This species perhaps represents the epitomy of adaptive shifts on oceanic islands.

Organic food energy is continually being washed into subterranean voids by percolating ground water and sinking streams. Other energy may be introduced by deeply penetrating plant roots and by dispersing animals. In non-cavernous areas this loss is probably not significant because the voids are small. But where there are extensive systems of interconnected subterranean voids such as one finds in basaltic or karst areas much of this energy is carried out of reach for surface detritivores. To be sure where the debris is trapped or concentrated such as near entrances some of it may be harvested by migrating surface animals. However, the rest is probably unobtainable to opportunistic surface species either because the resource is too diffuse to allow adequate harvestable energy to maintain their lifestyle, because of their inability to locate the scattered resources in perpetual darkness, or because they cannot cope with the constantly hydrating atmosphere. Some preadapted species and their associates, i.e., predators, etc., have made the adaptive shift to exploit this resource which I believe is relatively rich. Evolution has made them finely tuned to efficiently exploit the resources.

Basaltic lava, particularly pahoehoe, is so porous from gas vesicles, cracks, lava tubes, and other voids that there exists within the younger flows an extensive system of interconnected channels and air spaces. In the deeper zones of this system where the temperature is relatively stable, the relative humidity reaches equilibrium at saturation, and the evaporation rate is negligible. At these humidities insect blood is hygroscopic (Edney, 1977) and would therefore be continuously drawing moisture out of the air.

I believe that the major populations of cave animals live in the smaller interconnected voids within the lava below the variable temperature zone, and colonize the larger cave passages only where food and evaporation rate allow, and it is here that they have been studied. Therefore, caves are only a window to view the fauna within the voids in the rock. But it is an imperfect window, for it is a fragile one and gives the illusion of a food-poor environment. In few other habitats is man so clearly an intruder than in the subterranean world.

Conservation

Continental caves are often viewed as islands and their ecosystems share an apparent fragility in response to perturbations. Cave ecosystems on islands, i.e., island-like habitats within islands, may be in double jeopardy, and several of the newly discovered arthropods are candidates for endangered species status. What then is the future of this unique ecosystem, not even recognized before 1971? If perturbations had caused its demise sometime during the last 200 years, biologists would have continued to believe no such fauna had ever existed in the Hawaiian Islands.

On Hawai'i Island there are still many avenues of dispersal between lava tubes, and continual new flows can be expected; therefore, one can expect the survival of most of the cave fauna, barring any major catastrophies. On the older islands of Maui and Kaua'i the caves are eroded remnants, many of the avenues of dispersal are closed through erosion, and the cave animals lead a tenuous, threatened, or endangered existence.

Certainly caves fill and erode as natural processes, but man hastens the process. For example, a lava flow on Kaua'i was covered with 5 m of sugar cane bagasse in an effort to build up soil on the surface. The cave under the field became filled with fermenting molasses. The ecosystem and its specialized life was presumably destroyed. The destruction of the native forest and the life-giving roots destroys the hidden and still largely unknown cave fauna beneath. Unfortunately, caves and sinkholes are often used as garbage dumps. For example, in Offal Pit, which was used by a local slaughter house, there are hundreds, perhaps thousands of cow skulls and bones, and the downslope section is a mess of rotting tallow and bones. Only one native cave animal survives in this rotting soup and that is the native rock cricket, *Caconemobius howarthi*. Even human visitation disturbs the fragile ecosystem. Caves share with other discrete habitats such as montane bogs and sand dunes a vulnerability to trampling and physical disturbance. Tobacco smoke contains a powerful insecticide which certainly challenges, if not kills, many cave animals. The smoke from torches and cigarettes also lowers the relative humidity and may jeopardize the ecosystem. Heavily visited caves are often lacking many specialized species.

Many arthropods recently introduced by man, such as cockroaches, centipedes, millepedes, isopods, and spiders, have successfully colonized lowland caves. Some of these exotic, i.e., non-native animals have surely altered the ecology of the caves, but it is unknown whether any replaced native species in the cave ecosystem, since this is also the region most disturbed by man.

Lastly, caves are somewhat dangerous to the uninitiated. Recreational cave visitation by the public should be discouraged until adequate protection of sample caves and ecosystems is assured.

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THE MISSOURI COOPERATIVE CAVE INVENTORY PROJECT: A BIOLOGICAL RESOURCE SURVEY

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ABSTRACT

Missouri contains over 4000 known caves. A significant number of these caves are found on United States Forest Service and Missouri Department of Conservation lands. Management responsibilities for the cave resources on state and federal lands prompted the Missouri Department of Conservation, the Mark Twain National Forest and the North Central Forest Experiment Station-Columbia, Missouri to enter into a cooperative cave inventory agreement in October, 1978. Completion of the first two years of study revealed that state and federally managed caves contained diverse assemblages of fauna and many other significant cave resources. Many of the caves contain populations of federally listed endangered and threatened species. They could thus be candidates for critical habitat designation.

Over 230 caves have been inventoried on Missouri Department of Conservation and U. S. Forest Service lands to date. The majority of these caves represent vast research potentials. Although a biological analysis was the focal point of the inventory, many kinds of cave resources are considered when management plans are developed. With a recently awarded 20-month extension and the inclusion of caves on Missouri Department of Natural Resources, Division of Parks and Historic Preservation (state parks) properties, significant additional cave resources are expected to be discovered.

INTRODUCTION

Caving as a sport activity has greatly increased in Missouri in recent years. This fact, combined with the almost inevitable deterioration of cave resources resulting from heavy uncontrolled usage, indicated a need to assess and evaluate cave resources on public lands. In October, 1978, the Missouri Department of Conservation, the Mark Twain National Forest, and the North Central Forest Experiment Station-Columbia, Missouri, entered into a cooperative cave inventory project. It is the responsibility of the U. S. Forest Service and the Department of Conservation to direct their program activities toward managing and enhancing the environment for the widest range of beneficial uses without its degradation, risk to health or safety, or other undesirable consequences. Cave resources are undoubtedly an intrinsic part of our environment, but responsible management and enhancement of any environment cannot be accomplished without first identifying the elements of that environment. Cave resources require some very special considerations.

OBJECTIVES AND CONSIDERATIONS

Although a biological inventory of caves on U. S. Forest Service and Department of Conservation lands was the initial objective of the study, it soon became evident that many products would be realized from such a comprehensive undertaking. Some primary objectives of the inventory were to:

1. Determine the name and exact location of caves on the properties of the Mark Twain National Forest and the Missouri Department of Conservation.

2. Complete a comprehensive inventory of all known caves on the properties of the above-mentioned agencies.

3. Compile vertebrate and invertebrate species data gathered during the cave inventory. Published data will also be included with the information.

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4. Place special emphasis on gathering information on the status of federally listed endangered and threatened species and state rare and endangered species and their possible critical habitats. Emphasis was also placed on gathering data on species which are not on the federal or the state lists but have particular scientific, management, local or national interest in some specific location (i.e., *Typhlichthys subterraneus*, southern cavefish; *Typhlotriton spelaeus*, grotto salamander; and *Eurycea lucifuga*, cave salamander).

5. Provide information on present and potential recreational usage of caves on public lands.

6. Develop a cave classification system based on all data obtained by the cave inventory.

7. Provide recommendations for the management of cave resources on a per-cave basis to the responsible managing agencies.

At the present time, there are over 4000 known caves in Missouri that have been recorded and entered into a computer system by the Missouri Speleological Survey and the Missouri Department of Natural Resources, Division of Geology and Land Survey. With the cooperative sharing of this stored information, we determined that approximately 282 caves could be found on U. S. Forest Service lands and approximately 70 caves were owned by the Department of Conservation. Since a considerable proportion of caves in Missouri occur on state and U. S. Forest Service lands, they must undoubtedly represent significant natural resources. However, previous information concerning resources on U. S. Forest Service and Department of Conservation caves was virtually nonexistent. It was not evident that these caves contained unique and diverse resources until the completion of the first two years of the cave inventory project. Our goals are to further evaluate and identify cave resources on public lands and to develop a responsible management program to enhance cave resources.

BIOLOGICAL RESOURCES

Although objectives of the cave inventory were broad in scope, primary emphasis was on gathering biological data. Small collections of invertebrates were made by hand collection-search methods. Previous cave-collecting experience and consultation with experts on different faunal groups greatly reduced the possibility of harmful collections, thereby minimizing impact. Attempts were made to examine every conceivable habitat in each cave visited. Vertebrates were not collected but were examined and identified in the cave. The collections of invertebrate specimens were sorted, catalogued, labeled, and shipped to taxonomists for identification.

There are over 32 invertebrate taxonomists throughout the United States and Canada cooperating with identifications of cave fauna. The taxonomic groups of invertebrates and the cooperating professionals for the groups are given in the acknowledgements. Our catalogue of cavernicolous materials, volume 1 and 2, has over 2200 specimen entries to date. A total of 219 species of invertebrates have been identified. However, only approximately 60% of the materials have been examined. Over 50 species of vertebrates have been observed and identified, including rare and endangered species.

Many invertebrate species represent important zoogeographical records. Fifteen invertebrate species collected represent new, undescribed species. In most cases, enough specimens were collected to allow the cooperating scientists to publish new species descriptions. Additional materials of previously known, undescribed species were also collected and have in some cases stimulated continued taxonomic work on certain taxa. Greatly needed information collected on invertebrate species has provided valuable information on their distribution and population status.

PALEONTOLOGICAL RESOURCES

Missouri has been noted for bone deposits since Dr. A. K. Koch's visit in 1839. The almost constant cave environment is an ideal storage place for the remains of extant and extinct animals. Significant Pleistocene deposits have been unearthed in Missouri with a substantial percentage being discovered in caves. During the survey, nine U. S. Forest Service caves and eleven Department of Conservation caves contained materials of paleontological significance. One department-owned cave contained a deposit of the extinct flat-faced peccary (*Platygonus compressus*), and still another cave contained remains of the extinct dire wolf (*Aenocyon dirus*). Remains of species which are no longer indigenous to Missouri have been identified from some survey caves and are also valuable to paleontologists.

ARCHEOLOGICAL RESOURCES

A number of U. S. Forest Service and Department of Conservation caves in Missouri contained significant archeological materials. Although some state and federally managed caves have been examined by professional archeologists, the majority have not. Already many of these potentially important sites have been ruthlessly plundered by relic seekers and amateur archeologists, resulting in the loss of valuable data. Some surface artifacts were discovered in caves during the survey and several potentially important sites have been identified.

GEOLOGICAL RESOURCES

Few caves on U. S. Forest Service and Department of Conservation lands contain outstandingly rare of beautiful speleothems. It is truly unfortunate that most caves which once contained unique speleothems have been irreversibly vandalized. Only those areas of the cave which are not easily reached or are simply not known about have retained their pristine beauty. The few remaining caves which contain significant speleothem deposits will undoubtedly be protected for future study.

With such a large number of caves managed by the U. S. Forest Service and Department of Conservation, there are many excellent opportunities for the study

of karst geomorphology, stratigraphy, speleogenesis, and mineralogical and sedimentological studies. The many spring caves and caves with deep lakes and streams scattered throughout the state provide a variety of study for hydrologists and geologists.

RECREATIONAL RESOURCES

Recreational use of caves on public lands in Missouri has been phenomenal in recent years. The obvious vandalism and destruction of cave features and cave habitats (including cave fauna) has been extremely detrimental to non-renewable cave resources. There is, perhaps, a glimmer of hope with the recent passage of a cave protection law. House Bill No. 1192, known as the "Cave Resources Act", becomes effective on January 2, 1981, and provides for the protection of all natural cave features and cave gates and supports the Missouri Clean Water Act (in the form of ground water pollution). It is a Class A misdemeanor for each violation of the new law. Unfortunately, provisions for the protection of indigenous cave life were deleted.

Recreational use of caves is recognized as part of the multi-use philosophy employed by the U. S. Forest Service and Department of Conservation. However, both agencies are also responsible for wise management of natural resources. When the cave classification system and management recommendations are implemented, it is inevitable that certain caves will be closed to recreational use. For example, gray bat (*Myotis grisescens*) nursery caves are closed to public usage from April 1 through October 31, and Indiana bat (*Myotis sodalis*) hibernacula are closed from September 1 through April 30. Six Department of Conservation caves and one U. S. Forest Service cave have been closed because they are important to the survival of the two endangered species of bats.

Some caves will be opened only on a permit basis because of serious, unavoidable hazards. It is the managing agencies' responsibility to institute adequate warning procedures. It is reasonable to say, however, that the majority of the caves will remain open year round for recreational usage.

Efforts are being made to encourage the cooperation of sport cavers in the conservation of cave resources. Plans for simply-worded signs are being made and implemented. These signs will be placed near, or just inside, cave entrances and state briefly the cave visitor's responsibilities, safety and caving ethics. Educational public-awareness efforts in the form of television programs, public speaking, newspaper and magazine articles, public displays and narrated slide programs have been a part of the cave survey. With the cooperation and volunteer help of concerned individuals of the Missouri Speleological Survey, two caves have been cleaned up, and there are plans for more clean-up activities in the future.

PROJECT EXTENSION

As of October 1, 1980, the cooperative cave inventory agreement between the Mark Twain National Forest and the Missouri Department of Conservation was given a 20-month extension. Inventories of approximately 115 more U. S. Forest Service caves and eleven Department of Conservation caves are scheduled to be completed by May 20, 1982. Additionally, the Missouri Department of Natural Resources, Division of Parks and Historic Preservation (state parks), successfully negotiated with the Department of Conservation for inclusion in the cooperative inventory. The Missouri State Parks agreement should become effective in the fall of 1980. The additional inventory of approximately 70 caves on state parks lands, remaining U. S. Forest Service caves, and Department of Conservation caves is expected to greatly increase knowledge of Missouri cave resources. Cooperation between these three agencies has greatly enhanced speleo-conservation efforts in Missouri and should continue to do so in the future.

SUMMARY

Since the initiation of the cooperative cave inventory project in October, 1978, inventories of 174 U. S. Forest Service caves and 59 Department of Conservation caves have been completed. There remains approximately 115 U. S. Forest Service caves and eleven Department of Conservation caves to be found and inventoried.

Biological information gathered on such a vast number of caves scattered throughout Missouri provided important data on the occurrence and distribution of cavernicolous animals. Although only about 60% of the specimens collected from caves have been examined and identified by taxonomic specialists, 219 species of invertebrates have been identified. With the anticipated identification of the remaining materials, additional cave species will more fully complete the distribution and occurrence of cave fauna in Missouri. Fifteen new, undescribed species of invertebrates have been collected. A total of 54 species of recent vertebrates have been observed and identified in the survey caves. Comprehensive biological data on such a broad scale has provided needed insight into the conservation and management of cave fauna.

A cave classification system based on resource content and hazards will be devised and will determine management recommendations. Caves important to the survival of rare and endangered species and caves containing extremely fragile ecosystems, or other unique fragile resources, will be recommended for closure to public use. Other caves will be closed seasonally or access will be granted through a permit system. The majority of the caves will remain open for nonconsumptive recreational usage.

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PROTECTION FOR DIAMOND CRATERS, SOUTHEASTERN OREGON

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ABSTRACT

Diamond Craters, a 16,656 acre basaltic unit on public land which is managed by the Burns District of the Bureau of Land Management (BLM) is used as an outdoor classroom and laboratory by an estimated 7,000 visitors per year who are interested in basaltic volcanism, and/or intrigued by the survival of biota in semi-arid environments. Visitors include field trip groups and sight-seers touring the adjacent Malheur National Wildlife Refuge and other areas of the Harney Basin, students taking classes at the nearby Malheur Field Station and scientists studying various problems of the Northern Great Basin. Although Diamond Craters was identified as early as 1902 as exhibiting significant features, it has only recently become known as a museum of basaltic volcanism which may contain the greatest diversity of basaltic volcanic landforms of any area of its size in North America. Among these features are small but significant caves with unusual linings, as well as rare and fragile lava speleothems which are valuable to studies of lava cave speleogenesis.

The Bureau of Land Management has legally protected Diamond Craters, first under a RSPP classification (1956-1980) and currently under a pending protective withdrawal (1973-1991). Many of the most significant features, e.g., caves, craters, driblet spires, spatter cones and ramparts, flow lines, etc., are associated with or partially constructed of slab lava — the loose top one to four inch thick layer of the pahoehoe flows. This layer is desired by persons for use as decorative veneer building stone. Under the planning process, Diamond Craters has been proposed: (1) for designation as an Outstanding Natural Area (ONA) to be managed for its scientific, educational, scenic and recreational resources; (2) for designation as an Area of Critical Environmental Concern (ACE) to provide high priority status in management decisions; and (3) for permanent withdrawal to bar, without question or further legal proceedings, appropriation of the land by mining location.

INTRODUCTION

Hundreds of dark holes exist at Diamond Craters but the known cave passages are very short — they can be measured in only hundreds of feet. Few cavers visit the area. Why, then, is Diamond Craters being discussed at a National Cave Management Symposium? Because Diamond Craters, located approximately 50 miles southeast of Burns, Oregon, in an important speleological resource. Not only does it contain nearly every type of lava cave in miniature and unusual lava speleothems and linings, but cavers have joined BLM in the effort to protect the area.

The Bureau of Land Management is proposing to protect and preserve the 16,656 acres of public land within Diamond Craters with two complementary designations and a protective withdrawal. The Outstanding Natural Area (ONA) designation would recognize the presence of important natural resources at Diamond Craters, while the Area of Critical Environmental Concern (ACEC) designation would commit BLM to protect these important resources on a long term basis. The withdrawal, pending since 1973, would bar without question or further legal proceedings, appropriation of the land for mining. The Diamond Craters Outstanding Natural Area, as it would be named under these designations, would be managed for its scientific, educational, scenic and recreational resources.

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HISTORY OF MANAGEMENT

Diamond Craters has long been known as an area with significant geologic landforms including miniature lava caves (Russell, 1908; Piper et al., 1939; Peterson and Groh, 1964; Benedict, 1979a, 1980b; Gruber et al., 1980; Walker and Nolf, in press). The significance of the area was first officially recognized by BLM when the Oregon State Park System (OSPS) made a study of Diamond Craters along with other young basaltic areas in Oregon. The OSPS Superintendent stated:

"Since the use is not great at this time and may not be for a number of years, it would appear that the most satisfactory way to administer the area and preserve those features of public interest would be through your administration that new cinder cones not be opened or permits issued that would allow the destruction of the peculiar formations created in the lava flow" (letter of October 3, 1956).

In November, 1956, the lands administered by BLM at Diamond Craters were classified under the Recreation and Public Purpose Act (R&PP) to retain land

"in its present status and allow sufficient time for appropriate officials of the Bureau, the State of Oregon, and the National Park Service to examine and consider whether a portion or all of the land can be leased or sold to a qualified applicant, or held in withdrawal status and administered by a Federal Agency for recreational purposes."

The R&PP classification was revoked in March 1980.

During the early 1970's, the Bureau of Land Management began having problems with trespassers who removed slab lava in commerical quantities from Diamond Craters to use as decorative veneer stone. "Slab lava" is the loose, exposed upper one to four inch thick layer of basalt which separates easily from the main body of a pahoehoe flow. "Pahoehoe lava" forms from a very fluid basaltig magma which is highly charged with dissolved gases and sometimes forms crusts over channels, making lava tubes (Harter, 1970; Harter and Harter, 1980). Slab lava flows in the western United States are often vast rubble fields of low diversity, mostly lacking in significant and interesting volcanic landforms. At Diamond Craters, however, the slab lava areas comprise less than 10 percent of the total area and are generally of high diversity — many of the most scenic and/or scientifically significant landforms, e.g., lava flows, spatter cones, driblet spires, pit and collapse craters, caves, etc., are surrounded by or partially formed of slab lava. Frequently, this slab lava exhibits an intricately intermeshed pattern of flow lines which is vital to the study of the geological history of Diamond Craters. The slab lava areas are also important to the study of lava caves. According to Russ Harter (1979), a volcanogeospeleologist from the Southern California Grotto of the National Speleological Society (NSS):

"The surface lava associated with lava tubes at Diamond Craters is not only valuable for understanding caves there, but it is valuable because it provides analogs to lava tubes in other places where exposures are not as good. The surface lava rock at Diamond Craters that is desired by some as building stone is the same rock that is needed intact and undisturbed in order to provide a basis for the study of lava caves."

When slab lava is crushed or removed, much valuable scientific data are lost and scenic resources destroyed. Damage to these surfaces cannot be repaired. Therefore in 1972, BLM initiated a protective withdrawal to segregate the land at Diamond Craters from mineral entry more effectively than the existing R&PP classification.

The path to protection, however, has been slow and tortuous. An Environmental Analysis Record and a Staff Report were prepared during 1972 and forwarded to the State BLM Office. The withdrawal application was filed on March 23, 1973, and the notice was published in the Federal Register on April 26, 1973. The case file, however, was returned to the District on April 4, 1977, for updating and revision in accordance with section 204 of the new Federal Land Policy Management Act (FLPMA) which has been passed by Congress in 1976. Under FLPMA a withdrawal of over 5,000 acres must be submitted to Congress. FLPMA also required public input and integration of such actions into the planning system, i.e., the Management Framework Plan (MFP). The Burns District prepared the MFP, for the resource area which included the Diamond Craters and presented it for public input at a meeting in Burns on March 13, 1978, and a meeting in Portland, Oregon, on March 15, 1978. The MFP recommended that Diamond Craters be designated as an Outstanding Natural Area and that 16,656 acres of land be withdrawn. The notice of withdrawal was republished in the Federal Register on March 26, 1978.

During this same period, the winter of 1977-78, commercial stone interests removed, without permission, many tons of slab lava from the public land. Environmentalists who had supported designation and withdrawal under the MFP process strongly protested and demanded that BLM protect Diamond Craters by designating it as a Research Natural Area (RNA) (Hayse, 1978). The stone interests, on the other hand, demanded that BLM allow them to mine the slab lava. Before any decision could be made, BLM needed more information about the resources of Diamond Craters. It was only natural that cavers would get involved because several Oregon Grotto members had been exploring the caves there off and on since before 1961 (Anon., 1961; Benedict, 1973, 1974, 1976, 1979a, 1979b, 1979c, 1979d, 1980a, 1980b; Benedict and Gruber, 1980; Larson 1977, Nieland, 1976; Pope, 1978, 1979; Smolen, 1979).

Several significant events occurred during 1979 and 1980. BLM and independent researchers continued inventorying resources at Diamond Craters. On July 13, 1978, Diamond Craters was identified as an ACEC under the new guidelines published in the Federal Register. In the meantime, the state and federal natural area committees became interested in Diamond Craters and requested a report (Brown et al., 1979). Also, BLM personnel were invited to discuss Diamond Craters at the Far West Cave Management Symposium held in Redding, California during October

1979 (Gruber et al., 1980). On November 15, 1979, the state natural area committee recommended ONA designation for Diamond Craters and the preservation of the "complete suite of geologic forms"; ONA designation was recommended rather than RNA designation because the former would permit compatible recreational use such as student field trips, hiking, etc.; on April 10, 1980, another milestone was passed when the federal natural area committee unanimously endorsed the establishment of a Diamond Craters ONA for the "16,000+ acres." Cavers also voted to support this action. At a Seattle, Washington, meeting of February 17, 1980, the Northwest Region of the NSS voted to support designation of Diamond Craters as an ONA and the withdrawal of the area from mining. The Board of Governors of the NSS endorsed the same actions at their August 1980 meeting in St. Paul, Minnesota. In the meantime, BLM hired a Diamond Craters Coordinator to work during the 1980 field season — to assist field activities at Diamond Craters, give tours there and slide programs, prepare documents and live at the Craters. The documents included a new Environmental Assessment, a Land Report, and an ACE Plan Element.

WHAT ARE WE PROTECTING?

Basalt is the most common rock on earth — it abounds in the western United States and elsewhere. We have been asked if we really need to protect still another basaltic volcanic area when we already have the Craters of the Moon National Monument in central Idaho and the Lava Beds National Monument in northern California? The answer is emphatically YES!. To quote George Walker (1979), geologist for USGS, Menlo Park, California:

"Diamond Craters exhibits some of the best and most diverse basaltic volcanic features in the U.S. and all within a comparatively small and accessible area. The diversity of volcanic features makes it unique within the U. S. — perhaps within the Western Hemisphere."

GEOLOGICAL RESOURCES

Diamond Craters, a naturally interrelated geologic unit of Pleistocene volcanic landforms, illustrates a sequence of extrusive, intrusive and pyroclastic activity which produced six unusual, localized lava domes and the entire range of eruptive and collapse features that can be formed by basaltic volcanism. The complex eruptions ranged from very quiet, fluid flows extruded from fissures to violent, highly explosive confined steam explosions which produced tephra ranging in size from ash to truck-sized blocks. Some of the individual features are: kipukas of country rock; ash flows; pahoehoe flows with a variety of surface textures and microrelief, pressure ridges, lava toes, collapse structures and sinks, trenches, semi-trenches, and lava caves and tubes of diverse origins which contain exciting lava speleothems and linings; driblet spires and cones; spatter cones and ramparts; a variety of craters, vents, cinder cones and maars; and a group of elongate domes with diverse summit features including deep fissures, grabens, calderas, vent tube linings and pahoehoe moats. The great diversity of volcanic features can be explained by following sequence of events in the Northern Great Basin.

Diamond Craters is in a land dominated by volcanism. During the Miocene, between 16 and 12 million years ago, more than a hundred separate basaltic flows flooded over vast areas of southeastern Oregon. Gradually some of these basalts were uplifted and tilted so that the Steens Mountain, a 50 mile long fault block mountain, to the south of Diamond Craters, now rises about a mile above the general land surface. About nine million years ago, rhyolitic ash-flow tuffs began erupting in glowing avalanches from large magma chambers, located to the north of Steens Mountain— a broad undrained structural and erosional basin, the present Harney Basin, is believed to be the remnant of the obscure, buried calderas which resulted from these eruptions. The Harney Basin formed along the Brothers Fault Zone, "one of the fundamental structural elements of Oregon" which extends more than 250 miles between the Steens Mountain and the Cascade Mountains to the west (Walker and Nolf, in press). During the Pleistocene, glaciers formed in the mountains and a vast lake occupied the Harney Basin. This lake rose and fell, and at times the lakebed was nearly dry. Diamond Craters probably formed during one of the drier periods.

According to Bruce Nolf, the volcanologist who has studied Diamond Craters for more than a decade, Diamond Craters formed in two stages: (1) flood basalts, and (2) injection of basalts. The Diamond Craters flood basalts spilled out from fissures located near the southeastern margin of the Harney Basin, forming a nearly circular layer almost six miles in diameter and less than 350 feet thick on top of the lake sediments and the nine million year old ash-flow tuffs. While this initial basaltic layer cooled, basaltic magmas injected up into the layer from a number of localized, high level magma chambers — six lava domes bowed up. Their predominantly northwest orientation was controlled by the direction of the Brothers Fault Zone. The domes variously collapsed as the supporting magmas withdrew either internally and/or through extrusive eruptions. Some of the vents erupted quiet pahoehoe flows, forming caves, spatter cones, driblet spires and collapse craters, etc. Other vents erupted more violently producing spatter cones and explosion craters which ejected material ranging in size from ash to truck-sized blocks. Now most of the land area of Diamond Craters was covered by this ejecta (i.e., tephra). No wonder Diamond Craters exhibits so much geologic diversity with its domes, craters, lava flows and tephra covered areas.

BIOLOGICAL RESOURCES

"Diamond Craters is a natal classroom on public land for those interested in the processes of volcanism, and/or those intrigued by the survival of biota in harsh environments." (Benedict, 1979a).

Diamond Craters is located in the Northern Great Basin at elevations between 4150 and 4700 feet above sea level. It occurs at the ecotones between the Desert Shrub, and Shrub-Steppe and the Western Juniper-Big Sagebrush Zones and contains both unusual and representative species and communities of the Uplands and the Wetlands. Over

240 species of vascular plants have been identified from Diamond Craters; four species are being considered for listing on the proposed Oregon State List (Siddal et al., 1970; Gruber et al., 1979) and two species, formerly listed on the Federal Threatened List, are currently being reviewed. The wide diversity of geological substrates and landforms in combination with the very diverse vegetation, provides abundant nesting, resting and feeding habitats for wildlife, both vertebrates and invertebrates. Nineteen species of amphibians and reptiles, 52 species of mammals and 189 species of birds are known or suspected of occurring at Diamond Craters. To date, no rare or endangered species of animals are known from the Craters. However, Gruber has discovered a highly unusual mite inhabiting a deep fissure in Northeast Dome — the fissure is 40 feet deep, eight feet wide and several hundred feet long. Similar fissures in Arizona contain "cave adapted" invertebrates.

ANTHROPOLOGICAL RESOURCES

Although Diamond Craters is not known for its cultural resources, one or two lithic scatter sites have been discovered. Even more important, however, is the sediment record deposited beneath the waters of Malheur Maar, a freshwater lake 200 feet in diameter and 6 feet deep, which is located in one of the explosion craters of West Dome. According to Peter Mehringer, Jr., an anthropologist from Washington State University:

"Malheur Maar is the only low elevation desert lake between Canada and Baja which contains an unbroken sedimentary column which spans the past 6,000 years; the lake is especially significant due to its rapid rate of deposition, its permanency and its location at the shadscale-sagebrush ecotone."

Mehringer and his graduate students, as part of the Steens Mountain Prehistory Project (Aikens et al., 1979), have removed a 15-meter core of sediments from Malheur Maar. The core from Malheur Maar and amber rat samples from Surprise and Spatter Cone Caves along with materials from sites outside Diamond Crater are being studied in order to reconstruct the ecological history and the movement of humans in the Great Basin since the end of the Pleistocene.

NATURAL AREA VALUES

An estimated seven thousand persons are attracted to Diamond Craters annually despite the fact that almost no printed information is available to them which describes the natural resources there. Visitors include field trip groups and sightseers touring the adjacent Malheur National Wildlife Refuge and other points of interest in the Northern Great Basin. Some of the visitors are students and faculty from the nearby Malheur Field Station, an educational institution operated by Pacific University in cooperation with a consortium of 21 other colleges and universities in Oregon and Washington. Still other visitors are scientists studying various problems of the Northern Great Basin. Visitors are of every age group and come not only from all parts of Oregon and the rest of the United States, but from foreign countries as well.

MANAGEMENT PLAN FOR DIAMOND CRATERS

One of the documents prepared during 1980 by BLM was an ACEC Plan Element for the proposed Diamond Craters Outstanding Natural Area. An ACEC Plan Element is a management plan for a proposed Area of Critical Environmental Concern based on the guidelines published in the Federal Register on August 27, 1980. The Plan Element includes: (1) a proposed name, (2) a statement of the specific management objectives, (3) a description of the environmental resources, (4) a statement of the special management measures, and (5) a summary of public participation and record of public response. Most of this information had already been included in either the MFP or in the New Environmental Assessment and Land Report, which made it fairly easy to draw up the ACEC Plan Element for Diamond Craters. What are the specific management objectives and the special management measures which are listed in the Diamond Craters ACEC Plan Element?

SPECIFIC MANAGEMENT OBJECTIVES

Manage the natural resources of the approximately 16,656 acres of public land within this natural geologic unit, known as Diamond Craters, to insure that the unique assemblage of geologic features and ecosystems is preserved so that present and future generations may benefit from the exceptional scientific, educational, scenic and recreational values.

Pursue approval of the pending protective withdrawal.

Increase public awareness of the significance of Diamond Craters by designating it as an Outstanding Natural Area.

Develop a meaningful interpretative and informational program as followup of the 1979 and 1980 slide programs and field tours.

SPECIAL MANAGEMENT MEASURES

According to the ACEC guidelines, the specific management measures for Diamond Craters fall into two categories. Measures (b) through (g) will be carried out by BLM and measures (a) and (h) are the responsibility of others.

(a) Recommendation by the state and federal natural area committees of Diamond Craters as an Outstanding Natural Area — already accomplished.

(b) Designate Diamond Crater as an Outstanding Natural Area (ACEC).

(c) Develop and implement a boundary sign program to warn trespassers that the area is not available for mining or rock collecting.

(d) Restrict or exclude public use, if necessary, to protect specific geologic, botanical or zoological sites that are extremely fragile and unable to withstand heavy use pressure.

(e) Restrict all vehicle use to established and designated roads; close and reclaim all existing roads and trails which are not necessary for the scientific, educational and/or recreational management of Diamond Craters as an ONA.

(f) Prohibit the development of any new roads and trails unless they are necessary for the scientific, educational, and/or recreational management of the area for its natural values.

(g) Continue to provide information, slide programs and field tours within the limits of the District's other commitments. If necessary, develop an expert volunteer program to help carry out this objective.

(h) Withdraw Diamond Craters from mineral entry—only Congress can approve a protective withdrawal of over 5,000 acres—the reports are being prepared by BLM.

Now that you know what an ACEC is, you should be aware that any person can nominate an area for consideration as an ACEC provided the land is managed by BLM. Since BLM manages more land than any other federal agency, no doubt, at least one of your favorite caves will be on BLM land. If this is the case and you wish to nominate the area as an ACEC, just write to the Manager of the District where the cave is located and identify the area. Then keep track of what is happening to the area through the ACEC designation process.

WHERE ARE WE WITH DIAMOND CRATERS?

The paper work for Diamond Craters is almost done—at least for this round! You remember that BLM has been working on the project since 1956. Anyway, we have gathered a large body of supportive data indicating that Diamond Craters is indeed an unique area worthy of protection and preservation. We have strong public support for the proposed action—we have received endorsements from the state and federal natural area committees, the National Speleological Society, the Oregon Wilderness Coalition and numerous other individuals. The fate of Diamond Craters now rests with the higher levels of BLM and the Congress of the United States.

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THE ROLE OF THE KENTUCKY NATURE PRESERVES COMMISSION IN CAVE MANAGEMENT

*Wayne C. Houtcooper

ABSTRACT

The Kentucky Nature Preserves Commission was established by the 1976 General Assembly to conduct a statewide inventory of natural areas, and to develop a nature preserves system.

The Commission is an important resource available to aid the process of establishing cave management strategies through the application of 1) the Natural Heritage methodology of environmental inventory, and 2) laws to protect the identified natural features.

The inventory procedures are used to assess management priorities based upon 1) the number and rarity of elements of natural diversity, 2) the degree of threat to the system and/or its components and, 3) the level of present protection afforded those natural features.

The amount of legal protection that may be applied is, in part, dependent upon the specifically defined levels of permissible use mutually agreeable to the owner(s) and to the Commission.

An area of natural significance may be identified as a Registered Natural Area or may be dedicated as a Kentucky Nature Preserve. Both actions are attempts to protect and preserve important segments of our rich natural heritage for present and future generations to enjoy.

*Kentucky Nature Preserves Commission, 407 Broadway, Frankfort, Kentucky 40601

CAVE MANAGEMENT AND ENVIRONMENTAL ASSESSMENT ACTIVITIES OF THE TENNESSEE VALLEY AUTHORITY'S REGIONAL HERITAGE PROJECT

*Patricia A. Fink

ABSTRACT

The TVA Regional Natural Heritage Project is working to identify and protect significant natural features occurring in the seven-state Tennessee Valley region. The Heritage Project maintains a data base which contains information on threatened and endangered plant and animal species, State and Federal managed areas, sensitive habitats, champion trees, and unique geological features, which includes caves. The data management system was developed by the Nature Conservancy, and includes cross-referenced map, manual, and computer files. The data is used for environmental assessment and to identify significant natural areas in need of preservation. Efforts are then made to protect these areas.

Environmental assessment carried out by the Heritage Project consists of reviewing proposed projects located within the Tennessee Valley that will affect TVA lands or rivers, or receive Federal funds. These proposals are reviewed to determine whether or not the project will conflict with a significant natural feature, such as a cave. This technique has prevented adverse impacts to caves to identifying conflicts prior to construction activities.

TVA became active in cave management by efforts to protect the Federally endangered Gray and Indiana bats. Three caves — Hambricks, Nickajack, and Norris Dam — have been gated in order to prevent disturbance of their bat populations. Ten other caves on TVA lands contain important bat colonies, but because of their inaccessibility are not as vulnerable to destruction and disturbance. Several other caves on TVA lands are being protected by designation as Small Wild Areas.

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INTRODUCTION

The Tennessee Valley Authority (TVA), which is known primarily for its chain of lakes and its generation of inexpensive electricity, is charged with the responsibility of furthering the proper use, conservation, and development of the natural resources of the Tennessee Valley Region.[1] The TVA Regional Natural Heritage Project was created to assist in meeting this responsibility. The core of the Heritage Project is a data base of significant natural features, which includes caves. This data base is used to locate and prevent conflicts between sensitive natural resource features and proposed development projects. The Regional Heritage Project has also been involved in the protection of caves through cave gating, has supported cave-related research, and participated in cave management symposiums.

THE TVA REGION

The Tennessee Valley region includes 201 counties within seven southeastern states: Tennessee, Virginia, North Carolina, Georgia, Alabama, Mississippi, and Kentucky. This region encompasses the Tennessee River watershed, plus other areas that receive TVA electricity.

HERITAGE PROJECT METHODOLOGY

Regional Natural Heritage files contain data on the locations of threatened or endangered plant and animal species as defined by State and Federal agencies; managed areas such as national parks, national natural landmarks, and state wildlife management areas; champion trees; important biological areas such as heron rookeries and species type localities, and significant geological features such as caves and other karst features. Heritage Project data is gathered from current literature, museum and herbarium records, contacts with professionals, and field survey reports. Cave data has been collected from publications such as books by Barr (1961) and Matthews (1971) on the caves of Tennessee. Another major source of information regarding caves is the various state cave surveys such as the Alabama and Western Kentucky Cave Surveys. At present, these surveys are the best sources of information about caves in the TVA region. Other sources include contacts with cavers and professional speleologists, and occasional discoveries by TVA staff in the field.

The methodology for storing data was developed by the Nature Conservancy, a non-profit organization whose goal is the preservation of natural diversity through the acquisition and management of lands containing significant natural features. The TVA Regional Natural Heritage Project was established through a cooperative agreement between TVA and the Nature Conservancy on June 1, 1976. Six southeastern states — Kentucky, Mississippi, North and South Carolina, Tennessee, and West Virginia — also have their own Heritage programs.

Natural Heritage data is stored in three cross-referenced files. Each element, e.g., cave, is assigned a unique index code which identifies it throughout the data management system. All information pertaining to a particular element is stored and retrieved using the index code for that element. The data is stored as follows:

1. Topographic Map File - This file consists of a set of approximately 1600 U. S. Geological Survey topographic quadrangle maps which cover the 201-county TVA region. Each element occurrence is plotted on the appropriate topo map. The index code and latitude/longitude coordinates for each element appearing on the map are listed in the map margin.

2. Manual Files - Information about each element is transcribed on to standardized data sheets. These sheets are stored in three different files. The geographic file groups data sheets by topographic quadrangle. The element manual file contains a folder for each element, e.g., species, and may also contain distributional information, life history studies, and management information. The third file contains boundary, ownership, and management information for each designated managed area.

3. Computer File - This file serves as the bookkeeping system for the Heritage Project. Through the use of this file it is possible to rapidly retrieve specific subsets of the data base, e.g., all the Gray Bat (*Myotis grisescens*) localities in Fentress County, Tennessee. This feature is especially useful in the study of distributions of particular species. The computer file can also be used to generate maps depicting occurrences of elements.

HERITAGE PROJECT APPLICATIONS

Data from Regional Natural Heritage files is used primarily in environmental assessment. This process will be described in detail in the following section. Significant natural areas can also be identified and protected through the use of Heritage data. For instance, Heritage files can be used to enumerate occurrences of a particular species and thus aid in determining its relative rarity. Heritage data can also be used to locate areas where many different significant natural resource features are concentrated. Areas that represent examples of particular habitats such as heronries, or cedar glades, can also be located. Heritage data makes it possible to determine preservation priorities on the basis of sound data rather than subjective judgements. Areas on TVA land determined to have high priority for preservation, may be designated as either an Ecological Study Area, a Critical Habitat Area, or a Small Wild Area. Heritage data is also provided to State and Federal agencies responsible for the listing/delisting of threatened and endangered species. Serious researchers dealing with threatened and endangered species are also allowed access to Heritage data. Maps of Heritage data showing the distribution

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[1] Congress has defined this responsibility in three acts: (A) Tennessee Valley Authority Act of 1933, 48 Stat. 58-59. (B) The National Environmental Policy Act of 1959, 42 U.S.C. 4321 et seg., 83 Stat. 852, Pub. L. 91-190. (C) Endangered Species Act of 1973, 15 U.S.C. 1931 et. seg.

FIGURE 1. Sign placed at the entrance of each cave gated by TVA. (Photo by Linda Parrish)

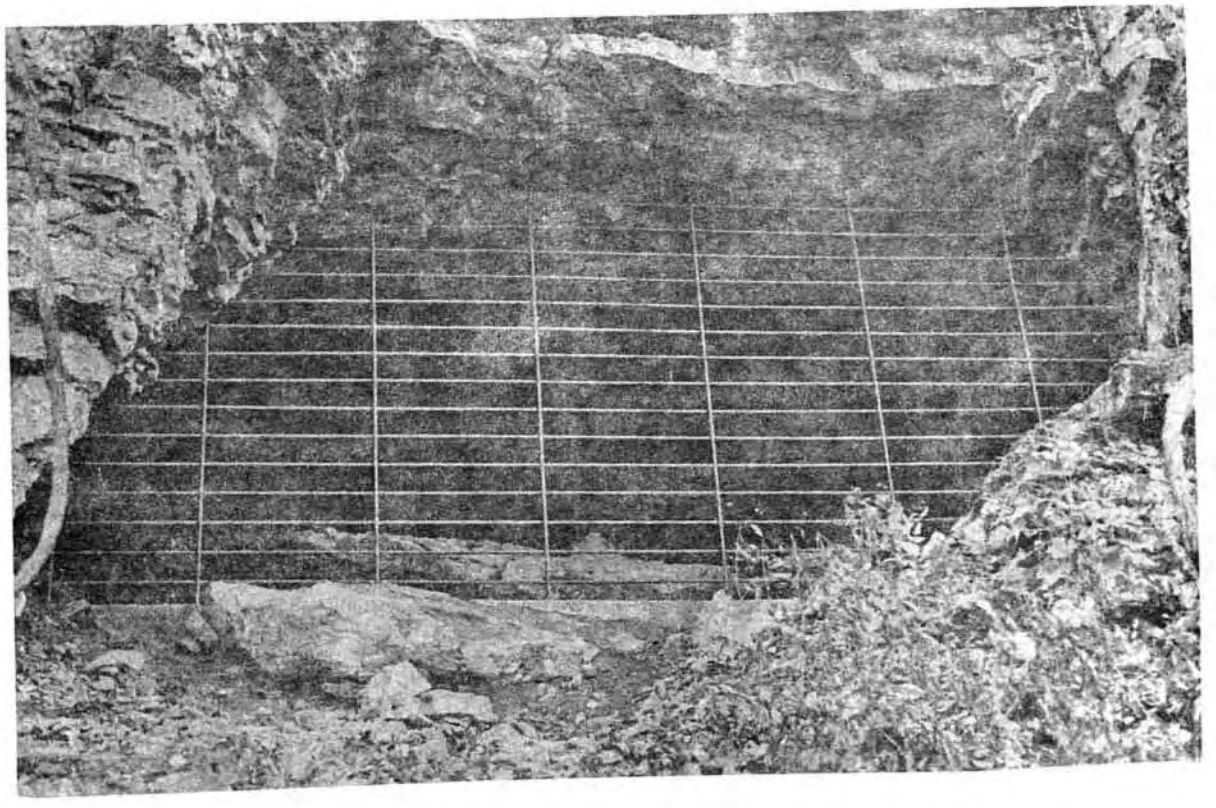

FIGURE 2. Gate at entrance of Norris Dam Cave. (Photo by Bob Currie)

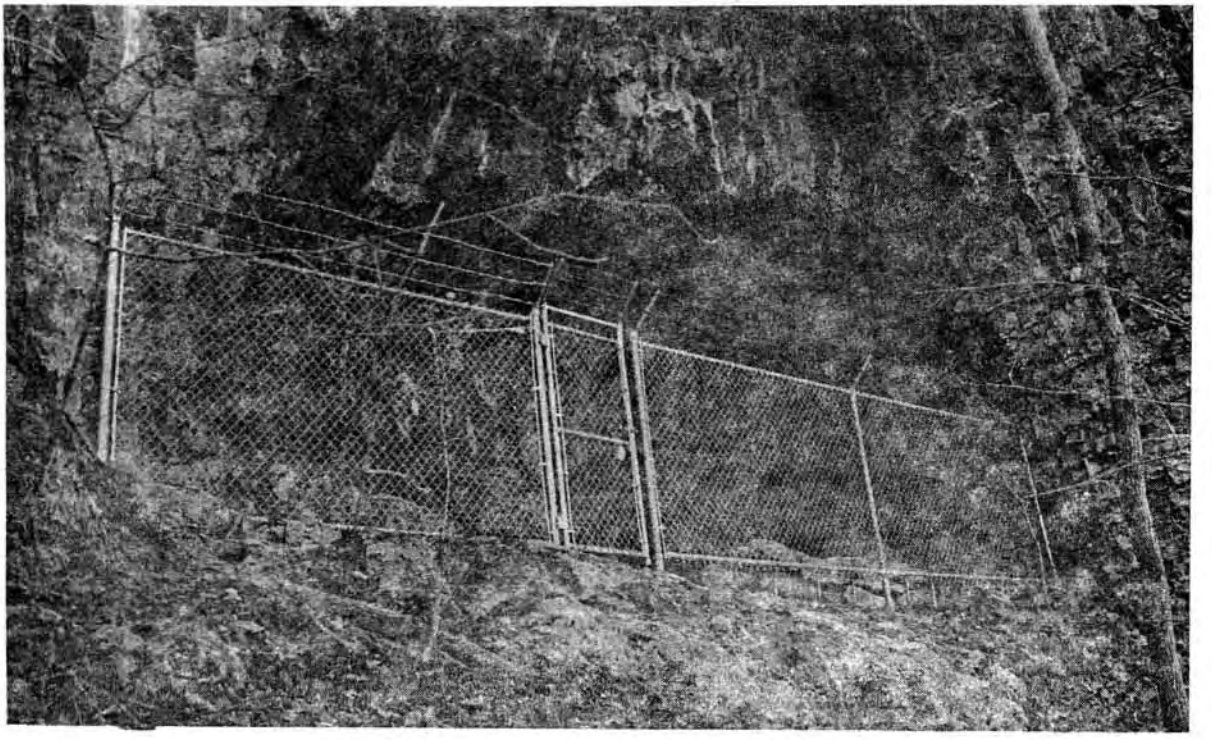

FIGURE 3. Gate at entrance of Norris Dam Cave. (Photo by Bob Currie)

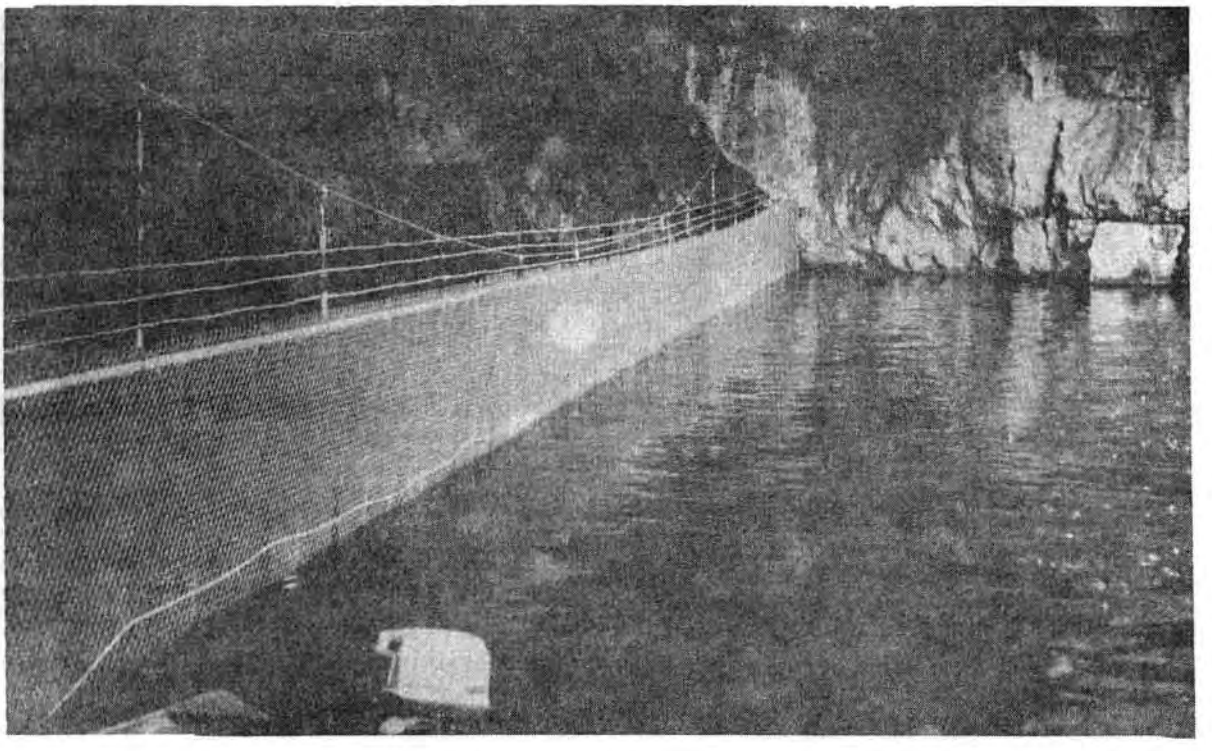

FIGURE 4. Gate at entrance of Nickajack Cave. (Photo by Ralph Jordan)

of a particular species can be used to identify areas in need of further research.

ENVIRONMENTAL ASSESSMENT AND CAVE PROTECTION

Heritage data is used in the protection of all caves in the TVA region rather than those just on TVA land, through the environmental assessment and review process. Environmental assessment involves the identification of significant natural resource features on a site proposed for development and then determining potential conflicts between the proposed project and the natural resource features in the proposed study area. For example, when a power plant site is proposed, Heritage staff examine the site to determine whether there are caves or other significant natural features present. If such features are found, the project may be modified or mitigation may result. This review process is geared to identify and resolve potential environmental conflicts in the earliest possible stages of a project.

There are three types of project proposals that TVA's Regional Natural Heritage Project reviews. These include any proposed project in the Tennessee Valley region that will receive Federal money or affects TVA lands, lakes, and rivers. These three types of projects are:

1. TVA Projects on TVA-owned and Private Lands — This category includes projects dealing with the generation of electricity such as power plant sites and transmission line routes, and other TVA projects such as parks and solar home sites.

2. Non-TVA Projects on TVA-administered Lands — This includes any project that affects TVA waterways. Most of these are small projects such as the building of boat docks, rip-rapping of shorelines, and dredging for gravel. Occasionally TVA will sell, lease, or give away lands for various purposes. These actions must also be reviewed and approved.

3. Non-TVA Projects on Private Lands — This category includes any project in the Tennessee Valley region that receives Federal money. This includes such projects as subdivisions that receive money from the Department of Housing and Urban Development (HUD), sewer systems that receive money from the Environmental Protection Agency (EPA), and any Federal, State, or County roads that are totally or partially funded with Federal money.

These projected proposals are typically submitted for Heritage Project review as one of three types of documents. The most detailed are Environmental Impact Statements (EIS's), which are done for major projects affecting many people or a large area of land. Environmental Assessments (EA's) are similar to EIS's but are for minor projects. 26a's, the name of which refers to a portion of the TVA Code, are small projects that affect waterways in the TVA region. Most project proposals include a short description of the project and a map of the affected area.

Project proposal review consists of each Heritage staff member locating the project site on the appropriate topo map from the Heritage Topographic Map File, and then checking to see if there are any possible conflicts within their field of training, e.g., caves, rare plants, rare animals. If there are no recorded occurrences in the study area then the project is approved or further field investigations are initiated. If there are conflicts between a proposed project and a known location of a significant natural resource feature, the group initiating the project proposal is informed. Many project proposals offer primary and several alternate project sites. In such cases, Heritage project review includes identification of the site or sites with the least potential for adverse impacts. If no alternate sites are provided and environmental conflicts are identified, Heritage staff members may field-check the proposed site to determine the nature and magnitude of conflicts and suggest possible mitigation measures.

CAVE MANAGEMENT

Through most of TVA's history, caves on TVA lands were either passively managed or ignored; the agency's main dealings with caves consisted of flooding them when TVA reservoirs were built. This was often done because the agency was unaware that caves existed on TVA lands. Through the data collection efforts of the Heritage Project, it is now known that at least 34 caves are located on TVA properties. Others are sure to exist but their location, which is often known only by local cavers, has not been provided to TVA.

TVA became involved in the active management of caves through its efforts to protect threatened and endangered animals such as the Gray and Indiana (*Myotis sodalis*) Bats, the Tennessee Cave Salamander (*Gyrinophilus palleucus*), and the Alabama blind cave fish (*Speoplatyrhinus poulsoni*). There are 13 caves on TVA land that are known to serve as habitat for Gray and Indiana bats. TVA's Heritage Project has worked with the U. S. Fish and Wildlife Service to gate three of the caves which were determined to be extremely vulnerable to disturbance. TVA agrees with many leading bat experts that gating should be used only as a last resort method of cave protection. The remaining ten caves are protected by other agencies and/or by their inaccessibility. Cave gates were constructed so that interference with bat movements would be minimized and the temperature, humidity, and airflow in the cave would not be altered. The gates were also built with a "weak link" so that people who were determined to breach the gate could do so without totally destroying the gate and cave entrance. Each entrance has a sign explaining why the cave is gated, the penalty for entering and/or damaging the cave, plus an address where more information can be acquired (see Figure 1). The three gated caves are described below.

Norris Dam Cave

Norris Dam Cave formerly contained a Gray Bat maternity colony and presently harbors a bachelor colony of approximately 7000 individuals. This cave is located on a nature trail approximately 300 feet downstream from Norris Dam. The entrances are large and inviting, and very accessible. The cave is large and offers relatively easy caving, making it popular for local children and tourists who have come to see the dam. One entrance has been gated with horizontal

bars, spaced far enough apart to allow the bats to enter and exit without interference (see Figure 2). The other entrance, located about 20 feet from the first entrance is gated by a fence topped with barbed wire. The fence contains a gate to allow traffic during the months when the bats are not present (see Figure 3). These gates are policed by TVA Public Safety Officers and the Tennessee Wildlife Resources Agency. In the half year that the gates have been in place, very few unauthorized people have entered the cave.

Hambricks' Cave

Hambricks' Cave contains a Gray Bat colony of approximately 10,000 individuals. It is located on Guntersville Lake, and is accessible only by water. The entrance is small, not particularly inviting, and only one of many cave entrances located in that particular bluff. The gate is constructed of chain link fencing which extends 15 feet beyond the entrance and a few feet below the water surface. This gate is monitored through an informal agreement with the Alabama Department of Conservation.

Nickajack Cave

Nickajack Cave houses a Gray Bat bachelor colony of approximately 50,000 individuals and provides habitat for the Tennessee Cave Salamander. It is located on Nickajack Reservoir in the area where the states of Tennessee, Alabama, and Georgia converge. It is accessbile only by water but it is easily seen from the road and lake and is subject to large amounts of traffic. It has a large, spectacular entrance which can easily be entered by boat. The entrance has been and still is a favorite place for fishermen to take shelter during storms. The fence, built of chainlink, is suspended just inside the entrance and extends both above and below the water (see Figure 4). The cave entrance is monitored by TVA Public Safety Officers and the Tennessee Wildlife Resources Agency.

Other Critical Caves

Blythe Ferry Cave houses a transient colony of Gray Bats and provides habitat for the Tennessee Cave Salamander. It is located in Chickamauga Reservoir near Chattanooga. The Tennessee Wildlife Resources Agency has primary responsibility for monitoring this cave.

Key Cave contains a Gray Bat maternity colony of approximately 24,000 individuals and it is the only known habitat for the Alabama Cave Fish. It is located in Pickwick Reservoir, near Sheffield, Alabama. The cave and its surrounding area have been designated Critical Habitat, and are included within the proposed Seven Mile Island Wildlife Management Area. TVA and the Alabama Department of Conservation will share the responsibility for monitoring the area.

OTHER CAVE MANAGEMENT ACTIVITIES

In the recent past, TVA became involved with the national cave management community through participation in regional and national cave management symposiums. TVA is working to gather information about active cave management techniques through these symposia and by supporting research on cave fauna. In 1980 TVA served as host of the Eastern Regional Cave Management Symposium and the National Cave Management Symposium. In 1981 TVA will be supporting the International Cave Management Symposium and Cave Camp, and the 8th International Congress of Speleology.

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A MANAGEMENT APPROACH TO PERKINS CAVE, VIRGINIA

*Roy D. Powers, Jr.

ABSTRACT

Perkins Cave, discovered by organized cavers in the late 1960's, is one of the most sensitive caves in the eastern United States. Perkins Cave is located in Washington County, Virginia. The cave is in middle Ordovician limestone and contains over 53,000 feet of mapped passage concentrated in a complex maze-like structure occupying an area equivalent to a square measuring 2,000 feet on a side. The cave contains an abundance of white formations ranging from small soda straws to massive flowstone.

The cave has been known to local residents since the early 1900's. At the time of discovery by the caving community, less than one-half mile of passageway had been entered.

In late 1974, the cave was purchased by independent cavers and management was attempted by them. This management was ineffective.

In 1977, the cave was again sold, this time to an NSS member who immediately proceeded to set up a structure , Perkins Cave Conservation and Management Society (PERCCAMS), to protect and manage the cave. This paper addresses the rationale and methodology used. The management has been effective and is one of the most successful models of private cave management systems.

The Perkins Cave Conservation and Management Society (PerCCams) is the most recent cave management organization in Virginia. The organization, governed by a board of directors, has approximately 20 members, who are veteran cavers of the Virginia region. These people have a wide variety of experience and expertise in cave management and conservation. They have elected to apply the most rigid and systematic control methods, some both unique and non-traditional, ever developed to conserve and manage a privately owned cave.

In an evaluation of managed caves in the Virginia region (Wilson, 1978) PerCCAMS ranked highest of all management groups.

Perkins - The Cave

Perkins Cave, located in Washington County, Virginia, was unknown to the caving community until March, 1958. The cave had been known to local residents, however, for over 100 years.

The traffic that the cave received over the years was light beacuse of its rural location and the fact that it was considered to be a very small cave. Cribb Cave, which was very large and located near Perkins, received most of the traffic. When Perkins was discovered by organized cavers, less than one-fourth of a mile of passageway was known.

The cave is developed on several levels in a complex maze and contains over 53,000 feet of known passageway. The cave is highly decorated, contains many low crawls, several streams and many long passageways, the longest being 1,400 feet in length. Despite its size, the lateral extent of the cave is only 2,200 feet.

The entrance is located on the southeast side of Clinch Mountain at an elevation of 2,200 feet. Development of the cave is joint controlled and the passages are developed along strike joints trending NNE and SSW.

Perkins is developed in upper Silurian limestone of the Tonoloway formation which has a shallow dip to the southeast (Holsinger, 1975).

The vandalism which has occurred to the cave has been moderate to heavy but has been restricted mainly to the front of the cave. Fortunately, the majority of the sensitive formation areas lie beyond and have experienced little or no vandalism.

Management History

With the discovery of Perkins by organized cavers, interest of the current owner increased. He, of course, had access to the information that the cavers were collecting and, as a result, aroused

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the interest of local residents, which resulted in an increase of traffic in the cave. This could have had disasterous effect upon the cave, except for a cave owner dispute which caused the cave to be closed except to the parties mapping the cave.

Cave Ownership - The First Attempt

In 1974, Perkins was purchased by unaffiliated cavers who attempted management of the cave. This first attempt was well thought out but poorly executed and resulted in management that was only partially effective, but was better than no management at all. In early 1977, the cave was again put up for sale and management ceased. During this period, the cave was again subject to vandalism.

Caver Ownership - The Second Attempt

In November of 1977, the cave was purchased by John Wilson, a caver who was determined to successfully manage the cave. Wilson, a member of the Bulter Cave Conservation Society, had experience in cave management and was well acquainted with the problems of cave conservation and cave management. Wilson immediately set about organizing PerCCAMS. An organizational meeting, open to all members of the caving community who were interested in managing Perkins Cave, was held. Officers were elected, by-laws written, goals established, and membership requirements defined.

The Goals of PerCCAMS

Four goals of the organization were clearly defined and methodology established (see Appendix i).

1. To secure the entrance and all future entrances so effectively that ordinary means will be inadequate to enter the cave without authorization.

In order to achieve this goal, the cave was gated. The gate was deliberately made massive to prevent entry by ordinary means. The gate itself was made in the form of a grid constructed of heat-treated steel. The gate was hinged from the bottom by loops of half-inch steel bars set into reinforced concrete. The locking arrangement consisted of a sliding 3-inch stainless steel pipe, which slides into sleeves set in concrete monoliths on either side of the gate. One-inch steel pins slide through the sleeves and pipe at each side of the gate and heavy-duty padlocks were inserted through the ends of the pins to prevent boltcutters from being used to cut the locks. The locks are protected by stainless steel boxes which are welded to the bottom of the sleeves. A rubber hood keeps moisture from the locks.

Since the gate was installed in mid-1978, there has been no forced entry into the cave and the gate has sustained no damage even though at least one breech of the gate was attempted.

It is the full intention of the society to prosecute, to the fullest extent of the law, anyone attempting illegal entry of the cave. All members of the society have been designated by Wilson as his agents and may bring charges against anyone violating the cave.

2. To take whatever measures necessary to minimize, to the greatest extent humanly possible, unintentional damage to the cave by people who to enter.

In order to achieve this goal, stringent rules were enacted to insure that each caver was properly equipped to cause as little impact upon the cave and its environment as possible: equipment or practices which might have an adverse effect on cave formations and cave life were banned; ratios of PerCCAMS members to non-members, procedures and routes for moving through the cave, were established; certain sensitive areas of the cave were closed for normal traffic; trips were required to be planned and organized in advance; valid reasons for trips were established; scientific collecting required prior approval by the board of directors; and accurate records of each trip were required.

3. To use the cave as a demonstrative project on how to manage a sensitive cave, thus contributing to the advancement of knowledge in this area.

Achieving this goal is an ongoing project by the members of the organization. Data is being compiled and papers have already been published concerning the methodology used by PerCCAMS.

4. To allow the use of the cave in ecologically-sound ways that may serve to demonstrate the value of caves in promoting the quality of life.

In order to achieve this goal, uses of the cave have been clearly defined. Several uses, such as tourism, have been banned. Each trip must be approved in advance and those not conforming to established uses require the advanced approval of the board of directors.

Conclusion

In the two years that PerCCAMS has been managed, Perkins cave traffic has been reduced, broken formations restored and the cave has been cleaned. New techniques and procedures have been developed. Data and information concerning cave management and conservation has been generated.

Literature Cited

Holsinger, J. R. 1975. Descriptions of Virginia Caves. Department of Conservation and Economic Development, Charlottesville, Virginia.

Wilson, J. 1978. Cave Management - The Virginia Experience.

APPENDIX i

PERKINS CAVE CONSERVATION AND MANAGEMENT SOCIETY (PerCCAMS) PURPOSES

Purpose

Perkins Cave is of such significant value that it merits extraordinary measures to preserve it. For this reason, the PerCCAMS shall be founded.

Goals

A. To prevent all people who would vandalize or otherwise harm the cave in any manner, from getting into the cave.
B. To take whatever measures necessary to minimize, to the greatest extent humanly possible unintentional damage to the cave by the people who do enter.
C. To allow and encourage the publishment of information about PerCCAMS and its finding in order to contribute to the advancement of knowledge of cave management.
D. To allow the cave to be used in ecologically-sound ways that may serve to demonstrate the value on caves in promoting quality of life.

Methodology and Regulations

A. 1) To secure the entrance, and all future entrances, so effectively that ordinary means will be inadequate to enter the cave, without authorization.
2) To make whatever efforts necessary to bring to justice anyone who illegally trespasses and enters the cave.
3) To set up sufficient procedures to limit the non-members of PerCCAMS so that they can be completely supervised while underground and to eliminate most people whose behavior might have undesirable effects on the cave.

B. 1) That PerCCAMS require all who enter the cave to have a primary light source that is reliable, and provides consistently bright light to minimize the possibility of unintentional damage to the cave due to poor visibility.
2) That PerCCAMS require that all cavers who enter Perkins Cave be equipped with hard hats and three reliable sources of light, and whatever other equipment is necessary and proper for the planned trip and what is generally recognized as being appropriate for safe caving.
3) That PerCCAMS ban any equipment or objects whose use or presence in the cave, over an extended period of time, could harm the cave or the cave life.
4) To limit access to Perkins Cave to PerCCAMS members and to require that a PerCCAMS member be on every trip into the cave.
5) To require that should a trip be subdivided, that a PerCCAMS member must be in each subgroup.
6) That on all trips into the cave the ratio of PerCCAMS members to NSS members not members of PerCCAMS, should not be less than one to two.
7) That on all trips into the cave the ratio of PerCCAMS members to non-PerCCAMS members who are not NSS members, shall not be less than one to one.
8) That all trips into the cave, PerCCAMS members should maintain line of sight contact with the non-members except when line of sight is not a safe procedure of moving through a given passage.
9) Should an exception in these caving regulations be needed for reasons that promote caving and cave conservation, exceptions may be made by the PerCCAMS Board of Directors.
10) Pets and other animals not indigenous to the cave, shall not be allowed in the cave except with prior approval of the Board of Directors and then only for scientific purposes.
11) All trips into the cave shall be prearranged to record visitation to the cave and all persons entering the cave must complete the cave use questionnaire, on each trip.
12) Smoking is prohibited in the cave.

APPENDIX ii

PERKINS CAVE CONSERVATION AND MANAGEMENT SOCIETY
LEGAL RELEASE AND INDEMNIFYING AGREEMENT

LEGAL RELEASE FORM: ALL PERSONS MUST SIGN THIS FORM BEFORE RECEIVING PERMISSION TO ENTER PERKINS CAVE. IF YOU ARE MARRIED, YOUR SPOUSE MUST ALSO SIGN...READ BEFORE SIGNING.

Name (Please Print)_____

Age: _____ Date: _____ Phone: _____

Address: _____

City: _____ State:_____

In consideration of the permission extended to me by the Perkins Cave Conservation and Management Society in entering Perkins Cave and for other valuable consideration, I do hereby, for myself, my heirs and assigns, forever release and discharge the Perkins Cave Conservation and Management Society, their officers or their membership and agents, whether acting officially or otherwise from any and all claims, demands, clauses of action, suits of liabilities arising out of entering Perkins Cave, caving trips and speleology, transportation to, during, and from caving trips, or caving areas, and operation incidental thereto.

I fully realize that when I enter Perkins Cave or otherwise participate in caving trips I may suffer injuries or death, and knowing this, I hereby voluntarily sign this legal form. I understand that any caving trips that I make in motor vehicles owned or operated by members of the Perkins Cave Conservation and Management Society, their associates or under the auspices or tutelage or control of any Perkins Cave Conservation and Management Society is made completely at my own risk.

I do hereby release and forever discharge the Perkins Cave Conservation and Management Society, their officers, or their membership or any other persons acting by or through the Perkins Cave Conservation and Management Society either directly or indirectly of any responsibility or liability of any nature whatsoever to me or to others for personal injury, death, or property damage which may occur either directly or indirectly as a result of my activities associated with cave exploring or speleology.

I make these convenants, releases and waivers to bind myself, my executors, assigns and other persons.

I further promise to bind myself, my heirs, administrators and executors to repay to the Perkins Cave Conservation and Management Society and any and all members or persons acting in connection therewith their heirs and successors and assigns any sum of money, that they or any of them may hereafter be compelled to pay for any reason because of my participation in such activity.

I further state that I have carefully read the foregoing release and indemnifying agreement and know the contents thereof and I sign the same as my own free act.

Given under my hand and seal this _____ day of _____, 19_____.

Caver (sign)_____

Spouse (if married, sign) _____

In Presence of:
Witness (sign) _____
Address _____

Witness (sign) _____
Address _____

APPENDIX iii

Perkins Cave Conservation and Management Society
(PerCCAMS)
P. O. Box 7007
Richmond, VA 23221

TRIP AND KEY REQUEST FORM

Send two copies of this form to the above address.
One copy will be returned to you with the key.

Please mail the Perkins Cave Gate Key to the following PerCCAMS member:

Name _____ Office Phone _____

Address _____ Home Phone _____

City _____ State _____ Zip _____

The trip is planned for ___ Day ___ Month ___ Year,

with _____ as Trip Leader.

The following PerCCAMS members will be on the trip:

Name _____
Address _____

Name _____
Address _____

Name _____
Address _____

Name _____
Address _____

The following non-PerCCAMS members will be on the trip:

Name _____ NSS Yes __ No __ NSS# _____
Address _____

Name _____ NSS Yes __ No __ NSS# _____
Address _____

Name _____ NSS Yes __ No __ NSS# _____
Address _____

Name _____ NSS Yes __ No __ NSS# _____
Address _____

Name _____ NSS Yes __ No __ NSS# _____
Address _____

Name _____ NSS Yes __ No __ NSS# _____
Address _____

All of the above (& those listed on the previous page) must have signed a release form in the past 2 years or the trip will not be approved. Please enclose all necessary release forms.

The following person has been informed of the details of this trip and will be called or visited upon our return from this cave trip, by approximately:

Time____AM PM _____Day _____Month ___Year

Name_____ Office Phone _____

Address _____ Home Phone _____

City _____State _____ Zip _____

This person will commence rescue procedures by calling, in the following order:

John Wilson (804)355-5203
(804)252-8252

_____PerCCAMS Member (___)_____

_____PerCCAMS Member (___)_____

_____PerCCAMS Member (___)_____

or Cave Rescue Communication Network (CRCN) at (804)924-7166,
if he or she has not been contacted by _____Time,

_____Day, _____Month.

Purpose of this trip: Check all that apply to this trip.

_____ A. Mapping - State area of cave to be mapped:

_____

_____ B. Cave Conservation

___ 1. Clean Up - Describe methods to be used and in what area of the cave:

_____

_____

___ 2. Restoration - Describe the restoration project, area of cave and methods to be used:

_____

_____

_____

_____ C. Familiarization - Trips must be 100% PerCCAMS members. Give area of cave:

_____

_____ D. Photography - Photographers must be PerCCAMS members. All photo trips are to support the purposes of PerCCAMS. Describe the goals of the trip and places to be photographed:

_____

_____

_____

_____

_____ E. Rescue - Complete this form as time allows.

_____ F. Scientific - No specimen collecting. Describe

_____

_____

_____

_____

_____ G. Exploration - All trips must have 100% PerCCAMS Members. Give area of cave to be explored:

_____

_____ H. Environmental Impact Studies - Evaluation of vandalism or study the potential effects of people and their activities upon the cave. In the event of gate violations, this form may be filled out after a short cave examination trip. Describe:

_____

_____

_____

_____ I. Cave Management - Trips must be to carry out the purposes of PerCCAMS. Describe:

_____

_____

_____ J. Community Relations - Requires board approval. Describe:

_____

_____

_____ Keys to the Farm gate ___ and the house ___ are desired. (Sometimes these keys will be same as cave gate)

_____ I understand that as trip leader of this trip into Perkins Cave, I am responsible for seeing that the intent of all rules and regulations established by PerCCAMS are carried out completely. I will see that each person on this trip complies with all PerCCAMS rules and regulations including posting the time in and out of the cave in the Cave Register. I will complete a trip report from within 14 days after the trip.

Signature _____

The use of the farm house and other facilities by PerCCAMS members is available upon request. These facilities are being made available by John Wilson at no charge to PerCCAMS members, provided that each trip leader takes responsibility in seeing that the house and building are left in at least as good a condition as they were found.

APPENDIX iv

P.O. Box 7007, Richmond, VA 23221

PERKINS CAVE TRIP REPORT FORM

Date _____

Trip Leader (Person responsible for the conduct of the party):

_____

Trip Members (if actual trip members were different in any way from those listed on the trip request form, list here):

This person is an addition___or deletion___ (check one)

Name _____ NSS # _____

Address _____

City _____ State _____ Zip _____

This person is an addition__ or deletion __ (check one)

Name _____ NSS # _____

Address _____

City _____ State _____ Zip _____

This person is an addition __ or deletion __ (check one)

Name _____ NSS # _____

Address _____

City _____ State _____ Zip _____

Actual purposes of trip, if different than the purpose stated on the trip request form.

_____

_____

_____

Areas of cave actually visited: _____

Time first person entered cave: _____

Time last person in group emerged from cave: _____

Results of trip (attach report if necessary): ____

_____

_____

_____

Observations that might be useful to PerCCAMS (attach report if necessary): _____

_____

_____

Enclosed is the Perkins Cave Key(s): Yes__ No____

Signature _____

THE EVOLUTION OF THE VIRGINIA CAVE COMMISSION

*John Wilson, Robert W. Custard, Evelyn W. Bradshaw, Philip C. Lucas, and John R. Holsinger

ABSTRACT

The Virginia Commission on the Conservation and Use of Caves published a report to the Governor and the General Assembly in less than a year with no direct appropriation and then ceased to exist.

The Cave Protection Act contained several major improvements over the old law, including the banning of speleothem sales and limitation of cave owner liability. Some of the recommendations of this commission are described in this paper.

The Study Commission recommended that a permanent Cave Commission be established. This came about in a two-step process. After much negotiating with the leadership of the Virginia General Assembly, that body approved a one-year commission with $8,000.00 in funds. This budget made it possible for accomplishing many things on a scale never before done in the cave community.

The Cave Protection Act was approved overwhelmingly by the General Assembly with little opposition but several amendments that protect the right of the cave owner to use his or her cave as he or she sees fit.

In 1980 the Cave Commission was made a permanent State Agency as part of the Department of Conservation and Economic Development. However, no additional funding was provided. Since no operating funds are now available for the commission, the interested cavers formed the Virginia Cave Conservancy to provide a means of funding, not only the commission, but also for encouraging the ownership and management of caves. The purposes of a conservancy are listed in the Appendix.

This cave conservancy would seek to raise funds from public solicitation fundraising projects such as bingo and dues, etc. The funds would go to support cave acquisition and management as well as to assist organizations such as the Virginia Cave Commission.

HISTORY OF THE ESTABLISHMENT OF THE VIRGINIA COMMISSION ON THE CONSERVATION AND USE OF CAVES

I first suggested the idea of a cave commission in 1970 to a caver in Richmond. He did not agree that getting the state involved with caves and caving would be a good idea. However, within several years, I did find a few cavers who agreed that a cave commission would be a desirable thing and by 1975, I had set the wheels in motion through Virginia State Delegate Bill Axselle. Together we set up a committee to study the problems of cave conservation and the role of the state in dealing with cave conservation.

The new committee was composed of cavers, a legislator, representatives of several appropriate state agencies and representatives of commercial caves in Virginia. After two meetings, it became apparent that the state agencies were not in favor of adding additional duties to their agencies. This, apparently because they felt that the General Assembly would not fund anything of this nature, and they did not wish to have any additional work without additional fundings.

So, the cavers were told by the representative of the agency that before their agency could support any on-going state activity to protect caves, we would have to thoroughly document almost everything about caves in Virginia. This request was beyond our resources to accomplish in any reasonable length of time. They were informed of our limitations, but said they could not help, other than to supply us with a copy of John Holsinger's book, Descriptions of Caves in Virginia. Up to that point, the commercial cave representatives had not, in any significant way, opposed what the cavers were trying to do.

*Virginia Cave Commission, P. O. Box 7007, Richmond, Virginia 23221

Since the current route appeared to be unproductive, I made the decision to go straight to the General Assembly with our ideas. I asked Delegate Axselle to draft a preliminary resolution, Joint House Resolution 10. I sent draft copies to everyone on this committee: commercial cave owners, agency heads, etc., plus all the NSS chapters in Virginia, and asked for their support and suggestions. No suggestions came in.

As a result, Axselle set up a public meeting with the Rules Committee prior to the start of the 1977 session of the General Assembly in order to get any input from the Rules Committee and other interested people. Several changes were suggested at this meeting, including the deletion of the word "overcommercialization; from the whereases. We agreed to that, and after that hearing, representatives of commercial caves never again spoke publicly against any of our resolutions at any hearing over the next three years.

The one commercial cave representative who spoke against the resolution at that hearing in 1975 opposed the concept of commissions in general. He was opposed to any cave commission because he believed that it would lead to government regulation of commercial cave operations, even though this was prohibited by the resolutions. This individual continued to oppose the commission to the end and tried unsuccessfully to get the Virginia Chamber of Commerce to oppose the resolution. I do not think that early opposition of the one commercial cave representative had any eventual effect on how long it took to get the resolution passed.

In Virginia, many legislators believe that bad laws and bad resolutions are worse than no laws at all. So, when there is a new concept proposed, the General Assembly tends to take its time while considering all aspects of the proposed law. Three or four years is typical for bills and resolutions of this type to be passed in Virginia. This was particularly true for this commission since it was not only a new concept for Virginia, but, to the best of my knowledge, it is the first commission ever established in the United States to study the overall use and conservation of caves.

The cave resolution was carried over in 1977 and then passed in 1978. The vote in the House was 67 to 7. It was amended by the Senate (funds deleted) and passed 40 to 0; the House then passed the Senate version. Resolutions do not require the governor's signature so the committee was approved as of the final day of the General Assembly in March, 1978.

We anticipated difficulty in getting the resolution passed and had planned an effort of several years to get the General Assembly used to the idea of a cave commission: I also planned to educate cavers as to the reason why such a commission was needed, and what the roles of commissions are in the process of establishing agencies and passing law. One of the things that help get bills and resolutions passed is to have an articulate group of citizens who can convince their delegates of the need and desirability of proposed legislation.

I found that many cavers did not understand the concept of commissions in general, even though the vast majority of laws in Virginia go the route of either Legislative Study Committee or Commissions. I had to convince cavers that ultimately the goal of protecting caves would be better served not solely by cave protection laws, but by on-going structure, commission, agencies whose purpose is to protect caves, educate people, and even manage some caves. It is unlikely that punitive laws alone can adequately protect caves.

It is desirable to have people within state government who will come up with positive solutions to problems and be able to react quickly when threats to caves become apparent. This process of working for the support of cavers began to get results in late 1977, when numerous cavers began to contact their delegates. But, ultimately the Commission was passed because Delegate Axselle was able to convince John Warren Cook, Speaker of the House and chairman of the Rules Committee to give the commission a try. I believe that 1978 was the first year that the commission could have established under the circumstances.

The several years waiting did give us the opportunity to develop a list of strong potential commissioners and make the necessary contact within the political framework. Most of the members on the list I suggested to Axselle were accepted by the Governor. The Governor appointed three commissioners who were suggested by other sources. The passage of this resolution is only a start. I believe that a permanent commission or agency will be necessary and our study commission has recommended this. I would estimate that it could take anywhere from three to ten more years to have this goal realized in its entirety, although we have been able to achieve some of our objectives already by 1979.

WORK AND RECOMMENDATIONS OF THE VIRGINIA COMMISSION ON THE USE AND CONSERVATION OF CAVES

The Virginia Commission on the Conservation and Use of Caves was to make a report to the Governor and the General Assembly; do this in less than a year with no direct appropriation and then cease to exist. That is what happened; its 43-page report was published and went to the Governor and the General Assembly with three major recommendations and extensive background material.

The Cave Protection Act contained several major improvements over the old law, including the banning of speleothem sales and limitation of cave owner liability. Some of the recommendations of this Commission are described on the next few pages.

Sale of Speleothems

A major recommendation of the Commission is that Virginia join West Virginia and Maryland in banning the sale of speleothems or their export from the Commonwealth for sale elsewhere (see proposed Virginia Cave Protection Act, Appendix). By eliminating this incentive for removing these mineral formations from caves, much vandalism should be stopped. Information on the provisions of the State cave protection law should be widely disseminated, perhaps by signs posted in cave entrances, to warn vandals that their activities are unlawful.

Generally speaking, there are two markets for speleothems — souvenir hunters and serious collectors of mineral specimens. A ban on speleothem sales will primarily affect the souvenir hunter who buys a small speleothem for a dollar or two from a wayside rock shop or souvenir stand. These souvenir speleothems are usually not particularly attractive once removed from their natural surroundings and have little lasting value. Souvenir hunters will probably never notice their disappearance if the sale of speleothems is prohibited. The potential economic loss to owners of rock shops and souvenir stands will be negligible as speleothem sales usually account for only a minute percentage of their business. Further, most of the souvenir hunters who would buy a speleothem if they were offered for sale probably will end up buying some other trinket if speleothem sales are banned.

For the serious collector of mineral specimens, a ban on the sale of speleothems will not prevent the legitimate collection of speleothems from caves simply by obtaining the prior written permission of the cave owner. With the profit motive for collecting removed, collecting of speleothems is expected to become limited, selective, and professional in the way it is done. Indiscriminate collection by profiteers operating without the cave owners permission hopefully will be eliminated.

Limitation of Cave Owner Liability

As recreational caving has become increasingly popular over the last decade, there has been a corresponding rise in the number of caving accidents. Undoubtedly this trend will continue as the sport of caving grows and increasing numbers of inexperienced and ill-equipped individuals enter caves.

For the cave owner, cave accidents represent a source of potential liability with which it is difficult for him to deal. Few cave owners can objectively evaluate the caving abilities of persons wishing to enter their cave. Further, few cave owners have ever been in their cave, and thus cannot evaluate the difficulty of their cave or the risks involved. Many cave owners are absentee land owners and, therefore, have little effective control over access to their cave. Thus, unless a cave owner closes his cave to all persons by gating it or posting it, he has little chance of limiting his potential liability.

The Commission, therefore, recommends that cave owners be absolved from liability in the event of an accident in their cave. Persons entering a cave would then have to do so at their own risk except at commercial caves where an admission fee is paid. The provisions of the proposed Cave Protection Act (See Appendix) will permit the use of caves for recreational and scientific purposes without imposing unwarranted liabilities upon the cave owner.

Proposed Permanent Cave Commission

The Commission recommends establishing a permanent Virginia Cave Commission composed of eleven members, serving three-year staggered terms (see proposed legislation creating Commission, Appendix). Most of the members should be persons active and knowledgeable in the management, exploration, study, and conservation of caves. Expertise in the fields of cave biology, geology, archeology, paleontology, history, and recreation may be represented.

It became clear during the Commission's work that there is a role in the Commonwealth for a permanent Virginia Cave Commission to provide consultative services to state agencies on problems related to the use, management, protection, and scientific interpretation of caves and karst landforms. (See appendix for documentation on past interaction between speleologists and State agencies.) This proposed permanent Cave Commission could also provide considerable assistance to state agencies by coordinating programs or activities that involve caves and karst with federal agencies, regional parks, local governments, and private citizens.

Caves on Private Property — The proposed permanent Cave Commission can play an important role in assisting private land owners in conserving and managing caves on their property. The legislation creating the proposed Cave Commission will specifically charge that body with studying ways the proposed Cave Protection Act can be more effectively enforced. Further, the proposed Cave Commission will be charged with studying the rights of the property owner under Virginia law in order to clarify who owns a cave when the surface rights and the mineral rights are separately owned. Lastly, the proposed Cave Commission will seek to identify significant privately owned caves in danger of being destroyed and will recommend steps which can be taken to protect these caves. Emphasis will be placed on ways the Commonwealth can encourage private individuals and groups to save these threatened caves. Purchase of significant caves by government agencies in order to protect them should be considered a measure of last resort.

Caves on Public Property — The number of Virginia caves on public property is presently unknown. Several cities and counties as well as two regional parks own caves. There are ten caves in the Jefferson National Forest and twenty caves in the Cumberland Gap National Historic Park. Caves are also known to exist in the George Washington National Forest and on State land owned by the Department of Highways, Division of Parks, and Commission of Game and Inland Fisheries. Only a handful of these caves are managed so as to protect the cave from vandalism and visitors from injury.

The proposed Cave Commission could be instrumental in assisting public agencies which own caves in Virginia in formulating and implementing management plans for their caves. An inventory of publicly owned caves in Virginia would be the logical first step in this endeavor. Further, the proposed Cave Commission would be able to put public agencies in touch with trained speleologists when cave-related problems arise.

Civil Defense — In the past, a number of Virginia caves have been designated as civil defense shelters. In many cases the caves selected were not suitable for this use (see Appendix for fuller discussion of civil defense and caves.) Typically caves are cold and damp, usually are remote from urban population centers, and occasionally are

subject to flooding. Many have vertical pits or small, tight passages. The proposed Cave Commission could prepare a list for use by State and federal civil defense agencies of Virginia caves suitable for use as civil defense shelters. This would prevent possible disasters arising as a result of the designation of inappropriate caves as shelters. It is recommended that signs now identifying inappropriate caves as civil defense shelters be removed.

Advising and Assisting Public Agencies — A major function of the proposed Cave Commission will be to advise and assist public agencies. There presently exists, due to the efforts of the Virginia Speleological Survey of the National Speleological Society, a wealth of data about Virginia caves, but this information is not generally accessible. The proposed Cave Commission will study ways and means of making these data more readily available to State agencies for their use in construction siting, land use planning, and environmental impact statement review. As previously mentioned, an electronic data storage and retrieval system maintained by an appropriate State agency seems to be the most logical way of providing ready access to these data.

The proposed Cave Commission will be able to act as a liason between caving organizations, cave scientists, public agencies, and the general public. For example, the proposed Cave Commission may be able to help local rescue squads obtain the assistance of experienced cavers to help them cope with the unique problems posed by cave rescue situations. Similarly, the proposed Cave Commission could assist in gathering input from interested parties if a State cave recreation plan is ever developed. (The need for and desirability of a cave recreation plan will be studied by the proposed Cave Commission.)

Lastly, the proposed Cave Commission will be able to play an important informational role by providing State agencies with general information about caves and by assisting these agencies in providing information about caves to the public. The scientific, recreational, and aesthetic value of Virginia's caves is not widely recognized. The proposed Cave Commission would attempt to generate an increased awareness of the value of Virginia's caves and the legal protection these caves are given under Virginia law. In this connection, the proposed Cave Commission could prepare or assist other State agencies in preparing publications on caves or cave-related problems.

Conclusion

Virginia's caves represent a unique, limited, and non-renewable natural resource of great scientific, historic, educational, economic, and recreational value. Vandalism and pollution are rapidly destroying this resource. In order to prevent Virginia's spelean wilderness from being destroyed within out lifetime, immediate steps need to be taken to protect Virginia's significant caves. The Commission recommends that a permanent Cave Commission be created to assist State agencies dealing with cave-related problems, that a new, more comprehensive Cave Protection Act be enacted, and that the Virginia Research Center for Archeology be granted a special appropriation for the 1980-82 biennium to conduct a two-year archeologic survey of Virginia caves.

ESTABLISHMENT OF A TEMPORARY CAVE COMMISSION AND PASSAGE OF THE CAVE PROTECTION ACT

The Study Commission recommended that a permanent Cave Commission be established. This came about in a two-step process. After much negotiating with the leadership of the Virginia General Assembly, that body approved a one-year Commission with $8,000.00 in funds. This budget made it possible for accomplishing many things on a scale never before done in the cave community. A summary of these accomplishments follows on the next few pages.

The Cave Protection Act was approved overwhelmingly by the General Assembly with little opposition but several amendments that protect the right of the cave owner to use his or her cave as he or she sees fit.

The caving community is indebted to the Commonwealth of Virginia and its General Assembly for establishing the first permanent Cave Commission in the United States, thus providing the framework for more effective attempts to protect Virginia's unique speleological resources.

The work of the Commission was also facilitated by the cooperation of the Virginia Speleological Survey, established in 1975 as the successor to the Virginia Cave Survey, which had been founded in 1954. We also appreciate the support of the more than six hundred members of the National Speleological Society residing in Virginia.

During the year the Commission held seven meetings for the purpose of coordinating activities. Minutes of these meetings have been deposited with the office of the Department of Conservation and Economic Development, for whose interest and cooperation Commission members are grateful.

Threats to Virginia's Caves

A large number of Virginia's significant caves are rapidly deteriorating as a result of vandalism and heavy traffic incident to the recent growth of recreational cave exploration as a sport. As a result, a large portion of Virginia's non-renewable cave resources are in danger of being destroyed within our own lifetime.

Significant Caves

A major accomplishment of the Commission in the year 1979-1980 was the designation of 200 caves and seven karst areas in the Commonwealth as "significant". Eleven criteria were used in evaluating which caves qualified for inclusion on the list: archaeologic, biologic, economic, aesthetic, geologic, historic, hydrologic, paleontologic, and recreational significance, length, and depth.

Carrying out this project entailed extensive review of available literature as well as canvassing all the members of the organized caving community in Virginia and issuing calls for information in the NSS News (organ of the National Speleological Society), Virginia Wildlife, and Virginia Minerals.

Publicly Owned Caves

Another accomplishment of the Commission was to determine the number of caves located on publicly owned property in Virginia and their location. With the assistance of the Virginia Speleological Survey and through correspondence with many public agencies, a list was derived. A total or 92 caves were found on publicly owned land: 45 on federal property, 39 on state owned lands, and 8 owned by cities or towns. The Commission recommends that this list be reviewed and updated after two years, and every five years thereafter.

The Commission has identified approximately ten percent of all known Virginia caves as significant because of rare features, animals found therein, or unusual conditions. Of all caves located on public property, 29% belong to this significant category, representing 12% of all Virginia's significant caves.

Many publicly owned caves contain evidence or artifacts of historical importance. Some were mined for saltpetre, which was used in the manufacture of gunpowder in the Revolutionary and Civil Wars. Only one, owned by the City of Staunton, is currently being utilized for storage. The City of Waynesboro has purchased a cave containing a deep underground lake for a potential water supply. At least one publicly owned cave contains an endangered species of bat.

Accessibility of Cave Data

Modern electronic data processing methods make possible the storage and easy retrieval of specified data on caves as they may be needed by state agencies or others for, for instance, environmental impact studies. Arrangements were made with the Virginia Speleological Survey, which possesses extensive files of cave data, to transfer the information into a computer format. The initial phase of setting up these computerized records was completed during the year, with the cooperation of the Division of Mineral Resources.

However, much more remains to be done in future years. While there are now over 2500 known caves in Virginia, there is also good scientific evidence to conclude that there may be hundreds, perhaps even thousands, of unknown, unreported, or undiscovered additional caves in the Commonwealth. Also, new information on known caves is constantly being received as the result of current investigations by the caving community.

Also related to this data collecting effort was a search to locate cave owners so that they might be informed of the aims and operations of the Commission and of the hope of the Commission to work cooperatively with them on cave protection. Because of the time required to ascertain the owner of a given cave, the main effort of the Commission to date has been with regard to ownership of the "significant" caves. Completing and regularly updating this list of cave owners will be one of the ongoing functions of the Commission.

Publicizing the Commission and its Services

To disseminate information widely about the existence of the Commission and its services, articles were written for the media by Commission members, including ones in Virginia Minerals and Virginia Wildlife, which resulted in several inquiries about caves from the general public. Another Commission member collaborated on an article on bats in the nationally-circulated Nature Conservancy News.

Letters were written to several state agencies and to all the public school systems in the Commonwealth, accompanied by a brief descriptive flyer, "Ten Questions about Caves and the Virginia Cave Commission." Members of the caving community in Virginia were canvassed to assess human resources available to give talks about speleology and assist the Commission in other ways. Signs were printed to inform the public about the Virginia Cave Protection Act. Private individuals inquiring about caves were usually referred to recognized local caving organizations, since this promotes both the safety of the individual and protection of the caves.

Cave Rescue

The Commonwealth is fortunate with respect to cave rescue. In this region cavers have, for a number of years, operated one of the most highly organized and effective cave rescue networks in the country. One of the Commission members is currently part of the team heading the cave rescue network for Virginia and West Virginia. Periodic training is provided for cave rescue workers, and the call-down list is constantly being updated. The network is also affiliated with the National Cave Rescue Commission, formally established by the National Speleological Society in 197[illegible].

Rapport with the state Office of Emergency and Energy Services has existed for some time.

Legal Questions about Cave Ownership

In investigating legal problems that may arise in connection with cave ownership, the Commission notes two precedent-setting cases from Kentucky.

The first is Cox v. Colossal Cavern Company (210 Kentucky 612, 1925), in which the principle of cave rights was established. In 1883, Mary Proctor, the owner of the land around Colossal Cave, sold the land but retained the "cave rights" for her own use. Her heirs inherited the cave rights and later sold them to the Colossal Cavern Company. In 1925, W. Perry Cox, the owner of the land around the entrance and all land above the cave, brought suit against the Colossal Cavern Company, seeking to gain control of the cave. The court held that although the owner of the surface normally owns everything down to the center of the earth, it was perfectly legal to separate the "cave rights" from the surface estate, just as had long been accepted practice for water and mineral rights. The Colossal Cavern Company was awarded all caves under Cox's land, access to the caves, and the right to show the caves to the public.

The second case was Edwards v. Sims (232 Kentucky 791, 1929), in which the notion of cave rights was further refined. The legal question in this

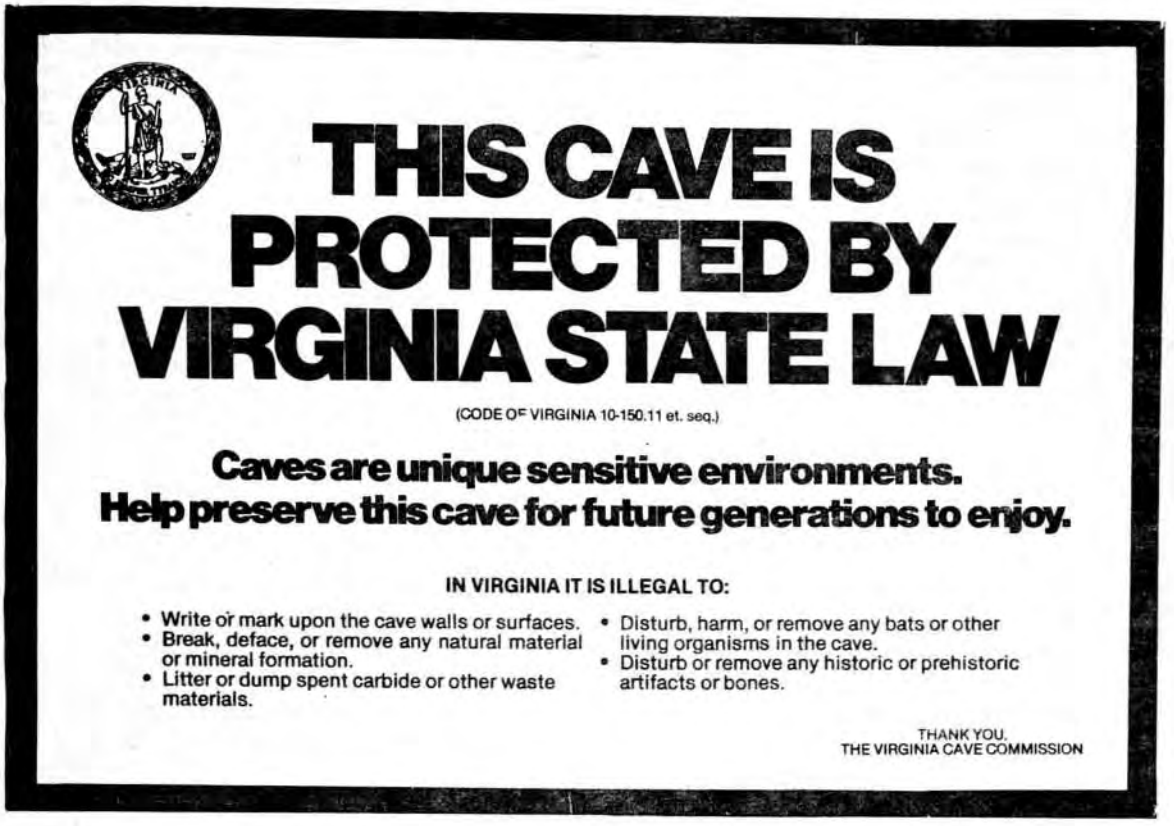

FIGURE 1. Signs intended for placement at cave entrances are designed to educate the caving public.

case was whether the circuit court of Edmonson County, Kentucky, had the power to order a survey of Great Onyx Cave. Edwards owned the cave entrance and was operating the cave commercially. Lee, a neighbor, believed that parts of Great Onyx Cave extended under his land and therefore belonged to him according to the ancient common law doctrine (that whoever owns the surface also owns to the sky and to the depths below), and that Edwards was therefore guilty of trespass. The Court decided that although Edwards owned the entrance to Great Onyx Cave, any parts of the cave extending under Lee's property belonged to Lee. Since the only means of determining whether trespass was occurring was to survey the cave, the court ordered a survey begun.

Protection of Significant Caves Through Acquisition

Where especially significant privately owned caves are in imminent danger of being destroyed, the Commission can encourage their conservation by interested individuals or conservation groups who might be willing to acquire rights to the property through purchase, lease, or easement.

The Nature Conservancy (TNC) may be mentioned in this connection. TNC is a national conservation organization dedicated to the preservation of natural diversity through the protection of lands containing the best examples of the natural world. TNC has helped preserve over 1.5 million acres of land through some 2,200 individual projects. TNC is funded by donations of land and money and through grants and membership fees.

Other conservation groups, especially within the organized caving community, also may be potentially willing and able to acquire significant privately owned caves to insure their preservation. In fact, two of the Commonwealth's largest "wild" caves, Butler Cave in Bath County and Perkins Cave in Washington County, are presently owned and/or managed by conservation groups established specifically to preserve them.

The Commission may be able to play a role in bringing together cave owners for whom cave are primarily a nuisance and those groups or individuals interested in cave protection, for the purpose of working out mutually acceptable terms for some type of transfer or shared responsibility.

Law Enforcement

An early task of the Commission was to study ways that the Cave Protection Act could be more effectively enforced. The Commission concluded that the effectiveness of the Act could be enhanced by using two basic approaches — informing the public about the law and the value of caves, and by assisting cave owners in formulating management plans to protect their cave property.

As part of its effort to assist cave owners, the Commission had three hundred signs made (Figure 1) which briefly outlined the provisions of the Cave Protection Act. These signs, made of aluminum, will be installed in significant caves around Virginia by cave owners and members of the caving

community. While they may not deter malicious vandals, these signs should help prevent the kind of damage to caves that results from carelessness and ignorance.

In its role of informing the public about caves and the Cave Protection Act, the Commission has carried out an active program. Information about the law has been widely disseminated through caving circles. In November, for instance, a full length article on the Cave Protection Act appeared in Virginia Minerals. More recently, the Commission had several thousand small brochures explaining the Cave Protection Act printed for distribution to recreational cavers. Presently, a number of informative exhibits on cave conservation are being built for display at Virginia's commercial caves.

Through additional publications, press releases, and a speakers' bureau currently being set up, the Commission intends to continue its efforts to educate the public about caves and the laws that protect them. It is anticipated that the Commission will also work closely with other state agencies such as the Virginia State Library and the Division of Mineral Resources, which also provide information about caves to the public. For example, the Commission is presently investigating possible sources of films or slide shows on caves which could be acquired to add to the present collection at the Virginia State Library. As other opportunities present themselves, the Commission undoubtedly will take the initiative in order to continue to provide the public with information about caves through a wide spectrum of media. Only an informed and concerned public can ensure the protection of Virginia's speleological resources.

Civil Defense

The Commission has not ruled out the use of caves as civil defense shelters, although a study of this undertaken in several western states by the National Speleological Society some years ago concluded that caves in their natural and unimproved state are unsuitable shelters for people during a nuclear attack.

Storage of materials in caves is less expensive than using the cave as a shelter for people; but both are expensive propositions in that initial modifications are usually extensive and the ongoing monitoring of access to the shelter is essential.

Recreation

Any position taken by the Commission on the development of the recreational potential of caving should be consistent with the basic principle for which the Commission was established: the conservation of caves within the Commonwealth.

In our opinion, visiting one of the several commercial caves in the Commonwealth is the preferable way to introduce the general public to the beauties and fascination of the underground world. The Commission should always be ready to provide guidance and information to commercial cave owners to aid them in enhancing the attraction of commercial caves to tourists from within and from outside the Commonwealth.

Because "wild" caves are used by both public and private groups for recreational purposes, the Commission should provide these groups with guidelines based upon the provisions of the Cave Protection Act. For individuals and groups who have not been provided with more inclusvie guidelines, signs summarizing the Cave Protection Act will be posted in most of Virginia's significant caves.

Conclusion

As public interest in outdoor recreation continues to grow and land development accelerates in the intermontane valleys west of the Blue Ridge, increased pressure will be put on Virginia's limited and fragile cave resources. In order to preserve the unique educational, recreational, scientific, historic, and economic value of Virginia's caves and karst areas, the Commonwealth needs to make a continuing commitment to safeguard this spelean wilderness. A permanent Cave Commission, composed of concerned citizens, working in conjunction with other agencies of the Commonwealth, appears to be the most effective vehicle for focusing the attention of both government and the public on this goal.

It is anticipated that future efforts of the Cave Commission to conserve Virginia's cave resources will fall primarily into four broad areas — collecting and maintaining a complete data file on cave resources within the Commonwealth, providing information to the public about caves, their value, and the laws protecting them, advising and assisting public agencies and private landowners making cave management and land use decisions, and studying those aspects of cave ownership and management that are directly affected by public policy.

The Commission has already made great progress in collecting and maintaining a cave data file. The establishment of the Virginia Significant Cave List and the inventory of publicly owned caves were great milestones in the assessment of Virginia's cave resources. The development of a computer data storage and retrieval system in cooperation with the Division of Mineral Resources has put a wealth of easily accessible cave data at the disposal of engineers and planners throughout the Commonwealth. A list of Virginia cave owners is currently being compiled. As more data becomes available, the Commission will add to and update these data files on a continuous basis.

In its ongoing role as a source of information about caves and their protection, the Commission has published several articles and brochures as noted above. In the coming year, the Commission plans to erect signs at significant caves stating the provisions of the Cave Protection Act and place displays at several of Virginia's commercial caverns. A continuing program of publishing articles and brochures on caves, their value, and their protection is also envisioned. The Commission's speakers bureau on cave-related subjects is expected to become a fully functioning entity. Cooperative efforts with other public agencies which provide information on caves to the public are anticipated as well.

The study functions of the Cave Commission will diminish significantly with the publication of this report. While some aspects of cave conservation such as cave ownership law and the effectiveness and enforcement of the Cave Protection Act will require further study, the basic studies establishing the value and extent of Virginia's cave resources and the threats to these resources have been completed. The principal focus of future annual reports by the Commission will be on the changes in the state of the Commonwealth's cave resources and on the Commission's ongoing efforts to conserve them.

In its advisory capacity, the Commission has been actively developing its ability to assist public agencies and private landowners engaged in making cave management and land use decisions. For example, data on the location and significance of caves along the proposed route of US #58 in Lee County was provided to the Department of Highways so that destruction of significant caves could be avoided. In another instance, the Commission notified the Virginia Research Center for Archeology about an important find of Indian inscriptions in a Bath County cave and arranged permission for a James Madison University archeologist to visit the cave to evaluate the significance of the find. With the new computerized data base developed by the Commission and the unusual speleologic expertise of the Commission's members, an expanding role is foreseen for the Commission in the development of cave management plans, the protection of significant caves, and the study of land use in karst areas. It is hoped that the Commission can continue to provide the focus for cave conservation efforts in the commonwealth and to serve as the source of authoritative information on all aspects of cave use from recreation to civil defense.

ESTABLISHMENT OF THE PERMANENT CAVE COMMISSION

In 1980, the Cave Commission was made a permanent State Agency as part of the Department of Conservation and Economic Development. However, no additional funding was provided. Since no operating funds are now available for the Commission, the interested cavers formed the Virginia Cave Conservancy to provide a means of funding, not only the Commission, but also for encouraging the ownership and management of caves. The purposes of a Conservancy are listed in the Appendix.

This Cave Conservancy would seek to raise funds from public solicitation fund-raising projects such as bingo and dues, etc. The funds would go to support cave acquisition and management as well as to assist organizations such as the Virginia Cave Commission.

APPENDICES

Virginia Cave Protection Act
Chapter 252

An Act to amend the Code of Virginia by adding in Title 10 a chapter numbered 12.2, consisting of sections numbered 10-150.11 through 10-150.18, and to repeal § 18.2-142 of the Code of Virginia, the added and repealed sections relating to the conservation and protection of caves; penalty.

Approved March 15, 1979.
Be it enacted by the General Assembly of Virginia:
1. That the Code of Virginia is amended by adding in Title 10 a chapter numbered 12.2, consisting of sections numbered 10-150.11 through 10-150.18 as follows:

CHAPTER 12.2
VIRGINIA CAVE PROTECTION ACT

§10.150.11. Findings and policy.— The General Assembly hereby finds that caves are uncommon geologic phenomena, and that the minerals deposited therein may be rare and occur in unique forms of great beauty which are irreplaceable if destroyed. Also irreplaceable are the archeological resources in caves which are of great scientific and historic value. It is further found that the organisms which live in caves are unusual and of limited numbers; that many are rare and endangered species; and that caves are a natural conduit for groundwater flow and are highly subject to water pollution, thus having far-reaching effects transcending man's property boundaries. It is therefore declared to be the policy of the General Assembly and the intent of this chapter to protect these unique natural and cultural resources.

§10-150.12. Definitions.—As used in this chapter, the following words shall have the meanings stated unless the context requires otherwise:

A. "Cave" means any naturally occurring void, cavity, recess, or system of interconnecting passages beneath the surface of the earth or within a cliff or ledge including natural subsurface water and drainage systems, but not including any mine, tunnel aqueduct, or other man-made excavation, which is large enough to permit a person to enter. The word "cave" includes or is synonymous with cavern, sinkhole, natural pit, grotto, and rock shelter.

B. "Commercial cave" means any cave utilized by the owner for the purposes of exhibition to the general public as a profit or nonprofit enterprise, wherein a fee is collected for entry.

C. "Gate" means any structure or device located to limit or prohibit access or entry to any cave.

D. "Sinkhole" means a closed topographic depression or basin, generally draining underground, including, but not restricted to, a doline, uvala, blind valley, or sink.

E. "Person" or "persons" means any individual, partnership, firm, association, trust, or corporation or other legal entity.

F. "Owner" means a person who owns title to land where a cave is located, including a person who owns title to a leasehold estate in such land, and specifically including the Commonwealth and any of its agencies, departments, boards, bureaus, commissions, or authorities, as well as counties, municipalities, and other political subdivisions of the Commonwealth.

G. "Speleothem" means a natural mineral formation or deposit occurring in a cave. This includes or is synonymous with stalagmite, stalactite helectite, shield, anthodite, gypsum flower and needle, angel's hair, soda straw, drapery, bacon, cave pearl, popcorn (coral), rimstone dam, column.

palette, flowstone, et cetera. Speloethems are commonly composed of calcite, epsomite, gypsum, aragonite, celestite, and other similar minerals.

H. "Speleogen" means an erosional feature of the cave boundary and includes or is synonymous with anastomoses, scallops, rills, flutes, spongework, and pendants.

I. "Material" means all or any part of any archeological, paleontological, biological, or historical item including, but not limited to, any petroglyph, pictograph, basketry, human remains, tool, beads, pottery, projectile point, remains of historical mining activity or any other occupation, found in any cave.

J. "Cave life" means any life form which normally occurs in, uses, visits, or inhabits any cave or subterranean water system, excepting those animals and species covered by any of the game laws of the Commonwealth.

§10-150.13. Vandalism; penalties.—A. It shall be unlawful for any person, without express, prior, written permission of the owner, to:

1. Break, break off, crack, carve upon, write, burn, or otherwise mark upon, remove, or in any manner destroy, disturb, deface, mar, or harm the surfaces of any cave or any natural material which may be found therein, whether attached or broken, including speleothems, speleogens, and sedimentary deposits. The provisions of this section shall not prohibit minimal disturbance for scientific exploration.

2. Break, force, tamper with, or otherwise disturb a lock, gate, door, or other obstruction designed to control or prevent access to any cave, even though entrance thereto may not be gained.

3. Remove, deface, or tamper with a sign stating that a cave is posted or citing provisions of this chapter.

B. The entering or remaining in a cave which has not been posted by the owner shall not by itself constitute a violation of this section.

C. Any violation of this section shall be punished as a Class 3 misdemeanor.

§10-150.14. Pollution unlawful; penalities.—A. It shall be unlawful for any person, without express, prior, written permission of the owner, to store, dump, litter, dispose of or otherwise place any refuse, garbage, dead animals, sewage, toxic substances harmful to cave life or humans in any cave or sinkhole. It shall also be unlawful to burn within a cave or sinkhole any material which produces any smoke or gas which is harmful to any naturally occurring organism in any cave.

B. Any violation of this section shall be punished as a Class 3 misdemeanor.

§10-150.15. Biological policy; penalties for violation.—A. It shall be unlawful to remove, kill, harm, or otherwise disturb any nautrally occurring organisms within any cave, except for safety or health reasons; provided, however, scientific collecting permits may be obtained from any cave commission established for such purpose or from the appropriate State agency.

B. Any violation of this section shall be punished as a Class 3 misdemeanor.

§10-150.16. Archeology; permits for excavation; how obtained; penalties for violation.—A. In order to protect the archeological resources not covered by the Virginia Antiquities Act (§10-150.1 et seq.), it shall be unlawful to excavate, remove, destroy, injure, deface, or in any manner disturb any burial grounds, historic or prehistoric resources, archeological or paleontological site or any part thereof, including relics, inscriptions, saltpetre workings, fossils, bones, remains of historical human activity, or any other such features which may be found in any cave, except those caves owned by the Commonwealth or designated as Commonwealth archeological sites or zones, and which are subject to the provisions of the Virginia Antiquities Act. Any violation of this subsection shall be punished as a Class 3 misdemeanor.

B. Notwithstanding the provisions of subsection A. hereof, a permit to excavate or remove archeological, paleontological prehistoric, and historic features may be obtained from the Virginia Historic Landmarks Commission. The Commission may issue a permit to conduct field investigations if the Commission finds that it is in the best interest of the Commonwealth, that the applicant meets the criteria of this section and the applicant is an historic, scientific, or educational institution, professional archeologist or amateur, who is qualified and recognized in the areas of field investigations or archeology. Such permit shall be issued for a period of two years and may be renewed upon expiration. Such permit shall not be transferrable; provided, however, the provisions of this section shall not preclude any person from working under the direct supervision of the permittee.

C. All field investigations, explorations, or recovery operations undertaken under this section shall be carried out under the general supervision of the Commissioner of Archeology of the Virginia Research Center for Archeology and the Virginia Historic Landmarks Commission and in a manner to insure that the maximum amount of historic, scientific, archeologic, and educational information may be recovered and preserved in addition to the physical recovery of objects.

D. A person applying for a permit pursuant to this section shall:

1. Have knowledge of archeology or history as qualified in subsection B. hereof.

2. Provide a detailed statement to the Comission giving the reasons and objectives for excavation or removal and the benefits expected to be obtained from the contemplated work.

3. Provide data and results of any completed excavation, study, or collection at the first of each calendar year.

4. Obtain the prior written permission of the owner if the site of the proposed excavation is on privately owned land.

5. Carry the permit while exercising the privileges granted.

E. Any violation of subsection A. hereof shall be punished as a Class 3 misdemeanor. Any violation of subsection D. hereof shall be punished as a Class 4 misdemeanor, and the permit shall be revoked.

F. The provisions of this section shall not apply to any person in any cave located on his own property.

§10-150.17. Sale of speleothems unlawful; penalties.— It shall be unlawful for any person to sell or offer for sale any speleothems in this Commonwealth, or to export them for sale outside the Commonwealth. Any violation of this section shall be punished as a Class 3 misdemeanor.

§10-150.18. Liability of owners and agents limited.— Neither the owner of a cave nor his authorized agents acting within the scope of their authority are liable for injuries sustained by any person using the cave for recreational or scientific purposes if no charge has been made for the use of the cave, notwithstanding that an inquiry as to the experience or expertise of the individual seeking consent may have been made.

Nothing in this section shall be construed to constitute a waiver of the sovereign immunity of the Commonwealth or any of its boards, departments, bureaus, or agencies.

2. That § 18.2-142 of the Code of Virginia is repealed.

HOUSE BILL NO. 1800

A BILL to amend the Code of Virginia by adding in Title 9 a chapter numbered 24.1, consisting of sections numbered 9-152.1 through 9-152.5, creating the Cave Commission its powers; duties; and the conduct of a cave study; appropriation and expenditure of funds.

Patron-Axselle

Referred to the Committee on Rules

Be it enacted by the General Assembly of Virginia:
1. That the Code of Virginia is amended by adding in Title 9 a chapter numbered 24.1, consisting of sections numbered 9-152.1 through 9-152.5, as follows:

CHAPTER 24.1
CAVE COMMISSION

9-152.1. Cave Commission established; compensation — A. There is hereby established in the office of the Department of Conservation and Economic Development the Cave Commission whose purpose shall be to implement the policy set forty in this article and to make recommendations to interested State agencies concerning any proposed rule, regulation or administrative policy which would directly affect or bear upon the use and conservation of caves in this Commonwealth. Members of the Cave Commission shall meet as necessary and serve without compensation but shall be reimbursed for their reasonable and necessary expenses incurred in the performance of their duties as Commission members.

B. The Cave Commission shall consist of eleven members who shall be appointed by the Governor on the basis of merit and shall be active and knowledgeable in the conservation, exploration, study, and management of caves.

C. Each member must be a citizen of Virginia. The members of the Commission shall serve for a term of one year commencing July one, nineteen hundred seventy-nine.

D. The Commission shall annually elect a chairman, vice-chairman and recording secretary.

9-152.2. Meetings. — the Cave Commission established pursuant to 9-152.1 shall keep a complete and accurate record of all Commission meetings, such record to be available for inspection by the public in the office of the Department of Conservation and Economic Development during normal work hours. Six members shall constitute a quorum for the transaction of business.

9-152.3. Functions of Cave Commission. — The Cave Commission may perform the following functions:

A. Serve as an advisory board to any requesting State agency on matters relating to caves and karst.

B. Conduct an inventory of publicly owned caves in Virginia.

C. Provide cave management expertise and service to requesting State agencies including the perparation of management plans for noncommercial caves on publicly owned property.

D. Identify all significant caves in Virginia and report any real and present danger to such caves.

E. Provide cave data for use by State and other governmental agencies which prepare or review environmental impact statements and land use plans.

F. Publish or assist in publishing articles, pamphlets, brochures or books on caves and cave-related concerns.

G. Facilitate data gathering and research efforts on caves and perform such other functions as may be deemed necessary in keeping with the general purposes of this article.

9-152.4. Cave Commission to study and report on cave matters of special concern. — In addition to all other duties of the Cave Commission, it shall be the responsibility of the Commission to study the following areas of general and special concerns and prepare a report to the Governor and General Assembly not later than June thirty, nineteen hundred eighty:

A. Ways in which State agencies can assist local authorities in obtaining the assistance of experienced cavers to help them in cave rescue situations.

B. Ways in which the State can encourage private individuals and conservation groups interested in cave conservation to purchase and protect significant caves in danger of being destroyed

C. Virginia laws relating to cave ownership in order to clarify ownership rights and determine potential liabilities.

D. Ways and means of making cave data available through an electronic data storage and retrieval system in order to assist public agencies in making decisions directly or indirectly affecting caves.

E. The need for and desirability of a State cave recreation plan.

F. Ways in which the Virginia Cave Protection Act can more effectively be enforced.

G. The use, present and future, of Virginia caves as civil defense shelters.

H. Ways in which the State can advise the public about the legal protection given to caves under the law and the penalties for violations of those laws.

9-152.5. Expenditures and funding. — The Commission may accept any gift, money, security or other source of funding and is authorized to expend such funds as are necessary in order to effectuate the purposes of this chapter.

2. That there is hereby appropriated from the general fund of the State Treasury to the Cave Commission the sum of eight thousand dollars in order to implement the provisions of this act for the 1979-1980 fiscal year.

ARTICLES OF INCORPORATION OF THE VIRGINIA CAVE CONSERVANCY

ARTICLE I — The name of the corporation is the Virginia Cave Conservancy.

ARTICLE II — The purpose of the corporation shall be
A. To promote the conservation of caves in Virginia and contiguous states.
B. To acquire the management rights of caves in need of protection and management when feasible and appropriate to adequately protect and conserve these caves and their contents; and to manage these caves in the best way possible to serve the public interest and protect the caves.
C. To promote the science and technology of cave management;
D. To promote the scientific study of caves;
E. To promote the quality of life in Virginia in so far as appropriate cave conservation and use can contribute to this.
F. To serve as a fund raising organization on a non-profit basis to help achieve the above purposes and to provide grants to other organizations which are devoted to accomplishing these same goals.

ARTICLE III — Membership in the Corporation is open to all interested persons coming within the purview of Article II above, who are approved for membership by the Board of Directors. All members of the Corporation shall be entitled to vote for the directors of the Corporation and shall be entitled to all of the privileges of membership.

ARTICLE IV — The affairs of the Corporation shall be managed by a Board of Directors which shall consist of the President, the Vice President, Secretary, the Treasurer and such other members as may be determined by the Board of Directors.

One-third of the members of the Board of Directors shall be elected each year at the Annual meeting of the Corporation. Terms of Directors shall be for three years. The officers shall be elected by the Board of Directors.

ARTICLE V — The address of the initial registered office is 2908 Idlewood Ave., in the City of Richmond, Virginia.

The City in which the initial registered office is located is Richmond. The name of the Corporation's initial registered agent is John M. Wilson, who is a resident of Virginia and a Director of the Corporation and whose business office is the same as the registered office of the Corporation.

ARTICLE VI — The number of directors constituting the initial Board of Directors is twelve (12) and the names and residence addresses of the persons who are to serve as the initial directors are:

John M. Wilson, President
7901 Dalmain Drive, Richmond, Virginia, 23228
Mail: 2908 Idlewood, Avenue, P. O. Box 7007, Richmond, Va. 23221
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INCORPORATORS:

John M. Wilson, President
Patricia J. Stephens, Treasurer

HIGH ADVENTURE UNDERGROUND - AN ADVENTURE CAVING PROGRAM AT ROCK BRIDGE MEMORIAL STATE PARK, MISSOURI

* Scott W. Schulte

ABSTRACT

Using wild caves at Rock Bridge Memorial State Park near Columbia, Missouri, a park-conducted adventure caving program introduces non-cavers to the sport of caving and to the ecology and geology of caves. The program helps to develop an appreciation for a relatively little known resource while satisfying the participants desire for an adventure. Cave trips are conducted so as to be exciting and informative, allowing the participants to explore and discover on their own. Trip leaders are along to interpret and insure that safe procedure is followed, but each group shapes their own trip. Both caves are exciting just to enter. One has a vertical entrance, requiring ropes to enter and exit; the other has a water passage for the first 800 meters, requiring a boat. The park supplies all of the specialized equipment needed. During the two years of experience with the program, the trips have generally filled to capacity and the program has received enthusiastic support from the participants. The caving program will continue as part of our Outreach Program bringing the thrill of caving and an understanding of caves to those who might otherwise never enter a cave.

The purpose of this presentation is to describe an adventure caving program conducted as part of an outreach program at Rock Bridge Memorial State Park.

Points covered include 1) Rock Bridge Memorial State Park and its cave resources; 2) outreach program philosophy and concept; 3) how a management scheme was developed; and 4) examination of the adventure caving program.

Rock Bridge Memorial State Park, with an area of 730 hectares, is located in Boone County about 6 kilometers south of Columbia, Missouri.

Devils' Ice Box is the principal cave in the park and is associated with the Pierpont karst. The Pierpont karst area is now partially in state ownership as part of the park.

Two of the primary goals of the park are protection and preservation of the caves and of a massive rock bridge for which the park is named.

Before we initiated the adventure caving program at Rock Bridge we carefully considered the situation and developed an overall management scheme for the park's cave resources.

Our first consideration was the resource. The dominant geologic features are the sinkholes and caves of the Pierpont karst.

The Pierpont area is well dotted with sinkholes which funnel water into the area's cave system. Only a few of the sinkholes, however, open into a cave.

Devil's Ice Box cave is accessed by a large sinkhole and is the most extensive cave in the area. With over 10 km of passageway the Devil's Ice Box underlies almost all of the Pierpont karst. Many side passages, domes, interesting formations and challenging passageways make the Devil's Ice Box an interesting cave to explore. Most challenging are the first 800 meters of passageway that are premanently flooded. The only access is via a boat or canoe.

Polly's Pot is the second largest cave in the park. Polly's Pot has about 800 meters of passageway and although not overly blessed with formation is still a very interesting cave. Entry is by a slender vertical shaft, a natural opening where the top of a dome has opened to the surface. The shaft drops about 15 meters straight down; ropes or cable ladders are needed to get in or out of the cave.

*Superintendent, Rock Bridge Memorial State Park
Columbia, Missouri 65201

Another important resource of the caves is the life that is found within. Associated with caves, of course, are bats, and the Devil's Ice Box is no exception. Most cave bat species of the area have been sighted in the Devil's Ice Box. The eastern Pipistrille bat, Big Brown bat and Little Brown bar are commonly seen in the cave. Two that are on the endangered species list, the Indiana bat (*Myotis sodalis*) and the Gray bat (*Myotis grisescens*) also often visit the cave. *Myotis grisescens* uses the cave while migrating and a guano pile suggests that the cave may have been used as a maternity colony site in the past.

Other cave life includes salamanders that find their way into the cave. Many invertebrates such as amphipods and isopods are found in the water. Insects and spiders can also be found in the cave. Neither cave fish nor cave salamanders have been found in the cave; but another creature, the pink planaria (*Macrotyla glandulosa*), is found only in Boone County, Missouri and perhaps only in Rock Bridge State Park. This flatworm has been found and identified only in the Devil's Ice Box and a spring in the park. The species has also been reported from Holten's cave (also in Boone County), but the identification has not been confirmed. Because the pink planaria is listed on Missouri's rare and endangered species list, we are very concerned with the study and protection of this animal. It will be recommended for inclusion on the Federal Rare and Endangered Species list.

Another consideration in developing management strategy for the caves was the demand put on the resource.

In addition to park tours, recreational cavers visit the caves. This type of activity is not heavy and results in about 15 to 25 trips per year to park caves. Most cavers are experienced and are members of speleological organizations. Another impact on the cave resources is development of the sinkhole plain that drains through the caves. Impact on the caves may be experienced through water pollution due to development and land use practices on those portions of the Pierpont karst that are not protected by state ownership. The area is rapidly shifting from primarily agricultural use to residential development.

Studies conducted in 1971 and 1973 were inconclusive regarding pollution effects to the cave stream system. Further studies have not been done. However, observations of stream organisms, which are good indications of water condition, does not indicate severe problems at this time.

Another more direct development consideration was a proposal to develop the Devil's Ice Box for easy access and to conduct interpretive tours within the cave. Development was to include a shaft opening into the cave upstream of the water passage and a boardwalk within the cave.

A third use of the cave is that of scientific research. Columbia is the location of three universities including the University of Missouri. There is also a federal fish research facility and the research facility of our sister agency the Missouri Department of Conservation. All of these facilities on occasion have reason to visit the caves at Rock Bridge for work on various research problems.

Also to be evaluated was the impact an adventure caving program would have on the resource.

Rock Bridge Memorial State Park has been conducting a pilot outreach program for about two years. The philosophy behind the program is that a state park could be more than a static entity — not just a place where people come to recreate.

We felt that by offering nontraditional programs we could provide experiences which would develop and reinforce the values embodied in the state park concept. Our goal was to develop appreciation and understanding of natural resources and to teach the skills needed to participate in various outdoor activities. Orienteering, backpacking, canoeing, cross country skiing, kayaking, winter camping, survival skills, nature study and cave exploration are some of the programs offered. The programs are offered to the public through the Columbia public school adult education program and to groups that ask for specific programs such as the Sierra Club, Girl Scouts, 4-H and university groups. These programs differ from traditional park programs in that while using the park as a resource base we offer these programs externally and are not limited to using the park as the program site. Through our outreach programs we are taking the park and experiences to the people

Because of the park resources, caving was considered to be a natural for inclusion in the outreach programs. Impact could not be overlooked and careful consideration was given to how the program could be compatible to the park's role in carrying out the mission of the Department.

As a state park, Rock Bridge Memorial State Park is administered by the Division of Parks and Historic Preservation of the Missouri Department of Natural Resources.

The role of the Division is twofold: preservation and recreation. Interpretation is a method used to assist in the preservation of our natural and historic resources as well as conducted in such a way as to be recreational for those taking part in a program. Within these guidelines a low impact caving program was deemed to be appropriate for Rock Bridge.

A final important item to be considered in the overall management scheme is the caves was safety. Both Devil's Ice Box and Polly's Pot are dangerous. The long water passage in the Ice Box and the vertical entrance to Polly's Pot exceed the usual hazards expected in caving.

In summary, we assimilated all of these factors into a management scheme for the park's caves.

The Resource

Demand - actual and projected role of park
safety.

The manner in which we are operating the caves now consists of the following items:

The caves will be closed from May to August.

Polly's Pot is locked.

No development is planned.

A permit system is used.

An adventure caving program is presented.

Description of Programs

Having outlined our basic cave management program and the reasons behind it, I will now describe the adventure caving programs we conduct at Rock Bridge.

The initial problem was to get the word out and develop an interest in our programs. Through trial and error we found that the adult education program offered by Columbia public schools was the ideal mechanism for promoting and registering our program. Their brochure, which included our courses, went to some 60,000 people in central Missouri. The adult education staff also handled registration and provided classrooms when needed and took care of getting educational materials.

For both cave trips we provided the basic caving equipment needed — a caving helmet and a Justrite electric headlamp for each person and a waterproof flashlight. We started the program trying to use carbide lamps because of the lower operating cost, but soon found that the carbide lamps were temperamental for inexperienced users and even in the best of conditions were a real time waster. Now we provide the headlamp and the flashlight and participant has to provide the batteries for those lights and an additional third source of light. We also provide the boats and climbing gear needed for the caves.

Devil's Ice Box trips are one-day affairs that start about 8:30 a.m. and finish about 10-12 hours later. Boats and gear are picked up at the park office and transported to the parking lot nearest the entrance. From there the gear and boats are hauled about 300 meters to the cave entrance, lowered down the Devil's Ice Box sinkhole and the trip is started. From initial meeting time to actually getting into the cave takes about an hour. Everyone is required to wear a coast guard-approved type III or better personal floatation device in the water passage. These are provided by the individual. Group sizes are kept to a total party size of 12 or less. Boats stay in visual contact of each other in the water passage and contingency plans are discussed prior to embarking on how a capsize rescue would be conducted. The water passage has several low spots and portages. Because of the awkward portage and long carry to and from the cave, we use plastic boats which are durable and relatively lightweight. Inflatable rafts are useful but deteriorate rapidly in the hands of uncaring users. The Devil's Ice Box can flood easily and we are very cautions about allowing entry when threatening weather is predicted. In times of doubt we consult with the National Weather Service, which has been most helpful in providing specific information needed for deciding on having a trip or not. If the likelihood of flooding is significant we cancel or postpone the trip.

Once beyond the water passage, the group or groups (groups of 8 or more are usually divided into 2 groups) are allowed to determine how or what they want to explore. Laminated sections of cave maps are provided and the park leader outlines various possibilities. A group may choose to explore on their own with the park leader providing information as requested, or they may choose to have the park leader show them various features of the cave, guiding the way and interpreting as they proceed. This open-ended approach seems to be well received and prevents the leader from adopting a "canned" presentation. Throughout its length the Devil's Ice Box is interesting to explore. Large and small formations, domes, side passages, water crawls, wades, tight passages, a chimney climb and wildlife all are new and exciting for the first- or second-time caver. They also learn how to eat lunch with mud. The impact of total darkness is emphasized as they try to manuever a short distance with no light. After exploring for 4 to 6 hours it is back to the boats and out to the surface world. Intense heat in September or freezing cold in February come as a shock as they emerge from the world to which they have become accustomed.

With all trips we conduct there is no free ride. The participants do not just leave the cave and wave goodbye. They return to the shop and assist in the tiresome task of cleaning all the gear that has been used. Every piece is individually cleaned, then insepcted by park personnel as it is readied for the next user. Throughout the trip we emphasize respect for the resource, the cave, and the equipment. When they leave, everything must be in as good or better condition than before they came.

Polly's Pot Trips

Polly's Pot workshops are for two days instead of one day as in the Devil's Ice Box trip. First on the agenda is a one-hour slide show introducing the people to caves and caving.

Next comes rope training. Rope work is necessary to get in and out of Polly's Pot and is also needed in Angels Roost passageway.

The first day (Saturday) is used to train in the safe use of rope work including rapelling, ascending and belaying.

We have chosen the rack and brake bar as the device we use for rapelling. We like the amount of control it gives us over varying loads and ropes. Used properly, we feel that it is safer. We generally use more bars than would be used by an experienced climber. We do this so that it is very easy for the new caver to slowly and easily control his descent. It is not our purpose to teach the excitement of a long, fast rappel. Rather, we want the participant to be able to go down the rope safely and in full control. A belay is always used.

In the afternoon we go to a training tower of the Columbia fire department for actual experience in rappeling, belaying, and ascending.

While this tower is not ideal, we prefer it rather than natural bluffs as a training site because of the extra control we have in observation of all operations. Care is taken to insure that all actions are safe and correct.

The next day (Sunday) we go into the cave. Not very long or especially attractive, Polly's Pot is nevertheless popular because of the novel entrance and the difficult passage at Angels Roost. Because of the logistics of getting in and out of the cave, we start with a group of 15 or 16 people and divide them into three groups. The groups arrive an hour apart and start their trips into the cave. Park personnel rig the ropes at the entrance and control the rappels. This takes about an hour per group. Meanwhile, one or two park employees proceed to Angels Roost and rig ropes there for the groups.

Each group is given a map and instructions, then they are on their own. They explore the cave and find their way on the map, arranging to be at certain points at certain times so that the groups remain separated.

Angels Roost adds a little excitement to the trip. At this point the cave seems to end, but there is a small tunnel about 4 meters above the cave floor which provides access to the rest of the cave. The problem is that the opening is above a pool of water. To reach dry passage without getting wet calls for different strategies depending on the individual. Some get wet. Getting back out of Angels Roost is even more difficult and those that are out of shape sometimes find it impossible without assistance.

Getting out of the entrance is also not easy but most have little trouble and enjoy the experience of ascending the rope. Those that find it too difficult can be pulled out using pulleys rigged to a rope. We prefer to provide this backup rigging rather than screening participants.

Screening would be difficult to do with fairness and accuracy. Many people are pleasantly surprised to find that they can do more than they thought. Also, being able to provide this type of backup prepares us for emergencies where rescue might be needed.

Both our caving programs are well attended and are a successful addition to our outreach program. If success is measured by satisfaction of those that have participated, there is no doubt that the program is worthwhile.

PRESERVATION, DEVELOPMENT AND MANAGEMENT OF CAVES AND OTHER KARST FEATURES WITHIN THE TENNESSEE STATE NATURAL AREAS SYSTEM

*Allen R. Coggins

ABSTRACT

Four of the 29 designated Tennessee State Natural Areas have been established specifically to preserve caves. They are Bone Cave State Natural Area, Van-Buren County; Dunbar Cave State Natural Area, Montgomery County; Morrill Cave State Natural Area, Sullivan County; and Carter Caves State Natural Area, Franklin County. Several other State Natural Areas contain caves and related karst features worthy of preservation, protection, and interpretation. The subterranian resources within these areas are listed and described along with the state's preliminary proposals for their security, development and management.

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THE PETTIBONE KARST - BIRTHPLACE OF THE NATIONAL SPELEOLOGICAL SOCIETY

*A. Plante

ABSTRACT

The Pettibone Karst of western Massachusetts is both a unique natural area and an important historic site to the National Speleological Society. On December 1, 1940, a group of New England cave explorers met in Pettibone Falls Cave for the purpose of ratifying the proposed constitution of the NSS.

The karst area is located in an outcrop of Paleozoic marbles, and represents a classic example of subdued marble karst. The area has a complex geological history, a unique ecology, and a long series of events involving human activity. Recent activities have placed the Pettibone Falls area in jeopardy, resulting in the formation of a Conservation Task Force by the NSS to preserve this area for its natural and historic value. Future utilization of the area will involve its value for recreation, research and education. The creation of a "Pettibone Karst Preserve" is being recommended to the NSS to carry out these objectives.

I. THE PETTIBONE KARST

Description — (Geography, Geology and Ecology).

The term "Pettibone Karst" (Figure 1) has been proposed (Plante, 1980) as the place name for a small upland valley located in the town of Cheshire, in northern Berkshire County, Massachusetts. This karst valley is largely located within a 1500-acre tract of land known as the Farnams Property, owned by Mr. Harrold Schacter of Mt. Kisco, New York. The karst valley encompasses slightly less than 200 acres, of which approximately 140 acres is on the Farnams Property. The remaining 40 to 50 acres are on two smaller parcels of land, described in deed descriptions as the Luther E. Wood Farm and the Dean Property. With the exception of a line of sinkholes extending northeast onto the Dean Property, all of the significant features are located on the Farnams Property.

The Pettibone Karst is bounded on the south and southwest by Pettibone Brook, which once followed a course through the southern half of the valley but has been rerouted by man. It is bounded on the east by a ridge rising from a watergap at Pettibone Brook and running northeast to Thunder Brook. On the west it is bounded by the southern ridge of the Mt. Greylock mountain range, from which Pettibone and Thunder Brook descend. To the north, the boundary is the drainage divide between Pettibone Brook and Thunder Brook. The most noticeable physical feature in the karst valley is the abandoned Farnams Quarry. Drainage throughout much of the karst valley is captured by this quarry and routed through Farnams Tunnel which runs easterly under the ridge some 2500 feet. A short distance north of the Farnams Quarry is the old Dean Quarry. Both of these quarries provide excellent geological cross sections of the karst's bedrock structure. Old quarry roads and several trails provide both vehicular and foot access to most areas of the valley.

Recent investigations (Plante, 1980) have shown that the Pettibone Karst is significant in its natural and historical aspects. The area is an outstanding example of karst and cavern development in a geologically complex setting. The bedrock is Bascom Formation marbles, lower-Ordovician in age, which comprise the uppermost member of the Stockbridge Marble Group (Herz, 1958).

The Pettibone Karst has several points which reccommend it as a natural area worthy of preservation, including its unique example of bedrock influence upon plant communities, the existence of a rare species of fern, and the overall diversity of communities in the valley. The major community in the valley is transitional low and mid-slope red oak (Jorganson, 1978). Portions of the valley support what appears to be a transitional mixed mesophytic community. Well developed karst topography exists in a stand of mature second-growth white pine. Along the eastern side of the east fault is a strand

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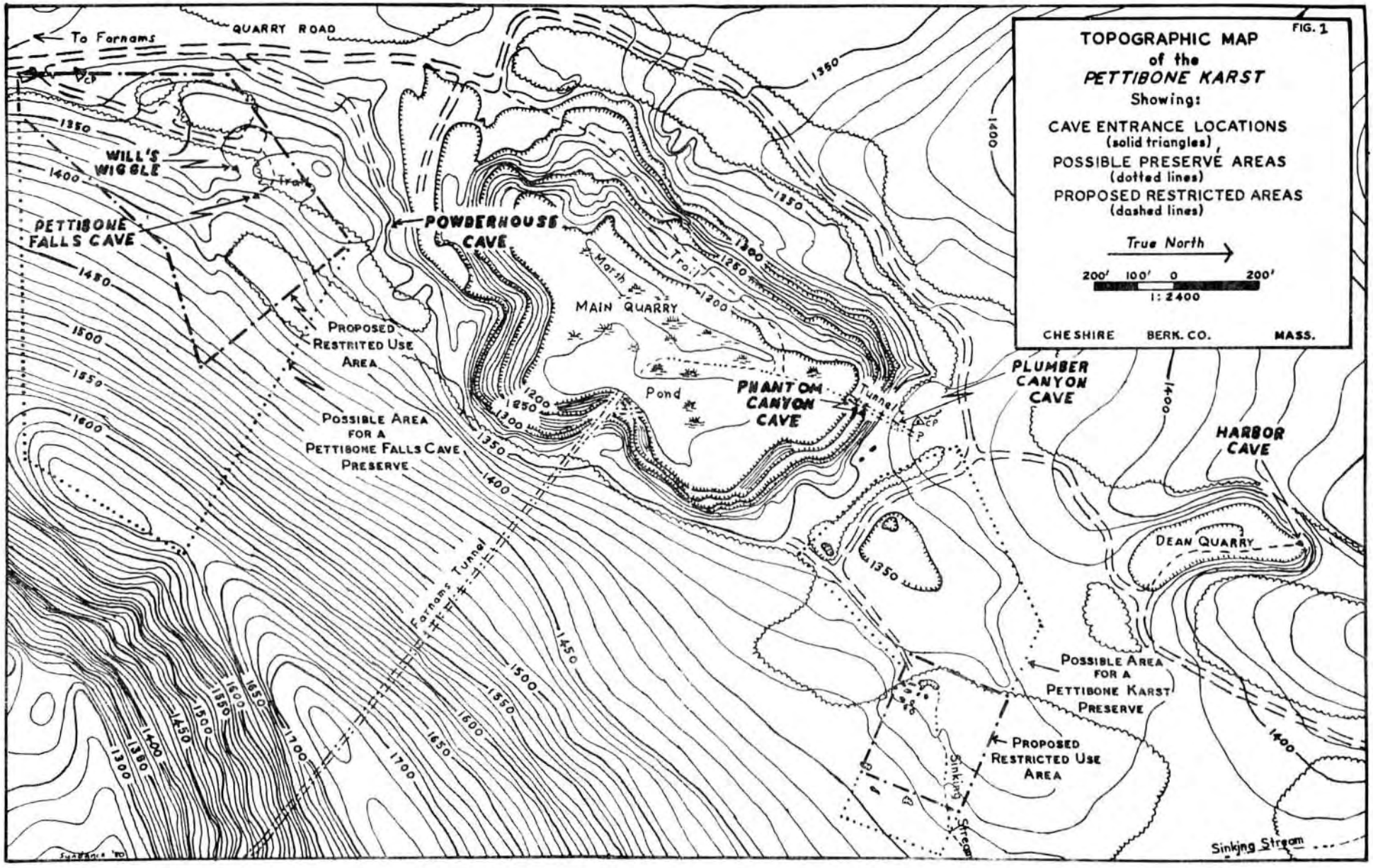
FIG. 1
TOPOGRAPHIC MAP
of the
PETTIBONE KARST
Showing:
CAVE ENTRANCE LOCATIONS
(solid triangles),
POSSIBLE PRESERVE AREAS
(dotted lines)
PROPOSED RESTRICTED AREAS
(dashed lines)
True North
200' 100' 0 200'
1: 2400
CHESHIRE BERK. CO. MASS.
To Farnams
QUARRY ROAD
WILL'S WIGGLE
PETTIBONE FALLS CAVE
POWDERHOUSE CAVE
Marsh
Trail
MAIN QUARRY
Pond
PHANTOM CANYON CAVE
Tunnel
PROPOSED RESTRICTED USE AREA
POSSIBLE AREA FOR A PETTIBONE FALLS CAVE PRESERVE
Farnams Tunnel
PLUMBER CANYON CAVE
HARBOR CAVE
DEAN QUARRY
POSSIBLE AREA FOR A PETTIBONE KARST PRESERVE
PROPOSED RESTRICTED USE AREA
Sinking Stream
Sinking Stream

of mature second-growth hemlocks some 50 to 75 yards wide and over a mile long. With the exception of a few stray individuals, this stand grows over schist bedrock and does not cross the fault onto the marbles - where the soil is more alkaline and apparently not as conducive to hemlock growth. In the vicinity of the marble knoll above Pettibone Falls cave this bedrock influence becomes a textbook example (S. O'Neill, pers. comm.). The ground cover species on the knoll are largely those which prefer limey soils, including dense colonies of both sharp-lobed hepatica and wild ginger, and dense colonies of both Maidenhair fern and Christmas fern. The understory and canopy on the knoll consist largely of transitional hardwoods such as red maple, ash, birch, and hop hornbeam. While a few yards to the east, across the fault, the limey soil species and transitional hardwoods on the knoll are largely replaced by ground cover species which prefer more neutral to acid soils, with the canopy of mature hemlocks mentioned above. The transition is relatively sharp, easily seen when walking through the area.

The single most significant species found in the karst is Walking Fern, *Camptosorus rhizophyllus*, which is listed as both a rare and local species that is very choosy of habitat (Cobb, 1963). The main colony in the karst is located just within the northern Farnams Property boundary. Smaller colonies and individual plants are found in and around the sinkholes further south. There are only two other stations known for this species in the state. Only one of the three confirmed stations is protected. This is Bartholomews Cobbles, a property of the Trustees of Reservations. Two other interesting species in the karst are the Showy Orchid and the Ebony Spleenwort.

Other, more common species which have been found in the Pettibone Karst include Rattlesnake Fern, Sensitive Fern, Yellow Clintonia, Jack-in-the-Pulpit, Columbine, and some two dozen other ferns and wildflowers which have been identified. The list of fauna noted in the Pettibone Karst is long, and includes at least two species of bats, red-tailed hawk, raven, sandpiper, wood duck, swallow, warbler, woodpeckers, owls, porcupine, osprey, bald eagle, transient Virginia deer, black bear, great blue heron, and numerous other birds and mammals.

Caves of the Karst

There are presently ten known caves in the Pettibone Karst, ranging in size from 10 feet long, Will's Wiggle, to 636 feet long, Pettibone Falls Cave.

Pettibone Falls Cave is the longest known cave in the state. Investigations (Plante, 1980) have shown that it is a remnant of what was once a much larger cave system, which included Powderhouse Cave and may have been integrated with caves under the karst north of the Farnams Quarry. Pettibone Falls Cave is a distal portion of the paleo-system. Passages in it range from small solution tubes to walking height joint passages. Though the cave is best known for its role in the founding of the National Speleological Society (NSS), it is also unique in the Northeast for its mineralogical content. Moon milk coats walls and ceilings in quantities unheard of elsewhere in the state, perhaps in New England. Areas of the cave are also heavily decorated with flowstone draperies, flowstone cascades, rimstone terraces, and several varieties of speleothems including helectites, soda straws, cave "coral", cave "popcorn", and the ubiquitous stalactites and stalagmites. Pettibone Falls Cave is in fact the most beautiful cave in the site. Fortunately its narrow entrance is protected by a sturdy gate to prevent vandalism.

Pettibone Falls Cave originally provided a subsurface drainage route to the Powderhouse Cave master conduit of the paleo-system. The west wall of this large solution tube is heavily scalloped, indicating that it once carried a high volume of water moving slowly north, probably towards the hugh joint caves north of the Farnams Quarry.

Plumber Canyon Cave and Phantom Canyon Cave are large joint-oriented caves on the northern side of the Farnams Quarry. They are both developed on N20°W joints, with ceiling heights upwards of 100 feet - which gives some indication of the extent of cavern development under the karst. Entry to Plumber Canyon Cave is gained through an old mine tunnel (not the Farnams Tunnel) which is now largely silted in and flooded beyond the cave. Phantom Canyon Cave is entered high in an inside corner of the quarry wall. On the wall just below and outside of the entrance is the remnant of a large solution tube. This tube's orientation and elevation suggest that it is a segment of the Powderhouse conduit. If it is, then some 1400 feet of the passage has been removed by quarrying, which provides a further indication of the extent cavern development has reached in the Pettibone Karst.

Harbor Cave is located in the northern corner of the Dean Quarry. Though its entrance portends a cave of considerable size, most of it has been removed by quarrying. What remains of the original, natural entrance is across the quarry to the southeast along the top of the wall. There is also a small dome in the wall there, on a direct line with remaining passage of the cave. Harbor Cave is now more of historical interest than geological.

Will's Wiggle Cave and Foxhole Cave, located near Pettibone Falls Cave and Powderhouse Cave, are disconnected portions of the paleo-system. Will's Wiggle is a short length of crawlway opening on a ravine formed by the collapse of the upstream end of the Powderhouse master conduit. Foxhole Cave is developed on a N35°E joint between passages on joints of the same set in Pettibone Falls Cave to the east and Powderhouse Cave to the west. This cave is now closed by fill.

High on the wall in the northeastern corner of the Farnams Quarry, Pocket Cave is found — which is believed to be a disconnected segment of Phantom Canyon Cave. Northeast of the quarry there is a small cave in one of the sinkholes on the eastern fault. This is Bobcat Den Cave, which has never been fully explored due to the instability of its entrance, developed largely in fault gouge. The name stems from evidence that it actually has been used as a den by bobcats. Further northeast along the fault, on the Dean Property, is the recently

re-discovered Lime Kiln Cave, also located in a sinkhole developed on the fault. It is a short solution tube on a N20°W joint. These five small caves complete the list of known caves in the karst.

At least three more caves are suspected to exist, all on N20°W joints. Overall, the degree to which cavern development has taken place in the Pettibone Karst is interesting. Cavern lengths and especially passage sizes are exceptional for this state. The evidence that a cave system of perhaps half a mile or more in length once existed here makes the area the most highly developed karst in the state by a long measure. Put simply, the caves of the Pettibone Karst are outstanding — each in its own right and when viewed as a part of the larger setting.

History

The history of exploration, visitation and use of the Pettibone Karst is largely known through oral accounts passed down through the years. Little could be found to document claims about the area, though a more detailed search may find documentation. The following has been pieced together from oral accounts and what documentation could be found. It is subject to verification.

Legend has it that Pettibone Falls Cave was discovered by Daniel Pettibone in the early 1800's (J. Moore, pers. comm.). This man was an early explorer and settler in the area. His grave is located in the old Farnams Cemetary. It is possible that he did discover one or more of the caves in the karst. Whatever the truth may be, knowledge of the cave(s) has been passed down through the years since the early 1800's.

It was shortly after Daniel Pettibone moved into the area that quarrying of the marble in the karst began. Several different individuals or families operated small quarries for building stone and agricultural lime through the 1800's (Voelher, 1952). The original quarry sites are located where the Dean Quarry is now and on what is now called the Dean Property. It wasn't until the early 1900's that the Deans became owners and operators of the quarries, and started quarrying where the Farnams Quarry is now. The U. S. Gypsum Company bought the area around the Farnams Quarry in the 1930's and stepped up operations considerably, working the quarries until 1968 — when the economics of modernizing the plant had to be faced and they decided to close down instead, probably due to the fact that the quarrying operation wasn't paying off well since they were quarrying Bascom Formation marbles and not Shelbourne marbles as they had thought.

The Pettibone Karst played a noteworthy role in American history during the mid-1800's. At this time a spot in Cheshire was being used as a stop on the famous Underground Railway used to move runaway slaves north to new homes as free men and women. To this day this place is known as "The Harbor". When authorities were afoot searching for the runaways, they were taken to one or more of the caves in the karst to be hidden until the authorities stopped looking for them. Clay Perry refers to this rather vaguely in one of his books (Perry, 1946), indicating that either Pettibone Falls Cave or the Farnams Tunnel was used as the hideout. Since the Farnams Tunnel did not exist before the 1900's it most certainly was not the place used and it is rather unlikely that Pettibone Falls Cave was the place either. Its low, wet, muddy, breakdown-jumbled and porcupine-inhabited passages would not recommend it as a hideout, however temporary, particularly if a better spot was available. Since the Dean Quarry was already in operation the odds are that the cave there was well known, and more readily at hand. What is left of that cave indicates that it was fairly spacious, and probably relatively dry near its entrance. It has been named Harbor Cave on the suspicion that it, rather than Pettibone Falls Cave, was the hideout. (It has also been suggested (J. Moore, pers. comm.) that Pettibone Falls Cave wasn't actually discovered until the early 1930's when the U. S. Gypsum Company bought the property.)

There is a long lapse of time between use of the cave(s) as a slaves' hideout and the next known visits to the cave(s). It was during the mid-1930's that Clay Perry came to the karst while doing field research for his first book on caves: "Underground New England". He and several other New England explorers spent some time in Pettibone Falls Cave, exploring and taking specimens of speleothems for study.

It was because of Clay's familiarity with Pettibone Falls Cave that it soon came to play a major role in the birth of the National Speleological Society (Perry, 1946; Stephenson, 1969; Lincoln, 1960; Hill, et al. 1966). When Clay learned of the newly organized D.C. Speleological Society he contacted Bill Stephenson. The D. C. explorers and New England explorers set about organizing the NSS. On December 1st of 1940 the New England group held a meeting in Pettibone Falls Cave to ratify the proposed Constitution. They formed the New England Spelunkers' Grotto, appointed a nominating committee for officers, and then journeyed to Bakers Quarry Cave in Lanesborough, where Clay Perry was elected President, Ned Anderson as Vice President, and Leo Lincoln as Secretary-Treasurer. Minutes of the meeting were transmitted to Washington D. C., and on January 1st of 1941 the NSS was chartered. The New England Spelunkers' Grotto was accorded the status of Grotto #1 of the Society. Thus does Pettibone Falls Cave hold a prestigious place in the history of the NSS.

The area was only visited sproadically by explorers from that time up until 1975. In the 1960's people working on the guidebook: "Caves of Massachusetts" (Hauer, 1966) undertook a rudimentary survey of the front part of Pettibone Falls Cave, publishing the map in the guide and listing the cave as only 120 feet long.

In the summer of 1975 a loosely organized group of area explorers working on a survey of caves in the country began investigations of the Pettibone Karst. What had been intended as a couple of weekend trips stretched into five years of surveying, studying, researching, landowner negotiations, and finally the formation of the Pettibone Karst Conservation Task Force (CTF) of the NSS.

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It is vital to the purpose of the Pettibone Karst CTF at this point to stress the historic significance of Pettibone Falls Cave to the NSS and to stress the role of Harbor Cave in American history. Combined with the natural merits of the Pettibone Karst, these historic events should make it imperative to the NSS to undertake whatever measures which may prove necessary to preserve the Pettibone Karst.

II. THE CONSERVATION PROBLEM

The Pettibone Karst Conservation Task Force (CTF)

In December of 1979 it was learned that the present owner of the Farnams Property was advancing plans to sell and harvest all marketable timber on the property, prior to selling the property. The original cutting plans gave a figure of 1.5 million board feet of timber to be harvested, roughtly 50% hardwoods and 50% softwoods. A revised cutting plan was filed later which reduced the harvest to about .75 million board feet, still roughly 50-50 hardwoods and softwoods. Under either of these cutting plans two stands of softwoods were to be harvested which stood to endanger the integrity of key areas of the karst. These stands include the white pines in the area of best developed karst topography northeast of the Farnams Quarry, and the portion of the hemlock stand to the east and southeast of the knoll under which Pettibone Falls Cave lies — with an estimated four to six thousand board feet of timber involved in these two areas.

Members of the Berkshire County Cave Survey, having spent the five years investigating the karst and its caves, became concerned that the harvest of these two key stands would do irreparable damage to the sinkhole plain northeast of the quarry, and to Pettibone Falls Cave. Immediate steps were taken to find a course of action which would prevent the damage from being done — and which would hopefully lead to preservation of the karst and certain other parcels on the property which are thought to be valuable natural or historic areas. One of the steps taken was to request Conservation Task Force status from the NSS Conservation Committee Chairman. Emergency action took place in January of 1980, confering provisional CTF status upon the group after discussion with the NSS Executive Vice President. Then, at the March 1980 meeting of the NSS Board of Governors (BOG), the new CTF received official confirmation. At the CTF's request, BOG earmarked $500 from the Save the Caves Fund for the CTF to use to purchase timber rights in the two key areas of the karst should it become necessary to do this in order to protect the sinkhole plain and Pettibone Falls Cave. An additional $100 was allocated to help defray the expenses of the CTF.

The Pettibone Karst CTF then saw, and still sees, its purpose as four-fold: 1) to stop the harvest of timber in at least the two key areas of the karst; 2) to investigate preservation options which the NSS might undertake to preserve the karst and its caves, particularly Pettibone Falls Cave; 3) to document claims of the Pettibone Karst's natural and historic importance, and 4) to work with any other conservation organizations which migh appropriately be asked to aid in preservation of the karst or the other areas of the property which merit looking into with an eye towards protection. This last was seen as a two-way street: the CTF would primarily be engaged in protection of the karst, receiving aid from other groups — and would, in return, aid other groups in any efforts they might undertake to protect other portions of the property.

The following paragraphs outline the findings of the CTF since January of 1980, emphasizing the severity of the problems involved.

The Conservation Dilemma

The present owner's interest in the Farnams Property is as a business investment. The property was purchased in 1970 from the U. S. Gypsum Co. as a speculative venture, both as a means to getting seven years of long-term investment tax credit, and with some hope of either developing the property or selling it to another development group. The seven-year period of grace ended in 1978, and since then the owner has been seriously looking for a buyer — asking $1.5 million for the entire 1500 acres (it was purchased for about $370,000). A prospective buyer was found in the fall of 1979 — Green River Trust of Nashua, New Hampshire. The owner then began advancing the plans to log the property before the sale went through. A purchase option was filed in February of 1980, with a rider attached which allowed the owner to carry out the timber harvest. The sale to Green River fell through, they dropped the option in May 1980, but plans for logging were well underway. Logging began in May, after an original starting date of February, which was abandoned due to delays. (The CTF likes to think that it had something to do with that.)

Obviously, there is a basic incompatability between the owner's interests in the property and those of the NSS. The courses of action open to the NSS are severely limited as far as the CTF has been able to determine. We do not have any legal grounds to interfere with the owner's use or sale of the property so long as use or sale are within the law and any environmental regulations which apply. All we can do is to keep our eyes open to be sure that laws and regulations are not breached — which we are doing as best we can. Other approaches to the problem have been tried, and have not met with success for the most part.

The owner was approached with the offer to buy the timber rights to the two key areas. He refused this offer, as it would place an incumberance upon the land that might hinder sale. But he did give a verbal promise at that time that the trees would not be harvested, which was better than nothing. The problem of creating obstacles to the sale of the property eliminates both the possibility of obtaining any conservation restrictions from the owner or of actually purchasing the two key parcels and the required rights-of-way. Purchase is impossible because the two parcels and rights-of-way would be so situated as to effectively divide the northwest quarter of the 1500-acre tract, or worse, divide the entire northern third depending upon the rights-of-way location(s).

The promise that the trees in the two key areas will not be harvested is a small "victory", if you will; but a verbal assurance is not exactly binding. Though we really expect that the owner will keep his promise as long as it does not cause him undue financial loss, we must always be prepared for a change. Presently, the owner has refrained from harvesting the softwoods — ostensibly to leave them as a selling point for the property. But should the market value of softwoods go up sufficiently, or a buyer be found who is not interested in the softwoods, then it is possible that they could be harvested, including those in the sinkhole plain and near Pettibone Falls Cave. Nor do we have any assurances that a new owner would be any more receptive to conservation concerns. In short, the prospects for preservation do not look good so far as any stop-gap measures or minimal resource efforts go.

Other Conservation Organizations

The CTF has been in contact with several other organizations: The Nature Conservancy, The Wilderness Society, The Massachusetts Audubon Society, The Trustees of Reservations, The Berkshire Natural Resources Council, The Cheshire Historical Commission, and The Massachusetts Applachian Trail Committee. Each of these organizations has been willing to offer aid in the form of advice, and in a couple of cases the help of their experts, which has been greatly appreciated. But, for varying reasons, none of these organizations can take any concrete action towards preservation of the karst, or of other portions of the property which we feel should be preserved.

Future Problems - An Assessment

Aside from harvesting timber, there are few uses which the Pettibone Karst might be put to, whether by the present owner or any future owner. The nature of the karst valley is actually almost self-preserving in some respects. It is basically undevelopable land, classified "sub-marginal" for most uses (Barlowe, 1978). The uses which might be considered are: renewed quarrying, use of the quarries for waste disposal sites, industrial or housing development, and agriculture or forestry. Each of these, including forestry, meet with obstacles which appear to make them unfeasible for the present and probably the forseeable future.

III. COURSES OF ACTION

Short-term Measures

There is little which the CTF or NSS can do to protect the Pettibone Karst so far as stop-gap, watchdog measures go. The courses of action available are all measures which cannot be expected to assure preservation. They would involve appeal to regulatory agencies, such as the EPA, and would undoubtedly lead to litigation in court, with no assurances that court decisions would prove favorable. Though some action along these lines may become necessary, this approach cannot be considered as a viable means by which the Pettibone Karst can be protected in perpetuity.

Proposal for a "Pettibone Karst Preserve"

For reasons outlined in the section of the paper which assessed land use, the CTF believes that the Pettibone Karst can be clearly shown to be a "white elephant" on the owner's hands. So long as any prospective buyers for the Farnams Property continue to be made aware of the uselessness of the karst valley the odds for sale of the property are greatly reduced. Therefore, it is quite likely that the owner will see the business sense of selling the karst valley to the NSS, thus ridding himself of one of the major obstacles to sale of the rest of the property.

Approaching the problem from this angle, the CTF has determined what it believes to be a minimum acreage of land in the karst valley which the NSS might be able to get the owner to part with and which would create a preserve encompassing the salient geologic and biologic features of the valley. This minimum area is approximately 112 acres, including an access corridor to Lanesborough Mountain Road. From the owner's viewpoint the proposed preserve boundaries would create a subdivision which would not leave any land-locked parcels or divide the remainder of the property in such a way as to hinder its sale. Nor would it remove from his ownership any significant amount of valuable property. Also, creation of the preserve would actually raise the value of the property surrounding it, making it more desirable for development or resource management. From the NSS's point of view, the preserve would encompass all of the significant karst features presently on the Farnams Property, including nine of the ten known caves in the karst, greatly facilitating access development for the preserve.

There are four major points to be considered in deciding whether or not to take on a project of this magnitude: 1) costs and funding; 2) landowner liability; 3) title; and 4) management.

Preserve Development and Management Recommendations

The CTF recommends that responsibility for management be placed in local hands, either with a committee such as the McFails Cave Committee or with a group of local directors of an educational corporation such as the Northeastern Cave Conservancy. We further recommend that, at least initially, key members of the management group be drawn from this CTF. Our people are presently the "resident experts" on the Pettibone Karst, and are in the best position to direct proper development and management of the preserve.

We recommend that the preserve be maintained as a day-use facility under a "pack it in - pack it out" policy, clearly posted and reiterated in any brochures. The same reasons which make the land undevelopeable for other uses hold true for camping — lack of sufficient water and difficulties with disposal of human wastes. Camping simply cannot be allowed here without adverse effects.

We recommend that the preserve be made a complete geologic and biologic sanctuary, posted against

hunting, trapping, and rock collecting. The flora and fauna found in the valley should be strictly protected, and rock collecting should be prohibited lest it lead to the collection of speleothems by people who are not fully aware of NSS conservation policies.

We recommend that the NRO be charged with carrying out the proposed developments which are needed or desirable, working on a voluntary basis and under preserve management direction. The following paragraphs outline the developments which the CTF recommends and the reasons for them.

The first priority should be fencing the quarries. We believe that this project should be carried out as a general public safety project, irregardless of whether or not there is any question of liability. It can be accomplished cheaply and adequately using heavy pole-size timber, which is available in quantity on the property. There is sufficient large stone for building stone walls should manpower be available. This might be a good way to go about it in open areas such as the south rim of the Farnams Quarry. The fences and/or walls should have warning signs posted along them informing people of the danger and telling them not to go beyond the barriers. Finally, we recommend that this project be completed before the preserve becomes open to the public.

A road will have to be built from Lanesborough Mountain Road into the quarry road in order to provide access for maintenance vehicles. We recommend that this be accomplished by obtaining a temporary access agreement from the Farnams Property owner to use the present quarry road for moving vehicles onto the preserve, and there building the road out to Lanesborough Mountain Road, using the large volume of quarried stone available at the quarries. There is more than sufficient stone available to build a crushed stone road 15 feet wide with a two-foot thick bed and grading where necessary. The bridge which must be built over Pettibone Brook can be constructed from available timber and stone. Water bars along slopes can be provided to prevent erosion.

We recommend that use of the road be limited to maintenance vehicles and that a parking lot be provided at Lanesborough Mountain Road for the public. Again, this project can be accomplished using available crushed stone. The access road can be sturdily gated at the parking lot, perhaps simply a sturdy register box which contains literature on the preserve and the NSS, and a lock compartment for donations.

The present system of trails in the preserve should be expanded to include access to more of the significant features. Where the old Pettibone Brook channel crosses the western fault there are both geologic and biologic features of interest. A trail is proposed here so that people can see the swallow holes along the fault as well as enjoy the interesting transitional plant communities in the area. The present trail leading to Pettibone Falls Cave should be extended to traverse the knoll and circle through the hemlock stand across the fault there, providing the public with a view of the striking example of bedrock influence upon plant communities.

Beyond the proposed developments mentioned above, the CTF recommends that the preserve be maintained as a primitive area. Any further work should be limited to routine yearly maintenance — road and trail upkeep, replacing signs, gate repairs, etc. Activities allowed on the preserve should be non-interference forms of recreation and study. Vehicles should be prohibited, including snowmobiles. Only things like hiking, cross-country skiing, perhaps ice climbing, (no rock climbing!), and, of course, cave exploration should be allowed. The area is simply not suited to intensive use or development.

Finally, the CTF highly recommends the development of an educational program at the preserve for local schools and groups. Volunteer guides can be used to introduce students and their teachers to the many and varied natural features of the area, as well as providing them with the historical background of the caves and quarries. We also recommend that a brochure be printed giving information for a self-guided tour of the preserve, with stops designated by numbered posts at the various points of interest. Above all, the educational value of the Pettibone Karst should be exploited in any and every way available that will do no harm. It is too rich an area to hoard or to simply go unused.

Conclusion

The Pettibone Karst of western Massachusetts is a unique and valuable natural and historic area. Its geologic and biologic features and historic background highly recommend it as a place for people to go, whether to learn or to simply enjoy themselves.

Though preservation of the area will not be easy to accomplish, the obstacles are not insurmountable. A viable plan has been worked out and forwarded here. The NSS is now faced with an important decision — whether or not to undertake a major project to preserve the Pettibone Karst, the birthplace of the society. The Pettibone Karst Conservation Task Force stands convinced that the society can undertake the project successfully and would be working in its own best interest to do so. We are ready and willing to go to work on the project, and will do everything within our power to see the "Pettibone Karst Preserve" become a reality

Acknowledgements

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Finally, if it were not for Lucia Saradoff, the threat to the Pettibone Karst would not have come to the attention of the NSS in time and logging would have destroyed two of the most significant features on the property. Lucia is owed a heartfelt debt of gratitude for her efforts to preserve the property.

APPENDIX A

Chapter 575 - The Commonwealth of Massachusetts

In the year One Thousand Nine Hundred and Seventy-two AN ACT ENCOURAGING LANDOWNERS TO MAKE LAND AVAILABLE TO THE PUBLIC FOR RECREATIONAL PURPOSES BY LIMITING LIABILITY IN CONNECTION WITH SUCH USE.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

Chapter 21 of the General Laws is hereby amended by inserting after section 17B the following section:

Section 17C. An owner of land who permits the public to use such land for recreational purposes without imposing a charge or fee therefore, or who leases his land for said purposes to the commonwealth or any political subdivision thereof shall not be liable to any member of the public who uses said land for the aforesaid purposes for injuries to the person or property sustained by him while on said land in the absence of willful, wanton or reckless conduct by such owner, nor shall permission be deemed to confer upon any person so using said land the status of an invitee or licensee to whom any duty would be owed by said owner. The liability of an owner who imposes a charge or fee for the use of his land by the public for recreational purposes shall not be limited by any provision of this section.

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MANAGEMENT TECHNIQUES FOR WILDERNESS CAVES

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ABSTRACT

This paper deals with some cave management techniques in use today that can be applied to wilderness caves, and some specific actions which may be taken by cave managers in order to better protect the wilderness cave.

INTRODUCTION

Basic to the management goals set forth in the 1964 Wilderness Act is the development of a management plan which will retain a cave's wilderness characteristics within acceptable limits. Specifically, these management goals are to administer the land "for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas and the preservation of their wilderness character...." (Wilderness Act, 1964).

Taking the bold step to assume that certain caves, portions of caves or cave-bearing areas under federal control will be designated as wilderness, guidelines need to be set concerning the specific actions and techniques which the manager should take in order to reach the stated management goals. The purpose of this paper is to outline a set of steps, actions and techniques which may be used in managing a federally designated underground wilderness area.

STEP ONE: HIRE A SPECIALIST

The first step an agency should take when managing a resource such as caves is to hire a specialist. This one action has the potential to do more for the resource than any other. A competent cave specialist could add the expertise and insight necessary to avoid crisis management which is so often the case. It would be his job to develop management plans, conduct inventories and classifications for each cave, issue premits, patrol the cave area, act as liasion and public relations man for local caving groups, and a myriad of other tasks all of which come under the heading of cave management. The following steps would be the responsibility of the cave specialist.

STEP TWO: DETERMINE ACCEPTABLE LIMITS OF IMPACTS

The first objective of an underground wilderness manager should be to set the acceptable limits of the human impacts which will occur within the cave environment. This can be done with the aid of a cave inventory. Such factors as critical environmental habitats, delicate formation areas, pristine passageways, and other wilderness characteristics for which the cave was designated should be the basis for determining these acceptable limits. Certain management techniques may be used in order to help retain wilderness characteristics. One of these techniques would be to establish carrying capacities for each cave. A valid system for determining carrying capacities has not yet been developed though the concepts and usefulness in relation to cave management has been discussed in previous symposia (Aley, 1976; Brucker, 1976; Forssell, 1977; Middaugh, 1977). Until a valid system is developed, the establishment of carrying capacities must be a subjective decision made by the cave specialist. Carrying capacities may vary from one section of a cave to another depending on the delicateness of the environment. Likewise, they may vary with time of year in respect to a hibernating or nursery bat colony or other such seasonal limitations. Carrying capacities may be set according to number of cavers in each group and also the number of groups allowed per month or year.

Another method of helping maintain the acceptable limits of human impacts on an underground wilderness is to develop a system of access controls. One of the most effective means of access control is the installation of a gate. Another means of access control is through the design of surface trails and paths (Gallagher, 1978). A third technique available to the manager to controll access is the type and number of permits issued. The number of permits issued relates directly to carrying capacity. The type of permit issued for certain caves may vary depending on the contents and fragilness of the individual cave. There are four basic types of cave permits. (1) The blanket permit would allow access to all parts of the cave on an unrestricted basis. Some caves may have multiple gates which would require the applicant to have prior knowledge of the cave and request the combination for each specific gate. (2) The trip leader permit would require at least one member of the party, the trip leader, to have visited the cave before. (3) The guided tour permit would allow a group to enter an otherwise closed cave or portion of a cave when accompanied by a representative

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of the managing agency. This type of permit may be restricted by the availability of manpower and money. (4) The research-only permit would be issued to groups who entered the cave to conduct authorized scientific research.

One other aspect of access control that may be considered in a wilderness cave is the establishment of low impact trails within the cave. The term wilderness cave might give the idea that one can run wild throughout the cave and go wherever he wants. It is obvious to the educated caver that the opposite is true. If acceptable routes are not provided, the imprint of man's foot will rapidly degrade an otherwise virgin floor. This trampling would not only degrade the scenic quality of the cave but would also damage the scientific value.

STEP THREE: USER EDUCATION AND INVOLVEMENT

The development of a user education and involvement program is probably the most valuable tool available to the cave manager. By properly informing the cave user as to the fragile nature of the cave environment and how to protect the cave from unnecessary damage, the manager initiates a preventative type of management instead of courting crisis management. A number of techniques are available. The most ideal way would be to have personal contact with each group prior to their entry. This is not always possible. An alternative is to send a conservation message out with each permit issued, though this is somewhat less effective. Specific instructions as to certain areas of the cave to avoid or to use special caution in due to hibernating bat colonies or endangered species should also be included.

Another method of educating the cave user is to notify each applicant that a bibliography of cave information is available upon request from the issuing office. This would aid in the self-education of the user but would require that such a bibliography first be compiled and made available.

Another opportunity to add to the public education of caves would be to develop a slide-tape series which could be loaned to schools or other interest groups. The education of the cave user can be increased substantially by organized caving groups such as the National Speleological Society, and various conservation task forces. The large majority of cavers are independent of groups such as this and would be informed of a cave conservation message when permits were issued.

The second part of this step would be to involve the user with the protection of the resource. This can be accomplished by soliciting the help of the user in detecting new vandalism, graffiti, or break-ins and requesting or requiring the trip leader to submit a short report when he returns the signed permit. This technique could serve a threefold purpose: (1) to place the visitor in a position of fellow guardian and protector of the cave, (2) serve as feedback to the manager of the condition of the cave which would aid in the monitoring of the cave system, and (3) serve as an indicator of responsibility of the user.

Other information may be requested on the returned permit or in the form of a questionaire such as the purpose of the trip, number of hours spent in the cave, distance traveled to visit the cave, likes and dislikes of the caving trip or management policies, and other questions which might provide valuable information to the manager for use in future decision making.

STEP FOUR: MANAGEMENT EVALUATION

In order to determine the degree of success or effectiveness of management practices these practices must be measurable. One method of measuring or evaluating management is by the initiation of a photomonitoring system. With strategically located photo points the cumulative impacts of visitor use can be documented. The monitoring system can be of good use in determining excessive use, vandalism, and changes in surface and can guide the manager in making decisions concerning use restrictions and passage closures (Stout, 1978). The use of photography as a management tool when used over a long period of time can serve as a guide to future managers and provide insight to the changes which have taken place over the years. A well planned documentation system should also include a written narrative to explain the changes which have taken place and should be correlated with a map to show location within the cave (Larson, 1978). This threefold method would allow a manager to ascertain the cumulative impacts on the cave environment and relate them to cave use pattern. This could also be used to add validity to the development of carrying capacities and eliminate the subjectiveness of "gut feelings".

Another means of measuring the effectiveness of wilderness cave management would be to conduct an annual biota inventory. This could make use of hibernating or roosting bat colonies, or number of beetles per given area, or other biologic communities as indicators of the amount of human encroachment and degradation to the troglobites' natural habitat. This would, of course, require a baseline for the assessments of the findings.

The proper use of a management evaluation system should be to determine if management goals are being met. If it is determined, through the use of management evaluation techniques, that excessive damage is occuring, the manager should then return to step two and adjust carrying capacities or initiate new means of access control.

This step would complete a set of management actions which should then be repeated on a regular basis to add to the accuracy of management decisions and the attainment of management goals.

SUMMARY

The management goals for areas designated as wilderness are to manage the resource for the protection of its wilderness characteristics and for its use as wilderness by future generations. The first step of an agency charged with these goals should be to hire a specialist. The specialist would then be responsible for establishing the acceptable limits of human impacts on the cave. Techniques available to aid in retaining wilderness

characteristics of the cave would be to determine carrying capacities, develop a system of access controls, and initiate a user education and involvement program. The final step would be to implement a management evaluation system by the use of photomonitoring or biological monitoring. If management goals are not being met then an adjustment of carrying capacities and access controls should be made.

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IS THE UNDERGROUND WILDERNESS CONCEPT PRACTICAL?

*J. B. "Buzz" Hummel

ABSTRACT

From a philosophical viewpoint most caves are defacto wilderness. This two-part paper deals with the practicability of designated underground wilderness from a legislative and managerial viewpoint. The second part of this paper discusses alternative and interim means of legislative and administrative protection.

Question: What type of designation is used to protect federal lands from misuse and degenerative development.

Answer: Ahh...Well you can make areas wilderness or all...well.

This is the case with most Americans. Outside of wilderness they are not aware that other protective statutory measures exist for federal lands.

This is the main reason the environmental community has come to use "Wilderness" as a catch-all measure to protect natural resources from misuse and/or development which may destroy natural values. Now cavers are doing the same thing, using Wilderness as a blanket protective measure to "save the caves".

First of all we should take a look at the concept of Wilderness and compare it to the new notion of "underground Wilderness". Individuals instrumental in creating our present Wilderness system envisioned Wilderness as...

> "a continuous stretch of country preserved in its natural state open to lawful hunting and fishing, big enough to absorb a 2 week pack trip...." (Aldo Leopold, 1921)
>
> "...I...shall use the word Wilderness to denote a region which contains no permanent inhabitants....and is sufficiently spacious that a person in crossing it must have a sleeping out experience." (Robert Marshall, 1950).

Early Wilderness philosophers believed areas of Wilderness should be large, natural, and still retain their primeval character.

Although caves are very unique and possibly the best example of an area primarily affected by the forces of nature, I don't feel they fit into the true criteria of Wilderness as outlined in the Wilderness Act. The size criteria states that an area must be 5000 acres in size or is of sufficient size as to make practicable its preservation and use in an unimpaired condition. Areas smaller than 5000 acres were generally thought to be islands, isolated small canyons and mesas.

The concept of wilderness underground is valid only if the surface area above the cave can also be managed in a manner which would protect and preserve the cave resources. This would mean either designating the surface as Wilderness or some other type of statutory preservation. If this was done then there would be no real need to designate the cave as Wilderness for it will be protected by the surface designation.

Surface management and size are only two of many reasons I feel that Underground Wilderness is not a practicable concept. Listed below are several additional reasons whose cumulative effect, presents a strong case on the invalidity of underground wilderness.

1. Most federally administered surface areas have been inventoried for wilderness characteristics by agencies such as BLM, NPS, USFS, USF&WS, etc. It would be extremely difficult to influence these agencies to backtrack and evaluate caves for wilderness potential.

2. Underground wilderness is a new concept, and does not easily fit into the parameters of the Wilderness Act. A new act may have to be written and passed by Congress, such as with the Eastern Wilderness Act of 1975, which contains less stringent wilderness criteria.

3. Size may be an inhibiting factor. The act states an area must be 5000 acres in size or of sufficient size as to make practicable its preservation and use in an unimpaired condition. This size requirement is not absolute, but most agencies do not consider small areas unless there is strong public support.

4. A great deal of public support would be needed to push a program such as this through the legislative ant hills of Washington. After witnessing

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the recent lack of support for wilderness by cavers here in New Mexico, I don't foresee strong support for underground wilderness in the future.

5. Proposed wilderness areas which do not contain traditional values, such as trees, lakes, and mountains are not readily accepted by the public. Diversity in wilderness landforms (deserts versus mountains) is still a new idea which the public has not embraced. Underground Wilderness would add to the landform diversity of the Wilderness system, but it too may have a problem being accepted by the public and land managers.

6. In the past the environmental community has used wilderness designation as a catch-all method for protecting areas from development and misuse. I feel that cavers are doing the same thing, thinking that Wilderness designation will protect and preserve caves. In reality it could draw more attention to cave resources and intensify management problems.

7. The concept of Underground Wilderness was initiated to protect unique cave resources from being destroyed by misuse or development. The need to protect caves is an immediate need; wilderness designation may take from 4-12 years, while other protective designations can be done in one day.

8. Wilderness legislation presently being voted on in congress contains "release language", which means that areas presently being dropped from the Wilderness review system, cannot be restudied for wilderness consideration in the future.

It's obvious that the concept of Underground Wilderness has several hurdles in its path. Getting the concept generally accepted may take some time, if ever. Our underground cave resources undoubtedly need preservation through statutory or legislative means. If wilderness is not the answer, what is? This leads us to the second part of this paper, alternative management measures and designations to Wilderness.

Cave resources on federal lands are administered primarily by three agencies: The Bureau of Land Management (BLM), the National Park Service (NPS), and the United States Forest Service (USFS). All three agencies are presently reviewing lands for possible Wilderness designation. But Wilderness is not the only management measure or designation these agencies have at their disposal.

All of these agencies have the power to enact special management measures to protect resources. These measures vary from agency to agency ranging from administrative regulations to formal statutory and legislative protection.

Unlike the long process of Wilderness designation, which can take quite a number of years, other protective measures such as emergency closures can be done in one day. Being most familiar with BLM regulations, I will list a few of the measures which could be used to protect and preserve cave resources.

Research Natural Areas

Provide procedures for management of public land having natural characteristics that are unusual or that are of scientific or other special interest. Primary purpose of research and education.

Outstanding Natural Area

Designation would establish procedures for the management of recreation to protect natural features unusual and outstanding in nature.

Primitive Areas

Provide procedures for management of natural undeveloped lands where the natural environment can be preserved by management of recreation activities and exclusion of additional roads and commercial developments.

Closure of Lands

This is a temporary restriction to protect the public and assure proper resource utilization, conservation, and protection of lands and resources.

Special Areas

An area established where resources require special management and control measures for their protection.

Areas of Critical Environmental Concern (ACEC's)

Used for identifying, designating and giving special management attention to Areas of Critical Environmental Concern. Will protect and prevent irreparable damage to important historic, cultural, or scenic values, wildlife resources or other natural systems, and protect life and safety from natural hazards.

Withdrawals

Lands can be withdrawn from grazing, mining, and other uses which may destroy unique resources, such as caves.

Both USFS and NPS have similar management tools at their disposal. But designations are meaningless without management plans. These plans spell out the purpose of the designation and the management objectives sought.

Pertinent designations and comprehensive management plans can protect and preserve caves as well or even better than Wilderness designations.

The immediate need of cave protection can be met only by some of the management measures previously mentioned. Underground wilderness, if it becomes a reality, is years away from being a management tool.

UNDERGROUND WILDERNESS

*Robert R. Stitt

ABSTRACT

Even before the passage of the Wilderness Act in 1964, caves were conceived of as an ideal example of wilderness. However, Federal agencies have been slow to accept and apply the concept of underground wilderness to the lands they manage. A concerted debate among conservationists, land managers, and the public over the past two decades has resulted in acceptance of the legality of the concept, but in little initiative to actually apply it to cave management by including caves as part of the National Wilderness Protection System on their own merit. Managers seem to feel that designation of caves as wilderness limits management flexibility and might make management more difficult. Conservationists, on the other hand, argue that it is precisely that limitation of flexibility which would lead to maximum preservation of the cave resource by preventing destructive use, without significantly limiting most use. The public, to a large extent not aware of the issues involved, seems to be afraid of the concept of wilderness, afraid that it will lock them out of the caves (but in fact they are effectively locked out anyway). Since no underground wilderness has actually been designated, it is difficult to say exactly how it would be managed, perceived by the public, or actually used. Such designation, of for example the eligible underground portions of Mammoth Cave National Park, would shift the focus of the debate from whether the wilderness concept should be applied to caves to how it should be applied. That discussion would ultimately be more useful for cave managers and would in the author's opinion be better for the cave resource.

Underground wilderness can be defined as wilderness lying beneath the surface of the earth. The Wilderness Act of 1964 (1) defines wilderness as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor and does not remain...retaining its primeval character and influence, without permanent improvements or human habitation...and which generally appears to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticable...has outstanding opportunities for solitude or a primitive and unconfined type of recreation...and may also contain ecological, geological, or other features of scientific, scenic, or historical value." Caves and cave systems are outstanding examples of wilderness by this definition. Applying the Wilderness Act definition to underground wilderness requires only the application of the legally accepted concept of vertical as well as horizontal boundaries to the wilderness study process.

It took many years for the Wilderness Act to wend its way through the legislative process prior to its passage in 1964. During those years many hearings and studies were commissioned by Congress. The most important of these studies, by the Outdoor Recreation Resources Review Commission, was considered carefully by Congress in the preparation of the final Act, and in its Study Report No. 3, caves were referred to as "important potential wilderness resources" and an appendix to the report dealt extensively with caves (2). Even though the Wilderness Act makes no specific mention of caves, it is clear that Congress was aware of their potential as wilderness and intended to include them under the Act, just as trees, mountains, rocks, and other natural features are included without specifically being named.

However, probably because of the relatively low profile that the friends of caves have exhibited over the years, there has been little public outcry for the protection of caves, and Federal agencies have generally viewed caves as an unfortunate accident—a feature which they wished they did not have to manage at all. In spite of many proposals by conservationists during the statutory ten-year review period following passage of the Wilderness Act that caves and cave areas be included in the National Wilderness Preservation System (NWPS), to date no Federal agencies have proposed any to Congress. Although caves have many times been protected and included in the system as part of land containing surface wilderness values, none have yet been included in their own right.

In Mammoth Cave National Park in particular, the fight has been long and almost bitter. At early Master Plan hearings in 1967, the National Speleological Society made a detailed proposal for underground wilderness. By the time the final hearings were finally held (after many postponements) in 1974, the National Park Service took the position that caves could not be part of wilderness because

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caves were not part of the land. A legal brief by the National Speleological Society (3) easily laid that and other objections to rest, and the Interior Department subsequently admitted that caves could be included in the NWPS—but they chose not to recommend any caves within Mammoth Cave National Park.

Arguments of proponents of underground wilderness stress that designation as wilderness would require higher standards of management, at least in theory avoiding some of the debacles that have occurred in Mammoth Cave National Park in the last few decades under Federal management. Statutory recognition of these goals, coupled with the recognition that caves are one of the finest examples of wilderness, since they represent one of the last parts of the land that is still unexplored, would be one of the best things that we could do for the world's longest cave.

Opponents of underground wilderness argue, on the other hand, that it would lock up the Park and limit management options, and that "we can't do it because we haven't explored all the cave." These hollow arguments on the part of the bureaucrats seem to be aimed at assuaging the fears of local residents who still resent early land condemnation practices in the Park and do not agree with the mandate of Congress that the Park should be managed for all of the people of the United States and not just for the benefit of a few in the local area.

Arguments against the underground wilderness concept by other participants in this panel seem to be of the nature of "well, we ain't done it yet, so let's not do it." Certainly the attitudes of the various agencies have reflected this viewpoint. Although the wording of the Wilderness Act was specifically modified by Congress during the process of passage to include areas of smaller than 5,000 acres if they were of "sufficient size as to make practicable [their] preservation and use in an unimpaired condition" thus admitting caves and cave systems (especially Mammoth Cave), the 5,000-acre issue is always raised by agencies, and none have applied this clause to caves.

The concept of underground wilderness is most applicable where surface areas are not eligible for inclusion in the NWPS because of human intrusions such as roads, building, etc. The best example of this is Mammoth Cave National Park, where the land surface was once farmland and has not yet, according to NPS biologists, returned to a truly wild condition meeting the criteria of the Act. Most of the Mammoth Cave System, below the ground, is of wilderness quality; and the National Park Service has already planned to manage the surface of the Park is ways compatible with underground wilderness preservation.

The best test of whether new legislation is necessary to enable caves to be included in the NWPS is to take the question to the halls of Congress. The only way this can be done without widespread public outcry is for a Federal agency such as the National Park Service to make an underground wilderness proposal for an appropriate area, such as Mammoth Cave National Park, and to let Congress make the final decision as to its original intent in passing the Wilderness Act of 1964. The idea of underground wilderness is not new; it has been around for over 20 years. It has not received widespread public support because of the attitudes of cavers who, because they fear increased cave vandalism that might result, have shied away from publicity for caves and cave conservation. Once the issue makes it into Congress cavers will rally around and support it.

The designation of an area as underground wilderness should not be the only technique used for cave protection on Federal lands. In areas where the concept is not appropriate, other methods of protection should be utilized. Buzz Hummel has outlined many of these in his paper. This does not mean that cave conservationists should abandon the fight to achieve underground wilderness protection where it is appropriate. Ultimately the existence of truly wild caves may depend on long-term statutory protection by inclusion of underground wilderness in the National Wilderness Preservation System.

When President Ford sent his wilderness message to Congress in 1974, he recommended no wilderness at all for Mammoth Cave National Park, but pledged that the question would be restudied after a few years. Five years have now passed, and since that is the usual period for a restudy in the National Park Service, that study should now be underway. Arguments that the cave is not all known are invalid, since the cave will never be completely known, and it is precisely this unexplored nature which makes it an outstanding example of wilderness. That review must include the subsurface as well as the surface portions of the land, and if either are found appropriate for inclusion in the NWPS, they should be.

The designation of eligible portions of the Mammoth Cave System in the National Wilderness Preservation System would shift the focus of the debate over underground wilderness from whether the wilderness concept should be applied to caves to how it should be applied. That discussion would ultimately be more useful for cave managers and in the author's opinion better for the cave resource.

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(1) Wilderness Act of 1964, 78 Stat. 890 (1964), 16 U.S.C. 1131 et seq. (1965).

(2) Outdoor Recreation Resources Review Commission, Study Report No. 3, Wilderness and Recreation — A Report on Resources, Values, and Problems, Washington: U. S. Government Printing Office, 1963.

(3) Stitt, R. R. "Legal Brief: Law and Sound Policy Require the National Park Service and the Secretary of the Interior to review the Underground Portions of Mammoth Cave National Park as to their Suitability for Wilderness under the Wilderness Act of 1964," Unpublished paper, June 25, 1974 (Submitted as part of the Hearing Record for the Mammoth Cave National Park Wilderness Hearings, May 27, 1974.)

DISCUSSION

Various members of the audience and the panel raised the following points in the discussion period (transcribed from Rob Stitt's notes):

The Wilderness Act is a poor tool for cave protection. A proper tool should be modelled after the Wild and Scenic Rivers Act as a specific tool rather than the shotgun approach of the Wilderness Act, including some caves as part of the Act and setting up a review process.

The publicity that goes with designation under the Wilderness Act is bad; it attracts people to the area.

Wilderness won't accomplish much.

Forest Service planning process is issue-oriented.

Cavers have the opportunity to raise the issue in each individual National Forest, as part of the planning process.

The presence of caves in an area can help to get it included as part of the NWPS.

Finally, Buzz Hummel summed up the whole issue: Nothing can be done without public involvement and support—and there is no public support for the inclusion of caves in the National Wilderness Preservation System.

RADIATION HAZARDS IN CAVES

*Robert T. Beckman

The possibility of radon-daughter hazard at Carlsbad Caverns was reported to the National Park Service (NPS) in 1975 (Ahlstrand, 1976). As a result of this report, the NPS initiated routine monitoring and an employee exposure record system. In an effort to investigate the problem further, the NPS requested assistance from the Radiation Group, Denver Safety and Health Technology Center, Mining Enforcement and Safety Administration (MESA), now Mine Safety and Health Administration, (MSHA). The results of the studies performed by the Radiation Group were reported by Ahlstrand.

Subsequent to the Carlsbad Caverns Survey, additional caves have been surveyed at the request of NPS, the Bureau of Land Management (BLM), and the Forest Service (USFS). In addition, we have assisted in the training of monitoring personnel and underground employees.

The radon-daughter hazard results from the presence of radium (Ra-226) in the country rock. The Ra-226 undergoes radioactive decay to form radon (Rn-222). The Rn-222 is a gas, and as such, is very mobile. A portion of the gas migrates into the cave atmosphere. The Rn-222 is not the major health hazard; because the decay rate of Rn-222 if relatively slow, very little of any inhaled Rn-222 decays in the lungs before it is exhaled. The major health hazard comes from the four short-lived daughters of Rn-222 (Po-218, Pb-214, Bi-214, and Po-214) commonly referred to as RaA, RaB, RaC, and RaC'. These daughters remain suspended in the cave air. When cave air containing these daughters is inhaled, a portion of the daughters are retained in the lungs. As these retained daughters decay, they deliver a significant dose of alpha radiation to the lungs. Epidemiologic studies have shown that exposures to radon daughters can lead to increased lung cancer risk (Lundin, et al., 1971). This epidemiologic study led to the establishment of an MSHA standard requiring that no underground mining employee be exposed to more than 4 Working Level Months (WLM) per calendar year.

Radon-daughter concentrations are measured by filtering the radon daughters from a known volume of air and counting the filter in an alpha detector of known efficiency (ANSI, 1973). Exposure records are maintained by recording the time that each employee is exposed to a particular radon-daughter concentration. The product of the WL and hours exposed is accumulated for each employee in working level hours (WLH) and the WLH are converted to WLM by dividing by 173. Under MSHA standards, no employee should be exposed to more than 4 WLM in any calendar year.

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The mining industry controls radon-daughter concentrations through the extensive use of mechanical ventilation; this option is not available in natural caves. The other method of controlling exposure is commonly called administrative control. This involves limiting the amount of time that an employee spends in the radon-daughter environment. Proper use of administrative control can insure that personnel are not overexposed.

Radon daughters are a hazard that is present in many caves. Screening of caves will indicate which of the caves contain significant hazards—employees at these caves must be protected against overexposure.

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CAVE RESTORATION AND CAVE MANAGEMENT

*Katherine Rohde

ABSTRACT

More than three years have passed since the restoration project at Carlsbad Caverns was begun. We learned which methods might work and we began to see what the scope of the project could be. Future work will be carefully researched and planned. We are realizing that cave restoration is not a "special" project, unrelated to cave management. Cave restoration is a factor in cave management and any restorative action should be considered with respect to the management plans.

The "state of the art" has not changed so very much. Many of the techniques and treatments are the same. We are looking more carefully at the techniques, the consequences of the "remedies" and trying to provide options or alternatives that will compliment the other cave management actions and decisions.

Chrome handrails, asphalt trails, underground lunchrooms and big old brooms. Hundreds of bright lights, little dead cave mites, pennies in pools and a thousand groups from a thousand schools. Chewing tobacco, cigarette smoke, someone at the back of the tour taking a toke. The Tamahawk in Sonora is gone. Carlsbad is full of emory chips and Mammoth has its share of lint. Don't despair. Don't give up. Here they come. Clear the way, the White Tornadoes, the cleaning knights. With pail, hook and ladder, enter the Cave Restorer.

The Cave Restorer entered Carlsbad Caverns three years ago. In the beginning it was an experiment. Each action was a trial and error process. Indeed, it did seem as if the cave restorer "whirled" into the Caverns. There was the feeling that this project could be completed in a couple of weeks. The results would be a clean cave; shining, squeaky clean, and as virgin as when first found. This was not to be the case.

The project started as an experiment. Many years of bright hot incandescent lights had provided an environment that was favorable for producing a thriving crop of green mosses and algae on cave formations that were near each light fixture. One such area was particularly visible. The Frozen Waterfall, a pure white cascade of flowstone, was marred by a large slimy dark green streak down the front of the formation. What process could be used to remove that streak? By talking with employees who had been at the Caverns for many years, it was determined that there had been periodic attempts to remove plant growth. It was not known exactly when, how often or even what chemicals had been used. In order to make a beginning, it was decided to try mixing calcium hypochlorite (a dry powder) with water, forming a liquid chlorine. This would be sprayed on the plant growth, allowed to work for a few minutes and then rinsed (diluted) with clear water. There would be a risk. It was not known what kind of reaction there would be. What if the Frozen Waterfall turned "Clorox Blue"? Because of that fear, a small out-of-sight portion of the Frozen Waterfall was test sprayed with chlorine. There was not a reaction, and cave restoration began at Carlsbad Caverns.

During the early stages of the project there was no formal plan of action. As an area covered with moss and algae was encountered, it was treated with chlorine after a test spray. However, from the beginning, notes were kept recording the date, the method used, how much chemical, if any, was used and the results of the treatment. As work progressed, consequences of development other than plant growth became evident. More possible projects became visible. More care was taken to document each action as thoroughly as possible including the condition before corrective action, results of that action and checks made several days later. It became evident that restoration at Carlsbad Caverns was not going to be a simple job. There was the possibility that a large and complicated project could follow if the park managers could be convinced that it was important and necessary.

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Due to documentation of the early work, as well as a new lighting system that utilized brighter lights and lit up more areas of the cave, support was given. Money was approved for a special project. These funds would be used to provide personnel, equipment and supplies. Cave restoration was still just an experiment, but it had the sanction of the title pilot project. Since it was an official project the activities needed to be planned more precisely if the project were to gain credibility. An understanding of what the goals of the project were to be was needed, as well as limits set on how much could and should be attempted. An inventory of possible projects or areas that needed attention was made along the three miles of developed trail. These were listed and divided into four categories: plant and algae removal, removing mud and fill, carrying out trash and litter and cleaning dust and lint from walls, floors and speleothems. These projects were then listed in priority based on 1) feasibility, 2) potential harm, and 3) necessity.

Restoration was defined. Guidelines and procedures were established. A specific objective would be set for each project. Procedures would be followed to try to ensure that no more damage would be done in the name of restoration. Documentation would remain important and would be done in as detailed a form as possible. Most importantly, each member of the crew would understand what cave restoration was and what objectives were to be accomplished.

As the project progressed it became evident that the few projects that could be done were only scratching the surface. It could be compared to wiping a spot off of a wall, only to find that the newly cleaned spot stands out, emphasizing how dirty the whole wall is. The wall is cleaned and the task has to expand to all of the walls. One of the limitations of the project was that cave restoration would be an attempt to return the cave to its natural state and any cave restorative action should not be noticeable. One of the signs of a successful job would be that it should be nearly impossible to tell at a glance that any area had been cleaned.

At the end of the five-month pilot program, several projects had been completed. Much of the noticeable plant growth had been controlled and an experimental schedule of cleaning established. Many bags of trash and litter were carried out. Dust and lint was washed or swept off of selected areas. Several areas were cleared of old trail mud and fill exposing some flowstone and a pool that had been covered for many years. Even with these objectives being completed there was a sense that much more could be done. It clearly was not a project to be started and finished in three months. Nor was it one to be done by trial and error methods. It was time to plan for the future. It was time for cave restoration to become a working element of cave management and no longer to be considered a special project.

Now, three years later, project results can be reviewed. What was accomplished? What was learned and most importantly, what action, if any, should be taken at this point? Generally, it was learned that cave restoration could not be treated as a straightforward cleaning project. It is very complicated and each action could affect not only the problem it was to cure, but might affect some other area as well. For every action there might be a reaction that would be more destructive than the original problem. At this time cave restoration is not agressively being pursued at Carlsbad Caverns. A beginning was made, but before any further work is done, questions must be answered. Research is necessary to ensure that the reaction to restoration will not be detrimental to the cave, its environment or its life.

PLANT GROWTH REMOVAL

Several times in the past, there had been attempts to kill the mosses and algae that grew in areas near the lights. No records were kept and the method or chemical used is not known now. In order to begin, a decision was made to try a liquid chlorine. A procedure was established for mixing the calcium hypochlorite (a dry granular powder) with water that would prevent accumulations of undissolved solids from being deposited in the cave. This was time consuming and it was tempting to short cut the procedure, resulting in the possibility of more residue being introduced into the cave environment.

A strong solution of hydrogen peroxide was tried, but it did not prove effective. Still looking for alternative methods, it was learned from other cave managers that Clorox bleach had been used in other caves. Clorox was tried in test areas of Carlsbad. It was found that the Clorox was more concentrated than the solution mentioned above and that it did kill and bleach the plant growth in most areas. Clorox did not need to be applied as frequently nor did as much of the chemical need to be used. There seemed to be no visible residue.

Records were kept of the different areas treated. These included the date of treatment, how much of the chemical was used to remove the algae/moss, how much time was needed and the results of the action (how much was killed, any adverse reactions). Periodic checks were made to see when the first signs of new growth appeared and this information recorded. From this information a schedule of cyclic treatment could possibly be developed.

Before any further chemicals are introduced into the cave, an inventory needs to be made of the types of plant growth that occur in the cave. This should also include where the plants are growing, with notes on surface type, humidity and temperature of the area, type and strength of illumination and distance of the algae from the light source. Research that has already been done in other caves should be consulted. Such studies have dealt with the effects of different treatment on the plant types and the rate and time required for plants to recover after treatment. Other studies have dealt with plant response to light, including photoperiod and wavelength requirements, as well as effects of certain algacides and herbicides on the different types of plants. These studies should be consulted and modified for the specific situation at Carlsbad.

Research is necessary to determine the effects of the chemicals on the biotic community of the cave. At the beginning of the project, a primitive attempt was made to test the effect of Clorox on the biotic community. Plots were established and inventoried for species and numbers of each. These areas were then sprayed with clorox and recounted. Results seemed to indicate that there was no effect on the populations of the test plots. However, since clorox is a strong algacide and according the the label, "kills germs", more accurate studies need to be done to answer the following questions.

1. Are any individuals killed outright at the time of application? If so, how will this affect species populations in the area? In the cave?

2. Does Clorox sterilize an area? If so, for how long?

3. Does Clorox affect the natural food sources? Will its use cause a disruption of the food chain?

4. What happens to the Clorox in the cave? How does it break down? Will a new foreign material be introduced into the cave as a precipitate?

5. If water is added to the Clorox (in the form of a rinse), will that reduce biotic mortality?

6. What is the chemical reaction of Clorox with the rock of the cave? With the "exotic" trash, i.e., metals and organic matter?

These questions should be answered for each chemical that might be considered for use in the cave.

There have been cave cleaning projects that have made use of steam applications. Again, research would need to be done to determine the effects of steam on the biotic community as well as on the cave microclimate.

DUST AND LINT

Dust and lint accumulations presented a dilemma for the cave restorer. Brushing and sweeping was attempted at several locations. Rinsing with water was also tried. These methods proved to involve much hard labor (hauling hoses, sweeping sticky lint and cleaning much larger areas than had been planned so that the cleared area would "blend" into its surroundings and not be obvious as a cleaned area) and was only applicable to smooth floors and flowstone. This method was not practical in delicate areas decorated with popcorn or aragonite or in areas of dehydrated and decaying calcite or in gypsum areas.

One possible solution is high pressure water applications in the form of a high pressure mist. Before such a step is taken, research again needs to be done to address these questions:

1. How will the high pressure water affect cave fauna?

2. Can enough pressure be applied in the form of a mist to wash the speleothems, yet not damage them, particularly soda straws, aragonite, decaying calcite and gypsum?

3. How can the washed off lint be collected so it can be removed from the cave?

OLD TRAIL FILL

Removing old trails that consisted of packed mud was one of the hardest (physically) and most tedious jobs, yet was often the most rewarding. It was exciting to remove mud and fill and expose hidden flowstone, rimstone dam or old pool. Careful research is necessary to determine that a proposed removal is an old trail and the fill was transported and placed there by man. Checking old trail maps and photographs is an important step as well as consulting with geologists to determine that original or natural cave is not destroyed. One of the major limitations of this project is the mandate to keep the cave natural. Can the project be undertaken and completed so as to blend in with the surrounding unaltered area (a smooth transition)? Where will the material that is removed be disposed of? What is the desired result and is it worth the large effort that will be required to satisfactorily complete the project?

CONCLUSION

From the above, it can be seen that cave restoration cannot be isolated by itself. Any action taken can cause a reaction in the microclimate, biological community or in the inorganic resource. Cave restoration is an element in cave management. It is necessary to understand that cave restoration is an attempt to heal or remove destructive or harmful effects of man's development and use, but it is not to re-create a new cave. Considering this, the first question that should be asked is: "Is cave restoration necessary?" Is the mistake harming cave in any way? What is the purpose of the restorative action? Aesthetic? Integrity of the cave? To prevent further degradation? If the restoration is desired, alternatives can be established in a plan. Research and data are needed to back up or justify these alternatives. Many elements of the Cave Management Plan will affect proposed restoration. Cave inventory (biota, speleothems, rare or not rare) and historical resources (old names, dates, graffiti, trash) are just two that might have an effect on proposed actions. Until research has been done and data and results have been reviewed, no major activity should take place. If the research shows that there is no alternative that is completely acceptable and satisfactory without trade-offs, and those trade-offs are not acceptable, then that project of cave restoration should not be done until an acceptable treatment is found. Perhaps the best alternative is to take steps to ensure that future development does not require cave restoration.

THE NATIONAL CAVE RESCUE COMMISSION**

*Lee Noon

The National Cave Rescue Commission is a commission of the National Speleological Society (NSS) operating under the office of the executive vice-president and consisting of one national coordinator and several regional coordinators who form the board of coordinators by which the NCRC is operated. Also of significance are the national medical officer and the national diving officer. These positions provide up-to-date expertise in their respective fields. These personnel interact with the Air Force Rescue Coordinating Center at Scott Air Force Base. Cooperation between these groups has made a significant impact on the immediate availability of transportation for cave rescue teams as needed.

Primary functions of the NCRC are: 1) to coordinate cave rescue operations, 2) to provide for cave rescue training, and 3) to act as the voice of the NSS on cave rescue matters. Additional functions are: 1) to develop a national standard for evaluation of rescue teams wishing to affiliate with the NCRC/NSS, 2) to solicit and publish papers and texts on cave rescue related topics, and 3) to initially establish and control a national inventory of equipment for training and rescues. The NCRC is not a rescue team, but is a coordinated group of independent rescue teams united by a common purpose and led by the NCRC board of coordinators.

In the performance of the first of the NCRC roles, cave rescue coordination, it is vital to have a telephone which is monitored around the clock by trained rescue coordinators. This telephone is provided by the RCC at Scott AFB where a highly skilled team of specially trained coordinators man a sophisticated control room for nationwide rescue operations of all types. The duty personnel obtain the information required to insure that the correct NCRC coordinator and rescue team or teams are added on the line with the person initiating the rescue call. (For the purpose of speed this should be a law enforcement officer.) If air transportation is required, the Air Force coordinates this. To reemphasize, the NCRC is not a rescue team that flies all over the United States, although many of the coordinators are leaders of cave rescue teams in their own areas. The NCRC will insure that the correct skills and equipment are provided by the teams responding and will stay by the telephone to provide any assistance necessary. While this is by far the most glamorous job of the NCRC, it is the job which consumes the least time.

The majority of work done by the NCRC is in our cave rescue training, both on the local and national levels. The annual Cave Rescue Seminar is a nationally conducted seminar which covers the methods of basic cave rescue and which also has a separate course for the development of team leaders. Both courses are six days in duration and provide the students with a cross-section of cave rescue skills. This currently is the only school of its type in the world. The faculty is a volunteer group of instructors who are individually recognized as experts in the various facets of cave rescue. From this school has developed a national curriculum which is being adopted by various government agencies as the minimum requirement in underground rescue.

As an additional benefit of the seminars, the NCRC has published the Handbook of Cave Rescue Operations in 1978. This manual is updated as new information and practices come on the national scene. It was updated in 1980 and is currently being solicited for presentation at various NSS functions. In addition to these papers, the NCRC is actively involved in the development of rescue equipment that is unique to the cave rescue environment. As many of the situations encountered on a cave rescue are far removed from the main stream of emergency medical and rescue knowledge, the equipment available from the local rescue agencies will not always work and may be extremely dangerous to the parties involved. For this reason the NCRC constantly keeps informed on the latest of rescue techniques and equipment in order that only the best and safest are used for cave rescues. Where equipment is not available we develop our own, such as the warm gas inhalator and currently experimental fiberglass "set-in-place" splints. Along the same lines, the NCRC maintains a cache of rescue equipment for training purposes on both the local and national level.

The NCRC staff will also serve as consultants on possible rescue situations and will also aid cavers throughout the country in interfacing with various government agencies for rescue readiness purposes. It is always better to be over prepared for the next rescue than to have that rescue come while you are thinking about getting ready. It is in this vein that the NCRC can provide the greater support for personnel involved with cave management whether wild or commercial.

One of the major aspects of cave management must be a rescue preparedness. A rescue can vary from a visitor to a commercial cave twisting an ankle and being helped out, to a major injury deep in a wild

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**The paper was presented by Don Paquette.

portion of the cave which requires many trained rescuers. While it is expected that the first incident would be handled by the staff, the second would almost certainly entail outside rescuers' efforts. Perhaps we can best see the need for preparation by reviewing a recent cave rescue in the wild portion of a commercial cavern. The owner of the cavern was on a trip with several experienced cavers and one novice on his first trip. The novice fell 30 feet into a pit, due to a freak accident, and suffered moderate rib and pelvic injuries. As the cavern is seasonal, the telephone was turned off and the nearest phone was three miles away. Outside rescuers were called in and the rescue was over in less than five hours after the fall. While this appears to be great news, there were some problems. Not having a telephone handy slowed the initial callout and caused problems in communications with the resource coordinator who was off site. Initial callout was to about 60 people and half of these were held on stand-by until the condition of the patient was known. Due to the problems of communications many people were held on alert after they were no longer needed. Even though the owner knew of the vertical sections in the wild portion of the cave there was no vertical rescue equipment at the cavern. As a minimum he should have had enough ropes and vertical equipment to do the known drops. Ideally he should have had several rescue pulleys, cams, a bolt kit, and first aid kit. Arrangements should have been made for access to a stretcher, if needed.

The best that can be done is to have someone from the NCRC or another caver who is very knowledgeable in rescue to review the cave with you. This way you, as a manager, can have the best possible preplanning for the unique aspects of your cave. While the NCRC can handle a rescue when it happens, we would prefer to prevent one or minimize the problems by preplanning wherever possible.

CAVE MANAGEMENT PLANS

*J. B. "Buzz" Hummel

In order to find out what the state of the art is for cave management plans, I wrote several people who are active in cave management and asked for copies of any cave management plans they might have. I followed up these letters with phone calls and discussed management plans with their originators. I learned that the state of the art of writing management plans is still in its infancy. These first management plans were done from a "seat of your pants" approach. Managers now writing cave management plans can contact these people to request copies of existing plans or information which may benefit them. Listed below are addresses of individuals who may be contacted for further information.

Non-Federal Management Plans

Management Plan for Knox Cave

Robert R. Stitt
1417 9th Avenue W.
Seattle, Washington 98119

Province of British Columbia Ministry of Forest

Management Plan for Candlestick Cave

Phil Whitfield
521 West Innes Street
Nelson, British Columbia, Canada

National Park Service

Lehman Caves

Edward E. Wood, Jr.
Lehman Caves National Monument
Baker, Nevada 89311

Grand Canyon National Park

Merle E. Stitt
Grand Canyon National Park

Carlsbad Caverns National Park

Ron Kerbo
Carlsbad Caverns National Park
3225 National Parks Highway
Carlsbad, New Mexico 88220

United States Forest Service

Pacific Southwest Region

Jim Shiro
U. S. Forest Service
636 Sansame Street
San Francisco, California 94111

Pacific Southwest Region

Jim Shiro
U. S. Forest Service
636 Sansame Street
San Francisco, California 94111

Ozark St. Francis National Forest

Richard A. Mills
District Ranger
Ozark National Forest
P. O. Box I
Mountain View, Arkansas 72560

Bureau of Land Management

Worland: Wyoming District

Bureau of Land Management
Bob Barry
P. O. Box 119
Worland, Wyoming 82401

Tom Aley
Ozark Undergound Laboratory
Protem, Missouri 65733

New Melones Cave - Cave Management Plan

Kevin Clarke
Bureau of Land Management
63 Natoma Street
Folsom, California 95630

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*Bureau of Land Management, P. O. Box 1397, Roswell, New Mexico

THE STATE OF THE ART IN MANAGEMENT PLANNING - A CASE FOR CAVER INVOLVEMENT

*Geoffrey B. Middaugh

ABSTRACT

Management plans are simply pieces of paper when they are not followed up with on-the-ground management actions. It is difficult to define a cookbook approach to management planning. Generally, management plans must focus the management actions to be taken from the general allocation decisions down to specific management actions. A great deal of research has taken place which gives a general guideline for management plans. Plans have to take general goals, articulate specific objectives from these goals, evaluate current situations and assumptions and prescribe specific management mechanisms to achieve the objectives. With this general format in mind for taking action, there are numerous avenues and places where caver involvement is needed and requested. Cavers should be aware of this approach and make sure they provide timely and appropriate guidance to the process. Management planning is a process. Cavers have to be involved with the process. When involvement only occurs at single points and times in the process, confusion and miscommunication occur. Relevant solutions to this problem include the use of steering committees, advisory committees, group field trips, and use of key contacts. A major solution for cavers is to understand the process.

The concept of a management plan is abstract. Management plans are pieces of paper which identify a number of actions that someone or some agency is going to take. Management plans abstractly can either indicate that a cave is going to be "protected" or it is going to be "gated". There is a distinct difference between words and actions, as I hope this paper will point out. The word "protected", for example, brings with it various action connotations, i.e., closed to public use, closed to recreational caving, withdrawn from mineral location, protection of the watershed for a cave, and so on. The action of "gating" has various connotations also. It may mean a barbed wire fence around the entrance, a sign telling people to keep out, or iron bars that allow neither cavers nor bats either in or out. The problem with developing management plans is one of agreeing upon the terms or the methods to accomplish a specific objective.

The purpose of this paper is to identify a general format for cave management plans, to identify a concept which leads to a mutual understanding of what a cave management planning process is, and to show how this process is accessible for caver involvement. This paper will focus on public land management agencies (applicable to state, as well as federal agencies), however, some of the concepts can also be applied to private institutions.

Many federal and state agencies are heavily involved in land use planning. Most plans involve allocation decisions which address how certain portions of the public lands will be managed and provide guidance for various activities by setting production goals, levels of protection or intensities of development. Both the Federal Land Policy and Management Act of 1976 (FLPMA) and the Forest and Rangeland Renewable Resource Planning Act of 1974 (RPA) provide Congressional guidance for developing land use plans with allocation decisions as the prime output. Allocation decisions are primarily concerned with broad views of land management — wilderness versus timber production, natural areas versus oil and gas production, or wildlife habitat protection versus intensive recreation use. Of course, these issues are not always polar, but allocation decisions usually decide parameters about how areas are to be managed in a broad multiple use sense. Dominant use and goals are usually established.

The next step in the land use planning process is to implement the allocation decisions with on-the-ground land management actions; convert "words" to "actions". For example, taking the allocation of a wilderness area and implement intensive management of the recreational uses in that wilderness area is taking action. Taking timber production goal and to initiate management plans to harvest timber is also taking action, but more

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familiar to cavers is taking the preservation goal for a certain cave and implementing on-the-ground actions to preserve the cave, research its values, and perpetuate its free-functioning natural ecosystem.

The tool for implementing allocation decisions is the management plan. How do the general allocation decisions convert to on-the-ground actions? How are the general allocation decisions funded and eventually implemented? This conversion of "words" to "actions" is the purpose of the management plan. The management plan serves as the budgetary document to identify costs and actions, as well as a decision-making guide. The management plan has to be flexible enough to adapt to changing land use conditions, as well as changing budgetary conditions, but specific and stringent enough to assure that the public commitment made as a land use allocation is met.

The management plan is a diverse document. However, its purpose is always the same: to bring about effective on-the-ground management actions. One of the more effective formats for guiding the development of management plans is the "goal achievement management framework". This framework borrows heavily from the administrative management concept of "management by objectives" and is discussed in greater detail in the book "Wilderness Management" by John Hendee, George Stankey, and Robert Lucas. This book will no doubt be a classic in terms of all types of management planning activities and not necessarily just for wilderness. The four items below are the framework to guide the development of management plans.

GOALS: Goals are broad statements of intent, direction, and purpose which describe ideal ends or effects. Goals are not usually quantifiable and, by definition, may be unachievable. It should be obvious that goals are always varied and different, depending on the agency or the purpose for which an institution exists.

OBJECTIVES: Objectives are statements which describe specific conditions sought at a particular point in time and define "what" will be achieved. Objectives also define standards to evaluate management actions. Objectives are quantifiable in terms of what is to be achieved (numbers of caver recreation days or acres of cave watershed protected). As federal agencies become more sophisticated in their land management process, management objectives are becoming more sophisticated and quantifiable.

CURRENT SITUATIONS AND ASSUMPTIONS: A description of the "current situation" usually describes the state of the resources at the present time. Is the recourse deteriorating? Is it being protected? Is it being overused? The "assumption" is a prediction of resource condition at a future point in time. The assumption is also an estimate of change that may occur to the resource.

MANAGEMENT MECHANISMS: Management mechanisms are the meat of management plans. These basically are the specific actions through which objectives will be achieved. They are the "how's" to achieve the "what's". They show how the cave will be gated or how many permits will be issued to achieve a desired state of protection. Management mechanisms also define standards for determining levels of change and levels of unacceptable change in terms of protection of the resource. No doubt, the management mechanisms compose the basic substance of management plans. All the tools of regulation, enforcement, inventory, development, access, use and protection are management mechanisms.

When developing a management plan, the "goal achievement framework" can be expanded upon and narrowed in scope. Some management plans require much more detail on management mechanisms. A management plan for a large area with numerous caves will concentrate more on the objectives for individual caves. Management mechanisms may come later. A management plan for one single cave may contain detail on standards and levels of unacceptable change. From experience, this framework has been found to be very workable. It provides a tangible framework for action in a format that the public can understand. It has been used for Wilderness Areas (with a good record of implementation), river management plant (similar to caves because of their linear systems and needs for quotas of use), and for natural areas with unique sensitive ecosystems.

The second part of this paper will deal with how cavers can constructively participate in the development of management plans. With the framework presented above, it is important that caver involvement be incorporated into all four decision points: Goal determination, objective formulation, current situations and assumptions and management mechanisms. It is important that the caving public and the management agency be talking about the same points in the process when they are trying to get on common ground. It does not do any good to argue about the type of gate to be placed on a cave when the cavers and the agency have not yet agreed on whether the cave should be a recreational cave or a research cave.

This approach is schematically presented in Figure 1. The inverted triangle represents the broad types of participation needs for determining goals and objectives. As planners begin to focus on assumptions and management mechanisms, the caver involvement needs to be more refined and focused on issues. The need for technical expertise also becomes more acute.

Cavers must realize that their involvement cannot occur at single points in time. Sporadic involvement causes confusion at focusing on the issues. Attending one public meeting does not constitute involvement. It may make one person aware of the goals, but it will not lead to resolutions of the problems by describing management mechanisms. The "goal achievement framework" is a process. It requires involvement throughout the process, over a period of time. It is not possible to understand what is being done or even being proposed without understanding the overall process. When involvement constitutes someone jumping in and out of the process, a great deal of confusion and miscommunication occur. If cavers are concerned with results, it is more effective to be involved

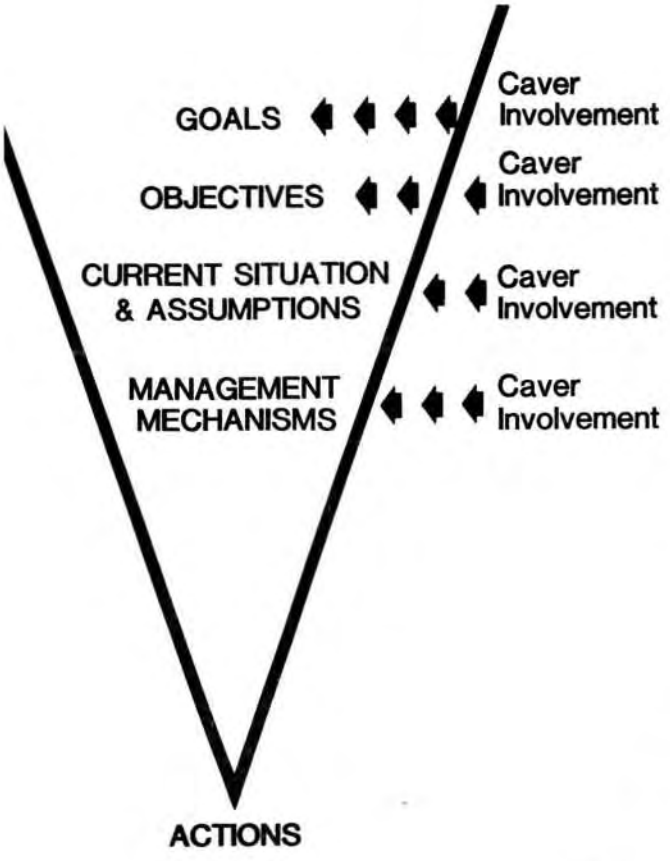

Figure 1

throughout the entire process rather than intermittent points in time.

The final issue of caver involvement will be to define specific ways that involvement can be utilized so that cavers can be involved in the entire management planning process. There are many techniques of involvement — both formal and informal. A public hearing with court transcriptions and formal presentations is quite formal. A friendly visit to the person who is going to write the plan is an informal approach. The weakest methods are those that occur at single points in time. Examples are public meetings, public forums, hearings and open houses. Attendance at these types of meetings always requires a follow-up of some kind whether it is a letter or a written statement. A person simply cannot attend one meeting and be involved. The strongest mechanisms of involvement include setting up of ad hoc committees and steering groups. The groups are set up to closely follow the actions of the entire management planning process. Involvement like this requires a great deal of work, but it usually achieves results. Other formal involvement mechanisms include advisory committees, groups field trips and constant communication through key contacts and individuals.

In summary, management planning is a process whose end is to provide for on-the-ground management action. The process is not simple, but can be presented simply as a framework focusing words into action. Cavers need to make themselves aware of the process and how they can use various techniques to access the process. The results of knowing the process and where and when to participate in it will be effective cave management.

CAVE LAWS OF THE UNITED STATES

*Evelyn Bradshaw

At the 1975 Cave Management Symposium, Rob Stitt of NSS presented a comprehensive study of cave protection laws in the United States: from which some of the following is extracted. In 1978 the Virginia Commission on the Conservation and Use of Caves assembled data on a number of such laws for background in drafting the 1979 Virginia Cave Protection Act.

Alabama

Alabama does have a liability exemption for owners or property used recreationally if there is no charge for such use.

In Alabama, according to Stitt, there was an attempt in 1973-1974 to establish a State Speleological Commission to regulate commercial caves and enforce law. Archeology was included. The usual prohibitions against vandalism etc. would have been included.

Arizona

§13-3702. Defacing or damaging petroglyphs, pictographs, caves or caverns; classification.

A. A person commits defacing or damaging petroglyphs, pictographs, caves or caverns if such person knowingly, without the prior written permission of the owner

1. Breaks, breaks off, cracks, carves upon, writes or otherwise marks upon or in any manner destroys, mutilates, injures, defaces, removes, displaces, mars or harms petroglyphs, pictographs or any natural material found in any cave or cavern; or

2. Kills, harms or disturbs plant or animal life found in any cave or cavern, except for safety reasons; or

3. Disturbs or alters the natural condition of such petroglyph, pictographs, cave or cavern or takes into a cave or cavern any aerosol or other type of container containing paints, dyes or other coloring agents; or

4. Breaks, forces, tampers with, removes or otherwise disturbs a lock, gate, door or other structure of obstruction designed to prevent entrance to a cave or cavern whether or not entrance is gained.

B. As used in this section, "natural material" means stalactites, stalagmites, helictites, anthodites, gypsum flowers or needles, flowstone draperies, columns, tufa dams, clay or mud formations or concretions or other similar crystalline mineral formations found in any cave or cavern.

C. Defacing or damaging petroglyphs, pictographs, caves or cavern is a class 2 misdemeanor.

Added Laws 1977, Ch. 142, § 100, eff Oct. 1, 1978.

California

§ 623 Caves

A. Except as otherwise provided in Section 599c, any person who, without the prior written permission of the owner of a cave, intentionally and knowingly does any of the following acts is guilty of a misdemeanor punishable by imprisonment in the county jail not exceeding one year, or by a fine not exceeding five hundred dollars ($500), or by both such fine and imprisonment:

1. Breaks, breaks off, cracks, carves upon, paints, writes or otherwise marks upon or in any manner destroys, mutilates, injures, defaces, mars, or harm any natural material found in any cave.

2. Disturbs or alters any archaeological evidence of prior occupation in any cave.

3. Kills, harms, or removes any animal or plant life found in any cave.

4. Burns any material which produces any smoke or gas which is harmful to any plant, or animal found in any cave.

5. Removes any material found in any cave.

6. Breaks, forces, tampers with, removes or otherwise disturbs any lock, gate, door, or any other structure or obstruction designed to prevent entrance to any cave, whether or not entrance is gained.

B. For purposes of this section:

1. "Cave" means any natural geologically formed void or cavity beneath the surface of the earth, not including any mine, tunnel, aqueduct, or other manmade excavation, which is large enough to permit a person to enter.

*Director, National Speleological Society, 1732 Byron Street, Alexandria, VA 22303

2. "Owner" means the person or private or public agency which has the right of possession to the cave.

3. "Natural material" means any stalactite, stalagmite, helictite, anthodite, gypsum flower or needle, flowstone, drapery, column, tufa dam, clay or mud formation or concretion, crystalline mineral formation, and any wall, ceiling, or mineral protuberance therefrom, whether attached or broken, found in any cave.

4. "Material" means all or any part of any archaeological, paleontological, biological, or historical item including, but not limited to, any petroglyph, pictograph, basketry, human remains, tool, beads, pottery, projectile point, remains of historical mining activity or any other occupation found in any cave.

C. The entering or remaining in a cave by itself shall not constitute a violation of this section.

Added by Stats. 1976, c. 1303, p. -----, § 2. Amended by Stats. 1977, c, p. -----, §1, urgency, eff. April 6, 1977.

1977 Amendment. Substituted in subd. (A)(2) the phrase "Disturbs or alters any evidence of archaeological prior occupation in any cave."

Library References — Health and Environment 37, 43. C.J.S. Health §§29 et seq., 35.

Earlier (the above material elaborates on the word spelunking in the earlier law shown below)

346 Permission to enter for fishing, hunting, camping, etc.

An owner of any estate in real property owes no duty of care to keep the premises safe for entry or use by others for fishing, hunting, camping, water sports, hiking, spelunking, riding, including animal and all types of vehicular riding, rock collecting, or sightseeing or to give any warning of hazardous conditions, uses of, structures, or activities on such premises to persons entering for such purposes, except as provided in this section.

An owner of any estate in real property who gives permission to another for entry or use for the above purposes upon the premises does not thereby (a) extend any assurance that the premises are safe for such purposes, or (b) constitute the person to whom permission has been granted the legal status of an invitee or licensee to whom a duty of care is owed, or (c) assume responsibility for or incur liability for any injury to person or property caused by any act of such person to whom permission has been granted except as provided in this section.

This section does not limit the liability which otherwise exists (a) for willful or malicious failure to guard or warn against a dangerous condition, use, structure or activity; or (b) for injury suffered in any case where permission to enter for the above purposes was granted for a consideration other than the consideration, if any, paid to said landowner by the state; or (c) to any persons who are expressly invited rather than merely permitted to come upon the premises by the landowner.

Nothing in this section creates a duty of care or ground liability for injury to person or property.

Added by Stats. 1963, c. 1759, p. 3511, § 1; Amended by Stats. 1970, c. 807, p. 1530, § 1; Stats. 1971, c. 1928, p. 1975, §1; Stats, 1972, c. 1200, p. 2322, § 1; Stats. 1975, c. 1303, p -----, § 1.

1970 Amendment. Substituted "fishing, hunting" for taking of fish and game" and added "riding" in the first paragraph; substituted "for entry of use for the above purposes" and "such purposes" for "to take fish and game, camp, hike or sightsee" and "rock collecting" in the first paragraph.

1972 Amendment. Included "animal and all types of vehicular riding" in the first paragraph.
Forms: See West's California. Code Forms.

Law Review Commentaries
Background and general effect of 1963 addition. (1963) 38 S. Var J. 647.

Colorado

Stitt notes a Colorado statute enacted before 1883 making it a crime to break, destroy, remove, or harm cave formations, or break and enter, provided, however, that a copy of said law is posted near the cave entrance. Conviction called for fine or imprisonment.

The clause in the Colorado law requiring the posting of a copy of the law near the cave if it's to be protected in effect makes the law useless except for protection of commercial caves, since in the absence of a caretaker any would-be vandal could merely tear down the sign and return the next day.

Florida

No reference to caves in law indexes.

Georgia

Chapter 43-25. Cave Protection Act of 1977

Sec.
43-2501 Short title
43-2502 Findings
43-2503 Definitions
43-2504 Vandalism unlawful
43-2505 Sale of speleothems unlawful
43-2506 Pollution and littering unlawful
43-2507 Wildlife
43-2508 Liability of owners and agents

Cross References
Penalty for violation of Chapter, see § 43-9916.

43-2501 Short title
This Chapter shall be known and may be cited as the "Cave Protection Act of 1977". (Acts 1977, p. 833, eff. July 1, 1977.)

43-2502 Findings
The State of Georgia hereby finds that caves are uncommon geologic phenomena and that the minerals deposited therein may be rare and occur in unique forms of great beauty which are irreplaceable if destroyed. It is also found that the wildlife which have evolved to live in caves are unusual and of limited numbers, and many are rare and endangered species, and that caves are a natural conduit for groundwater flow and are highly subject to water pollution, which has far-reaching effects transcending man's property boundaries. It is therefore declared to be the policy of this State and the intent of this Chapter to protect these unique natural resources. (Acts 1977, p. 833, eff, July 1, 1977).

43-2503 Definitions
Unless the context in which used clearly requires a different meaning, as used in this chapter:

A. "cave" means any naturally occurring subterranean cavity, including, but not restricted to, a cavern, pit, pothole, natural well, sinkhole and grotto;
B. "commercial cave" means any cave with improved trails and lighting utilized by the owner for the purpose of exhibition to the general public as a profit or nonprofit enterprise, wherein a fee is collected for entry;
C. "gate" means any structure or device located so as to limit or prohibit access or entry to a cave;
D. "owner" means a person who owns title to land where a cave is located, including a person who owns title to a leasehold estate in such land, and specifically includes the State and any of its agencies, departments, boards, bureaus, commissions or authorities, as well as counties, municipalities and other political subdivisions of the State;
E. "sinkhole" means a closed topographic depression or basin, generally draining underground, including, but not restricted to, a doline limesink or sink;
F. "speleothem: means a natural mineral formation or deposit occurring in a cave, including, but not restricted to, stalagmites, stalactites, helectites, anthodites, gypsum flowers, gypsum needles, angel's hair, soda straws, draperies, bacon, cave pearls, popcorn (coral), rimstone dams, columns, palettes, and flowstone. Speleothems are commonly composed of calcite, epsomite, gypsum, aragonite, celestite and other similar minerals;
G. "wildlife" means any vertebrate or invertebrate animal life indigenous to this State or any species introduced or specified by the Board of Natural Resources and includes, but is not restricted to, quadrupeds, mammals, birds, fish, amphibians, reptiles, crustaceans, and mollusks, or any part thereof. (Acts 1977, p. 833, eff. July 1, 1977.)

43-2504 Vandalism unlawful
It shall be unlawful for any person, without the express prior written permission of the owner, to willfully or knowingly

1. break, break off, crack, carve upon, write upon, burn or otherwise mark upon, remove, or in any manner destroy, disturb, deface, mar or harm the surfaces of any cave or any natural material therein, including speleothems;
2. disturb or alter in any manner the natural condition of any cave;
3. break, force, tamper with or otherwise disturb a lock, gate, door or other obstruction designed to control or prevent access to any cave, even though entrance thereto may not be gained. (Acts 1977, pp. 833, 834, eff. July 1, 1977.)

43-2505 Sale of speleothems unlawful
It shall be unlawful to sell or offer for sale any speleothems in this State or to export them for sale outside this State without the express written permission of the owner of the cave from which such speleothems were obtained. (Acts 1977, pp. 833, 835, eff. July 1, 1977.)

43-2506 Pollution and littering unlawful
It shall be unlawful to store in cave or sinkholes any chemicals and other materials which may be detrimental or hazardous to caves or sinkholes, to the mineral deposits therein, to the wildlife inhabiting caves, to the waters of the State, or to the persons using such phenomenon for any purposes. It shall also be unlawful to dump, litter, dispose of or otherwise place any refuse, garbage, dead animals, sewage, trash, or other such similar waste materials in any quantity in any cave or sinkhole. (Acts 1977, pp. 833, 835, eff. July 1, 1977.)

43-2507 Wildlife
It shall be unlawful to remove, kill, harm or disturb any wildlife found within any cave: Provided, however, that nothing contained in this Section shall be construed to repeal Section 32 of an Act completely and exhaustively, revising superseding and consolidating laws of this State relative to game and fish, approved March 7, 1955 (Ga. Laws 1955, p. 483), as amended particularly by an Act approved March 29, 1968 (Ga. Laws 1968, pp. 497, 515) {former § 45-208}, relating to scientific collectors' permits or any rules or regulations promulgated pursuant thereto or any Federal or State laws relating to the protection of certain plants or animals. (Acts 1977, pp. 833, 835, eff. July 1, 1977.)

43-2508 Liability of owners and agents

A. Neither the owner of a cave nor his authorized agents, officers, employees or designated representatives acting within the scope of their authority shall be liable for injuries sustained by any person using said cave for recreational or scientific purposes if the prior consent of the owner has been obtained and if no charge has been made for the use of such features and notwithstanding that an inquiry as to the experience or expertise of the individual seeking consent may have been made.
B. Neither the owner of a commercial cave nor his authorized agents, officers, employees or designated representatives acting within the scope of their authority shall be liable for an injury sustained by a spectator who has paid to view the cave, unless such injury is sustained as a result of such owner's negligence in connection with the providing and maintaining of trails, stairs, electrical wires or other modifications, and such negligence shall be the proximate cause of the injury.

C. Nothing in this section shall be construed to constitute a waiver of the sovereign immunity of the State or any of its boards, departments, bureaus or agencies. (Acts 1977, pp. 833, 836, eff. July 1, 1977.)

Illinois

From: The Windy City Speleonews, Vol. 17, June 1977

There follows a draft of a cave conservation bill for Illinois, written by Tom Lera, Windy City Grotto conservation chairman. State Representative Woody Bowman, a member of the Committee on Environment, has agreed to sponsor the bill. Letters in support of the bill, which has not yet been published and assigned a number, should be sent to your state representative and to Monroe L. Flinn, chairman of the Committee on Environment, whose address is 2746 Camp Jackson Road, Cahokia, Illinois, 62206, or 2080 State Office Building, Springfield, Illinois, 62706. Tom Lera would appreciate copies of any letters and any other comments you might have. His address is Apartment 16-D, 415 Aldine, Chicago, Illinois, 60657. (The proposed bill, modeled after an Alabama bill of several years ago, clearly needs a certain amount of more or less minor fiddling—e.g., "troglodite.")—Mixon

Synopsis: This bill provides for the preservation of caves and caverns and prohibits the destruction and taking of formations, plants, and animals living therein. It also provides for establishment of a State Speleological Committee.

A BILL TO BE ENACTED AN ACT

Providing further for the conservation of natural resources of the State; designating the caves and caverns of the State and the flora, fauna, mineral formations and deposits therein and other contents thereof for scenic and commercial purposes; regulating through licensure the use of such caves and their contents for commercial purposes; protecting the rights of property owners and the general public in caves; requiring cave owners to install and keep in repair certain equipment and abide by safety regulations when caves are opened to the public; providing for safety inspection of caves; establishing a State Speleological Committee; providing for the dissemination of information about Illinois caves and caverns to the owners thereof and to the public; designating certain acts relative to caves and caverns and their contents as criminal offenses and prescribing penalties thereof.

BE IT ENACTED BY THE LEGISLATURE OF ILLINOIS:

Section 1: Definitions

The following words and phrases when used in this Act have the meanings respectively ascribed to them in this section, except in those instances where the context clearly indicates a different meaning.

A. "Cave" means any natural subterranean cavity that is either fifty feet in length or in depth, or any combination of length and depth totaling fifty feet or that a person can enter to a point where daylight cannot be seen, or that contains obligatory cavernicolous fauna (animals obliged to live underground). The work "cave" includes or is synonymous with cavern, pothole, sinkhole, and grotto.

B. "Mine" means any subterranean cavity that is large enough to permit a person to enter to a point where day light cannot be seen, or that contains to obligatory cavernicolous fauna (animals obliged to live underground). The word "mine" includes or is synonymous with tunnel, aquaduct, or other manmade excavation.

C. "Speleothem" means a natural mineral formation or deposit occurring in a cave or mine whether attached or broken. This includes or is synonymous with stalactites, stalagmites, helictites, anthodites, gypsum flowers, needles, angle's hair, sodastraws, draperies, bacon, cave pearls, popcorn, rimstone dams, columns, flowstone, et cetera.

C. "Commercial Cave" means a cave utilized by the owner or lessee for the purpose of exhibition to the public, as a profit or non-profit enterprise, wherein a fee is prerequisite or solicited as a condition of admittance.

E. "Wild Cave" means a cave essentially in its natural state. Wild caves are not used for any commercial purpose whatsoever nor are shown on any scheduled basis to the public.

F. "Exhibition Cave" means a cave opened to the public for no charge. Exhibition caves are not classed as commercial caves even though shown on a scheduled basis.

G. "Gate" means any structure or device located to limit or prohibit access or entry to any cave or mine.

H. "Troglobite" means any animal or plant dependent upon a cave for its existence, even though it may exit the cave on occasion.

I. "Troglodite" means any animal or plant dependent upon the cave for its existence that normally never leaves the cave.

J. "Person" means any individual, partnership, firm, trust, association, corporation, company, municipality, or State.

K. "Owner" means a person(s) who owns title to land where a cave or mine is located including a person who owns title to a leasehold estate of such land.

L. "Supervision" means either the continuous physical presence of a certified, or permitted and/or licensed supervisor or in his absence, clearly legible instructions or directions for the precautions to be taken to prevent injury to persons, the environment, and artifacts.

Section 2: Committee

A Committee of no less than four nor more than six persons will be appointed by the Director of the Department of Conservation to assist him in reaching decisions on all matters pertaining to caves and mines which arise in connection with the administration of this Act. Such Committee members are to be residents of Illinois and not necessarily state employees. Committee meetings will be at least quarterly and the Committee is empowered to act at scheduled meetings regardless of the number in attendance. The Director of the Department of Conservation is the Chairman of this committee. This committee will be known, and is referred to throughout this Act, as the State Speleological Committee and is authorized to establish a program of education of the general public and an education of cave property owners to help them in preserving cave life within their property.

Section 3: Access and Ownership
Owners, both private and public, of cave and mine property may control access to the cave and mine property by either of the following methods:

A. Normal posting procedures.
B. Affixing a permanent notice at every entrance to each cave and mine stating restrictions, prohibitions, and any provisions for gaining entrance (if applicable), and a statement that violation of the restriction or prohibitions will be a misdemeanor under this Act.
C. Affixing a gate over the entrance subject to the restrictions in Section 7 of this Act.

An owner may not permanently block, fill, flood, or close access to specifically designated caves and mines, registered as a nature preserve by the Illinois Department of Conservation, Illinois Nature Preserves Commission, and the State Speleological Society pursuant to Section 7. Unless otherwise established through registration at the Department of Conservation and clearly posted at cave and mine entrances, caves and mines which are entirely or in part located within the boundaries of public property shall be open for recreational purposes.

Section 4: Liability
Neither the owner of a cave or mine nor his agent acting within the scope of their authority are liable for injuries sustained by any person using such features for recreational or scientific purposes if the prior consent of the owner has been obtained and if no charge has been made for the use of such features. An owner of a commercial cave is not liable for an injury sustained by a spectator who has paid to view the cave, unless such injury is sustained as a result of such owner's negligence in connection with the providing and maintaining of trails, stairs, electrical wires or other modifications, and such negligence is the proximate cause of the injury.

Section 5: Vandalism
It is unlawful and constitutes the crime of malicious vandalism for any person without express prior written permission of the owner or in public caves without the express permission of the State Speleological Committee to:

A. Break, break-off, crack, carve upon, write, burn, or otherwise mark upon, remove, or in any manner destroy, disturb, deface, mar or harm the surface of any cave or mine or any natural material therein, including speleothems;
B. Discard litter or refuse in any cave or mine;
C. Disturb or alter in any manner the natural condition of any cave or mine;
D. Break, force, tamper with, remove or otherwise disturb a lock, gate, door, or other structure or obstruction designed to control or prevent access to any cave or mine, even though entrance thereto is authorized by the owner thereof;

It is unlawful to offer for sale any speleothem obtained in contravention of Section 5(A), in the State of Illinois commercial caves obtained as authorized in said section except at licensed commercial caves selling material from their cave. It is also unlawful to export such items for sale elsewhere. Any person violating a provision of this section is guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one-hundred fifty dollars nor more than five-hundred dollars, and in addition thereto, may be imprisoned in the county jail for not less than ten days nor more than six months.

Section 6: Pollution
It is unlawful to store, dump, dispose of or otherwise place in caves or mines any chemical, refuse dead animals, sewage, trash, garbage or other materials. A person who violates any provisions of this section shall be guilty of a misdemeanor, and upon conviction thereof, shall be fined not less than one-hundred fifty dollars. A person who shall violate any provision of this section shall, the second offense, be guilty of a misdemeanor, and upon conviction thereof, shall be fined not less than five hundred dollars. A person who violates any provision of this section shall, for the third or any subsequent offense, be guilty of a felony, and upon conviction thereof, shall be punished by imprisonment in the penitentiary for not less than one year.

Section 7: Biological Policy
It is the policy of the State of Illinois to prevent the extermination of either plant or animal life in caves or mines. It is unlawful, constituting the crime of malicious vandalism, to remove, kill, harm, or disturb any plant or animal life either troglobitic or troglobitic: provided, that scientific collecting permits may be obtained from the Director of the Department of Conservation. Gates employed at the entrance or at any point within any cave or mine should consist of open construction to allow free and unimpeded passage of air, insects, bats and aquatic fauna. As the necessity arises, the State Speleological Committee and the Illinios Nature Preserves Commission is empowered to designate and establish certain caves and mines as Nature Preserves. These caves may be posted to prevent both accidental and intentional disruption of natural cave life. A person who violates any provision of this Section is guilty of a misdemeanor, and upon conviction thereof, shall be fined not less than one-hundred fifty dollars and not more than five-hundred dollars and in addition thereto, may be imprisoned in the county jail for not less than ten days nor more than six months.

Section 8: Archeological, Paleontological, and Historical Features
No person may excavate, remove, destroy, injure or deface any historic or prehistoric ruins, burial grounds, archeological or paleontological site including saltpeter workings, relics or inscriptions, fossilized footprints, bones or any other such feature which may be found in any cave or mine. A permit to excavate or remove archeological, paleontological, prehistoric and historic features may be obtained from the Director of the Department of Conservation of Illinois. The permit will be issued for a period not to exceed one year and may be renewed at expiration. It is not transferable but may work under the direct supervision of the person holding the permit.

A person applying for such a permit must:

A. Provide a detailed statement to the Director of the Department of Conservation of Illinois and the State Speleological Committee giving the reasons and objectives for excavation or removal and the benefits expected to be obtained from the comtemplated work;

B. Agree to provide data and results of any completed excavation, study, or collection at the first of each calendar year;
C. Obtain the additional prior written permission of the Director of the Department of Conservation if the site of the proposed excavation is on state-owned lands and prior written permission of the owner if the site of such proposed excavation is on privately owned land; and
D. Agree to carry the permit while exercising the privileges granted.

A person who violates any provision of this section is guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one-hundred and fifty dollars nor more than five-hundred dollars, and in addition thereto, in the discretion of the court, may be imprisoned in the county jail not less than ten days nor more than six months.

Section 9: Commercial Caves

The Department of Conservation is directed to establish standards of safety, including regulations relative to guard rails, bridges, ladders, stairs, platforms, walkways, barriers, paths, lights and emergency lights, etc., for all commercial caves in Illinois and to enforce such standards. The Department of Conservation shall establish a licensing procedure with annual renewals for all commercial caves in Illinois which will:

A. Require filing with the Department a detailed written plan of all intended modifications, including a complete, true plan and elevation map of the cave or mine, and stating that a copy of such map is at a readily accessible location near the cave or mine entrance. The plans must be approved by the State Speleological Committee before alterations begin;
B. Provide that danger to public health and safety, destruction of valuable scientific, anthropological, or extensive destruction of speleothems will be considered basis for rejection of submitted plans;
C. Require the owner of a commercial cave have the cave pass the initial safety inspection, and pay an inspection fee, obtain a license showing that the cave has been duly inspected and approved and conspicuously displayed at or near the entrance to the cave; and
D. Commercial caves shall be inspected by the Department of Conservation initially, before licensing and annually after initial licensing. Failure to maintain the cave in a condition at the time of initial licensing shall be cause for nonrenewal of the license. The Department of Conservation is granted the authority to fix the fee for the initial and annual inspection to cover the cost of these inspections, but such fee is not to exceed two hundred dollars for the initial inspection and fifty dollars for the annual inspection. Presentation of a certificate of inspection by a recognized liability insurance company shall be accepted in lieu of the annual inspection.

Section 10: Exception

Any provision of this Act may be waived provided a petition stating the reason(s), extent, limit, location, and expiration date of such request is filed with the State Speleological Committee and provided the Committee approves the petition. All or part of a petition may be rejected, or more information may be requested before a final determination is made on the matter. No action at all within 120 days of receipt by the State Speleological Committee of a petition, modification, or additional information shall constitute automatic approval. The provisions of this Act are severable. If any part of the Act is declared invalid or unconstitutional, such declaration shall not affect the part which remains.

Section 11:

All laws or parts of laws which conflict with this Act are hereby repealed. This Act shall become effective immediately upon its passage and approval by the Governor, or upon its otherwise becoming a law.

It is our understanding that the foregoing legislation did not pass but that Illinois cavers had some success with amending their Nature Preserves Act and an Act on Recreational Use of Land and Water Areas to include caves.

Indiana

Chapter 4 - Destruction Geological Formations

Section
35-16-4-1. Geological formations in caves - Destruction or injury prohibited - Violation, penalty.

35-16-4-1 {10-4530}. Geological formations in caves — Destruction or injury prohibited — Violation, penalty. Whoever, not having the express consent of the owner thereof, willfully, mischievously or maliciously disfigures, destroys or removes any stalagmitic, stalactitic or other geological formation or any part thereof found in any cave shall be guilty of a misdemeanor and upon conviction shall be fined not less that fifty dollars {$50.00} nor more than five hundred dollars {$500.00} to which may be added imprisonment for not less than ten {10} days or more than six {6} months. {Acts 1947, ch. 161, §1, p. 523} Title of Act. The title of Acts 1947, ch. 161, read: "An act to provide for the protection of geological formations in caves and prescribing penalties." In force August 21, 1947.

Chapter 4 - Destruction of Geological Formations {Repealed effective July 1, 1977.}

Section
35-16-4-1 {10-4530}. Geological formations in caves — Destruction or injury prohibited — Violation, penalty. {Repealed effective July 1, 1977.}

Compiler's Notes. This section (Acts 1947, ch. 161, §1, p. 523), concerning destruction of geological formations, was repealed by Acts 1976, P. L. 148, § 24, effective, July 1, 1977. For saving clause concerning crimes committed prior to that date see not to 35-41-1-1. For law on mischeif see 35-43-1-2.

Kentucky

433.870. Defacing or carrying away formation in cave exhibited to public. Any person who, without permission from the owner, shall destroy, break, tear down, write upon, mar, handle or carry away

any rock, wall, or other formation within any cave exhibited to the public as a natural attraction shall be fined not less than five dollars ($5.00) nor more than one hundred dollars ($100), or imprisoned not less than five (5) nor more than thirty (30) days, or both. (Enact. Acts, 1948, ch. 219).

Cross-references. Criminal mischief, KRS 512.020 to 512.040.

Collateral References. 52 Am. Jur. 2d. Malicious Mischief, §§ 1-11.

Footnote from Stitt: U. S. Constitution, Amendment V, preventing taking of property without just compensation. There is a judicial and legislative trend towards a broader interpretation in the area. In Cox v. Colossal Caverns, 219 Ky. 612, 276S.W. 543, Court of Appeals of Kentucky, 1925, the court found that when cave rights were severed from surface rights a cave owner had a right to preserve a cave, but not to destroy it, since that would affect the surface owner's rights. In the case of endangered species legislation, the right of the state to protect the resource is considered to override individual property rights.

Maryland

HOUSE OF DELEGATES

81r0954 No. 512 (PRE-FILED)

By: Delegate Munson
Requested: September 28, 1977
Introduced and read first time: January 11, 1978
Assigned to: Environmental Matters

Committee report: Favorable with amendments
House action: Adopted
Read second time: March 2, 1978

Chapter 341

AN ACT concerning

Caves

FOR the purpose of setting forth regulations regarding the use of caves; defining certain terms; prohibiting certain actions; allowing for permits under certain circumstances; and providing penalties for certain violations.

BY adding to

Article - Natural Resources
Section 5-1401 through 5-1406, inclusing, to be under the new subtitle "Subtitle 14. Caves"
Annotated Code of Maryland
(1974 Volume and 1977 Supplement)

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, That section(s) of the Annotated Code of Maryland be repealed, amended, or enacted to read as follows:

Article - Natural Resources
SUBTITLE 14. CAVES

5-1401.

(A) IN THIS SUBTITLE, THE FOLLOWING TERMS HAVE THE MEANINGS INDICATED.

(B) "CAVE" MEANS ANY NATURALLY OCCURRING VOID, CAVITY, RECESS, OR SYSTEM OF INTERCONNECTING PASSAGES BENEATH THE SURFACE OF THE EARTH OR WITHIN A CLIFF OR LEDGE,

EXPLANATION: CAPITALS INDICATE MATTER ADDED TO EXISTING LAW. {Brackets} indicate matter deleted from existing law. Underlining indicates amendments to bill. ~~Strike-out~~ indicates matter stricken by amendment.

INCLUDING NATURAL SUBSURFACE WATER AND DRAINAGE SYSTEMS. THE WORD "CAVE" INCLUDES OR IS SYNONYMOUS WITH CAVERN, ~~PIT~~, ~~POTHOLE~~, SINKHOLE, GROTTO AND ROCK SHELTER.

(C) "COMMERCIAL CAVE" MEANS ANY CAVE WITH IMPROVED TRAILS AND LIGHTING UTILIZED BY THE OWNER FOR THE PURPOSE OF EXHIBITION TO THE GENERAL PUBLIC AS A PROFIT OR NONPROFIT ENTERPRISE, WHEREIN A FEE IS COLLECTED FOR ENTRY.

(D) "GATE" MEANS ANY STRUCTURE OR DEVICE LOCATED TO LIMIT OR PROHIBIT ACCESS OR ENTRY TO ANY CAVE.

(E) "PERSON OR PERSONS" MEANS ANY INDIVIDUAL, PARTNERSHIP, FIRM, ASSOCIATION, TRUST, OR CORPORATION.

(F) "SPELEOTHEM" MEANS A NATURAL SECONDARY MINERAL FORMATION OR DEPOSIT OCCURRING IN A CAVE. THIS INCLUDES OR IS SYNONYMOUS WITH STALAGMITES, STALACTITES, HELECTITES, ANTHODITES, GYPSUM FLOWERS, NEEDLES, ANGEL'S HAIR, SODA STRAWS, DRAPERIES, BACON, CAVE PEARLS, POPCORN (CORAL), RIMSTONE DAMS, COLUMNS, PALETTES, FLOWSTONE, ET CETERA. SPELEOTHEMS ARE COMMONLY COMPOSED OF CALCITE, EPSOMITE, GYPSUM, ARAGONITE, CELESTITE AND OTHER SIMILAR MINERALS.

(F) "OWNER" MEANS A PERSON WHO ~~OWNS TITLE TO LAND WHERE A CAVE IS LOCATED, INCLUDING A PERSON WHO OWNS TITLE TO A LEASEHOLD ESTATE IS SUCH LAND~~ HAS THE RIGHT OF ACCESS (OR POSSESSION TO THE CAVE.

(H) "SPELEOGEN" MEANS ~~A SOLUTIONAL FEATURE OF THE BEDROCK, AND INCLUDES OR IS SYNONYMOUS WITH ANASTOMOSES, SCALLOPS, RILLS, FLUTES, SPONGEWORK, AND PENDANTS~~ AN EROSIONAL FEATURE OF THE CAVE BOUNDARY AND INCLUDES OR IS SYNONYMOUS WITH ANASTOMOSES, SCALLOPS, RILLS, FLUTES, SPONGEWORK, AND PENDANTS.

(I) "SINKHOLE" MEANS A NATURAL DEPRESSION IN A LAND SURFACE COMMUNICATING WITH A SUBTERRANEAN PASSAGE OR DRAINAGE SYSTEM.

(J) "CAVE LIFE" MEANS ANY LIFE FORM WHICH NORMALLY OCCURS IN, USES, VISITS, OR INHABITS ANY CAVE OR SUBTERRANEAN WATER SYSTEM, EXCEPTING, HEREIN, THOSE ANIMALS AND SPECIES COVERED BY ANY OF THE GAME LAWS OF THIS STATE.

5-1402
(A) A PERSON MAY NOT, WITHOUT EXPRESS, PRIOR, WRITTEN PERMISSION OF ~~THE~~ AN OWNER, WILLFULLY OR KNOWINGLY:

(1) BREAK, BREAK-OFF, CRACK, CARVE UPON, WRITE, BURN, OR OTHERWISE MARK UPON, REMOVE, OR IN ANY MANNER DESTORY, DISTURB, DEFACE, MAR, OR HARM THE SURFACES OF ANY CAVE OR ANY NATURAL MATERIAL WHICH MAY BE FOUND THEREIN WHETHER ATTACHED OR BROKEN, INCLUDING SPELEOTHEMS ~~AND~~, SPELEOGENS, AND SEDIMENTARY DEPOSITS:

(2) DISTURB OR ALTER IN ANY MANNER THE NATURAL CONDITION OF ANY CAVE:

(3) BREAK, FORCE, TAMPER WITH, OR OTHERWISE DISTURB A LOCK, GATE, DOOR, OR OTHER OBSTRUCTION DESIGNED TO CONTROL OR PREVENT ACCESS TO ANY CAVE, EVEN THOUGH ENTRANCE THERETO MAY NOT BE GAINED; ~~AND~~

(4) HOWEVER, THE ENTERING OR REMAINING IN A CAVE BY ITSELF SHALL NOT CONSTITUTE A VIOLATION OF THIS SECTION.

(5) UNLESS OTHERWISE ESTABLISHED BY THE SECRETARY AND CLEARLY POSTED AT THE CAVE ENTRANCE, CAVES HAVING ACCESS WITHIN THE BOUNDARIES OF PUBLIC PROPERTIES SHALL BE OPEN FOR RECREATIONAL PURPOSES.

~~(4)~~ (B) A PERSON MAY NOT DISPOSE OF, DUMP, STORE, OR OTHERWISE INTRODUCE INTO ANY CAVE, SINKHOLE, OR SUBTERRANEAN DRAINAGE SYSTEM ANY LITTER, REFUSE DEAD ANIMALS, SEWAGE, TRASH, GARBAGE, OR ANY CHEMICAL OR BIOLOGICAL CONTAMINANT WHICH IS POTENTIALLY DANGEROUS TO MAN OR ANY FORM OF CAVE LIFE.

~~(B)~~ (C) ANY PERSON VIOLATING ANY PROVISION OF THIS SECTION IS GUILTY OF A MISDEMEANOR, AND UPON CONVICTION THEREOF, SHALL BE FINED NOT ~~LESS THAN $150 NOR~~ MORE THAN $500, AND IN ADDITION THERETO, MAY BE IMPRISONED FOR NOT LESS THAN TEN DAYS NOR MORE THAN SIX MONTHS.

5-1403.
A PERSON MAY NOT SELL OR OFFER FOR SALE ANY SPELEOTHEMS IN THIS STATE, OR TO EXPORT THEM FOR SALE OUTSIDE THE STATE. A PERSON WHO VIOLATES ANY OF THE PROVISIONS OF THIS SECTION IS GUILTY OF A MISDEMEANOR, AND, UPON CONVICTION, SHALL BE FINED NOT ~~LESS THAN $150 NOR~~ MORE THAN $500 AND IN ADDITION MAY BE IMPRISONED FOR NOT LESS THAN TEN DAYS NOR MORE THAN SIX MONTHS.

5-1404.

(A) A PERSON MAY NOT REMOVE, DISFIGURE, KILL, HARM, DISTURB, KEEP, RESTRAIN, OR IN ANY MANNER ALTER THE NATURAL CONDITION OR ENVIRONMENT OF ~~ANY PLANT OR ANIMAL LIFE WHICH NORMALLY LIVES OR OCCURS WITHIN ANY CAVE OR SUBTERRANEAN WATER SYSTEM~~ ANY CAVE LIFE.

(B) NOTWITHSTANDING THE PROVISION OF SUBSECTION (A) OF THIS SECTION, SCIENTIFIC COLLECTION PERMITS MAY BE OBTAINED FROM THE SECRETARY. ~~GATES EMPLOYED AT THE ENTRANCE OR AT ANY POINT WITHIN ANY CAVE SHALL BE OF OPEN CONSTRUCTION TO ALLOW FREE AND UNIMPEDED PASSAGE OF AIR, INSECTS, BATS, AND AQUATIC FAUNA. A PERSON WHO VIOLATES ANY PROVISION OF THIS SECTION IS GUILTY OF A MISDEMEANOR, AND, UPON CONVICTION THEREOF, SHALL BE FINED NOT LESS THAN $200 NOR MORE THAN $500 AND IN ADDITION THERETO, MAY BE IMPRISONED FOR NOT LESS THAN 15 DAYS NOR MORE THAN SIX MONTHS.~~

(C) GATES EMPLOYED AT THE ENTRANCE OR AT ANY POINT WITHIN ANY CAVE SHALL BE OF OPEN CONSTRUCTION TO ALLOW FREE AND UNIMPEDED PASSAGE OF AIR, WATER, INSECTS, BATS, AND AQUATIC FAUNA.

(D) A PERSON WHO VIOLATES ANY PROVISION OF THIS SECTION IS GUILTY OF A MISDEMEANOR, AND, UPON CONVICTION THEREOF, SHALL BE FINED NOT MORE THAN $500 AND IN ADDITION THERETO MAY BE IMPRISONED FOR NOT LESS THAN 15 DAYS NOR MORE THAN 6 MONTHS.

5-1405
(A) A PERSON MAY NOT EXCAVATE, REMOVE, DESTROY INJURE, DEFACE, OR IN ANY MANNER DISTURB ANY BURIAL GROUNDS, HISTORIC OR PREHISTORIC RUINS, ARCHEOLOGICAL OR PALEONTOLOGICAL SITE OR ANY PART THEREOF, INCLUDING RELICS, INSCRIPTIONS, SALTPETER WORKINGS, FOSSILS, BONES, REMAINS OF HISTORICAL HUMAN ACTIVITY, OR ANY OTHER SUCH FEATURES WHICH MAY BE FOUND IN ANY CAVE, EXCEPT THOSE CAVES OWNED BY THE STATE WHICH ARE SUBJECT TO THE PROVISIONS OF THE ARCHEOLOGICAL RESOURCES ACT OF 1968 (TITLE 2, SUBTITLE 3).

(B) NOTWITHSTANDING THE PROVISIONS OF SUBSECTION (A) OF THIS SECTION, A PERMIT TO EXCAVATE OR REMOVE ARCHEOLOGICAL, PALEONTOLOGICAL, PREHISTORIS, AND HISTORIC FEATURES MAY BE OBTAINED FROM THE SECRETARY. THE PERMIT SHALL BE ISSUED FOR A PERIOD OF TWO YEARS AND MAY BE RENEWED AT EXPIRATION. IT IS NOT TRANSFERABLE BUT THIS DOES NOT PRECLUDE PERSONS FROM WORKING UNDER THE DIRECT SUPERVISION OF THE PERSON HOLDING THE PERMIT.

(C) A PERSON APPLYING FOR A PERMIT SHALL:

(1) HAVE KNOWLEDGE OF ARCHEOLOGY.

~~(1)~~ (2) PROVIDE A DETAILED STATEMENT TO THE SECRETARY GIVING THE REASONS AND OBJECTIVES FOR EXCAVATION OR REMOVAL AND THE BENEFITS EXPECTED TO BE OBTAINED FROM THE CONTEMPLATED WORK.

~~(2)~~ (3) PROVIDE DATA AND RESULTS OF ANY COMPLETED EXCAVATION, STUDY, OR COLLECTION AT THE FIRST OF EACH CALENDAR YEAR.

~~(3)~~ (4) OBTAIN THE PRIOR WRITTEN PERMISSION OF THE SECRETARY IF THE SITE OF THE PROPOSED EXCAVATION IS ON STATE OWNED LANDS AND PRIOR WRITTEN PERMISSION OF THE OWNER IF THE SITE OF THE PROPOSED EXCAVATION IS ON PRIVATELY OWNED LAND.

~~(4)~~ (5) CARRY THE PERMIT WHILE EXERCISING THE PRIVILEGES GRANTED.

(D) A PERSON WHO VIOLATES ANY PROVISION OF SUBSECTION (A) OF THIS SECTION IS GUILTY OF A MISDEMEANOR, AND UPON CONVICTION SHALL BE FINED NOT LESS THAN $100 NOR MORE THAN $500, AND MAY BE IMPRISONED FOR NOT LESS THAN TEN DAYS NOR MORE THAN SIX MONTHS. A PERSON WHO VIOLATES ANY OF THE PROVISIONS OF SUBSECTION (B) OF THIS SECTION IS GUILTY OF A MISDEMEANOR, AND, UPON CONVICTION, SHALL BE FINED NOT LESS THAN $100 NOR MORE THAN $500, AND THE PERMIT SHALL BE REVOKED.

5-1405.
(A) NEITHER THE OWNER OF A CAVE NOR HIS AUTHORIZED AGENTS ACTING WITHIN THE SCOPE OF THEIR AUTHORITY ARE LIABLE FOR INJURIES SUSTAINED BY ANY PERSON USING THE CAVE FOR RECREATIONAL OR SCIENTIFIC PURPOSE IF THE PRIOR CONSENT OF THE OWNER HAS BEEN OBTAINED AND IF NO CHARGE HAS BEEN MADE FOR THE USE OF THE CAVE.

(B) AN OWNER OF A COMMERCIAL CAVE IS NOT LIABLE FOR AN INJURY SUSTAINED BY A SPECTATOR WHO HAS PAID TO VIEW THE CAVE UNLESS THE INJURY IS SUSTAINED AS A RESULT OF THE OWNER'S NEGLIGENCE IN CONNECTION WITH THE PROVIDING AND MAINTAINING OF TRAILS, STAIRS, ELECTRICAL WIRES, OR OTHER MODIFICATION, AND THE NEGLIGENCE IS THE PROXIMATE CAUSE OF THE INJURY.

SECTION 2. AND BE IT FURTHER ENACTED, That this Act shall take effect July 1, 1978.

Missouri

Cave protection laws have twice been introduced but not as of January 1979 passed.

New York

No reference to caves in indexes to statutes but Stitt mentions a proposal (not passed) in 1974 to protect archeological artifacts in caves and include mud formations among speleothems as defined. The Sunday Caver (Adirondack Grotto) in June 1978 reported an amendment to the General Obligations Law to make it cover speleological activities and comments this should mean no more Knox Cave-type cases.

North Dakota

Statute books available only through 1977; no reference to caves.

Ohio

No reference found but Stitt believes there is a cave protection act similar to the early Virginia statute.

Oklahoma

Stitt cites a 1967 law making it a crime to vandalize formations, kill or harm plants or animals (Guano mining and killing predatory animals are exceptions), or litter or pollute caves.

Pennsylvania

Stitt notes a cave protection law proposal in 1973 failed after it had been amended to outlaw fornication and adultery everywhere. Pennsylvania does have a liability exemption for property owners if there is no charge for such use.

South Dakota

Stitt notes a South Dakota law enacted in 1939 making it a misdemeanor to mutilate or remove cave formations or carve initials in a cave.

Tennessee

39-4535. Defacing or injuring material in caves or caverns — Penalty. — It shall be unlawful for any person without the prior permission of the owner, to willfully and knowingly break, break off, crack, carve upon, write or otherwise mark upon, or in any manner destroy, mutilate, injure, deface, mar or harm any natural material found within any cave or cavern, such as stalactites, stalagmites, helictites, anthodites, gypsum flowers or needles, flowstone, draperies, columns or other similar crystalline material formations or otherwise; to kill, harm or disturb plant or refuse therein, or otherwise disturb or alter the natural condition of such cave or cavern; or break, force, tamper with, remove, or otherwise disturb a lock, gate, door or other structure or obstruction designed to prevent entrance to a cave or cavern, without the permission of the owner thereof, whether or not entrance is gained.

Any person violating any provision of this section shall be deemed guilty of a misdemeanor and shall be fined not less than ten dollars ($10.00) nor more than one thousand dollars ($1000.00) for each offense, or shall be punished by imprisonment in the county jail or workhouse for not more than one (1) year or both, in the discretion of the court (Acts 1967, Ch. 199, Sec. 1,2).

Texas

Art. 5415j. Caverns Protection Act

Policy

Section 1. It is hereby declared to be the public policy and in the public interest of the State of Texas to protect and preserve all caves on or under any of the lands in the State of Texas, including tidelands, submerged lands, and the bed of the sea within the jurisdiction of the State of Texas.

Definitions

Section 2. In this Act:

(A) "Cave" means naturally occurring subterranean cavity. The word "cave" includes or is synonymous with cavern, pit, pothole, well, sinkhole, and grotto.

(B) "Gate" means any structure, lock, door, or device located to limit or prohibit access or entry to any cave.

(C) "Person or persons" means any individual, partnership, firm, association, trust, or corporation.

(D) "Speleothem" means a natural mineral formation or deposit occurring in a cave. This includes or is synonymous with stalagmites, stalactites, helicities, anthodites, gypsum flowers, needles angel's hair, soda straws, draperies, bacon, cave pearls, popcorn (coral), rimstone dams, columns, palettes, flowstone, or other similar crystalline mineral formations commonly composed of calcite, epsomite, gypsum, aragonite, celestite, and other similar minerals and formations.

(E) "Owner" means a person who owns title to land where a cave is located, including a person who owns title to a leasehold estate in such land.

Vandalism; penalties

Section 3.

(A) It shall be unlawful for any person, without express, prior written permission of the owner, to willfully or knowingly:

(1) break, break off, crack, carve upon, write, burn, or otherwise mark upon, remove, or in any manner destroy, disturb, deface, mar, or harm the surfaces of any cave or any natural material therein, including speleothems;

(2) disturb or alter in any manner the natural condition of any cave;

(3) break, force, tamper with, or otherwise disturb a lock, gate, door, or other obstruction designed to control or prevent access to any cave, even though entrance thereto may not be gained.

(B) Any person violating a provision of this section shall be guilty of a Class A misdemeanor, unless he has previously been convicted of violating this section, in which case he shall be guilty of a felony of the third degree.

Sale of speleothems unlawful; penalties

Section 4.
(A) It shall be unlawful to sell or offer for sale any speleothems in this state, or to export them for sale outside the state, without written permission from the owner of the cave from which the speleothems were removed.

(B) A person who shall violate any of the provisions of this section shall be guilty of a Class B misdemeanor.

Pollution unlawful; penalties

Section 5.
(A) It shall be unlawful without prior permission of the owner to store, dump, dispose of, or otherwise place in caves any chemicals, dead animals, sewage, trash, garbage, or other refuse.

(B) A person who shall violate any provision of this section shall be guilty of a Class C misdemeanor. A person who shall violate any provision of this section shall, for the second offense, be guilty of a Class A misdemeanor. A person who shall violate any provision of this section shall, for the third or any subsequent offense, be guilty of a felony of the third degree.

Permits for excavations; how obtained; prohibitions; penalties

Section 6.

(A) No person shall excavate, remove, destroy, injure, alter in any significant manner, or deface any part of a cave owned by the State of Texas, unless he first obtains a permit described in Subsection (B) of this section.

(B) The General Land Office of the State of Texas may issue a permit under this subsection if the person seeking the permit furnishes the following information:

(1) a detailed statement giving the reasons and objectives for the excavation, removal, or alteration and the benefits expected to be obtained from the contemplated work;

(2) data and results of any completed excavation;

(3) the prior written permission from the state agency which manages the site of such proposed excavation;

(4) a sworn statement that he will carry the permit while exercising the privileges granted; and

(5) any other reasonable information which the General Land Office may prescribe.

(C) The General Land Office may for good cause revoke any permit issued under Subsection (B) of this section.

(D) A person who shall violate any provision of Subsection (A) of this section shall be guilty of a Class B misdemeanor. A person who violates any of the provisions of Subsection (B) of this section shall be guilty of a Class C misdemeanor and the permit herein authorized shall be revoked.
Acts 1977, 65th Leg., p. 565, ch. 200, eff. May 20, 1977.

Title of Act: An act to be known as the "Texas Caverns Protection Act"; relating to the defacing, damaging, and polluting of caves; the sale of speleothems; excavations; and providing penalties.
Acts 1977, 65th Leg., p. 565, ch. 200.

Library References
Health and Environment (key) 25.5. C.J.S. Health and Environment §§ 61 to 66, 69, 71 to 73, 78 to 80, 82 to 86, 88 to 90, 94, 104, 110, 115 to 126.

Virginia
(original) Enacted 1966

Code of Virginia, No. 18.1-175.1.

(A) It shall be unlawful for any person, without the prior permission of the owner, to willfully or knowingly break, break off, crack, carve upon, write or otherwise mark upon, or in any manner destroy, mutilate, injure, deface, mar or harm any natural material found in any cave or cavern, such as stalactites, stalagmites, helictites, anthodites, gypsum flowers or needles, flowstone, draperies, columns, or other similar crystalline mineral formations or otherwise; to kill, harm or disturb plant or animal life found therein; to discard litter or refuse therein, or otherwise disturb or alter the natural condition of such cave or cavern; or to break, force, tamper with, remove, or otherwise disturb a lock, gate, door or other structure or obstruction designed to prevent entrance to a cave or cavern, without the permission

of the owner thereof, whether or not entrance is gained.

(B) Any violation of this section shall be punished by a fine not exceeding five hundred dollars or confinement in jail not exceeding twelve months in the discretion of the jury or the court trying the case without a jury.

(revised)

Chapter 12.2
Virginia Cave Protection Act

Sec.

§ 10.150.11. Legislative findings and policy. — The General Assembly hereby finds that caves are uncommon geologic phenomena, and that the minerals deposited therein may be rare and occur in unique forms of great beauty which are irreplaceable if destroyed. Also irreplaceable are the archeological resources in caves which are of great scientific and historic value. It is further found that the organisms which live in caves are unusual and of limited numbers; that many are rare and endangered species; and that caves are a natural conduit for groundwater flow and are highly subject to water pollution, thus having far-reaching effects transcending man's property boundaries. It is therefore declared to be the policy of the General Assembly and the intent of this chapter to protect these unique natural and cultural resources. (1971, c. 252.)

§ 10-150.12. Definitions. — As used in this chapter, the following words shall have the meanings stated unless the context requires otherwise:

(A) "Cave" means any naturally occurring void, cavity, recess, or system of interconnecting passages beneath the surface of the earth or within a cliff or ledge including natural subsurface water and drainage systems, but not including any mine, tunnel, aqueduct, or other man-made excavation, which is large enough to permit a person to enter. The word "cave" includes or is synonymous with cavern, sinkhole, natural pit, grotto, and rock shelter.
(B) "Commercial Cave" means any cave utilized by the owner for the purposes of exhibition to the general public as a profit or nonprofit enterprise, wherein a fee is collected for entry.
(C) "Gate" means any structure or device located to limit or prohibit access or entry to any cave.
(D) "Sinkhole" means a closed topographic depression or basin, generally draining underground, including but not restricted to, a doline, uvala, blind valley, or sink.
(E) "Person" or "persons" means any individual, partnership, firm, association, trust, or corporation or other legal entity.
(F) "Owner" means a person who owns title to land where a cave is located, including a person who owns title to a leasehold estate in such land, and specifically including the Commonwealth and any of its agencies, departments, boards, bureaus, commissions, or authorities, as well as counties, municipalities, and other political subdivisions of the Commonwealth.
(G) "Speleothem" means a natural mineral formation or deposit occurring in a cave. This includes or is synonymous with stalagmite, stalactite, helectite, shield, anthodite, gypsum flower and needle, angel's hair, soda straw, drapery, bacon, cave pearl, popcorn (coral), rimstone dam, column, palette, flowstone, et cetera. Speleothems are commonly composed of calcite, epsomite, gypsum, aragonite, celestite, and other similar materials.
(H) "Speleogen" means an erosional feature of the cave boundary and includes or is synonymous with anastomoses, scallops, rills, flutes, spongework, and pendants.
(I) "Material" means all or any part of any archeological, paleontological, biological, or historical item including, but not limited to, any petroglyph, pictograph, basketry, human remains, tool, beads, pottery, projectile point, remains of historical mining activity or any other occupation, found in any cave.
(J) "Cave life" means any life form which normally occurs in, uses, visits, or inhabits any cave or subterranean water system, exception those animals and species covered by any of the game laws of the Commonwealth. (1979, c. 252.)

§ 10-150.14. Pollution unlawful; penalties. —
(A) It shall be unlawful for any person without express, prior written permission of the owner to store, dump, litter, dispose of or otherwise place any refuse, garbage, dead animals, sewage, toxic substances harmful to cave life or humans in any cave or sinkhole. It shall also be unlawful to burn within a cave or sinkhole any material which produces any smoke or gas which is harmful to any naturally occurring organism in any cave.
(B) Any violation of this section shall be punished as a Class 3 misdemeanor.

§ 10-150.15. Biological policy; penalties for violation. —
(A) It shall be unlawful to remove, kill, harm, or otherwise disturb any naturally occurring organisms within any cave, except for safety or health reasons; provided, however, scientific collecting permits may be obtained from any cave commission established for such purpose or from the appropriate State agency.
(B) Any violation of this section shall be punished as a Class 3 misdemeanor.

§ 10-150.16. Archeology; permits for excavation; how obtained; penalties for violation. —
(A) In order to protect the archeological resources not covered by the Virginia Antiquities Act (10-150.1 et seq.), it shall be unlawful to excavate, remove, destroy, injure, deface, or in any manner disturb any burial grounds, historic or prehistoric resources, archeological or

paleontological site or any part thereof, including relics, inscriptions, saltpetre workings, fossils, bones, remains of historical human activity, or any other such features which may be found in any cave, except those caves owned by the Commonwealth or designated as Commonwealth archeological sites or zones, and which are subject to the provisions of the Virginia Antiquities Act. Any violation of this subsection shall be punished as a class 3 misdemeanor.
(B) Notwithstanding the provisions of subsection (A) hereof, a permit to excavate or remove archeological, paleontological, prehistoric, and historic features may be obtained from the Virginia Historic Landmarks Commission. The Commission may issue a permit to conduct field investigations if the Commission finds that it is in the best interest of the Commonwealth, that the applicant meets the criteria of this section and the applicant is an historic, scientific, or educational institution, professional archeologist or amateur, who is qualified and recognized in the areas of field investigations or archeology. Such permit shall be issued for a period of two years and may be renewed upon expiration. Such permit shall not preclude any person from working under the direct supervision of the permittee.
(C) All field investigations, explorations, or recovery operations undertaken under this section shall be carried out under the general supervision of the Commissioner of Archeology of the Virginia Research Center for Archeology and the Virginia Historic Landmarks Commission and in a manner to insure that the maximum amount of historic, scientific, archeologic, and educational information may be recovered and preserved in addition to the physical recovery of objects.
(D) A person applying for a permit pursuant to this section shall:

1. Have knowledge of archeology or history as qualified in subsection (B) hereof.
2. Provide a detailed statement to the Commission giving the reasons and objectives for excavation or removal and the benefits expected to be obtained from the contemplated work.
3. Provide data and results of any completed excavation, study, or collection at the first of each calendar year.
4. Obtain the prior written permission of the owner if the site of the proposed excavation is on privately owned land.
5. Carry the permit while exercising the privileges granted.
6. Any violation of subsection (A) hereof shall be punished as a Class 3 misdemeanor. Any violation of subsection (D) hereof shall be punished as a Class 4 misdemeanor, and the permit shall be revoked.

(E) The provisions of this section shall not apply to any person in any cave located on his own property.

§ 10-150.17. Sale of speleothems unlawful; penalties. —
It shall be unlawful for any person to sell or offer for sale any speleothems in this Commonwealth, or to export them for sale outside the Commonwealth. Any violation of this section shall be punished as a Class 3 misdemeanor.

§ 10-150.18. Liability of owners and agents limited. —
(A) Neither the owner of a cave nor his authorized agents acting within the scope of their authority are liable for injuries sustained by any person using the cave for recreational or scientific purposes if no charge has been made for the use of the cave, notwithstanding that an inquiry as to the experience or expertise of the individual seeking consent may have been made.

Nothing in this section shall be construed to constitute a waiver of the sovereign immunity of the Commonwealth or any of its boards, departments, bureaus, or agencies.

West Virginia

West Virginia Bill - CBD914. HB: 1144. N. 1974

A BILL to amend chapter twenty of the code of West Virginia, one thousand nine hundred thirty-one, as amended, by adding thereto a new article, designated article nine, relating to the protection of caves within the state of West Virginia.
Be it enacted by the Legislature of West Virginia
That chapter twenty of the code of West Virginia, one thousand nine hundred thirty-one, as amended, be amended by adding thereto a new article, designated article nine, to read as follows:

ARTICLE 9. CAVE PROTECTION ACT.

#20-9-1. Definitions.
Unless the context in which used clearly requires a different meaning, as used in this act:
(A) "Cave" means any naturally occurring subterranean cavity. The word "cave" includes or is synonymous with cavern, pit, pothole, well, sinkhole and grotto.
(B) "Commercial cave" means any cave with improved trails and lighting utilized by the owner for the purpose of exhibition to the general public as a profit or nonprofit enterprise, wherein a fee is collected for entry.
(C) "Gate" means any structure or device located to limit or prohibit access or entry to any cave.
(D) "Person or persons" means any individual, partnership, firm, association, trust or corporation.
(E) "Speleothem" means a natural mineral formation or deposit occurring in a cave. This includes or is synonymous with stalagmites, stalactites, helectites, anthodites, gypsum flowers, needles, angle's hair, soda straws, draperies, bacon, cave pearls, popcorn (coral), rimstone dams, columns, palettes, flowstone, et cetera. Speleothems are commonly composed of calcite, epsomite, gypsum, aragonite, celestite and other similar materials.
(F) "Owner" means a person who owns title to land where a cave is located, including a person who owns title to a leasehold estate in such land. (1977, c. 142.)

§ 20-7A-2. Vandalism; penalties.
It is unlawful for any person, without express, prior, written permission of the owner, to willfully or knowingly:
(A) Break, break off, crack, carve upon, write, burn or otherwise mark upon, remove, or in any manner destroy, disturb, deface, mar or harm the surfaces of any cave or any natural material therein, including speleothems;

(B) Disturb or alter in any manner the natural condition of any cave;

(C) Break, force, tamper with or otherwise disturb a lock, gate, door or other obstruction designed to control or prevent access to any cave, even though entrance thereto may not be gained.

Any person violating a provision of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred and fifty dollars nor more than five hundred dollars, and in addition thereto, may be imprisoned in the county jail for not less than ten days nor more than six months. (1977, c. 142.)

§ 20-7A-3. Sale of speleothems unlawful; penalties.

It is unlawful to sell or offer for sale any speleothems in this State, or to export them for sale outside the State. A person who violates any of the provisions of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred fifty dollars nor more than five hundred dollars and in addition thereto, may be imprisoned in the county jail for not less than ten days nor more than six months. (1977, c. 142.)

§ 20-7A-4. Biological policy; penalties for violation.

It is unlawful to remove, kill, harm or disturb any plant or animal life found within any cave: Provided, that scientific collecting permits may be obtained from the director as provided in section fifty {§ 20-2-50}, article two of this chapter. Gates employed at the entrance or at any point within any cave shall be of open construction to allow free and unimpeded passage of air, insects, bats and aquatic fauna. A person who violates any provision of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than two hundred dollars nor more than five hundred dollars and in addition thereto, may be imprisoned in the county jail for not less than fifteen days nor more than six months. (1977, c. 142.)

§ 20-7A-5. Archaeology; permits for excavation; how obtained; prohibitions; penalties.

(A) No person may excavate, remove, destroy, injure or deface any historic or prehistoric ruins, burial grounds, archaeological or paleontological sites including saltpeter workings, relics or inscriptions, fossilized footprints, bones or any other features which may be found in any cave.

(B) Notwithstanding the provisions of subsection (A) of this section, a permit to excavate or remove archaeological, paleontological, prehistoric and historic features may be obtained from the director of natural resources. Such permit shall be issued for a period of two years and may be renewed at expiration. It is not transferable but this does not preclude persons from working under the direct supervision of the person holding the permit.

A person applying for such a permit must:

(1) Provide a detailed statement to the director of natural resources giving the reasons and objectives for excavation or removal and the benefits expected to be obtained from the contemplated work.

(2) Provide data and results of any completed excavation, study or collection at the first of each calendar year.

(3) Obtain the prior written permission of the director of natural resources if the site of the proposed excavation is on state-owned lands and prior written permission of the owner if the site of such proposed excavation is on privately owned land.

(4) Carry the permit while exercising the privileges granted.

A person who violates any provision of subsection (A) of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred dollars nor more than five hundred dollars, and may be imprisoned in the county jail for not less than ten days nor more than six months. A person who violates any of the provisions of subsection (B) of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred dollars nor more than five hundred dollars, and the permit herein authorized shall be revoked. (1977, c. 142).

§ 20-7A-6. Liability of owners and agents.

(A) Neither the owner of a cave nor his authorized agents acting within the scope of their authority are liable for injuries sustained by any person using such features for recreational or scientific purpose if the prior consent of the owner has been obtained and if no charge has been made for the use of such features.

(B) An owner of a commerical cave is not liable for an injury sustained by a spectator who has paid to view the cave, unless such injury is sustained as a result of such owner's negligence in connection with the providing and maintaining of trails, stairs, electrical wires or other modifications, and such negligence is the proximate cause of the injury. (1977, c. 142.)

Jerry Kyle of the Greenbrier WV Grotto comments about one section not in the WV law:

The following is a section which was included in the original bill but was deleted by the legislature. I include it because I personally feel it should be a major section of any law concerning caves.

"It shall be unlawful to store, dump, dispose of or otherwise place in caves or dolines, any chemicals, refuse, dead animals, sewage, trash, garbage or other materials. A person who shall violate any provision of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred dollars. A person who shall violate any provision of this section shall, for the second offense, be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than four hundred dollars. A person who shall violate any provision of this section shall, for the third or any subsequent offense, be guilty of a felony, and, upon conviction thereof, shall be punished by imprisonment in the penitentiary for not less than one year."

Wyoming

Wyoming Statutes 1977

§ 6-10-107. Injuring natural objects or formations.

Whosoever shall willfully and unlawfully deface, break off, cut, carve, print, mark or engrave upon or in any manner injure or deface any natural picturesque formation or stalactite, stalagmite, stalactitic or stalagmitic formation or any wall or interior, of any natural cave, cavern, geyser, or tunnel. Who shall willfully and unlawfully injure, break or destroy any formations of any natural mineral spring, or hot spring, their waters forming and building such formation through precipitation of minerals or chemicals, shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined in any sum of not less than one hundred dollars ($100.00), to which fine may be added imprisonment in the county jail of the proper county of not more than sixty (60) days. (Laws 1909, ch. 141, §1; C.S. 1919, §5865; C. S. 1920, §7154; R.S. 1941 §32-362: C.S. 1945, §9-2005; W.S. 1957, §6-229.)

Effective date. — Section 2, ch. 141, Laws 1909, makes the act effective from and after passage. Approved March 1, 1909.

In addition, Stitt discovered a 1973 statute specifically including caves in the general burglary statute.

Stitt comments:

There is a need for a nationwide coordinated effort to obtain adequate legislation in all states which have significant numbers of caves. The states can be classified as follows:

1. Those states already having an adequate cave protection law (Virginia, Oklahoma, and Tennessee).
2. Those states having a law on the books which is not adequate (Colorado, Wyoming, South Dakota, Indiana and Kentucky).
3. Those states where a law is currently being proposed (Arizona, New York, Alabama, West Virginia, Pennsylvania, Ohio, and Missouri).
4. Those states with no law which have significant caves worthy of protection (18 and Puerto Rico).
5. Those states having no significant caves worth protection (North Dakota, Kansas, Nebraska, and Delaware).

The chances of success in some states with low populations, little organized caving, or few commercial caves are small. Thus there are eight states in addition to those with existing inadequate laws where action should be concentrated for the most effectiveness. These include Arkansas, California, Florida, Georgia, Hawaii, Idaho, Montana, and New Mexico.

Subsequent to the date of the Stitt study, California and Georgia did pass comprehensive cave protection acts.

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	1978	1980
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	1978	1980
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John Fairchild Boyden Cavern Kings Canyon NP, California 93633	+	-
Stephen E. Fairchild Boyden Cavern, Sequoia Natl. Forest Cave City (Cal) Moaning Cavern, Sierra Nevada Rec. Corp. P. O. Box 959 Murphys, California 95247	+	+
Kurt H. Fiegel Archeologist KY Dept. of Transportation Route 8, Cardwell Lane Frankfort, Kentucky 40601	-	+
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Treva L. Gardner 30 Rolla Gardens Rolla, Missouri 65401	-	+
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Andy G. Grubbs UTG AMCS SWT. 1304 Bob Harrison Austin, Texas 78702 or Department of Biology San Marcos, Texas 78666	+	-
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Albert A. Hawkins Mammoth Cave National Park Mammoth Cave, Kentucky 42259	+	-
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Harry Heidemann Natural Bridge Caverns Rt. 3, Box 515 Natural Bridge Caverns, Texas 78218	+	+
Jody Hewston Seasonal Interpreter Lehman Caves Baker, Nevada 89311	-	+
Cato Holler, Jr. N.C.C.S. P. O. Box 100 Old Fort, North Carolina 28762	-	+
Susan Holler P. O. Box 100 Old Fort, North Carolina 28762	-	+
Wayne Holm P. O. Box 788 Cody, Wyoming 82414	+	-
Wayne C. Houtcooper Kentucky Nature Preserves Commission 407 Broadway Frankfort, Kentucky 40601	-	+

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Debbie King Boyden Cavern Kings Canyon NP, California 93633	+	-
Julian J. Lewis Teaching Assistant Department of Biology University of Louisville Louisville, Kentucky 40292	-	+
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Libby Nieland Box 9, St. Helens PS Cougar, Washington 98616	+	-
Peggy B. Nims National Park Service, Mammoth Cave Route 3, Box 15 Cave City, Kentucky 42127	-	+
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Ben Nottingham Great Smoky Mountains National Park Cades Cove Ranger Station Townsent, Tennessee 37882	-	+
Wesley Odel Crystal Onxy Cave Park, Inc. Route 2 Cave City, Kentucky 42127	-	+
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Michel Siffre 34 Rue Trachel Nice - 06000 France	+	-

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Ronald C. Wilson CRF Department of Biology University of Louisville Louisville, Kentucky 40292	-	+
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	1978	1980
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GEOGRAPHIC SUMMARY

	1978	1980		1978	1980
Arizona	4	0	North Carolina	0	3
Arkansas	4	3	North Dakota	1	0
California	10	6	Ohio	1	3
Colorado	2	2	Oregon	4	2
Georgia	0	2	Pennsylvania	0	2
Hawaii	0	1	South Dakota	2	0
Idaho	1	0	Tennessee	0	12
Illinois	1	2	Texas	9	3
Indiana	0	3	Virginia	1	2
Kentucky	4	27	Washington	2	1
Louisiana	0	1	Washington, D. C.	1	1
Maryland	0	1	West Virginia	2	3
Missouri	6	9	Wisconsin	1	0
Montana	1	0	Wyoming	7	1
Nevada	1	2	Canada	3	1
New Mexico	23	5	France	2	0
New York	1	0