PROCEEDINGS OF THE 1984 NATIONAL CAVE MANAGEMENT SYMPOSIUM

MISSOURI SPELEOLOGY

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PROCEEDINGS OF THE 1984 NATIONAL CAVE MANAGEMENT SYMPOSIUM

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INTRODUCTION

For five days in October, 1984, more than 120 individuals gathered to share concepts, ideas, management techniques, and research data at the 1984 National Cave Management Symposium. The theme for the biennial conference was "Cave Research - Illumination for Cave Management, a fitting theme since the conference assembled an excellent cross-section of cave managers, researchers, and others interested in the care, management, promotion, and protection of cave resources.

During two days of presentations, 43 papers were presented in 14 sessions, with topics ranging from cave biology, hydrology, archaeology, and paleontology, to cave management and resource planning. But regardless of the specific title and subject of a paper, during each presentation the underlying message was clear; study, interpret, promote, and manage, but most of all, protect this irreplaceable resource.

During two more days of the Symposium, more than a dozen field trips offered a brief but quality view of the cave and karst resources of the Missouri Ozarks. As with the papers, there was a field trip to fit the interests and needs of each individual. Those interested in doing some strenuous caving had ample opportunity, as did those more interested in seeing Ozark springs and surface karst features enhanced by fall foliage. Several fine commercial caves opened their doors to the symposium participants, encouraging visitors see the results of cave management by private individuals.

Like the days, the evenings were also full, with banquets, interesting and enlightening speakers, and audio-visual entertainment. Symposium participants attending Merlin Tuttle's program likely learned more about bats in 40 minutes than they knew previous. Brother Nicholas Sullivan, speaking on cave management in other countries, increased awareness of problems of cave management world wide.

The 1984 National Cave Management Symposium was a sharing of hopes, ideas, and fears. It brought together concerned individuals from federal and state agencies, private cave owners and managers, members of organized caving groups, and independent cavers; all there to hear, share, and learn. As long as groups like this, with such different backgrounds and specific interests, can assemble for a common concern, then Cave Management Symposiums will continue.

The success of the 1984 National Cave Management Symposium, and subsequently these proceedings, is due to the efforts of many people and groups and all deserve acknowledgment. The sponsors and co-sponsors previously mentioned deserve credit for contributing time, funds, and personnel necessary to organize and host the symposium. Scott Schulte, Chairman of the planning committee, the others listed below gave freely of their time and talent to insure the success of the symposium. Special thanks go to Marilyn Parker for retyping all of the abstracts and papers to place them in a common format and type style. Scott Schulte and David Hoffman proof-read and helped with manuscript layout. Of the 43 presentations given at the symposium, 28 are published in these proceedings. Abstracts are available for several presentations and these are also included. Speakers who did not submit abstracts or papers are also listed in the table of contents, for they certainly deserve recognition for their part in making the 1984 National Cave Management Symposium a success.

Editor

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THE NATIONAL CAVE MANAGEMENT COMMITTEE: A PROPOSAL FOR FORMALIZATION

by George Huppert* and Jer Thornton**

ABSTRACT

The great number of diverse agencies and organizations involved in cave conservation and management results in much duplication of effort and occasional work at conflicting purposes. It is proposed that a national committee be created of interested people from these organizations. The main purpose of the committee will be to encourage and maintain communication between cave managers, researchers, and cavers. This would also insure the continuance of the National Cave Management Symposia, maintain appropriate bibliographies and lists of resource people, and support publication.

INTRODUCTION

The variety of agencies and groups which are interested in cave management and are represented at this National Cave Management Symposium today illustrates the broad base of concern for caves as a natural resource. In consideration of the range of administrative authority represented here, it is apparent that there is a concomitant range of perceptions of the cave environment, its value, and its use. This perception of caves influences the management of caves and their ultimate conservation. The many possible management approaches are not universally applicable to every cave, or to the mandate of every agency, or any single groups reason for existence. However, in pursuing the literature, it quickly becomes obvious that there is much time and money wasted on duplication of effort on the preparation of cave management plans, the design and building of gates, and the implementation of other cave protection activities. There is a crucial need for a national committee to coordinate the efforts to increase efficiency, to avoid redundancy, and to maximize effectiveness.

GOALS OF THE COMMITTEE

The committee would be a non-aligned group whose goal is proper cave management resulting in the conservation of the resource. The major duties of the committee would include the following:

1. The primary role of the committee would be to insure the

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continuation of the National Cave Management Symposium by soliciting and accepting bids for the site of the meeting. The conference would be promoted by providing "seed money" to the designated host agency or group.

The symposium is of great importance to those individuals involved in cave management as a vital vehicle of communication. In some cases, it is the only source of information!

Seed money could be solicited from private donors, sponsoring agencies, and carry over money from previous Symposia. It is important to provide this money as a stimulus to receiving bids to host the meeting. It is an expensive undertaking.

2. The committee will serve as a clearinghouse for cave management, conservation information, and resource people. This action will save considerable time and wasted effort. It will give those contemplating a management program a focus for necessary information.

3. In order to insure dissemination of information the committee would sponsor a series of management training sessions for managers, researchers, students, and cavers. Several sessions have already been scheduled at Salt Lake City, Utah in February and at Elkins, West Virginia in March of 1985.

4. Designing and promoting legislation for the protection of caves and significant karst areas, and providing help to those already involved in such work, would be a major goal of the committee. Only by protective legislation can we hope to get long-term conservation of cave resources.

5. The committee would, of course, encourage research and projects on cave management and conservation. When, and if, funding is available some support should be offered for such work. Support could also be made available for the publication of deserving efforts. These funds would be solicited from speleological societies (CRF, NSS, ACCA, etc.), government agencies, private foundations, corporations, and universities.

6. While not a main goal at this time, the purchase of significant caves and karst areas should be considered if funding would allow it. Financial support might be offered to other conservation groups trying to purchase caves. The caves should be fully researched in order to determine the best management procedures to apply. It is possible that a system similar to that of the Nature Conservancy would work best. In that system the Conservancy turns the area over to a local group for management. Some times the deed is retained and sometimes turned over to the local management group. Occasionally, the deed is purchased by the local group. In any case the cave or karst area would be checked periodically by experts in order to insure proper management.

The above goals are ideals, some are attainable, some may not be possible. All will take some time and hard work to implement. Some of this work has already started.

STRUCTURE OF THE COMMITTEE

The committee would consist of a group of interested individuals representing all agencies and organizations concerned with caves. The committee should also have good geographical representation so that each part of the country could be represented. Hopefully, this would avoid the regional parochialism that can appear within such groups. The committee should meet at the National Cave Management Symposium at least. Perhaps an inexpensive newsletter could be periodically circulated among committee members.

The National Cave Management Committee needs to be formalized now. Hopefully, through its existence and efforts, the successes of the past can be emulated and enhanced, and the mistakes and failures avoided.

NOTE

During the National Cave Management Symposium held in Rolla, Missouri a series of meetings was held with the purpose of discussing and organizing the National Cave Management Committee. While the above goals were not adopted in their entirety, goals 1 and 2 were agreed upon. Rob Stitt was selected to chair the committee.

CAVE CONSERVATION EFFORTS IN ILLINOIS

by K. Andrew West* and James D. Garner**

ABSTRACT

At present there is no cave program, per se, in Illinois. Cave protection and preservation efforts are similar to those utilized to protect any other type of natural area. Efforts are underway to train Illinois Department of Conservation staff in cave ecosystem management techniques. Future plans include efforts to secure passage of cave protection legislation, to increase the number of cave surveys, to step up cave monitoring activities and to increase involvement of members of the private sector in cave management in Illinois.

INTRODUCTION

Illinois is not a major cave state but it does contain some significant cave systems. Many of these systems were recognized as essentially undisturbed natural communities and were designated as natural areas during the comprehensive Illinois Natural Areas Inventory (Ill. Dept. Conserv., 1978).

Although Illinois' major cave and karst area is within the Illinois Ozarks (an extension of the Missouri range, east of the Mississippi River), caves do occur within the limestone areas of northwestern Illinois (Bertz and Harris, 1961). The Ozarks contain the major Illinois caves and all of these caves are privately owned. Illinois' caves have never been comprehensively surveyed although the Caves of Illinois (Bretz and Harris, 1961) did list many of the state's caves. A few Illinois caves have been surveyed and mapped by members of National Speleological Society (NSS) affiliated groups (grottos). The Windy City Grotto of Chicago has surveyed and mapped caves in Monroe County and Jersey County, Illinois although most of this group's activities have been in the states of Missouri, Kentucky and Indiana. Most Illinois grottos use thier "home caves" as training areas or ignore them because they are not "challenging".

Cave ownership patterns in Illinois are typical of those throughout the rest of the eastern United States in that most are privately owned. Of the few publicly-owned caves in Illinois, most are located on Federal land in the Shawnee National Forest. The Illinois Department of Conservation (IDOC) owns three caves.

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CAVE PRESERVATION

Cave preservation in Illinois is one facet of the effort to protect and preserve all types of natural areas in the state. Illinois' natural areas preservation program was among the first in the country. The Nature Preserves Act of 1963 paved the way for a system of dedicated nature preserves. There are presently 126 preserves encompassing approximately 22,000 acres. The 1982 Natural Areas Preservation Act supplanted the Act of 1963 and expanded the powers of the state's Department of Conservation and the Illinois Nature Preserves Commission. The Commission consists of nine members appointed by the Governor and serves as the major policy-making body for the Nature Preserves System.

In 1975, the Department of Conservation contracted with the University of Illinois and the Natural Land Institute (a private, non-profit corporation) for a three year, comprehensive Natural Areas Inventory. This systematic effort to find, evaluate, describe and classify natural areas in Illinois identified over 1000 sites with essentially undisturbed natural areas, critical habitats for endangered and threatened species, outstanding geological features, significant aquatic resources, and areas used for scientific study or education. Thirty-five (35) sites contained caves that were classified as significant features. An additional eight (8) sites contained caves identified as exceptional features (Ill. Dept. Conserv., 1978). Some of these sites were purchased for dedication as nature preserves or were protected by other means. These remaining examples of the original Illinois landscape now comprise less than 0.6 of 1% of the total acreage of the state.

The nature preserves system and natural areas preservation programs are jointly administered by the Illinois Nature Preserves Commission and the Department of Conservation. They are joined by private conservation groups and agencies (notably the Nature Conservancy and Natural Land Institute), to promote and ensure preservation of natural areas. An aggressive management program is underway on the dedicated preserves and other natural areas. Sites owned by the Department are managed by state park, state forest, or other conservation area staff in accordance with guidelines developed by staff biologists and district natural heritage biologists. The natural heritage programs of the Department are administered from within the Division of Forest Resources and Natural Heritage.

Cave preservation efforts in Illinois are presently being channeled in two directions: (1) attempts are underway to bring more caves into public ownership and/or protection and (2) private sector cave owners are being encouraged to take action that will maintain the natural integrity of their holdings. In either case, there are options to be explored and obstacles to overcome.

The largest public cave owner in Illinois is the U.S. Forest Service. Present circumstances preclude dedication of any of these caves as nature preserves. There are, however, federal site designations available under which caves may be protected. Significant natural areas, including caves, can be classified as Research Natural

Areas. Such designation affords site protection that is nearly equivalent to that of a dedicated nature preserve. Areas designated as "minimum level management" sites or as "inclusions" are also protected from disturbance to a greater degree than are those areas managed for heavy public use. The staff of the Shawnee National Forest is currently in the process of writing a Forest Plan and significant natural areas, including caves, have been recommended for special designation by the Department of Conservation, the Nature Preserves Commission and The Nature Conservancy.

At present, the Department of Conservation owns three caves: Burton Cave (Adams Co.), Brainerd Cave (Jersey Co.), and Cave in Rock (Hardin Co.). None of these caves are located in a nature preserve. In order to preserve examples of all ecosystems representative of Illinois' original landscape, various ways to acquire caves are being explored.

Fee simple purchase is the most desirable method but is also the most difficult. Public reaction to the expenditure of state funds to buy a "hole in the ground" is often negative. Last year the Illinois legislature appropriated funds to purchase a cave in southern Illinois but the acquisition was vetoed. That the money was appropriated at all was considered a positive step. Future attempts to purchase caves will require increased efforts to educate the general public about the unique aspects of cave ecosystems.

Since most Illinois caves are privately owned, present management emphasis is on accommodating the private cave owner. Many owners of Illinois' natural areas have been approached by the Nature Preserves Commission or The Nature Conservancy as part of a comprehensive landowner contact program. Owners are informed about the Natural Areas Inventory and are asked to participate in cooperative programs. Short of outright sale of cave properties to a public agency, private cave owners are offered the options of nature preserve dedication, conservation easements, or the Illinois Natural Heritage Landmark dedication.

Many owners do not care for the permanence and/or restrictions that accompany a nature preserve dedication. An owner for whom this poses no problem does secure a tax advantage because land dedicated as a nature preserve is assessed (by law) at a value of one dollar ($1.00) per acre.

Illinois law gives the Department authority to enter into conservation easements or other agreements with private owners. Through grants or sale of an easement, a landowner gives up certain property rights to the Department which can, in turn, manage the resources of a site as if it were state property. Such easements may be for an extended period of time (50 - 100 years). To date, no easements have been installe Conservation easem nts show tremendous potential for protecting portions of cave watersheds by placing restrictions upon land use without removing property from private ownership. Easement purchases can be less costly than fee simple acquisitions. There is a tax advantage for the landowner as property with a restrictive easement is usually assessed at a lower rate than are unrestricted, productive lands.

The Natural Heritage Landmark Program consists of a contract between a landowner and the State of Illinois (represented by the IDOC and Nature Preserves Commission). The owner agrees to register his/her natural area and to protect it. Owners receive a certificate signed by the Governor and a sign designating their property as a Natural Heritage Landmark. The Department provides management assistance, including development of a management plan. A landmark is not a permanent designation; it may be terminated by either party upon 60 days written notice. If the property changes ownership, the landmark becomes void. This program has proven to be valuable in recognizing the owner's conservation ethic, in stimulating their interest in maintaining sites in their natural state, in securing some commitment towards preservation, and in building an attitude of trust between the owners and the state. The Landmark Program can be a means of securing a more permanent preservation commitment from an owner; after the contract has been in effect for several years, the owner may be more likely to dedicate his property as a nature preserve, or to donate, or will it to the state. To date, one cave has been designated as a Natural Heritage Landmark.

In 1983, the Illinois Forestry Development Act was passed, establishing a timber harvest fee to be used for cost-sharing practices in forest management. Qualified owners registering their productive forest lands may receive certification for tax reductions by conforming to recommended forest management practices. To qualify, an owner must have a certified management plan prepared by a competent forester and approved by the IDOC. Caves can conceivably be protected by addressing their protection as part of a comprehensive resource management plan. Although the Forestry Development Act was not specifically written to promote cave preservation, it may be used as a means to protect significant sites within a given private parcel.

Illinois does not have a law that specifically addresses cave protection. there have been a few attempts to pass such legislation but none have succeeded. Cave legislation might fare better if it were introduced as an amendment to the Natural Areas Preservation Act or similar legislation. There is little apparent public awareness of the need for cave protection legislation in Illinois. Current education efforts may increase the likelihood for passage of such a law in the future.

SURVEILLANCE AND MONITORING OF CAVES

Since the Illinois Natural Areas Inventory was completed in 1978, there has been a conscientious effort by the Department to annually inspect the natural areas identified during the Inventory. The character and fate of many of the sites are systematically charted in these annual inspections. However, there has been very little done to inspect or update the status of Inventory caves. Most natural areas are examined during aerial surveys; a cave's watershed may be examined, but there is no way to determine on-site problems within cave systems without entering a cave. Most people within the Department are not cavers. This situation is changing as the number of natural heritage biologists increases and specific training is being offered to allow routine monitoring of caves.

Caving groups can play a key role in maintaining records on the current status of Illinois' caves. A simple, abbreviated form may be submitted routinely by cavers cooperating with the Department, noting any problems observed within the caves (vandalism, pollution, etc.), or even recommending newly discovered or surveyed caves for inclusion into the Natural Areas Inventory.

The Department's Natural Heritage staff, particularly that of the mammalogy program, maintains records of bat populations within Illinois caves. Those caves with endangered gray bats or Indiana bats are surveyed in conjunction with federal agencies (notably the U.S. Fish and Wildlife Service) and the Illinois Endangered Species Protection Board. Summer entrance trapping and winter hibernaculum surveys are the two major means of population monitoring. Coordination with the Illinois Natural History Survey, to establish periodic monitoring of water quality and cave invertebrate fauna, is a goal for the near future.

Before entering into routine surveillance or ecological monitoring, a complete resource inventory must be made of a cave site: mapping of the cave itself, photodocumentation of major (or selected) cave features, qualitative biological inventories, and watershed characteristics. Only then is an agency, such as the Department ready to enter the developing art of cave management.

CAVE MANAGEMENT

Currently, Illinois has an aggressive management program on state-owned and many privately-owned natural areas. Sites are patrolled and inspected for problems, previous disturbances are corrected, exotic plant or animal species are eradicated, populations of significant species are monitored, and undisturbed natural communities are studied and maintained in their pristine states. Illinois is only now entering the field of cave conservation and management. The need for such an effort is recognized but, as in other states, priorities have not allowed a thrust in this direction.

Currently, the Illinois Department of Conservation is only modestly equipped to begin serious cave management. As Illinois embarks upon its effort to protect cave resources, the management staff will be trained to deal with problems peculiar to cave ecosystems. During the early stages, cooperation with caving groups will be very important. Cavers will be encouraged to lend their experience and enthusiasm to this effort.

Management and protection of Illinois' caves in the future will entail the development of a multi-faceted approach to cave conservation. A system for routine surveillance of caves, inspections for disturbances and potential threats can be coordinated between the Department and caving groups. Long-term ecosystem monitoring will be established, with researchers, cavers, and IDOC biologists cooperating using standardized methods for ecological monitoring. Special features, geological as well as biological, can be protected through regulation of public use and land use within a cave's watershed. Public use is a major issue in cave management. Any use must be compatible with the cave resource. Some caves must be seasonally closed during times when certain bat species use the cave as a hibernaculum. Restoration of vandalized caves will be undertaken so long as such work does not distract from management activities in significant or undamaged cave systems. Volunteers may be valuable for cleanup or restoration work within vandalized caves.

CONCLUSION

Efforts to preserve and protect caves in Illinois are just beginning but the foundation for a progressive cave conservation program is in place: a commitment to the preservation of natural areas, a professional staff and an established natural heritage program is in place, and a system for protecting significant sites is operative.

BIBLIOGRAPHY

Bertz, J H. and S. E. Harris, Jr., 1961, Caves of Illinois: Illinois State Geological Survey Report of Investigations 215, 87p.

Illinois Department of Conservation, 1978, Illinois Natural Areas Inventory, Technical Report: Springfield, IL, 426p.

THE FEDERAL CAVE RESOURCES PROTECTION ACT

by Jer Thornton*

ABSTRACT

The National Speleological Society has developed a "Federal Caves Resources Protection Act" directed at filling in the statutory holes which face Federal land managing agencies and cave conservationists, alike. Sent out for comments in earlier 1984, the final draft has been completed and efforts seeking its introduction and passage are presently underway.

This paper deals with the key elements of the proposed legislation and its current status.

THE FEDERAL CAVES RESOURCES PROTECTION ACT

The Federal Cave Resources Protection Act is a proposed bill intended to provide long needed statutory protection for Federally-owned wild caves, their contents and natural systems, by insuring that caves be considered in all land use decisions by Federal land managers; by providing land managers with statutory tools necessary to both cost effective and sound management, and by providing prohibited acts and penalties for those who would damage or destroy these resources. It is important that you keep in mind that this bill will affect only caves on Federal lands, and calls for gates and closures only in the case of very sensitive or fragile cave resources of ecosystems.

The reason for this is the Society's strong belief in the need to protect the sanctity of state and private land owner rights, and that the public domain should remain free of unnecessary restrictions for responsible land users.

IS THERE A NEED FOR THIS LAW?

Of course there is. It has been pointed out that there are several state and Federal laws which might be brought into play to protect caves. That's true. The Antiquities and Paleontology Acts will afford a certain amount of protection to those caves which are bona fide paleontological or cultural sites. But what about the rest? Well, the Rare, Endangered and Threatened Species laws will protect a cave if it is a critical habitat for listed life forms. But what about the creatures which are not listed or have yet to be discovered? Yes, there are laws which cover vandalism, littering, pollution and trespass---but remember government is unable to stop even highway

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littering. It's almost impossible to detect misuse of underground resources, and even tougher to prevent it.

Unlike picnic tables and trees in a park which can be either repaired, replaced or replanted, damaged cave resources---speleothems, speleogens, and fragile ecosystems, once destroyed, are lost---forever. Cave management poses some extremely unusual and tough problems and must, of necessity, resort to some extremely unusual solutions. KEEP IN MIND---CAVES ARE A FRAGILE AND COMPLETELY NONRENEWABLE RESOURCE!

SPECIFICALLY, WHAT ARE SOME OF THOSE PROBLEMS?

The Freedom of Information Act:

Often isolated, caves on the Federal domain are difficult to protect. Once entrance locations become well-known, preventing the destruction of this resource becomes even tougher. If an agency is aware of a cave's existence, it cannot legally refuse to provide information about that cave, including its location, to the public. For the Federal land manager who wants to provide sound management for these resources, the Freedom of Information Act stands like a brick wall, blocking his option to employ one of our most effective cave management tools---information restriction. Even gates, which are costly to install and maintain, are usually ineffective once a location becomes public knowledge.

For a Federal land manager this is a multi-faceted problem. In order to effectively consider all resources in land-use planning, requires that he know about those resources. The caving community, having compiled extensive wild cave records over several decades, usually refuses to provide Uncle Sam with this information except in a crises situation. Years of experience and hundreds of cases where volunteering location information has led to the destruction of caves, this reluctance by cavers to share information creates a serious Catch-22 situation.

It means that agencies usually become involved in protective cave management only after a conflict or threat emerges. Rather than being aware of the resource and able to anticipate and plan for problems, they are almost always faced with crises management. It also means that in order to obtain a complete cave resource inventory, they must (and often will) hire someone to "hunt" the same caves which the caving community has already located. Extremely costly, this undertaking cannot possibly be done properly in a reasonable amount of time.

Federal managers need the information. By allowing the exemption of information on sensitive caves, not only can these fragile resources be better protected, but the caving community will be more likely to open their personal files, saving hundreds of thousands of dollars that would otherwise be needed to "hire" someone to try and compile cave inventory.

THE MINING ACTS

Speleothems, the stalactites, stalagmites and other unique mineral forms found in caves, are currently classified as "curiosities" by the Bureau of Land Management and not subject to mineral claims. This is based on a 19th Century court case and an Interior Department decision. This status has remained unchallenged for nearly 100 years. However, geodes were also considered "curiosities" until last year when the Interior Department reversed this position. Even common rock, such as basalt or "lava" has recently been reclassified and is now subject to mining claim as a leasable commodity. These recent interpretative reversals have made it quite clear that money is now the most important criteria in determining the legal status of natural resources under the mining acts.

These decisions were based primarily on the fact that those seeking claims were able to show the possibility of making a profit. This means that, in spite of a single 19th Century case action, speleothems could become a minable commodity--like gravel.

Guano has been mined from caves for centuries for use in the manufacture of gunpowder and as a fertilizer. Under the present laws, guano mining is an activity which is tightly regulated when the site is also a known cultural or paleontological site. This regulation does not, however, apply to other caves. While there is no reason to halt the commercial extraction of guano, all caves should be inventoried and mining activities in sensitive caves restricted or closely monitored to ensure that the other values of caves are protected.

Other mining activities include the quarrying of limestone for the manufacture of concrete and oil leasing and exploration. These activities are not, if adequate measures are taken to protect the caves resources, incompatible with protective cave management. However, there is no specific statutory requirement to consider caves and in relationship to mining.

State and other Laws:

Of those states which have cave protection laws, in units of the National Park System, in specially designated management areas, or when covered by Federal Acts pertaining to antiquities, paleontological or rare, threatened or endangered species, caves can be afforded reasonable protection. However, most state laws are not totally effective. For instance, although Idaho, New Mexico and several other states have laws which make killing or disturbing cave life illegal without the permission of the land owner, the Federal government usually has no legal recourse except to grant permission.

Funding:

As you know, there is little or no extra money for new programs in increasingly tight Federal budgets. Lacking the expertise, the manpower and the funding to properly manage caves, our government cannot properly address the problems of cave management. Even the fees which are now collected for special management use permits and money collected as civil penalties for damage to wildlands resources are not available to the agency which collects them. This money is not used to restore damage or for management but goes into the general fund and is usually never seen again by the agency.

Many critical restoration projects, made necessary by misuse, cannot be funded--even though civil penalties, equivalent to the cost of damage may have been assessed and paid by the violator.

WHAT WILL THE FEDERAL CAVE RESOURCES PROTECTION ACT DO AND HOW WILL IT HELP?

Most importantly, the legislation will clear up several grey areas, providing caves with a legal status, eliminating inconsistent and arbitrary interpretations regarding where this unique natural resource fits into existing laws. Allowing for the flexibility needed to cope with specific local problems, it will also compliment national-level cave management policies like those recently implemented by the BLM and soon to be developed by the Forest Service.

Prohibited Acts and Penalties:

The proposed FCRPA prohibits acts which would damage, threaten or endanger cave resources and imposes both criminal and civil penalties for violations. A few people have expressed concern that these might be considered unusually severe. Again, please remember that this valuable resource is extremely fragile and totally nonrenewable. It's extremely difficult to detect and catch those in the act of destroying it, more so in fact, than catching the burglar who operates at night. Even litter removal can be a major undertaking in a cave. While using sinkholes and entrances as a dumping ground for garbage, animal carcasses, insecticides and other chemicals might also be considered "just littering", the affect of this type of pollution on a karst aquifer can create some extreme dangerous health hazards. In light of these factors, perhaps even stiffer penalties might be justified.

Exempting Sensitive Cave Locations From the Freedom of Information Act:

The most important element of this legislation will be to allow Federal agencies to withhold sensitive cave location information from the public. There are a number of people who feel that allowing the Federal government to withhold this information is a threat to scientific knowledge or research and the publication of that information. However, this is exactly the same way in which protection for sensitive archeological and paleontological sites is enhanced.

The exclusion of these site locations from the Freedom of Information Act has neither inhibited research nor encumbered the publication of scientific papers. It has, however, helped prevent unregulated use and destruction so that the sites are left both intact and undisturbed for meaningful investigation.

Without this exemption, the Federal Cave Resources Protection Act would be extremely difficult to administer. Not only would the effectiveness of the rest of this legislation be reduced, but the support of the caving community would be diminished.

Cooperative and Volunteer Management:

This bill calls specifically for the land manager to open communications and to work closely with the caving community, both in establishing local management directions and policies and in the actual administration of programs through the use of cooperative management agreements and volunteer contracts. This will allow the Federal government to place a major share of the burden of responsibility for the management of cave resources squarely upon the shoulders of the caving community, greatly reducing the need for additional budget appropriations or the diversion of limited manpower from other duties. The savings, in terms of things like inventory of cave resources, required under the Federal Land Policy and Management Act, would be immense.

Funding:

In order to further reduce the need for additional budget appropriations, this act includes a clause directing that recreational fees collected in conjunction with all special land use permits, and any civil penalties moneys collected for violations of the act, be returned to that agency to be used in the administration of those programs and for restoration of damaged resources.

Liability:

The legislation also contains an exemption for the Federal Government from liability for incidents arising out of recreational use of all public wild lands except when the agency is an invitee. This should also lead to a reduction in taxpayer money being wasted on legal fees and for settlements paid by the government for suits arising from recreational land user injury and death caused by Acts of God or natural hazards.

Management Planning:

Requiring that cave resources be considered in all land use planning decisions, the Act also allows for all parties involved, including the caving community, to be involved in the planning process.

Mining:

FCRPA will have little affect on existing mineral and energy activities. It would require that cave resources be considered in relationship to the impact of those activities. It would also allow for the removal of nuisance claims and the withdrawal of extremely sensitive caves and immediately adjacent areas, from mineral development. Finally, it statutorily exempts speleothems from mining.

Cave Fauna and Habitat:

Calling for the protection of all life forms found in a cave, this bill would also ensure the protection of caves which provide the habitat for those creatures.

Cultural and Paleontological Resources:

While there are already a number of laws covering cultural and paleontological resources on Federal lands, this legislation would increase that protection by providing another blanket of coverage. Not only are these resources mentioned specifically in the Prohibited Acts and Penalties section, but they are also given increased protection through the establishment of criteria for permitted removal activities.

HOW WILL THE FCRPA TIE IN WITH EXISTING PROGRAMS?

Because of the continuing decrease in Federal budgets, including those for the land and wildlife management agencies, the emphasis on volunteer participating in the development, implementation and administration of resource management programs is becoming critical. The organized caving community has been heavily involved in a number of Federal cave management programs for decades. The Cave Research Foundation has been handling the study and inventory of caves like Mammoth and Carlsbad for nearly two decades. Grottos, chapters of the National Speleological Society, have been actively cooperating in volunteer management programs on Federal lands throughout the United States for more than 30 years. These activities have included inventory, mapping, research, management plan development, gate design and construction and even administration.

Just this year, the National Speleological Society's Conservation Committee worked with the Bureau of Land Management to develop and implement the first national cave management policy. This also resulted in the signing of national Memorandums of Understanding between the BLM and both the Society and the Cave Research Foundation.

The Forest Service is presently working with the NSS, at the encouragement of the Society to develop similar national level policies and agreements.

The final major undertaking by the caving community, and perhaps the most important of all, is "Project We'll Help!". Due to a serious lack of personnel trained in cave management and the need for a large pool of trained volunteers, the Richmond Area Speleological Society (RASS) is sponsoring and funding the development and presentation of two national cave management training seminars in 1985. These seminars, open to anyone involved or interested in cave management, will be used to create the nation's first college level course in this field through the University of Missouri.

In addition to the RASS, the project's sponsor, and the University of Missouri's School of Forestry, Fisheries and Wildlife in Columbia, participants include representatives from the National Speleological Society, Cave Research Foundation, American Cave Conservation Association, National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Missouri Department of Natural Resources and the British Columbia (Canada) Provincial Parks.

PRESENT STATUS AND ACTIVITIES

Although a number of Federal legislators have expressed an interest in the FCRPA and Congressman Larry Craig of Idaho has said that he would probably sponsor the bill, we have yet to receive a firm commitment from anyone to introduce FCRPA in either the House or Senate.

At the present the Society is working for an introduction early in the first session in 1985. In order to build support for the proposed law, the Society is presently involved in a multifaceted campaign. In addition to conducting a letter writing campaign within the membership, support is being sought from other conservation organizations, including chapters of the National Wildlife Federation, National Audubon Society, Sierra Club and The Wilderness Society. This is being done by making presentations at state and local level chapter meetings and by direct contact at the national levels of these organizations. Other potential supporters are being contacted through a direct mail campaign.

CAVE RESOURCES PROTECTION ACT OF 1984

AN ACT [Working draft 10-4-84]
[lacking amenders]

To protect caves resources on public lands and Indian lands, and for other purposes.

SHORT TITLE

Section 1. This Act may be cited as the "Cave Resources Protection Act of 1985".

Section 2. (a) The Congress finds and declares that---

(1) caverns or cave resources on public lands and Indian lands are an invaluable and irreplaceable part of the

Nation's natural heritage;

(2) these resources are increasingly becoming endangered because of urban spread, increases in mobility and leisure time of recreationists, improper use, a lack of specific statutory protection, little or no supervision of use, and the lack of resources for administering agencies to properly manage cave resources;

(3) existing Federal laws do not provide adequate or comprehensive protection to prevent the loss or destruction of caves and their associated resources from acts of theft, vandalism or destruction; and

(b) the purpose of this Act is to secure, protect and preserve cave resources on public lands and Indian lands for the future use, enjoyment and benefit of all people, and to foster increased cooperation and exchange of information between governmental authorities and those who utilize cave resources for scientific, educational or recreational purposes.

DEFINITIONS

Section 3. As used in this Act---

(a) the term "cave resource" means a cave on public lands or Indian lands as herein defined together with associated topographic and hydrological features.

(b) the term "cave" or "cavern" means any naturally occurring void, cavity, recess or system of interconnected passages which occurs 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, and which is large enough to permit a person to enter, whether or not the entrance is naturally formed or man-made. The words "cave" or "caverns" shall include any natural pit, sinkhole or other feature which is an extension of the entrance.

(c) The term "natural resource" means any material occurring naturally in caves including, but not limited to, animal life, whether vertebrate or invertebrate; plant life; paleontological deposits; sediments; minerals; speleogens; speleothems; water and other natural resources.

(d) the term "cultural resource" means any historic or prehistoric human remains, artifacts, constructions or evidence thereof.

(e) The term "speleothem" means any natural mineral formation or deposit occurring in a cave. This includes, but is not limited to: stalactites, stalagmites, helectites, gypsum flowers, soda straws, lavacicles, anthodites, flowstone, tufa dams, clay or mud formations, concretions, draperies, rimstone dams, etc. Speleothems can be composed of calcite, gypsum, aragonite, celestite, silica, mud, basalt, or other similar materials or minerals.

(f) the term "speleogen" means the surrounding natural material or bedrock in which the cave is formed, including the walls, floors and ceiling and similar related structural and geological components.

(g) the term "Federal Land Manager" means, with respect to any public lands, the Secretary of the department, or the head of any other agency or instrumentality of the United States, having primary management authority over such lands.

(h) the term "public lands" means lands or mineral rights which are owned and administered by the United States, other than lands on the outer continental shelf and lands which are under the jurisdiction of the Smithsonian Institute.

(i) the term "Indian lands" means lands of Indian tribes or Indian individuals which are either held in trust by the United States or subject to a restriction against alienation imposed by the United States.

(j) the term "individual" means a person, corporation, partnership, trust, institution, association, or any officer, employee, agent, department, or instrumentality of the United States, or any Indian tribe, or of any State or political subdivision, thereof.

SPECIAL MANAGEMENT ACTIONS

Section 4. (a) Federal land managers may take special actions as necessary, consistent with the purposes of this Act, including but not limited to---

(1) Employment of cave resources management personnel;

(2) Appointment of volunteer cave management and admini-

strative personnel;

(3) Regulation and restriction of use of cave resources;

(4) Entering into volunteer management agreements with individual persons, members and associations of the caving community;

(5) Removal of nuisance mineral claims; and

(6) Withdrawal of cave resources from mineral claims, exploration and development.

(b) The Federal land manager may also appoint an advisory commission of professional cave managers, individual persons, and members of caving associations and the scientific community for the purpose of developing regulations pursuant to this Act, reviewing management plans for cave resources located on public lands or Indian lands, or to otherwise provide advice and assistance as deemed necessary in furthering the purposes of this Act.

(c) Federal land managers shall take such actions as may be necessary, consistent with the purposes of this Act, to

(1) ensure that cave resources on public lands and Indian lands are considered in land use policy decisions;

(1) foster and improve the communication, cooperation and exchange of information between Federal authorities responsible for the protection of cave resources on public lands and Indians lands and professional cave managers; and members and associations of the scientific and recreational caving community;

(2) encourage, support and assist volunteer groups and persons interested in providing assistance and expertise in managing cave resources on public lands or Indian lands.

CONFIDENTIALITY

Section 5. Informaton concerning the location of any cave or cave resource located on public lands or Indian lands may not be made available to the public under Subchapter II or chapter 5 of title 5 of the United States Code or unless the Federal land manager concerned determines that such disclosure would---

(1) further the purposes of this Act; and

(2) not create a risk of harm to such cave resources or to the lands located above such resources.

LIABILITY

Section 6. The Federal land manager and his agents shall not be liable for injuries, mental harm or death sustained by and person using public or Indian lands, including, but not limited to cave resources, for recreational, educational or scientific purposes. By granting permission for entry or use, the Federal land manager and his agents do not thereby

(a) extend any assurance that the premises are safe for such purposes, or

(b) constitute to the permittee 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 or ommission of a permittee except as provided in this section.

This Act shall not limit the liability which otherwise exists for (1) willful or malicious failure to guard or warn against a dangerous condition, use or natural structure; or (2) failure to guard or warn against a dangerous manmade structure, fixture or activity; or (3) for injury suffered in any case where permission to enter for the above purposes was granted for a consideration.

Nothing in this section creates a duty of care or ground of liability for injury to person or property.

COLLECTION AND REMOVAL

Section 7. (a) Except for caves within any unit of the National Park System, any person may apply to the Federal land manager for a permit to collect or removal any natural or cultural resource from caves located on public lands or Indian lands and to carry out activities associated with such collection or removal. The application shall be required, under uniform regulations under this Act, to contain such information as the Federal land manager deems necessary, including information concerning the time, scope, location and specific purpose of the proposed work.

A bond or money deposit shall accompany the application in an amount sufficient to (1) insure compliance with this Act or regulations thereunder; and (2) to offset any potential damage sustained by the cave resource as a result of the activities of the permittee.

(b) A permit may be issued pursuant to an application under subsection (a) if the Federal land manager determines, pursuant to uniform regulations under this Act, that---

(1) the collection or removal of specified resources is essential for conducting bonafide research projects, substantiated by an approved research proposal;

(2) the study will contribute to better understanding of cave resources or other natural resources and environments and their use by people and will not interfer with other public uses nor having a lasting or significant impact on the cave resources;

(3) the applicant is qualified to carry out the permitted activity;

(4) the natural or cultural resources which are excavated or removed from public lands or Indian lands will remain the property of the United States, and are not intended to be used primarily for the development of general study collections; and

(5) the activity pursuant to such permit is not inconsistent with any management plan applicable to the cave or public lands concerned.

(c) Any permit issued under this section shall contain such terms and conditions, pursuant to uniform regulations promulgated under this Act, as the Federal land manager concerned deems necessary to carry out the purposes of this Act.

(d) Each permit under this section shall identify the individual who shall be responsible for carrying out the terms and conditions of the permit and for otherwise complying with this Act and other laws applicable to the permitted activity.

(e) Any permit issued under this section shall be revoked by the Federal land manager upon their determination that the permittee has violated any provision of subsection (a) or (b) of Section 5, or has failed to comply with any other condition upon which the permit was issued. Any such permit shall be revoked by such Federal land manager upon assessment of a civil penalty under Section 6 against the permittee or upon the permittee's conviction under Section 5. Permits issued under this Act are not transferable.

[NEW] (f) Collection or removal of natural or cultural material from caves within units of the National Park System shall be carried out in accordance with existing statutes and regulations governing lands administered as part of the National Park system.

PROHIBITED ACTS AND CRIMINAL PENALTIES

Section 8. (a) No person shall break, break-off, carve upon, write, burn, mark upon, crack, remove, displace, or in any manner destroy, disturb, deface, mar, alter or harm any cave resources located on public lands or

Indian lands or any natural or cultural resources therein, nor shall a person enter with the intention of commiting of any of the above acts unless such activity is conducted pursuant to a permit issued under Section 4 or is exempted under Section 11.

(b) No person shall kill, injure, disturb, or otherwise interfer with any cave life, including any cave roosting bat, nor interfer or obstruct the free movement of any cave resource into or out of any cave located on public lands or Indian lands, nor enter any cave on public lands or Indian lands with the intention of killing, injuring, disturbing or interfering with life forms therein, unless such activity is conducted pursuant to a permit issued under Section 4 or is exempted under Section 11.

(c) No person may collect or remove any natural or cultural resources found within any cave on public lands or Indian lands except pursuant to a valid permit issued under Section 4 or as exempted under Section 11.

(d) No person shall possess, consume, sell, barter or exchange, or offer for sale, barter or exchange, any natural or cultural resource removed from any cave on public lands or Indian lands except pursuant to to a valid permit issued under Section 4 or exempted under Section 11.

(e) It shall be unlawful for any person to dispose of or leave any waste, garbage, refuse, food, fuel or other material whether solid, liquid, or gas within any cave on public lands or Indian lands or within any surface or underground features related to the cave resource, including, but not limited to sinkholes, or streams. This section shall specifically exempt acetylene gas emissions created by carbide lamps used as a source of light by persons using caves or caverns located on public lands or Indian lands.

(f) Anyone who should 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 permission of the Federal land manager thereof, shall be in violation of this Act, whether or not entrance is gained.

(g) Any person who knowingly violates, or counsels, procures, solicits or employs any other person to violate, any prohibition contained in this section shall, upon conviction, be fined not more than $10,000 or imprisoned not more than one year or both. In the case of a second or subsequent such violation, upon conviction such person shall be fined not more than $20,000 or imprisoned not more than three years, or both.

(h) The prohibitions contained in this section shall take effect upon the effective date of this Act.

CIVIL PENALTIES

Section 9. (a) (1) Any person who violates any prohibition contained in this Act or in any regulation promulgated pursuant to this Act, or in any permit issued under this Act may be assessed a civil penalty by the Federal land manager concerned. No penalty may be assessed under this section unless such person is given notice and opportunity for a hearing with respect to such violation. Each violation shall be a separate offense, even if such violations occurred at the same time.

(2) The amount of such penalty shall be determined under regulations promulgated pursuant to this Act, taking into account, in addition to other factors---

(i) the relative scientific, scenic or commercial value of the cave resource involved, and

(ii) the cost of restoration, repair, and mitigation of the resource or gates involved.

Such regulations shall provide that, in the case of a second or subsequent violation by any person, the amount of such penalty may be triple the first amount which would have been assessed if such violation were the first violation by such person. The amount of any penalty assessed under this subsection for any violation shall not exceed an amount equal to triple the cost of restoration and repair of natural and cultural resources damaged and triple the fair market value of resources destroyed, damaged or not recovered.

(b) (1) Any person aggrieved by an order assessing a civil penalty under subsection (a) may file a petition for judicial review of such order with the United States District Court for the District of Columbia or for the district in which the violation took place. Such a petition may only be filed within the 30-day period beginning on the date the order making such assessment was issued. The court shall hear such action on the record made before the Federal land manager and shall sustain his action if it is supported by substantial evidence on the record considered as a whole.

(2) If any person fails to pay an assessment of a civil penalty--

(i) after the order making the assessment has become a final order and such person has not filed a petition for judicial review of the order in accordance with paragraph (1), or

(ii) after a court in an action brought under paragraph (1) has entered a final judgement upholding the assessment of a civil penalty, the Federal land managers may request the Attorney General to institute a civil action in a district court of the United States for any district in which such person is found, resides, or transacts business to collect the penalty and such court shall have jurisdicition to hear and decide any such action. In such action, the validity and amount of such penalty shall not be subject to review.

(iii) Hearings held during proceedings for the assessment of civil penalties authorized by subsection (a) shall be conducted in accordance with section 554 of title 5 of the United States Code. The Federal land manager may issue subpoenas for the attendance and testimony of witnesses, the production of relevant doocuments and may administer oaths. Witnesses summoned shall be paid the same fees and mileage that are paid to witness in the courts of the United States. In case of contumacy or refusal to obey a subpoena served upon any person pursuant to this paragraph, the district court of the United States for any district in which such person is found or resides or transacts business, upon application by the United States and after notice to such person, shall have jurisdiction to issue an order requiring such person to appear and give testimony before the Federal land manager or to appear and produce documents before the Federal land manager, or both, and any failure to obey such order of the court may be punished by such court as a contempt thereof.

FUNDING

Section 10. (a) In addition to any monies appropriated by Congress for the purpose of furthering the purposes of this act,

(1) any monies collected by the United States as permit fees for use of cave resources shall be expended for the improved management and benefit of cave resources;

(2) any monies received by the United States as a result of the forfeiture of a bond or other security by a permittee who does not comply with the requirements of his permit; and

(3) any monies collected by the United States by way of civil penalties or criminal fines for violations of this Act shall be expended for the repair, restoration, improved management and benefit of the particular cave resource so affected or damaged.

(b) 43 U.S.C.A. annotated, Section 17-36 shall be amended to add the following subsection D:

D. This section shall not apply to the Cave Resources Protection Act of 1985.

SAVING PROVISIONS

Section 11. (b) Nothing in this Act shall be construed to affect any other than public land or Indian land or to affect the lawful recovery, collection, or sale of natural resources from land other than public land or Indian land.

(c) The provisions of this Act shall be considered severable and any determination of invalidity of any provision of this Act shall not impair the operation or effect of the remaining provisions.

THE MISSOURI CAVE CATALOG: A CATALYST FOR DISCOVERY, A TOOL FOR MANAGEMENT, AND AN INCENTIVE FOR CAVE CONSERVATION

by Jerry D. Vineyard* and Tami L. Martin**

ABSTRACT

The first computerized cave inventory in Missouri was developed on an IBM 360/45 computer, and was published in 1968 as the fifth in a series of Catalogs of the Caves of Missouri, listing 2,250 caves. The Catalog was updated in 1973, using new programming. The data was printed by the computer on multilith masters, which were then run on an offset printing machine to produce printed copies of the Catalog. In 1978, the Missouri Speleological Survey began issuing Catalogs as actual computer printouts, bound with preprinted introductory pages in order to give up-to-the-minute data rather than multi-year revisions. The most recent printout lists 4,513 caves in 78 counties, processed through IBM PCs, networked with a mainframe IBM 3033 computer, where the data base is stored. Numerous programs are utilized to query the data base for generation of cave lists to satisfy diverse informational needs. County lists, long caves, caves of the same name, location plots, mapped caves, and a plethora of other products can be generated. The availability of cave inventory information has been invaluable in guiding exploration and survey activities throughout Missouri, as well as being a catalytic factor in bringing speleology into environmental decision-making. Having an accessible inventory has spurred the discovery and reporting of new caves. Since cave inventory work began in Missouri about 1952, new caves have been reported and added to the data base at an average rate of 135 caves per year. Curiously, this discovery rate has shown little fluctuation, and it is currently stable.

INTRODUCTION

The Missouri Cave Catalog provides cave locations, certainly, but it is also an effective tool in cave management. It is the key to "mining" a much larger data base, yielding information that is used in cave science applications, making management decisions, classification of caves, and in many other ways. The first statewide catalog was issued as a mimeographed publication of the Missouri Geological Survey and Water Resources in 1952. Since then, numerous editions have been

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produced, some by the State agency, others by Missouri Speleological Survey, Inc. (a private, not-for-profit organization). The current version is a computer printout maintained and produced through the Missouri Geological Survey, a program of the Department of Natural Resources' Division of Geology and Land Survey. Distribution of the Catalog is limited through a cooperative arrangement with the Speleological Survey.

As a computerized listing, the Catalog is continually being updated. The current (09-10-84) version carries locations of 4,513 caves in 76 counties, and shows 1,841 mapped caves. However, not all caves shown as "mapped" in the Catalog are reposited in the cave files; a companion catalog listing cave maps currently in the cave files includes 1,712 maps, all of which have been microfilmed for security and are reproducible at more than one scale.

HISTORY OF THE MISSOURI CAVE CATALOG

A. The First Cave Listings: Caves are mentioned in the writings of the early state geologists, with actual listings of caves going back to the days of G. C. Broadhead (1863), who listed just a few widely-known caves of the time.

In the mid-thirties, Professor Joe B. Butler of the Missouri School of Mines and Metallurgy did some "tourist maps" of several mid-Missouri counties, including Pulaski and Phelps. On these he showed a surprisingly large number of caves, which were fairly accurately located, considering the county road map bases he used. He also issued an informal, untitled and undated, but annotated listing of the caves he found (Butler, ca. 1937). The Butler list made Pulaski County the leading cave county in the state, a distinction it held until the mid-1960's.

B. The Partial Catalog: Missouri Survey geologist named Willard Farrar compiled a list of caves that was issued in mimeographed form as the Partial Catalog of Caves in Missouri. Farrar had nurtured an interest in caves, but his major assignments were in areas such as clay resources. Tragically, Farrar was killed during World War II, but his notes on caves were compiled by the Survey into the Partial Catalog, and they formed the data base on which Bretz began to write "Caves of Missouri." Somehow Farrar's original notes were lost, perhaps during the years when Bretz was writing his report. As to Farrar's character and personality, and the source and extent of his interest in caves, nothing remains, or at least nothing has been written. Bretz is generally thought of as the father of speleology in Missouri, though it may be that Farrar should be accorded that honor, or even Professor Butler.

The issuance of the "Partial Catalog" as a multilithed report of the Missouri Geological Survey stimulated interest in the ranks of early-50's cavers in Missouri because one could obtain a copy over-the-counter or by mail from the Survey, for 25 cents, with no strings attached, because there was little or no cave conservation ethic in those days.

If the "Partial Catalog" was a "nudge" to caving, the publication of "Caves of Missouri" in 1956 was a "kick in the pants." Suddenly, a wealth of information was available in readable form, together with scientific theory about how caves came to be, including the unusual but fascinating terms, vadose and phreatic zones. Soon these terms were "household words" among cavers, who enthusiastically began piling caves into one zone or the other based on their perceptions of cave characteristics.

Bretz's book, perhaps more directly than indirectly, resulted in the founding of the Missouri Speleological Survey in 1956, with the enthusiastic encouragement of the late state geologist Dr. Thomas R. Beveridge. It was also a strong emphasis for cave inventory, because readers immediately saw that Bretz didn't know about hundreds of caves, and of those he knew about, his advanced age precluded the vigorous exploration that would have been required to understand all the implications of the resource. Nearly 30 years after Bretz, work is still far from complete.

Basking in the glow of accomplishment following the successful introduction of "Caves of Missouri," the Geological Survey hired Jerry Vineyard to update its Partial Catalog and the Bretz report. This was the beginning of a long-term association of the Survey with cavers.

It was not long before the question arose whether it was prudent to continue to make catalogs available indiscriminately to anyone who had 25 cents to spend. So, the Missouri Speleological Survey offered to take over sponsorship of the Cave Catalog. The Geological Survey agreed, and the 1964 Catalog was the first published privately.

C. Computerization: As the number of caves increased and the data base became more difficult to manage, computerization of the data began. The first computerized catalog was issued in 1968, through the cooperation of the MSM Spelunkers Club and the Computer Center of the University of Missouri-Rolla.

At first, the computerized data was simply printed out on multilith masters, which were then printed by machine and assembled into completed catalogs, thus avoiding the intermediate step of typing. Two subsequent editions of the Catalog were issued using this method, before the issuance of actual printouts was begun.

The software for the Catalog underwent considerable change from the initial programs that ran slowly and were costly to operate. Bob Hackbarth and others rewrote the programs in the 1970's in assembler language.

In the early 1980's, advancing technology in both hardware and software caused problems in keeping the Catalog in print. There were also funding problems involving the updating of the data base and rewriting the software. Eventually, the data base was shifted from the UMR Computer Center to the State Data Center in Jefferson City, accessed through the Division of Geology and Land Survey office in Rolla. The data base still resides there.

THE CATALOG CONCEPT

A. Basic premises:

The Missouri Cave Catalog is based on a simple set of premises that were established early in the development of the catalog.

(1) Caves are listed alphabetically by county, with location(s), topographic map, and miscellaneous data.

(2) Each cave is given a unique identifier, called an accession number, that always remains the same, even though the cave name may change.

(3) The Public Land Survey system (Section, Township and Range) is used for quick reference on topographic maps; latitude and longitude is used for accurate point locations capable of machine plotting.

(4) A coding system is used to indicate mapped caves, cave length, entrance dimensions, elevation, etc.

(5) The Catalog is primarily a resource inventory tool; it is not a comprehensive cave data base.

B. Derivative products:

The basic catalog is useful for resource inventory, classification and other broad purposes. For more specific purposes, data extractions can be made in considerable variety:

(1) Cave listings by individual county
(2) All caves of the same name
(3) Alphabetically by total resource (rather than by county)
(4) Caves by township, range or section
(5) Mapped caves
(6) Unmapped caves
(7) Caves with multiple entrances
(8) Caves by length (longest first, in descending order; caves within a range of lengths, etc.)
(9) Show caves (commercial cave)
(10) Caves by topographic quadrangle
(11) Caves shown on topographic maps
(12) Closed Caves
(13) Other data sorts as required

C. Maintenance and updating:

The cave catalog data base is currently managed at the offices of the Missouri Geological Survey in Rolla. The senior author is the manager of the Master Cave Files, from which the Catalog is compiled. Tami L. Martin is the direct compiler of the data, which comes primarily from members of the Missouri Speleological Survey as well as from other cavers, private citizens and agency employees.

As new caves are reported, they are entered in the Master Accession Number Catalog, then added to the Cave Catalog Data Base. Corrections and additions are made as necessary on an as-received basis, so the purchaser of a catalog will get the latest information received up to the date of purchase.

The Missouri Cave Catalog is now not so much a publication as it is a continuous process. Data comes in to the Geological Survey in many forms and in various stages of completeness, and each bit of information requires either a new entry or correction of a previous entry. This inherent maintenance requirement demands several kinds of staff and equipment resources. First, there must be overall coordination of the work, involving communication with the data repositors, and knowledge of the resources. Considerable staff time is needed for data input/corrections, especially for quality control and avoidance of duplication. Much of the data received comes in in non-standard formats, so it must be proofed and typed or retyped before it goes into the data base. Third, the EDP operations require the assistance of programmers and access to the computer system on which the data base is maintained. All of these operations are performed by staff not because they are doing a favor for cavers, but because caves as a resource are important to the Department of Natural Resources.

The cost of maintaining the Cave Catalog can be derived from the Division's time-accounting system, which breaks out Catalog maintenance as a reported activity. However, the figures include only the time reported for data input, EDP operations, and other work related to the data base, exclusive of the senior author's time, which is accumulated outside of the normal working hours.

In addition to the time required for maintaining the cave catalog data base, a great deal of time is needed for final drafting of cave maps that are submitted in pencil draft form. For Fiscal Year 1984 and the first two months of Fiscal Year 1985, the Division's Graphics Section spent 800 work hours in drafting cave maps. It is readily apparent that maintaining a cave catalog and related data base is not an easy or insignificant task.

THE CATALOG AS A CATALYST

A cave catalog in essence is an inventory and partial characterization of the cave resources of whatever area is covered. As such, it can be a catalyst or factual reference to help bring about significant beneficial changes toward cave conservation and management. The basic assumption is that factual and complete information on the resources can be effectively used to protect that resource. A case in point is the Missouri Cave Resources Act, enacted by the Legislature in 1980.

Six years were required to convince the Missouri General Assembly that action to provide protection to the state's cave resources was necessary. Given that considerable time and effort was needed to "learn the ropes" of the legislative process, the fact remains that the legislators had to be educated as to the number and variety and character of the caves in Missouri. In the absence of the cave catalog as an inventory of the resource, it would have been difficult to show that there was, in fact, significant resources worth enacting legislation to protect.

The Missouri Cave Catalog is the most effective tool available for finding new caves. The psychological impact of listings that are incomplete and/or incorrect can be extremely powerful. When cavers saw the "Partial Catalog of the Caves of Missouri" (Farrar, 1952), they immediately noticed omissions and began sending in corrections and additions. The process not only has not stopped, it also shows no sign of slowing after 32 years (Figure 1). An average finding rate of 133 caves per year, maintained over more than three decades, is a strong argument for the effectiveness of a cave catalog in increasing the known cave resources in any area where the concept is applied. Moreover, the same psychological impact seems to extend to cave mapping; the absence of a "mapped" symbol beside a cave in the catalog will generate a desire to map the cave.

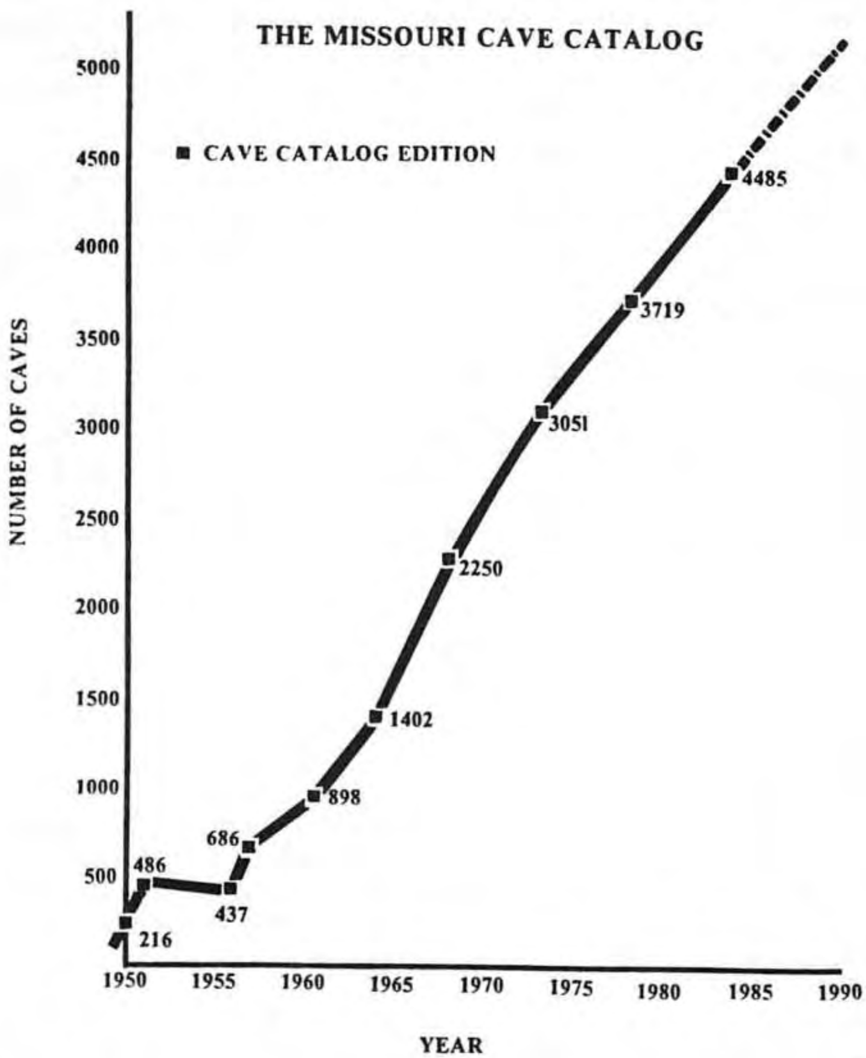

Figure 1. Graph of progress in Missouri cave inventory recorded by published cave catalogs.

SUMMARY

The Missouri Cave Catalog has been issued in various forms and under several administrative arrangements, for more than 30 years. During that time, it has progressed from an imprecise and incomplete listing of well-known caves to a comprehensive and relatively precise inventory of the state's cave resources. Computerized in the late 1960's, the catalog is now available in a standard county-by-county alphabetical listing, together with 12 or more derivative printouts that can be produced from the data base. The current edition lists 4,513 caves.

The development and use of a cave catalog is a strong impetus for inventory and characterization of cave resources because it stimulates interest in additions. This catalytic effect is also operative in stimulating cave mapping and county-by-county inventories. Lacking indications, as typified by catalog listings, that an area has cave resources, it is likely to receive less or no attention by cavers. However, even a small showing in a catalog can lead to significant discoveries. For example, in 1956, only four caves were known in Perry County, but today there are nearly 600 on record.

The Missouri Cave Catalog has been an important factor in the discovery rate of 133 new caves per year that has been maintained since the founding of the Missouri Speleological Survey in 1956. The rate of discovery continues at a high level, suggesting that the Missouri cave resource remains far from being completely inventoried.

CHRONOLOGICAL LISTING/BIBLIOGRAPHY OF MISSOURI CAVE LISTINGS/CATALOGS

Broadhead, Garland Carr

1863 The caves of Missouri: The Missouri Republican, November.

1867 Caves in Missouri: Missouri State Board of Agriculture, 3rd Ann. Report p.200-201

1874 Caves (of Missouri): Missouri Geological Survey, Report on Field Work of 1873-74, p.3539.

Owen, Luella Agnes

1898 Cave regions of the Ozarks and Black Hills: Editor Publ. Co., Cincinnati, Ohio, 228 p.

Fowke, Gerard

1922 Cave explorations in the Ozark region of central Missouri, in Archaeological investigations: Smithsonian Institution, Bur. Am. Ethnology, Bull. 76, p.13-100.

Farrar, Willard (?)

Uncredited, undated, but presumably the work of Farrar: Partial catalog of caves in Missouri (mimeographed): Missouri Geological Survey and Water Resources.

Farrar, Willard; J Harlen Bretz, et al.
1952 Partial catalog of caves in Missouri: Missouri Geological Survey and Water Resources, misc. publ., 44 p.

Bretz, J Harlen
1956 Caves of Missouri: Missouri Geological Survey and Water Resources, 2nd Ser., Vol. 39, 490 p.

Vineyard, Jerry D., D'Jeanne Stevens, Bonnie L. Wills, and John W. Koenig
1957 Catalogue of the caves of Missouri: Missouri Geological Survey and Water Resources, misc. publ., 50 p.

Vineyard, Jerry D.
1960 Supplement to the catalogue of the caves of Missouri: Missouri Speleological Survey, Columbia, Missouri, 31 p.
1964 Catalogue of the caves of Missouri: Missouri Speleological Survey, Newburg, Missouri, 99 p.

Vineyard, Jerry D. and Langford G. Brod, Jr.
1968 Catalog of the caves of Missouri: Missouri Speleological Survey, Rolla, Missouri, 178 p.

Vineyard, Jerry D. and others
1973 Catalog of the caves of Missouri: Missouri Speleological Survey, Rolla, Missouri, 178 p.

Vineyard, Jerry D. and (numerous) others
1978 Computer printout, catalog
to of the caves of Missouri:
1984 Missouri Department of Natural Resources, Geological Survey (5-p. introductory explanation appended to variable-length computer listing, as of date of computer run)

Vineyard, Jerry D., Tami L. Martin and (numerous) others
1984 on Catalog of the caves of Missouri, including derivative listings: Missouri Speleological Survey (introductory text appended to computer listings of variable length and context, issued as of date of computer run)

THE MICROCOMPUTER AS A MANAGEMENT TOOL WITH EMPHASIS ON CAVE MANAGEMENT

by Rob Stitt*

ABSTRACT

The microcomputer and its accessories can be an effective tool for increasing productivity in a small business or management activity. As a business tool used at a commercial cave, the microcomputer can be used for correspondence, accounting, and business analysis. For the cave manager the microcomputer can provide a convenient and fast method of storing and relating data, including, for example: cave inventory data, visitor user data, and use data. For the cave mapper, the microcomputer can be used for data reduction, display, and printing of maps. This paper presents an introduction to microcomputers, with suggestions for deciding which computer to but and how to integrate it into existing operations.

My qualifications for doing this paper include having been a caver for 25 years, an aspiring cave manager for 15 years, and a computer owner for almost 3 years. I am trained and employed as an electrical engineer, specifically designing process control systems. I own approximately $10,000 worth of hardware (IBM PC) and about $5,000 worth of software, and I have played and/or worked with most of it extensively. I do word processing and articles, maintain mailing lists, write programs (one sold and published in PC MAGAZINE), and even once in a while play a game or two (I happen to be into text adventures like Zork, especially those that take place in caves).

I. WHAT IS A MICROCOMPUTER?

The term microcomputer is generally used to refer to computers built using a "microprocessor", an integrated circuit chip that contains most of the circuitry necessary to be a computer. In this paper I will use the term "microcomputer" instead of the more common "PC" or personal computer. The microcomputer is contrasted with the "minicomputer" and the "mainframe computer" which are large and more expensive. In fact the microcomputer of today is more powerful than the mainframe of yesterday. My own personal microcomputer is from 5 to 20 times more powerful than the mainframe the university had when I was in college twenty years ago.

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The microcomputer has the following characteristics: It is relatively small, ranging in size from small hand-held portables to large desktop models weighing 50 or 60 pounds. Most of that weight is in the power supply. It is low cost. A useful microcomputer can be obtained for a few hundred dollars, and a complete computer system runs under $10,000, as opposed to $50,000 to $100,000 for a "minicomputer" system. It is self-contained, usually installed in a small cabinet, with all required peripherals occupying only the space of a desk top. The common microcomputers of the present tend to be single user, and to do only one task at a time. The next generation of microcomputers will be able to do several things and handle several operators at the same time. The most important feature of the microcomputer is that it is an interesting, challenging learning tool. You can have fun with one, also, since most machines have lots of game software available.

II. WHAT IS A COMPUTER FOR

Computers have a variety of uses, all of which may be more or less relevant to the cave manager. In this paper I will summarize general uses and then concentrate on particular areas most useful for cave management. Among general uses of the microcomputer are:

Word Processing--The computer is the world's greatest boon to writers, secretaries, and anyone who writes of reproduces things. This paper, for example, was started on an outline processor called "Thinktank", polished on a full scale word processor "Microsoft Word", and was essentially designed, written, and produced in about three evenings.

Computerized Typesetting--Using a word processor and a telecommunications link, it is possible for anyone to produce a typeset document for hardly more cost and probably in less time than by conventional old fashioned methods. Basically it involves writing the material on the computer, entering the correct commands to talk to a computerized typesetting machine, and they paying a minimal cost for the computer and operator time to process it. The catch, of course, is that you have to know what you are doing.

Fun and Games--Computers can be recreational and educational. They are useful for not only relaxing in your off hours playing arcade games, challenging your mind wandering through underground worlds playing adventure games (the original one of those was written by caver and CRF joint venturer Will Crowther) or writing your own programs for doing whatever you would like.

USE BY A SHOW CAVE MANAGER

For the show cave manager, or for that matter the manager of any small business, the microcomputer can be a valuable tool for keeping track of the business.

Business Tool--The microcomputer is a general business tool, useful for handling correspondence, keeping accounts, and generally doing the things that a small business needs to do.

Correspondence--Having a microcomputer means being able to turn out perfect letters, get things out quickly, and maintain records of correspondence.

Accounting--A microcomputer can enable the small business person to do their own bookkeeping, thus freeing them from the need to send it out and providing up-to-date control and knowledge of expenditures and income.

Business/Financial Analysis--There are a number of programs available for business analysis, and the spreadsheet is the perfect tool for making financial projections based on current information and expectations.

USE BY THE SCIENTIST

A. Cave Surveying and Mapping

Data Reduction--The microcomputer is the ideal tool for small scale data reduction, converting raw survey data to usable data for use in making maps.

Data Display--The microcomputer can be used to display computer maps, and with programs that will be available in the near future for microcomputers, to manipulate those maps to learn interesting things about cave stratigraphy and geography.

Map Production--The microcomputer, when used with "Computer Aided Design" (CAD) software can assist in the production of maps, although high quality maps aren't going to be possible until laser printers and better software are available at low prices.

B. Data Acquisition

Remote Monitoring--When coupled with the appropriate Input/Output (I/O) boards, a microcomputer can be used to collect data from a variety of sensors, including temperature, level, flow, light levels, etc. Currently the standard microcomputer requires more power than is available in the portable models, but costs and power consumption will come down in the next few years. A battery-powered computer, coupled with the right I/O boards and sensors, could be left in a cave to gather and store data over a long period of time. In a few years the price of this will be within the reach of the average caver.

Visitor Use Monitoring--A subset of data acquisition is for monitoring visitor use of a cave. Event inputs could detect the presence of humans at a cave, visitor center, or other location. These could be counted and recorded by a small computer.

USE BY THE AGENCY CAVE MANAGER

Data Management--The microcomputer is the ideal data manipulation and management tool. It can be used to store data, to sort and classify it, to find information, and to present the information in a form understandable to the public or other managers.

Cave Inventory Data--Functioning like a filing cabinet, data on caves or other resources can be stored, sorted, classified, and printed out. Information can be obtained very quickly. For example, a list of all caves in a certain area containing cave pearls could be quickly obtained (assuming that the information was in the data base).

Visitor/User Data--The data base manager (or filing program) can be used to keep track of visitor or user data while a spreadsheet could be used to present it in usable form or to make projections.

Cave Use Data--Records on cave usage by recreational cavers can be stored and referenced quickly. Cave permit information can be accessed, and statistical studies of use produced.

III. BUYING A COMPUTER

Presumably if you have gotten this far into the paper you are halfway convinced that you ought to but a computer for your cave management operation. Here are some pointers on making that decision and some guides to navigating your way through the computer labyrinth.

STARTING TO DECIDE

Before you even think about a computer, get your thoughts in order and determine why you need it.

First, make a list of all the things that you think you could use a computer for--Include, for the sake of this exercise, everything, even the fantasy things. Consult your friends, other computer users, and others in your office that you work with, or that work with computers. The odds are pretty good that once you actually get a computer, you will find lots of things to use it for that won't even occur to you at this early stage.

Determine what you need to do--Take each of the items in your list and describe exactly what it is that you need to do. Think in terms of inputs and outputs and what personnel will do the job. If you are currently doing the same things right not by hand, list what it takes to do that. The microcomputer may induce changes in the way you do things. This analysis of your operation will enable you to determine which kinds of software you will need, at least initially. You will want to investigate different types of software and figure out which one you want to buy for each of your uses.

How much money do your have?--Although computer prices are dropping rapidly, software costs are falling more slowly. Thus it may be necessary to budget carefully. An adequate small starter computer system can probably be obtained for under $3,000, but you will find yourself putting the rest of the money into it as your needs increase. A very adequate complete system can cost as much as $10,000, particularly by the time you include all the software for the first couple of years.

Before getting too far into this, it is a good idea to consider some reasons why not to buy a computer. If you can't deal with these problems, they maybe you should not buy one.

It can be a money sink--I have over $15,000 sunk into my small system (IBM PC, color monitor, hard disk, two printers, lots of expansion boards, software, etc.). I started at under $3,000. Somehow it just grew. Although I have a moratorium on new purchases on right now, I can see several things that I need.

It will not save you time, it just lets you get more done--Although a computer can be a great aid to improved productivity, once you have learned how to use it, at first the time required to learn new skills will make your productivity fall to zero. I don't think my microcomputer has saved me much time (I probably spend the same amount of time, or more, at the microcomputer that I used to spend at the typewriter) but it sure has boosted my output. Much of the time spent is in learning new things, in diddling with the operating system configuration, in solving problems (why did that @#$#%&* thing do that?) and until I got the hard disk, in making a connection to buy cheap floppies.

It will require you or your employees to master new skills--If you get a computer, you are going to have to learn new ways of doing things and ways to make an inanimate object do tricks. It can be time consuming as well as very frustrating. In the long run, I think it pays off, as you find yourself much more productive. But in the short run, you may wish you had never heard of the thing.

It can become the end instead of the means--It is very easy for operating the computer to become the thing you are doing, forgetting that you really started out to manage a cave. You could spend all your time feeding the computer instead of performing the tasks you bought it to do.

It can impose systems on you which may not be the best suited to what you need--You may end up changing the way you do things because your software requires that you need the programmer's conception of how things should be done. That may not be the best way to do what you need to do. With the availability of lots of different software packages, you have more choice, but you will still have to look at several, and maybe even try several, before you get the best one. Of course, that can cost money.

IV. SOME CONSIDERATIONS

The following are comments on some things you may wish to take into consideration while making your selection. These comments are not all-inclusive, are opinionated, and will probably be contradicted by someone else who holds other opinions.

16-bit Versus 8-bit--The main advantage of the 16-bit machines is that they can address more memory directly and generally are faster in operation. These advantages are disappearing with the advent of some new 8-bit machines that are designed to overcome these limitations.

IBM Compatibility--The buzz-word is "IBM Compatibility". The reason is that everyone jumped on the bandwagon and this is now a de facto standard for 16-bit machines. There are lots of machines that claim to be IBM compatible, but in fact only the IBM is 100% compatible. If you are interested in IBM compatibility, and have the money (about 15% more), then get an IBM. If you are willing to live with an occasional software problem, then many others, including some Zeniths, Compaq, Corona, Columbia, Eagle, and lots of others have varying degrees of compatibility.

Software Availability--Right now there are three standard software systems that have lots of software available; CP/M, Apple, and MS-DOS (IBM). Buying a machine compatible with one of these standards will assure a large choice in software. It is possible that the Apple MacIntosh system will become another standard, but it may take a few years.

Manufacturer's Longevity--If you are concerned that the manufacturer of your machine will still be in the computer business, and supporting the machine, in a few years, they you better buy from IBM or Apple. Many of the others will survive, but many won't. It may not make that much difference, anyway, since once you get through the start-up mortality, your machine probably isn't going to need much direct support, anyway. The real key is software availability.

Desk-top Versus Portable--There are really three classes of microcomputers: desktops that are not meant to be transported readily, the so-called "portables" that are really only "transportables", since they weigh 25 to 40 pounds, and the true portables (often called "lap portables") that weigh only a few pounds and can be put in a briefcase. If you want to be able to use a microcomputer at several different locations, but have a strong back and power available, buy a portable. If you want to take it to the field, get a "lap portable".

Upgrade Paths--If you are going to start out on a tight budget, then get a machine that can be upgraded easily by adding plug-in boards or accessories.

Memory Size--You will eventually need all the memory you can afford, within limits. I had 384 KB in my system, and just added another 64K. It speeds up operations (you can use part of the memory to simulate a floppy disk drive, but much faster), lets you do lots of things at once, and runs larger programs. For starting out, 128K is the minimum you can get by with in most machines.

V. MAJOR COMPUTER CATEGORIES

8-Bit--This includes the Apple, the TRS-80, many different CP/M machines, and almost all microcomputers designed or built more than three years ago. There are still lots of 8-bit machines that are adequate for most uses, and newer ones have been designed to run faster and address more memory, so they can be almost as good as a 16-bit machine.

CP/M--CP/M (Control Program/Microcomputer) is an operating system, and there are many small machines on the market designed to be compatible with it. There are thousands of programs available to run of CP/M microcomputers.

Apple--The classic 8-bit computer, that made microcomputers famous. There are thousands of programs available for the Apple II, also.

Some of the other 8-bit manufacturers include Morrow, North Star, Xerox, Osborne, Kaypro, you name it. There are or have been several hundred manufacturers in the computer business in the last ten years. Many have not survived.

16-Bit --The 16-bit machines have a larger working memory (registers) inside the computer, so they are able to work with more data at once. This makes them faster. A true 16-bit machine also uses a 16-bit I/O bus, but the most popular ones, the IBM compatibles, usually use only an 8-bit I/O bus, which makes them a bit slower.

8086/8 Based--These computers, including the IBM PC and its clones, use the Intel 8086 (16-bit I/O) or 8088 (8-bit I/O) chip as their central processor (CPU). In fact, most of the current crop of so-called "16-bit" machines use this chip, whether they are IBM PC compatible or not.

68000 Based--These computers, the most common of which is the Apple MacIntosh, use the Motorola 68000 chip. Many microcomputer experts believe that the 68000 is a better processor than the 8086, but the 8086 got into production first, and was able to use software developed for the 8-bit machines with only minor changes, so it became more popular.

Others--There are a number of other microprocessor chips around using 16-bit I/O or processing. However, they are not in common use and you are unlikely to run into them unless you buy a specialized computer.

VI. THE NEXT GENERATION

The next generation of microcomputers (which is just coming onto the market), will use more powerful 32-bit processors, or, as in the case of the IBM PC-AT, a more highly integrated microprocessor chip. They will address more memory, work faster, and be capable of multi-tasking and multi-user operation.

32-Bit--These machines won't be into mass production for a few years yet, but they will be very fast, address lots of memory, and will be very powerful.

Integrated Chips--These machines will combine more functions on the processor chip, including I/O functions, timers, and even some software. This will enable smaller, lower cost machines that are faster.

VII. HARDWARE ACCESSORIES

Accessories allow you to communicate with your computer; to put data in, to store it, and to get data out. Often they are included as part of a computer system, but it is also possible to mix and match and put together a hybrid system that can be cheaper than the "name brand" combo.

DISPLAYS

Color--A color display costs more, can be harder on the eyes, and may not have as good resolution as a monochrome display, but it can be better for displaying some data, and certainly better for playing games on.

Monochromes--Monochrome displays are usually green. Amber displays are supposed to be easier on the eyes, but the experts really aren't sure. A cheap, high resolution monochrome monitor suitable for text display can be obtained for around $120.

Disk Drives--Usually the disk drives come bundled with the microcomputer. You will probably want at least two floppy disks. A capacity of at least 300KB is necessary for any serious work. If you buy only one drive, you will spend a lot of time swapping disks around.

Floppy Versus Hard--Hard disks are becoming more common. Prices are coming down (a 10MB disk can be obtained for under $700). A hard disk is faster than a floppy, can store much more data, and will lose a lot more if it crashes. You will need to back up your hard disk onto floppies (keeping at least two sets) and on the IBM PC a 10MB hard disk takes 30 floppies and about two hours to back up.

PRINTERS

Dot Matrix--Although they are getting better, dot matrix printers have that "computer" look about them. They are also cheap and fast. For graphics work (like cave maps) they will put out medium resolution copy.

Daisywheel--The daisywheel printer works like an IBM Selectric, but the wheel is lighter weight than the ball so it can type faster. The cheap ones don't. A good one will cost $1,500 to $2,000. The electronic typewriter with a conversion card can be a cheaper alternative ($500 or less).

Laser (electrostatic) Printers--So-called laser printers work like a Xerox machine, except that instead of a copy being made from an existing document, an image generated by the computer is put on the drum and then transferred to paper. They are silent, fast, and still expensive, but the price is coming down rapidly. Look for these under $2,000 in late 1985 and maybe under $1,000 by 1986.

MODEMS

A modem is a device for interfacing a microcomputer with a telephone, so that computers can talk to one another at a distance. There are two types in common use. The 300 baud modem sends about 30 characters per second, while the faster and more expensive 1200 baud modem can send up to 120 characters per second. Even faster 2400 baud modems are coming onto the market. Probably the 300 baud unit is adequate for most use, but as 1200 baud modem prices drop, they will become more common.

VIII. SOFTWARE SELECTION

SOME TYPES OF SOFTWARE

Operating Systems--The operating system is what makes the computer work internally and enables it to communicate with the user, disk drives, printers, and other peripherals. The most common ones are CP/M for 8-bit computers and MS-DOS for the 16-bit machines.

USER SOFTWARE

Word Processor--This is the basic program that replaces the typewriter and does so much more. In particular it allows correction of errors on the screen, easy rewriting, and fast production of complex documents. WordStar is the old standby, but there are literally several hundred other programs of varying usefulness or usability on the market.

Spreadsheet--A spreadsheet program enables the manipulation of numbers easily and quickly. It usually allows entry of data into "cells" in rows and columns, and then calculates answers based on these numbers. Changing one number can make all of the other numbers change automatically according to the formulas that have been entered.

Data Base Manager--For keeping track of data in records. It can replace your filing cabinet.

Accounting Software--Simplifies and speeds up accounting. Enables the accounting non-professional to turn out passable books.

Communications Software--Talks to the modem and via the modem to other computers. Necessary if you are to have communications with other computer systems or tie into a network such as the Source.

WRITING YOUR OWN SOFTWARE

You may imagine that you can write your own software for a computer, and after you have learned how, that may be true. But if you are thinking about doing this, you might think about the following points first.

Takes Time and Knowledge--If you get into it, or have lots of time on your hands, writing your own software can be fun. However, you are probably wasting your time writing software for anything other than very specialized uses. It may pay to write your own cave map data reduction program although it can be done on a spreadsheet easier and faster. But writing your own word processor is a waste of time and energy.

Adapt the System to the Software or the Software to the System?--This is an interesting philosophical question. Should one buy a computer system that will run a particular piece of software, or should one buy what one wants and then write (or adapt) software to run on the system. Fortunately, with lots of ready-made software available at moderate cost, and lots of free public domain software around, this question becomes less important.

Windows--Windowing software promises to enable several different programs to work together, allowing passing data easily from one to the other and changing quickly from one to the other. However, promises is the correct word, for most of the systems announced are behind schedule or have not been very successful. I believe in a wait and see attitude.

SOFTWARE INTEGRATION

Making Your System Work Together--If you put together your own system from components, you will need some time and patience to get it all working. Right now, as I write this, for example, I am cursed with a printer switch-box that does not work and has been very reluctant to cooperate in fixing itself. It is not broken, it just won't work in my system. Eventually, I will probably get it working. But I have spent several very frustrating Saturday afternoons poring over manuals trying to figure out the problem.

IX. INTEGRATING YOUR COMPUTER INTO EXISTING SOFTWARE

To obtain maximum benefit in the shortest possible time you must plan carefully how you will work the new computer into your operations.

Plan Carefully--Besure that you have the transition figured out ahead of time.

Run Your Operations in Parallel--Don't stop doing something by hand just because you have a computer. Continue your accounting by the old method until you have gotten the computer working and set up. Run the stuff the old way for a couple of months after you get it on the computer, if possible. That way you can check your work, verify that the new system is doing what it needs to do, and be sure that you have it set up right.

The best use of a microcomputer at the start is to do new things you haven't done before. That way you can learn how to use it while doing new things, and not waste time getting frustrated with doing the old things twice. Don't throw away the old until the new is working. Don't stop using the old system, or throw away your data, until the new system is working well and has been proven out. Use your microcomputer for new or different things that you haven't done before and add the old things gradually as you get the system set up and figured out.

TRAINING IS A NECESSITY

If you have lots of available free time, you may be able to train yourself. But if you have office staff members who will be expected to make use of the new equipment, you should arrange for some sort of formal training, and give them time to get used to the new equipment and to try it out, even to play with it.

X. WHERE TO GET MORE INFORMATION

Magazines--There are lots of microcomputer magazines on the newsstand; probably a few less today than yesterday. For a good general all around introduction to computing with lots of reviews, I think CREATIVE COMPUTING is probably the best. If you are more technically inclined, read BYTE.

Books--Computer books have become big business. There are literally thousands of titles. The best thing to do is find a good bookstore with a broad selection of titles and browse until you find what you need.

Consultants--It may pay you to find a consultant to give you some advice, particularly on setting up a complete system. However, be a little wary. There are lots of self-proclaimed experts who may know something about some things, but may not be of much help in other areas. If you can find out enough on your own to ask intelligent questions before you consult the "expert", you will probably be better off.

NSS Computer Applications Section--The NSS Computer Applications Section is one of the largest in the NSS. It puts out a newsletter at frequent intervals and publishes information about cave related computer applications. For information, contact Bob Hoke, NSS Computer Applications Section, 8727 Hawshed Lane #12, Columbia, MD, 21045.

A COMPUTERIZED CAVE MANAGEMENT INFORMATION SYSTEM

by Roger W. Brucker*

ABSTRACT

A computerized cave management information system (MIS) is proposed to provide information to aid decision making, to answer questions, and to facilitate administrative work of managing cave resources. By using the computer many problems are solved, such as the loss of administrative control of data and policies due to transient management, the need for frequent updating of records and the problem of obsolescence, the unpredictable demand for information, the prohibitive cost of alternatives, and the readiness to support emergency operations. Needs are illustrated by a day in the life of a cave park manager, who is confronted by various kinds of demands for information and entry into caves. A system that will run on $4,000 to $6,000 of computer equipment is described in detail.

INTRODUCTION

The management of cave resources with a shortage of qualified staff is a nationwide problem. This paper describes a simple computerized management information system (MIS) for accomplishing many of the cave manager's tasks better, faster, and less expensively than conventional manual administration.

The computer is not a panacea, nor can it make sensitive or competent decisions. Couldn't a MIS be set up using just a file cabinet and a copy machine? An experienced cave administrator with sufficient clerical help could do it, but the objective is to obtain superior management despite personnel shortages. The computer can help deliver this goal.

WHY DO IT AT ALL

Why use a computer? Its purpose is to provide information necessary to support decision making about caves. It permits answering questions with interpretive information that is sufficiently thorough to satisfy most inquiries, without burdening the staff. It simplifies and speeds repetitive transactions, such as registering cave exploration parties. A computer system can make conservation programs more effective, and it may help save lives in an emergency.

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WHY DO IT THIS WAY

Tight staff budget problems can be alleviated by using a computer to provide clerical services which may be otherwise unaffordable. Transient management need not result in inexperienced managers making bad decisions because they lacked the right information. Data kept in the computer can be organized for usefulness and easy updating. A computer can eliminate the need to inventory forms and publications, by storing the latest versions for quick printout. The demand for cave data may be unpredictable. By using the computer, the data is not only available, but can be communicated by modem to any other computer over telephone lines. In case of emergency, the computer can guide the orderly implementation of procedures. Finally, the computer can guard against the loss of original cave data.

WHY DO IT NOW?

Consider a day in the life of a cave manager, Ranger K. at Big Cave National Monument. When he arrives at work the morning mail brings a letter from Sandy Crawl, asking permission to explore Agonizing Death Cave. He wonders what to tell Ms. Crawl as telephone interrupts. It is the Chairman of the Hollow Hills Grotto of the NSS. "Do you have any cave conservation projects our Grotto might tackle?" Ranger K. tries to think, and replies that he will call back.

At 9 AM Ranger K. meets with the Superintendent and Resource Manager to evaluate two research proposals. Both investigators want to do the same study, and a decision must be made. Afterward, a visitor stops by to request information about caves in the park. Next, a researcher drops off copies of two thick research papers on caves of Big Cave National Monument.

Now members of the Limestone Grotto have arrived to register to explore and survey Riverbank Cave (they obtained permission two weeks ago). The leader reports the cave had a large quantity of trash in it the last time they explored. A paving contractor introduces himself, and requests information on bidding the new walkway construction in Show Cave. Can he have a map?

After lunch, a university professor wants to know all about Saltpetre Cave. Ranger K. stops trying to dig out information when a cloudburst hits, accompanied by thunder and lightning. He worries about the safety of cavers in Riverbank Cave.

Suddenly, a dripping-wet explorer rushes into the office to announce that all 12 of the Limestone Grotto explorers are now trapped by high water in Riverbank Cave. It's an emergency! Of course all plans to edit the park newsletter are scrapped as Ranger K. searches for the latest emergency procedure.

KINDS OF DECISIONS GOVERN THE MIS STRUCTURE

Ranger K.'s decisions can be categorized as: 1. Policy,

2. Information release, 3. Time allocation and budgeting, and 4. Other resource utilization and allocation. His decisions relate to interpretation, recreation, research, and conservation. Any management tool that can gain him time in one area will permit him to reallocate that time to provide more service or to do a better job in another area.

To be useful, the MIS structure must support decision making quickly and simply. And it should be easy to learn.

Objectives for the system should also include implementation with existing staff, easy training in data entry to use, wide utility, reasonable security, and cost-effectiveness.

EQUIPMENT NEEDED

In 1984 prices, all equipment and software necessary to implement a MIS will amount to $4000 to $6000. We recommend a microcomputer that is capable of running software programs such as WordStar-MailMerge[1] and dBase II[2]. A good microcomputer with two floppy disks may be purchased for about $2000. While a minimum system can use a dot matrix printer ($600), a more readable daisy wheel printer ($1000) is preferred. Maps can be prepared on some dot matrix printers. Or you could buy a small flatbed map plotter ($1000). A modem will let you send and receive information between other computers similarly equipped ($500). And you should budget $1500 for software.

ORGANIZATION OF THE SYSTEM

Initially, the system may be implemented using a word processing software package like WordStar-MailMerge. A database may be added later. Package systems provide comprehensive instructions and reference materials, and you can obtain training if you need it. We recommend against setting up an elaborate custom-programmed system until you gain experience with a simple one.

Figure 1 shows the structure of the MIS as five groups of files: Data, Policy, Information, Tasks, and Lists. Each group may contain any number of files, which can be named in any logical scheme, depending on the computer operating system rules. Files may be added, updated, or deleted at any time. It is a good idea to backup the system by saving it on disks from time to time.

SYSTEM IN USE

Ranger K.'s day is different with the MIS installed. On arrival at work he prints a copy of the park exploration policy, rules, procedures and application form for mailing to Ms. Sandy Crawl.

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1. MicroPro International Corp.
2. Ashton-Tate

When the Hollow Hills Grotto Chairman calls, he brings up on the CRT screen of the computer a list of Conservation Tasks and Projects. He discusses these with the Chairman. They agree on one or two projects the Grotto will consider undertaking.

For his 9 AM meeting to evaluate two research proposals, Ranger K. prints the Research Policy and forms, and a copy of the Research

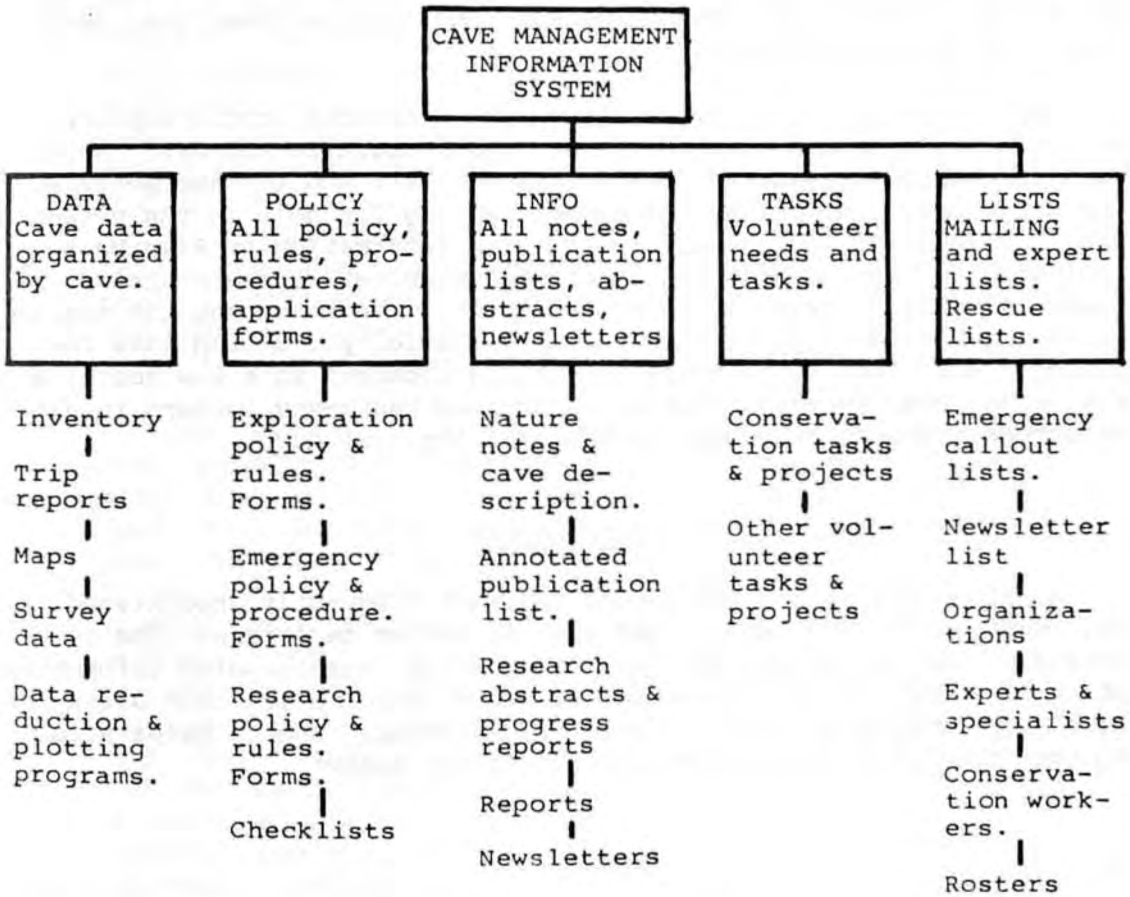

Figure 1. Cave management information structure.

Abstracts and Progress Reports. This will provide background information. He also prints the list of experts and specialists for a possible second opinion.

The visitor who wants information about caves in the park is handed a printed copy of Nature Notes & Cave Descriptions, a short document that is stored in the MIS.

The researcher's two reports are examined. Both contain abstracts. Ranger K. types the abstracts into the Research Abstract file. He also adds the reports to the Annotated List of publications, indicating where the reports can be found.

When the Limestone Grotto explorers arrive to enter Riverbank Cave, Ranger K. enters their names, destination, and estimated return time into the Report file on the computer. When he is told of trash littering Riverbank Cave, he immediately types a note into the Conservation Tasks & Projects file.

The paving contractor who wants a map is given a plot of Show Cave, which is output from the Map file on the computer.

The professor who comes after lunch is answered with a printout of the Inventory form for Saltpetre Cave, all trip reports, a map, and the Annotated Publication List. He may thus learn a great deal about the cave from these materials.

Upon hearing the report that the Limestone Grotto explorers are trapped in Riverbank Cave, Ranger K. turns again to the MIS. He prints out the current Emergency Rescue Call-out List and the Emergency Policy and Procedure and forms. He begins calling for help in the prescribed way. Then he prints out all of the file information on Riverbank Cave, including a map. When the staff and volunteer rescuers arrive, he is ready to brief them on the situation, the cave, and the available backup resources. Since this is our scenario, you should know that the outcome was that the cavers were found unharmed in a few hours, after the high water receded. Ranger K. printed thank-you letters to all the volunteer rescuers to go out in the mail the next day.

CONCLUSIONS

A cave MIS organized around the most frequently encountered tasks can save time and money, and lead to better decisions. The computer provides the advantage of rapidly updating fast-changing information, of preserving in machine-readable form information that often "gets lost" or misplaced when placed in drawers, and it helps stretch a minimal publications and stationery printing budget.

FORMULATION OF A MANAGEMENT ACTION PLAN FOR FITTON CAVE, ARKANSAS

by Steve W. Chaney*

ABSTRACT

Prior to National Park Service ownership, Fitton Cave went through several years of large fluctuations in use due to changes in private ownership and other factors. National Park Service acquisition of the cave was difficult and complicated and added to the difficulty in maintaining consistent protection for the cave. Following National Park Service acquisition, effective management of the cave remained complicated due to its poor accessibility and lack of entrance gates. Several innovative methods were contemplated to obtain entrance gates which eventually resulted in their installation. With this construction complete, the National Park Service was then able to implement plans to properly conserve the resources of the cave.

The agency is now attempting to manage one of the most popular wild caves in the Ozark region in a manner that will allow for reasonable recreational use and that will not allow unacceptable adverse impacts on the cave resource. A management action plan has been formulated through consultation with cave ecologists, biologists, recreational cavers and the general public. The plan encompasses all aspects of resource management that have potential to effect the cave resource including biology, hydrology and geology of the cave, surface management and the regulation of visitor use. A permit system with strict use limits is a part of this plan along with an extensive volunteer survey, research and service program. The management approach outlined in the plan is significantly different from other cave management strategies used in the Ozarks including those of other public agencies such as the U.S. Forest Service.

Fitton Cave or Beauty Cave, as it is also known, is located in Northwest Arkansas within the boundaries of Buffalo National River which is a unit of the National Park Service system. The cave is one of the most widely known wild caves in the region and is believed by many to contain more miles of passage than any other in the state.

Discovered in relatively recent times by most accounts, Fitton Cave has endured a multitude of owners with a wide range of management philosophies over the last half century. These philosophies varied

*National Park Service, Buffalo National River, Harrison, AR.

from plans to commercialize the cave and sink elevator shafts to near total exclusion of all use of the cave. Several different methods of controlling access to the cave have been used over these years with varying degrees of success.

The National Park Service came on the scene about 12 years ago when Buffalo National River was established. Shortly thereafter, the process was initiated to acquire the cave. This acquisition was much more complicated than had been anticipated and involved multiple surface ownerships, subsurface ownerships, assessment of mineral values and other interests which are seldom dealt with by acquisition personnel. The matter was finally untangled, however, due to legal technicalities concerning the final settlement of ownership interests, a period of time existed in which neither the National Park Service nor the previous owner claimed the cave. During this period, no control to access was exercised, and the unrestricted use of the cave resulted in a significant amount of resource damage. Finally in 1982, acquisition was finalized, and the National Park Service assumed control of the cave.

That Fitton Cave happened to lie within the boundaries of Buffalo National River was not a coincidence. The significance of the cave was recognized in National Park Service proposals and congressional testimony long before Buffalo National River's establishment. After establishment, the Master Plan for Buffalo National River outlined the management of the cave to be maintained as a wild cave with few or no manmade intrusions into the cave to facilitate visitor use.

When acquisition of the cave was completed in 1982, the National Park Service immediately implemented a mandatory but non-restricted permit system. Since no gates were on the cave at that time and due to its remote location, it was felt that any restrictions in the number of permits issued would encourage violations and would be next to impossible to enforce. This in turn would destroy the primary value of this interim permit system which was to gather data concerning use. A little less than one year later, funding was secured by the National Park Service for gating of the cave. Upon the completion of construction of these gates a restrictive cave permit system was implemented, and at the same time a proposed action plan for the management of the cave was introduced to the public by the National Park Service. The elements of this plan were drafted and reviewed by National Park Service staff at Buffalo National River, the National Park Service Southwest Regional Office in Santa Fe, New Mexico, and staff specialists from other parks. It was then presented at several grotto meetings in the region and distributed to all concerned individuals, and comments on the plan were solicited. All comments were reviewed, addressed and incorporated where appropriate, and the final plan distributed again to concerned individuals.

The components of this plan are similar to those of other cave management plans, however, some management activities are approached in a somewhat nontraditional manner. The objectives are generally stated to (1) provide protection for the cave resource, and (2) to provide opportunity for recreational and scientific use. Program elements needed to accomplish these goals are stated as (1) a structured inventory and survey, (2) a comprehensive research program, (3) an efficient and effective resource protection and monitoring program, (4) a feasible rehabilitation and restoration plan, and (5) an effective visitor information and safety program. The plan states that it is expected that most management actions called for will be carried out through the use of volunteers including the surveying and mapping of the cave, coordination of which has recently been undertaken by the Cave Research Foundation. The plan outlines several other needed cave management activities for which the National Park Service hopes to recruit volunteer assistance to accomplish. Consequently, several elements are purposely built into the cave permit system to encourage participation in volunteer management activities. While the National Park Service cannot and will not abdicate its responsibilities as the manager of the cave, we intend to use some fairly innovative methods to accomplish our goals. One such program is that which has been proposed as a joint project of the National Park Service and the Spelean Research Associates to hire a cave monitor to carry out routine resource monitoring activities in the cave. Another example is that of soliciting donations from Buffalo National River's natural history association to fund the establishment of a photopoint monitoring system. Several other projects are under consideration in which entities other than the Federal government may supply funding and/or manpower in order to accomplish activities which have traditionally been totally dependent upon the resources of the Federal Land Manager.

Visitor safety is another point where this plan varies somewhat from the traditional cave management approach. While the National Park Service assumes the responsibility of informing visitors of the inherent hazards and dangers of use of the various portions of the cave, the primary responsibility for assurance that the individual can cope with these hazards remains with the individual. What this means is that only very basic safety equipment is required of cave users, that no proficiency or adequacy standards or check out procedures are exercised, and that very few permanent climbing aids or other safety related installations will be used.

This decision was made partially in response to public comment and the logistical problems that would be encountered if such a system were implemented. The primary impetus behind this policy however is that the cave is intended to be managed as a wild cave system and, as in other wild or backcountry areas, National Park Service policy is to minimize actions that would cause an intrusion of the wild character of the resource.

The regulation of visitor use is undoubtedly the most controversial component and, as might be expected, evoked more comments than any other portion of the plan. Initial use limits were based on a combination of factors including recommendations from other cave managers and researchers, existing condition of the resource, and apparent resource impacts resulting from existing use levels. This is also true for other use restrictions called for in the plan such as group size, maximum trip length and prohibited activities. The actions in this section are admittedly based on somewhat arbitrarily determined factors. However, the entire thesis of this plan lies in the principle that all monitoring and research activities will be aimed at showing in what manner the established standards are affecting the cave resource so that they may then be adjusted to attain our stated objectives which, as previously mentioned, are (1) to protect the resource, and (2) to provide opportunity for recreational and scientific use. In other words, we have fired our shot. What is before us now is to find where the bull's eye lies.

Thank you for your time, and I hope you all may sometime have the opportunity to visit this outstanding resource.

CAVE MANAGEMENT ON THE MARK TWAIN NATIONAL FOREST

by William L. Kickbusch*

ABSTRACT

Project areas including significant geological features (caves, rock formations, sinkholes) will have a prescribed treatment that will protect the physical aspects of the feature.

No camping will be permitted within 100 feet of significant caves, rock shelters, springs and designated rock formations as signed.

Caves will be classed in one of three categories: Unrestricted Caves, Restricted Caves and Closed Caves. The specific standards for managing each cave are described in the cave inventory report. The three categories are described as follows:

Unrestricted Caves:

Not guaranteed safe, but least dangerous to people unskilled in caving techniques.

Little or no known or potential cultural resources and Natural History value, or ones which will not be adversely impacted by uncontrolled public usage.

No known Federally listed threatened and endangered species, State listed rare and sensitive species, or other biologically significant species or ecosystems, or ones which will not be adversely impacted by uncontrolled public usage.

Restricted Caves:

Some, but not all, of these caves would require technical skills beyond that of the average Forest visitor and could present substantial hazards to the user.

Cultural resource presences will not be a disqualifying factor. These caves may have natural history resources that merit some degree of protection.

May include caves containing Federally listed threatened and endangered species, State rare and sensitive species, and other biologically significant species and/or ecosystems requiring seasonal protection.

*Recreation Staff Officer, Mark Twain National Forest, Rolla, MO.

Closed Caves:

Public safety alone will not mandate a closed status.

Designated critical habitat or those caves containing evidence that indicates importance to the perpetuation of species identified as Federally listed Threatened and Endangered requiring year-round protection.

All caves will be identified as Management Area 9.2 until their significance for formal designation is resolved.

Caves categorized as "Restricted" or "Closed" will be identified as management Area 8.1 and have a specific management action plan developed.

Caves categorized as "Unrestricted" will be managed in conjunction with the Management Area in which they occur. The cave inventory report and Forest-wide standards and guidelines will be applied.

Since the establishment of the National Forest System in Missouri in 1939, Forest administrators have known there were cave resources to be managed. In the early years of custodial management little was known about caves, so little or no attention was given to the cave resource.

With the passage of the Historic Preservation Act in 1966, caves and their management took on a new meaning. However, no management direction was developed. Some specialists took a good deal of interest in what was happening and developed some guidelines which the unit manager could follow. In reality, little management occurred. Certainly no effort was made, nor any funds expended, to accurately locate and inventory the cave resource on the Forest.

In 1973 the Endangered Species Act was passed. This added a new emphasis to caves under the land administered by the Mark Twain National Forest.

Finally, in September of 1978, in cooperation with the Missouri Department of Conservation, a comprehensive inventory of the cave resource of the Mark Twain was undertaken. For the next four years Gene Gardner, who some of you know from past meetings, and for those who don't know him, he'll be giving a paper Saturday morning in the Missouri Room on "Invertebrate Fauna from Missouri Caves and Springs", headed this survey. Gene and his associates crawled in, over, around and through 226 caves on the Mark Twain National Forest.

Before one can manage a resource it is important to know where it is and something about it. Most land management people, be they public or private oriented, know a whole lot more about what is above ground than they do about what is below ground. In developing the survey strategy and techniques we felt it important to have someone who had an interest in caves and cave management from more than a recreational standpoint. Gene is a biologist so the inventory system used was developed to include the biology as well as the recreation and safety aspects of the cave resource.

As a part of the cooperative effort, along with the inventory we decided we needed a uniform cave classification system and some management recommendations that would be uniform for all of the caves on the Forest. The first step in developing appropriate management recommendations was the creation of a cave classification system which would apply to all caves on the Mark Twain National Forest. We did not want to reinvent the wheel as several cave classification and/or rating systems have been developed in recent years. Some are very complex and really not usable to land managers who are not intimately familiar with the resource they are attempting to manage. One major consideration in arriving at the final classification system was that it be adequate to base management recommendations on and yet simple enough that the management direction would be understood and applied on the ground. The classification system used for the cooperative cave inventory was prepared by establishing criteria for the cave resources and structural characteristics of caves found in Missouri's National Forest.

A very basic three category rating system was developed, utilizing portions of the content and hazard classification developed by Trout in 1978 for caves in New Mexico, combined with criteria that was developed for our own need. The three categories are UNRESTRICTED, RESTRICTED, and CLOSED. For each category management direction has been developed and is presently contained in the Draft Forest Land Management Plan.

The Draft Forest Land Management Plan is presently being reviewed in house and should go out for public review and comment early in 1985. In the meantime we are managing the caves in basically the fashion as that being proposed.

Now, what about the management of these caves?

As a general FOREST POLICY: 1) Camping will be prohibited within 100 feet of any cave or rock shelter. 2) No list of caves will be developed for general public distribution.

Caves in the UNRESTRICTED category are usually () small, not necessarily safe, but are the least hazardous to the average Forest visitor who is unfamiliar with proper caving equipment and unskilled in caving techniques. (2) These caves have little or no known potential cultural resources and natural history value, or ones which will not be adversely impacted by uncontrolled public usage. (3) These caves contain no known residents or seasonal populations of federally listed threatened and endangered species, or State listed rare and sensitive species or other biologically significant species or ecosystems. If such species exist in these caves or use the caves, they are not likely to be adversely impacted by uncontrolled public use.

The proposed management direction for UNRESTRICTED caves is:

1. No permit would be required to visit one of these caves.

2. These caves will receive periodic inspections for safety purposes, litter cleanup, and removal of signs of vandalism.

3. For the most part Forest visitors will be allowed to discover caves on their own. However, if the demand is great enough we will develop a Recreation Opportunity Guide for a selected few caves that Forest visitors could find and explore. A Recreation Opportunity Guide is simply a one sheet description of the cave giving its location and what recreation visitors will find and a description of the experience they can expect when they visit this particular cave.

We have had a large increase, recently, for all types of information on caves on the Mark Twain National Forest. I believe a majority of the interest has been a direct result of the publicity of this symposium. However, if I'm wrong and there is a real increased interest in caving we will be developing Recreation Opportunity Guides for some caves sooner than we expected.

Of the 226 known and inventoried caves 164 or 73% are listed as unrestricted. Of these, it is anticipated at this time no more than 20 will have a Recreation Opportunity Guide developed. This would leave about 145 or so caves that the recreating public could find on their own and explore at their own risk. That takes care of UNRESTRICTED caves; now how about the RESTRICTED caves?

Caves which have been classified as RESTRICTED were because of either content, hazard, or both. The criteria used for CONTENT was:

1. Federally Listed Threatened and Endangered Species

If the cave was being utilized as maternity sites for Gray Bats (myotis grisescens) or hibernacula for Indiana bats (myotis sodalis), it was classified as RESTRICTED. Also, any cave that it was demonstrated to be of critical seasonal importance to a federally listed threatened or endangered species was classified as RESTRICTED.

2. State listed Rare and Sensitive Species

It may be necessary to restrict visitation to a cave during a particular season to provide adequate protection for these species.

3. Rarely encountered, Unusual or Biologically Significant Populations of Cave Fauna

It may be necessary to restrict numbers of visitors and/or time of visitation to protect those certain cave fauna that need it to keep them from becoming extinct.

4. Cave Natural Areas

Some caves may qualify as a Natural Area under the State Natural

Area classification system. If a cave is so classified visitation may need to be restricted either to numbers, time of year, and/or both to protect the very environment that made it qualify as a Natural Area.

5. Rare or Unusual Formations, and

6. Paleontological Resources may also be present.

The criteria used for Hazards included:

1. Vertical Drops over 3 meters

2. Deep water - Unavoidable water depths of more than 2 meters

3. Flash Flooding Potential - Caves with a known history of flash flooding

4. Loose Rocks or Collapse Hazard

5. Confusing Passageways

These are all hazards that the average Forest recreation visitor is not equipped to handle, so these caves were classified RESTRICTED.

How about management of RESTRICTED caves? Each cave in this category will have a specific management plan. More than one cave may be included in the same plan. Items to be considered in the management plan are:

1. Who will be allowed in the cave? Everyone or only certain selected groups.

2. What restrictions will be necessary? Numbers at one time, total closure during some parts of the year, special equipment needed for safety of user.

3. User Control. Sign, gate or both.

4. Permit Need and Conditions. If a permit is necessary who, what, when, where and how one can be obtained.

5. Signing. Wording, location, number, placement.

6. Interpretative Material.

7. Enforcement Actions Needed

Every Restricted cave will be signed noting the restrictions.

Of the 226 inventoried caves 60 or 26% are listed as restricted. In the final analysis some of these 60 may move to the closed category for one reason or another. From the recreating public standpoint it should be noted that 99% of the caves on the Mark Twain National Forest are presently classified as either unrestricted or restricted and only 1% or 2 caves are classified closed.

The third classification was CLOSED.

The criteria used were:

1. Caves that have administratively or legislatively designated cultural resources or contain evidence and are being studied.

2. Caves that exhibit natural history values of such uniqueness that they should be protected from general public visitation.

3. Caves that have federally designated critical habitat requiring year-round protection.

Public safety alone will not mandate a cave be given closed status. Each cave that is put in the closed category will have its own unique management plan.

Some of the more general items as they relate to cave management on the Mark Twain National Forest are:

1. We intend to keep the information we have on each cave ADMINISTRATIVELY CONFIDENTIAL. This means the information will not be available to the general public but certainly anyone with a legitimate use will have access to the information.

2. All information known about caves under lands administered by the Mark Twain National Forest has been placed in the files of the Missouri Speleological Survey, Inc.

3. Visitation to most caves within the Mark Twain National Forest will be permitted whenever possible, but without degradation of cave resources.

4. Caver safety is a priority when allowing access to caves.

5. Each cave in the Restricted and Closed categories will have a sign near the cave noting the classification, reason for classification, and a request for cooperation from the Forest user who may come across the cave while engaged in some other recreational pursuit.

In summary, there are 226 caves located and inventoried within the Mark Twain National Forest. There are probably another 50 which are known about, but have not been inventoried. Our cave classification system includes three categories - UNRESTRICTED, RESTRICTED, CLOSED. The management direction presently contained in the Forest Land Management Plan, briefly stated, for UNRESTRICTED is: A Forest recreation visitor can find and visit these with little or no restrictions other than those imposed to protect the resource.

RESTRICTED - Each cave in this category will have its own management plan. Forest recreation users may be restricted as to party size, season and activities allowed during a visit to these caves.

CLOSED - Is just what it means. These caves will be closed to the average Forest recreation visitor. A few selected persons may be permitted in these caves for scientific study under a permit system only.

As a closing note on the management of caves on the Mark Twain National Forest, I would like to mention the volunteer agreement between the Mark Twain and the Missouri Speleological Survey who are doing cave mapping in our caves. This agreement continues to be an excellent working agreement that is providing another element to the data base. The maps are first class quality and will be a tremendous asset to the unit managers.

CAVE MAPS AS MANAGEMENT TOOLS

by Scott House*

ABSTRACT

Cave maps are an essential tool for land-cave managers. Cave maps have been with us for many years and thousands of uses have been found. Cave maps range in quality from simple sketches to elaborate three-dimension projections. The production of cave maps is a time consuming, precise process involving modern drafting techniques. The uses of cave maps fall into six (6) main categories:

1. Land Management
2. Inventory
3. Visitor Management
4. Interpretive
5. Scientific
6. Show-Cave

Why make cave maps? This is a question that frequently arises when the topic of cave mapping comes up. I am perhaps not the best person to answer this because I am a cave map maker and only occasionally a user. The simplest answer is "because they are there". In this paper I hope to look at some of the reasons why cave maps are made and to answer this best we need to look at the many ways that cave maps have been used.

Cave maps have been with us for many, many, years. One early example is a sketch map ("eye Draught") of Mammoth Cave, Kentucky, that was drawn sometime around the War of 1812. This map used little floor detail but instead relied on extensive notations to explain the cave passages. One of the earliest maps of a Missouri cave is one made of Marvel Cave around the turn of this century (Figure 1). This map is not a bad piece of work; among other things it utilizes considerable floor detailing. The 1940's saw a variety of maps produced in Missouri; several of these were produced by students of J Harlen Bretz. Each of these is different but interesting in its own way. The old Round Spring Caverns map, for example, uses contour lines to show the fluctuations of the floor, walls and ceiling (Figure 2). Over the past 30 years symbols have been standardized in Missouri under the leadership of cooperators of the Missouri Speleological Survey. Symbols nationwide vary considerably from group to group and the attendant frequent altering of symbols can prove to be very confusing to the average user (Figure 3). In the early 1970's there seemed to be a trend toward greater and greater use of specialized symbols that further confused the situation. In general the MSS has rejected this specialization, preferring to use pictorial representation and occasional notation in place of specialized symbols (Figure 4).

*Missouri Speleological Survey, Arnold, MO.

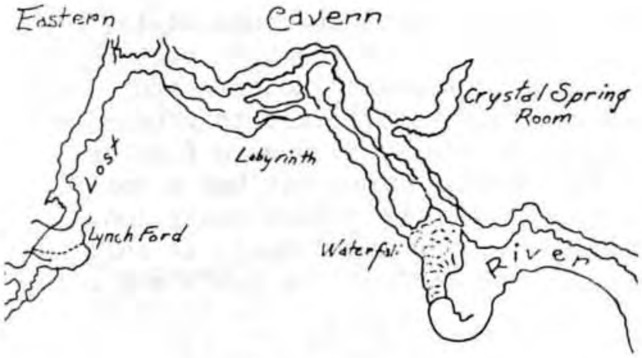

Figure 1.

Early map of Marvel Cave.

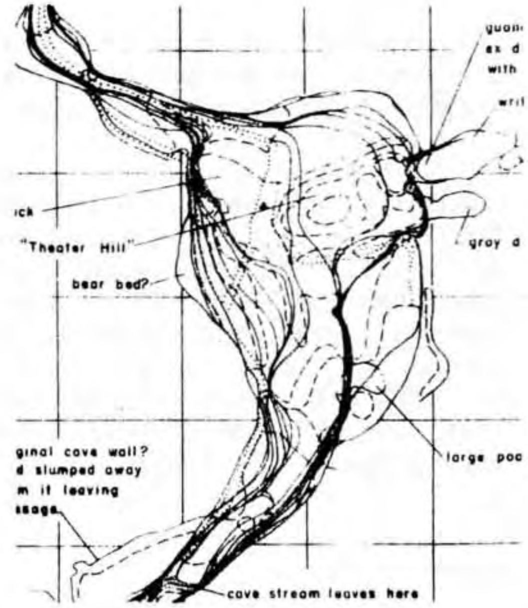

Figure 2.

Floor and Ceiling contours on map of Round Spring Caverns.

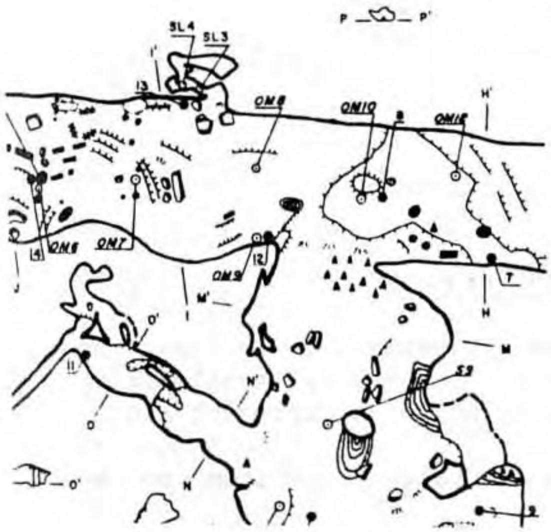

Figure 3.
Cave map containing confusing symbols.

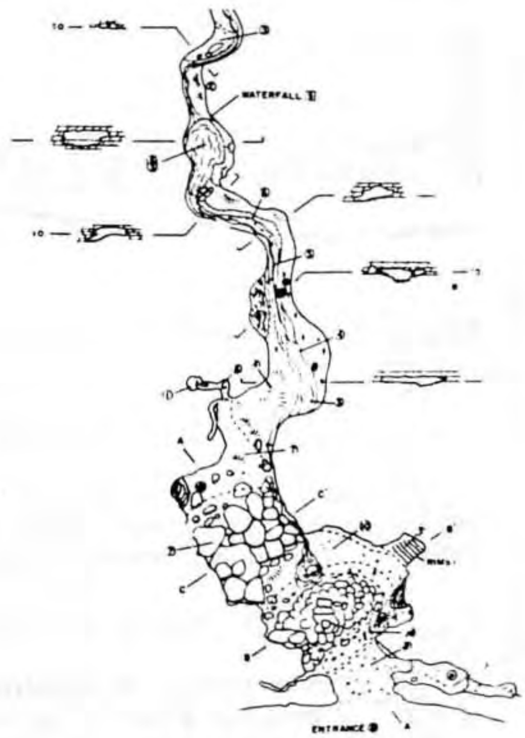

Figure 4.

Cave map containing pictorial representations and standard notations to show passage data and features.

The general topic of cave map symbols continues to be a source of much discussion in the speleological community and it is likely that further changes in the symbols will be coming.

Most cave maps contain a plan view and cross sections of the cave passage. A profile view of the cave or of certain sections is frequently useful but relatively few cartographers include them. This is usually because such profiles are fairly difficult to produce but also because many caves (particularly in Missouri) are so flat lying. Crevice Cave, for example, is nearly 28 miles long but has a vertical extend of less than 200 feet. Profiles would be ridiculously long and of very little use. Pleasant Hill Cave, on the other hand, is only 300 feet long but has a vertical extent of over 60 feet. A profile here is very informative (Figure 5).

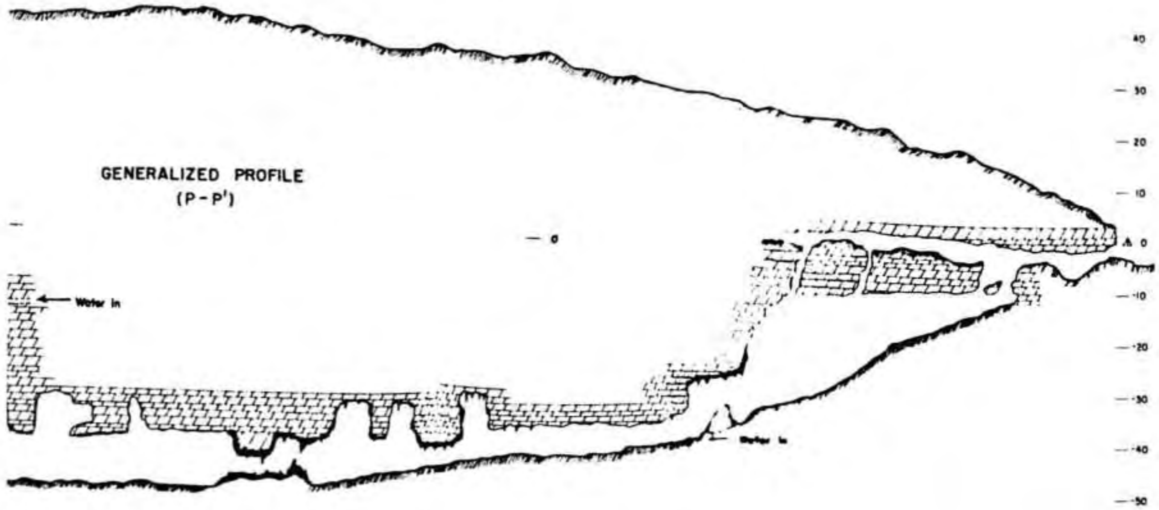

Figure 5. Vertical profile of Pleasant Hill Cave.

HOW CAVE MAPS ARE PRODUCED

It is not the intent of this paper to explain fully the methods of cave surveying; there are many other references available on that subject. Briefly, however, the essential steps in surveying are:

1. A front station is selected in a straight line from the rear station.
2. The distance is measured.
3. A compass bearing is read.
4. An inclination (if necessary) is read.
5. Up, down, left, and right measurements from the station are taken.
6. A sketch of the passage is made. (Normally the most difficult part, Figure 6.)

Once the field survey is done the truly difficult part begins: drafting. The first step is to plot the survey line. This can be done

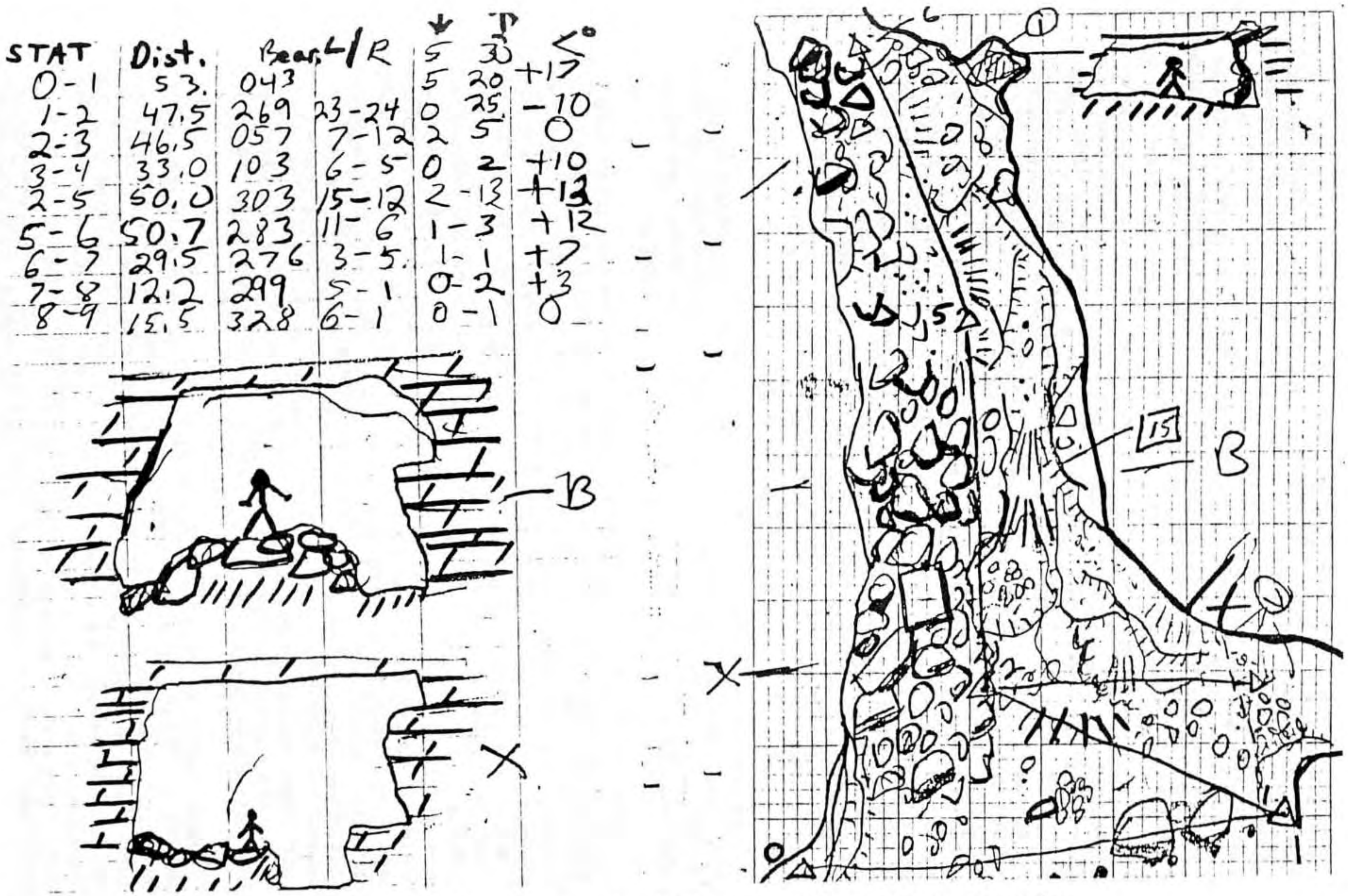

Figure 6. Field notes and sketch map made during surveying.

in one of two basic ways: the survey line may be hand plotted with protractor and scale or the data may be reduced by trigonometric methods (frequently by computer) to a coordinate system (called latitudes and departures by surveyors). This coordinate system is far more accurate and offers much more flexibility in terms of deciding on map size and scale. Once the survey line is plotted the walls are located by using the left and right measurements from the field survey. Then begins the task of drawing in the walls. Once these are drawn in the draftsman adds the floor detail, cross sections and notes. After the pencil draft is completed, usually on graph paper, a piece of mylar is laid over the map and the final ink copy is produced. The resulting maps may be reproduced in a variety of ways. By using a heat transfer process copies on mylar or paper can be produced. The map can be photographically reduced and printed by offset methods. Small maps may be copied directly by xerographic methods. Lastly, the map can be put on microfische and copies generated through microfische print machines. Map drafting and reproduction is not a cheap process; setting up a drafting facility usually requires an outlay of many hundreds of dollars, a fact that is frequently overlooked by cave managers desiring a map.

USE OF CAVE MAPS

We can split the use of cave maps by land and cave managers into two major categories: resource protection and interpretation. This is a simplification and many uses fall into both categories but let us consider these major divisions and investigate further.

Line maps of caves can be plotted onto topographic base maps. These maps are of much use in determining property acquisitions and legal questions of ownership. These can also show the relationship between various caves and can lead to further discoveries of cave passages and entrances. At Onondaga Cave State Park a topographic overlay was useful in determining the location of new water mains and road developments, the idea being to avoid negative impacts on the fragile cave passages below (Figure 7). In Perry County topographic overlays have helped geologists and land use specialists determine drainage areas for major cave systems; in that area numerous problems with groundwater pollution are beginning to "surface" and the maps are of major importance. Occasionally road projects have been built in high cave density areas and cave map overlays have helped prevent damage to both the caves and the proposed roads. This does not mean that wise choices have always prevailed: parts of the Cherokee Cave in St. Louis were destroyed for a highway project even though maps showed that sufficient bedrock existed to support the road.

Maps have a definite use in the area of cave inventory which is usually a first step in managing a resource. Unfortunately, the inventory frequently precedes the mapping of a cave. I would suggest then that the best approach might be to inventory caves on a periodic basis using maps as a base on which to make notes. For example: a geologist might use a cave map on a geologic inventory trip to note joint patterns, unusual mineralization, lithologic changes, etc. Similarly, resource management specialists could note such items of

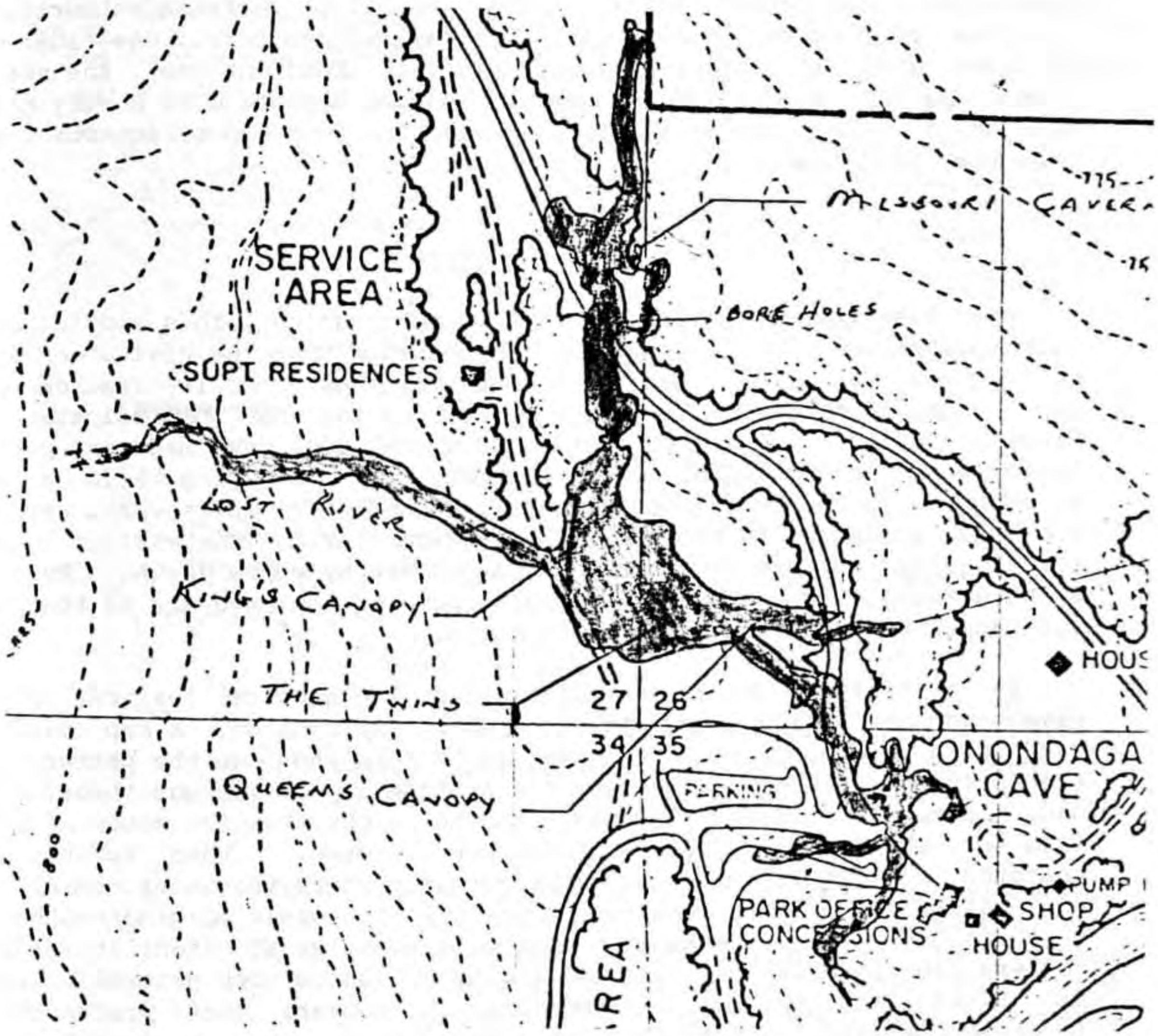

Figure 7. Plan view of Onondaga Cave with topographic overlay.

interest as use patterns (trash, vandalism, etc.), safety hazards, cave life, archeological or paleontological potential, photo locations, etc. Putting such information directly on a cave map saves much time and eliminates problems caused by unclear designations: instead of "the passage on the left side approximately 300 paces from the entrance" one can have an exact mark on the map designating the spot where three blind salamanders were found. Since cave passages frequently reflect geologic conditions such as folds and lineaments planners can derive patterns from cave maps that may help predict or explain groundwater flow in an area. Biologists using a cave map can accurately plot the locations of hibernating bats or bat maternity colonies in a format that is useful for quick data retrieval.

Cave maps are also extremely useful in publications, particularly in-house reports on investigations such as archeological and paleontological excavations or biologic and geologic studies. As historic records of natural features cave maps are excellent; one example comes to mind: the destroyed portions of Cherokee Cave. Cave maps were also once highly favored by civil defense authorities, one-time proponents of using caves for fallout shelters. One final use of cave maps in this area would be a very important one: the use of cave maps as an aid to cave rescue. A good map would be a very great aid in a rescue, particularly to advise the rescuers of equipment aid personnel requirements.

INTERPRETATION

How does interpretation differ from information. In a simple sense "interpretation" is "information" explained. Thus the visitor or user of a park, facility, forest, or show cave has hopefully reached some new understanding of information after he has participated in "interpretation". In a cave oriented surrounding cave maps can play a large part in successful interpretation. The old saying tells us that a picture is worth a thousand words; a good cave map is worth several thousand words. An overlay map can quickly orient the visitor to the relationship between the cave and the topography above ground. Even on such a simple map the main features both in the cave and in the park (or campground, etc.) can be easily shown.

In a visitor center a map might show historical features of the cave, another could show the routes of exploration. A map could be used with an exhibit on cave formation to help show how the patterns of the cave are related to the geologic setting or how various theories of cave formation are demonstrated. Another might show the zones of cave life or where preferred habitats are located. When springs are featured in visitor use areas, maps can show where the water comes from and help the visitor understand the important role of groundwater in our society. Geologic maps can also be used to great effect in helping to explain the areal geologic setting that creates such natural wonders as caves and springs. Sometimes it appears that professional interpreters and naturalists are hesitant to try to inject more advanced science into their interpretations for fear of leaving their audience behind. My experience in education tells me that one's audience will live up to (or down to) one's expectations. Too many exhibits tell us only the obvious and do little toward expanding the horizons of the visitor. If we wish to further educate the public we must not make the assumption that they are incapable of learning.

A good example of interpreting the resource is at Devil's Well in the Ozark National Scenic Riverways. Here the National Park Service has developed the Well so that visitors can peer into the lighted Well from the safety of a wooden platform at the entrance. A fine brochure uses a cave map (and geologic information) to explain how the Well fits into the Cave Spring supply system (Figure 8). Hopefully the NPS will also prepare a wayside exhibit at Cave Spring on the Current River and connect the two features with a trail so that the inquiring visitor can view both features and better understand the connection between them.

The Devil's Well brochure is just one of many brochures which use cave maps. Most of these are for show caves both private and public.

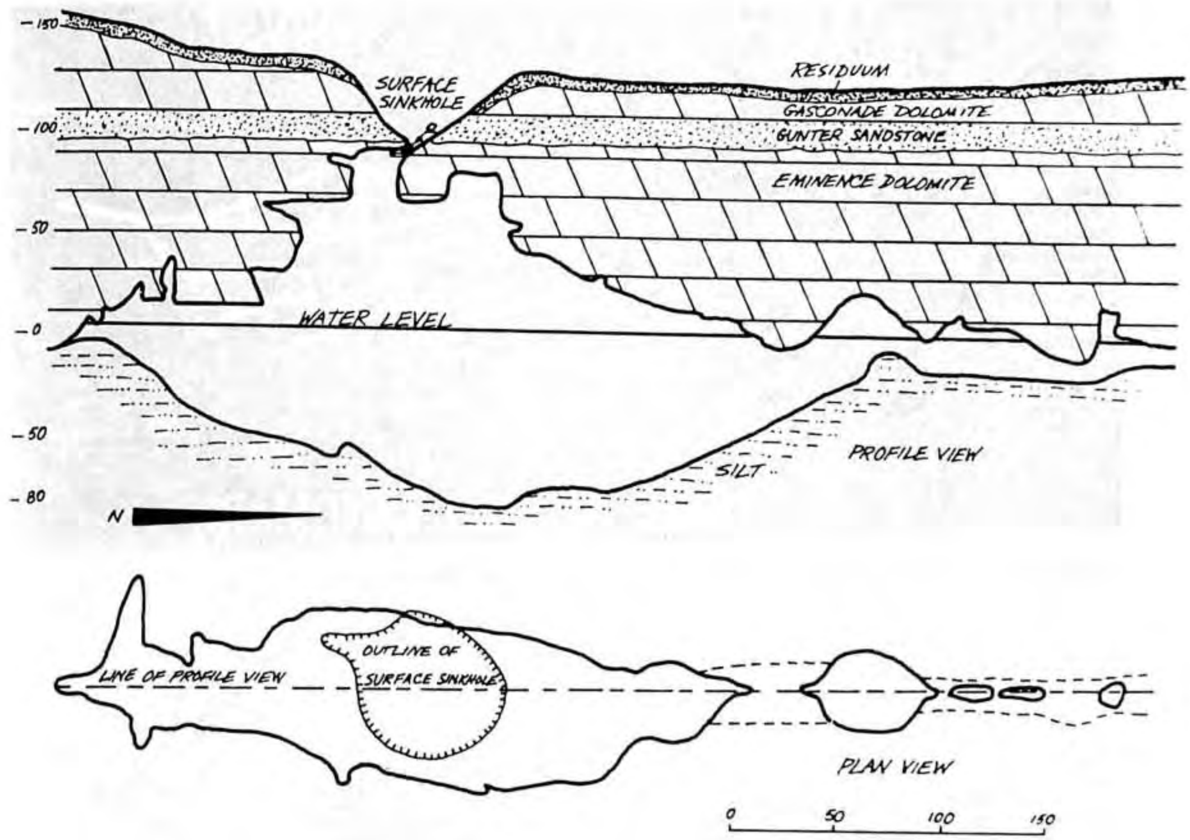

Figure 8. Plan and profile view of Devil's Well from National Park Service brochure.

Using maps in this fashion helps orient visitors even before they arrive on the site. Thus not only do visitors have a sense of what awaits them but they also develop enthusiasm for their coming experience. Many times the most important and most interesting feature of a cave is the pattern of the cave and cave managers ought to promote this. A good example of a cave map being used to demonstrate the cave pattern is on some Mark Twain Cave brochures which include a line map of the cave (Figure 9).

There are other uses for cave maps in show caves besides brochures. Every show cave ought to have a map on display in their visitor centers; these have great potential for showing the visitor what is going to be seen on the tour (Figure 10). Future developments are best planned on maps; estimates of cost can then more accurately be made. Proposed renovations can also be drawn in on a map, sidewalks and electrical circuits can be plotted on a map with ease. One of the recurring problems in show cave operation is the training of guides. By putting annotated notes on a cave map the management can quickly develop training materials for guides. Such a map can show discussion stops, formations of note, warnings ("watch your step"), etc. (Figure 11).

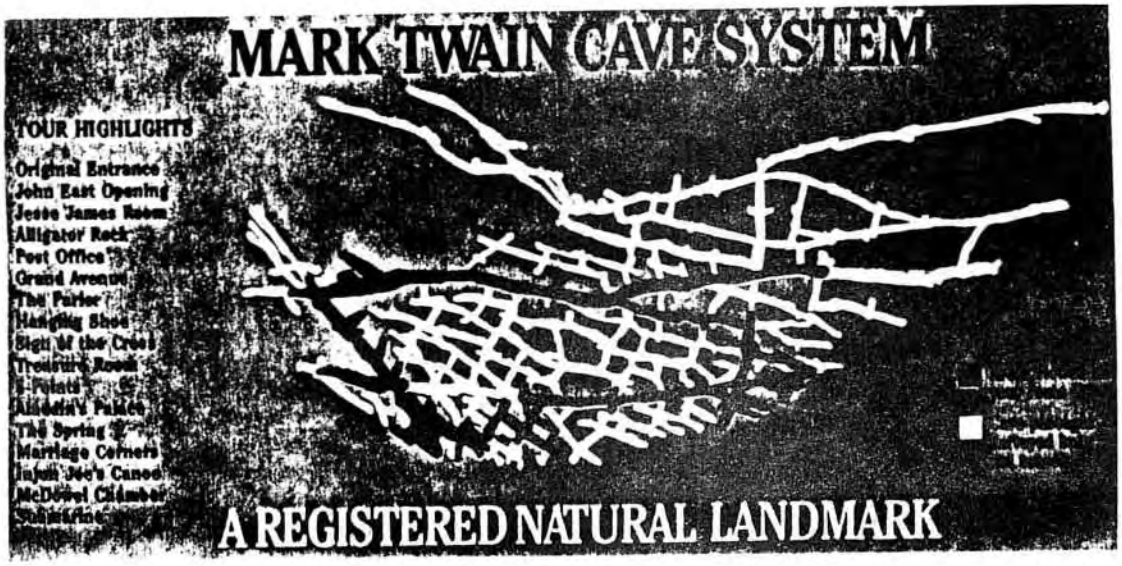

Figure 9. Cave map from Mark Twain Cave brochure.

Figure 10. Simplified map of a commercial cave illustrating features seen on the tour.

GETTING MAPS MADE

How does the landowner or cave manager get maps produced of his cave? Hopefully, some cave mapper might volunteer to do it. If this does not come to pass then one might attempt to solicit a volunteer through local or national cave research groups. It helps to have some sort of cooperative plan formulated in advance. The Missouri Speleological Survey currently has volunteer agreements with the Ozark National Scenic Riverways, Mark Twain National Forest, and the Missouri Department of Conservation. These agreements cover some travel and organizational expenses as well as provide for facilities such as camping places for the volunteers. The expenses that are incurred are minor compared to the great value of the final product. The words of warning: before agreeing to a cave mapping project be sure that the

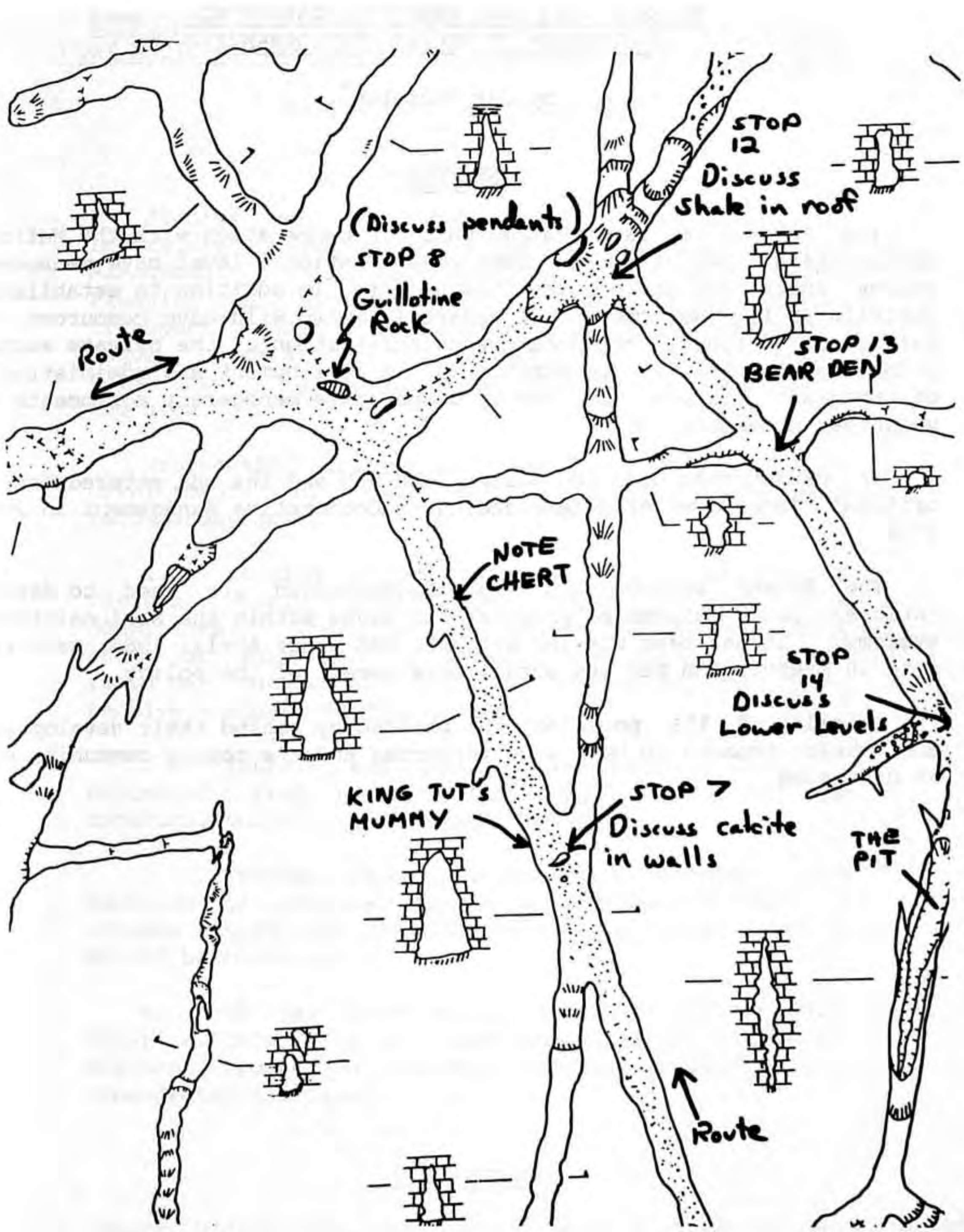

Figure 11. Example of how cave maps can be used for instructing new guides.

surveyor actually has a record of producing the maps that he promises. Many more maps have been promised than actually produced. We of the Missouri Speleological Survey are proud of our record of producing cave maps and we will continue to produce them for years to come. Why? Because the caves are there.

FEDERAL WILD CAVE RESOURCE MANAGEMENT: AN OVERVIEW OF RECENT DEVELOPMENTS

by Jer Thornton*

ABSTRACT

The Bureau of Land Management, in cooperation with the National Speleological Society, has completed a national level cave management policy which was implemented this summer. In addition to establishing guidelines for management of Federally owned wild-cave resources, the policy is strongly oriented toward utilization of the private sector, primarily the caving community, in the development and administration of programs through the use of cooperative management agreements and volunteer contracts.

In conjunction with the policy, the BLM and the NSS entered into an official Memorandum of Understanding on Cooperative Management in June, 1984.

The Forest Service has also acknowledged its need to develop national level management policies for caves within the National Forest system. It has been working with the NSS since April, 1984, gathering data in preparation for the actual development of the policy.

Details of the policies, the philosophy behind their development, and their impacts on both cave resources and the caving community will be discussed.

EFFECTS OF LAND MANAGEMENT ON CAVE AND WATER RESOURCES, DRY MEDICINE LODGE CREEK BASIN, BIGHORN MOUNTAINS, WYOMING

by Tom Aley* and Cathy Aley*

ABSTRACT

Studies were conducted by the Ozark Underground Laboratory under contract to the Bureau of Land Management in the Dry Medicine Lodge Creek Basin. Plugging of groundwater recharge and groundwater transport conduits with sediment and organic matter in lands underlain by the Madison Limestone/Jefferson Formation is a potentially serious resource problem in the area.

Groundwater tracing and other field work led to the development of four principal land management recommendations:

1. Sinking stream segments should be located through field observations under varying flow conditions. These sinking stream segment should be shown on maps and in reports and files used for resource management planning to insure that they receive adequate consideration.

2. Sinkholes and sinking stream segments should be protected from roads, truck trails, and from the unnatural addition of sediment and debris.

3. Through sound land management techniques, the addition of unnatural amounts of sediment and debris to streams which are tributary to sinking stream segments should be minimized.

4. If tar sand mining occurs as strip mining, major efforts will be required to minimize erosion, sediment production, and other potentially adverse upon groundwater and caves.

INTRODUCTION

The Ozark Underground Laboratory, under contract to the Bureau of Land Management, U.S. Department of Interior, conducted a series of investigations in the Dry Medicine Lodge Creek basin during the summer of 1983. A principal purpose of the investigations was to assess the effects of wildland management activities on cave and water resources in this topographic basin.

*Ozark Underground Laboratory, Protem, MO

HYDROLOGY OF THE DRY MEDICINE LODGE CREEK BASIN

Dry Medicine Lodge Creek has a topographic drainage basin of 44.9 square miles. It is located northeast of Hyattville, Big Horn County, Wyoming. Dry Medicine Lodge Creek is a tributary to Medicine Lodge Creek; the mouth of Dry Medicine Lodge Creek is about 4.7 miles northeast of Hyattville in an area locally known as Taylor Ranch.

Our hydrologic work was focused on areas underlain by soluble rocks. In the study area, this was primarily lands underlain by the Madison Limestone. A geologic map of the area (Lowry, et al., 1976) combines rocks assigned to the Madison Limestone, Jefferson Formation, and Three Forks Formation into a single mapping unit. However, the Three Forks Formation is apparently absent in the Dry Medicine Lodge Creek basin (Lowry, et al., 1976). The Jefferson Formation, which consists of brown dolomite, gray to tan limestone, and yellowish-gray siltstone (Lowry et al., 1976) underlies the Madison Limestone. For purposes of our investigations we have assumed that any units of the Jefferson Formation which may be present in the Dry Medicine Lodge Creek basin will hydrologically function in a manner similar to units assigned to the Madison Limestone. Stratigraphic mapping to distinguish between the Madison Limestone and the Jefferson Formation was beyond the scope of our project, and would not have been of much practical utility for the purposes of our investigations. It is worth noting, however, that geologic units underlying the Madison Limestone may be responsible for the numerous lakes found in the lower portions of La Caverna de los Tres Charros (Tres Charros Cave).

Based on the geologic mapping by Lowry et al. (1976), approximately 13.3 miles of the channel of Dry Medicine Lodge Creek is underlain by the Madison Limestone/Jefferson Formation. In addition, there are approximately 27.8 miles of stream channels tributary to Dry Medicine Lodge Creek which are underlain by Madison Limestone/Jefferson Formation. Adding the two values, the total length of stream channel in the Dry Medicine Lodge Creek basin which is underlain by soluble rocks of the Madison Limestone/Jefferson Formation is approximately 41.1 miles.

In general, stream channels in the Dry Medicine Lodge Creek basin which are underlain by rocks assigned to the Madison Limestone/Jefferson Formation are important groundwater recharge areas. When streams with perennial or nearly perennial flow enter areas underlain by rocks mapped as Madison Limestone/Jefferson Formation, the streams disappear into the groundwater system within a short distance. This can be seen on Dry Medicine Lodge Creek a short distance upstream of La Caverna de los Tres Charros; on Taylor Cow Camp Creek a short distance downstream of the Bureau of Land Management (BLM)-U.S. Forest Service (USFS) boundary; and on an unnamed tributary to Dry Medicine Lodge Creek (in this report we will call this unnamed tributary Old Cabin Creek) in the NE 1/4 of Section 17, T. 51 N., R. 88 W. All of these points were sites we utilized for the injection of groundwater tracing agents.

During snowmelt periods and major thunderstorms there is some surface flow in most stream channels which cross the Madison Limestone/Jefferson Formation. This occurs either because the solutionally widened lateral conduit systems do not have capacities large enough to accommodate these large volumes of water, or because there are finite limits to the amounts of nearly vertical infiltration which can occur through the stream channels.

La Caverna de los Tres Charros experiences major annual flooding throughout the lower portions of the cave system during snowmelt runoff periods. Lake levels in the lower portions of the cave rise 80 or more feet in elevation, and serve to backflood cave passages. Although there are no records, this flooding probably persists for several weeks each year. The flooding of La Caverna de los Tres Charros occurs because the conduit systems draining the lakes do not have flow rate capacities large enough to accommodate peak flow rates in the underground streams which contribute waters to the lakes. In many soluble rock areas, groundwater recharge rates commonly exceed groundwater transport rates, and underground flooding results. During periods of extensive underground flooding some portions of the groundwater system are filled with water and groundwater recharge rates in portions of surface stream channels are decreased. Our field evidence indicates that this is a common situation in the Dry Medicine Lodge Creek basin during snowmelt periods and perhaps also during major thunderstorms.

Our hydrologic work in the Dry Medicine Lodge Creek basin during the summer of 1983 included six groundwater traces. The tracing was designed to determine hydrologic relationships between sinking surface streams, cave streams, and springs in the area.

Our groundwater tracing work utilized four different tracing agents. These were: 1) fluorescein dye, 2) optical brightener dye, 3) direct yellow 96 dye, and 4) Lycopodium spores stained with saffranin O dye. The methods for tracing and detection followed procedures outlines in Aley and Fletcher (1976).

A detailed discussion of our 1983 groundwater tracing work is found in Aley and Aley (1984). A thorough discussion of these traces is beyond the scope of our current paper, however, it is appropriate to briefly summarize the findings. All of the tracer injections were at points where surface streams disappeared underground; all tracer sampling sites were located either within cave systems or at springs.

Our groundwater tracing showed that sinking streams are major (and sometimes predominant) sources of water for the caves streams of the area. Sinking streams are also major (and sometimes predominant) sources of water for those springs which have recharge areas which include appreciable lengths of surface stream channels underlain by the Madison Limestone/Jefferson Formation.

Our groundwater tracing showed that travel times through the groundwater systems were rapid. Travel rates for first arrivals of tracer pulses were typically on the order of hundreds of feet per hour. Tracing agents tended to move as pulses rather than becoming heavily diluted within the groundwater system. Typically, almost all of the tracer from a particular injection site would pass a downstream sampling station in a period of a few days. Based upon these observations it appears that the groundwater systems within the soluble rock units serve more to transport water than to store it. Low flows of springs and cave streams in the area are primarily regulated by geologic units other than the Madison Limestone/Jefferson Formation. These findings are not unusual for limestone or dolomite units which have experienced substantial development of secondary permeability.

Our groundwater tracing showed that most or all waters from La Caverna de los Tres Charros (Section 5, T. 51 N., R. 88 W.) also pass through Bad Medicine Cave (Section 13, T. 51 N., R. 89 W.). Waters from La Caverna de los Tres Charros also discharge from Upper, Middle, and Lower Dry Medicine Lodge Creek Resurgences (Section 23, T. 51 N., R. 89 W.) and from Upper and Lower Taylor Ranch Resurgences (Section 4, T. 50 N., R. 89 W.). Waters from La Caverna de los Tres Charros which discharge from the Taylor Ranch Resurgences almost certainly pass through Bad Medicine Cave; many of these waters almost certainly discharge from the Dry Medicine Lodge Creek Resurgences, flow on the surface for a short distance, and then sink again before reaching the Taylor Ranch Resurgences.

Based upon groundwater tracing and flow rate observations, there is a substantial amount of groundwater "missing" from downstream segments of the Dry Medicine Lodge Creek Basin. The combined flow of the three Dry Medicine Lodge Creek Resurgences was about 2.9 cfs on July 26, 1983. At the same time water was entering the groundwater system in the La Caverna de los Tres Charros area at a rate estimated at about 7 cfs. All of this water, plus an allowance of another 3 cfs from other tributary areas, flowed through Bad Medicine Cave. Based upon July 26, 1983 conditions, the volume of "missing" groundwater at the three Dry Medicine Lodge Creek resurgences was about 7 cfs.

The waters which discharged from the three Dry Medicine Lodge Creek resurgences flowed down the surface stream channel and then again sank into the groundwater system. It seems probable that all of this water subsequently discharged from the Upper and Lower Taylor Ranch Resurgences. The combined flow of the two Taylor Ranch Resurgences was about 4.5 cfs on July 26, 1983; this is 1.6 cfs more than the estimated combined discharge from the three Dry Medicine Lodge Creek Resurgences. The difference in discharge between the two groups of resurgences could be due entirely to groundwater contributions from areas topographically tributary to Dry Medicine Lodge Creek downstream of the Dry Medicine Lodge Creek Resurgences. Even if this is not the case, it is apparent that most of the water "missing" from the Dry Medicine Lodge Creek basin between Bad Medicine Cave and the three Dry Medicine Lodge Creek Resurgences does not reappear at either of the Taylor Ranch Resurgences.

Monsson (1974) gaged the combined flow of Taylor Ranch Resurgences on September 19, 1974 at 0.60 cfs. On September 20, 1974, he gaged the flow of Dry Medicine Lodge Creek upstream of La Caverna de los Tres Charros at 1.98 cfs. On the same date the flow of Taylor Cow Camp Creek was gaged at 0.39 cfs. Based upon these values, in late September, 1974 Dry Medicine Lodge Creek basin was "missing" in excess of 1.77 cfs. At this time of year evapotranspiration losses downstream of the three Dry Medicine Lodge Creek resurgences should have been negligible.

Based both upon our work and the work of Monsson (1974) we believe that an appreciable part of the water yield from the Dry Medicine Lodge Creek basin is "missing". More stream gaging would be very helpful, especially now that it can be tied to groundwater tracing results.

In conjunction with groundwater trace 3 we sampled Medicine Lodge Creek (the basin south of Dry Medicine Lodge Creek) at a point just upstream of the mouth of Dry Medicine Lodge Creek; we did not detect any tracer dye at this site. Therefore, none of the "missing" water appears in the Medicine Lodge Creek basin upstream of the mouth of Dry Medicine Lodge Creek. We doubt that it would appear downstream.

In addition to walking Dry Medicine Lodge Creek from Bad Medicine Cave downstream to the Taylor Ranch Resurgences, we also examined this stream between the Taylor Ranch Resurgences and the mouth of the stream. We did not find any other significant springs which would account for the "missing" water.

A third possibility is that the "missing" water discharges from one or more springs in the Trapper Creek basin, which lies north of the Dry Medicine Lodge Creek basin. On August 2, 1983, we conducted a hydrologic reconnaissance of this basin. In the SE 1/4, SW 1/4 of Section 21, T. 52 N., R. 89 W. a series of at least five principal springs discharge to Trapper Creek from low solutional passages on the south side of Trapper Canyon. The principal springs discharge in an area about 75 feet long. The solutional passages from which the springs discharge cannot be entered. The combined flow of these springs was estimated at 10 cfs on August 2, 1983. The flow of Trapper Creek about 1/4 mile downstream was estimated at 10 cfs on August 2, 1983. The flow of Trapper Creek about 1/4 mile downstream of these springs was estimated at 15 cfs on August 2, 1983; all of this flow was derived from springs in Section 21.

The elevation of the major springs on Trapper Creek in Section 21 (we will call these the Section 21 Springs) was about 6,760 feet. The elevation of our sampling site in Bad Medicine Cave was 6,880 feet. This point in Bad Medicine Cave is thus 120 feet higher than the Section 21 Springs and 5.3 miles straight line distance away. The potential hydraulic gradient between Mad Medicine Cave and Section 21 Springs is thus about 4.3 feet per 1,000 feet. Although this may seem a very gentle gradient, it is larger than many of the groundwater gradients involved in interbasin groundwater transport in the Missouri karstlands (Aley, 1978). Aley (1978) successfully traced both fluorescein dye and stained Lycopodium spores in Missouri from a sinking stream segment of the Middle Fork of the Eleven Point River to Big Spring, a large tributary to the Current River. The straight-line travel distance for this trace was 39.5 miles, and the mean gradient was 1.93 feet per 1,000 feet; the travel rate for the first recovery of the tracing agents was 669 feet per hour assuming straight line travel.

A fourth possibility for the flow route of the "missing" water is that it recharges groundwaters within the Big Horn basin. Wells such as the new municipal water supply wells for Worland located in the Blue Ridge area west of Hyattville have encountered large volumes of good quality water. These wells are apparently extracting much or most of the water from solutional openings in the Madison Limestone and perhaps in stratigraphically adjacent soluble rock units. Streams such as Dry Medicine Lodge Creek could be extremely important in recharging such wells, and the importance of this recharge would increase as water extraction from deep wells in the Madison Limestone and adjacent geologic units increases. When karst or paleokarst aquifers are developed as major water supply sources, rapid and long-distance conduit groundwater flow and induced groundwater recharge in areas remote from the pumping wells commonly occurs. This should be recognized in water resource planning in the Big Horn Mountains.

EFFECTS OF LAND MANAGEMENT ON CAVE AND WATER RESOURCES

La Caverna de los Tres Charos and Bad Medicine Cave are located on public lands administered by the Bureau of Land Management. At least 90% of the water which enters La Caverna de los Tres Charros is yielded from public lands administered by the Bighorn National Forest. We estimate that about 70% of the water which enters Bad Medicine Cave is also derived from National Forest lands, with BLM administered lands contributing most of the remaining water.

La Caverna de los Tres Charros is a cave system with numerous streams, waterfalls, and lakes. Bad Medicine Cave is primarily a passage filled with a major underground stream. Our groundwater tracing demonstrated that both of these caves are directly connected with surface streams. The waters found in the caves are primarily derived from waters sinking in the channels of surface streams. In some cases, sinkholes have formed in the surface stream channels, and much water enters the cave systems through these sinkholes.

La Caverna de los Tres Charros is almost devoid of cave formations (speleothems). Although we have not seen most of the passages in Bad Medicine Cave, we anticipate that this cave probably also lacks substantial speleothem decorations. It is worth noting that Great X Cave (in the adjacent Trapper Creek Basin) apparently contains some substantial displays of speleothems.

Because of the direct connections between the caves of the Dry Medicine Lodge Creek basin and the sinking streams of the area, the most significant impacts on the caves from land management activities will be water related. More specifically, the most significant impacts will be associated with water quality in the streams and with sediment and debris loads in the streams. Since the caves in the area are generally undecorated with speleothems, management activities on lands immediately overlying the caves in the Dry Medicine Lodge Creek basin are not generally crucial to the protection of resources in the underlying cave systems. This generalization presumes that such surface management activities do not result in accelerated erosion or accelerated transport of organic material into the streams (and ultimately the caves) of the area.

Tremendous amounts of sediment and organic debris are flushed into the cave systems of the area through the sinking streams. As an example, there are a number of sticks and even some logs jammed in passages in La Caverna de los Tres Charros. Large amounts of organic debris can be seen at many points in the cave where waters temporarily slow in velocity or pond. This is very noticeable around the lakes in the lowest portions of La Caverna de los Tres Charros.

Under natural conditions the streams of the area transported substantial quantities of sediment and organic material. These materials in turn entered the cave systems. Without doubt grazing, road building, and logging in the area have all tended to accelerate the transport of these materials into the streams and ultimately the caves of the area. The question of concern is, has this change been detrimental to cave or water resources? Based upon our examination of the area and underlying cave systems, our understanding of groundwater transport in karst systems, and the results of groundwater trace #5, it is our conclusion that the increased contribution of sediment and organic material into groundwater systems of the area has been harmful to both water and cave resources. Damage has occurred to groundwater systems through the plugging or partial plugging of solutionally enlarged conduits through which water naturally travelled into and through the groundwater systems. Cave resources have been damaged by the deposition of sediment and debris in cave passages, and particularly in some of the lower gradient passages such as the ponds and lakes in La Caverna de los Tres Charros.

Groundwater trace #5, the Second Taylor Cow Camp Creek trace, was conducted using stained Lycopodium spores. The injection site contributes water to La Caverna de los Tres Charros.

The Second Taylor Cow Camp Creek trace was designed to help characterize the nature of the groundwater system between the injection site and the Upper and Lower Taylor Ranch Resurgences. From previous groundwater tracing we knew that water from the injection site discharged from both Upper and Lower Taylor Ranch Resurgences. Lycopodium spores were used as the tracing agent since they have a mean diameter of 33 microns and can be removed from water which passes through fine sands or smaller materials. The spores can probably also be removed from water which passes through a moderate amount of combined organic material and sediment.

Lycopodium spores have been successfully traced for straight-line distances of up to 39.5 miles (Aley, 1978). Such traces require turbulent flow of water through conduit systems which are wider than the diameter of the spores. Groundwater velocities and gradients in the Dry Medicine Lodge Creek basin are great enough that Lycopodium spores should be readily transported through the groundwater system unless they are forced to pass through sand, sediment, or organic material (or a combination of these) which would remove them through filtration. Since Lycopodium spores were not recovered either at Upper or Lower Taylor Ranch Resurgence, it is our conclusion that the spores were removed through filtration.

It should be noted that no Lycopodium sampling was done in Bad Medicine Cave. It would be interesting to determine if spores can travel between La Caverna de los Tres Charros and Bad Medicine Cave, or between Bad

Medicine Cave and the Taylor Ranch Resurgences. Such an investigation was beyond the scope of the current assessment project.

If the spores were removed by filtration, then there can be no traversable air-filled or water-filled cave passage passing the complete distance between the tracer injection point and the Taylor Ranch Resurgences. This will undoubtedly be a disappointment to cavers. However, from a natural resource management standpoint, there is a more serious implication of our inability to recover Lycopodium spores from the two Taylor Ranch Resurgences.

If the spores cannot be flushed through the groundwater system, it does not seem reasonable to assume that sediment and debris entering the groundwater system would be flushed through the groundwater system. Large volumes of sediment and organic material are currently entering the groundwater system in the Dry Medicine Lodge Creek basin through sinking stream segments such as those where we have injected our tracing agents. The streams in La Caverna de los Tres Charros and Bad Medicine Cave carry large loads of sediment and organic material. Unless most of the sediment and debris which enters the groundwater system in the Dry Medicine Lodge Creek basin is rapidly flushed through the groundwater system, plugging of the solutionally widened conduit systems which transport water through the subsurface will ultimately occur.

The plugging of conduit systems in karst areas results in a decrease in recharge of groundwater systems which supply both springs and wells. When this occurs, streams which used to sink into the groundwater system transport more of their water on the surface than was the case under natural conditions. This would adversely affect water flows from springs, possibly reduce water volumes available for extraction by wells, impact trout streams, and result in more water losses through evapotranspiration.

In some of the Ozark karstlands extensive and destructive logging and grazing in the late 1800's and early 1900's caused accelerated erosion and ultimately the plugging of groundwater recharge zones and other groundwater conduits (Aley, 1978). It has only been in recent years that sound land management has restored groundwater recharge to more near-natural conditions (Aley, 1978). Similar situations can also be seen in urban karst areas where land development introduces large volumes of sediment and organic material into groundwater systems. We see no reason that plugging of the groundwater conduit systems could not occur in areas such as the Dry Medicine Lodge Creek basin. This is particularly true in view of the fact that sinking streams are the major water input zones for the groundwater systems of the area, and that these streams transport large sediment and debris loads.

Based upon historic problems with plugging of karst groundwater systems elsewhere in the world and the results of our attempted Lycopodium spore tracing, it is our recommendation that land management agencies in the Dry Medicine Lodge Creek basin should accept the karst groundwater system plugging problem as a land management premise. To insure the protection of water and cave resources in the Dry Medicine Lodge Creek basin, land management actions should protect sinking stream segments from waters transporting excessive amounts of sediment and/or organic debris. Furthermore, land management actions should seek to reduce the amounts of sediment and organic materials introduced into streams upstream of sinking stream segments.

The Dry Medicine Lodge Creek basin and adjacent public lands in the Big Horn Mountains receive extensive use. Present land uses which have the potential for adversely impacting water and cave resources include livestock grazing, logging, and recreational activities. Strip mining of tar sand deposits, should it develop in the area, could also adversely affect water and cave resources.

Since the grazing season in the Big Horns is short, range stocking is heavier than might otherwise occur. Even if the carrying capacity of the land for livestock (which is based primarily on forage production) is not exceeded, the heavy stocking results in accelerated erosion. Many of the soils in the area are erosive, and livestock trails (particularly those leading into stream channels) produce substantial amounts of sediment. Livestock water in the area is provided almost entirely by unfenced streams, which of course focuses livestock use and resulting accelerated erosion in areas where much of the sediment can readily enter flowing waters. In that portion of the Dry Medicine Lodge Creek basin upstream of the two Taylor Ranch Resurgences, essentially all of the streams enter the groundwater system of the Madison Limestone/Jefferson Formation through the channels of sinking streams.

Timber harvesting (logging) also occurs in the Dry Medicine Lodge Creek basin. Past logging operations short distances upstream of sinking stream points in Taylor Cow Camp Creek and Old Cabin Creek were visited. In general, the logging did not leave a band of undisturbed vegetation along the streams, but instead logged up to the stream bank.

Other activities associated with the logging were not always set back from stream channels. For example, a log landing was constructed on Taylor Cow Camp Creek only a few hundred feet upstream of the major sinking stream segment on this stream. A short distance downstream of this landing the truck trail constructed at the time of the logging is currently collapsing into a sinkhole. It is likely that Taylor Cow Camp Creek sank in the vicinity of the new sinkhole prior to the construction of the logging truck trail, and that the sinking point was partially covered with a dirt, rock, and debris fill to support the truck trail.

We also examined truck trails constructed in conjunction with logging on Dry Medicine Lodge Creek downstream of the mouth of Taylor Cow Camp Creek, and on Old Cabin Creek. The truck trails are generally built along the streams and include numerous stream crossing. Many of the truck trails were not put to bed at the end of the logging, but are no longer passable due largely to washouts of stream crossings and certain other truck trail segments. These truck trails obviously added large volumes of sediment to runoff waters both during and subsequent to the logging operations.

More recent logging operations in the region display more concern for the protection of water resources than do the older operations. This is the direction that both policy and practice is taking in public agencies. In our recommendation section of this report (which follows the present section) we have identified the nature of the protection necessary for water and cave resources in those areas underlain by the Madison Limestone/Jefferson Formation.

Recreational activities in the Dry Medicine Lodge Creek basin can also adversely impact cave and water resources. First, if cave visitors marred cave features, this would obviously damage and degrade the resource. We found no problems of this sort currently existing in La Caverna de los Tres Charros; we encourage BLM to maintain their vigilance.

It is through vehicle use that recreational activities create their most significant adverse impacts on water and cave resources in the Dry medicine Lodge Creek basin. Many truck trails in the area show abundant evidence of severe erosion; some abandoned truck trails have been eroded into large gullies. The truck trails serve both recreational and other land uses (such as grazing) in the area, but a real or perceived recreational demand to keep truck trails open undoubtedly has major impacts on public agency decisions in the area.

Through signing programs, a number of the truck trails in the area are being closed. For public land management agencies this is always a difficult task, and a task which can fail due to inadequate public support and compliance with closures. We are encouraged by the closure of some of the more erosive truck trails; this is an important step in protecting water and cave resources in the area. Even though closed, some of the former truck trails continue to erode and produce substantial amounts of sediment. There is an obvious need in the area for restoration work on and along some of these closed truck trails. In some of the severely disturbed areas the erosion problems are too severe to leave the rehabilitation to nature; rehabilitation work with men and equipment is needed to minimize continuing severe erosion problems.

There is a potential new land use which may occur in or near the Dry Medicine Lodge Creek basin in the future. This is the mining of tar sand deposits. It is our understanding that technology for extracting petroleum products from the tar sands is probably the most significant barrier to the mining of tar sands in the area. If these processing problems can be overcome, then tar sand mining in the area may become economically feasible.

If tar sand mining ultimately occurs in the area, it will probably be conducted by strip mining. Based upon our knowledge of strip mining and the examination of the existing site, the mining of tar sands in the area could substantially increase sediment loads in the streams of the area. Since the tar sand deposits are associated with geologic units which overlie the Madison Limestone, many of the prospective tar sands mining areas are upstream of sinking stream segments. Should mining of these deposits occur, cave and water resources in the region could be significantly impacted by sediments (perhaps including sediments with hydrocarbons). If such mining were occurring, there would probably be potentials for liquid spills of hydrocarbons into streams and ultimately groundwater systems.

LAND MANAGEMENT RECOMMENDATIONS

The following land management actions are recommended to insure adequate protection for water and cave resources in the Dry Medicine Lodge Creek basin. Most of the recommended actions are for rather standard steps to reduce erosion and the addition of sediment to streams. While concern for erosion and sediment loads in streams should be a component of land management on all public lands, it is our conclusion that the effectiveness of these actions must be substantially better than "average" on the Dry Medicine Lodge Creek basin because of the interactions between surface waters and groundwater.

In the following tabulation each recommendation is underlined, and the rationale is briefly explained.

1. <u>Sinking stream segments should be located through field observations under varying flow conditions. These sinking stream segments should be shown on maps and in reports and files used for resource management planning to insure that they receive adequate consideration.</u>

Sinking stream segments are critically important groundwater recharge zones. As such, they warrant identification and special management.

2. <u>Sinkholes and sinking stream segments should be protected from roads, truck trails, and the unnatural addition of sediment and debris.</u>

Plugging of portions of the groundwater systems of the area is of major concern. Obviously, major attention needs to be directed at sinkholes and sinking stream segments since these are the places where most of the sediment and debris would enter the groundwater systems and the associated caves.

A portion of the truck trail constructed along Taylor Cow Camp Creek in conjunction with logging of the area is now collapsing into a sinkhole. Prior to the construction of this truck trail, the area where the sinkhole is now developing was undoubtedly a sinking stream (and perhaps was a sinkhole). The construction of this truck trail and the present collapse in the area has contributed tons of sediment to the underlying groundwater system and ultimately to La Caverna de los Tres Charros and Bad Medicine Cave. Subsidence and/or collapse of roads or other structures must be anticipated in sinking stream areas, and for this reason alone such areas are undesirable for the location of roads and structures.

3. <u>Through sound land management techniques and strategies, the addition of unnatural amounts of sediment and debris to streams which are tributary to sinking stream segments should be minimized.</u>

Essentially all of the sediments and debris which enter groundwater systems and caves of the area are transported by streamflow. Since the groundwater system and the caves can be adversely affected by unnatural additions of sediment and debris, efforts are needed to minimize the addition of these materials to streams which ultimately contribute to groundwater systems and caves.

To the extent possible, road crossings of streams should be avoided in valleys upstream of sinking stream segments. Where it is necessary that they be constructed, they should be designed and constructed as permanent features. Alternately, if they are to be used only for a period of a few months, they should be removed and the area restored after their period of utility.

If roads must be located in sinking stream valleys or in valleys tributary to sinking stream segments, the roads should be designed, constructed, and maintained in such a way as to not produce excessive erosion nor to be severely eroded by high flows.

The truck trail along Dry Medicine Lodge Creek from Taylor Cow Camp Creek to the Taylor Ranch Resurgences is an example of the type of road which can severely impact cave and groundwater resources. It has numerous stream crossings (most of which have washed out during high flows) and substantial segments have been almost totally removed by erosion. This truck trail has undoubtedly introduced hundreds of tons of sediment into Dry Medicine Lodge Creek and the sinking stream segments in this basin.

Within the Dry Medicine Lodge Creek watershed, existing areas with severe erosion should be stabilized. Some of the worst of these are associated with old truck trails. Erosion gullies which currently transport substantial quantities of sediment have typically received little if any stabilization or restoration efforts. In areas experiencing severe gully erosion, adequate stabilization of erosion gullies will require work with men and equipment to minimize continuing severe erosion problems.

In areas upstream of sinking stream segments, filter strips of uncut and undisturbed natural vegetation should be left between stream channels and areas which are logged. This should apply both to perennial and intermittent stream channels. The width of the filter strip should be greater in areas near or adjacent to identified sinking stream segments than in areas more remote from sinking stream segments. We have no recommendations for the precise widths of filter strips, and believe that they can best be determined from local experience. The filter strips should be wide enough to effectively protect stream channels from most of the sediment and organic material derived from the logging operation.

It is generally acknowledged that much of the sediment produced from logging operations is derived from roads and truck trails, skid roads, and landings. An effective filter strip must always be left between these features and stream channels upstream of sinking stream segments. The need for an effective filter strip should be a major factor in locating roads and truck trails, skid roads, and landings in or near stream valleys.

Grazing is a major source of accelerated erosion in the Dry Medicine Lodge Creek basin. During the period of our field work Forest Service lands were receiving much heavier grazing use than were similar BLM lands. Perhaps this relationship changes as the season progresses.

Presumably the grazing use of the area is governed by calculated carrying capacities. When properly calculated, carrying capacities should reflect both the ability of the forage plants to recover from grazing and the capacity of the land to withstand erosion and other resulting resource degradations. We recommend that carrying capacity calculations for lands in the Dry Medicine Lodge Creek basin be periodically reassessed to insure that they are set at levels which protect not only the forage but also the soil, water, and cave resources of the area.

Problems of sediment production from grazing are increased by allowing livestock to have totally free access to the streams. The result of the free water access is that livestock develop and use some steep and erosive slopes in reaching the streams. Where these problems are most severe, deflector fences could be useful in reducing erosion and protecting water and cave resources.

4. <u>If tar sand mining occurs as strip mining, major efforts will be required to minimize erosion, sediment production, and other potentially adverse impacts upon groundwater and caves.</u>

There are few land uses which historically have caused more sediment production than strip mining. We know little about the potential problems of revegetating tar sand strip mines, but did note during our visit to the mining area north of Sheep Springs that natural vegetation was not becoming established in that disturbed area. In addition to stabilization of exposed earth and re-establishment of adequate vegetation on mined areas, sediment retention ponds would almost certainly be needed between mining areas and sinking stream segments.

REFERENCES

Aley, Tom and Mickey W. Fletcher, 1976, The water tracer's cookbook: MO. Speleology, Vol. 16:6. pp. 1-32.

Aley, Tom, 1978, A predictive hydrologic model for evaluating the effects of land use and management on the quantity and quality of water from Ozark springs: Mo. Speleology, Vol. 18. pp. 1-185.

Aley, Tom and Cathy Aley, 1979, Cave assessment, monitoring, and management recommendations for La Caverna de los Tres Charros, Bureau of Land Management, Worland District, Wyoming: Ozark Underground Laboratory contract report for Bureau of Land Management. 81p.

Aley, Tom and Cathy Aley, 1984, Cave and karst hydrology assessment for Dry Medicine Lodge Creek and Trapper Creek Basins, Wyoming: Ozark Underground Laboratory contract report for Bureau of Land Management. 113p.

Bureau of Land Management, 1978, Worland District cave management plan: Bureau of Land Management, 37p. plus appendix and maps.

Lowry, Marlin E., Hugh W. Lowham, and Geogory C. Lines, 1976, Water resources of the Bighorn Basin, Northwestern Wyoming: U.S. Geol. Surv. Hydrologic Invest. Atlas HA 512. 2 large sheets.

Monsson, George N, 1974, Reconnaissance report on the La Caverna de los Tres Charros cave system, and its hydrology: Ms. rept. 11p. + map.

HYDROGEOLOGIC ASPECTS OF THE NOVEMBER, 1981 LIQUID FERTILIZER PIPELINE BREAK ON GROUNDWATER IN THE MARAMEC SPRING RECHARGE AREA, PHELPS COUNTY, MISSOURI

by James E. Vandike*

ABSTRACT

The concepts and techniques that apply to cave management can also apply to the management of a spring. Many Ozark spring systems consist, in part, of water-filled caves. A major difference between management of an air-filled cave, especially one lacking a significant cave stream, and a cave-spring system is the size of the management area. A large spring system may be recharged from an area of more than one hundred square miles. Thus, surface activities in areas miles from a spring can drastically affect water quality of the spring.

In November 1981, a leak from a buried section of an ammonium nitrate-urea pipeline released a large amount of nitrogen-rich material in a karst watershed in south-central Missouri which recharges Maramec Spring, a privately owned first magnitude spring. The Spring is used for trout rearing by Missouri Department of Conservation.

Water-quality degradation began at the spring eight days after the spill was reported. Dissolved oxygen decreased from the normal 7 to 8 mg/l to less than 0.2 mg/l. Nitrate plus nitrite content peaked at 4.2 mg/l and ammonia levels exceeded 2 mg/l. The pipeline company initally estimated that the spill released only 1,344 gallons. However, calculations based on water-quality samples and daily discharge measurement at Maramec Spring indicate that about 24,100 gallons of liquid fertilizer leaked from the pipeline. A hydrograph analysis of Maramec Spring and water-quality samples indicate that the leak probably began at least five days before it was discovered.

On May 13, 1982, 3 gallons of Rhodamine WT fluorescent dye was injected into a losing stream at the break site. The dye began emerging from Maramec Spring between 11 and 12 days after injection.

Detailed water-quality sampling and associated field work allowed accurate documentation of the damages caused by the spill. The same concepts would apply to water quality problems in caves containing streams.

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In November, 1981, a liquid fertilizer pipeline break in Phelps County, Missouri caused groundwater contamination for more than a month in an area where residents depend on private wells for water supply,and caused near total destruction of aquatic life at Maramec Spring.

One of the prices paid for progress is the increased risk of environmental accidents. The fertilizer pipeline is understandably a benefit, one that affects thousands of farmers in the Midwest. It allows the rather bulky nitrogen fertilizer to be moved long distances economically. Unfortunately, this pipeline is about 50 years old and regardless of care and maintenance, it, like all pipelines, is subject to leaks and breaks.

When dealing with a spill such as this, generally three steps are followed. First, the spill site is examined, an estimate of how much material was spilled is made, and the spill is cleaned up as much as possible. Second, the effects of the spill are predicated and the magnitude of the effects estimated. The third step is to establish some kind of monitoring program to assure detection of the spilled material and to monitor its effects on the environment.

The fertilizer pipeline break was reported November 15, 1981, and the site was visited by personnel from the Missouri Division of Environmental Quality Emergency Response Team. The break occurred where the buried pipeline crosses under a small, spring-fed tributary of Dry Fork in southeast Phelps County (Figure 1). At the time, there was no flow upstream from where the fertilizer entered Dry Fork, but downstream for about a mile, there were numerous pools with flow between them. At the end of the pools, the bed of Dry Fork once again was dry and remained so for about 10 miles downstream. Williams Pipeline Company, owner of the pipeline, estimated the amount of material lost at 32 barrels, or 1,344 gallons, a relatively small amount. This estimate was based on the size of the hole in the line and the estimated length of time the line had been leaking. The landowner had been near the break site the day before but saw nothing unusual, so the length of time the pipeline had been leaking was estimated at one day. The pipeline company installed large pumps in the creek to irrigate the nitrogen-rich water in the pools onto the adjacent flood plain. Because of the relatively minor amount of material apparently spilled, the prompt clean up work by the company and the relatively isolated rural setting, it appeared the spill would cause no major problems.

To understand the environmental problems occurring after the spill, it is necessary to have some understanding of the geology and hydrology of the spill site and Dry Fork basin. Dry Fork is a tributary of the Meramec River and drains about 380 square miles. Bedrock in this area, as throughout much of the Ozarks, is composed primarily of Ordovician carbonate rocks with smaller amounts of sandstone and chert. The Gasconade Dolomite, oldest unit exposed in the basin, is a cherty dolomite and, in the Ozarks, contains numerous caves and large springs. The Roubidoux Formation, an interbedded sandstone and cherty dolomite, forms the bedrock surface throughout most of Dry Fork basin. The Jefferson City Dolomite, an argillaceous cherty dolomite crops out along the western drainage divide area. All these units, but

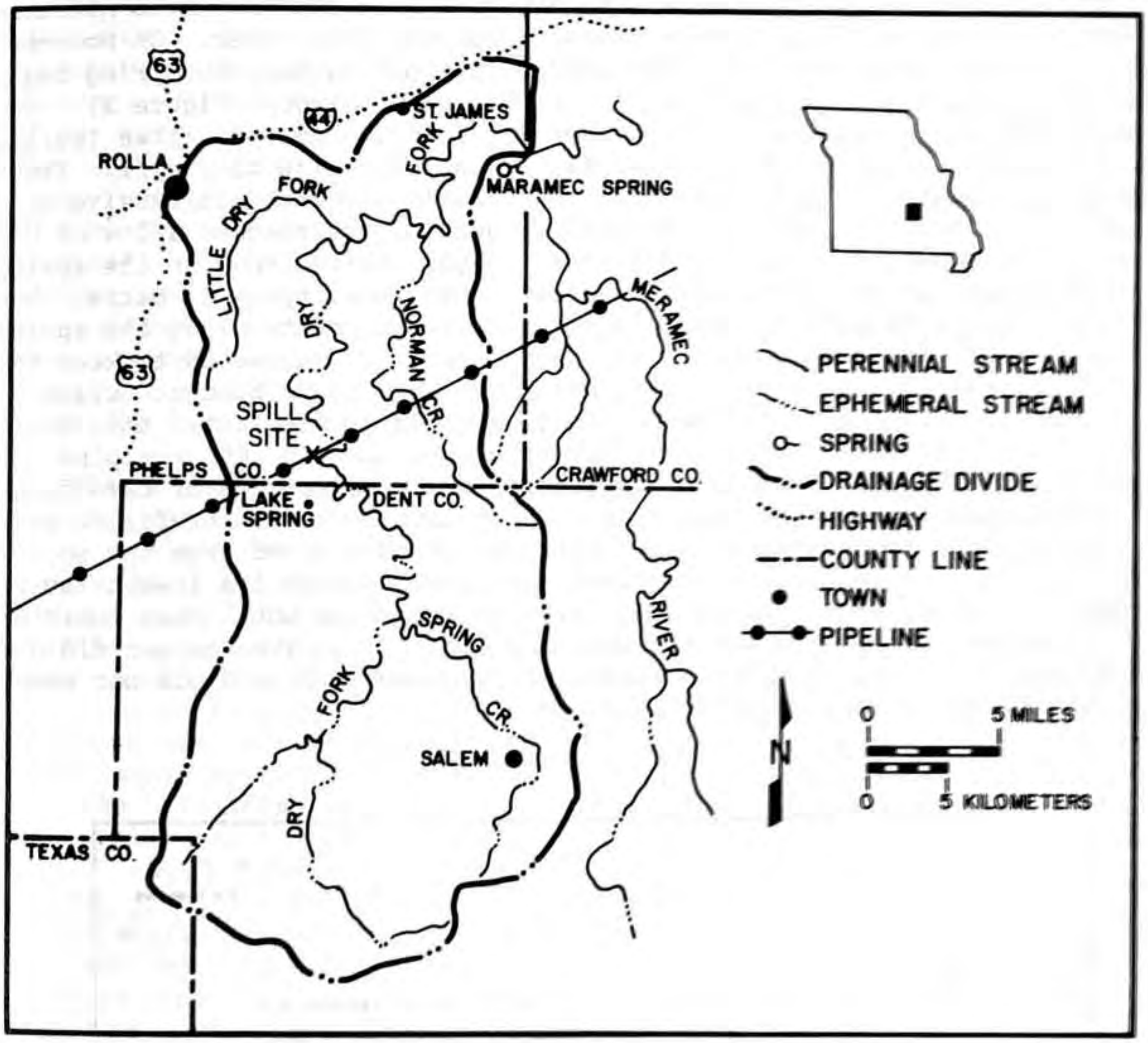

Figure 1. Location map of the Dry Fork-Maramec Spring area, Missouri.

especially the Gasconade Dolomite and Roubidoux Formation, have been extensively weathered, both near the surface and in the subsurface. The weathering has left a pinnacled bedrock surface covered with a thick mantle of residuum, and created a subsurface drainage system that pirates most of the surface water in the basin. A stream with as much drainage as Dry Fork should have perennial flow, but throughout much of its reach, Dry Fork, as its name implies, is dry. Only after heavy or prolonged rainfall does its channel contain water throughout its length. Dry Fork is a losing stream. Most of the water falling on Dry Fork basin does not leave the basin in the stream, but instead flows through openings into the subsurface and enters the groundwater system. Most water that disappears from the surface in Dry Fork basin recharges Maramec Spring.

The liquid fertilizer carried in the pipeline consists of 45.1 percent ammonium nitrate, 34.8 percent urea, and 20.1 percent water. Ammonium nitrate and urea have a high oxygen demand. Both dissociate to form ammonia ions in solution and, in the presence of oxygen, will form nitrite and, if sufficient oxygen is present, will form nitrate. The chemical reaction removes dissolved oxygen from water. On November 22, 7 days after the spill was reported, trout at Maramec Spring began showing signs of stress due to low dissolved oxygen (Figure 2). Two days before, dissolved oxygen measured 7 milligrams per liter (mg/l), essentially normal. By November 23, it had decreased to 3 mg/l. Trout require about 7 mg/l dissolved oxygen to thrive but can survive at 5 mg/l. Dissolved oxygen continued to decline and reached a low of 0.2 mg/l, remaining below 1 mg/l for 8 days. Large trout in the spring basin were moved downstream, where water quality was better but thousands of fingerling trout in concrete impoundments along the spring branch had no such chance. An enormous effort was needed to keep the fish alive. Aerating the spring water by large pumps brought oxygen up to about 5 mg/l, at which level the fish could survive until they could be moved to another facility; nevertheless, about 37,000 sculpins and many trout dyed. Even more significant were the species of cave fauna - salamanders, crayfish, and fish - which live in the water-filled cave system that feeds the spring. Hundreds of them moved from the spring system to the surface while dissolved oxygen was at its lowest level. Many of them were netted and kept in aquariums until they could be reintroduced into the spring, but many died. Dissolved oxygen did not increase to life-supporting levels until December 5, and did not reach a more normal 7 mg/l until December 29.

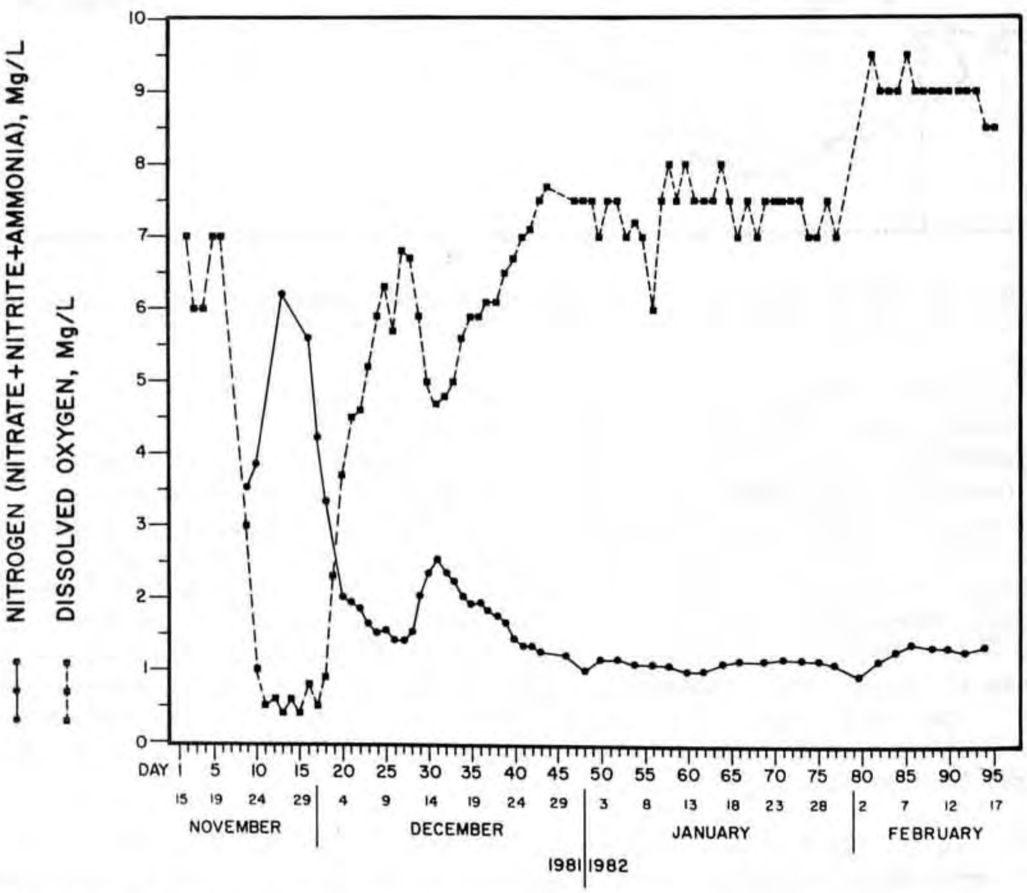

Figure 2. Dissolved oxygen and nitrogen changes at Maramec Spring.

It is obvious that 1,344 gallons of fertilizer spilled nearly 13 miles from Maramec could not cause water-quality degradation of the magnitude experienced. Maramec Spring, fourth largest spring in Missouri discharges an average of 93 million gallons per day; dilution would have been enough to render 1,344 gallons of fertilizer completely harmless. From November 23 until almost March, water samples were taken regularly at Maramec Spring and analyzed for ammonia, nitrite, and nitrate. Dissolved oxygen readings were also taken daily. The discharge of the spring is measured daily by means of a U.S. Geological Survey staff gage and rating curve. Background nitrogen content for the spring was estimated at 1 mg/l, based on historical water-quality data. Based on this information, about 575 barrels, or 24,150 gallons, of liquid fertilizer was actually lost from the pipeline, about 18 times the 32 barrel amount estimated by the pipeline company.

The reason for the error in the initial estimate by the pipeline company can be found in the water quality and spring discharge data. Water quality at Maramec Spring began to deteriorate 5 to 7 days after the spill was reported. The spill site is almost 13 miles from the spring. If the fertilizer traveled that distance in 6 days, it would require a velocity of 2 miles per day, not an impossible rate, but quite high. On December 1 and 2, about 1.5 inches of rain fell on Dry Fork basin, causing the discharge of Maramec Spring to more than double within hours after rainfall ended (Figure 3). Maramec Spring, like many large springs in the Ozarks, responds quickly to precipitation, but the additional water initially flowing from the springs is not the same water that fell as rain. Rain water entering the groundwater system raises groundwater levels in the recharge area and forces water already in the groundwater system to move through more quickly. The water-quality graph (fig.2) shows when water from the December 1 and 2 rainfall at the spill site reached the spring. Nitrogen began to decrease and dissolved oxygen to increase December 2. These changes continued until December 12. Thereafter, dissolved oxygen began to decrease and nitrogen content began to increase, reaching respective lows and highs on December 15. When rain began falling on December 1, about 750,000 gallons of water, containing as much as 175 mg/l total nitrogen, was in the pools along Dry Fork where the spill occurred. In addition, an unknown amount of fertilizer still remained in the gravel deposits underlying the flood plain. This material, washed into the groundwater system by the rain, emerged 12 days later at Maramec Spring and caused the second period of poor water quality.

Thus, it appears that the pipeline actually began leaking at least 6 days before the leak was detected. The coarse alluvial material underlying the flood plain and discrete openings in the bedrock allowed much of the fertilizer to escape into the subsurface before leaking fertilizer finally surfaced. Later, a dye trace substantiated the groundwater travel time from the spill site to Maramec Spring. On May 13, 1982, 3 gallons of Rhodamine WT 20% fluorescent dye was injected into the spring-fed tributary where the spill occurred. Daily water samples were taken at Maramec Spring and a fluorometer was used to analyze for dye content. The dye began emerging from Maramec Spring between 11 and 12 days after it was injected (Figure 4).

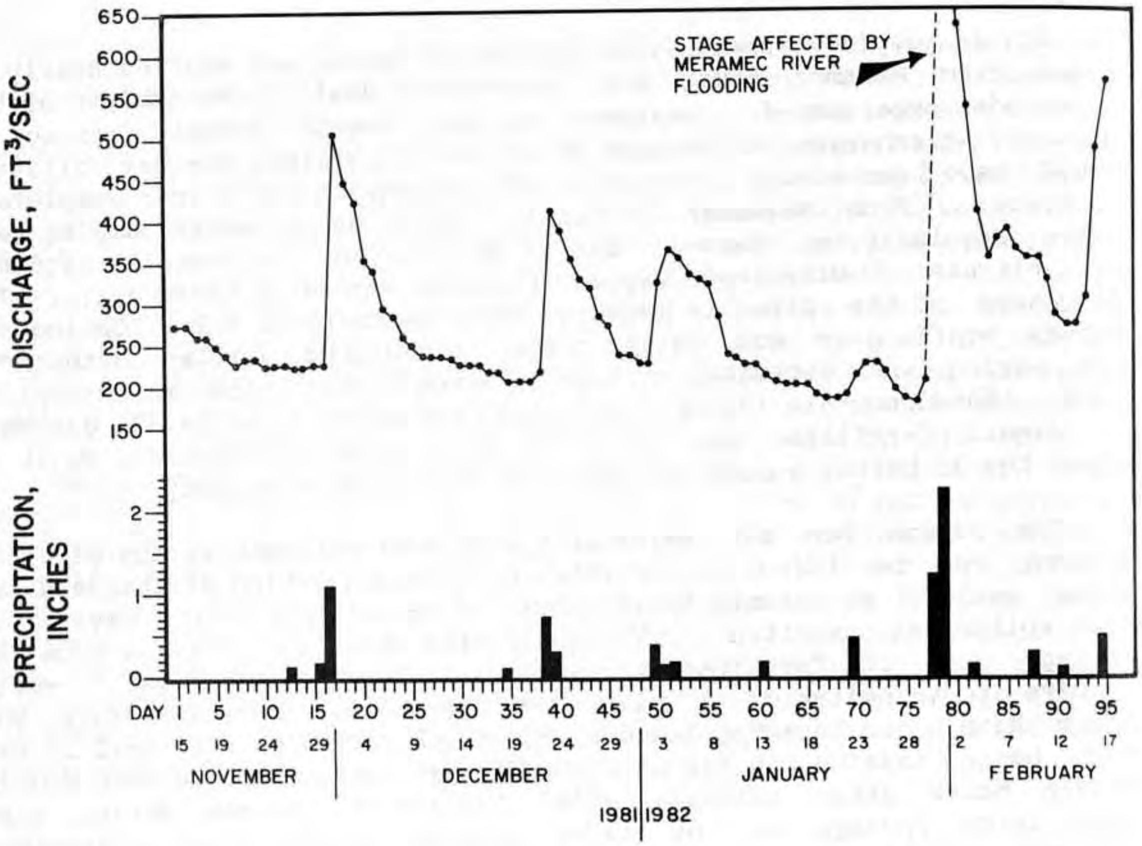

Figure 3. Area precipitation and discharge at Maramec Spring.

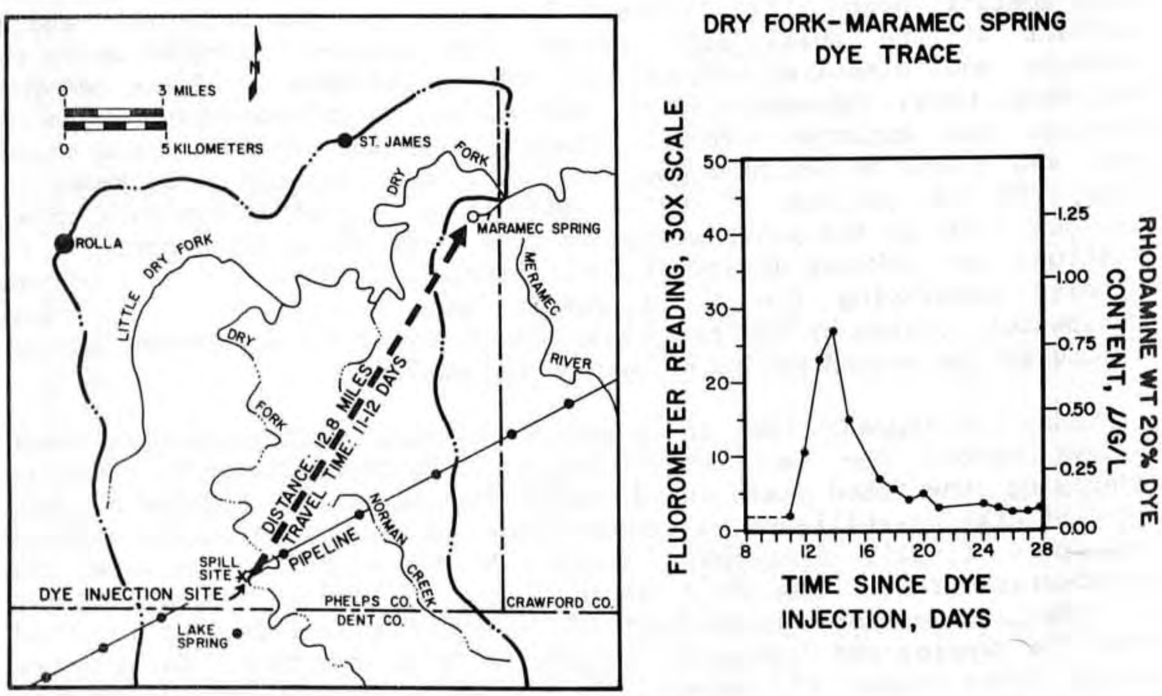

Figure 4. Results of the Dry Fork-Maramec Spring dye trace.

The spill site and Maramec Spring are nearly 13 miles apart. Obviously, the spilled material degraded groundwater quality between these two points. The karst groundwater system, which allowed the rapid contamination of Maramec Spring, probably prevented widespread prolonged groundwater contamination in Dry Fork basin. The groundwater moving from losing zones along Dry Fork to Maramec Spring flows through conduits or discrete openings in the bedrock. Some of the conduits must be fairly large to allow water to move at the measured groundwater velocity of more than 1 mile per day. The entire groundwater system feeding Maramec Spring channels nearly 100 million gallons of water each day to the spring. In so doing, the conduit system serves as a drain, inducing groundwater to flow toward it, keeping the spilled liquid fertilizer from spreading laterally, and confining the contamination to a rather narrow zone. Unfortunately, it is not possible to determine the exact path the water follows from where it disappears from the surface at the spill site to where it resurfaces at Maramec Spring. As a health and safety measure, a large area in northern Dry Fork basin was designated as possibly affected by the spill. On December 3, 18 days after the spill was reported, health officials began sampling wells in a large area between the spill site and Maramec Spring. Approximately 468 samples from 381 private wells were analyzed for nitrate. About 50 percent of the wells contained less than 1 mg/l nitrate as nitrogen, and 96 percent contained less than 10 mg/l, the maximum recommended limit for drinking water (Figure 5). Seventeen wells, 4 percent of those sampled, contained greater than 10 mg/l nitrate. Since there are numerous sources of nitrogen other than spilled fertilizer, further testing was performed on water samples from high-nitrate wells. The wells were resampled and analyzed for ammonia, nitrite, total Kjeldahl nitrogen, sulfate, chloride, and orthophosphate. Though all the wells contained high levels of nitrate, none showed elevated levels of ammonia or nitrite. All of the wells had chloride contents ranging from 3 to 13 times above background. Both nitrate and chloride are associated with organic waste such as septic system and lagoon effluent, and barnyard runoff. These data indicate the wells were being contaminated by sources other than the pipeline. Five months later the wells were resampled with the same results. Nitrate levels were still high in all, but Maramec Spring water quality had been normal for 5 months. Most of the polluted wells were fairly old and contained less than adequate lenghts of casing, most of which was probably not sealed properly. Several wells had above-ground construction defects. All were located close to sources of organic wastes. Since May, 1982, dye traces proved two of the wells to be hydraulically connected to nearby septic systems.

The fact that the high-nitrate wells in the area were found to be contaminated by sources other than the pipeline does not mean that no wells were affected by the spill. Health officials began sampling about 24 days after the leak is estimated to have begun. By this time, the approach of normal water quality at Maramec Spring indicated most of the spilled fertilizer had been purged from the groundwater system. Some wells drilled into or near the conduit system may have been affected. If so, the effects were not discovered because water quality had returned to normal by the time the wells were sampled. In this type of groundwater system, contaminants move through quickly, so a well may only be briefly affected. Only 4 percent of the wells sampled

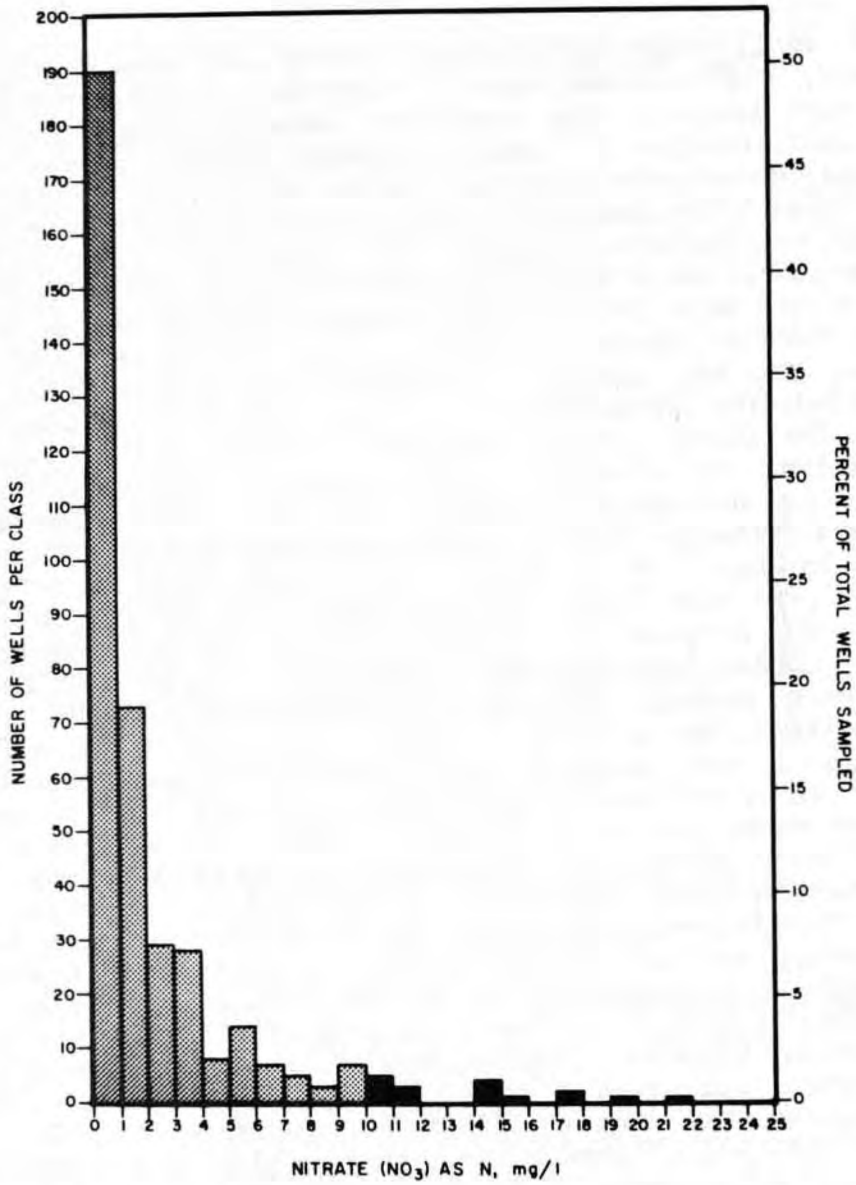

Figure 5. Number of private wells sampled versus nitrate content in northern Dry Fork basin.

showed nitrate above 10 mg/l. Background nitrogen in unpolluted groundwater in the basin is believed to be about 0.05 mg/l, but due to surface-subsurface connection through solution-enlarged openings in the carbonate bedrock, improper well construction, and abundant nitrogen sources, private wells typically contain 10 to 100 times background amounts of nitrogen. This is true for the entire Ozark region.

There has never been a detailed hydrologic study of the Dry Fork-Maramec Spring area. During the few weeks after the pipeline break, more information was obtained about groundwater quality, surface-subsurface relationships, and directions and rates of groundwater than had been known before the spill. Had detailed information been available, and had there been a more accurate initial estimate of the amount of material spilled, much time and money would have been saved. In karst areas, it is seldom possible to confine a large spill and remove the material before it enters the groundwater system. After a spill, only nature can be counted on to clean it up. Pipelines are necessary for fluid transport, but there will be pipeline breaks no matter how well lines are monitored and maintained. Accurate, detailed information about surface water and groundwater must be available so that intelligent decisions can be made quickly in the event of environmental accidents.

THE APPLICATION OF DYE TRACING TO THE PROTECTION OF CAVE ENVIRONMENTS

by James F. Quinlan*

ABSTRACT

Water tracing, generally with dyes, can be undertaken in order to determine the relations between a cave (or spring) and the adjacent terrain. The need for such research is a function of the geologic, hydrologic, faunal, and aesthetic significance of the site to be protected, the extent of urban and industrial development within a 1 to 20 or more mile radius from it, and the probability of such development having a potentially adverse effect on the cave or spring. Before any tracing is done, however, the local geology and hydrology should be evaluated in order to see if there are natural barriers to contamination (features that tend to protect the cave or spring), or whether stratigraphy and geologic structure tends to cause pollutants to converge on it. Applications of dye tracing to the protection of Mammoth Cave and its unique fauna and to the protection of water supplies in Kentucky are summarized.

CAVE MANAGEMENT: A NEW BEGINNING AT WIND CAVE

by Katherine Rohde*

ABSTRACT

Wind Cave presents special challenges to effective and protective cave management. Now exceeding forty miles in length, and with more than 1,000 known leads, it is more important than ever that a strong cave management strategy be implemented. The very history of the cave's exploration and exploitation, added to the incredible complexity of its forty miles of passage increases the problem of managing this resource in the best manner for future generations to enjoy.

The first step in cave management is to inventory the cave, to determine what resources are present. The size of the cave, the maziness of its passages and the fact that there have been so many people involved in the cave have made use of established inventory procedures impractical. Many individuals and groups have been involved in the explorations and discoveries at Wind Cave throughout its 103 year history, and because of its complexity and size, many people are going to have to be involved in the gathering of data that will provide Park management with the tools with which to protect fragile cave resources and to provide enjoyment of the resource to all visitors no matter what their skill level; from guided tour through the developed portions, to a caving experience by permit in specially zoned areas.

Planning for Cave Management at Wind Cave includes utilizing all of the groups or individuals presently using or working in the cave to assist with inventory through the use of a Trip Report form developed at Wind Cave. Strategies will be examined and evaluated for recruiting other assistance in the inventory process, as well as to assist with other cave management actions. These would include photomonitoring, research, search and rescue, and other expanded uses of the cave resource.

Cave management is a topic that is much discussed by cavers, cave owners, Federal and state agencies and others who have an interest, of one kind or another, in caves. Cave management objectives and practices are varied and depend upon the manager and the purpose of the management plan. It can cover many areas ranging from protection of

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drinking water sources, to protection of endangered species, to development of a commercial tour, to providing opportunities for recreational caving.

Cave management is rarely simple. At Wind Cave the considerations that have to be addressed under cave management, like the cave itself, are extremely complex. Cave management in one form or another has been practiced at Wind Cave since its discovery. While legends of the native Americans in the area of the Black Hills indicate that they probably were aware of caves, there is no physical evidence at Wind Cave that native Americans had ever used or entered the cave. Therefore, it can be said that cave management began at Wind Cave in 1881, when the cave was first discovered by non-native American settlers.

During the first ten years after Wind Cave's discovery, there were sporadic ventures into its windy darkness. Perhaps the fourteen inch diameter entrance provided a barrier that prevented many people from entering. However, by 1887, newspaper accounts tell of large groups of people going out from the town of Hot Springs to picnic and explore the cave. In that year a new artificial entrance was opened next to the natural opening.

Planned exploitation of the cave began in 1890 with the arrival of J. D. McDonald, an agent for the South Dakota Mining Company. He was hired to look for valuable minerals that might be mined in Wind Cave. It did not take long to determine that while the cave contained many marvels of nature, valuable minerals were not among them. Although the mining company lost interest, the McDonald family saw that the cave might prove valuable in attracting tourist dollars. They began to make "improvements" to the cave; widening passages, building ladders and stairways, in order to entice visitors from the nearby resort of Hot Springs to participate in an all day cave tour. A side line to the cave tour business was the sale of speleothems to visitors. While the entrepreneurs were wise enough to refrain from taking samples along the tour routes, they did enter areas in side passages and "mined" geodes of dogtooth spar calcite, frost work, popcorn and boxwork for sale to their customers.

Perhaps the first real attempt at trying to collect knowledge about the cave can be attributed to the McDonald's sons, particularly the youngest, Alvin. Armed with candles for light and balls of string to enable him to find his way out again, Alvin crawled and pushed his way through the maze of passages, exploring and naming the wonders that he found. While he did no actual surveying, he did write of his adventures and discoveries in his diary. His descriptions of routes, rooms and speleothems that he found can be considered to be an early resources inventory. Even today the diary provides locations of speleothems, descriptions of passages, as well as gives present day cave managers some indication of what portions of the cave might have looked like, before they were impacted by exploration, mining of speleothems and repeated travel.

By 1898, McDonald had acquired a business partner and it was not long before differences in philosophy caused a breech in the partnership. Both parties realized the potential value, in tourist dollars, of the cave resource, and both parties wanted sole control. The disagreement went to the courts where it drew the attention of the General Land Office, since the cave was on public domain. An agent for the Office was sent to investigate the situation. His report, in addition to finding that neither claimant had a right to the land, described the unusual features to be seen and said that the cave was "...one of the most extensive...in the Union". The land was withdrawn from settlement, and legislation was introduced in Congress in 1901 to set Wind Cave aside as a National Park.

Theodore Roosevelt signed the legislation establishing Wind Cave as the nation's seventh National Park in 1903. Wind Cave was the first National Park set aside to protect a cave, and this was the beginning of the modern cave management dilemma in National Parks. What does one do with the cave? The first years as a National Park were lean with little money for operation and personnel. As more visitors discovered the Park, they required more services. Along with those requirements and the addition of more surface area and wild life herds in 1912, more money became available to the Park. The cave was left to manage itself for the most part. Any cave management activity consisted mainly of improvements and additions to the tourist trails in the cave. There was no real effort to study and explore this resource, or to determine its relationship to and how it was affected by the activities on the surface above.

The last major development in the cave was accomplished by the Civilian Conservation Corps during the 1930's. Between 1935 and 1938, the first electric lights were installed in the cave. The old wooden stairs were replaced by concrete stairs, and trails were widened, leveled and paved. The elevator shafts were dug and the first elevator installed. The surface features over the cave were also altered with the construction of the visitor center, roads, parking areas, residences and maintenance facilities.

In 1958, a renewal of interest in the cave resources was initiated by a group of cavers from the Colorado Grotto, affiliated with the National Speleological Society (NSS). They surveyed and mapped several miles of cave passage, much of which had been explored by the McDonalds, Park employees in the early Park years, and members of the Civilian Conservation Corps. The interest continued and grew, along with the cave, when Herb and Jan Conn spent a year exploring and mapping their discoveries. Their contribution to the knowledge of the cave included discovering the small opening that was to lead out into the great expanse of the western portions of the cave and make Wind Cave one of the longest caves in the United States. They followed the cave down to the water table at Calcite lake and out to the then largest room, the Club Room.

The next surge of activity was begun in 1970 by the Windy City Grotto. Upon discovering that there was no complete map of Wind Cave, they mounted a push to explore and finish mapping all of Wind Cave. By the end of their fourth summer, the cave mileage stood at 26 miles, with no end in sight. Exploration and surveying by several individuals and groups has continued to add mileage to the cave. In 1979, one of the members of the Windy City Grotto project, John Scheltens, returned to the area and under a Special Use Permit, continued to explore and survey the cave. Many hours of work and caving by John and his crews, Wind Cave employees, and students of the National Outdoor Leadership School have brought the total number of miles up to 41. The result of the activity begun in 1958 is more than 41 miles of cave, thousands of leads to be checked, an incomplete faunal survey, a partial study on the barometric winds, one Master's thesis on the paleo-cave fills, and miscellaneous papers by various geologists on the boxwork, CO_2 content and chemical analysis of cave water and the origin of the cave.

Cave management up until 1984 was an odd collection of several, separate surveys. There was no coordination and no single map which included all of the survey data. Any planned management activities related to visitor management in the developed section of the cave; tours, trail maintenance, lighting, etc... Wind Cave is ready for, and needs a cave management program, in order that managers can better understand the resource for which they are responsible to "Protect and Preserve". By having a better knowledge of the cave resources, a data base can be developed. When any activity is proposed that might affect the cave resources, Park Management will have the information that can be used to make a wise decision and insure that the cave resources are not adversely impacted by the proposed action.

From the preceding brief history, it is evident that many individuals have been involved in the "management" of the cave resources at Wind Cave. The complexity of the cave, coupled with the history of exploration and use, create a real challenge to the cave manager. It means that the over all Cave Management Plan will have to be one of coordinating and organizing separate projects, research studies and inventory of resources, in order to create a whole picture. Because of the cave's large size and complexity, cave management must depend upon many people to produce the data. Cave management strategies must include developing the tools and methods to gain, coordinate and use the data, so the Park Management will have the information on which to base decisions that will be in the best interests of the cave.

The first step was to compile all of the survey data into one system and onto one map. A cooperative agreement was drawn up, giving responsibility to one individual for collecting all survey data from all groups involved in the surveying and exploration of the cave, reducing, adjusting and plotting the data, and keeping track of the mileage. Standards of survey have been established so that uniformity of method and data collection is assured.

A basic inventory of cave resources is needed. Due to the size and complexity of the cave system, it is not feasible to "resurvey" and produce a complete cave inventory in a trip, or even after a series of trips. Probably "one" type of inventory procedure cannot be established for the entire cave. The cave will be divided into zones or areas, which can then be used as parameters and serve to limit the frame of reference. The zones will allow the cave to be divided into smaller sections so that a coordinated, organized inventory will be possible. This will eliminate the overwhelming frustration that comes from trying to deal with 41 miles of a cave, with no two passageways alike. The zones will also be used in other management projects, as well as being used in planning strategies in the Cave Search and Rescue Plan. The zones will be established with input from cavers who are familiar with the cave. Establishment of zones may be determined by accessibility and major routes, distance, stratigraphic location or a combination of these and other factors.

In order to begin collecting data, a trial Cave Trip Report Form was developed for use by cavers entering the undeveloped portions of the cave. It is only a draft and as it is used, will be changed and modified to provide the information that is needed. It has now been in use for nine months, and while providing useful data, it is not yet in a form that is easily used in the field, and the information gathered is not easily retrieved, or exactly what is needed.

For inventorying and collecting data in portions of the cave that have been mapped, a modified Trip Report will be developed and used. Reports will be compiled and areas covered by each report and type of information reported will be noted on a master map. Priority areas can be designated as needing to be inventoried and assigned to interested groups or individuals wishing to assist with caving projects.

Groups or individuals involved in exploring and surveying new cave passages will be given a card with "reminders" to be on the look out for. The note taker of the survey party will be responsible for inventorying during the survey trip. Observations will be noted on the sketch, or in a separate section of the survey book using survey station(s) as references. This data will then be transferred to an inventory form similar to that used in the "old" portion of the cave. All inventory data will be coded and a computer file program developed for easy storage, retrieval and use.

Coordination and effective use of the people involved are the keys to carrying out a successful cave management program at Wind Cave. National Outdoor Leadership School (NOLS) uses a section of the cave to teach students enrolled in the basic caving section of their Semester Program, basic, safe caving techniques. Cave conservation is strongly stressed on all cave trips. In order to emphasize the need for cave users to act responsibly when using this fragile resource, NOLS has agreed to assist the Park with Cave Management projects. The NOLS students are the guinea pigs in developing the inventory procedures. They have pioneered the use of the Trip Report Form. They have recorded their observation of the conditions of cave resources, location of resources, and particulars of routes. In addition, each NOLS section donates one day of the course to working on a project in cave management which is determined by the Park Cave Management Coordinator. These projects in the past have ranged from eradicating algae; to removing trash; to assessing the best techniques, equipment and routes for evacuating a patient from specified locations along the developed tour routes. In the past year, NOLS students and instructors have provided many hundreds of hours of help on these projects that would otherwise have remained undone. Giving the groups tasks in cave management creates a consciousness in the new cavers as to the fragileness of the cave environment, and emphasizes the care that must be taken to ensure that the resource is not adversely impacted by our actions.

National Park employees will also have opportunities to assist in cave management projects. In addition to those involved in the exploration and survey of new cave passage, employees who do not have the skill or inclination for long hard survey trips, yet wish to "cave", can become involved in the inventory projects. As restoration projects are identified and prioritized, employees will be able to assist with these. Even the employee orientation trips (which are an accepted use of the cave in order to familiarize employees with the cave so that they can better share their knowledge of the cave with visitors) will provide information. A form is being developed which will ask cavers to note (in already inventoried area) any changes or impacts that they can see have occurred since the last time that they were in that particular area, or along that route.

In summary, cave management at Wind Cave is just beginning. It will take coordination and participation by the National Park Service, working closely with the cave user groups. Exploration and survey will continue to be a major focus in cave management, as the thousands of leads lure cavers on. However, inventory of resources and collection of information about the cave has started and will expand. This management plan can provide an opportunity for interested cavers to become actively involved in the cave management program. Park management will be more active in reviewing all actions taking place in the cave, not only in the "wild cave" areas, but in the developed portions as well. Those determined to have a negative impact on the cave will be changed. The impacted and developed areas of the cave will be inventoried for needed restoration activities. Where possible, or when these are determined to be adversely impacting the cave resource, results of past management actions will be mitigated. (Remove trash, old trail fills, air lock the artificial openings) Many questions have already been identified as needing to be answered in order that Park Management have the information on which to base decisions about actions that will be in the best interest of the cave. As the expansion of cave use through the inventory and survey projects is implemented, many more questions will arise. Determining research needs will always be a part of any cave management program. It is critical to realize that as the cave continues to grow, and the knowledge about the cave increases, management of the cave resource first must catch up, then keep up.

CAVE MANAGEMENT AND THE MILITARY: AN EXAMPLE AT FORT LEONARD WOOD, MISSOURI

by Emily S. Brown* and Charles M. Niquette**

ABSTRACT

Cave management at Fort Leonard Wood is a recent concept. Until only a few years ago, the installation's caves were largely overlooked by planners because they held very little promise as aids for military training activities. They were considered to be natural formations used for weekend outings and exploration, but not as a resource warranting management. This perception is changing. In the mid 1970's Fort Leonard Wood's interest in cave resources was initiated with the ratification of the Endangered Species Act. It was believed that several caves on the installation housed federally endangered bats. However, since the U.S. Fish and Wildlife Service did not designate any of these caves as critical bat habitat, the concern for caves subsided. It was not until the early 1980's, when the first large-scale archeological survey of Fort Leonard Wood was conducted to comply with federal laws, that concern for cave resources was renewed. As a result of this survey, it was discovered that every cave and rock shelter examined contained archeological materials. Moreover, widespread vandalism of these sites was also noted. There seemed to be a positive correlation between the degree of impact caused by vandalism, the size of the cave, and the richness of the associated archeological deposits. In accordance with several federal laws, efforts to preserve these cultural deposits has stimulated a realization that the caves themselves are resources worthy of protection.

Fort Leonard Wood has initiated various measures to protect the archeological materials in its caves, but with limited data available on only a few caves, management possibilities are impeded. The installation has taken the initiative, in conjunction with the Missouri Department of Conservation, to identify and describe the physical, ecological, and archeological resources of each cave. From this information a cave resource management plan will be developed and implemented. Fort Leonard Wood has a prime opportunity, owing to its size, location, and federal status, to protect and preserve a very limited and valuable resource.

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DEVELOPMENT OF AN OPTIMAL CAVE GATE FOR PROTECTION OF ENDANGERED CAVE DWELLING BATS

by Steven P. Christman*

ABSTRACT

The gray bat (Myotis grisescens), Indiana bat (M. sodalis), and big-eared bat (Plecotus townsendii ssp.) are federally listed endangered species that require undisturbed caves for their survival. Although fewer than 10% of known caves are critical to the survival of these 3 species, protection of these caves from human vandals has proven difficult. Steel gates have been constructed at several important bat caves, but many of these have been breached by trespassers. Some cave gates have caused behavioral changes in the emerging bats, and some gray bat maternity colonies have actually abandoned their caves following protective gating. We do not know what types of bar or gate designs are most acceptable to the bats. I propose to test bat response to various gate designs with a series of choice experiments in which the emerging bats are presented with two or three, 1 m by 1 m windows simulating potential gate designs. From among several "people-proof" gate designs, we will ask the bats to select the one they prefer to fly through.

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DESIGNING A BROCHURE FOR YOUR CAVE

by Gordon Smith*

ABSTRACT

Caves that are managed for public use usually require a folder or brochure giving information on the cave.

Prior to designing a brochure it is important to research folders from other caves that have been produced since the early 1800's in this country. A review of other brochures will give you ideas for your brochure and help you avoid some of the mistakes of the past.

Design of your brochure is dependent on many factors. For example, is the purpose of the folder to attract visitors or merely to provide information? How will the brochure be distributed? What is your budget and how many brochures will be needed? What time period will the brochure be good for?

Examples of good and poor brochure design are given, as well as cost data for brochure printing.

*Tourist Information Service and Marengo Cave Park, Marengo, IN.

PUBLIC RELATIONS IN CAVE MANAGEMENT

by Jay Jorden*

On the subject of public opinion and politics, Abraham Lincoln once remarked, "Public sentiment is everything. With public sentiment, nothing can fail. Without it, nothing can succeed".

Participants in organized caving are involved in the management of a natural resource -- the underground wilderness. But, perhaps regrettably at times, the human factor plays as much of a role in the management process as the caves.

Management has been defined as the process of planning, organizing, decision-making, and controlling. The process -- which some call a science and others an art -- impinges upon both the caves and the cavers.

It has been said that natural resource management is 90 percent managing the public and 10 percent managing the resource.

This fact established, cavers both individually and within the Society have inherited the roles of building and maintaining good public relations with noncavers.

Application of public relations is readily identifiable on a local level. Cavers are already familiar with building good PR with landowners in their localities. This process is crucial in obtaining access to caves, permission to explore them on an ongoing basis and the possibility of being introduced to other landowners who have caves on their property.

Successful rapport with cave owners brings many rewards to the caver. New underground vistas are revealed to explorers, and with them the increased chances of finding deeper pits, surveying longer caves and making biological and geological discoveries.

But public relations involves much more than dealing one-on-one with cave owners. Cavers who are also concerned environmentalists can convey their beliefs, ethics and concerns about the underground wilderness -- and the threats to its continued existence -- to large numbers of people.

Cavers have organized into groups which have taken on these tasks. The National Speleological Society, incorporated in 1941, was established to (1) further the scientific study of caves, (2) improve methods of exploration, (3) promote various scientific projects and publications, and (4) provide a membership society for cave explorers.

But the society's goals have expanded in recent years to include education. Those who cave softly have already learned, either through

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Society grotto training, or reading conservation-oriented literature, but must in turn educate the broader public to the need for preserving a nonrenewable resource. The educational purpose of public relations can change the attitudes of many, through conveying the conservation message summed up in the slogan, "Take nothing but pictures, leave nothing but footprints, kill nothing but time".

But the story will not tell itself. Public relations, by definition, is an active pursuit: helping the organization organize activities that build and maintain solid and productive relations with the public at large and with "special publics", which will be defined later, and then helping the organization and its publics accommodate to each other.

We have surpassed the passive process of answering media inquiries about caves as our only activity.

The NSS Board of Governors, in its manual, described the Public Relations Committee as "responsible for seeing that proper and correct information relating to caves, caving and cave rescues reaches the national press. They also publicize Society awards, elections and important meetings. The Chairman is encouraged to organize a public relations workshop at the convention to give help and suggestions to grotto public relations chairmen".

But cavers and nonprofit organizations such as the Society, concerned with cave management, face competition for the various media of communication through which to convey their safety and conservation messages. Private industry and business possess cadres of highly trained and well-paid sales and public relations personnel, whose job it is to put their organizations' "best foot forward" through the media, and who have money for massive PR and/or advertising campaigns.

The society in recent years has shown a trend toward public relations activity in the active dimension, as opposed to passively waiting for media organizations to make inquiries and then answering them. The society's conservation and safety message has been disseminated to media organizations through a printed fact sheet and other materials. Press releases have detailed the conservation achievements of the Society, including the historic signing of the Memorandum of Understanding this year with the Bureau of Land Management of the U.S. Department of the Interior and the Cave Research Foundation. A similar approach would be used when memorandums are signed with other federal agencies.

Releases have been prepared upon the occasion of passage of state cave protection acts, and the same format could be used for details concerning the Federal Cave Protection Act project. Informational packets on that legislative proposal have been prepared by the Conservation Committee and other steps taken to publicize the bill by the NSS Cave Conservation and Management Section. A draft of a press packet explaining the functions of the National Cave Rescue Commission, for use by media organizations both during cave rescues and in feature articles, has been prepared.

All the above measures attempt to use publicity to promote the Society's cave management efforts and portray the Society in its best possible light.

Every organization has a reputation, just as does every individual. And organized caving has, through the years, had to earn the reputation and confidence that it now enjoys and that the public perceives.

Inalterably, prestige and public goodwill are assets which organizations jealously covet in other groups, and treasure once acquired.

Every group practices public relations, whether it recognizes it as such or not. Its actions convey certain impressions to the public. Over the years, the Society has recognized the importance of PR in its effectiveness in conveying the cave conservation ethic, and promoting other ideals. This recognition has occurred over the same time frame with a development within the practice of public relations that truth and integrity in informing the public -- not mere publicity-seeking -- should guide communications. The denial of information or misinformation to the public by an organization is destructive to all parties.

In interpreting these ideals in policy, the Society has determined that it does not necessarily want to promote caving as an activity to those of the general public who are nonparticipants, but it should nevertheless avail itself to persons who have already become involved in caving or who have become so interested in the endeavor that they might otherwise seek other outlets for their activities than those sanctioned by the Society.

This is precisely where public relations faces one of its greatest tasks: that of satisfying those needs manifested by the public for correct information about caving through the media and through other channels such as education, while at the same time protecting fragile cave environments around the nation and worldwide.

Public relations in the cave management sense consists of four elements: (1) it is a cave management philosophy; (2) it is an expression of this philosophy in policy decisions; (3) it is action resulting from these policies; and (4) it is a two-way communication which contributes toward the creation of these policies and then explains, reveals, defends or promotes them to the public so as to secure mutual understanding and goodwill.

Few subjects concern the public more than environmental ones. Although concern first surfaced in the 1940's regarding the environment and cave management in particular, the general public has been slower to react. One could argue that concern about the underground wilderness has paralleled -- or lagged some distance behind -- sentiment concerning the environment in general. How much similarity in sentiment, no one really knows. But laws regulating caves and deleterious effects on them have been of interest for some time. Because of this, public relations has been necessary to interpret environmental developments, counsel on the effects of proposed governmental and private-sector actions and to communicate the accomplishments of cave managers or their response to criticism.

Part of the management function of PR evaluates these public attitudes, then identifies the policies and procedures of an individual or organization with the public interest and executes a program of action.

Public opinion is the expression of a belief held in common by members of a group or public on a controversial issue. PR seeks to measure, analyze and then influence this public opinion.

Devices such as opinion studies, opinion surveys and response evaluations to public relations programs enable the organization to formulate policies that are more palatable to the publics.

Opinions may be shared on a number of concerns, or problems, which face the cave manager. Environmental problems which impinge on caves include water pollution, solid waste disposal, land use, toxic substances released in the air and water and traffic in caves.

These opinions on varying concerns may be held by a number of different audiences, or publics. These include, but are not limited to, government officials, scientific and academic groups, community leaders, managers of companies that impinge on land use or air and water quality around caves, and the media in general.

Booklets, newsletters, slide presentations and motion pictures can be used to keep important publics informed about the environmental problems facing caves, and cavers. But for specialized audiences, those in cave management should rely on face-to-face meetings where ever possible. In communicating with the scientific community, for example, the following are useful: (1) direct mail to well-targeted groups, (2) symposia, seminars and other scientific meetings, (3) setting up a procedure to answer criticism immediately and forcefully through contacts with appropriate governmental, scientific, academic and environmental groups and ready-to-use in-depth background material, and (4) putting the best foot of cave management forward through every means available in repeated messages.

In the environmental inventory, a successful communicator should (1) keep informed of all major happenings in the environmental front, particularly by anticipating those developments that could affect cave management; (2) pressing leadership in caving to establish their own priorities in cave management through the preparation of a corporate-style environmental policy statement; (3) collecting, analyzing and interpreting available facts in environmental areas that might affect cave management to assure that leadership in conservation is informed; (4) preparing informational materials on matters that could come under public scrutiny, and keeping these updated with sound, supportable facts -- an example being the NSS' "bats need friends" brochure prepared with the aid of Dr. Merlin Tuttle and Conservation Committee chair Jer Thornton along with others; (5) being prepared to challenge sensationalized attacks through the above means; (6) keeping members of cave conservation organizations informed of environmental programs and plans, and their possible roles; (7) establishing the organizations' reputation for credibility in the environment, by deeds as well as words; (8) calling on experts available within organizations as resources and assisting them in the preparation of technical stories and interpretation of complex data for the layman; and (9) always enforcing strict integrity and accuracy in the organizations' communications relating to cave management, with all major stances supportable by scientific documentation.

For better or worse, most natural resource operations depend upon people -- and, therefore, politics -- for success. Public relations, if used to its full capabilities, can be of immense benefit in gaining acceptance of cave management programs.

CAVE DATA BASES REVISITED: 1984

by Jerry D. Vineyard*

ABSTRACT

Responses to a questionnaire mailed to all known state cave data base compilers show that only five of sixteen states have computerized cave data bases. Several other states either have computerization underway, or plan to do so. Reporting states indicate a wide range in completeness of data. Missouri records 4,513 caves and 1,712 maps; Tennessee has 3,950 caves and over a thousand maps; Virginia has 2,456 caves but no firm figure on maps; Alabama follows with 2,338 caves and 1,600 maps; Texas has 1,900 caves and several hundred maps. The other states have far fewer caves, with the lowest number in Louisiana with five caves and five maps. Nearly all data bases have restricted access; copies of the data are usually available at cost to qualified users. Problems include the costs of maintaining data bases and the personnel to manage them; loss of records in personal files; reluctance of cavers to share data; and the inherent impermanence of volunteer organizations. Despite problems, cave data base activity is growing.

INTRODUCTION

This is a progress report on cave data bases in the United States, attempting to assess the degree to which they characterize the cave resource, and how successfully they function in a cave management context. Cave data bases, as used in this paper, are files of information on caves in a particular state or part of a state, kept in a specific location and capable of access. Most of the data bases now in operation are either computerized, or plans are being made to do so. The microcomputer promises to revolutionize cave data base activity, bringing sophisticated data manipulation in reach of the many cave data base coordinators who generally operate on a volunteer basis with extremely limited funds.

SCOPE AND LIMITATIONS OF DATA

The information on which this paper is based was collected through a questionnaire sent to all known cave data base custodians. White's paper (1983) on the same subject contained a list of cave data bases he had identified; others came from leads in the NSS News, from NSS Internal Organizations, and from personal contacts. White summarized

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the progress of cave data bases, including the publication of comprehensive reports (as, Caves of Virginia, Caves of California, etc.); my paper addresses the question of how well the extant data bases characterize the resource, and how they are used in cave management.

The questionnaire (Figure 1) was a simple, one-page form designed to gather some basic information without requiring too much time and effort from the respondent. As with any survey conducted by questionnaire, the results are only as good as the questions asked, and only as complete as the responses received.

CAVE DATA BASE

STATE: **CONTACT PERSON:**

1. **Is there a centrally-managed cave data file in your state?**
2. **Who, or what agency or group, is the custodian/manager of the files?**
3. **Is the file computerized?**
4. **If the answer to (3) is yes, what kinds of products can be extracted from the data base?**
5. **What restrictions are there on access to the cave data files?**
6. **How many recorded caves are there in your state?**
7. **How many cave maps are there in your cave files?**
8. **Are cave maps and copies of reports available to the public? If so, what restrictions, if any, are imposed?**
9. **From what sources do most of the cave data come?**
10. **Other comments and/or suggestions?**

Figure 1. Questionnaire for compiling a status report on the progress of cave data bases in the United States.

Response was very good for the eastern part of the United States, but other than Texas, there was no response from the western states

(Figure 2). This does not necessarily mean that there are no state cave surveys in the West; simply that I had no responses, nor, in most cases, did I have anyone to send a questionnaire to. Perhaps this paper will elicit response from any cave data base custodians who were not included.

WHAT IS A CAVE?

While this paper emphasizes numbers of caves and numbers of cave maps as a way of comparing state-to-state, it is not an exact relationship. There is no universally-accepted definition of a cave. Pennsylvania requires that caves be "measurable in feet;" Tennessee has an arbitrary minimum dimension of 50 feet long or 40 feet deep or have a 30-foot pit. Missouri records "divable springs," because karst springs are simply water-filled caves. And, the Missouri files contain maps of springs up to 300 feet deep and over a quarter mile long.

Some cave data managers handle the short/shallow problem by including "for the record only" caves. The problem with this plan, though, is that an arbitrary length limit that may seem reasonable to cavers, who are usually not interested in short caves or shelter caves, may not adequately characterize the cave resource, which may be viewed differently by, say, archaeologists. Until there is a universally-accepted definition of what constitutes a cave, it will be difficult to compare cave resources from state-to-state.

CHARACTERIZATION OF THE RESOURCE

The enactment of cave protection acts in at least 17 states, and current efforts to persuade Congress to pass a national cave protection act, indicates a growing awareness that caves are a resource and not a liability. The question, then, is how well the various cave data bases characterize the cave resource in specific areas? The answer would be particularly important, for example, in trying to pass a cave protection act in a state where there was no cave data base to demonstrate what resource required protection.

While a questionnaire survey of 16 states cannot adequately represent the entire country, some tentative conclusions can be drawn. First, it is readily apparent that there is wide variability in the completeness of resource inventories from state-to-state. Second, it is equally apparent that most of the data is closely held and that few decision-making bodies (i.e., government agencies and quasigovernmental planning groups) have access to information that can adequately characterize the quality and extent of cave resources. Third, computerization promises to revolutionize the processing of cave data, but shows little indication of solving the complex sociological problems inherent in building and maintaining cave data bases. Fourth, most cave data bases are developed and maintained on a volunteer basis, with support from governmental agencies in only a few states.

The fifth and perhaps most significant conclusion is that there is little sense of community among the cave data base managers. There are

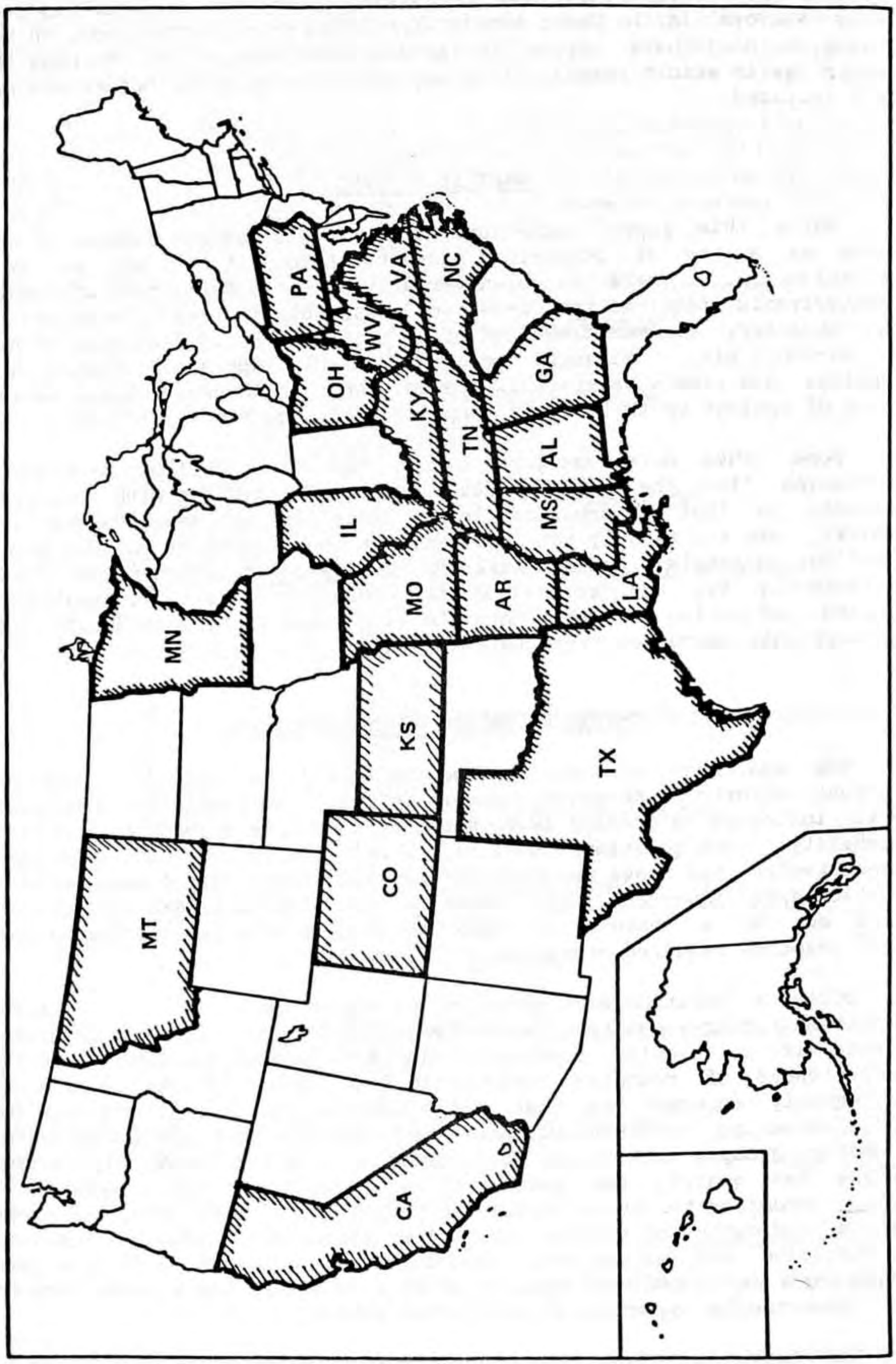

Figure 2. State cave data bases, 1984.

no uniform standards for data reliability, no provisions for data exchange, no mapping standards, not even a uniform definition of a cave. In short, if we were asked to defend our beloved caves against some pervasive threat, we would have a difficult time even saying how many caves there are in this country, and an even more difficult time demonstrating why these caves are worth being saved from whatever threatens.

A NATIONAL CAVE RESOURCE DATA SYSTEM

The conclusions I have drawn from a survey of cave data base managers show a resource that is inadequately characterized, and therefore in jeopardy. One way to improve the situation and to offer greater protection to cave resources of this country is to devise a system able to protect the resource from the traditional threats (vandals, quarry operators, rockhounds, biological collectors, teenagers, etc.) while at the same time defining a resource that deserves protection from ultimately greater threats -- urbanization, highway construction, acid rain, dams & reservoirs, herbicides and pesticides, groundwater depletion, and many other current and future threats, In a common cause, the cave data bases in the various states can become a powerful tool for management and protection of the resource.

Currently, the cave data bases are maintained by a wide variety of mostly-volunteer organizations, with little uniformity and communication. What is needed is a system of national standards and definitions, quality control for data collection, and ways of giving a sense of community and/or regionalism in viewing the national cave resource. Whether this can be done under the aegis of any of the current cave-oriented organizations is an unaddressed question, but one that should be asked by the National Speleological Society, for example.

The widespread development and use of microcomputers in managing cave data bases is a significant and highly beneficial trend. If a communication network between cave data bases could be developed, we could mount formidable efforts in, say, support of a national cave protection act, and we could exert pressure in regional situations, as in water resource developments, that may threaten caves.

INDIVIDUAL STATE SUMMARIES

The following state summaries were compiled from responses to the questionaire (Figure 1), and compiled in Table 1.

ALABAMA

Number of Caves: 2,338
Number of Cave Maps: 1,600±

The Alabama Cave Survey is one of the oldest and most successful state cave data bases. The Alabama Cave Survey was a leader in

TABLE 1

State Cave Data Bases, 1984

State	Number of Records	Number of Cave Maps	Computerized?	Availability
Alabama	2338	1600	yes	limited
Arkansas	1800±	100±	no	limited
Georgia	318	280	yes	limited
Illinois	300±	30	no	limited
Kentucky	744	744	no	limited
Louisiana	5	5	no	open
Minnesota	400±	75±	no	MSS members only
Mississippi	52	41	no	limited
Missouri	4513	1712	yes	limited
North Carolina	426	410	no	limited
Ohio	180	68	in process	limited
Pennsylvania	862	not filed	yes	limited
Tennessee	3950	1000±	yes	limited
Texas	1900	several hundred	partly	limited
Virginia	2498	many hundred	in process	limited
West Virginia	2300	1150	in process	limited

computerization of cave data; they began early to encode a wide range of information into their data base. Using standard software available, plus user-written programs as necessary, they can extract information from the data base in whatever arrangement it is needed.

The Files Director works with a data base stored on an IBM 3033 mainframe, accessed through SYNCSORT, EXTRIEVE, and IEBGENER, with SAS for statistical analysis. IBM PC and Apple II microcomputers can also be used to manipulate the data.

Alabama digitizes cave maps so they can be autoplotted as overlay sheets for topographic maps. To do this, they first had to develop digitized topographic maps, which is also critical to the location systems. Alabama is one of many states that use the Public Land Survey system (section, township, and range) of land location. The PLS system is fine for finding locations on a topographic map, but it gives locations as blocks or parcels of land rather than as point locations To be plottable by computer, one needs point locations as would be given by latitude and longitude, so the Alabama Cave Survey has a program that will convert PLS locations to latitude-longitude. This sounds simple enough, except that the PLS land net is not everywhere consistent, so it must be digitized line-by-line and programming written so that conversions can be made to latitude and longitude, which <u>is</u> a precise and consistent system.

ARKANSAS

Number of Caves: 1,800±
Number of Cave Maps: 250±

Certainly Arkansas is one of the most exciting states for caving, with a potential that is far from being realized. There _is_ a centrally-managed cave data base, but the sustaining organization to keep it going is not currently active. There was an Arkansas Speleological Survey, and then an Association for Arkansas Cave Studies, but neither is now operative, and the Arkansas Geological Commission shows little interest in speleology.

The files are not computerized, and Arkansas caving tends to be carried out through a series of independent, project-oriented groups with little inclination toward developing an organized, cooperative cave data base. Nevertheless, there _are_ files and there _is_ interest in making them more useful.

GEORGIA

Number of Caves: 327
Number of Cave Maps: 208

Georgia has a computerized cave data base similar to the systems in use by Alabama and Tennessee, giving the kind of data exchange capability that would be useful on a regional or national scale in resource characterization/management. The Georgia Speleological Survey has mapped about 64 percent of Georgia's known caves, a considerably higher percentage than most other states have.

The data base is maintained on an Apple II microcomputer, and has the capability of storing digitized cave maps and digitized cave locations, which makes it possible to draft map overlays for topographic maps showing cave locations and outlines. As with other fully computerized data bases, printouts can be generated in any desired configuration.

ILLINOIS

Number of Caves: 300±
Number of Cave Maps: 30±

Illinois has some fine caves and a history of speleological research that includes J Harlen Bretz, who co-authored "Caves of Illinois" for the Illinois State Geological Survey. There is an Illinois Speleological Survey, in name at least, with one person as custodian and manager of the cave data base. There are few requests for information from the files, so security has not been a problem. In fact, most of the data came originally from the NSS cave files, and from "Caves of Illinois." The files are not computerized.

KENTUCKY

Number of Caves: 744 (Western Kentucky Speleological Survey only)
Number of Cave Maps: 744

For a state that has the world's longest caves and is generally thought to have large numbers of caves, there is surprisingly little effort toward a comprehensive cave data base. There are no central files, and the extent of computerization is for word processing only.

There are at least two sets of Kentucky cave data files (not duplicates, however). The Western Kentucky Speleological Survey issues an excellent annual report that could be a model for other states.

LOUISIANA

Number of Caves: 5
Number of Cave Maps: 5 (with a total length of 393 feet)

Louisiana is not generally regarded as a cave state, so it is not surprising that only five caves are known in the entire state. However, all five have been mapped, so presumably there is no continuing need for a Louisiana Cave Survey. Most of the information on Louisiana caves, according to John Sevenair, is contained in a five-page scientific paper.

The five known caves in Louisiana are small, sandy holes, unattractive to vandals, and the locations are published in the low-circulation "Proceedings of the Louisiana Academy of Sciences" (1983).

MINNESOTA

Number of Caves: 400±
Number of Cave Maps: 75±

The Minnesota Speleological Survey has a centrally-managed cave file, but it is more a collection of cave reports than an organized data base. It is not computerized, and no one really knows how many caves have been recorded, because there is a tendency to "rediscover" caves and give them new names.

Despite the fact that Minnesota does not have an organized data base, the necessary structure seems already in place. The Minnesota Speleological Survey has been active long enough to develop the kind of long-term capability needed to build and maintain a strong and useful central data base. The estimated 400 known caves would be likely to increase with the kind of caving pressure that could be focused through a strong coordinating effort.

MISSISSIPPI

Number of Caves: 52
Number of Cave Maps: 41

Mississippi once had a centrally-managed cave data base, but it has been lost for some ten years. There were topographic maps with cave locations spotted, plus numerous cave maps, but the only thing that remains is the information in published reports.

The 41 cave maps show a total of some 7,000 feet of passage. Three of Mississippi's caves have been destroyed.

MISSOURI

Number of Caves: 4,513
Number of Cave Maps: 1,712

Modeled after the Virginia Cave Survey, the Missouri's Speleological Survey, Inc., was founded in 1956 at the suggestion of the State Geologist. This resulted in an unusual, and highly successful, commensal relationship between a state agency and the resident caving community. The state geological survey serves as the repository, reproduction facility, and general service unit for the consortium of caving organizations and individual cavers known as the Missouri Speleological Survey. It is the unique cooperation between the private sector and a governmental agency that has given permanence and purpose to the long-term efforts to inventory and study the caves of Missouri.

The Master Cave Files are maintained by the state geological survey, from data reposited mostly by cavers. When new data comes in, it is processed onto standard forms, maps are microfilmed, and duplicate copies are made for the satellite files in two other major caving centers. In this way, even if one set of data should be destroyed, two reasonably complete duplicate sets will still be available.

Computerization of the data base began in the early 1960's, beginning with the first publication of a computerized cave catalog in 1964. In subsequent years, the technology advanced to the point where a formally-published cave catalog is no longer issued. Instead, the user receives an up-to-the-minute computer printout of whatever part of the data base is needed, from a complete state cave catalog to listings for specific areas and/or parameters.

The 1,712 cave maps on file have all been microfilmed and copies are instantly available from aperture cards processed through a reader-printer. Full-size copies made from the originals through an Ozalid process are also available.

The Missouri cave data base has been operative for more than three decades. The spirit of cooperation that emanates from the successful establishment of a centrally-managed cave data base is credited with stimulating the discovery and reporting of new caves. The Missouri cave list has had a sustained average growth of nearly 150 caves per year since 1956, with no sign of diminishing. How long this high discovery rate can be maintained is uncertain.

In addition to the Missouri Cave Catalog and various spin-off data compilations that can be made, the Missouri Speleological Survey also publishes the quarterly journal, Missouri Speleology, which carries county-by-county and/or area-by-area cave surveys. These are largely compiled from the cave reports and maps already in the data base.

The history of cave work is also important, and that is addressed through MSS Liaison, a monthly newsletter that carries activity reports of the various member groups of the Missouri Speleological Survey. In addition, there is a monthly article detailing activities and material accepted for the cave files. Both Liaison and Missouri Speleology have nearly three decades of uninterrupted publication history, so the development of the Missouri cave data base is usually well documented.

To complement the Missouri Cave Catalog, there is a Missouri Cave Map Catalog listing the 1,712 cave maps currently in the files. This catalog is updated approximately annually. All except a few of the maps are available on a limited basis, from either microfilm or paper prints from the original maps, most of which are on Mylar. the oldest map in the collection is one from Kansas City (Jackson County), dated 1906.

NORTH CAROLINA
Number of Caves: 426
Number of Cave Maps: 410

The North Carolina Cave Survey is in the enviable position of having 96 percent of its known caves mapped. They have a centralized cave data base, but it is not (yet) computerized. Data from the files is available to anyone or any agency with a legitimate need for the information, but requests are screened carefully.

OHIO

Number of Caves: 180
Number of Cave Maps: 68

The Ohio cave data base is maintained at Wittenberg University, where it is in the process of being computerized. The data are being coded for easy retrieval in any format desired.

The Wittenberg University Speleological Society has a journal, Pholeos, which carries - sans locations - most of the reports and maps that come to the data files.

PENNSYLVANIA

Number of Caves 900±
Number of Cave Maps: 862

The Pennsylvania cave data base is a project of Nittany Grotto, supported by the Mid-Atlantic Region of the National Speleological Society. Penn State University also supports the effort, as a public service to the state. It is probably one of the most modern and thoroughly computerized cave data bases in any state. With approximately 96 percent of the known caves mapped, Pennsylvania is ahead of most other states in this respect.

The products available in computer-printout format include as many lists and reports as one can imagine from a data base that has a wide range of data elements. While maps and survey data are not digitized, the files do contain data elements on cave length as well as much detail on the types of passages, elevation changes, and other information taken from maps.

Perhaps the most innovative and useful feature of the Pennsylvania Cave Survey is the excellent "Data Collection and Information Manual" (Wheeland, 1983), that is used as a guide for coding cave data. It contains detailed and straightforward instructions for encoding the cave data for computerization. The 48-page manual contains everything from the definition of a cave to a listing of code numbers for all topographic maps in Pennsylvania. As cave data bases increase in size and complexity, it will surely be necessary to develop instruction manuals to improve the consistency of information entered; Pennsylvania has shown how to do it.

Information for the Pennsylvania Cave Survey comes largely from published data in Mid-Atlantic Region Bulletins, state reports, and National Speleological Society Bulletins. Unpublished reports and individual reports are the least-productive sources of information.

TENNESSEE

Number of Caves: 3,950
Number of Cave Maps: 1,000±

The Tennessee Cave Survey has a fully computerized and extensive cave data base that is maintained on Georgia Tech's mainframe computer. To build and maintain the data base, the Tennessee Cave Survey requires that a detailed form be filled out before any cave is added to the files. Further, the cave must be at least 50 feet long or 40 feet deep or have a 30-foot pit. The files are IBM PC and Apple-compatible. Cave listings are available by county or by topographic map.

The Tennessee Cave Survey has plotted cave locations and cave maps on USGS topographic maps, and will provide microfiche copies at a cost of only 25 cents each. This is a useful service that no (?) other cave survey provides (Alabama generates overlays for full-size maps, however). Such a service would be welcomed by many, but it would require close attention to questions of availability.

The Tennessee Cave Survey has two meetings per year -- spring and fall. The spring meeting is more like a seminar, with talks, slide shows, and discussions of work in progress or planned. The fall meeting is more like a business session, with election of officers, distribution of computer products, and related activities.

TEXAS

Number of Caves: 1,900±
Number of Cave Maps: "Several hundred"

The Texas Speleological Survey was organized in 1961, and, as is the case with many other cave surveys, has always existed on a shoestring. Nevertheless, they have a history of accomplishment in which they can take considerable pride. The files are maintained at the Texas Memorial Museum in Austin. Computerization is only partial (listing only), but plans are to use microcomputers at a later date, using Base III.

The data base consists of well-organized files arranged by county (Texas has 76 cave-containing counties out of 254), with accessory files of literature, biology, and maps.

VIRGINIA

Number of Caves: 2,498
Number of Cave Maps: "Many hundreds"

Virginia has one of the oldest state cave surveys, one that has been the model for similar efforts across the country. The files are maintained in the home of the president of the Virginia Speleological Survey. There is a partial duplicate file kept elsewhere, for security. Computerization of Virginia's extensive data base is now in process.

Virginia stands third behind Missouri and Tennessee in number of recorded caves. The Virginia Speleological Survey is not sure how many cave maps they have on file, but the long history of cave work in Virginia guarantees a large and difficult-to-manage cave map collection.

WEST VIRGINIA

Number of Caves: 2,300±
Number of Cave Maps: "About half" (1,000±)

West Virginia is in the early stages of computerizing its large cave data base, which is not yet centralized. They have a system of County Directors who gather, process, and file the data, which is currently held individually by the Directors. Overview of the data base is a shared responsibility (see Appendix I).

When computerization is completed, it will be possible to extract from the data base products listing such variables as length, depth, geologic formation, mapping status, number of streams, entrances, and other information, by county.

With some of the longest and finest caves in the nation, West Virginia has a long and distinguished record of contributions to speleological literature. They have published seven cave survey bulletins since 1971, with an aggregate total of about 1,000 pages. They also published the 1983 NSS Convention Guidebook, "Caves of East-Central West Virginia," and 13 other bulletins are in progress.

CAVE MAP FILES

The difficulty of keeping track of cave maps is apparent when one asks how many caves have been mapped in a given state. Most state cave surveys simply do not know. "Hundreds," "many hundreds," and "we don't know," are typical responses. The hardest part is simply filing the maps, which always seem to come in a wide range of sizes, on anything from drafting linen to graph paper to freezer paper to Mylar. Typically, the maps will be of varying quality, from sketches to transit surveys, and from pencil drafts to computer-plotted outputs to artistically-drafted masterpieces.

Once a cave map is completed and filed in the data base, there may not be a convenient and/or economical way to make copies. Cavers tend to like long, wide sheets, showing a lot of passage detail, but copying them may be both expensive and impractical. Few cave surveys have access to machines capable of copying large-format maps, even if they happen to have been drafted on material from which machine copies can be made.

Most cave mapping is done by organized caving groups who usually work independently. For this reason, duplication of effort is a perennial problem, but one that can be minimized through frequent communication through a coordinating group such as is provided by several state cave surveys.

DATA AVAILABILITY

If there is a mindset common to all state cave data base managers, it is surely availability and data security. Among the states responding, only Louisiana and Mississippi have no particular concern about who or what agency has access to cave information; no known vandal would be attracted to the caves in those states. The other state cave surveys all share a sort of proprietary feeling that cave data should definitely <u>not</u> be available to the general public. The lack of confidence in the public's ability to use cave data responsibly generally extends to governmental agencies as well. In fact, governmental agencies are frequently thought to be more irresponsible than any other entities because of their propensity for publishing specific locations.

Cave listings or catalogs involve a certain amount of risk to the resource. It is widely perceived that such lists have the potential to cause problems if they fall into the wrong hands. To minimize the problem, most data base managers use a system of screening requests for the data, either through membership screening, deliberations of a governing body, or requiring demonstration of a "need to know." In some cases, simply going through the required procedures to show responsibility to acquire a cave list may be enough to discourage all but the most persistent.

Excessive concern over data security may be extremely counterproductive in cases where two or more groups working in the same area do not trust each other. There may be two or more cave data bases, mutually exclusive, with no way of knowing what each collection contains, and no reliable information on the nature and extent of the cave resource in the state. While it is imperative that caves be protected from vandalism, pollution, and pressures from construction/urbanization, it is difficult to protect a resource that cannot be quantified and adequately described.

While the data are closely held with respect to availability, few state cave surveys have fail-safe systems in place to make certain that a fire, tornado, flood or other disaster will not destroy the entire data base. Those systems that are computerized are likely to have backup tapes or disks that are stored separately from the primary ones, but not always. Several of the cave file coordinators maintain the entire files in their homes, with no duplicate files. No amount of homeowners insurance could replace a few filing cabinets filled with the results of 20 years of cave reporting and surveying, nor, in any case, could one establish the value of such a file in case there was insurance.

Some data bases are maintained in university and/or government agency facilities, which probably gives an extra measure of security. Nevertheless, a change of administration, transfer of personnel involved, or loss of funding may threaten the security of even these files.

Missouri has a system whereby the Master Cave Files are kept in a government office, but duplicate files are maintained in two other locations, so that if any one file is destroyed, it theoretically can be rebuilt from the other two. Duplicate tapes of the computerized data are kept in an archival-quality vault so that information, too, is secure. All cave maps are kept in metal map files, and all maps are microfilmed on 35 mm archival-quality film, so that the map files, too, are protected.

Perhaps the best security of all is provided by publication and wide dissemination of the results of cave studies, but this is practical only in cases like Louisiana, where there are few cave resources that are generally not threatened in any way.

APPENDIX I
CAVE DATA BASE CUSTODIANS/MANAGERS

ALABAMA:

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MANAGING A SHOW CAVE

by Bob Bogart*

ABSTRACT

The terms "conservation" and "preservation" are widely popular today with nearly everyone, from the general public to long time advocates of the wise use of natural resources. However, in years past, natural resources, including caves, were widely thought to be inexhaustible and conservation and preservation practices were not widely implemented.

Early man, who often utilized caves, had little use for them except as places of shelter and protection and, being a continuous survival situation, used whatever resource was necessary to survive. A fortunate side-effect of early man's treatment of caves is a record of his existence preserved in sediments in caves and writings on cave walls. Later, exploitation by mineral seekers, onyx miners, gunpowder manufacturers, and even cave tour guides, showed little more thought toward preservation of caves than did early man.

Mark Twain Cave near Hannibal, Missouri has been in operation since 1886 and is the oldest show cave in Missouri. It has seen many of the problems of early cave management attitudes and a study of its operation history provides an excellent critique of the early management of a cave resources. When compared to Cameron Cave, the newest show cave in the State, which is located just a few hundred feet from Mark Twain Cave, the impact of modern management practices is easily seen. Much progress has been made in the management of show caves and exploitation toward education and preservation.

The world of caves is a world known well by relatively few people, and, when we consider the potential for knowledge, how many of us are included in this group. Ask any person you meet if he supports the preservation of caves, he is likely to say "yes" because it is popular in our day to give lip service to the preservation of anything, regardless of what it might be and regardless of the subject at hand. I specifically say lip service, because our practices may be entirely different, as any journey down some highway or along some stream will tell you when you see the litter that has been discarded or the vandalism in general that has taken place.

*National Caves Association and Mark Twain Cave, Hannibal, MO.

All of us present today realize that caves are especially vulnerable parts of our environment, and that conservation and preservation programs are necessary to protect them, but, as in some other fields, sometimes the people closest to the problem are among the worst offenders. But that is another story.

Now, I would like to present to you the show cave operators story and give you an overview as it were of the philosophies and thinking behind the managing of show caves, how they started, how they have changed through the years, and what we might expect in the future.

As I look at the group, I see several of you undoubtedly better qualified to address this subject than I, but through some process of elimination, attrition, or refusal by others, the buck stopped with me. Mark Twain Cave has been in operation for 98 years, having first opened for tours in 1886, and the fact that I operate the oldest show cave in Missouri probably had something to do with the selection. Incidentally we also operate the newest show cave in Missouri, our Cameron Cave. During these 98 years, our own ideas and attitudes toward cave management have changed considerably.

We may be the oldest show cave because we had a master story teller named Mark Twain telling stories about our cave. Mark Twain wrote about the cave in five different books, and any of you who have read them realize Mark was an avid cave explorer in his younger days, and he was very much fascinated by our cave. He said in his autobiography, "I seemed to tire of everything I did, but I never tired of exploring the cave."

When we speak of managing a show cave, I'm sure you realize we are not talking about business management, but rather preserving the cave as it should be, and at the same time providing your visitors with a worthwhile experience. These two goals are not as far apart as some of you might think. Keeping them in balance has presented some problems in the past. Many of the earlier problems were brought on by our own wrong attitudes, but I submit to you that most of our problems now and in the future will be imposed on us by outside factors.

In order to better understand some of these problems, we probably need to begin our study at a logical place, like the beginning.

We know that from the beginning of time, man has been fascinated by caves. Even before the days of recorded history, early man recorded a kind of history in the form of drawings and hieroglyphics on cave walls in various parts of the world.

For centuries, man used raw materials available to him for whatever purpose without regard to conservation or replenishing the supply, and he treated caves the same way. Only in the last few years have we come to realize that a cave, rather than being a place, is an environment that needs to be protected and that management programs are necessary to maintain them as the valuable resources they are. In deference to our show cave operators, may I say that we as a group are vitally aware of this, and as a group have become the most ardent proponents of protection and conservation.

We have all heard that "every cloud has a silver lining" and so it is with the misuse of caves. For example, our own cave located as it is near the Mississippi River, was frequently used by Indians as an overnight stop on their journey up or down the river. Smoke stain on the walls near the entrance and artifacts left behind attest to this. Other caves with larger entrances and rock shelters were frequently used by the Indians as homes, sometimes for generations. Apparently one tribe would occupy the cave for a period of time, and, for some reason or another, would move on. Then sometime later another tribe would come along and occupy the same cave. If the first tribe had left behind any debris or belongings, the new tenants would cover everything with dirt and start over with a clean floor. So our silver lining is that we have some very good records on how these people lived.

At times Indians used caves for purposes other than shelter. When we read the history of Wyandotte Cave in Indiana, we learn the Indians in that area mined flint in the cave. The flint was carried outside where it was fashioned into tools and weapons. Also at Wyandotte, the Indians may have mined calcite and onyx. Many tribes took great pride in jewelry. They mined copper in the great lakes area, and mica in the Appalachians. No doubt the onyx and calcite was fashioned into jewelry, although calcite being of a soft nature, no calcite jewelry has ever been found.

Other caves were used by the Indians as religious temples and still others were used as health centers because they had water with curative properties, or others had waters that would confer good fortune on whoever might drink of it. This feeling is still prevalent among cave visitors today, because some pools of water in show caves contain a goodly number of coins.

When our country was first settled, the early towns were located on the eastern seaboard where there were few caves nearby, but some early accounts of the travels of missionaries and fur trappers tell how some of them were taken to cave haunts known and revered by the local Indians. And thus began the show cave industry in America.

The first commercial use of caves undoubtedly involved using them for the storage and ageing of beer, wine, and cheese, and the growing of mushrooms. These uses were prominent in Europe in areas where caves were located, and later such uses were brought to America. We are told that one reason St. Louis became a beer capital is because of the caves underneath the town where the beer could be stored and aged. When the caves were large enough, they were often used as beer gardens.

During this period, other people used caves as dance halls, skating rinks, and theaters.

Throughout the early history of the commercial use of caves, several other uses keep occurring, notable involved with the search for gold or other precious metals, or jewels, and even the mining of onyx, which wrecked many a beautiful cave. And we shouldn't forget the pirates and outlaws who used the caves for hideouts. In every case, the idea was the same, to use the resources without any regard for the future.

One of the important early commercial uses of caves was the manufacture of gunpowder. This was essential to the frontier, because of the distances from the powder factories in Europe and the east. It was common frontier knowledge that saltpetre for making gunpowder could be gotten from manure piles. The frontiersmen had very few manure piles, but some ingenious soul experimented with the dirt from a cave floor and found the saltpetre could be leached from it. Moreover, this earth covered several cave floors in large quantities. By 1799, Mammoth Cave was known as a source of nitre, and a few years later, Wyandotte Cave was also producing saltpetre. These caves played decisive roles in the history of our country, for they produced much of the gunpowder for the War of 1812. During this same period, several caves in Missouri were mining saltpetre. Meramec Caverns produced vast amounts, and Mark Twain Cave was mined later, during the Mexican War.

After the War of 1812, large scale mining of saltpetre in caves began to dwindle, and in a couple of years stopped almost entirely. In the meantime, something unexpected had happened. The miners had begun to talk about the wonders of Mammoth Cave, and by the year 1815, people were coming to visit the cave for pleasure. And about this same time, although mining was still going on to some extent at Wyandotte, tourists began arriving there.

Several years before this, Weyer's Cave, now known as Grand Caverns, and some of the other Virginia caves located near the larger centers of population had already become known as show caves, and several famous people, among them George Washington and Thomas Jefferson, were said to have been among the visitors.

As word got around that caves were interesting places to visit, people that had caves on their property began to consider the idea of opening their cave to visitors. One such person was Lester Howe. He had undoubtedly read some of the glowing newspaper accounts of the other caves then being shown, and decided he had a cave as good as the others, so he opened the cave that now bears his name, Howe Caverns in New York.

These first show caves had several things in common. Most of them had guided tours, some conducted by the owner, but all were long and strenuous. Lester Howe, for example, offered a tour that lasted about eight hours. At first, operators did nothing to improve their cave, so the visitors expected to return exhausted and covered with clay. Howe and some of the others furnished their visitors with uniforms to protect their regular clothing. All furnished a candle, lantern, or some kind of torch. In areas where there were large chambers, guides would frequently light a strip of magnesium and hurl it into the area he wished to light. These lights all gave off large volumes of smoke, and some gave off noxious fumes.

It wasn't long until Howe added gas lamps to a part of his cave to help the visitors to see. Apparently, the gas pipe proved to be a good handhold for a stumbling visitor, so the lighting system was always out of order.

As people came to visit the caves in larger numbers, the owners were continually trying to offer new and better tours. Many explored their cave for new areas to open for show. Others would break off formations and give them to the visitor as a memento. For years, there was only one philosophy prevailing: Try to outdo the other fellow, more cave, more spectacular sights, many were not beyond embellishing the work of nature to make it more sensational. During these times, there was no TV or theme parks, so natural attractions had very little competition, and most of them prospered.

The show cave industry came to Missouri in the late 1800's. Starting it off was a book written by Mark Twain and published in 1876 where Tom Sawyer and Becky Thatcher were lost in the cave. Shortly after the book was published, people began coming to Hannibal to visit the cave as well as other points of interest in the area. The people who owned the cave at that time operated a brick plant on the property and were not particularly interested in showing the cave. Now there was a steamboat landing and a railroad siding nearby, and visitors arrived anyway. So they assigned the job of cave guide to John East, one of their employees who lived in a company house on the property. Many of the early cave guides were colorful characters, and John East was no exception. He soon acquired a reputation for being a good story teller, and he liked nothing better than to tell visitors some wild tales of his early experiences in the cave. And for an admission price of ten cents, he would often keep visitors in the cave for several hours or until their candles had nearly burned out. But John also liked to fish, so visitors who arrived when he had a fishing trip planned did not fare nearly so well. John's tours were similar to what the other show caves offered. They were strenuous with several clay banks to climb up or down, and visitors returned covered with clay and candle wax, and they each had a piece of calcite John had urged them to break off in passing.

Now and then something unexpected took place which added to the excitement of the tour. One time when John was on a tour, he came upon two men who had slipped into the cave unnoticed. One of the visitor's said under this breath, "That's Jesse and Frank James."

Another man who lived nearby and who was also interested in the cave was Evan Cameron. He was a dairy farmer, but acted as a guide whenever the occasion warranted. In 1923, the owners fell on troubled times financially, and offered the cave for sale. Cameron bought the property, and it is now owned by his descendents.

The first thing Cameron did was to see that a guide was stationed at the cave and was available every day year round. He also replaced the candles with Coleman lanterns, and dug the clay banks down so they could be walked down instead of having to climb. But each visitor was still offered a piece of calcite before he left. Today, a piece of calcite is still a popular souvenir, and it is easily gathered outside where the rock outcrops. Also in 1923, the visitors were invited to go exploring on their own after they had completed the regular tour. The show cave industry has come a long way in 150 years. Nowadays, Missouri has a cave inspection law which helps protect the visitor and make the tour more enjoyable for him, and also a cave vandalism law which protects the operator. Gone are the days when a woman Geologist, Luella Owens, wrote in the 1890's:

> "Unfortunately, most Ozark Caves have been deprived of great quantities of their beautiful adornments by visitors who choose the best and remove it in such quantities as may suit their convenience and pleasure. Those who own caves, and those who visit them would do well to remember that if all the natural adornment should be allowed to remain in its original position, it would continue to afford pleasure to many persons for an indefinite time; but if broken, removed, and scattered, the pleasure to a few will be comparatively little, and that short lived. The gift of beauty should always be honored and protected for the public good."

In this era of the TV special, theme parks, and gambling casinos, I feel the day of the artificial spectacular is drawing to a close, and the trend is back to natural, which is, after all, the thing we show best.

The show cave industry is at a plateau right now, as there have been few new caves opened in the last few years. Whether or not this trend continues depends on the discovery of new caves in accessible locations. For the present, the industry is healthy and the operators themselves are the most protective of their property. And they are policing their property so that visitors are for the most part treating their caves with respect.

There are some potential problems with outside pollution, particularly where the cave is located close to an urban or resort area. But the biggest problem we have is the so-called sport caver who shows no particular regard for your property, and thinks his lip service to a love for caves entitles him to help himself to anything he wants or to discard anything he doesn't want. Most operators have solved the problem by closing their cave to these people. Some of them decide to join a regular tour, but they still have to be watched closely.

As a group, I feel we are managing our resources well these days. We are not going to foul our own nest. After all, our future business life depends on our maintaining our properties in the best possible condition.

HISTORICAL INVENTORY BEFORE CLEAN UP

by Tom Meador*

ABSTRACT

Evidence of past use and exploration of a cave are valuable assets that must be protected during cave clean-ups and other "restoration" type activities. Steps in the protection of these assets include inventory, evaluation, and on-site protection. Some items may be designated for removal for study and protection in less destructive environments. Workers available during clean-up activities should be made aware of features needing protection.

*National Speleological Society, El Dorado, TX.

CAVE ATTRACTIONS AND THEIR PLACE IN THE TRAVEL INDUSTRY

by Russell Campbell*

ABSTRACT

Three ingredients are necessary to support a travel industry; leisure time, disposable income, and transportation.

Even the rugged life of the country's early settlers was occasionally touched by caves. The functional values of shelter and storage were no doubt of initial use. Settlers lacked most of the three travel ingredients, but at some point life became easier. If a cave was in the area they became social gathering areas, valued for natural air conditioning. Curiosity led the adventuresome to explore. Some of the Country's oldest show caves have their roots in the 18th century.

The Industrial Revolution produced vast changes for American society, fostering recreational travel. Now in increasing numbers America's wealthy traveled. More people shared time, money, and most importantly rail transportation. At first travel was limited to natural wonders; the sea coast and mountains. Our first attractions developed. Some of the very caves explored by settlers were popularized by rail service. Resorts developed in the form of health spas associated with mineral springs. Still travel was limited to the wealthy.

Continued mechanization and World War I created demand for and availability of leisure travel in the middle class. When Henry Ford mass produced an automobile for the average man, the travel industry sparked to life. Middle income auto travel initially followed the pattern of earlier rail travel, though regionalized. Families traveled to natural wonders, including existing cave attractions.

Depression and hard times dampened travel in the 1930's but the W.P.A. projects set the stage for a post World War II boom.

This paper will address the role played historically by cave attractions and follow their influence through the boom years of the forties and fifties. It will attempt to assess the state of and role the show caves play in today's travel industry.

*Fantastic Caverns, Springfield, MO.

Three ingredients are necessary to support a travel industry: leisure time, disposable income, and transportation.

THE PAST

Even the rugged life of the country's early settlers was occasionally touched by caves. The functional values of shelter and storage were no doubt of initial use. Settlers lacked most of the three travel ingredients, but at some point their lives became easier. If a cave was in the area they frequently became social gathering areas, valued for natural air conditioning. Curiosity led the adventuresome to explore. Some of the Country's oldest show caves have their roots in the 18th century.

The Industrial Revolution produced vast changes for American society, fostering recreational travel. In increasing numbers America's wealthy traveled. More people shared time, money, and most importantly, rail transportation. At first travel was limited to natural wonders: the sea coasts and mountains. Our first attractions developed. Some of the very caves explored by settlers were popularized by rail service; caverns like Luray, Grand, and Mammoth. Resorts also developed in the form of health spas associated with mineral springs. Still, travel was limited to the wealthy.

Continued mechanization and World War I created demand for, and availability of, leisure travel in the middle class. When Henry Ford mass-produced an automobile for the average man, the travel industry came to life. Middle income auto travel initially followed the pattern of earlier rail travel, though regionalized due to our primitive highway system. Families traveled to natural wonders, including the existing cave attractions.

The 1920's were an important decade for show caves. Carlsbad Caverns was popularized by stories appearing in national journals and by the photographs of Ray Davis. Ray Davis pioneered cave photography and offered America its first views of underground beauty. Carlsbad Caverns became a National Monument in 1923. In 1930 the Caverns became one of twenty-eight National Parks. The role of Floyd Collins, more certainly of his death in Sand Cave, cannot be overlooked. As morbid as it sounds, the press coverage of the ill-fated rescue attempt created one of the largest news stories of 1925. In 1926 an act of Congress set the stage for Mammoth Cave National Park. While the park was not dedicated until 1946, Mammoth Cave was at last administrated by the Kentucky National Park Commission and the Mammoth Cave National Park Association. Under this joint administration, knowledge and development of the cave again expanded.

Depression dampened travel in the 1930's but the W.P.A. and C.C.C. projects produced much needed improvements in our Parks System and expanded a primitive highway network. We now had a transcontinental highway system. This period also saw development of a new type of overnight lodging to serve the traveler. Our first motels were built.

World War II interrupted travel activities for six years. The technological improvements made during the War, however, were instrumental in producing the modern automobile. Following World War II the stage was set for an unprecedented expansion of recreational travel. The average American's automobile was now capable of traveling sixty miles per hour (mph), we had a national highway system, and thanks to continued mechanization and our labor movement, Americans had increased leisure time and disposable income. Existing show caves, both public and private, were inundated. Those who had received publicity prior to the War were in the best position. Carlsbad Caverns saw attendance grow from 193,000 in 1945 to nearly 552,000 in 1952. We also saw the proliferation of billboards. The success formula in the private sector was to have a cave reasonably accessible to highway traffic, a counter to sell tickets from, and billboards. It was about that simple. Many of the existing caves saw rapid expansion. Cave attractions handled a high percentage of the traveling public. They were one of the very few existing attractions and were set to prosper throughout the 1950's.

The 1950's brought something else to the travel industry. When things get too prosperous, somebody else wants a piece of the action. The travel industry was booming. Serious competition was developing: small frontier cities, reptile gardens, water sports, outdoor theaters, and early theme parks. Our economy was strong, creating increasing demand for the expanding travel attractions.

If the 1950's boomed, the 1960's and early 1970's were icing for the cake. Our economy continued to expand rapidly. The 60's decade saw unprecedented economic growth. We now had the interstate highway system, 70 mph speed limits, and automobile air conditioning. American society was affluent and mobile. Travel was fashionable. Our preoccupation with travel might well be reflected in the General Motor's advertising campaign of the early 1960's, "See the USA in your Chevrolet". Competing attractions increased in number, but in the prosperous times there seemed "plenty to go around". According to an experienced cave manager referring to this period, "In the 60's and early 70's operating a cave was much simpler. It pretty well boiled down to how hard you wanted to push your attendance curve up, as to what degree you increased your advertising budget".

THE PRESENT

The late 1970's and 1980's have produced new circumstances. We have seen a recession, gas shortage and associated price increases, rampant inflation, and another recession; hard times for our society. Cave attendance began declining as early as 1972.

A survey was conducted this summer to collect information on show caves. Forty-four cave attractions responded, thirty-five from the private sector and nine state and federal operations. Figures 1 and 2 show when the caves were opened and the years of most growth. Attendance is profiled in Figure 3. The majority of today's cave attractions were opened between 1850 and 1950. The 1920's and 1930's saw more caves opened than any similar period. When recreational travel was emerging, as early as the Industrial Revolution and as late as WW II, cave attractions played heavily in travel plans and saw

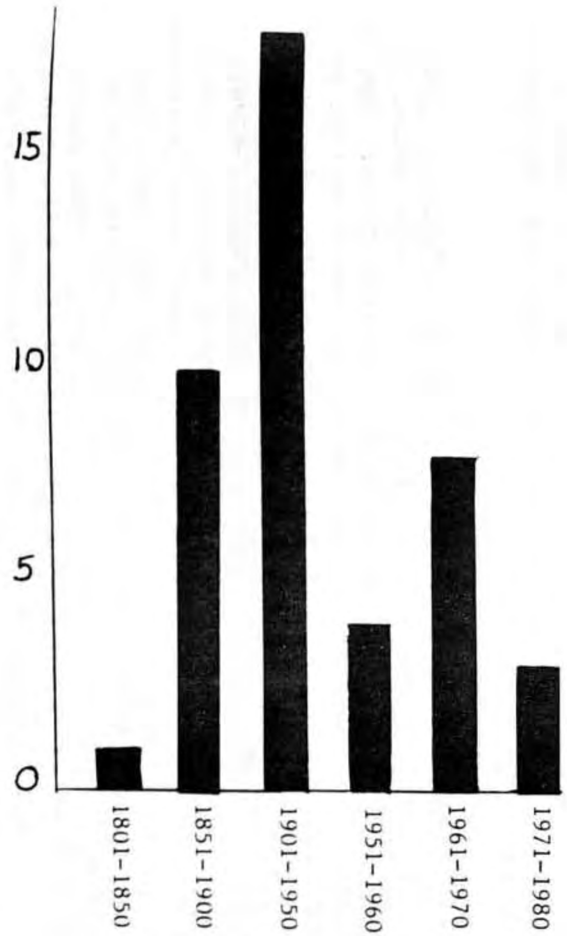

__Figure 1.__

Opened to public.

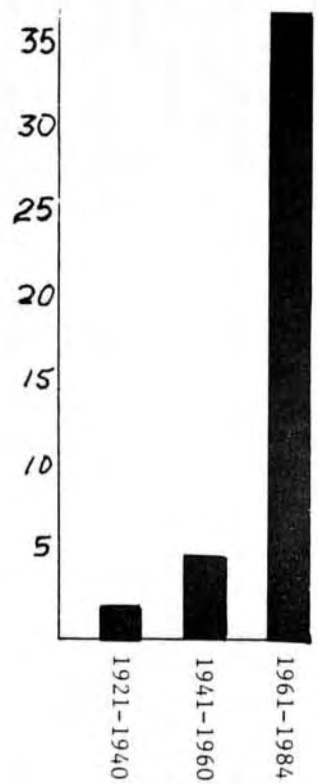

__Figure 2.__

Years of most growth.

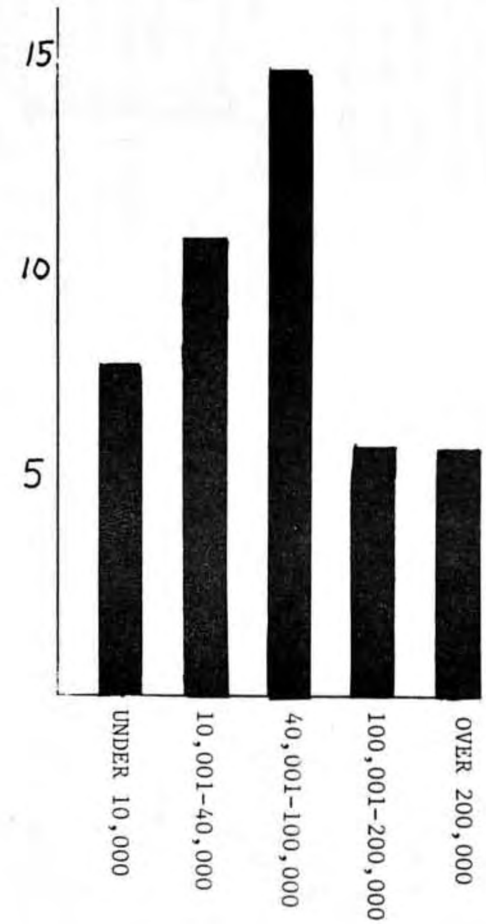

__Figure 3.__

1983 attendance profile.

little in the way of competition. During the expansion of the 1950's, 1960's and early 1970's cave attractions were established and many scored large traffic increases. Caves still figured heavily in travel plans, even though late in this period large man-made entertainment complexes made the industry leaders. Historically caves have played a big role in recreational travel. Caves were the original tourist attractions.

What have the later 1970's and 1980's brought? Cave attendance has been generally declining. Figure 4 reflects record attendance years. Most of the surveyed caves recorded peak attendance between 1973 and 1978. Figure 4 indicates the 1980's have seen a little improvement. It should be noted, however, that the caves recording record years in 1982 and 1983 are either relatively new attractions or lower volume facilities. Figure 5 profiles the record years at the twelve surveyed caves having attendance over 100,000. Personal conversations and survey comments indicate a gentle upturn occurred in the 1980's perhaps tied to a slightly improved economy.

THE FUTURE

It would be tempting to show the correlation between declining cave attendance and a declining economy and just close this matter. The cause and affect relationship is no doubt very real and significant. No doubt as Americans' discretionary spending increases, so will cave attendance. This, I am afraid, would be shortsighted. There are other forces working on cave operators: public perception of show caves and changing demographics.

Public perception and market appeal are two closely related matters. The public's interest in caves historically has been high. The publicity afforded cave explorations and discoveries during the 1920's and 1930's generated much interest. The bold publicity and roadside promotion of the 1950's and 1960's continued the appeal. This interest was generated in newly mobile society. Few people had seen a cave. The cave tour was a thrilling new adventure. There were few competing attractions. Market appeal was high.

I suspect today's travel market place is quite different. Look at the options afforded: theme parks, music shows, water attractions, state and federal parks, cruises, packaged overseas tours. The list goes on and on. Contrasted to our competition caves may not be the thrilling adventure they once were perceived to be. I also would speculate that a high percentage of the market has visited at least one cave in their lifetime, again reducing the sensation of adventure. Cave operators may have further reduced their appeal by their inability to change with the times. Most cave tours are almost exactly the same as they were in the 1960's. For that matter many cave facilities look like they did in the 1960's. Unfortunately most private cave attractions are marketed just as they were in the 1960's. These points all contribute to a general perception of decreased value and over commercialization. I guess I would have to say that many cave managers seem to have been asleep for the past twenty years. They have just been trying to continue doing what was successful earlier. I might note

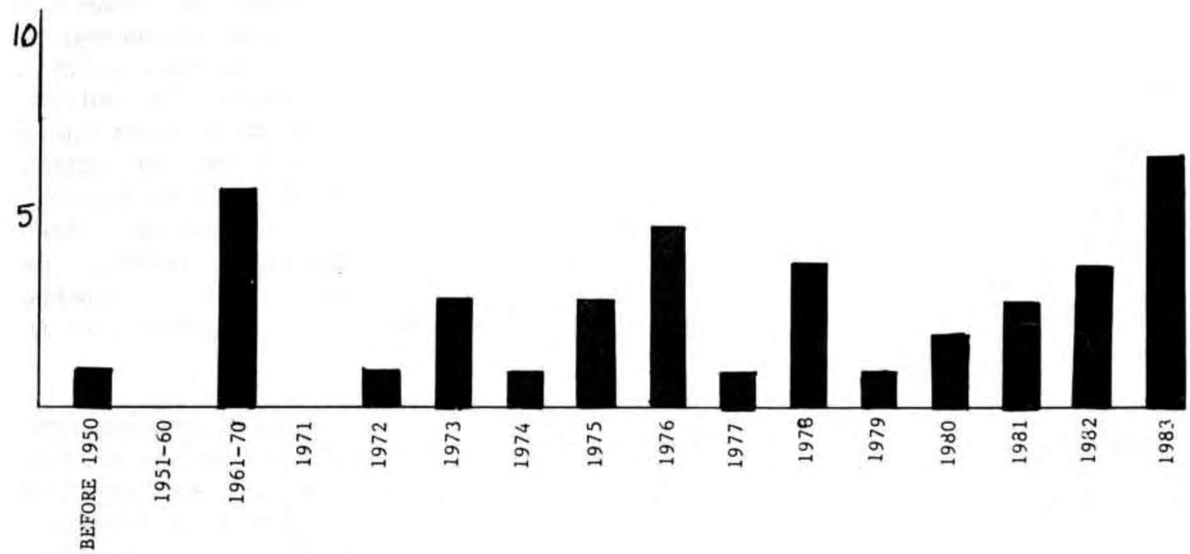

Figure 4. Record attendance years.

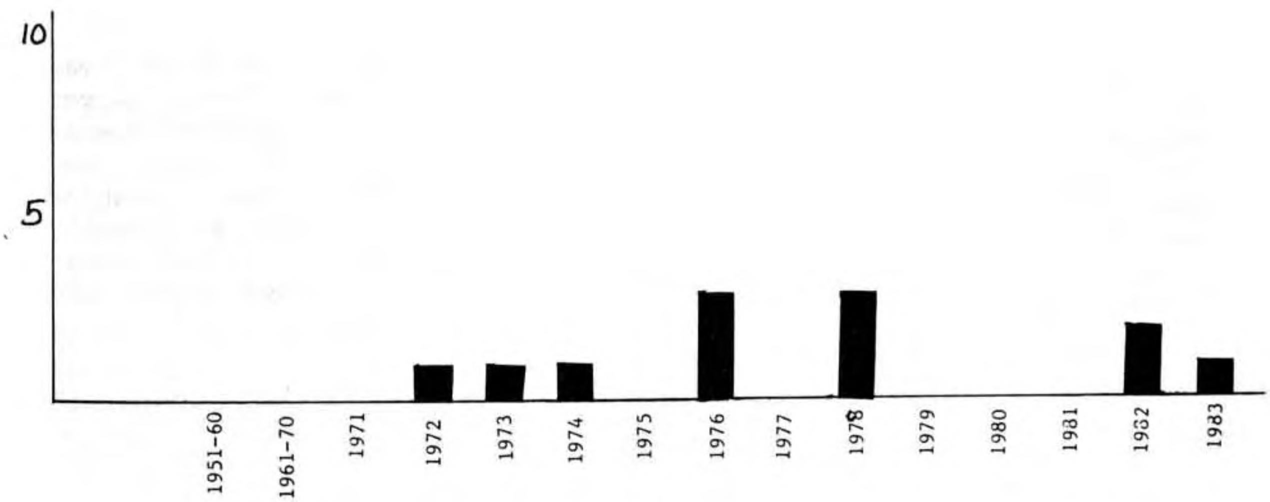

Figure 5. Record attendance years at caves over 100,000.

that the three large (100,000+) cave attractions recording record years during 1982-83 were all opened since 1962 and have broken some of the traditional molds. There simply has been too much imitation in the industry and not enough creation. Cave management needs to "take the blinders off" and go to work. If our produce demand is decreased by poor public perception we need to work to change the perception. This is a manageable situation. Public perception can be changed by individual attractions taking a hard look at themselves and increasing their entertainment and hospitality values: Go look for that "better idea". Perception can be changed through regional and national trade associations. We need to demonstrate and communicate our value. Most importantly we need to generate interest in caves in our youth. We need to cultivate our next market. School systems are eager to receive quality educational materials. Why does General Motors advertise in Boy's Life?---To cultivate their upcoming market.

Demographics are changing. Not only is our population changing character and shifting,it is getting older. Most cave tours are either physically difficult or are considered to be difficult. As "America Grays" what will happen to cave attractions? If some medium and long range changes are not implemented, our market appeal will be further reduced. This aging of our population may well be the most significant problem to confront cave management. Those who adapt to serve these customers will necessarily be making the decisions in the next 5-10 years. "Times are changing."

CONCLUSION

Cave attractions have been popular for 50 years. Attendance seems to have been generally declining since the mid 1970's. I would expect many cave operators will continue to see generally declining crowds. Others who are serving contemporary markets will grow. The future, now more than ever, belongs to the creative organizations that recognize what the public is looking for. Twenty years from now we will probably see fewer show caves. This is not predicting doom, but rather recognizes a challenge. CAVE OPERATORS: Survey the times, survey the market, take a good look at what you offer and go to work.

ENDANGERED BAT PROTECTION AT BUFFALO NATIONAL RIVER, ARKANSAS

by Milford R. Fletcher, Ph.D*

ABSTRACT

In 1981, the National Park Service identified needs to protect endangered species of bats in five caves at Buffalo National River. These caves (Peter, Crane, Fallout, Cave Mountain, and John Eddings Cave), were fenced to protect bats during specific times of the year. Protection of these caves cost approximately $19,000 each.

Specifically, Cave Mountain Cave is a hibernaculum for Gray and Indiana bats, with a potential for the return of a maternity colony. The other caves are primarily bachelor colonies used by Gray bats during the summer, although one or two may have potential as a Gray bat maternity colony. The cave entry fences are well signed, and all of the caves gated are open for at least a portion of the year for visitors to use.

INTRODUCTION

Since 1975, the National Park Service has been surveying caves for endangered species of bats at Buffalo National River. Largely through contacts with the Cave Research Foundation (CRF) and the Arkansas Association for Cave Studies, more than 100 caves have been identified, and many of these have been surveyed and mapped. Through contract with Dr. Michael Harvey, Memphis State University, five caves were identified in 1979 and 1980, as being significant habitat for either Gray Bats (Myotis grisenscens) or Indiana Bats (Myotis sodalis). In 1981, Dr. Harvey completed a report to the Arkansas Game and Fish Commission, the U.S. Forest Service, and the National Park Service. This report entitled "Endangered Bats of Arkansas: Distribution, Status, Ecology, and Management" called for management actions consisting of gating / fencing and signing caves within the boundaries of Buffalo National River. Four of these caves (Fallout, Crane, Peter, and John Eddings) are summer colony caves for Gray Bats. Cave Mountain Cave, also known as Boxley Bat Cave, is a known hibernaculum for both Gray and Indiana Bats, once was reported to contain the largest hibernating colony of Indiana Bats in Arkansas. At one time as many as 7,000 Indiana Bats were reported in the cave. John Eddings and Cave Mountain Cave are quite extensive, while Fallout, Crane and Peter are small in size and extent.

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PLANNING PHASE

In March of 1981, the National Park Service began making preparations to protect these caves during certain times of the year. In April of 1981, the caves were visited by personnel from the U.S. Fish and Wildlife Service, Buffalo National River, and Regional National Park Service personnel from Santa Fe, New Mexico. In June of 1981, formal consultation with the Fish and Wildlife Service was initiated to comply with the Endangered Species Act of 1973 and subsequent amendments. Fish and Wildlife Service approval under Section 7 of the Endangered Species Act was far from automatic. A lively debate ensued regarding how the caves were to be gated, when the caves should be opened to the public, and the realities of both funding and logistical problems for gating or fencing these caves. Fencing, rather than gating, was chosen as the preferred alternative for reasons stated later. In September, 1981, archeological clearances were begun by NPS archeologists from Santa Fe, and the results of these clearances are shown on Table 1.

Cave	Days to Survey	Comments
John Eddings	4	Three test trenches Lithic fragments present
Cave Mountain Cave	1	Two test holes Flakes, etc. present
Peter	3	Three test pits Cultural material present to 140 cm
Crane	2	Two test trenches No sherds, shell, or bone encountered in trench 1. Trench 2 had cultural material to 1 meter deep
Fallout	4	Three test pits Cultural material present to 180 cm

Table 1. Archeological clearance data from five endangered bat caves at Buffalo National River.

It should be noted that archeological testing was in the predetermined fence site and was not intended to be an analysis of the significance of the site. Testing revealed one cave to be of considerable significance, and it has been suggested that this cave be permanently closed to visitation to protect not only the bats, but the archeological site itself. If site damage occurs, this may be considered.

There is considerable evidence that these four caves are utilized seasonally and sporadically by Gray Bats and censusing their numbers is difficult. For example, in Peter Cave, on August 10, 1979, there were approximately 2,500 Gray Bats present. Yet, on August 29, 1979, less than two weeks later, no bats were present. In John Eddings Cave, on August 7, 1979, there were no Gray Bats present. Yet, 11 days later, there were more than 1,500 Gray Bats present. Gray Bats marked June 27, 1980 in Fallout Cave appeared the next day in Peter Cave, a linear distance of some six miles. These caves are all in close proximity to the Buffalo River and it is assumed that the river bottom constitutes their foraging grounds.

SELECTION OF GATES / FENCES

So, on July 29, 1981, after determining the extent of fencing that would be needed, bids were advertised and a contract awarded to Van Horn Construction of Russelville, Arkansas, to construct and install fences around these five caves. Fences were chosen over gates for several reasons. First, and most importantly, fences, if placed away from the cave mouth, do not significantly restrict bat movements to and from the cave. Second, the problem of predators catching bats as they negotiate through gates is avoided. Finally, external fences avoid the possibility of changing air flow patterns associated with both internal and external gates. It has been reported that changing the air flow and therefore the temperature of a cave by as little as 2^{o} F. may have a decimating effect on hibernating bats.

Fence construction for Crane, Fallout, Peter and John Eddings Caves began in the fall of 1981, after gray bats had left for hibernation, and was completed in early 1982. Cave Mountain Cave was not fenced until late spring of 1982 to avoid disturbing any hibernating bats. Table 2 summarizes the cost of this fencing effort. Fence details are shown in Figure 1.

Cave	Linear Feet	Total Cost	Unit Price $/lin. ft
John Eddings	93	$10,416	112
Crane	101	$18,473	182
Fallout	196	$28,077	143
Cave Mountain Cave*	324	$29,462	91
Peter	38	$7,110	187
TOTAL:	752	$93,538	$\overline{X}$ = $124/ft.

Table 2. Cost analysis of five cave fences for endangered bat protection at Buffalo National River, Arkansas.

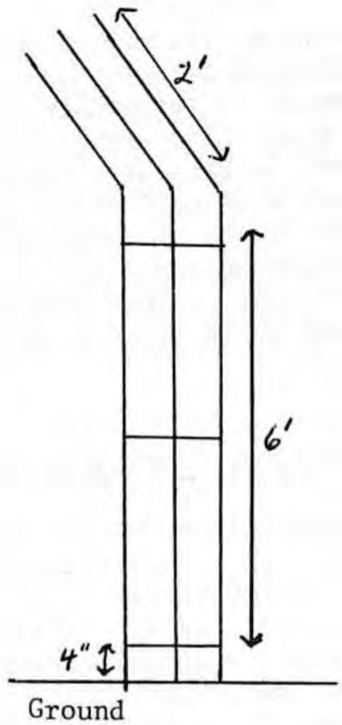

Figure 1. Fence details, bat caves at Buffalo National River, Arkansas. Fence is constructed of 5/8" square galvanized steel bars welded at each point. six-foot pannels are set in cement with 2" x 2" tubular iron and 1.5" x 1.5" steel bars in the horizontal members.

The bids for fencing these caves were cause for considerable consternation. However, it must be remembered that these bids include not only the construction of the metal panels which constitute the fence itself, but installation of the fences. All materials, fence panels, water, cement, drilling tools etc., had to be physically carried to the cave site. The contractor also hoped to make a modest profit.

FUTURE CONSIDERATIONS

After the fences were installed, an interpretative sign was installed at each fence stating the reason for closure of the cave and the times of the year the cave is open to human visitation. So far the fences appear to meet their objectives. Some minor vandalism has been reported but, for the most part, the fences appear to be successful and the public seems to be accepting the need for protection of the bats. One or two of the caves show potential as a grey bat nursery cave. The National Park Service will continue surveys and protection of the bat populations at Buffalo National River with the knowledge that every reasonable effort has been made to protect these endangered creatures from human disturbances.

SUBTERRANEAN CONTAMINATION OF MARAMEC SPRING BY AMMONIUM NITRATE AND UREA FERTILIZER AND ITS IMPLICATION ON RARE CAVE BIOTA

by Ronald Crunkilton*

ABSTRACT

One of Missouri's most serious environmental catastrophes occurred in November of 1981 when an estimated 80,000 liters of liquid ammonia nitrate and urea fertilizer spilled at a pipeline break near Dry Fork Creek. Dry Fork is a losing stream and a recharge area for Maramec Spring, the state's third largest spring. Seven days following the break, dissolved oxygen at Maramec Spring, a distance of 21 kilometers from the break site, dropped to less than 1 mg/l for nine days resulting in a loss of over 37,000 fish. Ammonia and nitrate nitrogen concentrations were elevated in the spring for over 38 days. Aquatic organisms killed included the rare Salem cave crayfish *Cambarus hubrichti* and the southern cave fish *Typhlichthys subterraneus* which had not previously been reported from the Meramec basin. The extent of damage to subterranean aquatic life and their prospects for recovery are difficult to predict and may never be fully known. This incident points out the vulnerability of springs and their unique fauna to waterborne pollutants. Additional hydrological studies are needed to define and protect the recharge basins of many springs and cave systems of noted significance.

The Missouri Ozarks are characterized by one of the nation's greatest abundance of springs. Over 1,100 springs have been identified and measured in the state (Vineyard and Feder 1974). Five of Missouri's largest springs have discharges that exceed 400,000 cubic meters per day placing them among the largest in the United States. This concentration of springs is the result of soluble dolomitic rock formations and karst topography. Water infiltration in these areas is most frequently associated with connections between surface fractures and faults in streambeds and deeper solution channels. Underwater movement may follow these fractures or tubular openings for many kilometers and possibly cross different drainage basins before surfacing as a spring. These geological characteristics also make this extensive karst area and its associated aquatic life especially vulnerable to the entrance and transmission of waterborne contaminants. This paper discusses an incident that resulted in severe degradation of the water quality and fauna of Missouri's third largest spring.

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In November of 1981 a break was reported in an interstate pipeline and an estimated 80,000 liters of liquid ammonium nitrate and urea fertilizer were spilled near Dry Fork creek (Figure 1). This section of Dry Fork was believed to be a major recharge area for Maramec Spring located 21 kilometers to the northeast (see Hydrologic Aspects of the November 1981 Liquid Fertilizer Pipeline Break on Groundwater in the Maramec Spring Recharge Area, Phelps County, MO by James E. Vandike published in this proceedings, 7 pp).

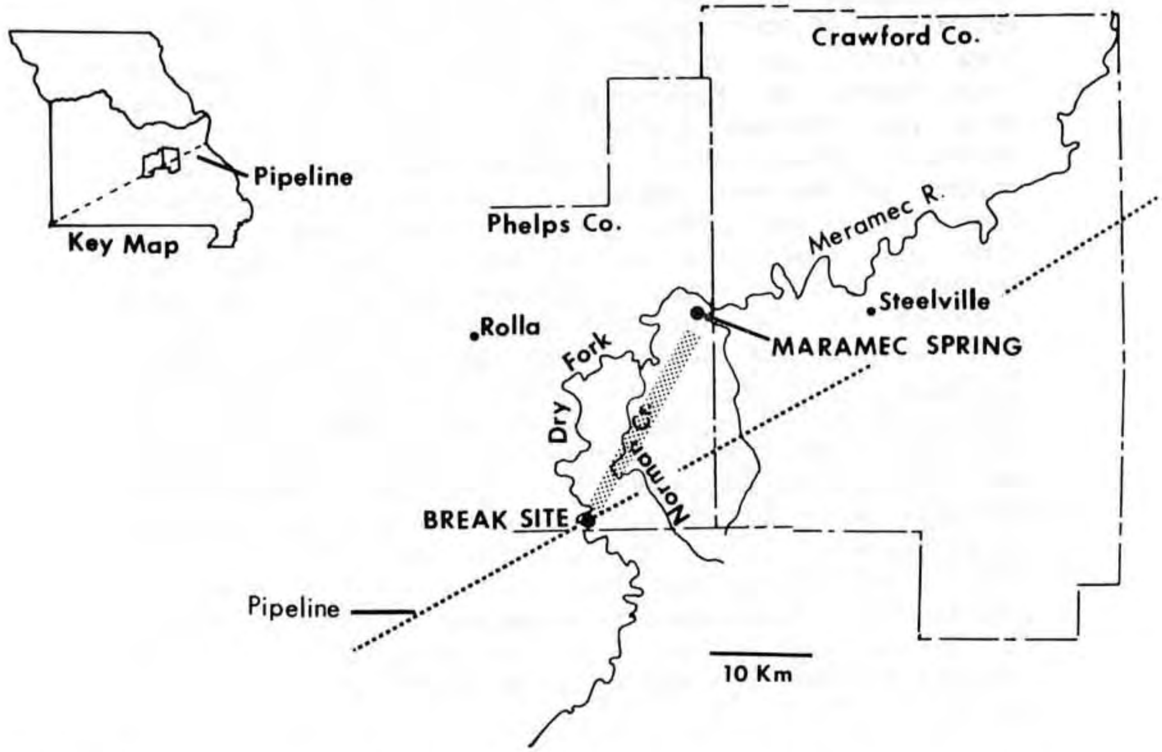

Figure 1. Location of fertilizer pipeline, break site, and Maramec Spring in Missouri.

The liquid fertilizer was a mixture of 45% ammonium nitrate, 35% urea, and 20% water by weight. Dissociation and biochemical transformation of these compounds in the aquatic environment consumes oxygen and yields toxic and non-toxic compounds. Ammonium nitrate dissociates into ammonia and nitrate. Nitrification of ammonia consumes oxygen and yields nitrite which is subsequently biochemically converted to nitrate. The reaction is:

$$NH_4NO_3 + 2O_2 \rightarrow 2NO_3 + H_2O + 2H.$$

The uptake of oxygen by this reaction is of reduced significance in surface waters because of photosynthetic oxygen production and physical aeration. However, in groundwater the oxygen content is fixed at the point of entry into the aquifer and is subject to reduction by a number of chemical and biological processes before it issues forth in a spring. Therefore, oxygen consuming contaminants that enter the recharge system of a spring represent a much more serious threat than the same substance in surface waters.

Maramec Spring is fed through a large phreatic cave (Figure 2). Scuba divers have penetrated the cave 550 meters to a depth of 65 meters. The spring outlet empties into a 1.2 hectare basin that is formed by a shallow rock dam placed across the spring branch. The spring outlet is constricted by a 2 x 3 meter opening and orifice water velocities are such that Scuba divers have only been able to penetrate the cave during periods of lowest discharge. The high water velocity caused by this constriction is believed to prevent the movement of organisms into the cave from surface waters. Beyond this narrow opening the cave widens into a large room of 30 x 20 x 5 meters with a gravel bed that slopes down to a tubular passage at a depth of 20 meters. The passage continues a steep descent to a depth of 40 meters, then gradually drops over areas of extensive breakdown. Several breakdown rooms, the largest with a 20-meter ceiling are found at a depth of about 60 meters.

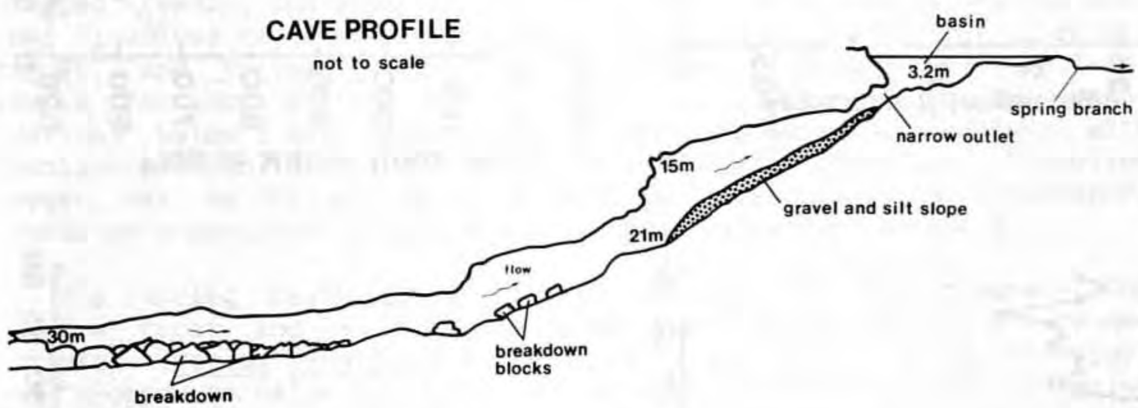

Figure 2. Profile of subterranean cave at Maramec Spring. Redrawn from survey by Roger Miller and Raymond Fogarty, 1978.

IMPACT ON WATER QUALITY

The loss of over 80,000 liters of fertilizer into the recharge system had a severe and prolonged impact on the water quality of Maramec Spring. Seven days following the spill, dissolved oxygen at Maramec Spring plummeted from a normal of 7 mg/l to less than 1 mg/l (Figure 3). Dissolved oxygen concentrations remained below 1 mg/l until day 18, then rebounded to near normal levels due to a rapid increase in spring discharge caused by 25 mm of rainfall on day 16. Dissolved oxygen dropped again but less precipitously to 5 mg/l as spring discharge declined. Following additional precipitation on day 38, dissolved oxygen concentration at the spring returned to normal levels.

Ammonia, nitrate, and nitrite concentrations were elevated above background levels (Figure 3). Ammonia is a natural product of

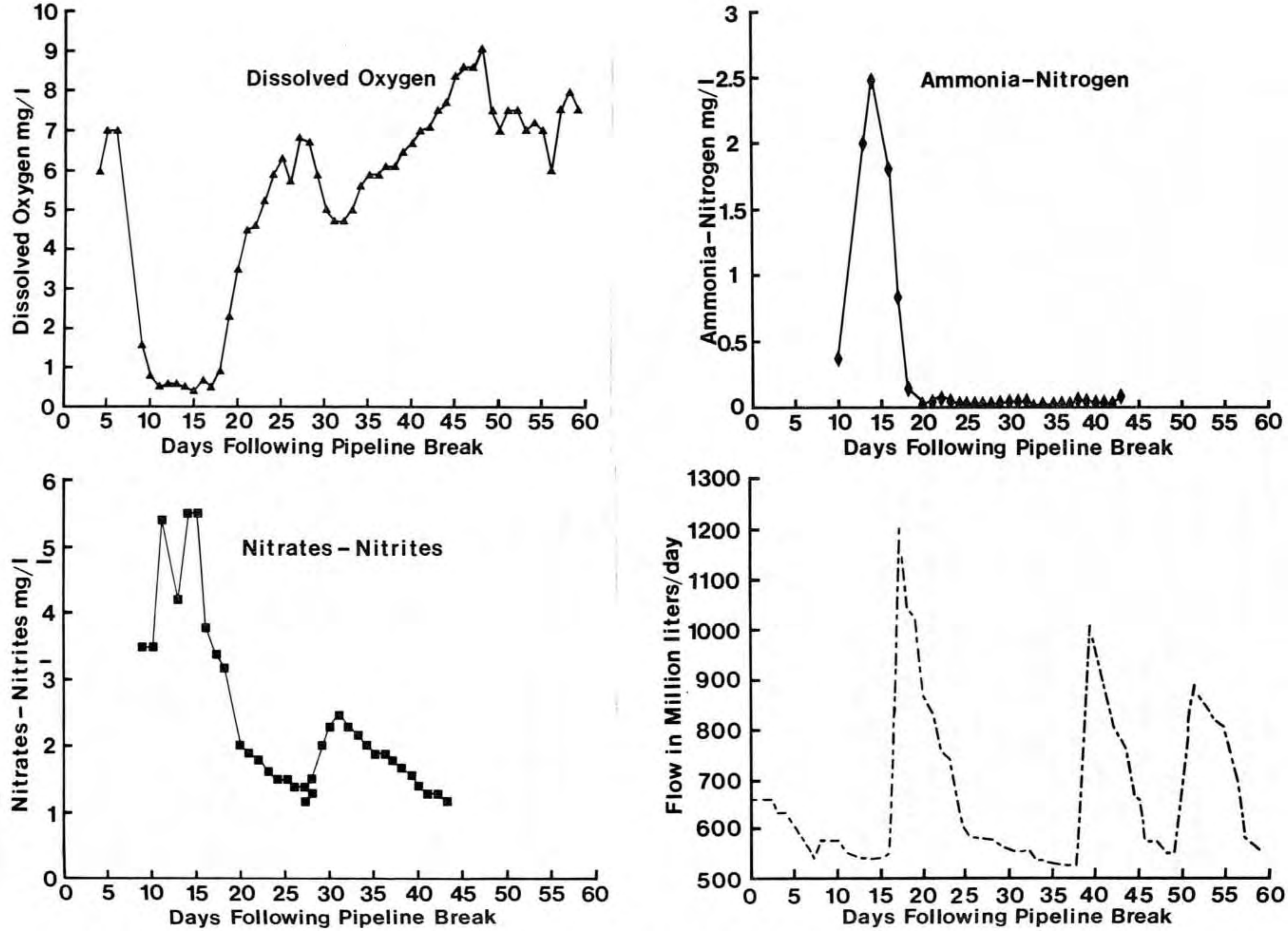

Figure 3. Dissolved oxygen, ammonia nitrogen, nitrate-nitrite nitrogen, and discharge following the pipeline break and fertilizer spill at Maramec Spring.

decomposition, but the concentration rarely exceeds 0.1 mg/l in unpolluted water. The concentrations increased to 2.5 mg/l between days 10 to 15 following the break, then decreased to normal levels by day 20. Nitrate and nitrate concentrations in unpolluted water are normally less than 2 mg/l. Concentrations were elevated to 5.5 mg/l between days 10 and 15, then decreased rapidly with increased spring discharge. A secondary peak was observed on day 31 as spring flow decreased further, but concentrations dropped to normal levels with a second surge of rainfall induced spring flow 38 days following the spill. Elevated nitrates were attributed directly to the nitrate present in the fertilizer and to the conversion of ammonia to nitrates.

IMPACT ON SPRING LIFE

Maramac Spring is located in a privately owned public park. The Missouri Department of Conservation raises rainbow trout (Salmo gairdneri) in raceways adjacent to the spring for stream stocking. Seven days after the spill was reported, rainbow trout at the spring stopped feeding and began to show other signs of stress associated with low dissolved oxygen. Trout require a minimum of 4-6 mg/l of dissolved oxygen, and prefer levels near saturation. They may survive lower levels for short periods of time, but adults rapidly succumb to concentrations below 1 mg/l. An intensive effort to aerate the raceways with gasoline-powered pumps was successful in reducing mortality. Dissolved oxygen was maintained above 3 mg/l for several days until transport trucks were obtained to move the live trout to another hatchery.

The spring basin could not be aerated and an estimated 1,000 rainbow trout and 35,000 mottled sculpins (Cottus bairdi) and banded sculpins (Cottus carolinae) were killed by day 11 when dissolved oxygen had dropped to below 0.5 mg/l. No mortality occurred beyond the spring basin because the water was re-aerated as it passed over a shallow rock dam on the outlet stream.

On day 10 southern cavefish (Typhlichthys subterraneus) were observed floating in the spring basin and in the outlet stream. Over the course of five days nearly 1,000 of these rare fish were estimated to have been flushed from the spring system. The low dissolved oxygen immobilized, but did not appear to be the direct cause of mortality in this species. The fish had lost equilibrium, were floating on the surface, and did not respond to stimuli. A number of individuals were transferred to oxygenated water and regained equilibrium with no apparent ill effects. However, it was unlikely that any cavefish survived predation after being swept downstream into the spring branch.

The Salem cave crayfish (Camberus hubrichti) was also flushed from the spring system. Many of the crayfish responded to the low dissolved oxygen by moving to shallow water and climbing onto damp leaves or into water filled crevices near the shore where atmospheric oxygen could be more effectively used. However, by day 14 no additional live crayfish could be found and mortality was believed to be complete. Over 10,000 individuals were estimated to have been killed.

A small number of cave dwelling grotto salamanders (<u>Typhlotriton spelaeus</u>) were also found dead in the spring basin. This species was probably never present in great abundance in this spring system. At other Missouri springs they are most abundant in streams of terrestrial caves that have large populations of bats (Johnson 1977). They are especially susceptible to low dissolved oxygen because the respiration of this species is based almost entirely on dissolved rather than atmospheric oxygen. Numerous other cave organisms killed included amphipods, isopods, and gastropods, but no attempt was made to quantify these losses.

Mortality of these organisms was believed to be the result of low dissolved oxygen rather than ammonia, nitrite, nitrate, or urea toxicity. Nitrates and urea are essentially nontoxic to most aquatic life. However, ammonia and nitrites were of concern. The toxicity of ammonia is related to pH, temperature, and dissolved oxygen content. The single most important factor is the concentration of undissociated ammonia (NH_3) which is a fraction of total ammonia and is pH dependent). The 96-hour acute LC_{50} for rainbow trout is 0.5 mg/l NH_3 (Herbert and Shurben 1964). Based on the maximum reported ammonia nitrogen concentration of 2.5 mg/l and the pH of the spring water, the calculated concentration of the toxic form is less than 2% of the reported 96-hour LC_{50} value for rainbow trout. The toxicity of ammonia to cave crayfish is unknown, but a surface dwelling species <u>Orconectes</u> <u>naias</u> was found to have an LC_{50} value of between 2.2 and 4.6 mg/l (Hazel et al. 1979; Evans 1979). Thus, the cave crayfish may be less susceptible to ammonia than rainbow trout and were probably not affected by the ammonia component of the fertilizer.

Although nitrates were a major component of the spilled fertilizer, they are essentially nontoxic to aquatic life. However, nitrification of ammonia to nitrates was deleterious as demonstrated by the consumption of oxygen in this biochemical process. Nitrites are an intermediate product of nitrification and have been shown to be toxic to rainbow trout in low concentrations. However, nitrites are chemically short-lived and normally are rapidly converted to nontoxic nitrates. The concentrations of nitrite at Maramec Spring were: (1) only about 1% of the nitrate concentrations; (2) well below lethal levels; and (3) of little immediate consequence to spring life. The nitrates and urea did result in excessive growths of algae in the spring branch which persisted for several weeks following the spill. However, the impact of these nutrients was not investigated further.

There is no published information available on the tolerance of the southern cavefish to low dissolved oxygen. However, observations indicate a greater tolerance to low levels of oxygen than other surface dwelling fish at Maramec Spring. All amblyopsid fish have lower metabolic rates than comparative sized epigean fish, apparently an adaption for a limited food supply in springs (Paulson 1963). Water in some spring systems is subject to periods of low dissolved oxygen due to seasonal inputs of organic matter and fluctuations in flow. One could speculate that a lower metabolic rate and a reduced respiratory oxygen demand could account for the greater tolerance of this species to low dissolved oxygen.

The southern cavefish is a blind, white troglobitic species that rarely exceeds 50 mm in total length. It had not been previously reported from the Meramec River Basin. It was known in Missouri from specimens that were collected in the Osage, Black, and Spring river systems (Pflieger 1975). Disjunct populations exist in Tennessee, Alabama, and Kentucky. Since the cave at Maramec Spring had been explored in some detail without observing these fish, it is possible they were flushed from remote areas of the recharge system.

Prospects for rapid recovery of the southern cavefish at Maramec Spring are dim. Aquatic cave organisms are characteristically long lived and have a very limited reproductive potential. Fecundity of individuals and the intrinsic rate of increase of a population are low where predation is minimal and food is limiting. Paulson (1963) reported that the southern cavefish averaged 49 ova per female, a figure that is much lower than epigean species. Several years would be required to restore numbers in a depleted population.

The Salem cave crayfish is endemic to the Missouri Ozarks and previously was known only from a handful of specimens from cave streams of the Eleven Point, Current, and Meramec river basins. It is endangered in Missouri. It reaches a length of approximately 100 mm, lacks pigment, and has degenerate eyes. The number of specimens reported to have been killed at Maramec Spring exceeded the previous known total population of the crayfish.

The longevity of the Salem cave crayfish has been the subject of speculation. No one has attempted to age the species. However, Cooper and Cooper (1976) followed the growth of a troglobitic species in Shelta Cave, Alabama, <u>Orconectes</u> <u>australis</u> and estimated a minimum age of 37 years for a 47 mm individual. Application of these figures to other species is questionable, but it is reasonable to expect much slower growth and greater longevity than is commonly found in other invertebrates. The absence of predators, constant temperature, and limited food supply could be expected to account for the longer life span of many troglobitic species.

Several hundred of the Salem cave crayfish were examined and several were carrying fertilized eggs and newly hatched young on the ventral side of the caudal appendage. Virtually nothing is known of the reproductive biology of this species and this was the first observation of gravid specimens. Prospects for recovery of this species are unknown.

Approximately 200 cavefish and crayfish were removed from the spring and held in aquaria until water quality at the spring improved. Ten weeks after the spill they were returned and released near the spring outlet. The ability of these organisms to repenetrate the cave system through the constricted opening is questionable. High water velocities probably prevented any recolonization in this manner. The most promising expectations for recovery are that reservoir populations of these species remain deep within the cave system in areas that were unaffected by the fertilizer spill. However, there are no geological data available that could substantiate this possibility. The large volume of contaminant spilled and the measurable impact on water quality 21 kilometers distant at the spring outlet following substantial dilution indicates this was an environmental accident of catastrophic proportions.

This incident demonstrated the vulnerability of troglobitic aquatic organisms to environmental contamination. Environmental disturbances far removed from a cave organism's habitat may have dire consequences on their survival. This is especially true in karst areas where spilled materials may disappear rapidly into the aquifer only to reappear later at some distant point with devastating impact. Pipelines are especially dangerous because large volumes of toxic material can be spilled in a matter of hours. An additional problem with long pipelines is that accurate predictions of spilled material cannot be made using internal auditing procedures. The company that owned the pipeline in this incident underestimated the quantity involved by a factor of ten. The final estimate of spilled fertilizer was made by measuring the concentration of fertilizer components that emerged from the spring.

An additional problem in addressing this type of environmental accident is the lack of knowledge of the hydrology of a recharge system. The source of water for Maramec Spring had not been confirmed prior to this incident. A more thorough knowledge would have allowed resource managers to identify this area as environmentally sensitive and to request that additional precautionary measures be taken to insure the integrity of the pipeline. Additional hydrologic studies are needed to identify critically sensitive areas for many other springs of noted significance.

Once the extent of the recharge area is known, an effort should be made to identify potential sources of contamination. In addition to known discharges from municipalities, industries, and agricultural feedlots, logical points where accidental spills could occur should be identified. These include railways, highways, and pipelines. It is also important to work closely with state and local emergency spill response groups to encourage rapid response to incidents and use of appropriate cleanup methodology to minimize the chance of surface movement of contaminants to areas where infiltration may occur.

This incident resulted in the payment of a $108,000 fine by the pipeline owner to the state of Missouri for damages caused by the spill at Maramec Spring. The company also agreed to additional improvements in the pipeline in environmentally sensitive areas at a cost of over one million dollars. However, it should be pointed out that a monetary value cannot address the true costs of damage to a unique resource that may have been permanently altered.

CONTROL OF EXOTIC PLANT GROWTH IN CARLSBAD CAVERNS, NEW MEXICO

by Tom Aley*, Cathy Aley*, and Russell Rhodes**

ABSTRACT

Studies were conducted on exotic plant growth in Carlsbad Caverns by the Ozark Underground Laboratory in 1983 and 1984. We identified 26 species of algae, plus moss protonema and two ferns. There may be a total of 100 to 200 species of algae growing in the cave. The "algae-like" growth found in Carlsbad Caverns is about 70% blue-green algae, about 20% green algae, and about 10% moss protonema. In addition, there are diatoms present in about 25% of all clusters of algae growth in the cave. Although yellow-green algae are present in the cave, they are found in very few locations.

Many of the algal genera, and three of the algal species, found in Carlsbad Caverns have also been found growing in total darkness in other caves. We cannot expect algal growth, once abundantly established due to artificial lighting, to quickly disappear if we deprive it of light.

Light intensities were measured at a number of sites. In alcove sites, the minimum light intensity threshold for algal growth has a mean value of 1.6 foot-candles with a standard deviation of 0.7 foot-candles. In non-alcove sites (which constitute most of the cave conditions) the minimum light intensity threshold for algal growth has a mean value of 4.4 foot-candles, with a standard deviation of 1.9 foot-candles. As a general objective, lighting in moist or wet alcove sites should avoid light intensities greater than 0.9 foot-candles. In non-alcove sites, lighting on moist sites should avoid light intensities greater than 2.8 foot-candles.

Some studies were also conducted on chemical plant control agents. The best agent for general plant control appears to be 5.25% sodium hypochlorite (bleach) solutions. Copper sulfate and calcium hypochlorite solutions have caused damage to cave features when test-applied in Carlsbad Caverns.

INTRODUCTION

The growth of algae, moss, and moss protonema is a common problem in electrically lighted caves. The plant growth can seriously damage

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speleothems. The surfaces of some speleothems in Carlsbad Caverns have been turned to a jello-like substrate by algal attack; other speleothems have been discolored. In addition, plant growth detracts from the natural appearance of caves and damages the natural integrity of the caves and their features. Prevention and control of exotic plant growth in electrically lighted caves is a necessity.

The Ozark Underground Laboratory, under contract to the National Park Service, conducted investigations at Carlsbad Caverns. The investigations were designed to develop strategies and approaches for minimizing and preventing the unnatural plant growth within the lighted portions of the Carlsbad Caverns. Field and plant identification work was conducted in 1983.

PLANTS PRESENT IN LIGHTED PORTIONS OF CARLSBAD CAVERNS

Studies by Claus (1962; 1964), Hajdu (1966), Jones (1964), Kol (1967) and others have shown that many species of algae can grow in caves under conditions of total darkness. This growth is generally not obvious to people other than algologists, and is seldom, if ever, green in color. Our studies were not concerned with this "natural" plant growth. Instead, our studies were concerned with the visibly obvious plant growth found in the vicinity of electric lights.

We collected 32 samples of vegetative growth in Carlsbad Caverns. The sampling sites were scattered throughout the lighted portions of the Caverns. We tried to sample as wide a range of conditions as possible. In trying to select a wide range of conditions we paid particular attention to differences in the appearance of plant growth, differences in substrate and substrate moisture, differences in the types of lights present, and differences in the intensity of lighting. All of the sampled sites had plant growth that was visually obvious. Sampling was biased in favor of selecting sites with either luxuriant or extensive plant growth.

Two species of ferns were found growing around electric lights in Carlsbad Cavers. These were: Cytomium suriculata and Dryopteris filix-mas. Fern growth is very rare in Carlsbad Caverns. It seems likely that fern growth requires more intense light than is generally available. It appears, however, that there are suitable habitats for ferns in Carlsbad Caverns which are not being utilized.

The only mature stages of moss which we found in Carlsbad Caverns were restricted to moist cracks on ledges just inside the natural entrance. These plants receive all of their light from natural lighting. The only species found in this area was Phelonotis fontana. Moss protonema were found at three sampling stations within the lighted portions of Carlsbad Caverns. All fern and moss identifications were made by Mr. Steve Timme, Department of Biology, Mississippi State University.

A total of 26 different algae were found in vegetative samples collected from Carlsbad Caverns. All algal identifications were by Russell Rhodes. The identified algae were as follows:

Blue-green algae

Aphanothece castagnei
Aphanothece nidulans
Chroococcus schizodermaticus
Cyanidium sp.
Dermocarpa versicolor
Gloeothece confluens
Lyngbya diguetii
Lyngbya nana
Lyngbya perelegans
Oscillatoria sp.
Schizothrix pulvinata
Schizothrix rupicola
Scytomena schnidtii
Stigonema mamillosum
Symploca thermalis

Green algae

Chlorella sp.
Chlorosarcina sp.
Hormidiopsis sp.
Pleurococcus sp.

Yellow-green algae

Botrydiopsis sp.

Diatoms

Diploneissp.
Fragilaria sp.
Melosira sp.
Navicula sp.
Nitzschia spp.
Synedra sp.

We compiled a rather extensive list of algae which have been reported in the literature as growing in total darkness in caves elsewhere in the world. Three of the blue-green algae which we identified from electrically lighted areas in Carlsbad Caverns have been reported as growing in total darkness in other caves.

Aphanothece castagnei has been reported (Hajdu, 1966) growing in a black "smut ring" in a zone of total darkness in Matyas Mount Cave, Budapest, Hungary. At one of our sampling stations in Carlsbad Caverns we noted that much of the sampled alga had a dense black color.

Chroococcus schizodermaticus, is reported from zones of total darkness in Peace Cave, Hungary (Claus, 1962). This species is abundant in Carlsbad Caverns; it was present in about 16% of our vegetative samples.

Syngbya diguetii has been reported by Claus (1962) in Peace Cave, Hungary. Claus (1964) also found this species in Baradla Cave, Hungary. Both of these collections were in total darkness.

In Carlsbad Caverns we found that a number of the algae were present in only a single vegetative samples. No species of alga was found at more than 16% of the total vegetative sample sites. From these observations it is obvious that the total number of alga species present in Carlsbad Caverns is substantially larger than the list which we have developed. In view of the wide range of site conditions found in Carlsbad Caverns and the results of our sampling, we would not be surprised if there were a total or one or two hundred different species of algae growing in lighted portions of the Caverns.

The algae and "algae-like" growths we see in Carlsbad Caverns are about 70% blue-green algae, about 20% green algae, and about 10% moss protonema. In addition, there are diatoms present in about 25% of all of the clusters of algae found in the Caverns. The yellow-green algae are present in the Caverns, but they are found in very few locations.

NATURE OF THE LIGHTING SYSTEM

There are 43 different kinds of light bulbs in the cave, and identical bulbs are commonly found in several different types of fixtures with different types of shields, covers, and focusing grids. Fluorescent lights provide most of the general lighting in the Caverns. Incandescent lights are primarily used to high-light selected features. Mercury vapor lights are primarily used to dimly illuminate distant ceilings. there are approximately 907 lights in the Caverns; this excludes lights in rest rooms, the Lunchroom, and in signs.

Visible plant growth was associated with 43% of the 277 lights inspected. Visible plant growth was associated with 56% of the fluorescent lights, with 18% of the incandescent lights, and with 19% of the mercury vapor lights.

One possible reason that plant growth is more commonly associated with fluorescent lights than with incandescent or mercury vapor lights is related to the pattern of lighting. Fluorescent lights produce a more dispersed and more even intensity of lighting than is produced by incandescent lights. The dispersed and more even intensity of fluorescent lighting commonly has the effect of putting more cave surfaces "at risk" for plant growth than would be the case with the more highly focused incandescent lights. Incandescent lights can be focused and shielded much more readily than can fluorescent lights.

A second possible reason that plant growth is more commonly associated with fluorescent lights than with incandescent lights involves substrate moisture conditions. Incandescent lights produce more heat and thus more substrate desiccation than fluorescent lights. If moisture is only marginally adequate for plant growth, the sites which experience the least desiccation are the sites where plant growth is most likely to occur.

Finally, there are differences between the general objectives of the different types of lights. The objective of the fluorescent lights is to provide a general lighting of the cave; the incandescent lights are used primarily to highlight features; the mercury vapor lights are primarily used to illuminate distant ceilings. Comparison of the extent of plant growth associated with different types of lights must recognize the differences among the objectives of the various types of lights.

SUBSTRATE FACTORS AFFECTING PLANT GROWTH

Plant growth surfaces in Carlsbad Caverns are often cooler than room temperatures. Only at relative humidities of nearly 100% do we find plant growth surfaces warmer than room temperatures. It does not appear that the lighting system is encouraging plant growth by appreciably increasing the temperature of plant growth surfaces. Heat input to plant growth surfaces from the lighting system probably results in significantly increased evaporation from the growth surface, thus tending to discourage rather than encourage plant growth.

With adequate moisture and light, plant growth will occur on essentially any substrate found in the Caverns. Plant growth was noted on all types of speleothems, on limestone, gypsum, and sediment. Plant growth was also noted on plastic light shields, metal fixtures, and mortared surfaces.

Substrates can be classed as either soft or hard surfaces. Soft surfaces include sediment and assemblages of weathered speleothems, inactive coral, and moon-milk. Hard surfaces include rock and firm-surfaced speleothems. In Carlsbad Caverns, we sometimes found visible plant growth on apparently dry substrates; these substrates were typically soft surfaces. We suggest that soft substrates can store more moisture than hard substrates, and that this prolongs the period of moisture availability for plants on soft substrates. We also suggest that capillary forces can move water through soft substrates to points where plant growth occurs.

We conducted a 110 day growth plot study in Carlsbad Caverns to determine if all cave substrates receiving adequate moisture had relatively equal susceptibility to plant growth. The growth plot used a 2-inch deep plywood box which was divided into six equal compartments. The compartments were 3.5 inches wide and 46.5 inches long. Compartments were separated from each other by wooden dividers 0.75 inches thick.

Each compartment was numbered and filled flat to the top of the box with a selected substrate material. The selected substrates were as follows:

Compartment 1: Limestone pebbles collected from the surface in the employee housing area.

Compartment 2: Lint and minor amounts of associated sweepings collected from areas along the trail in the Big Room.

Compartment 3: Yellow silt from beneath flowstone near Cave Man Junction in the Big Room.

Compartment 4: Red mud which had been scraped and washed from flowstone in the Dome Room.

Compartment 5: Crushed gypsum (with some gypsum chunks) from areas near the trail in the Big Room.

Compartment 6: Washings from the trail at a point near the entrance to the Dome Room. The trail was washed about two weeks prior to the collection of the washings; the washings had been covered with sediment. The washings were moist, sticky, and black.

After the compartments were filled they were heavily watered with a suspension of algae and water derived from the cave. The algae were collected from vegetative sampling stations where nine different species of algae were identified.

The growth plot was illuminated with a 40 watt C75 fluorescent light installed at the end of the compartments. All compartments received equal light; light intensity in the compartments ranged from 16.0 foot-candles to 57.2 foot-candles. The compartments were watered about once a week with water from an unlighted pool in the Dome Room; this watering was done by National Park Service personnel after our field work in the area was finished.

On February 28, 1984 we discussed the growth plot with Mr. Ron Kerbo, cave specialist at Carlsbad Caverns. Mr. Kerbo reported that some plant growth was visible in all of the growth compartments. Compartment 4 (the red mud) had the least plant growth. Compartment 2 (which contained lint and sweepings) contained a heavy algal growth which substantially exceeded the amount of growth in any of the other compartments.

Substantial quantities of lint occur in localized areas of Carlsbad Caverns; some of the lint is periodically collected and removed from the Caverns. Since most lint is derived from clothing which has been washed and subjected to fluorescent optical brightener dyes, one can search for the presence of lint with an ultraviolet "black light". We examined various cave surfaces with an ultraviolet light and found lint to be present on most cave surfaces. The amount of lint present varied dramatically among examined sites.

Most detergents contain phosphates, and we would expect residual phosphates to be found on lint. Phosphates are notorious for causing excessive algal growth in streams and lakes. It is our suspicion that the excessive plant growth on the lint compartment is a result of appreciable phosphate on the lint.

Based upon the growth plot study, the lint (and materials associated with the lint) could be an important nutrient source for algal growth in Carlsbad Caverns. This finding represents yet another reason for the routine removal of lint from cave surfaces. If the important nutrient associated with the lint is phosphate, periodic removal of lint from cave surfaces will not remove all of the phosphates. Phosphates, in the presence of calcium ions, form chelates which will remain on calcareous surfaces such as speleothems and limestone.

The phosphate chelates can be utilized in subsequent algal growth.

We had expected to find excessive algal growth associated with trail washings since such washings contain substantial amounts of organic material. Although some algal growth did occur on trail washings, algal growth on this substrate was not substantially different from algal growth on other types of substrates. It should be noted, however, that trail washings create a substrate which has a high moisture storage capacity. Moist substrates are favorable sites for plant growth in the Caverns; creation of artificially moist substrates in the Caverns through trail washings is an undesirable situation.

LIGHT INTENSITY FACTORS AFFECTING PLANT GROWTH

Our studies of light intensity were designed to answer the following five questions for conditions in Carlsbad Caverns:

1) What is the minimum light intensity threshold beneath which plant growth is generally negligible or minor?

2) Is there a general light intensity which tends to maximize plant growth in the cave? If so, what is it?

3) Is there a general maximum light intensity above which plant growth in the cave does not occur? If so, what is it?

4) Will plant growth disappear if lights are moved and former growth areas receive very low light intensities?

5) Are some of the inaccessibly high areas receiving sufficient light that plant growth is, or might be, a problem?

Light intensities were measured with a Gossen Luna-Pro SBC light meter equipped with a spherical 180 degree light diffuser. The meter has greatest sensitivity in low light intensities; it can measure light intensities from 0.016 to 32,000 foot-candles.

Measurement of incident light requires that the light meter be placed at the target site and aimed toward the light source. There are points where one cannot readily reach the target site; we used a Multibeam Spot Attachment to the Gossen meter for estimating incident light reaching remote target sites. This spot meter has three separate measuring angles: 1, 5, and 10 degrees. The spot meter reading is a measure of light reflectance in the area viewed through the meter.

Our procedure for estimating incident light intensity at remote target sites was as follows. First, we would identify the remote target site for which we wished to make an incident light intensity estimate. We would then select an accessible site which appeared to have similar color and reflectance to the remote target site. At this accessible site we would measure incident light, then measure reflected light with the spot meter. We would then calculate the percentage relationship of incident light to reflected light. This value would then be applied to the spot meter reading for the remote target site.

We believe the estimates which we derived are accurate enough for management purposes.

During our field work we noted that light intensity was obviously an important control mechanism operating to limit or prevent plant growth. We identified sites where it appeared that low light intensity (rather than moisture or some other variable) was the mechanism limiting the extent of plant growth. At these sites we identified the point which received the smallest amount of light but which still displayed visible plant growth. We then measured incident light reaching this point.

In a few cases the plant growth associated with a light covered a particularly large area. In some of these cases we identified two or more plant growth points which were receiving minimal amounts of light; such multiple points were always at least three feet apart. We would then make light intensity measurements at each of these identified points. Finally, in some cases we could distinguish in the field between two different types of algae associated with the same light. If the two types of algae differed in the minimum light intensity which produced visible growth we would make minimum light intensity measurements for each of the obvious types of algae.

During measurements of minimum light intensity producing visible plant growth we noted that many of the measured values were substantially lower in small alcoves than in any other setting in the Caverns. As a result, we stratified our measurement sites into two classes: alcove sites and non-alcove sites.

We do not know why visible plant growth should occur at substantially lower light intensities in alcove sites, but we believe that the relationship is real. The minimum light intensity which produced visible plant growth was not uniformly low in all of the sites.

A total of 14 measurements were made on minimum light intensities producing visible plant growth in alcove sites. The mean minimum threshold intensity was 1.6 foot-candles; the range was from 0.6 to 3.2 foot-candles. The standard deviation of the mean was 0.7 foot-candles.

The vast majority of the lighting in Carlsbad Caverns is in non-alcove sites. A total of 39 measurements were made of minimum light intensities producing visible plant growth in non-alcove sites. The mean minimum threshold intensity was 4.4 foot-candles; the range was from 1.0 to 8.0 foot-candles. The standard deviation of the mean was 1.9 foot-candles.

During our field work we measured the light intensity associated with the maximum amount of plant growth at 52 sites scattered throughout the cave. The values ranged from 6.3 foot-candles to 92.0 foot-candles. In view of this range, calculation of the mean value would not be useful. The median value was 20.0 foot-candles; the mode value was 11.3 foot-candles.

Only 8% of the points with maximum plant growth occurred at light intensities lower than 10.0 foot-candles. A total of 15% of the points with maximum plant growth occurred at light intensities between 10.0 and 11.3 foot-candles. In terms of management guidance, it appears that anytime light intensities equal or exceed about 10.0 foot-candles on moist sites there is a good chance that plant growth will be maximized, or at least that it will be extensive.

In electrically lighted caves, plant growth is sometimes absent from areas which are very brightly lighted. The upper light intensity limit for plant growth occurs at lower light intensities on damp substrates than on wet substrates because of moisture availability. Increasing light intensities dries damp surfaces, thus reducing or preventing plant growth. In contrast, wet substrates often have sufficient moisture to overcome the desiccating effects of high intensity lighting.

The maximum light intensity recorded on any wet speleothem in Carlsbad Caverns was 562 foot-candles on a stalagmite on the Devil's Hump. The stalagmite was used as a convenient shield for the lighting. The most brilliantly lit point on the stalagmite which had visible plant growth received 130 foot-candles of incident light. The general limiting factor for plant growth appears to be substrate desiccation rather than light intensity per se.

Sheps (1972) experimented with transplanting algae within Lehman Caves, Nevada. Transplanted algae survived and grew at sites where algae had previously not grown. An obvious implication of Sheps (1972) findings is that plant growth, once established in a suitable site in a cave, could continue to survive in that site even if conditions at the site were changed to the extent that the site was no longer generally "suitable" for plant growth.

One way of removing "suitable" conditions for plant growth at a site is to dramatically decrease light intensity. There are several places in the Big Room where visible plant growth is apparently related to the old lighting system (which was replaced in 1975 and 1976); these sites receive very little light from the current lighting system. A good example can be seen in a very dimly-lighted area high above Crystal Springs Dome.

There are algae growing in dim light near Mirror Lake. This is another example of residual growth from previous lighting systems, although we are not certain that the change in light intensities in this area occurred during 1975-1976. The measured light intensity at a plant growth site next to the Mirror Lake sign is 0.21 Foot-candles. Algae growing on draperies behind the sign receives 0.26 foot-candles. This is not a alcove site.

The technical literature, our experience in other caves, and our observations in Carlsbad Caverns convince us that established algal growth in caves will not necessarily disappear if light intensities are dramatically reduced. Because blue-green algae have chlorophyll and accessory pigments, they are particularly likely to withstand extremely low light intensities once they have become established. The management significance of our observations is that any program of decreasing light intensities at particular plant growth sites must be accompanied by treatment to kill the existing growth. It is also possible that visible plant growth may become established at particular sites only under very favorable conditions. Without treatment, the plant growth may persist through periods where conditions are unfavorable for the establishment of new growth.

Blanchard Springs Caverns in Arkansas has been open to the public since 1973. In the last year or so personnel have begun to notice some plant growth on a very high and inaccessible ceiling where visible growth had previously not existed. With this situation in mind, we spent half a day in Carlsbad Caverns examining generally inaccessible sites for the possible presence of plant growth.

Using binoculars and a powerful light beam one can do a reasonably good job of examining distant cave surfaces for visible plant growth. Aside from some growth high on the Temple of the Sun, some growth high above Crystal Springs Dome, and some possible growth on some brightly lit draperies on the left side of the trail between Rock of Ages and Painted Grotto, there does not appear to be much plant growth in highly inaccessible areas. We examined Twin Domes and the Giant Stalactites near the Totem Pole very carefully, and could detect no plant growth. Substantial areas receive light intensities (estimated with the spot meter) substantially in excess of the intensity associated elsewhere in the Caverns with the minimum light intensity threshold for visible plant growth.

Most of the highly inaccessible cave surfaces which we examined appear to be dry, and this may be the principal reason that we did not find visible plant growth. However, there are a number of inaccessible areas which do produce drippage water, and it would seem that at least a few of these receive light intensities of at least 4.4 foot-candles (the main minimum threshold light intensity determined for non-alcove sites in Carlsbad Caverns). Although we are happy that there does not appear to be visible plant growth in inaccessible areas, we are uncertain why this is the case. Low light intensities and substrates which are generally both hard and dry may be the general answer, but we are not convinced that this is the total answer. It is also possible that algal spores have difficulty reaching the high ceiling areas and establishing growth.

MANAGEMENT RECOMMENDATIONS FOR PREVENTION AND CONTROL OF PLANT GROWTH

We developed and recommended a management strategy for the prevention and control of exotic plant growth in Carlsbad Caverns. In the following paragraphs we have summarized the principal recommendations resulting from our investigations. If the strategy which we developed is followed, we estimate that the following results can be attained in Carlsbad Caverns:

1. A 70% reduction in the annual amount of cave surface areas where plant growth occurs.

2. An 85% reduction in the annual volume of plant growth in the Caverns.

3. A 90% reduction in the annual volume of chemical agents used to control plant growth.

4. A 30% reduction in the annual man-hours of cave restoration work necessary for plant control efforts.

Plant growth must be prevented to the extent reasonable. The plant growth which occurs must be routinely killed to protect cave resources.

There is a major need for an initial one-time plant prevention project in Carlsbad Caverns. This includes the completion of the installation of all lights in the Caverns; many lights are simply lying on cave features and were never actually installed.

Maximum light intensities reaching moist alcove surfaces should be less than 0.9 foot-candles if plant growth is to be largely prevented in such sites. Maximum light intensities reaching moist non-alcove surfaces should be less than 2.8 foot-candles if plant growth is to be largely prevented. Where this value is undesirable for interpretive or other reasons, plant growth can be minimized and often prevented by keeping light intensities reaching moist surfaces at less than 3.6 foot-candles.

Focusing grids help focus light from fluorescent fixtures upon target surfaces; the grids reduce the intensity of the light "spilled" onto non-target surfaces. Much of the plant growth in the Caverns is associated with spilled light. Focusing grids reduce spilled light intensities on plant growth surfaces in Carlsbad Caverns by an average of 53%; the grids can greatly reduce the extent and severity of plant growth. Since the focusing grids primarily reduce the intensity of spilled light, use of the grids does not significantly alter the appearance of the cave to visitors.

Focusing grids should be used on most fluorescent lights which illuminate substrates where plant growth may occur. Placing used fluorescent tubes inside fluorescent fixtures often reduces the intensity of light reaching non-target surfaces where plant growth can occur; the use of such tubes is locally appropriate.

Frequent inspection and minor plant control work is a key feature of an efficient and effective plant prevention program. The frequency of inspection and treatment is based upon site-types, moisture conditions, and associated light intensities. Inspection frequencies vary from once per year to six times per year.

Copper sulfate, hydrogen peroxide, commercial solutions of hydrogen peroxide and phosphoric acid, and calcium hypochlorite solutions should not be used for plant control work in Carlsbad Caverns. The only plant control agent which we recommend is sodium hypochlorite solutions in concentrations ranging between 4.2 and 5.25% sodium hypochlorite.

Our studies indicate that sodium hypochlorite solutions seldom if ever alter speleothem colors. Such solutions also do not appear to interfere with calcite deposition on speleothems.

Spray application of sodium hypochlorite solutions is faster than brush application. Brush application disturbs soft substrates, and should not be routinely used on anything other than hard substrates. Brush application seems to put fewer offensive odors into the air than spray application. Brush application is probably the better approach for treating hard substrates in confined areas where smell and fumes are particular problem.

The rinsing of treated cave surfaces after bleach application is desirable if appreciable amounts of dead plant growth are present. The routine rinsing of treated surfaces with only minor plant growth does not appear to be necessary.

No scrubbing of cave surfaces should be done after bleach application. It has been our experience that, in areas with heavy plant growth, the dead plant material can be easily washed off with water if one will wait for a few days to a week until fungus growth loosens the dead plant material.

REFERENCES

Aley, Thomas, 1972, Control of unwanted plant growth in electrically lighted caves: Caves and Karst, vol. 14:5, pp. 33-35.

Aley, Thomas, 1976, Recommendations for the control of plant growth in Blanchard Springs Caverns: Ozark Underground Laboratory contract report to Ozark-St. Francis Nat'l. Forest under PO 334-10-76, 44 p.

Aley, Thomas and Aley, Catherine, 1984, Control of exotic plants in Carlsbad Caverns: Ozark Underground Laboratory contract report to Southwestern Region National Park Service under contract CX 702930029, 131 p.

Bamberg, Samuel A., 1973, Environments in Lehman Caves, Nevada: Bull. Nat'l. Speleol. Soc., vol. 35:2, pp. 35-47.

Claus, George, 1962, Data on the ecology of the algae of Peace Cave in Hungry: Nova Hedwigia, vol. 4:1, pp. 55-79.

Claus, George, 1964, Algae and their mode of life in the Baradla Cave at Aggtelek II: Intern'l. Jour. Speleol., vol. 1, pp. 13-20.

Cubbon, B.D., 1976, Cave flora, In T.D. Ford and C.H.D. Cullingford. The science of speleology, pp. 422-452.

Dalby, D.H., 1966, The growth of plants under reduced light: Studies in Speleol., vol. 1:4, pp. 193-203.

Hajdu, Lajos, 1966, Algological studies in the cave at Maytas Mount, Budapest, Hungary: Intern'l. Jour. Speleol., vol. II, pp. 137-149.

Hamilton-Smith, Elery, 1977, Introduction to management of Australian caves and karst areas: Proc. Second Nat'l. Cave Mngt. Symp., Mountain View, AR, pp. 97-102.

Kol, Erzsebet, 1967, Algal growth experiments in the Baradla Cave at Aggtelek: Intern'l. Jour. Speleol., vol. II:4, pp. 457-474 + 5 tables.

Lefevre, M. and G.S. Laporte, 1969, The "maladie verte" of Lascaux: Studies in Speleol., vol. 2:1, pp. 35-44.

Lemon, Lowell, 1976, Algae control and removal from cave formations: Proc. First Nat'l. Cave Mngt. Symp., Albuquerque, NM, pp. 64-65.

Mason-Williams, A., 1967, Further investigations into bacterial and algal populations of caves in South Wales: Int. Jour. of Speleol., vol. 2, pp. 389-395.

McLean, J.S., 1976, Factors altering the microclimate in Carlsbad Caverns, New Mexico: U.S. Geol. Surv. Open-file rpt. 76-171, 56 p.

Nagy, J.P., 1965, Preliminary note on the algae of Crystal Cave, Kentucky: Intern'l. Jour. Speleol., vol. I:4, pp. 479-490.

Rohde, Katherine and Kerbo Ronal, 1978, Cave restoration--an underview of correcting overviewing: Proc. Third Nat'l. Cave Mngt. Symp. pp. 58-59.

Sheps, Lillian, 1972, The effects of photoperiod and some microenvironmental factors on plant growth in Lehman Cave, Nevada: Bull. Nat'l. Speleo., vol. 34:1, pp. 15-25.

Stark, N., 1969, Microecosystems in Lehman Cave, Nevada: Bull. Nat'l. Speleo. Soc., vol. 31:3. pp. 73-82.

Went, F.W., 1969, Fungi associated with stalactite growth: Science, vol. 166, pp. 385-386.

Williams, M. Ann Mason, 1967, Further investigations into bacterial and algal populations of caves in South Wales: Intern'l. Jour. Speleol., vol. II, Part 4, pp. 389-395.

INVERTEBRATE FAUNA FROM MISSOURI CAVES

by James E. Gardner*

ABSTRACT

A biological inventory of 436 caves and ten springs, found in 38 counties in Missouri, was conducted from September, 1978 through August, 1984. Records resulting from this study were based on collections of more than 4,500 invertebrate specimens, combined with taxonomic determinations and contributions from some 59 invertebrate systematists. Some 413 invertebrate species have been identified as a result of these collections. Data provided for each species include systematics, occurrence, natural history notes, known geographic distribution, and records from previously published materials.

The total invertebrate fauna represented a horsehair worm, two flatworms, three leeches, thirty snails, nineteen isopods (11 aquatic and 8 terrestrial), sixteen amphipods, nine crayfish, eight pseudoscorpions, five diplurans, three mayflies, a dragonfly, six crickets, one hundred twelve beetles, a psocid, eight hemipterans, a homopteran, two dobson flies, eleven caddisflies, two stoneflies, nine moths, twenty-five flies, three fleas and five hymenopterans.

Each species was classified according to its probable ecological role in the subterranean environment (troglobite, troglophile, trogloxene or accidental). Thirty-nine invertebrate taxa were categorized as troglobitic, including a flatworm, two snails, nine aquatic isopods, one terrestrial isopod, nine amphipods, two crayfish, a pseudoscorpion, a spider, a symphylan, four millipeds, five springtails, and three diplurans.

At least twenty-six invertebrate taxa represented previously undescribed species. thirteen of these undescribed taxa were categorized as troglobites, including three aquatic isopods, a terrestrial isopod, four amphipods, two springtails and three diplurans.

INTRODUCTION

Interest in Missouri subterranean fauna began over a century ago when Ruth Hoppin collected animals from caves in southwestern

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Missouri. Two Harvard professors, Samuel Garman and Walter Faxon (1889), studied and identified her collections and published one of the earliest known accounts of Missouri's cave fauna. Studies of particular interest soon began, such as Crosby (1905), spiders of Rocheport Cave. Many new cave animals were subsequently studied and described from the cavernous areas of Missouri.

It was not until the 1950's that ecological studies of Missouri caves and their associated fauna were made. The early species lists of Hubricht (1950) and Nicholas (1960) served to stimulate much further research on Missouri cave fauna. Lewis (1974) produced an annotated list of invertebrates from Mystery and other caves in Perry County, Missouri. Pflieger (1974) provided an annotated list of 69 species known to inhabit Missouri springs and their subterranean sources, but was limited to records of amphipods, isopods, crayfish, certain aquatic invertebrates, snails, salamanders, frogs and fishes. Craig (1975) reviewed cave fauna reports for Missouri, and later (1977) completed a list of invertebrate fauna of caves that would have been inundated by the now-deauthorized, Meramec Park Lake, on the Meramec River, in east-central Missouri.

Regional studies contributed much to the understanding of Missouri cave fauna and their geographical affinities. Peck and Lewis (1978) provided data on zoogeography and evolution of subterranean invertebrate fauna of Illinois and selected southeastern Missouri counties. Marquart (1979) completed a survey of the troglobitic crayfish of Missouri. Craig (pers. comm.) conducted a study of the subterranean invertebrates of the Ozark Plateau and is preparing to publish his findings.

Records of invertebrate cave fauna for state and federally managed caves in Missouri were incomplete and insufficient. Craig (1977) provided data on nine state owned caves in the now-deauthorized Meramec Park Lake area. Additional records from state and federally managed caves were scattered throughout the literature. Despite these records, there were no concise base line data for subterranean invertebrates inhabiting publicly owned caves. In order to provide for the conservation of these biological resources, an inventory became necessary. The results of these inventories are presented in a Missouri Department of Conservation special publication, entitled "Invertebrate Fauna from Missouri Caves and Springs".

DESCRIPTION OF STUDY AREA

There are more than 4,400 caves (Vineyard, 1984) and countless numbers of springs in Missouri. Data presented in the final publication were from the biological inventory of 436 caves and ten springs found in 38 Missouri counties (Figure 1). Descriptions of some caves and springs, where specimens were collected, can be found in publications by Bretz (1956), Beveridge (1980), Weaver and Johnson (1980), and Vineyard and Feder (1974), to name only a few.

Study caves and springs were chosen almost exclusively on the basis of their occurrence on state and federally managed lands. Although this fact contributed to biases associated with the study, they were diverse enough in nature to represent an acceptable sample of Missouri's cavernicolous fauna. Collecting efforts were usually limited to a one-time visit to each cave. Each cave was searched extensively and limited collections of invertebrates were made.

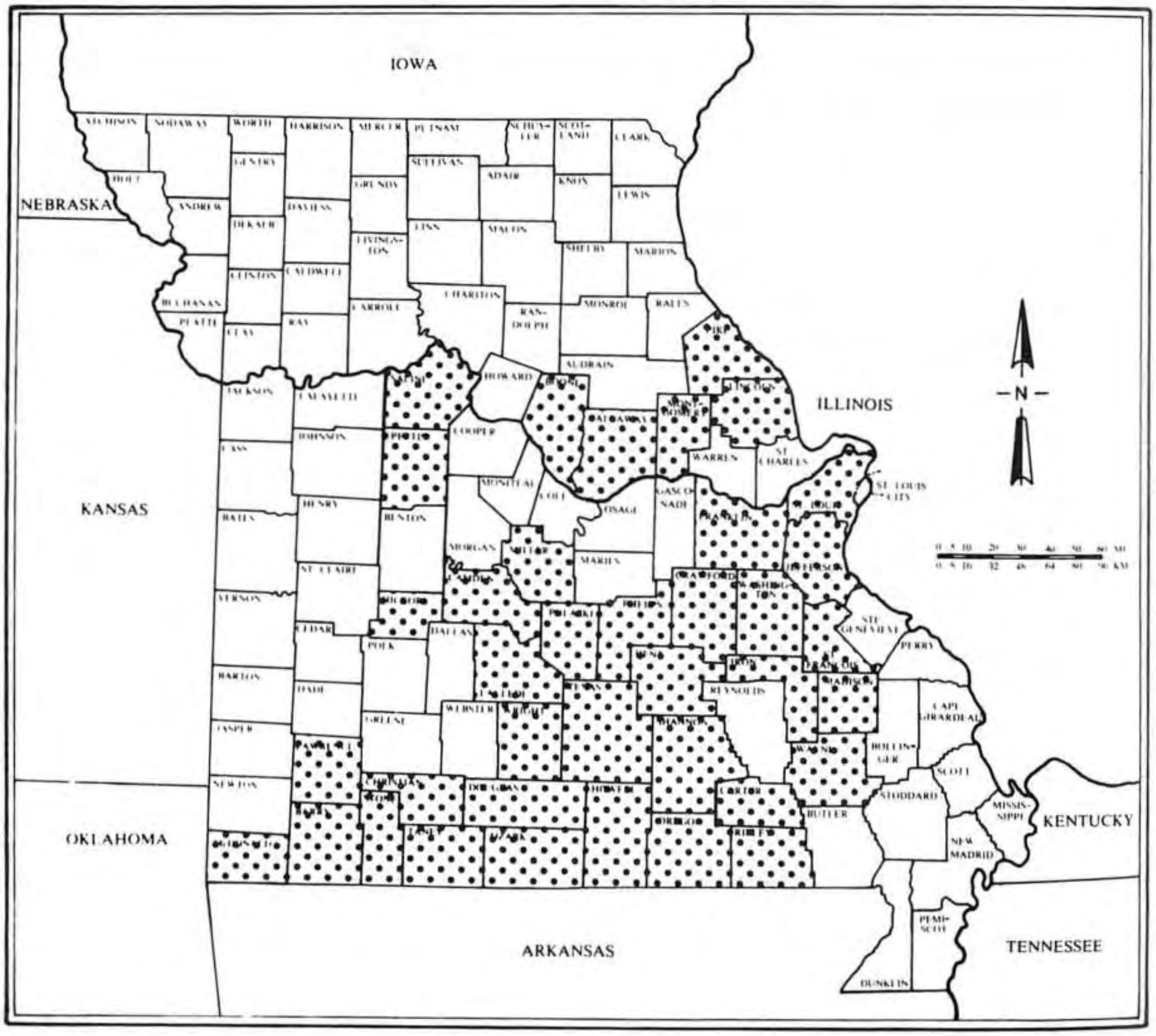

Figure 1. Missouri counties containing 436 caves and ten springs from which invertebrate specimens were collected.

ANNOTATED LIST OF INVERTEBRATE FAUNA

To provide a more complete and useful understanding of each cave organism, each species' probable ecological position in the cave environment was described. The four ecological classifications of cavernicoles used in this study follow the system of Barr (1968). The commonly used terms were: (1) Troglobites, or obligatory species which can live only in cave habitats, and are unable to exist in epigean environments. They usually show specialized morphological adaptations (e.t., depigmented, nonfunctional eyes, the hypertrophy of certain sense organs). (2) Troglophiles are commonly found in caves and complete their life cycle there, but are capable of existing in ecologically similar, noncave habitats (e.g., beneath a house, deep in forest litter, and under logs and rocks). (3) Trogloxenes commonly occur in caves for shelter and favorable microclimate, but must periodically leave the cave to complete their life cycle (e.g., feeding and/or reproduction). (4) Accidentals cannot normally survive in caves and usually have fallen, been washed, or wandered into a cave. Accidentals do not play an important role in cave species associations or total fauna distribution, but may serve as food sources for other cave inhabitants. They were included in the publication, because they served as records which may influence their future classification, and several represented significant taxonomic materials.

Although this study presented data from over 4,500 invertebrate specimens, representing 413 species, from Missouri's subterranean habitats, it is by no means complete. Some taxa were still poorly known to systematists and could not be identified to specific levels (e.g., Apochthonius and Lirceus). Materials of certain taxonomic groups have not yet been sorted, or submitted to systematists for identification, for lack of a known authority. Other specimens require more detailed study, and determinations of some materials submitted to taxonomists are not yet available (e.g. Acari, Thysannura). Several specimens represented undescribed species that have not yet been fully studied and described. Determinations of some materials require taxonomic characteristics found in other life stages.

DISCUSSION

The primary objective of the invertebrate study was to provide data on systematics, occurrence, natural history, and geographic distribution of subterranean invertebrate fauna from selected caves. The quantitative information, presented in a publication, was expected to create a limited data base for future evaluations of habitat degradation and possible changes in species compositions. Additionally, these data may provide incentives to conduct future research by identifying cave fauna of interest. Perhaps additional taxonomic studies will result from providing systematists with additional specimen materials. Another important objective of the invertebrate study was to identify species which need special protective management. Lastly, the study was conducted toward gaining a better understanding of Missouri's subterranean invertebrate fauna, and to a lesser degree, the invertebrate cave fauna of east central North America.

The result of this investigation could not have been so meaningful without the cooperation and contributions of more than 59 invertebrate systematists. In many cases, they not only identified the specimens, but provided information on phylogenetic rank, natural history, and distribution. These types of data made each species' account much more meaningful. Systematists who identified taxonomic groups most often reviewed that section of the publication to which they contributed determinations.

Scientists and researchers in cavernicolous invertebrate fauna are encouraged to request the publication from: Natural History Section, Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO 65102.

ACKNOWLEDGEMENTS

The data represented in the invertebrate study was the result of cooperation, assistance and support given by a great number of scientists, land managers, and state and federal agencies. The Mark Twain National Forest, North Central Forest Experiment Station-Columbia, Missouri, Missouri Department of Natural Resources, Ozark National Scenic Riverways, and the Missouri Department of Conservation provided cooperative funding for the study.

LITERATURE CITED

Barr, T. C., Jr., 1968, Cave ecology and the evolution of troglobites: In Dobzhansky, T., M. K. Hecht and W. C. Steere (eds.). Evolutionary biology, Vol. 2, Appleton-Century Crofts, New York:35-102.

Beveridge, T. R., 1980, Geologic wonders and curiosities of Missouri: Mo. Div. of Geol. Land Survey, Ed. Series #4, 2nd ed., 452 pp.

Bretz, J. H., 1956, Caves of Missouri: Mo. Geol. Survey and Water Res. vol. 39, 2nd ser., 491 pp.

Craig, J. L., 1975, A checklist of the invertebrate species recorded from Missouri subterranean habitats: Mo. Speleology, 15(2):1-10.

__________, 1977, Invertebrate faunas of caves to be inundated by the Meramec Park Lake in eastern Missouri: NSS Bull., 39:80-89.

Crosby, C.R., 1905, The spiders of the Rocheport Cave, Missouri: Can. Natur., 37:367-369.

Faxon, W., 1889, Cambarus setosus: p. 237 In Garman, S. (author), Cave animals from southwestern Missouri. Bull. Mus. Comp. Zool., 17:225-239.

Hubricht, L., 1950, The invertebrate fauna of Ozark caves: NSS Bull., 12:16-17.

Lewis, J. J., 1974, The invertebrate fauna of Mystery Cave, Perry County, Missouri: Mo. Speleology, 14(4):1-19.

Marquart, D., 1979, Troglobitic crayfish of Missouri: Unpubl. MS thesis, Central Missouri State University, Warrensburg, 39 pp.

Nicholas, B. G., 1960, Preliminary list of troglobites of Missouri: Mo. Speleo., 2(2):30-37.

Peck, S. B. and J. J. Lewis, 1978, Zoogeography and evolution of the subterranean invertebrate faunas of Illinois and southeastern Missouri: NSS Bull., 40:39-63.

Pflieger, W. L., 1974, Fauna of Missouri springs: In Vineyard, J. D. and G. L. Feder (authors), Springs of Missouri, Mo. Geol. Surv. Water Res., Water Res. Rpt. 29, p. 3-42.

Vineyard, J. D., 1984, Catalog of the caves of Missouri: Mo. Speleo. Surv., 239 p.

__________ and G. L. Feder, 1974, Springs of Missouri: Mo. Geol. Surv. Water Res., Water Res. Rpt. 29, 239 p.

Weaver, H. D. and P. A. Johnson, 1980, Missouri the cave state: Discovery Enterprises, Jefferson City, 336 p.

CAVE RECONSTRUCTION

by John Lambertz*

ABSTRACT

The largest and most visited, of the 13 caves open to the public, is Dancehall Cave. From when the area was first seen by white men in 1835, most of Dancehall Cave was inaccessible to all but dedicated cave explorers because of the rocks and debris that had been washed into the cave. In the 1930's, the Civilian Conservation Corps worked on the Park and began the clearing of Dancehall Cave, laid stone walls and flooring and opened a stream channel to stabilize the cave and make it accessible to the general public.

On August 30, 1980, a 100 year rain fell on the 860 acre watershed that flows into this cave. This rain caused a flash flood that washed out 6,000 square feet of stone flooring, 540 lineal feet of concrete sidewalk, most of the lighting fixtures, and blocked one entrance with debris. The task that faced the park staff was how to repair the cave and make it safe for the park visitors. Initial estimate for the repair cost was $100,000.

In July 1982, a special appropriation was received from the Iowa General Assembly for the repair of the damage. The appropriation was for $50,000. To make the best use of the money allocated, the Iowa Men's Reformatory at Anamosa was contracted to provide the labor for the project. During the last half of 1982 and early 1983, the debris was removed from the cave entrance, the stream channel cleared of debris, holes washed in the floor filled, and new flooring and sidewalks constructed. During the summer of 1983, an inmate crew was again used to rebuild and repair over 6,000 square feet of stone retaining walls.

Dancehall Cave was reopened to the public in June 1983, with just under $50,000 spent on the project. Another project is now beginning to stabilize the watershed to try to prevent this amount of damage from happening again and to reduce the maintenance requirements for this cave.

Maquoketa Caves State Park is located eight miles northwest of Maquoketa in east central Iowa. The 272 acre park has 13 caves open to the public (Figure 1). The caves differ in length and ruggedness.

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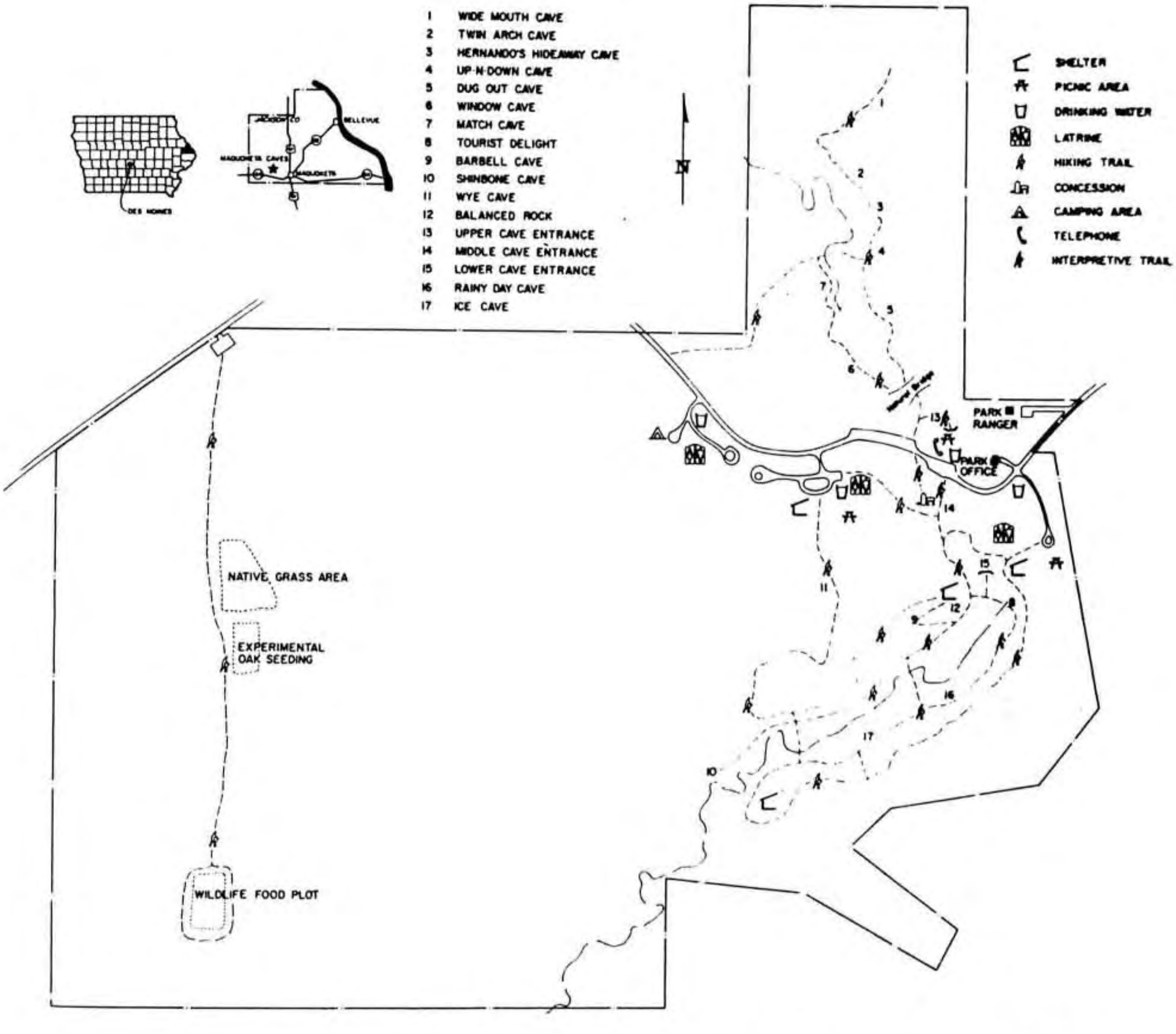


Figure 1. Location map, Maquoketa Caves State Park, east-central Iowa. (Source: Iowa Conservation Commission park brochure.)

They range in length from just a few yards to over 1100 feet. One large cave has sidewalks and electrical lights, in another explorers must crawl over 800 feet using flashlights. The largest and most visited is Dancehall Cave. Dancehall Cave is now approximately 1100 feet in length. It may have originally been over two miles long. The base rock of the area is Hopkinton Dolomite from the Middle Sulurian age (Hinnman, 1981). The caves on the park lie basically on 3 compass headings, indicating that the caves were formed off fracture lines. They eroded further by solutional activity. As the main cavern eroded back, the side passages became separate caves (Gilbert, 1980). Dancehall Cave has three entrances. The upper and lower entrances were formed by the eroding ends of the cavern and the middle entrance by a collapsed sinkhole. Located 100 yards upstream from the upper entrance is a 75 foot high natural bridge which is the result of a collapsed room (Figure 2).

The first white man saw the cave during a hunting trip in 1835. Joshua Bear and David Scott thought they had a herd of deer trapped in a box canyon. Since it was late in the day, they set up camp and thought they would resume the hunt in the morning. In the morning the deer were nowhere to be found. They had escaped through the cave.

By the 1860's, the area known as Burt's Cave, was a popular place for exploration, parties, and picnics. Tour groups were brought in from all over eastern Iowa. In 1868 a 50 by 100 foot dance floor was constructed just upstream from the natural bridge. Until the 1890's, the area was so popular that local grocers were advertising food for "cave parties".

Unfortunately during this period, the natural beauty of the area was declining as shown in this article from the Maquoketa Record (August 11, 1876).

> "Many people are visiting Burt's Cave these days, and it is an elegant drive up the old ridge road and back by the Beldena pony farm. The writer visited the caves Sunday and found the place rather less attractive than it was 25 years ago when nature held full sway. Some of the large trees in the vicinity have been destroyed, the main cave is impassible from mud and water and cattle have been allowed to roam at will through the old dance hall. However, we are assured by the owner J. B. Morehead that he will see that no more timber is cut and that the cattle will be kept out. The beauties of the natural bridge remains (sic) unchanged."

Also from the History of Jackson County 1879,

> "The ceilings of these caves are hung with the most beautiful stalactites, and upon the floor the corresponding stalagmites, the slow deposits of the centuries, rise to meet their companions above. Unfortunately for the beauty of these caves, no effort has been made to preserve the natural ornamentation of the ceilings, and the glittering pendants have been broken off, or knocked

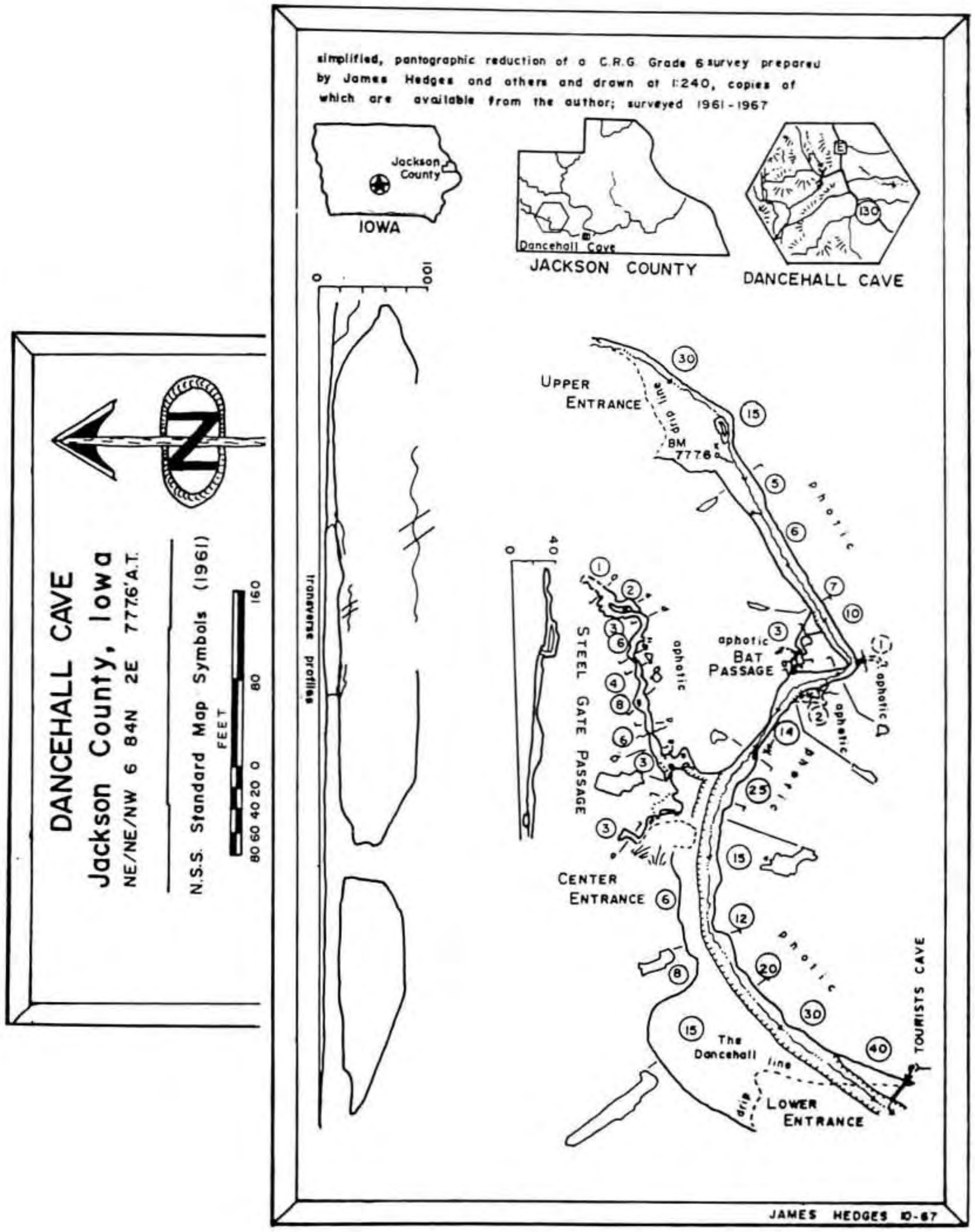


Figure 2. Plan map of Dancehall Cave. Drawn by James Hedges, Big Cove Tannery, Pennsylvania, October, 1967.

down by visitors until only a fraction, and the least interesting of these lime deposits, remains."

Following a period of decline in popularity, the area now known as Morehead Caves, regained its popularity with the advent of the automobile. In 1916, an elaborate 25 page brochure was printed describing all the features of the area. It also alluded to research being done in the caverns. The brochure also refers to caves that can't be found today. From the descriptions, these lost caves if found could be of great scientific and tourist value.

In 1919, the people of Manquoketa asked that the Morehead Caves be made into a state park and that improvements be made in the area. In 1920, state officials toured the area. In February 1921, the cave was one of four sites selected out of 175 proposed areas for parks. The Morehead Caves were purchased in April 1921. The original purchase for the park was the 16 acres that contained Dancehall Cave.

It wasn't until the 1920's that much work was done to improve the area. With the opening of a Civilian Conservation Corps (CCC) camp in Maquoketa, the long awaited work began on the park. The first order of business was to clear the mud and debris from Dancehall Cave. Plans called for the use of rail tracks, mine cars, and air compressor drills to break up and remove the fill (Jackson Sentinal, December 19, 1933). Formal plans were drawn for the cave improvements in 1934 by Rex L. White (Renovating Main Cave, Maquoketa Caves State Park, October 23, 1934).

From conversations I have had with some members of the CCC who worked on the park that instead of the rail cars and air compressor drills that wheel barrows, sledge hammers, and chisels were the main tools of the project. To keep the equipment sharp and in working condition, a blacksmith shop was set up inside the cave at the middle entrance. They kept a crew working in the cave round the clock (personal communication, CCC camp reunions, 1983 & 1984). The CCC was aided in their work by the Chamber of Commerce and inmates from the Men's Reformatory at Anamose (Jackson Sentinal, December 31, 1935). The CCC worked on the park from 1933 into 1936. Besides opening up the cave, they laid stone retaining walls and stone flooring. Outside the cave, they built shelter houses, stone retaining walls, trails, walkways and stone steps.

In the spring of 1938, a Work Progress Administration (WPA) grant for $13,168.88 was issued for park improvements (Jackson Sentinal, May 17, 1938). Among the projects that were funded was the finishing of the cave channel clearing project begun by the CCC in the lower portion of Dancehall Cave. In 1929, a flood damaged the completed project (Jackson Sentinal, July 21, & August 8, 1939). Until 1948 not much more was done on the park. Then G. L. Ziemer, state engineer, assessed the damage done nine years earlier. He reported damage to the retaining walls in the middle entrance. Approximately 50 feet of flooring (from wall to wall) was washed out to a 10 foot depth. Debris was washed into the upper entrance, and minor damage was done to the electrical lighting system (Ziemer, 1948).

Prison labor was used early in the 1950's to repair the damage done in 1939. They repaired the flooring and the entrance steps, and removed the debris and ruble that had washed into the cave (Iowa Conservation Commission, 1952). Local people assisted with labor and equipment. For instance, the electric powered cement mixer that was lowered into the middle cave entrance on a rope. During that repair project a flash flood came through the cave. All of the workers got out safely and the equipment was not damaged, but all the supplies for making the concrete were washed away (Personal communications, Paul Sagers, 1979).

Later improvements included 422 feet of sidewalks inside the cave in 1968. Handrails, sidewalks, and steps leading to the upper and lower entrances were improved in 1969 and 1970. A new lighting system was added in 1976.

On August 30, 1981, a 100 year rain of up to 10 inches fell on the 860 acre watershed that drains into Dancehall Cave. The rain started to fall at 11 PM and by 7 AM the next morning, the cave had been flooded. As I went to make my morning check of the cave lights, I was greeted by a log and debris jam in the upper entrance. Looking up at the wall above the entrance, water marks showed that the water had been 40 feet deep. The water was still high enough that I did not enter. It was obvious that the lights in the low ceiling areas would need to be replaced so I left the park to get new fixtures.

After my Conservation Aide finished her routine maintenance chores, she went to the middle entrance to check the walks, and came back to my office saying, "You won't believe this...". Looking upstream from the middle entrance there was a lake, downstream the stream channel was filled with debris, at least 10 feet deep and over 100 feet. A six foot deep hole replaced the first ten feet of the sidewalk to the lower entrance. Further down that walkway, there was a three foot crawl space where once we could walk. In the Dancehall, at the lower entrance, there was four to five inches of new silt on the floor.

Outside the lower entrance most of the stone retaining walls were missing and the stream channel was about 20 feet shorter. Besides being shorter the water fell 15 feet off the end, where it only fell five before. The entrance to Tourist's Delight Cave usually has a small spring coming out of it. At this time it was like a small horizontal geyser, a two foot stream of water shooting out about ten feet from the base of the cliff.

Later that afternoon, the water had receded below the sidewalk level and we entered the cave. Just inside the upper entrance, the only portion of the floor not washed away was the sidewalk. Farther in the floor remained but was covered with mud, tree trunks, and other debris. Also there were foot and one half thick sidewalks that had been turned on their side and slid crosswise across the width of the cave. At the sharp turn, we saw the other end of the lake that we had seen from the middle entrance. The water-area covered about 200 feet of the cave. After viewing this the District Supervisor was called.

Temporary signs and barricades were erected to close Dancehall Cave to the Public (Figure 3).

In September, I floated through the washed out area of the cave in a homemade inner tube float to further assess the damage. The upper washout area was a uniform five feet deep. The lower washout varied in depth from four to 14 feet (Figure 4).

In October 1981, the Northeast Park District dozer was brought to the park to begin rebuilding roads and trails damaged by the rainfall and subsequent flooding. The main work was rebuilding the trail that leads from the main road through the park to the upper cave entrance, the only entrance that is accessible to equipment. Two sections of the trail were completely washed away and had to be relocated. Two other sections had to have tubes placed in the washouts and filled. The area from the natural bridge to the upper cave entrance needed to be completely reconstructed. After this was completed an attempt was made to remove the debris in the cave entrance with no success. Later it would take a backhoe, a crawler/loader, and men with chain saws to remove the blockage.

The next step of the repair work was to relight the cave so work crews could see. To repair the lights, a way was needed to hold a ladder up to reach the light fixtures over the areas of open water. With the help of a local welding shop, a pair of ladder stands were designed and made to span across the cave. These stands were similar to house floor jacks but were made to take the lateral load. The outside was square tubing that would slide into the square tube and had a hole drilled through it for the adjusting pin. A plate with a pointed one inch rod on it was welded to one end of the square tubing. The inside tube had a one inch turnbuckle, with one end ground to a point, welded to the outside end.

To repair the lights a crew of three rangers, a ladder, the ladder supports, and a 14 foot flat bottom boat went into the cave. From the boat, the ladder supports were extended to the closest setting and the pins put through the tubes. The turnbuckles were then extended until the points were embedded in the cave walls. This was a difficult task from the constantly moving boat but was accomplished without anyone falling into the water. After both supports were in place, the ladder was set up and extended to the light to be repaired. As one ranger would repair the light, the others would light up the work with a flashlight and try to keep the boat in place. The light repairs over the open water took two days and another day to replace the remaining lights.

In January 1982, the Conservation Commission requested $50,000 from the legislature to fund the restoration of the cave (estimate for the repairs was $100,000). The request was not recommended for funding by the Governor and was not funded. Late in the spring, one of the projects that had been funded had to be delayed and the Commission was allowed to transfer those funds to other projects. The cave project then received $50,000 to begin the repair work.

The next step was to decide how the renovation was to be done. The Chief of the Lands and Waters Division, Superintendent of Parks,

Figure 3

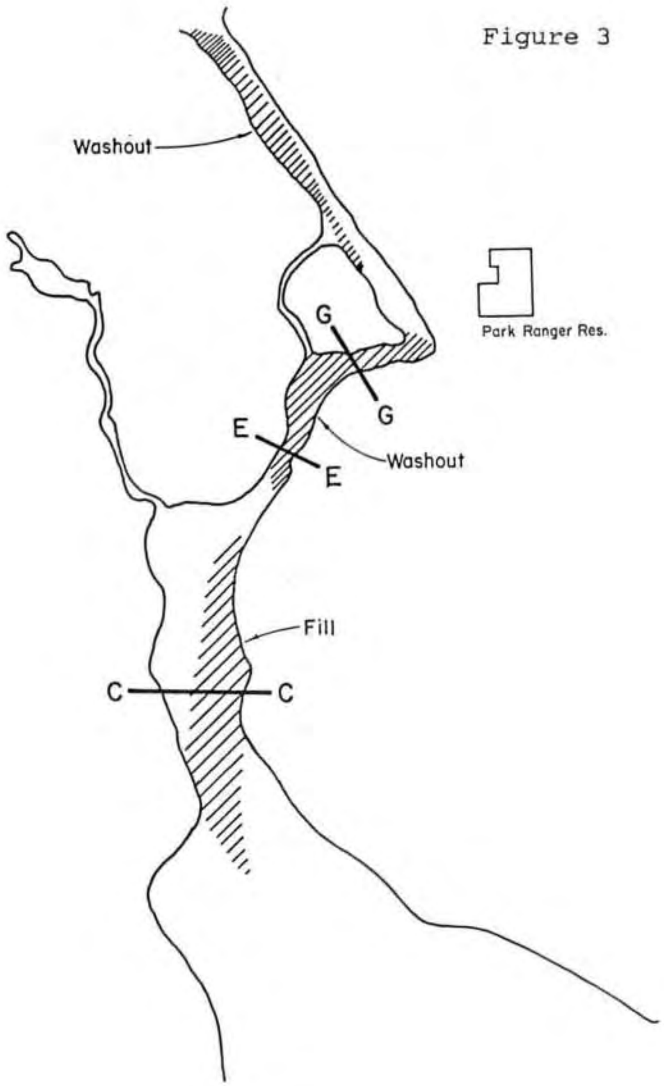
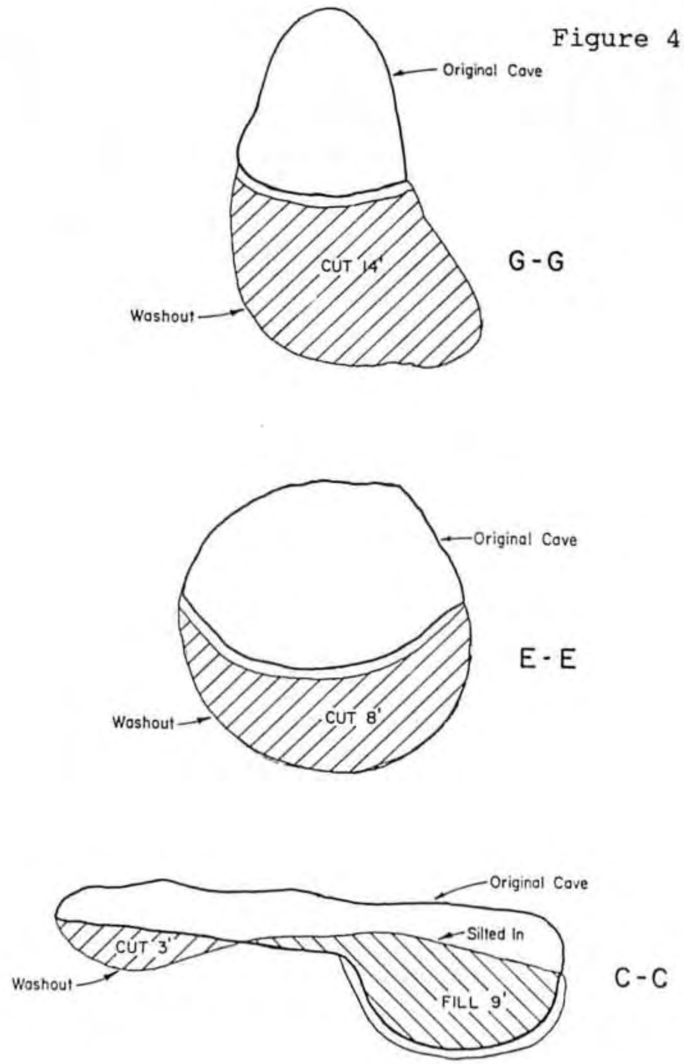


Figure 4



<u>Figures 3 and 4</u>. Plan view and cross-sections of main cave showing changes caused by flood erosion and deposition (modified from White, 1934, by Iowa Conservation Commission staff artist).

Associate Superintendent of Parks, Northeast District Parks Supervisor, Chief of Administration Division, and Superintendent of Engineering toured the damaged areas with the Park Ranger, to see the damage first hand and to formulate a plan on how to proceed with the renovation. Unable to reach a consensus, the Director and Assistant Director of the Commission came to the park and toured the cave with the Park Ranger and District Supervisor and decided to try to return the cave to its previous condition. The Chief of Lands and Waters then contracted the Department of Corrections for a six man crew and a guard to come from the Men's Reformatory at Anamosa each day. They provided the bulk of the labor for the renovation work.

The first week of August 1982 was the beginning of the intensive work on the project. Before this time, the park staff worked in the cave moving stone when possible. A newly hired crew chief and Park Ranger went to the Reformatory and received training in preparation to working with an inmate crew. The staff also built a 120 foot long chute system out of wood and corrugated tin to allow rock and concrete to be moved into the cave at the middle entrance. We also laid a water line to the middle entrance and installed additional lighting for the areas where the work was to begin.

During the second week of August, the inmate crew began their work. Using picks, shovels, sledge hammers, and wheelbarrows, they began to move debris from the stream channel to fill washed out area upstream. Where broken flooring, uprooted sidewalks and debris had covered the sidewalk from the middle to lower entrances, they also removed this to a small washed out area so a new sidewalk could be placed there. In this way a portion of the cave could be reopened even if the funding ran out before the total job was completed.

The flooding had opened an underwater passage to Tourist's Delight Cave, located just below the lower cave entrance on the east side of the valley. The water in Dancehall was being pirated out through this passage. The opening to Tourist's Delight was enlarged and lowered to assist in the removal of water in Dancehall as the rock fill was displacing water in the washouts. The fill was placed only in one half of the washout to allow the water unobstructed flow to the draining area.

Near the end of August, the people who regularly worked in the upper area of the cave, moving the silt and organic debris, began to complain of lightheadedness and upset stomachs. Work was halted in that area of the cave and the local gas company checked the area for any gas resulting from the decomposition of the organic matter. No gas was detected but it was felt that some form of gas might be presenting a health hazard. At this point, a contractor was hired to remove the blockage at the upper entrance. This increased the air flow through the cave and there were no further complaints of health problems from the workers.

Between the middle and lower entrances where the sidewalk had been, the debris and old walk were removed and the washout was filled in and stabilized with a stone retaining wall. A new sidewalk, with curves in it to follow the cave form, was an improvement over the previous straight walkway. The mortar, for the stone sidewalk forms, was made above ground in a one bag tractor mounted mixer and sent down the chute to the waiting wheelbarrows. The stone sidewalk forms were attractive and would blend the sidewalk into the surrounding floor. Concrete was purchase from a local company and sent down the chute to wheelbarrows to pour the 180 foot sidewalk and steps.

While the work was being done on the sidewalk, a portion of the crew was still removing debris from the stream channel and filling the washout upstream. They were also removing mud and filling the washout from the upper end. By mid November, the fill material inside the cave was beginning to run out and a loader from another park was brought in to dig fill material to be brought into the cave. As the washout area near the upper entrance was being filled, springs feeding water into the caves became apparent. To help control this water, two five inch drain lines were laid in the fill. Each line was 430 feet long with a riser at the beginning. These would come up through the flooring to help control any water while the new floor was being laid. The tile lines were also to relieve any pressure that the springs might create under the floor. The system worked fine while the floor was being poured and controlled the water for four days, then water from the springs began to come out the risers. The tiles must have relieved the pressure, but in the opposite way than intended.

The last part of November was spent bringind gravel and fill lime into the cave to give the flooring a good base. The remaining displaced sidewalks and damaged flooring were broken up with sledge hammers and moved by wheelbarrows to the remaining areas that needed fill.

During the first week of December, there was a rainstorm and the cave was flooded for two days. Normally this type of flood would not have been a problem had there been a floor in the cave. This flood removed all the drain tiles, planking for running the wheelbarrows on, and several of the lights in the low area of the cave. It also brought in logs, silt, and some ruble. The drain tiles and planking had to be brought back to the cave by hand. Some were more than one quarter of a mile down stream from the cave. The lights were repaired, the logs cut up and removed, and the gravel, silt, and ruble were wheeled farther into the cave for fill in some areas that were washed out during this flood. The trail to reach the upper entrance had to be cleared of fallen trees to allow the tractors to reach the cave.

In October 1982, a request was made to purchase flagstone to set into the concrete flooring. This was to give it the same look as the original CCC floor. The stone was finally received in January 1983. Personnel and equipment from other parks assisted in moving the flagstone to the cave before snow could close the trail to the cave. During three days, 47 tons of two inch flagstone was moved into the cave. Also during these days, ten rolls of reinforcing wire mesh were taken to the cave.

During January 1983, the Ranger from Wapsipinicon State Park at Anamosa began coming with the inmate crew for added security. This allowed us to have an enlarged crew of ten inmates to help make sure the cave was ready for the concrete pouring scheduled for the end of the month at which time the prison labor program would end. This expanded crew moved the flagstone inside the cave to the various distribution points, laid an additional 100 foot tile line to control water that was working its way to the surface in the area where the floor would be poured, finished leveling and putting the base rock in for the flooring, dismantled and stored the chute system, set steel posts to be used to tie the forms for the sidewalks, and laid the reinforcing mesh.

To move the volume of concrete needed to replace the flooring, it was decided to use a concrete pump. Early in November, several pumping companies were contacted for bids. Only one company had enough pipe to do the job. After several meetings with the pumping company, the concrete supplier, the Commission's inspecting engineer, and the Park Ranger; the equipment was brought in on January 24th. For the setting up and the pouring operation the expanded inmate crew and a crew of 15 district park personnel were needed. A pipe line of four and five inch steel pipe was set up covering a distance of over 700 feet. The pump was set up near the middle entrance. From the pump into the cave, the pipe was set vertically for 40 feet to the bottom of the middle entrance. It was then laid upstream to the upper cave entrance, with the last section of pipe being a semi-flexible rubber hose. All the pipe had to be carried by hand into the cave because a recent snowfall made the trail to the upper cave entrance impassable for equipment. Each ten foot section of pipe weighed 50 pounds.

On the 25th and 26th, the pouring of the floor took place. The company suppling the concrete opened two of their plants and had a third ready. The concrete was being made with 180 degree F. water and calcium chloride because of the cold weather. As each ten foot area was poured the rubber pipe and a ten foot section of steel pipe were removed. The rubber pipe was reinstalled and the pour continued. The section of steel pipe was cleaned out and taken back up the middle entrance to the company's truck and washed out with hot water under pressure. The pumping process was not as easy as it sounds. The lack of space to move the pipe meant that shoveling and raking of the concrete was required. Also, when the operation began it had to continue until the stopping point for the day. Plugs tended to form in the piping if it stood for any length of time. To keep the operation working and the crew fed, a lunch area was set up in the park's interpretive center and the crew ate in shifts. The prison supplied the sandwich material with the park staff and neighbors provided hot soup.

After the concrete had been laid and leveled, a bucket brigade style line was set up to pass the flagstone to the people setting it in the fresh concrete. Even with the wetter than normal concrete for the pump, the flagstone has to be pressed on very hard to get it set into the concrete. During the two days of the floor pouring, 208 cubic yards of concrete and over 40 tons of flagstone were used.

Some minor injuries occurred. One man got concrete splashed in one eye. Several people got concrete in their boots. This caused varying degrees of "concrete poisoning" from the abrasion and skin irritation.

January 27th was the last day for the inmate crew. It was spent cleaning up the area and equipment, and hauling tools and excess material out of the cave. After that day, the Ranger and crew supervisor worked on building forms for the 230 feet of sidewalk that was needed to restore the interior of the cave for pedestrian traffic. On February 14th, the pumping equipment was brought in again. As before, the crew of 15 district park personnel was brought in to set up and pour the sidewalk. This time the pipeline was only 450 feet long. In five and one half hours on the 15th, the crew had poured the sidewalk, cleaned the pipe, and had taken all the pipe and tools out of the cave and were ready to go home. During that time 63 cubic yards of concrete went into the sidewalk. But it wasn't until 8 PM that the final trowelling and broom finish could be done by the Ranger and crew supervisor. After this the crew supervisor was laid off.

In the spring of 1983, the park staff removed the sidewalk forms, rebuilt 50 feet of sidewalk and steps, another 15 feet of sidewalk, and removed the extra flagstone from the interior of the cave. In June 1983, the cave again was reopened to the public.

July 1983 saw the return of the inmates to the park. A new crew supervisor was hired to help rebuild the retaining walls that had been destroyed in 1981. This time the mortar mix was made near the upper entrance in a tractor mounted mixer which was then driven into the cave. About 200 feet inside the cave, the mortar was dumped into two wheeled concrete carts. From here it was pushed to the work locations, up to 1000 feet from the loading area. A concrete runway was made in the stream channel, between the middle and lower entrances, to make a smooth place to run the carts on. A set of wooden tracks was made to cross the remaining debris in the stream channel outside the lower entrance. This project lasted from mid July through mid September, when the funding for the inmate labor ran out. Besides building retaining walls, this crew repaired walls, tuck pointed much of the walls that had survived the flood, and rebuilt walls and flooring under two shelters built by the CCC.

By September 16, 1983, when the inmate crew finished, the $50,000 special appropriation was almost exhausted. The vast majority of the funds went for material with a portion to reformatory reimbursement for a part of the guards salary, and some of this also went towards the salary for the crew supervisor in 1982. A portion was recalled by the Governor as part of an across the board budget reduction. The tools, gasoline and equipment maintenance, gasoline for the prison van, and park staff salaries came from the Maquoketa Caves Park operation budget, and that cost hasn't been calculated. After the project was finished, a contractor who saw the work estimated he would have bid at least $150,000 to do the work.

During the total life of this project over 6,000 square feet of flooring was replaced, 525 lineal feet of sidewalk built, 4,000 square feet of retaining walls repaired and 6,000 tuck pointed, and 500 tons of debris was moved to fill the wash outs. To accomplish this 873 man days of inmate labor were used and contracts were let for the clearing of the upper cave entrance and for the pumping of the concrete. Material used included 114.5 tons of sand for concrete and masons mix, 47 tons of flagstone, 910 lineal feet of drain tile, 291.5 cubic yards of concrete for flooring and sidewalks, 133 bags of Portland cement, 548 bags of masonry cement, and numerous smaller purchases.

To help prevent this from happening again and to reduce the maintenance from the periodic minor flooding, a plan is being developed to control the watershed above the park. This is being done by the Soil Conservation Service and will help them demonstrate what can be done in watershed control. Since most of the work will be done on private ground, a three way cost share between the Conservation Commission, Soil Conservation Service, and the individual landowners is proposed. Five major structures are being designed to control the flow of water onto the park. These would have a 25 year design life rather than the usual 10 year, for increased water storage capacity. This system will help protect the cave restoration work that has been done over the last two years, reduce routine maintenance in the Dancehall Cave, and would allow other development in the park's main valley.

REFERENCES CITED

Gilbert, C. Hriss, 1980, An overview of Maquoketa Caves State Park: Report for Geology of Iowa, 012:109.

Hinnman, Dr.Eugene and Dr. Paul Christiansen, 1981, Natural resource study, Maquoketa Caves State Park, Jackson County, Iowa: Iowa Conservation Commission, Des Moines, Iowa.

Iowa State Board of Conservation, 1937, Iowa state parks and Preserves-calander year in 1977 review: Des Moines: State of Iowa.

Roetzel, Kathleen, 1980, An archaelogical and architectural historical survey of Maquoketa Caves State Park, Jackson County, Iowa: Division of Historic Preservation, Des Moines, Iowa.

White, Rex L., 1934, Renovating Main Cave (project plans): Iowa State Conservation Commission files.

Ziemer, G. L., 1948, Report on Maquoketa Caves: Iowa State Conservation Commission files.

(author unknown), 1879, The history of Jackson County, Iowa: Western Historical Company, Chicago, IL.

(author unknown), 1916, Morehead Caves souvenir brochure: Grant Publishing Company.

NEWSPAPERS CITED

Jackson Sentinal, Maquoketa, Iowa, December 19, 1933, December 31, 1935, May 17, 1938, July 21, 1939, August 8, 1939.

Maquoketa Record, Iowa, August 11, 1876.

CAVES AND CANOES: MANAGING CAVE RESOURCES IN A RECREATIONAL PARK

by Christopher M. White*

ABSTRACT

Established as our nation's first scenic riverway in 1964, Ozark Riverways has over 134 miles of clear streams, nationally famous springs, sheer bluffs and over 200 caves. In an average year, over 300,000 people will canoe the Riverways. Many are beginners out for a day's outing and lacking a strong conservation ethic. These canoeists (and other recreationists) stop by many of the caves visible along the banks of the Current and Jacks Fork rivers.

Unprepared to go caving, and sometimes intoxicated, they present a challenge to the Riverway's staff. Increasing vandalism and risk of serious injuries, endangered species, and simple overuse are some of the major problems.

This paper will examine the typical cave use and user, and how Ozark Riverways is dealing with both protecting the cave resource while allowing for public use.

Many times we think we're doing something right, but to an objective observer there may be another easier method to reach our goal. So we bring in experts who retain this objectivity. This paper is about a unit of the National Park Service called Ozark National Scenic Riverways in southeast Missouri and how different experts are helping us reach our goal of maintaining caves in the Riverways for both use and observation. We will always be trying to improve our knowledge. In order to look at present conditions, it's important to have an understanding of the past. Over eons, the Current and Jacks Fork rivers (located in southeast Missouri) cut into the slowly uplifting dolomite and limestone underlying the area. Water flowing underground slowly dissolved and carved out numerous caves. In addition, a tremendous amount of the underground water reappeared as enormous springs, one flowing as much as 200 million gallons a day. Steep bluffs, sharp hills, and rocky soil were a result. Most of the "hills" are actually knobs left from the early streams and rivers. Early man probably followed the rivers upstream to settle the floodplain. Indians settled in several places along the Current where a broad bench made of enough fertile soil to raise crops. Several caves along the river appear to have been used by Native Americans for temporary lodging. As the more fertile lands around the Ozarks were settled, white settlers began to drift through the area. By the 1830's

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they had set up small farms along the rivers and pushed out the Indians. Early settlers floating the rivers probably also used caves for shelter and in some places, for food storage.

During the Civil War, caves in the area were used, put to several uses. Powder Mill Cave is reported to have been used for saltpetre production. Hospital Cave got its name by being used by both sides for a recuperation facility. Courthouse Cave was used to hide records relating to the town of Eminence. Other caves were used by civilians to hide possessions or themselves as roving bands of quasi-military troops from both sides swept through on periodic raids. Shortly after the Civil War, Jesse James and his gang are purported to have used several caves for hideouts. These caves are now within the boundaries of Ozark Riverways.

The next settlement period was related to the enormous stands of virgin timber. During the late 1890's, extensive timber cutting occurred in the area. The boom period lasted through to the late 1920's, when most companies ran out of high grade virgin timber. The cutting practices of the time resulted in gravel-choked streams, clogged springs, and the discovery of many of the caves we explore today.

Coinciding with the lumbering era was the arrival of the railroads. This opened the area to easy access and numerous fishermen, hunters and recreationists took advantage. People began to notice the scenery; clear streams, big springs, well decorated caves, and talked about setting aside the area. Floating the river and camping on a gravel bar were part of that experience. Doubtless, many floaters also explored some of the numerous caves that are along the rivers' edges.

During the 1930's and 40's, the State and U.S. Forest Service acquired cut-over forest land that had been abandoned by the timber companies. The State purchased land along the Current and Jacks Fork rivers at Round Spring, Alley Spring and Big Spring. These were designated as state parks and developed by the Civilian Conservation Corps in the 1930's. Cabins, campgrounds, rest rooms, museums, picnic shelters and a dining lodge were some of the developments. Branson Cave near Alley Spring was also purchased and developed, with a walkway leading into the cave.

During the 1940's, a Corps of Engineers study identified the Current and Jacks Fork rivers as ideal for a dam. Obviously, the presence of numerous caves and springs was not taken into account. Threatened with development, the rivers were the subject of many columns in the regional newspapers supporting the idea of setting aside the rivers under the protection of the National Park Service. By 1955, a serious push began to get the area protected. After a long series of political maneuvers, legislation was finally passed in 1964 declaring the two rivers to be part of Ozark National Scenic Riverways. An area one mile long on each side of the towns of Eminence and Van Buren were left outside the Park boundary. Public Law 88-492 specifically mentions both air and water-filled caves (read springs) for preservation. Under the direction of the National Park Service, land acquisition was begun. By 1972, enough land had been acquired to officially establish the Riverways. But in some ways, the job had just begun. Many of the caves in the long, narrow Park boundary were well known to local residents and had been subjected to much use and abuse. Designation as a unit of the National Park System brought an increasing number of visitors. Several privately owned buildings within the new park area had facades or decorations of various speleothems. Before examining the various cave management studies, let's look at the use of the Riverways and where caves are located within its boundaries.

There are three categories of cave users. The first group is the experienced caver who comes to go caving. Properly prepared (hopefully), this group has few problems and does little disturbance to the resource. More potential for abuse lies with some local residents, mostly young males perhaps fearful of caves. Trips into a cave are often a measure of one's macho image and reminders of the visit are often available in broken cave formations and empty liquor bottles. However, not many caves are visited and their impact, although perhaps heavy on a few caves, is not a problem compared to the largest group of users. This third group is the incidental caver, one whose caving experience is only a small part of the reason to visit Ozark Riverways. Of the incidental cavers, the largest group are canoeists.

In 1973, there were 1.5 million visitors to the Riverways. Of that 9.7 percent, or 146,000, were canoeists. Ten years later, total visitation was 1.8 million, but the percentage of canoeists had almost doubled--to 16.7 percent, or 303,000. This is important to cave management as many of caves in the Riverways are easily accessible and/or visible from the river.

Over one-third of the canoeists are in groups of 20 or more. Most go on weekends in the summer, on the upper Current, have little or no formal canoe handling training, have one or two flashlights, and many are drinking copious amounts of beer. It's not unusual in July or August to have 600-800 canoes launch from one landing to float a river the width of five cars parked side by side. Now, a brief look at the Riverway's caves.

Caves in the Riverways are in dolomite, tend to be small (400-1,000 feet), and horizontal in development. Over 225 are located within the narrow Park boundaries and their total could be as high as 300. They tend to be wet with a stream or two, muddy, at one time well decorated, and most have at least a few examples of cave life. Many of the incidental cavers are repeat visitors and the location of many of the popular caves are handed down from year to year. So far, there have been very few reported accidents and no fatalities. The information just presented was gathered over the years.

Cave management at Ozark National Scenic Riverways is reflected in its cave management studies and inventories. Few reports on caves in the area are known before the 1950's. Several local histories mention caves used for different purposes. However, comprehensive survey was not done until 1956. In his 1956 edition of "Caves of Missouri", J Harlan Bretz mentions several caves within the Riverways boundaries. Several years later, Jerry Vineyard completed his master's thesis on Devils Well, a prominent feature in the Riverways. At the same time, the fledgling Missouri Speleological Survey was exploring and preparing reports on caves in the area.

In "Report on Ozark Rivers National Monument Proposal" (NPS, 1960), there are several pages devoted to the springs and caves of the area. The report notes that some of the caves are "quite extensive and magnificently decorated with dripstone." (Page 7). It goes on to mention Jam-Up and Round Spring caves and the numerous sinks. Obviously, the karst features of the area were considered important enough to the Monument Proposal to be worth highlighting.

In 1973, Tom Aley, then a hydrologist with the U.S. Forest Service, published "An Approach to Cave Management". Although he was addressing problems in the adjacent Mark Twain National Forest, many of these problems were and are endemic in the Riverways. It was an early attempt at rating caves based on hazards, cave life, etc. In it, Aley also identified recognized problems with heavy cave use. This included vandalism, trampling, muddy tracks on cave formations and bat disturbance.

Another study important because of its omissions, was "Safety Evaluation of River-Use at Ozark National Scenic Riverways", (Weaver, 1975). In the report, Weaver was to identify "hazardous and potentially hazardous conditions and practices within the Riverways associated with recreational use of the area." Comments were made about launch area problems, injuries and their cause, hiker's problems, etc. No mention is made of caves or any associated problems.

Brief mention of floater problems is found in "Impact of Floaters on Ozark National Scenic Riverways", (Sutton, 1976). In his master's thesis, Sutton looks at the "effects of floaters on the Current and Jacks Fork rivers of the Ozark National Scenic Riverways". His emphasis was on soil typing and a short study of soil erosion along the riverbank. Under "recommendations", Sutton notes: "Heavy use at site 14 (Blue Spring) is resulting in erosion, vegetation deterioration and soil compaction. This site is a cave site. Foot trails could be blocked with locust trees or other natural barriers to discourage entry into the cave." And, "Cave Spring and Pulltite Spring have become traditional stopping points for canoeists. Major change in the vegetation and soil have been caused at these landings. The construction of permanent landing facilities would prevent further erosion of the bank area. Permanent trails should also be developed at these popular areas." (Page 101).

Sutton's study is the first about the Riverways the author is aware of that mentions any problems associated with caves. Yet, no report touched on resource problems inside the caves. It was four more years before this problem was dealt with.

In "River Recreation Research at Ozark National Scenic Riverways", (Marnell, et al, 1977), the problem of "damage and vandalism to natural features inside the caves" is discussed. No mention is made of habitat destruction. The report recommends "site hardening" at popular sites (steps, moorings, etc.) and a "limited amount of resource manipulation." Caves were recognized as part of a floater's experience and some suggestions were made to restrict or lessen impact. This is the first study that attempts to deal with user-related problems.

The Riverway contracted with Tom Aley to do the first cave management study of Riverways' caves. It was completed in 1980. In the first of two comprehensive reports titled "Cave Management Investigations in the Ozark National Scenic Riverways", Aley "evaluated the significance and extent of cave resources within the Riverways, identified the situations and problems affecting cave resources within the Riverways, and assessed 19 caves and complexes of caves and developed management conclusions and recommendations for these caves." (Page 7).

Based largely on cave location reports from the Missouri Speleological Society, Aley visited 19 caves. He included a brief description of the cave and an inventory of cave life. At the end of each report, Aley includes a set of management conclusions and recommendations. Signing is suggested for most of the caves. One item of special note is the statement that "not much is known about the type or extent of visitation to these and other Riverways caves." Not until the summer of 1985 will this essential study be done. The importance of Aley's report is that for the first time, Riverways' management acknowledges that caves are a resource to be managed along with the canoeists and other recreationists.

Phase II of Aley's report dealt with an additional 60 caves within the Riverways' boundaries. In addition to the Phase I objectives, Aley also looked for signs of archeological resources. Also of note in his introduction is the statement, "There are probably more caves within the Ozark National Scenic Riverways than in any other National Park Service - administered area in the United States." Based upon our estimates of the number of visitor days of non-guided cave use, total cave use within the Riverways exceeds that which occurs in any other NPS - administered area in the United States."

The caves studies in Phase II ranged in significance from Devils Well to small caves such as Ditch Cave. Although he did not extensively explore all the caves, Aley did produce an impressive document to guide managers in protecting the cave resources. These reports are very important. They compiled a great deal of information from different sources and pointed the way for cave management in the 1980's.

In December of 1981, the Riverways released the Draft General Management Plan (GMP) for the Riverways. On page 41 under "Resource Management", a full page deals with caves. It notes that eight are listed as outstanding natural features. The fragile nature and chance for serious injury in caves is discussed. Objectives for caves:

> "include the protection of irreplaceable resources while providing for visitor use, promoting appreciation through interpretation, and furthering education and scientific research. The proposed course of action for cave resources is to complete inventories and management plans for all caves, with increased development and maintenance of some for visitor use."

Finally, a brief listing of needs included continuing cave inventories and additional research in several areas. The GMP very succinctly sums up needs in the Riverways. Final approval of the GMP was in early October, 1984.

The most recent reports are by the Gardners, Parts I and II of "Cave Resources of Ozark National Scenic Riverways - An Inventory and Evaluation", 1983 and 84. In it, the authors conducted a biological inventory of caves based on Aley's list and also made some management recommendations. Also, they suggested a cave classification system for both cave life and cave hazards.

This briefly describes the major documents that guide or influence cave management in the Riverways. Some of the problems encountered in implementing the guidelines are the next issue. Without the guidelines and management recommendations of these reports, there would be no direction. However, the next and more difficult problem is to get cave management started in a multi-resource park. This is difficult due to remoteness of caves, low visibility of resource degradation, lack of public pressure, and low funding priorities. All are interrelated.

Ozark Riverways caves are remote physically from people making management decisions. They can easily drive through a campground, check a visitor center or drive along part of the rivers. To see the caves requires a good deal of time and preparation. The people in the field are busy dealing with the floods, canoeists, or immediate repairs to picnic areas, campgrounds, day use, etc. Few have time or the interest to go into caves to clean up litter or check for vandalism.

Vandalism and general resource degradation in the caves is also difficult to see, measure and assess. It's easy to see a broken door, pothole in a road, campsite trampling, or littering or popular river sites. Base studies have been done on areas along the river. So, easily measurable, quantifiable data are available. However, much of what happens in a cave is difficult to measure or quantify. How can you notice if several more speleothems are missing or there are less bats roosting?

Public pressure for cave preservation is little and low key. Few visitors notice less speleothems or cave life from year to year visits. Fewer still see cave environments as fragile and easily destroyed. The crowding and litter along the rivers are their immediate concern. They can easily compare the condition of a campground, launch area or rest room. Jet boats and tire tubes intrude on their recreational experience. These, then, are the subjects of letters to the Riverways or to their Congressmen. In turn, these are the issues dealt with by the staff based on its meager resources.

Finally, without a recognition of need, there is little money made available to deal with the problem. Priorities are set based on perceived need. Broken rest room doors, littered campsites, and crowded river conditions are seen as immediate needs to be given high funding priority. Caves, out of public and staff view, without baseline studies or public pressure, are placed low on the lists of perceived needs.

Many other Park resources suffer from these same problems. The key difference is that damage to caves or cave life takes so very long to recover. Hillsides denuded of trees during the early 1900's lumbering era are now covered with new growth. Streams choked with gravel are slowly stabilizing, and gravel bars being revegetated. In little over one generation much of the habitat disruption is recovering. Deer, turkey, raccoon, fox, and other surface wildlife have recovered so well through resource management that hunting is again allowed. But the gray bat and the Indiana bat, and in particular the speleothems of many caves, need hundreds or thousands of years to recover. The slow rate of change in cave environments means a much longer recovery time for the subsurface environment.

We as managers can afford to delay decisions on resource preservation of surface features for several years with few ill effects. Delay the same underground decisions and the damage will never heal in generations. That is why these problems are so important and need immediate action.

What is being done to deal with the problems of cave management in the multi-resource Ozark Riverways? The answer lies in one word: "Education." The education of both the Riverways' staff and general public. An immediate need is education management staff members. In the long term, it is making visitors more aware of the unique and easily destroyed cave resources. First, a look at existing and proposed actions for the management staff.

A continuing activity is an ongoing project by the Missouri Speleological Survey (MSS) to survey and map caves within the Riverways' boundaries. Topographical maps of the river corridor are marked with the location of all known caves. Copies are donated to the Riverways. Currently, over 120 caves have been mapped, which is about half of all known caves. Also, the MSS provides us copies of trip reports to these caves that describe in detail many features found in them. The map and reports can be used to locate likely archeological cave sites, likely cave life or bat habitats, assist in case of a cave accident in knowing the cave layout, and make the managers and field staff aware of the caves in their part of the Riverways.

This past year (1984), guidelines were developed for diving in the Riverway's springs and caves. These are intended to allow continued use of the resource by experienced divers doing research. Also, they are the first of their kind for any National Park Service area. Based on a great deal of research, the guidelines incorporate a lot of existing guidelines by the NSS and other agencies. It is hoped that cave diving guidelines will help protect the underwater caves and also prevent injuries or fatalities by inexperienced or incompetent divers.

The Riverways is a member of the Missouri Caves Association, a group of show cave owners from both Missouri and northern Arkansas. Bi-yearly meetings allow an exchange of ideas with the private sector. It also serves as a point of contact for the private sector to see what is being done for caves in a public area.

This spring, the Park will start on a Cave Management Plan. Based on input from the above-mentioned documents, a comprehensive plan will be developed to manage caves in the Riverways. Before becoming final, it will be placed for public review at several meetings.

This summer, with a grant from the American Cave Conservation Association, a survey will be made of cave visitation and use. Emphasis will be on establishing estimated visitation at some of the more popular caves developing profiles of types and percentages of cave users by seasons. Under the direction of Alan Everson (University of Missouri-Columbia), the survey will employ both direct and indirect sampling of cave visitation and users. The results of the study will be used to help in developing the Cave Management Plan for the Riverways.

Public education takes many forms. Formal tours two hours long are given in mile-long Round Spring Cave. Emphasis is on ecology and geology of a cave system. Limited to 15 people per tour, the participants carry lights along the gravel paths of this formerly commercial cave. On the river, roving interpreters stop at caves and springs along the way. Emphasis is on deterring people from damaging caves while also helping "one-flashlight" groups whose batteries died halfway out.

A new cultural demonstration at Pulltite Spring will have a person familiar with spring hydrology. Law enforcement rangers also assist by warning or ticketing canoeists found with speleothems or found damaging caves. Evening programs given weekly at the five major c pgrounds include many on various aspects of caves and springs. Emphasis is on the fragility of the resource and the need for conservation. Guided hikes at one area take interested visitors to a small wild cave to help teach proper caving skills and etiquette.

Printed material includes cautioning notes in several brochures. These cautions warn of some of the hazards involved in caving. A brochure about Devils Well was produced and printed in 1984. Next year, a brochure about Round Spring Cave is planned. It will include safety tips and will mention cave systems' fragility.

A final step in the education process is the placing of advisory signs and in a few instances, gating. Starting this summer, signs will be placed in the cave entrances of many, more popular caves. They will stress proper cave behavior and briefly cover cave systems. Gates have been placed on only four (Wallace Well, Devils Well, Round Spring and Bat Cave). It's unlikely that more than 10 caves will be be gated, out of over 240.

CONCLUSIONS

Cave management at a recreational area is one of many demands placed on managers. Caves are just a part of many natural and cultural resources. High visitation and the demands placed on maintenance of major developed facilities make it difficult to fully meet so many different needs.

As man settled the area, use of caves increased. Early settlers saw caves like other resources, as unlimited and to be exploited. Visitors to the area were and still are attracted by the rivers, but also wander into the nearby caves. Management focuses on the more obvious problems, and don't see the remote, hidden caves needing much attention.

Over the years, different studies conducted by researchers and the Riverways' staff have documented the need to take action to protect cave resources. These reports help convince managers of the need for additional action to prevent further resource degradation. Continuing research is needed and scheduled that will identify type of users and amount of use in representative caves. These data will help refine the pending Cave Management Plan that will be developed in the next two years. This should help insure that the next generation will be able to enjoy the caves in Ozark Riverways as much as this generation.

REFERENCES

Aley, Thomas, 1980, Cave management investigations in the Ozark National Scenic Riverways, Missouri: Contract report prepared for Ozark National Scenic Riverways, National Park Service by Ozark Underground Laboratory, 124 p.

Aley, Thomas, 1981, Cave management investigations in the Ozark National Scenic Riverways, Missouri: Contract report prepared for Ozark National Scenic Riverways, National Park Service, 157 p..

Bretz, J Harlan, 1956, Caves of Missouri: Missouri Geological Survey and Water Resources, vol. 39, 2nd ser., pp. 439-444.

Everson, Alan and Chilman, Kenneth C., 1984, Preliminary analysis of "Final Comments" from 1984 Ozark National Scenic Riverways User Interviews (6/2/84-7/22/84 only): Unpublished report submitted to the National Park Service, Van Buren, MO, 9 p.

Gardner, James E. and Taft, John B., 1983, Cave Resources of the Ozark National Scenic Riverways-an inventory and evaluation: Missouri Department of Conservation contract report prepared for Ozark National Scenic Riverways, 90 p.

Gardner, James E. and Taft, John B., 1984, Cave resources of Ozark National Scenic Riverways-an inventory and evaluation, Phase II: Missouri Department of Conservation contract report prepared for Ozark National Scenic Riverways, 139 p.

Missouri Speleological Survey, 1977, Caves of Reynolds and Shannon Counties: Missouri Speleology, vol. 17, nos. 1-2. 68 p.

Missouri Speleological Survey, 1982, Caves of the Jacks Fork Valley: Missouri Speleology, vol. 22, nos. 1-2, 62 p.

Missouri Speleological Survey, 1984, Caves of the upper Current River Valley: Missouri Speleology, vol. 22, nos. 3-4. 120 p.

Sutton, Steven Wayne, 1976, The impact of floaters on the Ozark National Scenic Riverways: University of Missouri-Columbia, Contract report prepared for Ozark National Scenic Riverways, National Park Service, 152 p.

Denver Service Center, National Park Service, 1981, Draft general management plan, Ozark National Scenic Riverways: p. 41-42.

National Park Service, Ozark National Scenic Riverways, 1978, River recreation research conducted at Ozark National Scenic Riverways 1970-1977: a summary of research projects and findings: Unpublished reports, 139 p.

Vineyard, Jerry D. and Feder, Gerald L., 1974, Springs of Missouri: Missouri Geological Survey and Water Resources, WR-29, 272 p.

Weaver, Glenn, 1975, Safety evaluation of River-use at Ozark National Scenic Riverways: Unpublished report submitted to National Park Service, Van Buren, MO, 48 p.

CAVE RESCUE - A CASE HISTORY

by Jeffrey N. Scott*

ABSTRACT

Informing local fire departments of their potential in cave rescue situations can prove to be invaluable in the form of organization, personnel, physical resources, and training. The Boone County Fire Protection District has recognized its potential and responsibility in cave rescue. With the assistance of other agencies, the Fire Protection District has worked toward developing a well trained cave rescue organization within the community.

Cooperation of multiple agencies in the areas of planning, training, and on-scene operations will result in an effective cave rescue organization. Evaluation of your cave rescue organization must occur to improve the level of performance. This evaluation can be accomplished effectively through realistic cave rescue drills with all agencies represented. These are the topics that the Boone County Fire Protection District has addressed in preparing for cave rescue.

CAVE RESCUE - ARE YOU PREPARED?

Cave rescue is a topic of concern in communities that have underground caverns, unfortunately most communities are not prepared to handle a cave rescue situation. The Boone County Fire Protection District has prepared for its cave rescue potential. The Boone County Fire Protection District is a volunteer department consisting of 130 members, 9 fire stations covering over 500 square miles. There are over 60 known caves in Boone County, Missouri and with the large number of university students in the area, the caves are explored frequently. In the past 15 years we have had several incidents in area caves that required the services of our organization. One incident resulted in the drowning of two cave explorers.

The past incidents made us aware of problems in dealing with cave rescue and we have identified what areas that we needed assistance. I met with the Superintendent of Rock Bridge State Park, Scott Schulte, to deal with some of these areas of concern. There are three caves within this particular state park. One cave has about 7 miles of passageway. Together we looked at our situation and made plans to handle cave rescues in the immediate future. We then started to work on a 16-hour cave rescue class to be given to the Fire District Rescue Squad. We utilized several information sources, the main one being the Manual of U.S. Cave Rescue, by the National Cave Rescue Commission. We worked on the class in a local cave with the help of the Fire District

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and the Department of Natural Resources. After practicing evolutions and developing our own ideas and procedures we were ready to teach the class. I was contacted by the Missouri Fire & Rescue Training Institute and asked to present the class at the Missouri State Fire School. We believed that this would be a good opportunity to make individuals aware of the cave rescue problem our state has. We presented a two day class. The first day was indoor covering types of caves, equipment needed, tactics, strategy and organizational structure of cave rescue. The second day the class would go to a local cave and conduct a mock cave rescue. A victim would be positioned in the cave with traumatic injuries. The class would be required to organize their search, there would be a medical team to provide medical care and an evacuation team to locate and remove the patient from the cave. We would monitor the operations and provide instruction and guidance wherever needed. Each class provided us with different problems that we had to address. This was an excellent way to improve our class and our own organization.

The class, has been given three times at the State Fire School. The turnout has not been as we had hoped. We had hoped to attract more students from southern Missouri but the majority of students were from our own area. Informing local fire departments of their cave rescue problem is the key to increase the interest level in attending future classes.

In our community the Fire District has the number of personnel to respond quickly to a cave rescue; it has the communications link that is needed for notification of other agencies and personnel, and to provide additional communications during rescue operations. We also have the medical and vertical rescue capabilities. I provided classes on vertical and horizontal techniques utilized in cave rescue to better prepare the personnel for evacuation operations. In addition to these classes, a 16 hour cave rescue class was provided to the Rescue Squad.

I worked with several organizations within our community that could be utilized during an incident. I had representatives from the area hospitals and ambulance services in the classes so they could understand the hypothermia problem to the patient and the lack of communications to the hospital once inside the cave. The Missouri Department of Natural Resources was represented by Scott Schulte. They had equipment, maps and knowledge of the caves in the area. There is also a local chapter of the National Speleological Society, the Chouteau Grotto. They can provide experienced cavers for search and additional personnel. Classes were provided to personnel from the different agencies so they would know their responsibility during a cave rescue operation.

MOCK RESCUE

After providing the different agencies with adequate training to handle a cave rescue scene, we developed a scenario that would require six different agencies to work together to accomplish a successful rescue. I positioned two victims 1 1/2 miles into Devil's Ice Box Cave. The injured victim was in an area that required extensive vertical rigging for evacuation. The second victim was just disoriented and further into the cave. The cave provided a logistics problem for the incident commander. The first half mile required boats for passage. Each search team consisted of a member from the Chouteau Grotto and a member of the Boone County Rescue Squad. This was done to provide an experienced caver with a medically trained firefighter that understood the overall organization. The medical teams were paramedics from the University of Missouri Ambulance Services, Fenton Ambulance Service and Boone County Fire Protection District. The evacuation teams were members of the Boone County Fire Protection District and Columbia Fire Department. There was a Chouteau Grotto representative assigned to the search officer to assist in assigning teams their areas. The evacuation officer organized his teams and equipment for what possible tasks that lay ahead.

The operation started at the Rock Bridge State Park Office. The scenario was given to the agencies by Scott Schulte, he provided additional information and equipment necessary. He then became an assistant to me in monitoring the operations. Captain Herb Stanley of the Fire Protection District was the assigned incident commander. He coordinated the agencies and their operations. All personnel entering and exiting the cave were recorded by the commander's aide.

The search teams got underway first and through proper leadership the victims were found within two hours. The medical and evacuation teams began patient stabilization and treatment. The technical areas were rigged by the evacuation teams and patient removal began. During this operation recall of the search team had taken place and they began to exit the cave. The injured victim was evacuated successfully from the cave within three hours of discovery. The total time of the exercise was 7 hours. The removal of evacuation equipment and personnel started after the patient's removal. There were 30 personnel involved in this exercise, all were used for a specific purpose in which they had past experience or training. The purpose of this training session was to bring together the skills of the personnel from various agencies in a practical exercise.

When an incident occurs that requires cave rescue, the Fire Department and medic unit will be notified of the location and additional information necessary. The cave rescue equipment not carried on the Rescue Squad will be picked up at the State Parks Office and the Fire department personnel will bring their own personal caving gear. The Chouteau Grotto will be notified and they will start their call up procedure. The Boone County Fire Protection District will be in charge of the scene, the teams will be organized at the command post and responsibilities assigned.

It is not practical or responsible to expect one organization to handle the cave rescues within your area. Complicated cave rescues can take days to complete. If you don't have multi-agency cooperation, such incidents can often result in a disaster. We have experienced several positive side effects from this training. We have opened the doors to other areas that multi-agency cooperation can be useful. There has been an increased interest in caving by fire department members which keeps them current on their skills and also makes available additional equipment sources. We have received media coverage on our training sessions which gives us an opportunity to provide safety advise to would be spelunkers.

Through proper training and preparedness our community can now effectively handle a cave rescue - can yours?

DEVELOPING A LOCAL CAVE RESCUE GROUP

by John C. Hempel*

ABSTRACT

As our nations population increases and more people turn to outdoor recreation to escape our crowded cities, the frequency of cave related emergencies will increase.

In the last 20 years, the Eastern Region of the NCRC has documented a steady climb in reported incidents involving novice and experienced cavers. Many of these accidents have occurred on public land under the control of state or Federal agencies. These agencies often are faced with a cave emergency that they have not been trained to deal with or that they have no response team available for. Local fire and rescue squads experience the same problems on the local level when the incident is on private land.

This paper discusses several pre-incident steps that can be taken to assure a prompt life saving response to an in-cave emergency and suggests some ways of promoting squad interfacing on a local level.

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THE NATIONAL CAVE RESCUE COMMISSION, AN OVERVIEW

by Don Paquette*

ABSTRACT

Cave rescue is probably the most difficult type of rescue to perform. It is most similar to mountain rescue but has the added difficulties of very tight passages and the absence of natural light. The problem is further compounded by the additional factors of infrequent actual major rescues, a high degree of personnel turnover, and the independent spirits of many cavers going against the organizational discipline used by many rescue agencies. With the upgrading in equipment technology many cavers are pushing to underground areas not thought possible a few years ago. The potential for rescue situations is staggering.

The National Cave Rescue Commission was chartered by the National Speleological Society during the mid-1970s to solve many of the potential rescue problems and NCRC has gone through many changes evolving into the communication, resource management, and training group that it is today. This paper will discuss what the NCRC is, how it is organized, what it does, and probably most important what it does not do. Problems and goals of the commission will be highlighted. Time will be available at the end of the paper for questions and discussion.

Cave rescue is probably the most difficult type of rescue to perform. The techniques in use today have been borrowed from many other facets of search and rescue operations and modified and integrated with techniques developed specifically for cave rescue. From the vertical techniques used for years in mountain rescue to the search management procedures used in the wilderness combined with stretcher handling contortions used only underground the concept of cave rescue is extremely broad and highly challenging.

The potential for major cave rescue is higher today than ever and growing almost daily. Caving has increased in popularity as a sport as fast as backpacking, running, cross-country skiing, and other outdoor activities in the last decade. More people are doing caving. The great strides made in equipment technology are allowing more people to push those leads farther than before. Better ropes, wet suits, and poly-pro are allowing those less than as hardy as the rugged old-timers to go places often deemed impossible just a few short years ago. Knowing that a person can slip and break an ankle just walking down the

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sidewalk, and keeping in mind the environment common to every wild cave the potential for problems is staggering.

Additional factors compound the problem. In spite of the increased potential over the years the number of actual major rescues is very infrequent. This makes keeping a finely honed rescue group difficult. People find it hard to practice skills that may never be needed. The environment of the cave presents a major barrier to professional rescue groups with little or no caving experience. The average individual probably will spend three to five years of his life as an active caver before going on to other hobbies. This turnover results in a manpower pool that is usually willing to help but still learning the basics. A highly skilled rescue team requires organization, leadership, followership, and discipline to function well in adverse situations. Most of the individuals who take up caving and stay are headstrong, highly independent types of people who often resent the paramilitary structure in other types of rescue groups. Considering all of these aspects the possibility of successful cave rescue often seems impossible.

In the mid-1970's the National Speleological Society chartered the National Cave Rescue Commission. It was originally a group of commissioners and coordinators headed by a national coordinator. The basic function of the commission was to investigate and list rescue groups potentially useful in cave rescue situations, interface with government agencies, and provide training. Through the effects of speleo-politics the structure of the commission was slightly modified into what it is today. The commission consists of a board of nine regional coordinators, a training coordinator, a medical officer, and a diving officer. They are appointed by the board of coordinators and each appointment is approved by the NSS Board of Governors. The board of coordinators elects a national coordinator. Each coordinator has the responsibility of maintaining a current resource listing for his area, encouraging training and providing training assistance as necessary, and communicating frequently with other NCRC coordinators. The commission as a whole holds a week long seminar on Cave Rescue Operations and Management, normally the week prior to and in the vicinity of the NSS Convention. The NCRC published the first US Manual of Cave Rescue Techniques, and is in the process of writing the first revision. The system of organization has been very effective in that the types of cave rescue problems encountered or expected varies widely among the many caving regions in the United States. Each coordinator is familiar with both his local caving environment and his type of people. He can prepare for the problems in his area and maintain contact with other coordinators about cave rescue in general. This allows him to be aware of the locations of the often rare and highly specialized equipment that may be needed. If the occasion arises where a particular resource is needed and not readily available the NCRC is aided by the Air Force Rescue Control Center located at Scott Air Force base in Illinois. They provide air lifts of necessary personnel and equipment.

The National Cave Rescue Commission is not a glorified cave rescue team that flies all over the country when needed. Rather it is a communication, resource management, and training group that is made up of cavers that have a high interest in rescue and readiness. Our ultimate goal is to have every cave rescue handled on a local level.

With this in mind several goals have been established to achieve this state of readiness. One of the toughest is equipment. Rescue caches' are expensive and cavers are notoriously poor. The goal is to have both a rescue cache' and a training cache' in each major caving area. We currently have a cache on each coast of the United States. Reaching this one will require a lot of perseverance. We set a goal of a quarterly newsletter to be sent to persons interested in cave rescue. Two issues have been published and the project looks successful. Another one is the establishment of a cash award to be presented at the NSS Convention annually for the best new cave rescue equipment or technique developed. This is to encourage and maintain interest in cave rescue among the average caver.

As you can see we have come quite a way in the last decade, but we still have a long way to go. If you are interested, or know of any one who is interested, in cave rescue please contact your regional coordinator and offer your help. These guys are very busy overworked people and can use some help. We cannot afford to lose sight of our most valuable resource, and this is you, someone who is interested in caves.

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A PLEISTOCENE CAT IN A MISSOURI CAVE

by James E. Vandike*

ABSTRACT

In 1982, beautifully preserved tracks thought to belong to a large Pleistocene feline, Panthera leo atrox, were found in a south-central Missouri cave. The cave was first explored in 1978, and had been entered by small groups only four times before the tracks were discovered in a dry, clay-floored passage about 1,000 feet from the entrance.

Panthera atrox became extinct about 8,000 years before present and its remains have been found in numerous places in southern North America. It was the largest Pleistocene North American cat and despite numerous fossil finds, this represents the first time that tracks of the animal have been found. The rarity of the tracks and the possibility of further paleontological finds make it important that the cave be protected from random entry.

The cave is Federally owned and is located in a remote part of the Mark Twain National Forest. Currently, secrecy and an entry passage containing waist-deep water are all that is protecting the cave from visitation. In the near future, the cave should be gated in such a manner to not only preclude unwanted visitors but also not draw attention to the fact that the cave is being protected. Posting of signs is also not recommended to avoid drawing unwanted attention to the cave.

Caves harbor a variety of natural treasures and one of the greatest rewards of cave research is knowing that the potential for substantial discovery exists at any time. A cave's unique environment helps make this possible; the perpetual darkness, constant temperature and humidity, and relative inaccessibility to most people - all serve to help preserve features and protect them from natural and human damage. Even in well-traveled caves, it is possible to find things that others have passed by. The careful eye of a patient observer is often all that is needed.

In 1982 such a discovery occurred in a little known cave in south-central Missouri. My wife, Sharon, and I found the cave when I was researching a Master's thesis. I certainly can lay no claim to first seeing the cave or visiting the entrance area, as there was ample evidence to indicate pot hunters and casual visitors had been there

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before. But untrod clay banks a thousand feet from the entrance, which can be seen only after traversing a semi-miserable water crawl and some areas of moderately deep water, proved that there had been no human entry until our first trip in 1978.

The first three trips into the cave, made by Father Paul Wightman, Sharon, and myself, consisted of mapping and exploration. Each trip increased our knowledge, bettered the map, and also kept extending the known limits of the cave. Unfortunately, we had to move from the area during the summer of 1978, before completing exploration and mapping. By this time, the cave was known to contain at least 4 major passages. The north-trending entrance passage, about 1,100 feet long, ranges from less than 3 feet high, with several inches of water, to about 6 feet high, with up to 4 feet of water. Widths range from about 25 feet to less than 3 feet. The entrance passage leads to a room some 200 feet long and 25 to 30 feet wide, with ceiling height varying from 5 to 15 feet. There is a 5-foot waterfall roughly in the center of the room. The stream passage continues upstream from this room but has not been explored beyond a few hundred feet. Two other passages intersect the waterfall room. The west passage ends in flowstone blockage some 800 feet from the waterfall room. This passage is generally fairly low, narrow, floored with clay, and is several feet higher than the stream passage. The second passage trends eastward from the waterfall room. This passage is much larger than the entrance and west passages; it is generally more than 30 feet wide, up to about 15 feet high, and the north wall is well decorated with speleothems. A calm pool at the apparent end of this passage marked the limits of exploration in 1978.

A two-year hiatus interrupted work in the cave. Study resumed in 1981 when Gene Gardner, then a biologist with the Missouri Department of Conservation, examined the cave fauna. In June, 1982, Gene and I returned to the cave with Bill Palmer, Education Coordinator with the Missouri Department of Natural Resources, and Jerry Vineyard, Assistant State Geologist with the Missouri Division of Geology and Land Survey. The trip was intended for relaxation; we had all taken vacation time to do some fun caving and photography. Jerry Vineyard is an ardent observer who misses little while moving through a cave. After photographing the waterfall, Bill and I had moved to the east passage. While Jerry and Gene were trying to find us, Jerry spotted a number of animal tracks preserved in clay banks along a trail that I had made and followed on my three previous trips into the caves.

Initial examination of the tracks told us several things. First, the beautifully preserved tracks contained no claw marks, meaning the animal had retractile claws. Second, the tracks contained four toe impressions. Together, these characteristics indicated a cat or cat-like animal. Third, and probably most obvious, the size of the tracks told us that they were not made by any species now living in the state, country, or continent. The tracks measured just under 7 1/2 inches wide. So fresh looking were they that it was difficult not to glance behind occasionally, "just to make sure".

Six months later, Gene, Bill, and I made four plaster casts of two of the best tracks. During the same trip, an additional cave passage was discovered by following the tracks over a clay bank and breakdown mound bordering the quiet pool near the end of the east passage. Claw marks of the cat were found in two places where the animal slid down clay banks. Vertebrate paleontologists Russell Graham and Jim Oliver, both with the Illinois State Museum, have also visited the cave, and volunteer mappers working in cooperation with the U.S. Forest Service are currently surveying the cave.

Establishing the species of cat that made the tracks is difficult. Based on the size of cats still living in North America, it is safe to say that the tracks found belong to none of these. Quite probably, the tracks belong to a species that inhabited the area sometime during the Pleistocene Epoch. As recent as less than 10,000 years ago, several species of large cats roamed the mid-continent region. In the late Pleistocene, large cat tracks could have been made by representatives of two genera: Panthera and Smilodon. Smilodon, commonly called the sabertooth, is known to have ranged over North America during the Pleistocene. The animal was not a true cat and, based on casts of foot bones provided by the Los Angeles County Museum, was too small to have left the tracks. Two species of large cats in the genus Panthera roamed the area during the Pleistocene. Panthera onca augusta, the Pleistocene jaguar, is known to have inhabited the region. In fact, tracks and bones belonging to this species were found in a Tennessee cave several decades ago. Like Smilodon, however, this animal was probably too small to have made tracks of the size that we found. Most likely, the tracks belong to the extinct species Panthera leo atrox, the American lion, a Pleistocene cat that surpassed the modern lion in size. A very close match was obtained between the plaster casts of the tracks in the cave and casts of the foot bones of Panthera leo atrox provided by the Los Angeles County Museum. Size estimates, also provided by the Los Angeles County Museum, indicate the adult male American lion stood about 48 inches high at the shoulder and weighted approximately 900 pounds, a formidable animal by anyone's standards.

More information will emerge as work in the cave progresses. As indicated earlier, mapping is continuing and, when completed, the resulting cave map will be used as a base on which to plot locations of individual tracks. To help mappers avoid damaging the tracks, track areas were marked with fluorescent orange flagging and, when possible, the most important individual tracks were enclosed by flagging. Future studies were planned to inventory the tracks and claw marks, and search for other physical evidence of the cat's presence. Stride measurements will be attempted if sufficient adjacent tracks are found.

The tracks are a significant paleontological discovery. Cat tracks have been found in several North American caves, including one in Missouri, but never of this size. If the tracks are indeed those of Panthera leo atrox, they are apparently the first discovered, and the protection is essential. The cave, in the Mark Twain National Forest, continues to be protected from random entry only by secrecy and the hydrologic characteristics of the entrance passage. Unfortunately, however, secrets are difficult to keep forever; hence, a gate will eventually be necessary to control entry. When the cave is gated, it would be desirable to place the gate beyond the twilight zone so it could not be seen from the entrance. The water crawl would serve as an excellent first defence from intrusion, and the gate would be difficult to breach if it were located where it would be difficult to reach with heavy tools.

The discovery of these tracks should serve as a reminder to all who work with caves that significant paleontological and archaeological finds can occur even in well-traveled caves. Tracks in clay look much like depressions made by water dripping from the ceiling. Bones can be mistaken for broken speleothems. It is always tempting to concentrate on the walls and ceiling of a cave, to look at speleothems or other, presumably more interesting, features, and to observe the floor only when necessary to avoid obstacles; but it is sobering to remember that any one of the irreplaceable tracks Jerry discovered, because he looked at <u>all</u> of the cave, could easily have been obliterated by a misplaced boot.

DEVELOPMENT OF A NON-INTRUSIVE POPULATION SURVEY TECHNIQUE FOR OZARK AND VIRGINIA BIG-EARED BAT MATERNITY COLONIES

by Fred Bagley* and Judy Jacobs*

ABSTRACT

The purpose of this study was to develop a technique for censusing endangered big-eared bats (Plecotus townsendii virginianus and P. t. ingens) that would be maximally accurate yet minimally disturbing to the bats at their maternity colonies. Bat activity was observed at the entrances of two maternity colonies of P. t. virginianus in West Virginia using a night vision scope and infrared lighting, and without entering the caves. Twenty all-night observations were made at the entrance of an ungated cave, and 19 all-night observations were made at the entrance of a gated cave from April through July, 1982.

The technique revealed a group emergence in the early evening, lasting from 1 to 1.5 hours, depending on the colony stage. The patterns of emergence and return were found to vary as the maternity season progressed.

Counts at the ungated cave revealed a 22-day period (June 7 - June 28) when the population remained relatively stable (253.9 $\pm$ 6.9 bats, at 99% confidence level). Bats at the gated cave were attacked at least twice by a domestic cat prior to the removal of this predator on June 20. There was a temporary decline in use of the cave entrance and disruption of the nightly activity patterns during the time of harassment by the predator, which precluded the determination of a stable time period for the gated colony.

It is concluded that this technique, with some modifications of the lighting scheme, is consistent and can be used in determining population trends with minimal disturbance to the bats in their maternity colonies.

Several years ago, we began work on the recovery plan for the endangered Ozark big-eared bat (Plecotus townsendii ingens) and Virginia big-eared bat (P. t. virginianus). These endangered bats are subspecies of the more common Townsend's or Western big-eared bat (P. townsendii). The Ozark big-eared bat occurs in eastern Oklahoma, northwestern Arkansas, and perhaps southern Missouri. The Virginia big-eared bat occurs in Kentucky, Virginia, West Virginia, and perhaps North Carolina.

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As our efforts toward preparation of the recovery plan progressed, we became concerned with the lack of information on population trends of these endangered bats, the lack of a standardized survey technique and the impacts of research biologists entering active maternity colony sites. As we became more familiar with these creatures, we began to wonder if it might be possible to somehow census their maternity colonies without ever entering the colony site. This idea intrigued us and became important to the development of the recovery plan because if we could come up with an accurate, yet minimally disturbing census technique, it would be possible to follow population trends (without harming the populations in the process) and it would be possible to evaluate the effectiveness of various recovery efforts incorporated into the recovery plan.

We thought it might be possible to actually count the adult female population one at a time as they emerged from or returned to their colony site, if they did this as a group. The literature on the emergence pattern of big-ears was unclear. It indicated that perhaps big-eared bats emerge shortly after dark, perhaps they emerge in several emergence pulses over the course of the night or perhaps they even have an emergence just before dawn. It was critical to development of a survey technique to understand the emergence patterns of the species and to have some idea of how that pattern might change as the maternity season progresses, the weather changes, and the phases of the moon change. It was also important to know when the best time would be to survey the colony. If we surveyed too early in the maternity season, some adult females might not have arrived at the colony site; if we surveyed too late, young might have already begun to fly and their fluctuating numbers would give misleading results. And finally, it was very important to have some idea of the effect the new technique was having on the colony.

With these thoughts in mind, we set out to study the nocturnal activity patterns and seasonal population fluctuations of big-eared bats at cave entrances. First, we had to develop a study technique which would enable us to monitor bat activity. After some experimentation, we settled on using an infrared light source (provided by miner's lamps with infrared filters) combined with a night vision scope (to allow observation of the bats in the dark). The idea was for the observer viewing through the scope to see the bats as they passed through the infrared light beam at the cave entrance. We decided to record data on a hand-held tape recorder by counting the number of big-eared bats that flew out of the entrance and the number that flew in per 10 minute interval. Using this approach, we found that under proper lighting conditions big-eared bats could be distinguished from other bat species by their long ears, large size and characteristic flight pattern.

Our field work was conducted for 39 nights at two caves in Pendleton County, West Virginia, in the spring and summer of 1982. Observations were conducted from dusk to dawn. Our data revealed four distinct nocturnal activity patterns which changed as the maternity season progressed. In April, big-eared bats began returning to the cave shortly after the emergence. The early return to the cave was probably related to the cold night temperatures of early spring and the lack of flying insects. From mid-May to mid-June, the colonies nocturnal activity pattern was characterized by the colony emerging from the cave over a one-to-two hour period, remaining outside the cave for most of the night and returning to the cave just before dawn. It was during this period that the young were being born and nursed during the day. By June 24, there was an increasingly evident post-emergence return (beginning immediately after completion of the emergence) of a small portion of the population and a re-emergence of many of these bats. The re-emergence was followed by a gradual return to the cave which accelerated sharply as dawn approached. By late June, a predawn emergence interrupted the gradual return to the cave and was promptly followed by a rapid return concluding at dawn.

The post emergence return was likely caused by a small number of young which were beginning to fly out of the cave at night but returned to the cave shortly after the emergence was completed. It seems likely that the predawn emergence was also related to activities of the young. By late July, the nocturnal activity pattern exhibited a post-emergence return of roughly 1/2 of the colony completed later than in June, a predawn emergence of variable size and a great deal of "bat traffic" in and out of the cave all night long.

The population counts revealed a 22-day period (June 7 - June 28) when the population remained stable (253.9 ± 6.93 at 99% confidence level). Counts in April were lower than those obtained during this stable time period, indicating all of the females had not yet arrived at the colony site. Counts in May were almost 20% above the stable time period and may reflect the presence of transient males and non-reproductive females in the colony that dispersed to other areas as the maternity season progressed. By June 29, a significant number of additional big-eared bats, presumably the young, were beginning to fly and the population counts were increasing. This trend continued until the counts of late July indicated that there had been a 92.5% reproductive rate.

Our observations (discussed above) indicated that the technique causes no abandonment, significant population reduction, or other permanent adverse effects when employed at big-eared bat maternity colonies. Observations at the second cave were inconclusive in this regard as reduction in the size of the colony during the reproductive period paralleled predation activity by a house cat. (Once the cat was removed, the colony returned to the cave.)

These efforts have provided the necessary information to allow us to design a survey technique which does not require entering the colony site, provides consistent counts of the population during the stable time period, and will allow monitoring the success of various recovery efforts. Best of all, the technique has now been developed so that all night observations are no longer necessary. Observations typically begin about 8:45 pm and end about 10:15 pm. This allows the observers to get a decent nights sleep, prevents unusually sore rear ends (cave rocks are unusually hard) and allows the colony to return to the cave without human presence. This technique has now been used at all known endangered big-eared bat maternity colonies for two years.

TAPHONOMIC RESEARCH AT SHIELD TRAP CAVE, CARBON COUNTY, MONTANA

by James S. Oliver*

ABSTRACT

Zooarcheologists who are concerned with interpreting bone modification distribution patterns have long recognized the importance of distinguishing the patterns made by man from those created by carnivores. The study of geological processes that may create similar patterns has been neglected. In an attempt to access the taphonomic effects of some definable geological processes, excavations were undertaken at Shield Trap Cave (24CB91), a 14-meter deep animal pit cave located in the Pryor Mountains of south-central Montana (elevation, 2,606 meters). Pit caves are closed systems, physically isolated or otherwise insulated from many agents active in the surface ecosystem. Thus, small pit caves like Shield Trap provide a context in which the taphonomic effects of a discrete set of geological processes may be scrutinized.

Sediment and stratigraphic analyses have shown that roof-fall was the major depositional process during Middle and Late Holocene. Roof-fall events combined with an apparently low, fine sedimentation rate created an angular, grain-supported deposit. The presence of at least 65 bones with periosteal reactive bone growth, a trauma induced growth associated with healing fractures, indicates that a number of animals survived in the trap for one to three weeks. The presence of polish on 40% of the bison bones with reactive bone growth indicates that these animals did not passively await death; rather, a considerable amount of activity is suggested.

Roof-fall and trampling on angular talus floors created a number of bone modifications similar to those produced by humans. These include impact fractures, impact flake scars and flakes, and scrapes and slices. That these damages were observed should not be surprising given the geological context; roof-fall events, and trampling of bone on angular chert-rich floors simulate mechanical processes associated with human activities.

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CAVES AS ARCHAEOLOGICAL SITES: SCIENTIFIC POTENTIAL AND MANAGEMENT NEEDS

by R. Bruce McMillan*

ABSTRACT

Caves have served as habitation sites for Early Man since the initial settlement of the New World. Some of the earliest evidences for man in both hemispheres derive from cultural horizons buried in their entrance sediments. Depending on size and location, they have served as loci for a variety of human activities.

The contextual record of geological, biological, and cultural phenomena buried in sediments beneath cave floors can, when properly recorded through controlled excavation and analysis, yield significant insights into the past climatic, biotic, and cultural history of a region. Truly, caves are nature's "time capsules" and often offer optimal opportunities for integrated interdisciplinary studies of the evolution of Late Quaternary landscapes including the activities of *Homo sapiens*.

This paper will address the importance of archaeological sites found in caves as they relate to an understanding of a region's prehistory, the unique properties of cave sites when compared with open-air sites, and the types of evidence for habitation as well as mortuary and ritual activities. Most examples will be drawn from caves in the Ozark Highland region of southern Missouri, sites most familiar to the author. Pothunting in caves during this century--the indiscriminate looting of sites for personal gain--has seriously depleted this once valuable scientific and cultural resource and makes management of the few remaining undisturbed sites of preeminent concern to insure that, for the public good, future destruction is minimized.

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PALEONTOLOGICAL RESOURCES IN CAVE ENVIRONMENTS

by Russell W. Graham*

ABSTRACT

Caves serve as natural repositories for paleontological as well as archeological resources. Paleontological remains can document past biotas and environments. They are, therefore, of fundamental importance in understanding our past heritage. However, these resources are nonrenewable and once lost, they are gone forever. To insure effective management and preservation of these extremely important resources, it is mandatory that management / conservation personnel have a firm grasp of the nature of the paleontological record.

Normally paleontological resources in caves consist of the teeth, bones, and shells of organisms. However, in certain circumstances, especially dry caves, perishable remains (dung, hair, soft tissue, plant material, etc.) may also be preserved. Even fragile traces of life such as foot prints and claw marks may be recorded on the floors and walls of caves. All of these paleontological resources require special consideration with regard to their protection, preservation, and conservation.

The contextual record of paleontological resources is as important as the specimens themselves. Contextual relationships can provide information on the origin and inherent biases of fossil accumulations, on special relationships (eg. predator / pray) between organisms preserved in fossil deposits, on the use of caves by fossil animals (dens, hibernacula, etc.) and on a variety of other phenomena. Therefore, fossil specimens should only be removed from caves in the case of emergencies or under the supervision of trained specialists.

This paper will illustrate the variety of paleontological resources encountered in caves and their significance. The preservation and conservation of the valuable resources will require the cooperation of scientists, management personnel, and laymen.

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PRELIMINARY REPORT ON THE SMALL MAMMAL FAUNA OF FALSE COUGAR CAVE IN THE PRYOR MOUNTAINS OF MONTANA

by Neal Woodman*

ABSTRACT

False Cougar Cave is a small solution cavern located at an elevation of 2,590 meters above sea level near the top of East Pryor Mountain in Carbon County, Montana. Excavations in the cave from 1978 through 1983 uncovered a sedimentological and paleontological record spanning the late Pleistocene and Holocene to the recent. The end of the Pleistocene is marked by an erosional unconformity, and marked faunal changes occur between the Pleistocene and middle Holocene units which bound this hiatus. Further changes in the fauna occur through the Holocene units.

Few late Pleistocene/Holocene small mammal sites from Montana have been thoroughly studied, and False Cougar Cave represents an important contribution to our knowledge of the faunal history of the Rocky Mountain Region. The fauna of False Cougar Cave includes the first records of Dicrostonyx torquatus and Spermophilus variegatus for the state, and records of range changes for Phenacomys intermedius and Sorex merriami. All are significant for understanding the biogeographic histories of these animals and the dynamics of faunalistic response to late Pleistocene/Holocene climatic change. However, human occupation of the cave, and use of the cave by foxes, coyotes, and probably raptors, indicate a complex taphonomic history which has not yet been totally worked out.

The False Cougar Cave Project clearly illustrates the importance of mutual cooperation between scientific institutions and agencies managing caves on public lands. The scientific information which will be gained from False Cougar Cave will not only provide a better understanding of late Pleistocene/Holocene environments, but it also will assist the U.S. Forest Service in their management of these valuable resources

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UNDERGROUND THEMES

by Katherine Rohde*

ABSTRACT

Interpretation has always had a special place within the National Park Service. If done effectively, interpretation can increase visitor understanding enjoyment and appreciation for the Park's resources and through appreciation, a desire to protect those resources. Cave interpretation presents special challenges and problems which are accurately described in "Boredom in Paradise: A Hard Look at Cave Guide Training" by W. T. Austin and Tom Chaney. The caves under the management of the national Park Service are not immune to those problems. Interpretation in the National Park Service has evolved and changed. New techniques are tried, discarded, or adapted to meet the needs of both the visitor and the resource. These techniques, both for training and presentations, can and should be applied to cave interpretation.

Wind Cave has accepted the challenges: 1) To protect this valuable cave resource, and all caves. 2) To motivate interpreters to want to protect the caves and to share their desires and motivate visitors to do the same. 3) To dispel the myth that cave interpreters cannot practice the current techniques of interpretation and have to memorize a spiel.

At Wind Cave, interpretation is based on the theory that motivation produces more desirable results than just education. Motivation is best done by someone who believes in what they are doing and is involved in a personal way with the resource, in this case; Wind Cave and other caves. As a motivator, the interpreter cannot rely upon a script or canned spiel because each visitor has his or her own personality. However, the interpreters cannot do their job without adequate training and organization. The organizational principle employed at Wind Cave is that of themes. These are the unspoken ideas behind each presentation and are used to "guide" our audiences, on their own, to predetermined destinations. Each interpreter must develop their own theme based upon their feelings, impressions and interests about Wind Cave. Each tour then varies, depending on the personalities and interests of the visitors, blending with the individuality of the interpreter. Yet, each tour is unified by its own individual theme

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or focus and all of the themes are unified by the basic themes encompassed by the National Park Service.

Interpretation, as a management tool in the U.S. National Park Service, had its beginning in 1920 when "nature guides" were hired by the Park Service at Yosemite National Park to "counteract those persons who would selfishly destroy park values".[1] This concept spread to other National Parks throughout the system to become the "most direct and important function of the Service".[2] This same concept is one of the major contributions by the U.S. National Park Service to park systems, not only throughout the United States, but all over the world as well. The scope and quality of interpretation in the National Parks of the United States is one of the features that makes them standout over other park systems.

There are many different definitions of interpretation, but the one that embodies interpretation's role in park management and resource protection states: Through interpretation, understanding; through understanding, appreciation; through appreciation, protection. Interpretation in this vein should be an important component of cave management. If those of us who know and appreciate the beauty, uniqueness and mysteries of cave resources feel that it is important to preserve them, then effective education and information needs to be disseminated to the non-caving public in order to foster an awareness, appreciation and a desire to protect these fragile resources.

Commercial or developed "show caves" can have a major role in this education. These caves provide an opportunity for millions of people to experience a cave, to enjoy its beauty and to gain an appreciation for its worth. Visitors can do this while traveling on paved and lighted trails, without the incumbent natural "hazards that might otherwise cause them to think of caves only as nasty, dark holes in the ground. Guided tours can provide education about caves to these large numbers of people and create a pool of non-cavers who are enlightened as to the value and importance of caves. Tours also provide the opportunity to educate people as to how to behave in caves and thus protect the fragile features and ecosystems. Educating people, not hiding the caves from them, seems to be the ultimate answer to cave protection.

Admittedly, there have been problems with the "traditional" cave tours. Critics may question the idea that the commercial tours, as they are often presented, can be important components of cave management. The guide can only give a memorized "tape recording", lacks enthusiasm for and knowledge of the resource and gives the impression of being, and probably is, bored. Consequently, the first time cave visitor gains no enthusiasm or understanding for the value or excitement of caves.

Boredom manifests itself in other ways that can influence visitor behavior and thus, be detrimental to cave preservation. These guides tend to try and find ways to alleviate the boredom, and often in ways that are contrary to what is acceptable behavior in caves. their actions may also be contrary to the message cave managers want visitors to take with them. For instance, guides may bang on stalactites, set up fake formations, move formations from one area to another, and play practical jokes on one another. Another characteristic of guides tours in "commercial" caves is that the traditional messages given on them do not provide the information necessary for participants to form a positive cave protection ethic. All too often the information is superficial, such as guides giving fanciful names to formations and rooms, or telling jokes and amusing stories about things that do not relate to the cave resources. There seems to be a myth that factual information is uninteresting, and that visitors to caves are not interested in the real facts. Therefore, they should not be subjected to them. This is simply not true. Factual information can be just as interesting as fiction, and even more so, particularly if the guide is enthusiastic, knowledgeable, and uses techniques that will cause the visitor to become excited and enthusiastic about this special resource.

Thus, it seems that the guide is a crucial factor to be considered, if cave tours are to be a viable cave management tool. The training and supervision that the guide receives ultimately puts the responsibility on the cave manager. W. T. Austin and Tom Chaney have discussed this very issue in their paper "Boredom in Paradise: A Hard Look at Cave Guide Training". In their paper, they have identified and acknowledged the problem that is inherent on many cave tours; routine, the guides's lack of enthusiasm for the resource and the job, and boredom. Austin and Chaney offered suggestions for ways to begin to reverse this process and to provide the kinds of training that will breed enthusiasm and interest in the guides and thus, infect visitors. This paper is important to the future of cave interpretation, and is food for thought. If interpretation is indeed to be a tool for management, a cave tour with any or all of the afore mentioned symptoms of a bored guide could actually be giving visitors a message that is contrary to the objectives of a cave manager, and have a negative impact on the preservation of cave resources.

WIND CAVE TOURS - THE PAST

Using the ideas presented in "Boredom in Paradise" as a springboard for change, interpretation at Wind Cave National Park was evaluated as to its role in resource management and its effectiveness. The majority of the interpretive activities in the Park center around the cave resources. During the period of highest visitation, from Memorial Day to Labor Day, thirty-two tours enter the cave daily. Cave tours leave every twenty minutes on either a Half Mile Tour (one hour, fifteen minutes) or the One Mile Tour (one hour, forty-five minutes). Each guide takes a minimum of three and as many as five tours a day. Due to the frequency of tours and the configuration of the tour routes, the tours cannot deviate from the standard routes. In the past, tour guides were given standard explanations and information about the human history of the cave, biology, formation of the cave, and cave exploration. They learned the routes, what to say and where to say it, by following more experienced guides. While not actually "required", an unwritten tradition emerged as to what information was to be given in which locations. Standard analogies and explanations evolved and were used by many of the guides, as the best explanations. In evaluating the cave interpretation program, the training of guides and the information presented on the tours was carefully scrutinized. In addition to those two areas, observations were made of the factors indirectly affecting interpretation, such as employee attitude about the cave and tours, and noting if, then when, "burn out" occurred.

While the quality of interpretation seemed high, because the information was basically accurate and was presented in a professional manner, under close scrutiny, there were hints of "Boredom in Paradise". Every tour sounded the same. Everyone stopped in the same places and give the same information and stories in those places. A rare variation might occur when the boxwork was explained in a room other than the Post Office. when it was explained, however, the words were the same. The explanation was correct, but sparkle and enthusiasm were often not present. Another clue, less direct, but an indicator just the same, was the attitude towards the "regular" cave tours (Half Mile and One Mile Tours) exhibited by employees who were working at the Park for the second, third, fourth or more season. Having to give these tours could be avoided by becoming one of the team who guided the Historic Candlelight Tours (a living history tour). If one spent many hours researching a character who had been involved in the operations at Wind Cave during the 1890's, and learned all that they could about life styles at that time, then designed and made an authentic costume of that time period, one would not have to give very many "regular" tours. Guides could dress up and give tours that were fun, not boring. There seemed to be a lack of enthusiasm for the cave itself. Rather than delve deeper into the information about the cave resources and learn more about the very qualities that make Wind Cave so unique and different in order to generate enthusiasm, employees turned to interpreting people and an era of history, in a costume to find that enthusiasm necessary to do their job.

CHANGES AT WIND CAVE

As a result of evaluating the tours and guide training at Wind Cave, a major change in the focus of cave interpretation, the methods of presenting tours and the method of training guides was implemented. These changes complemented each other and built a base of support for achieving Park Management goals concerning the cave resources.

The formula that was used incorporated three ideas; enthusiasm, knowledge and involvement. Enthusiasm for the resource, the people encountered and the job can be gained and can continue to grow by searching for as much knowledge about all aspects of the cave resource. Enthusiasm is easy to create early in the season. The trick is how to maintain it over the course of the summer, and that is where knowledge and involvement enter the scheme. Enthusiasm is a catalyst that can push people into wanting to learn more, and as they learn more, they want to become involved with the cave resource in some way. This involvement may be assisting in exploration, research or restoration. If employees are involved, the enthusiasm is maintained and each of the elements continue to recycle and feed each other.

THE TOUR

In order to implement the changes, a different approach to tours had to be considered. In the past, the guides were expected to stop at specified locations and to impart certain information during the tour that visitors "should" hear. This method may have offered some assurance to park management that all visitors were getting the same accurate information, and that all guides were giving quality tours.

Perhaps consistency could be expected in the above situation, but there are some problems with this kind of transmission of information. If a tour with standard information is given several times a day by the same person, the tendency to sound like a tape recorded message is almost assured. Visitors hear, but do not listen. Guides become bored and have to struggle to respond to visitor questions that are beyond the realm of their knowledge or worse yet, are asked at the "wrong" time.

In order that spontaneity and enthusiasm be introduced into the tours, changes were made. The required stops and list of subjects to be covered were dropped. Guides were given the freedom to research and develop their own tours and were encouraged to not give the same tour time after time. By being able to be flexible in where they stopped, and more importantly, in what they could say, guides would be better able to respond to the needs and interests of the visitors. In this way the visitor experience could be made more meaningful. The visitor's interests would be aroused and they would be more apt to absorb the message that management wanted them to remember and to take with them when they left the park.

There are some restraints that are necessary to give a basic structure to this new freedom. The key to this method of developing and presenting tours is the Theme. An explanation of this technique is addressed later in this paper. Visitor safety and conservation of cave resources must be addressed. If there is to be information that is required to be shared on each and every tour, it is that which informs people of the potential hazards of which they need to be aware. These include dimly lit trails, wet trails and stairs, low ceilings and how visitors can avoid having an accident. A message of equal importance is one which explains the fragile nature of cave resources and the kind of behavior that will do the least harm to them and assure their preservation. The messages are more than "do not touch" and "watch your step". They are not recited just at the beginning of each tour. Rather, they are alluded to throughout the entire tour at opportune times and are woven into the information presented on the tour.

THEMES

The theme is the central organizational framework of the cave tour. The theme of any tour is the principle idea or message of which the guide would like to make participants aware. All of the information that is then shared during the tour supports and develops that idea. A theme leads the visitors in the direction of thought that the guide wishes them to follow. It provides a thread of continuity throughout the tour. Instead of the tour being a series of non-related stops, the theme allows for the stops to be separate, yet each one adds more information, building support for the theme. By the end of the tour, the guide's purpose will have been accomplished.

Just what is a theme and how does it work? It is somewhat difficult to explain, and it has taken two summers to develop a reasonably simple explanation. A theme is a single idea. A theme can be stated in a simple sentence, with a single subject and verb. Most importantly, the theme is the one major idea that the interpreter (guide) wants participants to remember six months after taking the tour. For example, a theme of a cave tour might be: Caves cannot be considered to be isolated from the surface world. All of the information that is then shared with visitors is going to be building support for that idea. Hopefully, the end result will be seen in the future when the visitor, who has all but forgotten the specific facts about his trip through Wind Cave, hears of sewage being dumped into a cave system, he will remember the idea that caves are not isolated from the surface world. Perhaps, then he will take some kind of action to educate others about the value of caves, and the fact that the sewage will not only affect that cave ecosystem. Because of the interrelationship of cave to surface, that sewage could very well pollute domestic water supplies.

Very often the theme is subtle and underlying, not actually stated. What is repeated and stated throughout the tour is the "vehicle" that is used to carry out the theme. A mistake made frequently is to call the "vehicle" the theme. In the example of a theme given above, a possible "vehicle" might be the role of water in the cycle of a cave. The water is not the theme. It is used to develop the theme. For instance, the development of a cave system depends upon water entering the fractures from some source on the surface. Later in the cycle, water plays a role in the decoration of the cave, again seeping in from the surface where it fell as rain or snow. This same surface water might enter the cave and influence the location or habitat for cave troglobites. Visitors to the cave experience water in the form of high humidity or dripping water. In the far distant future, water may contribute to the demise of a cave through surface erosion. finally, water's role in pollution or destruction of cave resources by a lack of understanding of hydrology might be touched upon. The "vehicle" of water develops the theme that cave cannot be considered to be unrelated and not connected to the natural processes taking place on the surface.

A theme can have many different vehicles. For instance, the vehicle in the above example might have been time, impacts, light or any of a number of other ideas. This flexibility allows the guide to develop ideas for many different tours that will support that important idea they want people on the tour to remember about caves. Having a variety of tours from which to choose helps to prevent boredom, as the same tour idea does not have to be used over and over.

The tour consists of factual and interesting information about the cave and the things that people are seeing and experiencing, given in a series of stops along the tour route. Each stop is designed to provide information that will gradually develop the theme. By the end of the tour, visitors should be able to take the information that they have received and develop their ideas about the resource. If the theme has been skillfully presented, the visitors should reach the conclusion or idea that the guide has been striving to develop on the tour. The guide may help them by actually stating the theme in a conclusion. A strong conclusion ties all the loose ends together. Visitors take that main idea away with them, and may not even realize it until much later, when some incident, or conversation triggers the memory.

The partner to "theme" in making every tour different and exciting is the visitor. Each visitor has different interests, experiences and expectations. Every tour has different visitors. Thematic interpretation allows the guides to respond to visitor interests. Once the guide has decided upon a theme and the vehicles to carry it through, the tours should not be written out completely. They can be too easily memorized, and the guide is again giving the same information, in the same words, in the same place every time. A memorized message, even if thematic, does not allow the guide to be able to respond to visitors interests. By using a theme, and having the flexibility of choosing one of several vehicles to convey that theme, the guide can actually provoke visitors to ask questions or make statements that will alert the guide as to the interests of the participants. Of course, the cave, how it affects the guide, and how the guide changes in mood or responds to the cave each time that guide enters the cave cannot be ignored. The challenge to the guide is to read those visitors and to respond to their needs and interests. Using the visitor's experiences, as well as his own, enables the guide to create a unique tour every time he enters the cave. If a guide considers all of the above variables and knows how to use them, there should never be "Boredom in Paradise".

GUIDE TRAINING

Training is a critical factor in guide performance. This is especially true if the unrestricted tour format is to provide accurate information and a meaningful and effective experience for participants. As was pointed out by Austin and Chaney, having new guides trail along with old guides may be the cause of boredom. Besides the probability of new myths being creased and wrong information being perpetuated, new guides tend to pick up bits and pieces from each tour that they follow. Their tour becomes a composite of many other guides' tours. They never really create their own tour style in which to share their personal excitement and understanding about the cave.

Following old guides is no longer a training method at Wind Cave, and is not encouraged in any form during the training period. However, after guides have developed their own styles, they are encouraged to go on each other's tours in order to offer suggestions for improving the tour and to share ideas. Training is designed to give the guides the building blocks with which to build their own individual tours. It consists of sessions on cave geology (both general and Wind Cave specific), types and development of speleothems, human history of the cave, caving techniques and cave exploration. Cave management and Off Trail Cave Travel Policy are also discussed. Several trips are made through the cave to allow guides to become familiar with routes, location of phones, light switches and first aid caches. They are encouraged to become very familiar with the cave and what resources and features are encountered along the tour route. In addition to the trips through the cave made as a "class", they are encouraged to make trips into the cave in small groups or alone in order to learn and "feel" the cave.

In addition to cave oriented information, training sessions are held on communication theory and skills. In order to effectively share a message, guides need to know the theories behind good communication skills and how to communicate. The importance of good grammar, pitch, rate and volume of voice are reviewed. Other methods of communication such as how our actions either support or belie our words in non-verbal communication, are discussed. Ways in which to initiate intrapersonal communication with small groups are investigated. This communication skill is one that is crucial to reading a group in order to discover their levels of experience and interest. It also helps visitors and the guide to be more at ease and less formal with each other.

During the training process, other training sessions are presented that introduce interpretive techniques and skills to the guides. How can the information be presented most effectively, so that visitors will understand, be provoked to participate in the experience and thus, retain the most from their experience? As mentioned before, there seems to be a myth that visitors to caves want only to be entertained, to see pretty things and to be awed by the biggest, longest, wettest, darkest, or whatever! Experience has shown that the majority of visitors are thinking, caring, aware people. They are not unreceptive to factual information and issues, if these facts are relevant to their experience and knowledge. By being introduced to different and varied interpretive techniques, the guides are armed with ideas about how to involve visitors and thereby create an excitement and enthusiasm for cave resources. A person lecturing and throwing out reams of information is one technique, and is probably not the most effective one. Guides are encouraged to be creative and to develop ideas and techniques for sharing information that will involve the visitor. Some techniques include questioning strategies, such as asking visitors to observe and provide answers or theories. Another technique might be to have samples of speleothems or photos for visitors to look at, or have available a carbide lamp or other prop that will demonstrate an idea or thought. Utilizing one or all of the group to illustrate a point; perhaps asking a visitor to assist you by holding a prop or your light; or by having all the visitors test their hand-span and see just how small an area each one might be able to squeeze through, are all ways of involving the visitor. People will remember more of the information and experience if they have been actively involved in its dissemination, and not just being passive listeners.

"Thou shalt not inflict interpretation." Now that the restrictions on the type and amount of information that a guide may share have been removed, and the guide is fired up with enthusiasm, there is a real temptation for them to tell <u>all</u> that they know about caves. It is important that guides become skilled at sifting through all of the information that is now available to them, and create their tour for each specific time and group. By using the theme as the frame work, and by reading the group, guides should be able to decide on a "vehicle" and create a general outline of what they want to cover on the tour during the few minutes prior to beginning the activity.

It is necessary that guides keep increasing their knowledge and that they not be content with that which they learned during training. The idea is not for the guides to have reams of information that they will inflict on poor, captive audiences. However, they must have abundant information and understanding stored in order to provide an answer to any question, related or not to their theme, or know where to go to find the answer. For instance, the information that a guide was planning to share that would support a chosen theme on a particular tour might not have included anything about the Civilian Conservation Corps, and the developments to the cave and surface for which the CCC was responsible. The guide needs to have a knowledge of that era and the projects undertaken by the CCC in order to answer the visitor's question regarding the date that the first elevator was installed into the cave. During training, the basic information is given. It is then up to each guide to continue increasing his or her information base.

After the training has occurred, and the guide is giving tours, it is the responsibility of management to audit and evaluate those tours. This allows supervisors to see that the information is accurate and pertinent. Most importantly, it allows the supervisor to see that the information being shared with visitors will produce the desired effect and meet objectives established by management. Auditing also provides the guides with feedback about their tour and allows them the opportunity to change and improve, which will greatly increase the potential effectiveness of the tour as a management tool.

INVOLVEMENT WITH THE CAVE

The last element in the formula is involvement with the cave resource by the guides. Off trail trips are scheduled to several areas of the cave. These trips provide an opportunity for guides to experience and practice the skills needed to move in the cave, as well as offering a chance for them to experience the cave in its natural state. These trips are usually to areas which because of their names may elicit questions from visitors, or areas that guides often refer to on their tours. Trips might go down to the water table (The Lakes), or to an area that is rich in historic artifacts and graffiti (Guides's Discovery). If the guides have actually seen and experienced these things, they can add a personal touch to their tours by relating their experiences, first hand. Nothing aids infectious enthusiasm more than the personal experience. It helps visitors to realize that the guides are human, and gives the visitor something to emulate. Visitors become enthusiastic about caves because the guide is enthused and interested in caves.

On trips into the wild sections of the cave, guides practice caving techniques that will enable them to move safely through the cave and will cause the least impact to the resources. They are encouraged to participate in different types of trips. Opportunities are available to assist in surveying, inventorying cave resources, or any monitoring projects that are in progress. Cave restoration projects such as algae control, removing graffiti or litter and trash are excellent projects for creating a feeling of involvement and commitment to the cave's protection. By providing employees opportunities to interact with the cave to have a role in its management, they are going to be committed to cave preservation and stewardship, and will want to share that idea with visitors they encounter on their tours.

The results of these changes in the focus of interpretation and the methods of presenting cave tours at Wind Cave have been encouraging. The guides admit that the theme concept is more demanding because it does not allow them to develop one "outstanding" tour and use it over and over all season long. Having to stay alert and make use of new information, new participants on every tour, and their own changing perceptions has increased their interest in the resource. Tours have improved, and the guides' interest and enthusiasm for the cave is evident in the tours that are being presented. Enthusiasm has grown, not only for Wind Cave, but there is more of an interest in other caves. Guides are not bored, or boring! They are taking an interest in the cave and volunteering to assist with management project. The enthusiasm and concern is infectious. If a guide can succeed in causing a visitor to question some of the management strategies that are not in the best interest of the cave, (i.e., Why are propane tourches being used in the cave to dry the trail? or What effect does building a parking lot over a cave have on the cave?) through participation on a Wind Cave tour, then management has been successful in its attempts to share with visitors the unique and fragile wholeness of caves. The goal of creating an awareness in the visitor about the value of caves has been met.

At Wind Cave the interpretation focuses on the special resource of this particular cave system. However, the message that we strive to present is that Wind Cave is an example of one of the many equally beautiful and unique cave resources found in the world. All caves and the resources that they contain are deserving of our interest and respect. Through interpretation at Wind Cave, visitors can gain an understanding of the value and uniqueness of caves. By understanding the interrelationship of Wind Cave to the surface above, and the strange and little understood processes that created the beauty found in this cave system, visitors will gain an appreciation for these underground worlds. By appreciating the fragileness, timelessness and processes occurring in Wind Cave, perhaps visitors will gain a desire to protect and preserve all caves and the resources associated with them. This is the goal of interpretation at Wind Cave.

CAVE MANAGEMENT - AN OVERVIEW

by Brother Nicholas Sullivan, F.S.C.*

The very fact that this symposium is being held and that I am requested to summarize cave management practices around the world indicates a realization of the importance of proper cave management. I would like to open the talk with a few sweeping generalizations based on personal observations; then outline distinctive and unusual problems in an area that may not be overwhelmingly familiar to many present but which relates to a delicate aspect of cave management.

1. All conscientious cave supervisors are a bit paranoid. In every country there seems to be an unending conflict between the bureaucratic demands of providing entertainment, enlightenment and education to as many visitors as possible while simultaneously maintaining caves in a pristine condition. In third world countries particularly it is extremely difficult for dedicated cave managers to convince governmental agencies of the need to restrict or police movements through caves. It should be pointed out here that only in a few countries are tourist caves managed on an individual basis under private ownership. Excluding privately owned caves in the United States, United Kingdom, France and Brazil, just about every other country maintains control of the caves either at the national or local level; sometimes both. Thus, most cave managers are employed by some governmental or quasi-governmental agency. In some countries this results in exemplary management and interpretation - Yugoslavia, Rumania, Hungary and Lebanon are prime examples of this. In many other countries cave preservation has a low budgetary priority with the result that even spectacular caves are managed on a rather haphazard basis. The many beautiful caves of Thailand, Philippines and Mexico, for example, seem in danger of total destruction because of the apathy of local governmental officials.

2. Successful cave management is, to some degree, inherently self defeating. The more visitors, the more restrictions. Until the time that we can schedule tours through the lunar lava caves earthlings are going to have to cope with increasing numbers of individuals who, for one reason or another, want to visit caves. The many public caves in Kwelin Province, China, seem to have reached saturation and only by marching through hundreds of visitors at a time can any semblance of order be maintained. It should be stressed that there is a cultural basis for visiting caves in China since to many citizens these are sacred areas that may contain the remains of their ancestors. Some caves in Japan, Okinawa, Malaysia and Thailand also receive great crowds of visitors. One wonders just how much the average visitor to these caves learns about speleogenesis and the distinctiveness of the cave environment. Many of these visitors have absolutely no interest in such facts. This audience is well aware of the steps taken by the superintendent and staff of Carlsbad Caverns and at Mammoth Cave National Parks to cope with summer crowds. But even if trains, as at

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Postojna, a cable car or any other type of people mover is utilized to accelerate the passage of visitors, have these visitors learned much of the cave itself?

3. There is an increase in the sophistication of visitors to caves. There are really two aspects to this phenomenon. 1. In Western European and North American show caves there is a need for intelligent, discursive explanations. The days of looking for the statue of liberty on the far wall are not completely gone, but more and more visitors possess a background in geology and natural history that encourages a less emotional approach to cave viewing. This may reflect the effort of such agencies as the U.S. National Park Service and the French Bureau of Tourism that are successfully upgrading all phases of cave interpretation. 2. Until recently in many parts of the world caves were viewed as sinister and even evil places, never to be visited. In 1967 I was totally thwarted in my attempts to take a university class of biology students into several large caves west of Ceba, Philippine Islands, because of the universally accepted belief, even by the departmental chairman, that caves were dwelling places of satanic spirits. Many of you are keenly aware of the extreme difficulty in obtaining guides to actually enter caves in many countries of eastern and southern Africa and some Central American countries. In just twenty years I have noted a greater degree of interest in caves in Indonesia, Philippines, Puerto Rico and South Africa. With a continuing rise in literacy rates, education, and yes, even TV, we can expect many more individuals to express a desire to see the interior of a cave. What impact this will have on cave life, existing cave art, cave meteorology and cave mineralogy is a bit terrifying to contemplate. As more roads and airstrips continue to be constructed it can be assumed that by the year 2000 just about every large cave system will be accessible to casual visitors. No longer can we rely on fear and superstition to stall persons from penetrating a cave beyond the twilight zone. The unfortunate emphasis on the possibility of caves (and mines) as possible refuges from nuclear explosions has focused attention on caves in many countries of the civilized world that had little regard for them previously.

4. A cave is more than just an opening in the ground. The whole catchment area of any cave needs as much protection as the cave itself. Even if there is but a small stream flow or discharge these must be maintained in a pristine condition for proper preservation of formations and wildlife. The concept is, frankly, difficult to convey in many countries. The need to preserve the vegetation above the cave; not significantly enlarge previously existing cave entrances; the need to maintain a non-polluted water supply; to limit fuel lines, electrical systems and transportation systems from impinging on the cave environment; the need to maintain the integrity of the limestone, lava, or whatever substrate in which the cave is formed; these are all essential to proper cave management. Here it must be stated that there are few countries that seem to have any program for preservation of the total cave ecosystem. In Japan, Australia, United States, Canada and the United Kingdom federal and state parks do fulfill this requirement, if only accidentally. It is not going to be easy to integrate control of the subsurface environment with above surface activities.

Allied to this is a problem that many scientists would rather ignore since it is far more rewarding to concentrate on the study of the cave itself. This is a consideration of the impact of the facilities of the cave, especially those caves that attract large amounts of visitors. Parking areas, restaurants, roads, trails, camping areas and the ever present souvenir stands all play a role in the spelean environment. This is not the place to delineate, in detail, solutions. In many European countries these ancillary activities are frequently better organized than tours in the cave itself. Up to 10% of those visiting Mammoth Cave and Carlsbad Caverns National Park never enter the caves. I have noted at state parks in Australia as high as 25% of persons camped on a holiday weekend at a cave site that did not enter the cave itself. Certainly, environmental engineering skills are essential in planning the cultural surroundings of a cave in such a manner as to enhance rather than detract from the cave ambiance. I would suspect that a neat, clean entrance would impress upon visitors the need of maintaining a similar environment underground.

5. Proper cave management is a universal concern. Four cave management symposia have been held in Australia and a significant volume of evaluation criteria for cave and karst heritage has been recently published there, (Davey, 1984); one in Greece; three in France; and one in South Africa. Regional meetings in many other countries, especially where there is a direct and some would say, rigid, control by the government of cave utilization at least reflects a recognition of the need. Neither human nature nor the cave environment changes from country to country, except for accidental differences which are easily understood.

To illustrate one of the major problems of cave management, relations with property owners and government officials, and at the same time to illustrate how these relations affect the investigation of caves in an area that may be unfamiliar with many attending this symposium, I would like to present a case history dealing with the karst terrain of North Queensland, Australia. It is of more than passing interest since solution of the issues raised have demanded the personal intervention of the Premier of Queensland.

There is an extraordinary expanse of Silurian limestone centered around the small village of Chillagoe, 220 km west of Cairns. Here an area of tower karst some 40 km long and 5-10 km wide stretches across a semi-arid section of the Atherton Tablelands, from south of Chillagoe to the Walsh River. Within this area there are approximately 50 limestone towers, each separated from their neighbors by 1 - 3 km. These towers reach up to 80 m above the surrounding plain and are severely eroded by the heavy summer rainfall, the rainwater dissolves the limestone producing rillenkaren and flat shallow pans called kameaitsa. Although some caves with obvious entrances have been known near Chillagoe for almost 100 years it was not until 20 years ago that a serious survey of the caves was undertaken. Originally members of the Sydney Speleological Society made surveys of nearly 50 caves in the late 1950's and 1960's but found the 4,000 km round trip journey over poor roads from Sydney to Chillagoe rather difficult to maintain a prolonged study. After several expeditions they were succeeded by a group of cavers from Cairns that adopted the name Chillagoe Caving

Club. During the course of 15 years they have explored, surveyed and mapped over 400 caves within 25 km of Chillagoe. At the same time they have assisted many biologists, archeologists and paleontologists in locating a large number of scientifically significant caves. Five years ago the Chillagoe Caving Club started pushing farther north into the Mitchell Palmer limestone, extending roughly 150 km to the north as far as the Mitchell River. There is only one readily navigable road through this terrain, although several tracks do permit access by four wheel drive vehicles. The Mitchell Palmer area has been surveyed from the air and has over one hundred towers similar to those around Chillagoe. However, only a few of these caves have been studied but there is an indication of even richer paleontological, archeological and biological sites in the thousands of caves that must exist in the Mitchell Palmer limestone.

Some twenty years ago the Queensland National Park and Wildlife Service incorporated about a dozen of the limestone towers near Chillagoe into the Chillagoe Muncana Caves National Park (there have been several variations of this name) and assigned four rangers to the Park. Five of the caves are open to daily visitation by tourists, two of which are self guiding. The daily tally of visitors normally ranges from three to twenty. However, at holiday times it is not unusual to have as many as four busses of visitors arrive. Most visitors camp in or near Chillagoe. The National Park and Wildlife Service has taken an active role in preservation of the caves in their jurisdiction. Unfortunately many of the distinctive limestone towers are outside the park boundaries and are subject to limestone quarrying and other commercial uses. Prevention of quarrying would have a severe negative impact on the fragile economy of Chillagoe.

In 1978 I first visited the area and was impressed by the rich scientific potential. Since then I have led four expeditions to Chillagoe, mainly for biological and paleontological studies. On all of our expeditions we have received extraordinary cooperation and support from members of the Chillagoe Caving Club, and from the staff of the QNPWS in Cairns and Chillagoe. They have guided us to many remote caves; supervised rigging ladder pitches; provided invaluable logistical support and frequently assisted in the collection of scientific specimens. In 1984 the Queensland government released the volume Chillagoe Karst which is based almost completely on field work of the Chillagoe Caving Club.

Many significant scientific discoveries have been made at Chillagoe and are reported elsewhere. The Queensland National Park and Wildlife Service have also been extremely cooperative and we have excellent relations with all levels of administration in the QNPS. There are tentative plans to establish a permanent research station near Chillagoe where Australian, U.S. and other cave scientists could continue these studies on a year round basis. The earliest known site of human occupation in Northern Queensland is in Walkundea Cave, part of the Chillagoe Complex (Campbell, 1982).

Because of the many discoveries, the Chillagoe Caving Club wanted to make a thorough survey of the Mitchell Palmer area and particularly a significant exposure of limestone on a station known as Mt. Mulgrave.

This is crown land; i.e. owned by the Queensland Government but leased for 30 years to the present tenants of Mt. Mulgrave. Although the lease on the property specifically states that individuals engaged in scientific research have right of access, the present tenant of Mt. Mulgrave has refused permission to the Chillagoe Caving Club and to other scientists, myself included, to enter the property. One solution to this problem would be to declare that sections of Mt. Mulgrave containing the tower karst be classified a national park. This would constitute less than 10% of the total station and consists of an area unsuitable either for farming of cattle grazing because of the rugged topography. However, some of the present area land owners oppose what they feel is governmental intrusion.

Because of our good relations with the QNPS I was requested by the Chillagoe Caving Club to intercede with the Queensland Government about the problem. This resulted in a series of negotiations that have extended over three years with regional and national officers of the National Park System, an impressive array of cabinet ministers and eventually the Premier himself. The first meeting with the Premier was at his request. Before indicating final solution, a number of points emerge:

1. In Australia at least many government officials realize the importance of studying caves and preserving them.

2. Notwithstanding this, all elected and politically appointed officials have to be cautious in making any decision that affects their constituents.

3. Without sounding trite, one must always realize that the great majority of governmental officials are intelligent, dedicated persons who are frequently subject to pressures unknown to occasional visitors. Form letters are rarely read attentively, nor action taken on matters mentioned in them.

4. I do not make the next statement to give offense, but most officials are disinclined to discuss matters of any sort with individuals of sloppy decor, arrogant mien or disheveled appearance. Frankly, I have been astounded on occasion at the lack of external respect demonstrated by cavers both in the United States and elsewhere. Unless one is prepared to appear decently dressed one should never negotiate any matters pertaining to cave access or utilization.

5. It is almost impossible to convey to the average newspaper or media reporter what one is studying in a cave, or why caves need to be protected. Admittedly this is a personal observation but I urge all to use the utmost caution in discussing cave preservation with reporters who are not personally known and or who have not demonstrated responsibility in reporting matters of a speleological nature.

Ready access to Mt. Mulgrave has still not been obtained, mainly due to the refusal of the landowner to allow members of local caving clubs to enter his property. The many government officials involved have acknowledged the illegality of the landowner's position and have, in fact, indicated this to the landowner both orally and in writing.

One cabinet officer offered to have me protected by six armed members of the government constabulary, but I refused feeling that one should be able to conduct speleological research in a relaxed manner. Also, had an emergency arisen that needed more manpower or reserve equipment it would have created an extremely awkward position vis-a-vis the landowner. Also, although I have been assured that no harm would come to me were I to visit the caves under discussion, the members of the local caving group still could not visit and their presence is essential for support, mapping and on going exploration when I am not present. There are hundreds of other caves in the Chillagoe area that can be studied. Patience is needed here, as in many negotiations. We must realize that caves may have existed for many millions of years and in remote areas there is no overwhelming need to explore them today. Obviously, this philosophy cannot apply to those caves in danger of being polluted or affected by current situations.

REFERENCES CITED

Chillagoe Caving Club, 1982, A speleological field guide of the Chillagoe Muncana Rockwood areas in far north Queensland, Australia: Chillagoe Caving Club, Cairns, 187 p.

Davey, P. F., Editor, 1984, Evaluation criteria for cave and karst heritage of Australia: Report of the Australian Speleological Federation National Heritage Assessment Study, Helictite, 15(2): 1-40, 1977.

Hamilton-Smith E., Editor, 1976, Cave management in Australia: Proceedings of the First Australian Conference on Cave Tourism, Jenolan Caves, N.S.N. 10-13, July, 1973, Australian Speleological Federation, Broadway, NJW, 109 p.

M I S S O U R I   S P E L E O L O G I C A L   S U R V E Y,   I N C.

The Missouri Speleological Survey, Inc., is a non-profit organization of groups and individuals in the state of Missouri who are engaged in study and research in speleology. The Survey actively promotes research in all various groups within the state and promotes cave conservation as a means of insuring the continued availability of caves in their natural state. To implement these aims and purposes, the survey publishes a journal, current cave catalogs, cave maps, and a monthly publication designed to keep cooperators informed on the progress of current research.

The Survey is incorporated as a non-profit organization under the laws of Missouri and is administered by a Board of Directors, with one director elected by each member organization and the President elected by the Board. The Directors meet at specified intervals to formulate the policies and activities of the Survey.

The Survey is supported by the Missouri chapters of the National Speleological Society, local caving clubs, other agencies, and individuals who are interested in caves. Funds for the operation of the Survey come primarily from the sale of publications and maps, and from grants and gifts.

The Missouri Department of Natural Resources, Division of Geology and Land Survey and the National Speleological Society have actively supported the Survey since its inception in 1956. The Division of Geology and Land Survey provides a permanent repository and reproduction service for cave maps and maintains a cooperative cave file. The Society has provided grants, encouragement, and technical assistance. During recent years the Survey has worked with the National Park Service, National Civil Defense, Nature Conservancy, the Forest Service, and other state and local organizations, as well as with individuals and cave owners.

The Missouri Speleological Survey is primarily a service organization, and in this capacity it provides numerous services for its cooperators that would be difficult for individuals or local organizations to provide. The Survey's status as an independent research organization allows much more effective interaction with other organizations than would normally be possible on a local scale. When requests for information or assistance come in from other agencies, the directors are often able to pass them along to appropriate local groups or individuals for action.

The Missouri Speleological Survey does not presume to be a national cave research organization. It was conceived and is operated primarily for the study of the speleology of Missouri. It is designed to be compatible with other state and national groups having similar aims, purposes, and standards.

C O N S E R V E   M I S S O U R I ' S   C A V E S