National Cave Management Symposium Proceedings

Albuquerque, New Mexico 1975

National
Cave Management Symposium

Proceedings

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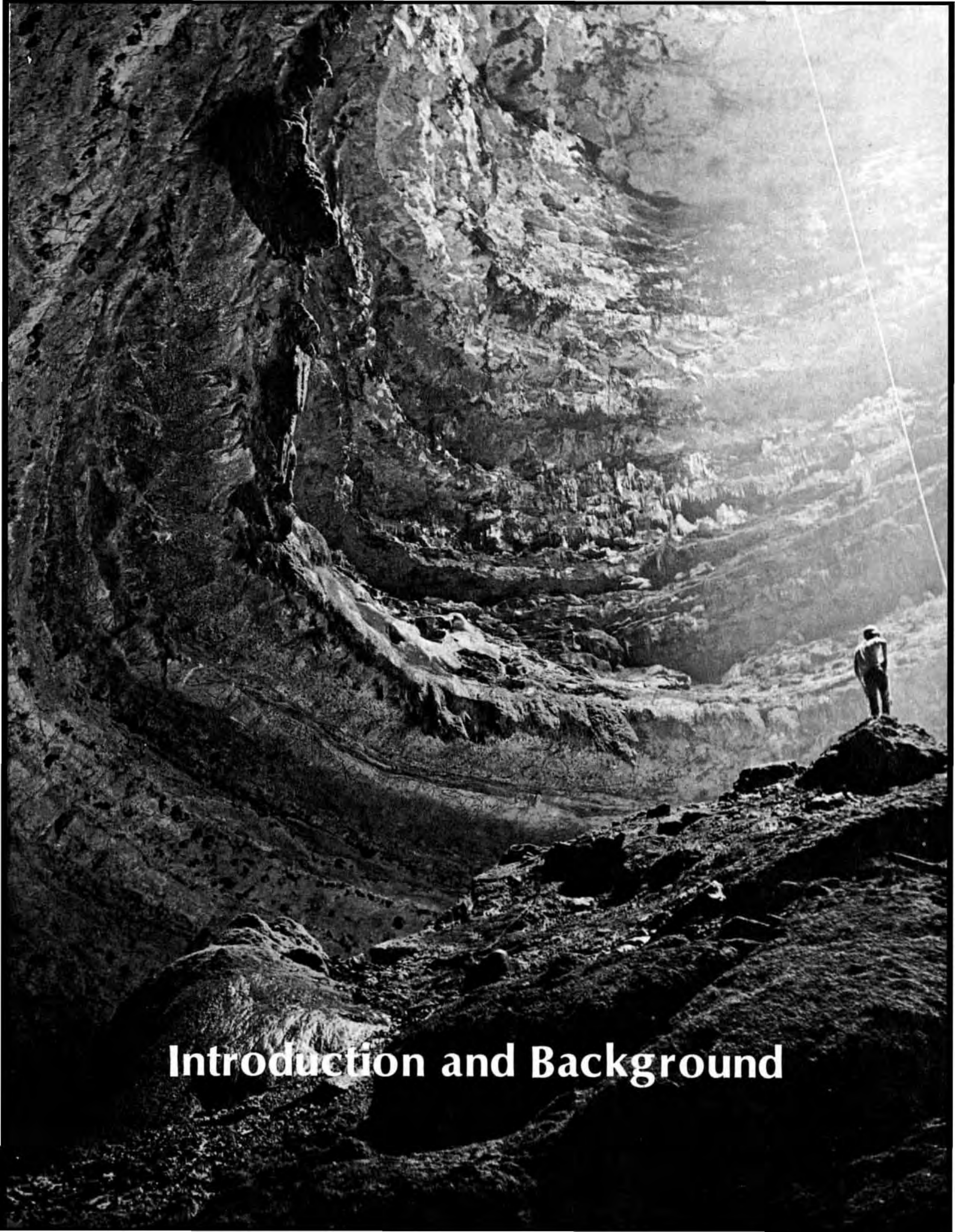

Introduction and Background

Economic Role of Caves Stressed

Caves contribute to the economy of New Mexico, Lt. Gov. Robert Ferguson told delegates Monday at the First National Cave Management Symposium.

The symposium, sponsored by the Bureau of Land Management, U.S. Forest Service, National Park Service, National Speleological Society and the Cave Research Foundation began Monday and will run through Friday at the Hotel Plaza in Albuquerque.

FERGUSON WHO was introduced as being from the "heart of cave country," in Lea County, N.M., told the group that some of the most excellent examples of cave resources are found in New Mexico.

"New Mexico has a wide variety of caves, both private and public," he said. He added that some 350 caves are located on BLM, NPS and Forest Service land.

Following his keynote address, Roger Brucker, an expert on caves, and an author of an upcoming book on the subject, said there are three main problems facing caves — caves are fragile, they are undergoing increased pressure from more people who want to go into them and more cavers want access to caves on public land.

HE SAID more cavers, climbers and divers are maintaining they have a right to risk their lives in caves if they want to and these people are not going to go away.

The problems combine, Brucker said, to make cave managers wonder how they are going to manage caves as a fragile resource, but at the same time allow people into them.

"The central goal is to save the cave," he said.

He said cave managers, likewise have every right to ask the name and address of individuals going into caves as well as asking where they intend to go and to furnish a report on what they saw and did while in the cave.

BRUCKER ALSO encouraged delegates at the symposium to support the concept of caves as an "underground wilderness" and encourage legislation in that area.

He said the underground wilderness of a cave fulfills the same basic human needs for remoteness and solitude as an above ground wilderness and should be considered in the same context.

The objective of the symposium is to improve communications between the cave scientists, cave managers and spelunkers for the purpose of improving and attempting " to standardize cave management techniques and policies to better protect cave resources.

Spelunker's Group To Surface in City

Lt. Gov. Robert Ferguson will deliver the keynote address Monday when scientists from around the nation gather in Albuquerque for the First National Cave Management Symposium.

The symposium, sponsored by the Bureau of Land Management, U.S. Forest Service, National Park Service, National Speleological Society and the Cave Research Foundation will allow representatives of government agencies to meet with speleologists to discuss the problems of managing the fragile environments of caves.

The symposium will be held Monday through Friday in the ballroom of the Hotel Plaza in Albuquerque.

The objectives of the symposium are to improve communication between the cave scientists, cave managers and spelunkers for the purpose of improving and attempting to standardize cave management techniques and policies to better protect the cave resource.

"Caves contain unusual and fragile environments and shelter many rare and endangered species. They represent outstanding natural biological laboratories where scientists can study the adaptation of animals to a lightless environment and therefore require careful and well-informed management," said Paul Petty, chairman of the symposium and recreation planner with the New Mexico State Office of the BLM.

C6 THE NEW MEXICAN
Thurs, Oct. 9, 1975

Trash leads to cave

TUCSON, Ariz. (AP) — A junior high school teacher and two pupils discovered a cave unknown to Coronado National Forest officials near here, but a trail of trash let them know they weren't the first ones inside.

And there's been further damage in the two months since Charles Sylber and David Ahnell, 13, and Michael Howard, 14, found the Villasenor cave in Sabino Canyon.

"Somebody took a carbide lamp and scorched an arrow on the wall pointing to the entrance," said Louise Strong, who teaches science with Sylber at Emily Gray Junior High School here and is a member of the Escabrosa Grotto of the National Speliological Society.

"We didn't need that, or the gum wrappers someone else left behind," said Mrs. Strong.

Sylber said he thought the cave, named after Emily Gray principal Ruben Villasenor, had not been explored until he spotted spent matches and rusty flashlight batteeries on two of the cave's three levels.

Mrs. Strong registered the cave, which has nine rooms and is 117 feet long, with the National Speliological Society, but that doesn't mean it'll appear in any tourist advertisement, like Colossal Cave near here or Grand Canyon Caverns near Peach Springs. The society keeps its good news to itself.

Cave explorers, or spelunkers, don't like to struggle through dark, narrow, underground passages only to find natural formations chipped by souvenir hunters, littered with trash or scrawled with initials.

cavers, tired of being called on to rescue the unprepared from underground predicaments, have tried posting signs and even sealing some caves with steel gates. Arizona's only cave-explorer death occurred when a man disregarded a sign warning of a 300-foot drop near the entrance to a Tucson cave.

"We've had one gate torn off seven times," Mrs. Strong said. "That's not always a real effective way of protecting the caves."

Other means to protect the caves are being discussed this week as the Speliological Society, Cave Research Foundation, the U.S. Bureau of Land Management, Forest Service and National Park Service hold a symposium in Albuquerque, N.M.

Among those attending is Mark Grady, archaeologist with the Arizona Shate Museum here.

"The cavers think the best in cavee conservation is achieved through secrecy," Grady said. "But the custodians of public land must know about these resources if they are to manage them."

On the other hand, management people need to demonstrate that they understand the fragile nature of caves, and the needs of cavers as well as all others who visit multiple-use land, Grady added.

"Then there's the whole question of whether caves represent a wilderness which shouldn't be entered at all," Grady said. "I'm optimistic for some sort of rational discussion, but there's going to have to be a compromise."

Welcoming Remarks

Robert E. Ferguson*

Good Morning, Buenos Dias!

On behalf of Governor Jerry Apodaca, the people of New Mexico and myself: Welcome to New Mexico:

Welcome to the First National Cave Management Symposium.

I understand we are privileged to have representatives from outside our national borders: British Columbia and our good friend to the south: Mexico. We are all very happy to have you with us.

Representatives from sister states, federal and state agencies, various private organizations, and interested citizens—welcome.

I realize you have a busy schedule, and an interesting one I might add. However, I would like to note for you that we have many interesting events and beautiful sights in New Mexico ranging from Albuquerque itself with the world Championship Balloon Meet and Old Town, to Sandia Peak, to Santa Fe, to all of New Mexico. We hope you will have the opportunity to see and enjoy some of it.

While I was musing over the many sights of New Mexico, I was struck by the appropriateness of your meeting place.

Some of the most excellent examples of cave resources, causes for concern for them, the people concerned, and methods to conserve and manage the resources are found in New Mexico.

Perhaps from this state picture we can draw some conclusions for the national picture. First, regarding the cave resources: New Mexico has a wide variety of caves, limestone, lava, gypsum, both wild and commercial. There are caves on private lands and state lands. the state has about 350 known caves in all. The Bureau of Land Management, the National Park Service, and the United States Forest Service, all administer lands with caves in them in New Mexico. Many new caves are found every year by both governmental and private organizations and individuals. The number and locations of caves are expanding—but only slowly. It is important that measures be taken to conserve this limited resource.

The causes for concern, are of course the increased interest and use by people. New Mexico is experiencing an increase in visitors every year. People are seeking new places and experiences for their growing recreation time. They are looking for that unique experience to talk about. Caves can provide those new experiences. (To illustrate this increased interest of cave resources in New Mexico, let us look at Carlsbad Caverns National Park, a well known example of cave resources in New Mexico.) It is one of the major tourist attractions in the Southwest. Consider some of these points:

1. The five-year visitor total through 1974 was 3,802,220 visitors, and well over 17 million since 1923.
2. The peak day was July 2, 1972, with over 12½ thousand people counted at the caverns.
3. The State Department of Development estimates the occupants of each tourist vehicle will spend $50 a day. This means a lot to the economy, even if a more conservative figure is used. This park of 46,800 acres has over 60 wild caves of various sizes. An example of the popularity of *inner space* is the interest in New Cave, one of the wild caves of the park that has been partly tamed. New Cave has been visited by over 13,000 people since its opening in September 1973. The interest of the public in a *different* experience is underscored when one realizes there are no elevators, electric light systems, nor easy trails to this cave in Slaughter Canyon.

New Mexico has a wide range of concerned people. New Mexico is one state in which the Bureau of Land Management, the National Park Service, and the U.S. Forest Service are all active. These are the major federal agencies providing recreational opportunities and their management. A variety of conservation groups are active here. Private organizations and people have been working with the governmental agencies to create an integrated management scheme for our cave resources. In short, we have a broad base of concern and action.

Together these groups have sought methods to conserve and manage the cave resources. Together these groups have established a continuing relationship to provide more information and better management for conserving cave resources. The National Cave Management Symposium is a natural outgrowth of the New Mexico efforts, and similar efforts in other states.

This Cave Management Symposium is intended to develop means whereby this question can be answered: How can a limited and fragile cave resource be managed for an unlimited and unknowledgeable user? To answer this question, certain goals have been recognized for your symposium:

1. Gather and share information needed to protect cave resources.
2. Establish an open line of communication among managers and cavers.
3. Gather basic data needed for policy preparation by managers.
4. Determine ways of promoting safe and responsible use of caves.
5. Review management techniques to establish common methods.
6. Determine ways of providing visitor use opportunities without serious resource damage.

It seems the examples of cave resources, causes for concern, the people concerned, and methods to conserve and manage are all here from New Mexico and elsewhere. Here at your First National Cave Management Symposium, I would like to add my support to those who planned this symposium, to you who are here, and to those who will benefit from it. This symposium offers all of you an opportunity to exchange knowledge which can lead to understanding of cave conservation and proper management, for the benefit of those yet to come. I share your concern with you, and I hope you achieve the goals of your symposium.

It has been a sincere pleasure to me to welcome you.

* Lieutenant Governor, State of New Mexico.

Caves and Cavers—An Overview

Roger W. Brucker*

Caves and Cavers—An Overview is a broad subject. The only improvement would be to call it an *underview*. We have been made aware of the goals of this gathering, so I would like to talk about some problems and some opportunities.

I am not speaking so much as the President of an organization interested in caving, but rather as a caver with 25 years of intimate association with caves, with cavers, and with those who manage caves. These years of experience have taught me two things that can be illustrated by some stories. Those two things are the need for *flexibility* and a willingness to be proved *wrong*.

The first story concerns a graduating medical student attending his graduation exercises. The speaker, an illustrious physician, told the young doctors that if they learned nothing else, they must *never* change their diagnosis. To do so would cause the patient to lose confidence. The young doctor opened his office and the first patient was a gaunt, elderly man. Without hesitation the physician probed and palpitated him; listened through his stethoscope and peered into his throat.

"You have a case of locked bowels," said the doctor with certainty.

"But Doc, I've had diarrhea for three days. You *can't* be right," said the patient.

"Hmmm," said the doctor. "I stick by my diagnosis. You have a case of locked bowels. But yours are locked in the open position." *Flexibility.*

The second story is of a man who owned a large factory, and whose only peculiarity was that he liked to blow the whistle promptly at noon to show his authority. Each morning on his way to the factory he would pause in front of a jeweler's window and set his large gold pocket watch by the chronometer in the window. This practice continued for many years. One day the jeweler was out washing the window. The factory owner said to him, "Say, how accurate is that chronometer?"

"It's accurate to the split second," said the jeweler. "Why, every day I set it with the noon whistle." A willingness to be proved *wrong*.

So to conclude my opening remarks, don't be afraid to speak up during these sessions (you're among friends). And welcome the opportunity to be proved wrong.

THREE PROBLEMS AND THEIR OPPORTUNITIES

My purpose is to comment on three problems facing all of us. When I speak of opportunities, I do so with some humility and some suggestions. I leave the answers to the young doctor and his rapid diagnosis.

The first problem is that *caves are fragile*. We used to think of a cave as a wild place, like an ocean or a mountain. Lightning and other forces of nature might do their worst, but in the end, the mountain endured. Man might even sculpt the heads of four Presidents on a mountain, but there were plenty of unscarred mountains left.

Our realization that caves are fragile grew out of increasing knowledge about the cavern processes. Twenty years ago one could find sewage in a cave and regard it as an assault on one's nostrils or on one's aesthetic sensibilities; now we know it is an assault on a diverse life web so illusive to the casual observer that he may be unaware of it. The more we know about caves, the more fragile they seem.

What is the opportunity? Just this, of all the ways of thinking about a cave, there is one way that will help simplify what is being observed. When things are simpler, they are usually easier to understand. That way is to think about cave fragility as an input-output problem. You put in water and under certain conditions mineral-laden water comes out. You put in food and not much organic matter comes out (it suggests that some of the food is eaten). You put in cavers and adventure stories come out. You put in rockhounds and stalactites come out. And so on. The usefulness of thinking of caves and cave problems in input-output terms is that it requires one to consider caves from the process point of view.

Cave processes are changes through time. For example, studies of the chemical action of water in karst have shown that most of the waters are neither wholly saturated with mineral, nor wholly mineral-free. The water is constantly being mixed, picking up some mineral here, depositing a little there. So one of the basic cavern processes is that the forces that create a cave also destroy it.

Since water is so basic to many cavern processes, how can one assess the probable impact of a proposal to divert water from a cave? The answer is that the many roles of water include the processes of dissolving and depositing, and also of transporting inorganic and organic materials. Systematic inquiry along the lines suggested by the sessions in the next few days can sharpen your own sensitivity to the problem of cave fragility.

A second problem is that there is *increased pressure on caves*. More people than ever want to get into caves—and they are not just cavers. Of course this is a by-product of a worldwide population problem. The damage to caves is done by what the people use up, what they do with the leftovers, and what they do out of ignorance and cussedness. We will hear a lot about the effects of sewage pollution, water diversion, contamination, destruction and vandalism and what can be done to arrest or reverse those problems.

Many private landowners with caves have become fed up with inconsiderate cavers. They have locked up or blown up caves. Cavers—guilty and innocent—look to the remaining caves for satisfaction. The pressure from this source will continue for the forseeable future.

But there is an even more insidious set of adverse cave pressures, institutional pressures, often backed by government agencies. The Corps of Engineers' plan to flood the Meramec basin, in Missouri, is an obvious, dramatic example. But how can one explain the continued diversion of natural spring water from atop the longest cave by the National Park Service? When the Engineers are involved, it is insensitivity, politics, crassness, and stupidity. When the

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National Park Service is involved, it becomes a budget problem or a question of priorities. Blame-finders can have a field day pointing to institutions and individuals that abuse caves. My suggestion is that we find better ways to bring the facts to the attention of the individuals and institutions. For example, most budget problems are a question of the allocation of resources, not the amount of resources available (there's never enough). So it falls upon those who care about caves to describe their value in such a way that anybody can see that their value exceeds the modest cost of protection.

A third major problem is concentrated on cave guardians and managers. *More cavers* than ever before *want access to caves* on state and federal lands. Like access to public records, the issue of access to public lands will intensify.

With it comes the old riddle—at least as old as the Bible—"Am I my brother's keeper?" Do I, a free-born, God-fearing, taxpaying, credit-card carrying citizen have the right to risk my life in your cave if I choose? Some here will instantly recognize that for the word *cave* one might substitute mountain, vertical wall, or water. For years we have stammered with answers. It was always easier to answer people who would timidly go away. But increasingly, the cavers, and climbers, and divers won't go away. Like our own children they demand"Why, Daddy?" Of course we devise methods to specify qualifications and think up schemes to test competence. But each year dozens of Qualified Divers die; there are no guarantees here nor anywhere.

One suggestion is that we re-think the whole relationship with cavers. In the Cave Research Foundation that question was put to us by some of the most risk-conscious landlords in the country—the owners of Floyd Collins Crystal Cave. "How do we know you won't sue us if you get killed or hurt?" they asked. Our solution was—and is—what lawyers call the *joint venture*. A joint venture is a joint undertaking, something like a business partnership, but with a larger element of risk involved. A joint venturer—as we call individual cavers—is a co-taker of the risks and rewards. This distinguishes the relationship from the guide-visitor, proprietor-customer, landowner-guest, or employer-employee relationships so widely known.

I am not a lawyer, so I don't give legal advice, but I think the joint venture concept is a very attractive one that ought to be investigated by those who manage caves and worry about their responsibility for the cavers. It may apply to your situation.

What about caver abuse of the cave? I have met very few cavers who did not want to do a good job protecting the caves. Where they fail, the cause is more often ignorance or carelessness. So I suggest that most cavers will respond enthusiastically when informed of the fragile nature of a given cave. There is an interpretive opportunity here, probably easily within the capability of everyone in this room for the cave known best to you.

GOALS COME BEFORE PLANNING

Whenever managers encounter problems they make plans. Every management textbook tells us that goals must be set, objectives spelled out, before we begin planning. The adage is still true: if you don't know where you are going, any road will do. Stated in other terms, goal-less planning is a very long and expensive process because in the absence of goals one must plan for everything. In the face of the three problems I believe are most important for us to consider—the fragility of caves, the increased pressure on caves, and more cavers wanting access to caves on public land—what kind of goals might be appropriate?

It seems to me that a goal called *save the cave* may be central to every other consideration we discuss this week. Everyone is for saving caves, and redwoods, and whales, and you name it. But are there opportunities for creative policies to achieve the goals once the enthusiasts go home?

Let's look at a couple of possibilities. The first I call an accountability policy. A man once applied for a job. In his resume the personnel man noticed one item that caused him to ask, "It says here you were a soldier in World War II. Were you a good soldier?"

The job applicant thought hard because it had been a long time, then his face brightened, "Well, we won the war, didn't we?" *Accountability*.

One way in which accountability can work is that those who manage caves and permit others to visit them unsupervised have a perfectly reasonable right to ask for the name and address of all those who want to go in the cave. Secondly, they have every reason to ask where they intend to go. Of such simple factual data is the accountability chain forged. A third reasonable requirement is that the cave visitor who does not pay money ought to furnish some sort of report on what he did and what he saw.

Now the reason for doing this is not so much to accumulate records, but to demonstrate that you take accountability seriously because the cave is a fragile resource. Fragile resources are not trusted to irresponsible people who refuse to account for themselves.

The second suggestion is that cave managers can grow a concern for cave conservation on the part of individuals and groups. Many cave managers do a superb job at such education, telling visitors that they may not handle the formations because the oil in the skin wrecks the formations.

Groups can be impressed with cave conservation more from the attitude you display toward the caves than from lectures. I think if everyone of you here told the caving groups you encountered that there was to be a cave clean-up weekend at your favorite cave on a certain date, you'd have lots of help. The benefit is partially in having a cleaner cave, but mostly in having a cadre of individuals who have *demonstrated* a conservation act. Conservation behavior beats conservation rhetoric every time.

What other suggestions related to goals can be useful? I suggested that in the accountability policy area, one might require little reports on what people do, see, and find in your cave. Each time such a report is received, there is a golden opportunity for goal sensitivity training with cavers. A report, no matter how skimpy, is information. One may ask what insight does this provide that we didn't have before? Can we use any of this information to predict outcomes in the future? Can we use the information to help control adverse outcomes or promote desirable outcomes? Questions like those are bound to get both you and the caver into what amounts to a goals discussion. The objective is to achieve *mutual* cave-related goal setting. If that sounds like a joint venture—believe me, it is part of it. Goals are like the bullseye on a dart board. One might learn to throw darts without such a target, but the presence of a target gives a fixed point for improving later performance.

If we are to tackle cave problems with wise policy based on goals, where are we to get answers when we can't afford to run our own experiments, or don't have time to find out how long it takes for sewage to overwhelm a diversified cave community? One answer is this symposium. I believe this must be the largest collection of serious cave specialists and thinkers ever assembled at one place. What an information resource! I hope you will pick the brains of everyone here (with a warning that most can be proved wrong at one time or another).

We have an opportunity as a result of this symposium to create an informal communications network. The roster itself provides all we need, especially if we take time to jot down our annotations of who knows what. While on that subject, I would urge each of you to trust your own experience as you take part in the presentations. At the same time, be ready to doubt your own conclusions.

Whether you are trying to refine goals or solve an urgent problem, the ideas you gain from this symposium are really just raw material. You still need to find out what works and do more of it. And you have to find out what doesn't work and do less of it. To find out these things, I once learned a secret from a market research expert that I'd like to share with you. He said the function of market research is to fail cheaply. Of course, market research is supposed to find out what works, but the trick is to do it in such a way that if the thing you are testing won't work, you find that out before spending much time and money.

In the cave management area *failing cheaply* is a most useful approach. For example, if you wonder whether any sort of joint venture system might help you in the management of visitors to your cave area, your first step would *not* be to print up a lot of forms. Your first step would be to write or telephone your agency's legal counsel to explore the idea. If the legal expert told you to forget the idea, you're out a phone call. If he thinks it might work, get him to prepare a sample joint venture form, or get one from the Cave Research Foundation. Mimeograph the forms before you get them printed. The *fail cheaply* idea is that you pursue the line of inquiry most likely to cause the idea to fail at each stage and at least expense. If all signals remain *go*, you proceed to the next step.

When the Cave Research Foundation and the National Park Service personnel at Mammoth Cave discussed working out a joint emergency and rescue policy about 15 years ago, the administrators used the *fail cheaply* idea to good advantage. The Superintendent said, "You prepare a proposed policy and let us look at it." There was no risk, yet if we hadn't been able to start somewhere it might have reduced the possibility of every achieving a joint policy. We now know the wisdom of that approach. The policy has been revised at least three times, and neither party hesitates to change it when it can be strengthened.

THE UNIQUENESS OF THE CAVING EXPERIENCE

I want to turn now to the topic that I believe makes this symposium so valuable—the relationship of the unique underground caving experience and the necessity for underground wilderness. What is the appeal of caving? Why can't cavers just jump out of airplanes, buy a hang glider, a motorcycle or aqua-lung and get their thrills some other way? I believe the answer to that question is the uniqueness of caving as an experience.

That experience combines the nature of people and the nature of caves. I believe that most children are born with a kind of instinctive curiosity that results early in the development of exploring behavior. As Ashley Montagu concludes in his book *Touching**, infants move through a period in which they gain information tactilly to a period in which they gain much of their information visually. Both senses continue through life as important information receptors, but Montagu cites evidence to support the view that much emotional development depends on continued tactile stimulation. I think many societal pressures repress exploring behavior by making many forms of it socially undesirable or unacceptable. Thus, when Freud and Jung suggested that going into a cave is a symbol of a subconscious desire to return to the womb and escape life, they may have described a very basic tactile meaning. My only purpose in bringing up the subject is to suggest that the love of cave exploring may fill basic needs in some people while it is repugnant to others.

Many of us who have been asked why we go in caves have looked unseeingly into the distance and finally replied, "I guess I just like it." To be sure, there are many appeals—the aesthetic appeal of the roundness of forms and non-linear aspect of the cave passages, the intellectual challenge of knowing where one is in relation to the surface or other parts of the cave, the feelings of remoteness, the challenge of an achievable goal that yields to honest work, the shared trust and joy of companions, and so on.

In no other activity that I know does one literally slide the whole body through sand and mud and over rocks. One is *in* a cave; and to some it is a satisfying, deeply personal experience. As one mountain climber put it, if you have to ask "why", probably you will never understand the answer.

If the individual's need is basic, then the cave itself must be unique. The nature of the cave is best summed up as darkness and silence, two conditions not found in a sustained way in any other natural earthly environment. Further reflection reveals other conditions and relationships that the mind and soul can engage with satisfaction; a pattern to be perceived out of apparent chaos, natural processes to be understood once the sequential relationships are classified, and delights of discovery to be savored with Gestalt glee.

I submit that the cave environment alone can satisfy this basic need in some people. That is why there is an intense effort to establish the concept of *underground wilderness* in this country. Underground wilderness is the essence of the worthy goal I proposed by the statement: *Save the cave*. Unless one understands the deeply felt passion that many underground wilderness advocates bring to their efforts, one cannot understand their persistence and tenacity. They see their struggle as basic to life itself, not an abstract esoteric exercise.

Why are the underground wilderness advocates so zealous? One definition of a zealot is a person who, having lost sight of his goals, redoubles his efforts. But I think most of those who want underground wilderness have a clear idea of its benefits. Perhaps in trying to state those ideas in the remaining few minutes, we will bring this overview back to its starting point.

The purposes of underground wilderness, as a legislative concept embracing a protected cave, are three:

1. To provide a natural laboratory where processes and things can be studied through time in a natural way. This does not mean undisturbed, for we understand many perturbations of nature, like forest fires and animal predatoriness are facts of nature. It does mean relative freedom from man-made disturbances and from any but primitive experimental studies. It is the *through time* aspect of the natural laboratory that Underground Wilderness protects.

2. An Underground Wilderness provides a cave management and environmental benchmark by which one

* Montagu, Ashley. *Touching; the Human Significance of the Skin.* Columbia University Press, New York, 1971. 406 pp.

can assess the success or failure of management decisions made about caves elsewhere. Only if some caves are protected through every tomorrow can one refer to them for answers to questions we don't know enough to ask today.

3. A purpose of Underground Wilderness is to provide wilderness experiences, where remoteness and solitude mingle with self-reliance and adventure. A protected cave will assure this basic resource in perpetuity. It is not the numbers of people who use the wilderness resource, it is the quality of the experience obtainable from it through time that is central to the issue of wilderness. Wilderness uses are many and varied, and the benefits, I believe, are only glimpsed by a few. When several legislatively protected underground wilderness areas are established, I predict we will experience an overwhelming flow of benefits to enrich mankind.

Two facts must be emphasized: Only the people, through government, can provide underground wilderness; their representatives in the U.S. Congress enacted the enabling law more than 10 years ago. Secondly, there is no such thing as *too much* underground wilderness. If we make a mistake, and 500 years from now managers decide that we have 10% too much of it, then what is the harm? We have preserved our options for the future, and we trust that they will make wiser decisions than we can if they have better information than we now have.

These comments should provide some insight into the reasons for such intense, perhaps passionate interest in underground wilderness by some of the participants in this symposium.

Let me try to pull these ideas and suggestions together in a few sentences. Cave managers will do well to adopt an attitude of flexibility and a willingness to be proved wrong by better information. Three fundamental problems facing us are that caves are fragile, there is increased adverse pressure on caves, and more cavers want to enter the caves. We suggested that such problems do not yield to neat recipes; they require innovative and creative experimentation and solid common sense. Refuse to do any planning for caves until you have addressed yourself to the goals. *Save the cave* is central to it all, and such a goal could be approached by strategies of accountability, conservation teaching with goal sensitivity training, and perhaps through non-traditional relationships such as the joint venture idea. Good ideas are where you find them; the participants in this symposium provide a ready-made reservoir of ideas and information you can tap. Where no information exists, devise methods of *failing cheaply* as you develop your own expertise from experience. We asserted that caving is unique because it fulfills a basic human need. Unlike a fad, it won't go away. We also asserted that Underground Wilderness is the only prudent way to assure wise cave management through time, and that belief accounts for the passion of underground wilderness advocates. We are engaged in exploring behavior in the hours and days ahead. I hope this overview will help put some of the solid ideas you will get into a meaningful frame of reference.

Finally, I leave you with a riddle that expresses my deepest wish for your personal enlightenment. What kind of animal can see equally well from both ends? The answer is a *cave blindfish*. I wish good seeing to you all.

Uses of Caves

Charles Larson*

Caves have been viewed, and used, in four basic ways: as natural enclosures suitable for protracted use, as a source of precious minerals and raw materials, as objects of wonder to be briefly visited as a recreational pursuit either gratis or by paying admission fees and/or taxes and, only recently, as natural laboratories where the most unique of geological processses and ecological systems may be studied.

Utilization of caves as enclosures—by far the prevalent and longest-enduring use—dates back to earliest man. Even before abstract thought—if, indeed there was such an evolutionary step—it is likely that caves were instinctively used as *shelters*. And small wonder it was, for caves are *ready made* natural enclosures requiring little or no modification for immediate use as shelter, refuge or place of reverance.

SHELTER

Early cave dwellers were superstitious, but of necessity prudent, and could quite comfortably reside in the entrance areas and consign the dark nether reaches—seldom if ever visited—to gods and demons.

Fortunately, the house keeping habits of early cave dwellers were sloppy and, consequently, we know a great deal about their culture. By selective and careful excavation of cave dwelling sites, archeologists accumulate great amounts of knowledge about cave dweller's habits and approximate dates of habitation. Caves so old as to have completely filled in or collapsed have yielded evidence of occupation several hundred thousand years ago. Use of caves as shelters continues in many parts of the world even today, though not on the scale of past eras.

Refuge was an important use of the sturdy natural enclosures caves provided, second only to shelter. It made little difference if the refugee's flight was preconceived or desperate; from beast, man or the law; caves were excellent hiding places.

Many battles have been fought at cave entrances, even as recently as the late 1800s when skirmishes between the U.S. Cavalry and Indian tribes occurred at Infernal Caverns, California, Salt River Cave, Lava Beds and other locations. Earlier, during the Civil War, caves were occupied by soldiers from both sides. Stonewall Jackson used Grand Caverns, Virginia, for quartering troops and Melrose Caverns was used, and defaced, by troops under General Fremont's command who were later driven out by Stonewall Jackson, who used the cave in similar fashion. Boone Cave, Missouri, sheltered guerillas and roving bands of robbers during and after the war and later became a pirate's retreat. Soldiers from the North and South retreated to caves as battles raged up and down the Shenandoah Valley. Rebel Cave, Missouri, was named after seven confederate soldiers, who were executed after being found there. Linville Cavern, North Carolina, protected deserters from both Civil War armies.

No one knows how many caves were used as robber's roosts, but of record alone the number is impressive. Jesse James, possibly the country's most itinerant outlaw, reputedly used Meramec Caverns as a hideout during the 1870s. Also on his itinerary was Robber's Cave, Nebraska, following the Northfield Bank job, and among others, Big Spring Onyx Caverns in Missouri. Another legendary owlhoot, Sam Bass, was said to have hidden a $2,000,000 treasure in Texas Longhorn Caverns.

The bloodiest cave history of all time concerns Cave-In-Rock, on the Ohio River. A band of pirates operated from this cave, siezed passing boats, killed the crews and, for an astonishing period of time, brazenly floated the ill-gotten gains to market. Following this episode the cave became a *den of iniquity* managed by successive entrepreneurs, most notorious of which were the Harpe brothers who laid to rest many unwary travelers. Bone Cave, Missouri was another pirates den. Outlaws once hid in Colossal Cave, Arizona, and counterfeiters once operated out of Dunbar Cave, Tennessee. Heaven knows the number of caves that sheltered illegal distilleries. The number of caves named *Moonshiners Cave* is staggering.

Many caves were used by political refugees. It's said that one signer of the Declaration of Independence, Thomas Hart, fled from Tories to a Connecticut cave where, assisted by friends, he lived for several months. New York's largest cave, Howe Caverns, formerly used as shelter by the Mohawk Indians, became a Revolutionary War haven for an unlikely duo—a Jewish trader and a Protestant minister. Many caves were used as way stations on the Underground Railway which spirited slaves to freedom. Big Spring Onyx Caverns, Missouri, was one such cave.

Recently, during the bomb paranoia following World War II, many caves were designated radioactive fallout shelters. They were appropriately fortified against fallout, stocked with water and rations, and held in readiness for the big blast. They were a dismal prospect indeed, these tombs stocked with water, survival crackers and crude sanitary facilities. Perhaps fortunately, few survived the depredations of vandals for any appreciable length of time.

STORAGE

To practical minded persons the world over, caves have appeared as natural enclosures ideally suited to certain types of storage. Fruits, grains, hay and vegetable materials have been successfully stored in caves. The environment of many caves is suitable to archival storage. Especially in areas of recent vulcanism, many residences are built over cave and utilize the cool cave air. Certain ice caves are still being used for refrigeration. Names like Meat Cave, Butter Cave, and the like attest to their use for refrigerated storage. A northwest cave named Christmas Tree Cave was, as the name suggests, used to store same. At one time, St. Louis brewers stored their beer in caves.

Munitions were stored by Oliver Hazard Perry in Perry's Cave and by Civil War General Lyons' forces at the battle of Wilson's Creek. Boone Cave, Missouri, was used as powder magazine for forts along the Missouri River in 1812. Old Spanish Treasure Cave, in Arkansas, and Spanish Cave,

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Colorado are said to have yielded gold or were used to store gold.

REVERANCE

Early men were superstitious, the deep recesses of caves were dark and largely unknown, and it was natural that caves would be revered. They might not actually enclose gods and demons but they could very well be the entrances to such godly regions. Significantly, the best primitive cave art and relics of superstition are found, not in the twilight zone, but farther back in dark areas of caves. the Indian name *Manitou* (God) was given to an Alabama cave. In South America, pits and caves were holy places used for worship and, sometimes, human sacrifice. Far inside an Oregon cave, massive amounts of charcoal have been found in what is thought to be an early religious site. Carbon dating and growth rings have established the date of the burned wood as prior to 1370 A.D.

Caves have served as burial places the world over. Moaning Cave and many others in California's Mother Lode Country were selectively used for burial and, it is believed, re-burial. Grand Canyon Caverns, Arizona, were once a Hualapai burial site. Squire Boone's remains lie in a cavern of the same name and the famous solo caver Floyd Collins rests in Crystal Cave. A bizarre internment was that of one Cave Wilson who, as he requested, was pickled in salt and placed in a cave together with a barrel of whiskey which was to be enjoyed at some later date by a group of his friends. His friends dutifully congregated at the appointed time, but the whiskey had vanished.

Marvel Cave, in Missouri, was once used as a prison and Oliver Hazard Perry used Perry's Cave as a prisoner of war camp. The infamous Newgate Prison, in Connecticut, housed prisoners before, during and after the Revolutionary War. It began as a cave, was enlarged when mined for copper and eventually became a prison.

MANUFACTURING AND PROCESSING

Just as caves make snug residences, secure hideouts and storage places, so too they could house manufacturing and processing operations. Distillation of spirits was probably the prevalent manufacturing operation carried out in caves, but no exact figures are available. Many have enclosed mushroom farms and several have been used to age cheese. A blue cheese was manufactured in a Washington cave using a mold imported from Roquefort, France and the product was said to rival or exceed the French product. The manufacture of gunpowder, closely allied with the extraction of saltpeter from cave earth, was carried on in many a cave. The Wyandotte Indians operated a factory in Olentangy Caverns, Ohio, where arrows and stone tools were produced. Smokehole Caverns, in West Virginia, was used by Indians for smoking meat and later by moonshiners. Moonshiner's Cave and Arnold Ice Cave, in central Oregon provided a welcome combination for thirsty cattlemen of the early 1900s. Ski Hi, a Kentucky cave, with a chimney, natural ventilation and a stream, was used for years as a slaughterhouse.

Onondaga Cave, Missouri, and Cove Run Cave, Pennsylvania, were used as reservoirs; Horse Cave, Kentucky, housed an electric power plant. An Indiana poultry farmer housed his flock of several thousand chickens in a cave during hot weather. Bethlehem Steel Corporation used a cave as a World War I artillery firing range.

Offal Enclosures

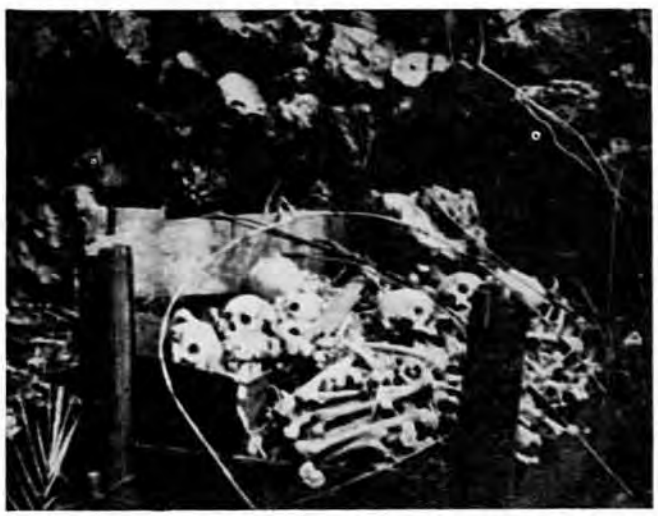
Perhaps no more disgusting use of caves exists than their use as depositories for all manner of refuse. All over the country caves have been, and in many areas continue to be, used as garbage dumps, burial pits for dead animals and *out of sight, out of mind* repositories for industrial wastes. Especially in areas of recent vulcanism, it has not been uncommon for builders to simply drill into the earth until a void is encountered, into which wastes are channeled. Fortunately, and primarily as a result of the pollution of ground waters by such waste sites, the practice is dwindling.

MINING

Caves have been mined for minerals with real or imaginary value. Early cave miners collected various stones and secondary minerals thought to possess magical powers. Others mined caves for materials used in weapons and tools. One Trout Creek Cave, in Oregon, yielded quartz for the making of arrowheads. The method used was unique. Large fires heated the cave's crystal lining to several hundred degrees farenheit. Cold water from a nearby stream was then used to quench and shatter the crystal into usable pieces.

One mineral, saltpeter, a necessary ingredient in the manufacture of gunpowder, had a very real value. The early settler's lives depended on it. Early in the Revolutionary War it was discovered that saltpeter could be obtained from cave earth which eventually became the principal source of the mineral in the US during the War of 1812 and, for the Confederacy, during the Civil War. Some Confederate soldiers were assigned to permanent duty as saltpeter miners.

For many years, caves near the fringes of the expanding nation—far from transportation routes—remained the source of the vitally necessary mineral. During the Civil War it was discovered that saltpeter could also be obtained from guano. One enormous guano deposit, in Frio Cave, Texas, was mined almost continuously from the Civil War to the present. The value of guano as a nitrogen-rich fertilizer was considerable and its removal from Frio Cave, as well as many other caves, continued long after different processes



Common grave of Japenese Soldiers in Shinzato Cave, Okinawa. *Photo by Goud Sedohr* in the manufacture of gunpowder caused the decline of saltpeter mining.

Silver, copper, lead, gold, and other valuable minerals have been mined from caves which intersect or approach mineral deposits. Tragically, many caves have been, and continue to be, mined out of existence as limestone quarrys consume entire mountains.

Speleothems have always attracted a large segment of the population and exploiters have ever been ready to profit from their sale. The majority of rock shops and some privately owned commercial caves sell cave formations. Fortunately, few concessionaires at government-managed cave sites have sold speleothems and the practice is declining among commercial caves. Onyx Cave, Arkansas, was mined for onyx and, at one time, a fine pottery clay was mined there and made into pottery, which was manufactured inside the cave. Epsom salts were once mined from Wyandotte Cave. Ice was mined from virtually every known ice cave in the US before refrigeration was available and the practice is still engaged in by tourists.

ODD USES

A few uses of caves are not easily classified. To use a cave as a fictional subject is a delightfully non-destructive use. Many hair-raising novels are about caves. Samuel Clemens used his personal experiences with Mark Twain Cave, in Missouri, in five different novels. Fictional parallels to true cave discovery stories abound and who hasn't read of Ali Baba's treasure cave.

Bear Cave, in Michigan, was used for the filming *The Great Train Robbery*. Hundreds of weddings have been held in Bridal Cave, Missouri, and out in Nevada, Devil's Hole was once called Miner's Bathtub after that practice.

Dances have been held in caves; indeed, some caves were extensively modified for that purpose. Often, young people kept their dancing secret from puritanical parents by locating the event in a cave.

RECREATIONAL USE

A public interest in caves grew out of their widespread use as saltpeter mines, and entrepreneurs were quick to recognize that caves contained another kind of gold—the sightseer's dollar. The era of cave commercialization began following the War of 1812 and, if the occasional, unfortunate sale of speleothems is ignored, was until recently the best thing that ever happened to caves. It's not important that some commercial cave ventures are utterly tasteless, but it is of great benefit that cave owners realize that by protecting their cave and its decorations they preserve a virtually inexhaustible resource.

The value of this resource is perhaps best illustrated by an event that occurred a few years ago. Sea Lion Caves, in Oregon is a privately owned commercial cave; large as littoral caves go but miniscule in comparison with other caves, and inhabited by a herd of fat, oily sea lions. The state of Oregon offered to buy the cave for $1,000,000—and the owner turned it down.

Commercialization of eastern caves exploded, which fostered the cave wars of the 1920s and '30s, when competition became downright unfriendly. There were more than a few *accidents* as zealous cave owners fought it out for the sightseer's dollar.

Today, more than 200 commercial caves are operated in the US. This figure includes eight cave sites maintained by NPS, two managed by USFS and one semi-commercialized by BLM. These government agencies manage lands including hundreds of other caves, of course, but the foregoing are principally cave sites.

At about the same time that cave commercialization blossomed, and as a result of social and technological advances which allowed scientists to think about other things, an awareness developed that caves were not simply subterranean cavities, but unique natural features. Speleology, at first an amalgam of several time-honored sciences, was born. Speleologists were quick to recognize that there were only so many caves, that no new caves could be formed in a meaningful time frame, that unique features in many caves were already forever destroyed and that such destruction was accelerating. As a consequence, cave preservation has been one of speleology's primary goals.

A NEW USE FOR CAVES

Largely as a result of the discovery by speleologists that caves were unique natural features, a new cave use classification has been recognized. Called variously cave preserves, wilderness caves, study caves—names which amount to the same thing—these caves are protected from excessive visitation and environmental contamination. The purpose of this use (or non-use, if you will) is to perpetuate as many as possible of the cave's unique features and yet allow scientific study to progress therein.

While this use of caves is on the increase, and is increasingly advocated, it is not a new concept. For example, the National Park service has managed two caves in the Lava Beds National Monument (Crystal Ice and Fern) as de facto cave wilderness for years. This may be moot inasmuch as the monument is already a wilderness.

CONTEMPORARY USES

It is apparent that, until recently, little thought has been given to the possibility that caves might eventually be *used up*. Far too often man's use of caves could better be described as misuse. Fortunately, few examples of pre-1900 type uses of caves remain.

The many thousand known U.S. caves are broadly, and arbitrarily divided into *commercial caves* and *wild caves*, the latter signifying that they are *not* managed—which, of course, isn't true, for nearly all cave owners, public or private, exercise some degree of control over their caves. Wild caves are used primarily for recreation by an ever-increasing number of cavers. Estimates of the size of this group range from 50,000 to 100,000 and up.

Over 200 commercial caves are used by now-highly-mobile sightseers—called *tourists*. Several million tourists visit caves each year.

Speleologists use wild caves, commercial caves and the wild parts of commercial caves as natural laboratories in the science and study of caves.

In the final analysis, today's use of caves is predominantly recreational.

CONCLUSION

Former uses of caves seldom gave consideration to the welfare of the cave itself, and current uses leave something to be desired, but there are encouraging signs. Those with the most interest in caves are awakening to a need for long-range planning. This increasing concern is manifested in the first National Cave Management Symposium, held in Albuquerque, New Mexico, in October 1975. This meeting will profoundly affect the future uses of caves—for the better.

Who Are Cavers?

Nick Noe*

A caver can be nearly anyone. A caver is probably the last person you would suspect. They can be 65-year-old grandmothers who explore deep pits or infants piggybacked along by their parents. Most cavers are taxpayers or their offspring. They resist further classification into political ore religious subgroupings. Some are undoubtedly unique beyond description and independent cusses as well.

Statistics tell us that cavers average about 20.1 years of age, are 98 percent Caucasian and 80 percent male (no wonder they're wierd). Their education is a matter of dispute. Comments left in cave registers suggest at least a high school education; but cryptic signatures and graffiti on cave walls indicate a subprimary level of intelligence. 24 percent are first time visitors and 5 percent are confirmed cave addicts. The remaining 61 percent are occasional cavers. A survey of light sources reveal that 55 percent use carbide lamps, 40 percent use ordinary flashlights and the remaining 5 percent use electric helmet-mounted lamps.

A history of cave register programs may be helpful at this point. In 1968, a survey of four popular Arizona caves revealed that 80 percent of their visitors were first-time cavers. Nothing was done with the statistics other than to publish the random comments found in the register in the local cave club's newsletter.[1] Most of these comments were humorous and largely unprintable. However, the experiences of the local homing pigeon club in the cave seem to be noteworthy. Found was the wry comment: *Damn birds don't fly too well in here.*

In 1973 there appeared the publication *Caves of Colorado* which publicly divulged the location of many previously undescribed wild caves. Local cavers, fearing a significant impact therefrom, undertook a study to determine actual impact from this and other sources of information. A program combining both live interviews with cave registers revealed that 80 percent of cave location information was by word of mouth. Of the remaining 20 percent, *Guide to the Colorado Mountains* accounted for nearly all of the responses citing publications as their source of information with *Caves of Colorado* netting 2 percent of the remainder.[2]

The questionaire used in the Colorado study was so successful that it was appropriated for use in Indiana, which at the time was experiencing its own dilemmas with cave guidebooks. Concurrently, the Caver Proliferation Committee of the NSS was determining, on the basis of the data from the Arizona registers and owner registers in Indiana that the number of cavers was increasing approximately 9 percent/year. The committee estimated that the number of cavers in the country was from 200 thousand, on the low side, to 2 million, on the high side. Educated guessing averaged this out to 600 thousand cavers in the U.S.[3] Preliminary results from the Indiana impact survey were made available in 1974. Forms had been placed in 10 popular Indiana caves with various degrees of effectiveness according to incidence of vandalism and persistence of maintenance. Results were similar to those in Colorado with 80 percent citing word of mouth, 19 percent media and 1 percent other sources. 22 percent were first-time cavers.

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The Indiana program was two-pronged. Not only did it reveal important statistics; but it offered an opportunity to circulate a cave conservation pamphlet as well.

In 1975, the NSS was offered an opportunity to purchase one of the better-known and traveled caves of the northeastern United States. To assess potential and develop a management plan for this cave,[4] an on-site survey combined with a cave register was used to study traffic through the cave. Of the 59 cavers participating, the report revealed that many of the cavers came during the week and gave the following information:

> *21 percent of the cavers were female. The median age was 22.5. 26 percent were visiting their first cave. The average number of caves visited within the last two years by those who had been caving before was 10.4, although this was increased greatly by four individuals who had been to more than 50. 55 percent were wearing hard hats; 34 percent used carbide lights and 46 percent used flashlights as a primary light source. 7 out of the 59 had only one light source. 76 percent had informed responsible people of their whereabouts, but only 53 percent had given their expected time of return. Finally, most of the cavers, although they were not NSS members, agreed that the NSS motto could easily be followed or is easily followed. Six people felt that it was a ridiculous statement.*

Most recently John Wilson of the NSS Social Science Section has developed a uniform program to extract meaningful data from cave registers. By using a standardized form distributed on a national basis and computer compilation of coded inputs, we can construct a truer picture of the average caver and make the necessary policy adjustments on a real-time basis. Use of this procedure in West Virginia has already provided us with a few surprises. Wilson[5] found from 642 respondents who visited 8 caves between January and May 1975 the following:

> *Results indicated that the average caver is 21.5 years old and that 1 in 6 is an NSS member. Eighty percent are male and the majority are not affiliated. The average caver has been in almost 11 caves in the last 2 years, however, almost one in every four cavers is on his first cave trip and the mean number of cave trips in the last two years is one. The most frequent year that he first entered a wild cave is 1975.*

Cave registers can take almost any form and usually depend on whatever the person placing the register can scrounge. In dry western caves, coffee cans or institutional food jars are popular, although by no means exclusive. Cannister registers made of soil pipe with fittings as well as converted 30 caliber ammunition cans are commonly found in wetter eastern caves. Whatever the type, a register is characterized by the function which it is intended to perform, namely, a device to record information which the visitor chooses to impart. The obvious inference is that you can lead a horse to water, etc. The supposed virtue of the register as a deterrent to placing names on cave walls has never been proven, although it is often the cause for the initial placement of some registers. The NSS cave register program is today predicated on a philosophy of cave conservation. In practice this means constructive placement of a cave register in a location most accessible to the cave visitor; the idea being to reach the greatest number of people who cave with the messages of cave conservation and NSS fellowship on a local level. This was not always the case. Early registers were patterned after their mountain-top cousins and were intended to document physical achievement by their placement in the most inaccessible portions of a cave. State Cave Register coordinators currently shoulder the responsibilities for maintaining records of caves where registers are placed, delegating maintenance and re-suply chores to willing volunteer victims and attempting to compile local statistics when possible, and pass them on to national computer analysis.

Problems of conducting a successful cave register program are significant and twofold. The initial problem is one of maintenance. There are three factors which make maintainence a difficult and sometimes frustrating chore. Moisture is a villain of the first magnitude. Rusted registers, soggy paper and soft pencils are the best symptoms of excess moisture. Attempts to combat moisture with dessicants have all had shortcomings. Waterproofing compounds may be harmful to the ecosystem and Carbide can be a safety hazard as well as messy (or worse if spilled). Another factor is vandalism. Registers are often destroyed or missing. They are probably the victims of the same people who write on walls or break the formations. I have a name for this nebulous person. I call him *Nalph Raider*; because under these set of circumstances the consumer is the problem. The final factor is lack of manpower. If one person is responsible for the conduct of a multi-register program, the data may be rendered obsolete by the time it is collected and processed. The second problem posed by the conduct of a cave register program is what to do with the data which is somehow miraculously collected.

Coherent, meaningful and lasting results cannot be achieved without extracting statistical data from the sign in sheets and publishing it for others to make policy and administrative decisions on the basis of sound contemporary information. This is often an insurmountable task without money, manpower and time. Use of computers can simplify and speed this process; but their implementation can be impeded by availability, cost of operation, lack of standardized data input methods or shortage of qualified operators sympathetic to project goals.

A discussion of Cavers and Cave Registers would be superfluous to these proceedings without an examination of how the register can be used as a tool for improved cave management. It cannot be stressed too strongly that maintainence is essential for a successful cave register program. This may pose an insurmountable problem for any governmental agency which has to live with budgetary limits and manpower ceilings imposed by either OMB or austere congressional appropriations. Another question raised by potential involvement in such a program by any governmental agency is that of project duration. Is such a program to be open-ended to provide a constant source of current information; or can an adequate data base be generated for future decisions with a finite program? The opportunity for increased computer access by such an agency may mitigate problems of time, money and manpower; but there is no assurance that it can provide the answer to demands which exceed resources.

It is my opinion that cave registers achieve their greatest value as a barometer for future resource allotment. Levels of visitation/demand would predicate either tighter controls, if the resource were limited, or relaxed control mixed with a diversion to other nearby resource caverns, if not limited. Trite as it may sound, the possibilities for better cave management through register use are unlimited. The challenge lies in knowing what questions to ask the visitor.

We do have some answers provided by register data. This data has shown that there are three basic types of cave visitor. The first we shall call the veteran or *true caver*, or perhaps just plain *caver*. This type is characterized by a good knowledge of caving techniques and respect for potential dangers, frequent trips, a comprehensive awareness of conservation principles and practices and is usually affiliated with the NSS or another organized caving club. The second type we shall call the *spelunker*. He has a basic knowledge of caving techniques and safety procedures, makes infrequent trips, has a sketchy knowledge of conservation and is non-affiliated but has heard of the NSS or one of its affiliated grottoes. He either does not wish to join or does not know where to find organized groups. The last species shall be designated *speleobopper*. This person has no knowledge of techniques or safety, is there for one time only and will probably never return because he is there on a whim to try it once, attend a party or , goes in because a buddy does. He has no conservation awareness and is non-affiliated either because he is turned off by caving or is ignorant of the existence of organized caving and could care less.

In concluding, I would like to offer some suggestions for coping with the problems of caver proliferation and the dwindling quality/quantity of our cave resources as a consequence thereof. It would behoove the National Speleological Society to establish a liaison committee with the National Caves Association. This committee could serve the following functions. It could investigate the possibilities for diverting initial caving experiences into existing commercial caverns and out of wild caves. This would profit both the commercial entrepreneur and wild cave. If the first-timer were to undergo the customary adverse reaction to his caving experience, there would be a better chance for adequate response to those reactions in the environment of a commercial cave. This committee could also review and overhaul philosophies governing interpretive displays. New methods of displaying speleothems without creating a corresponding demand, introducing the NSS to the public and graphically demonstrating just how fragile the cave environment really is could all be explored. The NSS should examine possibilities for sponsoring guide education seminars through its Federal and NCA liaison committees. This could make more wild trips through public or private caves possible with knowledgeable chaperones. I believe in *show and tell*. It has the potential to be our most valuable conservation tool. Participating federal agencies should be encouraged to use cave registers as interim tools to monitor potential underground wildernesses against overuse while wilderness decisions are being weighed. This could avert de facto crossings of the threshold of non-wilderness caused by day-to-day cave traffic decisions. Finally, NSS members should be exhorted to write their Federal Senators and Representatives to bring to bear political pressure aimed at appropriating more funds, without OMB interference, for those agencies which manage caves. Such funds would be used to raise personnel back to acceptable levels for proper cave management, implement long postponed plans for facility renovation and improvement of interpretive displays and hasten the commission and execution of those studies essential to wilderness and master plans.

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Results of the Arizona Cave Register Program

Robert Buecher*

The data used for this study was collected in Arizona caves. There is no reason to believe that the relationships found in the study are restricted to only the Southwest. Most of them are as valid in Virginia as Arizona.

About 10 million people visit U.S. commercial caves every year. I have estimated that there are 1 to 2 million visits to *wild* caves annually and that this figure is increasing at about 10% yearly. This growth rate is probably about the same as the growth rate of all outdoor recreational use.

If we keep close track of cave registers and copy down and file each name, a few striking facts emerge about the distribution of visits. First, by using the actual number of signatures as a base, we find that some people make more than one visit so that the number of different individuals is less than the number of signatures. The ratio of individuals to signatures is very constant. For all the caves that I checked it ran 67%. The number of one-time visits to a cave is about 75%. These ratios stabilize after about one year and remain constant for at least 5 years. In other words, the average *caving life-time* of a caver is one year or less and 50% of all visitors will not go caving more than once. The only opportunity we have to provide conservation and safety information is during that one visit.

Visits by members of organized caving groups accounted for about 25% of repeat visits. As the frequency of a caver's visits increases, so do the chances that that individual is a member of an organization. The most surprising find is that there is no difference in visitation patterns between organized and unorganized cavers. In other words, if we have a cave that only N.S.S. members visit, and there are 100 visits, a total of 67 individuals visited the cave and 50 (75%) of them only went once! The use patterns of organized and unorganized cavers are the same, there is no clear-cut difference between the two.

The average *caving life-time* appears to be less than one year. This is my interpretation of the fact that visitation ratios stabilize after one year. An analysis of N.S.S. membership records indicate that a person's average stay in the N.S.S. is 4½ years, and for those members that are in longer than that, the stay is only 7 years.

I do not know of any study on the age distribution of the caving population. However, for organized cavers an average age of 20 years would seem to be about right. Unorganized cavers probably average slightly younger, perhaps 18 years. We should realize that caving, as a sport, only really started 25 years ago. Organized caving is still in the process of *maturing* and we should expect the average age of cavers to steadily increase. Also, we are now on the verge of the family caving boom.

Women's Liberation has not yet made much of an inroad into caving and it remains a male dominated sport. The N.S.S. membership contains about 18% women. Register data suggests that about 16% of all cavers are women. The data also indicates that while there are fewer women cavers, they are as active as the men, and the caves as difficult. We should expect that as the caving population matures we will find a greater percentage of women cavers.

Caving is, for most, a leisure sport and so most caving is done on weekends and holidays. The period between Friday night and Monday morning accounts for 85% of all caving. Sunday (41%) is the most popular day. Only 10% of all caving is done during non-holiday weekdays. Note that caving is a 24-hour-a-day weekend phenomina.

When studying group size, it is customary to divide groups in the register by drawing a line between different groups. I have analyzed 1000 signatures and they indicate that the average group size is 3.9 people. Groups of 10 people or less account for 98% of the trips, with 3 being the most common group size.

During the last few years, there have been several chances to observe how the caving population responds to outside variable changes. One of these is the recent difficulty in obtaining gasoline. In January, 1974, the gas shortage hit Arizona, for a month it was very difficult to get a tank of gas. Traffic in Hidden Cave declined 62%, Cave of the Bells 24%, Agua Caliente 32%, Scroll 70%; Van Horn *increased* 14%. It is obvious that the amount of caving in the Tucson area decreased dramatically. Most of the visitors to caves use them for recreation, when the cost of that recreation becomes too high, the use of caves for recreation stops. The fact that traffic in Van Horn increased reflects an interesting sidelight. Register data and personal observations indicate that the traffic caused by organized cavers *increased* in many caves because of the gas shortage. Cavers faced with a dwindling and expensive gas supply traveled to the areas with the highest concentrations of caves. Also there is a mood that the situation will worsen and that now is the time for long trips and the closer local caves should be saved for the future. There is little doubt that the supply of gas will have an effect on cave traffic. It appears that its major impact will be among the unorganized cavers.

Another outside variable is the impact of gating a cave. An interesting chance to observe this impact of gating turned up in an Arizona caving area. The area has three caves with ½ mile of each other, Onyx Cave (1500 signatures a year), Bells Cave (350 signatures a year), and Hidden Cave (130 signatures a year). In September 1974 Onyx Cave was leased by the Escabrosa Grotto of the N.S.S., it was gated in November and entry is now by permit only. The present traffic in Onyx is about 500 people a year. With this decrease, one would expect a rise in the Number of visits to the other caves. However, it appears that, after 6 months, there has been no shift to the other nearby caves. The dramatic drop in traffic at Onyx is also surprising. It is now at ⅓ its former level and there has been no attempt to discourage people from obtaining a permit. It would, therefore, seem that people are easily discouraged and that there is no compensation for the gating of one cave by an increase in visits to nearby ungated caves. People will generally seek other pasttimes rather than other caves.

The purpose of this paper has been to familiarize people with the caving population. Hopefully it will illustrate that cavers have many traits in common with other groups, and a few differences. It is also hoped that the size and direction that caving is headed has been explained.

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Cave Management Problems of the National Park Service

Tom Ela*

This bureau of the Department of the Interior has long been associated with cave management, the first being at Wind Cave National Park, established in 1903. This was before the National Park Service was created in its present form to administer the parks and monuments. The U.S. Forest Service helped us out in early days, taking care of three of the early cave monuments until 1933. There are eight parks and monuments now bearing the word *cave* as part of the title. There are several others which have caves as included features—fringe benefits—enhancing the total park scene. These often provide the park management with special and unpredicted problems. I recall a young fellow came to me in Great Smoky Mountains National Park where I was Chief Ranger and said his companion was trapped in a small cave. With equipment and a rescue party we went after the victim, but our informant and guide to the site couldn't find the cave. We tried every hole in the area, and finally found a very lonely and scared young man who was happy to be rescued from a cave we didn't know existed.

Our management of caves varied in intensity according to importance of the site as measured by visitation. The cave parks were widely scattered and were of all sizes and contained caves which were as different as the numbers represented. Each furnished a different challenge for development and use. This led to a number of decisions and actions which may be harshly criticized when viewed today under our rigid natural resource management policies and operating standards. Our current problems stem from many of these situations inherited from well-intentioned former managers who could not possibly envisage the pressures of the 1970s and who did not always realize the fragile nature of cave environments and were concerned principally with displaying unique cave features. Access, lighting, and visitor use were predominant planning priorities.

Paths and ladders required continual refinement to provide increased safety to visitors and for protection of the features. Accident records reveal that some of these improvements caused hazards not present before. Paved paths became slippery and frequent sweeping and resurfacing were necessary, whereas the early crude trails were walked with care because hazards were readily recognized, and accidents were avoided.

New developments permitted greater numbers of visitors, which in turn created greater numbers of people problems. Not only were there apparent pressures of automobile traffic, needs for parking space, places to eat, sleep and related necessities, but, also, there were subtle differences which often went unnoticed for many years, for instance, temperature, humidity, water levels, numbers of animals, gradual accumulations of dust, color changes, and so forth.

The sheer splendor of the great features of Carlsbad Caverns, as an example, has been preserved, but research proves the less visible changes which are serious threats to the integrity of the entire site. Reversal to pristine conditions must be management's objective, even if impossible to achieve.

Increase in visitation to the caves constantly reminds the manager of the need to establish realistic and credible capacity numbers to assure most people of a memorable and satisfying cave experience. The challenge is to arrive at acceptable figures which may be compared to a capacity seat count at any theater or sports arena.

Protection of the visitor takes many forms. Not only must we protect each person from the hazards of strange surroundings, but also we must consider every known human weakness that can lead to an accident. Regulations already on the books, strictly enforced, assist us greatly. They are modified as time and experience point out the need, but we are convinced that our social order requires legal restraints and will continue to look for the most effective rules to protect the features and the viewer. Regulations, adequately enforced, will offer protection to our wild caves scattered throughout the parks, many of which are still only occasionally seen by those who are so well represented at meetings such as this.

Protection from an invisible danger of which we were unaware until recently now is being studied. Radioactivity emitted from radon gases has been detected in variable amounts and is probably present in most caves. Careful and precise measurements are currently being taken at Carlsbad Caverns to assure that people visiting and working there are not subjected to levels of radioactivity which are not acceptable under OSHA standards. This could well be a challenge to all cave managers and owners and should be investigated thoroughly by competent persons.

Our problems include provision for an interpretation program. The visitors are entitled to know something about the caves being managed by us. It is a continuing challenge to furnish clear, understandable signs, exhibits, and talks that will enhance a cave visit and not detract or mislead. The best interpretation will serve not only to inform but to provide protection for the features by encouraging cooperation through understanding. A well-conducted interpretive program can and should be a tremendous aid to management.

Speaking as a representative of the National Park Service, I hope that this Cave Symposium will assist us in becoming better managers than sometimes we were in the past—and this is not to admit failure, merely human fallibility. This meeting may also serve to remind cavers of the responsibility which is theirs while unattended in inner space. Attaining complete mutual cooperation must be our goal to preserve and yet use our cave resources.

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Cave Management Problems of the Forest Service

Richard Spray*

The title of our particular segment this morning is *Management Problems*. For me, this has been a little sticky to put together from the standpoint of the Forest Service, because as I see it, we have only one problem, and he's standing here right now, or perhaps I typify the problem. That problem is, learning the awareness and sensitivity to caves, and learning to talk with cavers. Speaking from my own personal background, I've learned to talk with loggers, ranchers, climbers, backpackers, other users of the National Forests, but in putting together this symposium, this is the first time I've ever had the pleasure of communicating, talking and working with cavers. It has been a real education, let me assure you. A pleasant one, don't get me wrong.

To start with what our problems in the Forest Service are in regard to cave management, I will give you a short background on the Forest Service, because if you are like I was with caves and cavers, you probably don't know much about the organization other than it is a bureaucracy. The Forest Service does have legislative authority to manage caves. All agencies work within legislative authority, and we have ours. If I read the legislation right, the right and the mandate to manage cave resources is contained in the Multiple Use Act. That Act states that we will manage various resources for multiple purposes and for sustained yield. Several of those resources are contained in caves, or as Mr. Brucker pointed out this morning, there's an output that relates to those resources. Those resources are water, wildlife, and recreation.

Our organizational structure is basically broken down into three major subfunctions: The National Forest System, which most people identify as the F.S. This is the system of the organization that manages the National Forests. It's the part of the organization that I belong to. The other two parts are State and Private Forestry, which is an area of Forest Service operation that helps State Foresters and other State organizations. Fire control, reforestation, and forest management are State and Private Forestry responsibilities. We also have a separate Research Branch. Of interest to you in that Research Branch is a considerable recreation management research program. A lot of the research deals with wilderness management, with how people react in various recreation situations, sociological questions, and this kind of thing. I think a lot of this strongly relates to cave management.

Going back to the National Forest System—we are organized in Regions. I'm from the Southwestern Region, which comprises Arizona and New Mexico. There are eight other Regions running all the way from the Eastern Region to the Pacific Northwest, Alaska Region, and others. We have representatives here today from many of those Regions. I suspect they have the same problem I do, and that is wondering what this cave resource thing is all about, and just how do we go about getting started with management without messing it up.

Under the Regions are the National Forests, which are the basic unit of the National Forest System, an example is the Lincoln National Forest, in the southern part of New Mexico. In the National Forest is the managerial unit called the Ranger District. If you go to visit a cave, and want to find out some information, and if you check in ahead of time, it will be the District Ranger or one of his assistants who will probably have the best information for you.

Chuck Godfrey talked about BLM problems and managing caves, and we share many of those problems with the Bureau of Land Management. Basically, I feel that the way this symposium came about reflected both the frustration in the Forest Service and the Bureau of Land Management in finding out what cave management was all about and if there was such a thing.

We are decentralized in the Forest Service. That means that the local District Ranger has quite a bit of latitude in managing the resources under his care. You may wonder how we manage to keep control over a situation like that. Several years ago, a book was devoted to that question. I can't remember the exact title but the gist of it was that the Forest Service manual system, which to us sometimes seems very cumbersome, is what exerts the control at the District level so that there doesn't have to be constant centralized supervision. We have 21 feet of Manuals—that's shelf space. That's a lot of stuff for a District Ranger to have to know about. But if he wants to know about caves, at least as far as my research has been able to take me in the 21 feet, I haven't been able to find where the words cave or caving are mentioned, so, unlike the Park Service, I don't believe we have a specific policy relating to caves.

We do have many people engaged in National Forest management who are interested in caves, so it is not a subject that is completely abandoned. We have here today a geologist from our Regional Soil and Water Branch; our Wildlife people who are here communicated with me almost daily when this symposium was being planned. They are very much interested in the wildlife resources in caves. We have several people representing recreation management here. So we do have the interest; we need to find answers to our questions.

Several questions that occurred to me relate to cave management problems. We need to know what caves we have. This is the inventory system that Chuck Godfrey spoke of. We need to know what resources these caves contain. We need to know how human use affects those resources and how suddenly and drastically. How do the resources interrelate with each other? What is the ecology of the cave? What management options are open to us as managers? I think many of us, without giving it a great deal of thought in the past (and I have to speak for myself here), have thought of caves as *Carlsbad Caverns, Mammoth, Oregon Caves*—developed caves—and this is about the extent of our thought on caves. It is becoming more and more clear to me that this isn't the only option we have.

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Then what are the priorities? Probably in relating these questions, I've opened some questions in your mind as to why I didn't voice some other questions, and this relates back to that number one problem—that we need to learn more about caving and caves.

The objectives for the symposium were printed on the inside cover of the program. They are important enough that I would like to repeat them here.

The goals of this symposium are to exchange data on caves and to improve communications between cave owners, speleologists, cave managers, and cavers. Through these, we hope to upgrade cave management techniques and policies to better protect our virtually nonrenewable cave resources.

To me, that is the number one package of objectives that we have here. The proceedings will go a long way in spreading the value of this symposium far beyond the numbers of people in this room. One thing I would like to say for myself is in learning to talk to cavers, in working with this symposium, it's been an education to me to learn a little bit of the politics of your caving organization. There are some; I'm sure you are very much aware of them—I'm just beginning to learn. So I hope you will excuse myself and maybe some of the others here that aren't that aware of what they are—we may stumble and make some errors during the week. What we basically want to learn to do is how to talk to you and how to communicate back and forth so that we can get on the job that needs to be done. I think if we can do that, 90 percent of our problem will be licked. Once we've got communications open and the problems defined, the other 10 percent of doing the job will be easy to come by.

Cave Management Problems of the Bureau of Land Management

Charles Godfrey*

The Bureau of Land Management, BLM, is responsible for the administration of 400 to 500 million acres of public lands in the eleven western states and Alaska. Nearly all of these states contain caves. Many of these caves are located on BLM administered lands and are essentially wild or undeveloped caves.

Some 100 caves have been identified in the 5-million-acre Roswell, New Mexico, District alone. In the past 5 to 10 years there has been a substantial increase in public visitation to caves. It is estimated that there are currently 5000 visits annually to 9 caves in the Roswell District which have been gated and placed under a permit system. This 5000-visit figure includes visits by both novice cavers and experienced cavers. Although statistics are not currently available on the number of caves and cave visits for all of the BLM Districts, it is known that significant numbers of both occur in several of them.

At the present time, the BLM has no Bureauwide policy specifically aimed at cave resource management. There are no uniform procedures for cave inventory; no guidelines for preparation of cave management plans or cave entry permit systems; and on top of this, there is a shortage of personnel for cave management.

What kinds of problems have arisen from this combination of increasing public interest in cave exploration and the lack of cave management procedures? The answer to this question is multi-faceted but it can be broken into two major categories. These categories are very closely related and the problems of one cannot be solved without considering the problems of the other. The first category is that of problems associated with the destruction of the resource and the second is problems associated with the management of people. Let us consider some examples of these problems.

A few years ago a school teacher discovered a cave on BLM administered lands west of Las Vegas, Nevada. He reported the location of the cave to the local BLM office, and at the same time, the location of the cave was published in the local newspaper. A few days later, officials from the Las Vegas District Office visited the cave. They discovered that it was a valuable resource that warranted further investigation. The District Office contacted a recognized speleologist and requested preliminary mapping and inventory of the cave. One of the findings of this study was that the cave was being subjected to excessive vandalism. This vandalism took the forms of destruction and removal of speleothems, painting on the walls and littering within the cave. In the light of this report a decision was made to gate the cave. On two occasions gates were constructed and grouted into the rocks at the cave entrance. Also on two occasions these gates were ripped from their mountings and thrown into the canyon below by persons desiring entrance to the cave. Finally, a decision was made to pour a concrete plug into the cave entrance to prohibit entry until such time as adequate management practices could be instituted. Was the problem solved? NO! Lacking guidance and personnel, the District was unable to prepare management plans and no management practices were initiated. Within a few days after the completion of the concrete work, persons wanting to explore the cave had excavated a tunnel around the plug and the entrance was open once again. Today, very little of the natural beauty of that cave remains.

This was not just an isolated instance. A number of the caves located within the Roswell, New Mexico, District, have undergone similar problems. Although fortunately with less totally destructive results in most cases. The damage has taken many forms. Speleothems have been lost or destroyed through commercial mining and amateur collecting. Additional speleothems have been damaged through wanton vandalism or careless cave travel due to overcrowding or simple ignorance of the fragile nature of cave formations. In attempting to combat these types of resource damage, gating programs and permit systems have been initiated. As in the case of the Nevada cave, these have been primarily stop-gap measures or holding actions to protect the resources from damage and the visitors from hazards. These measures have not always been successful. Gates have frequently been damaged or had the locks destroyed by persons either unwilling or unable to get permits. Permit systems have been difficult to administer due to the large geographic areas covered by both districts and the fact that cavers frequently travel from one district to another or one state to another, and are not aware of the requirements for a permit or the procedures to obtain one.

Even if gating and permit systems work they are not total solutions to the problem. It is recognized that due to the delicate ecological balance within a cave, each cave has a visitor carrying capacity. In most instances, on BLM lands, these capacities have not been determined and are probably being exceeded, even where permit systems are in force.

Still another problem arises in the area of visitor safety. Which caves are safe for people to visit and which are not? What degree of experience or type and amount of equipment is needed to safely enter a given cave? How do you determine who can safely explore a cave and who cannot?

All of these questions are unanswered, yet the answers to these and many more are necessary to develop criteria for management plans, entry permits and management staffing requirements.

We do not anticipate coming up with these answers on our own, nor do we anticipate that all of the answers will proceed from this symposium. We do anticipate that what we can learn here and whatever additional exchanges of information are generated here will take us a long way down the right road.

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A Commercial Cave Manager Comments on Management

H.R. Anderson*

I'm here today representing the National Cave Owners Association of which I am President. We are on our way to our National convention in Missouri which convenes on the 13th of this month. Within your flyer here that you sent, when you state you tried to pick the brains of those people that are in the know in this area of management, I think that you overlooked the point of not contacting the National Cave Owners Association. They, in my belief, know more about cave management than you can find printed any place in the world. We are required to make a profit or we cannot be in the business. I'm a little different than the rest of you, I have to deal with the Forest Service. My particular plot of ground lies in the middle of a National Recreation Area which is controlled by the Forest Service, and a portion of it by the Park Service. The logistics for my cavern are something that you can't believe until you see it. Not only do I have to maintain a Navy, to get across the lake, but I have to maintain a large force of transportation vehicles to get 900 feet up the side of a mountain to go into our caverns. We have several members of the National Cave Association here today, from Texas, Ohio, New Mexico. We extend a grateful invitation to any of you to visit any of our caverns at any time, if you really want to see management at its best, for I have seen it. We've been all over the United States and all over the world visiting privately owned caves and caverns. Once we make a mistake we pay for it, we can't put in for another appropriation.

Members of the National Cave Association on a convention tour of Lake Shasta Caverns.

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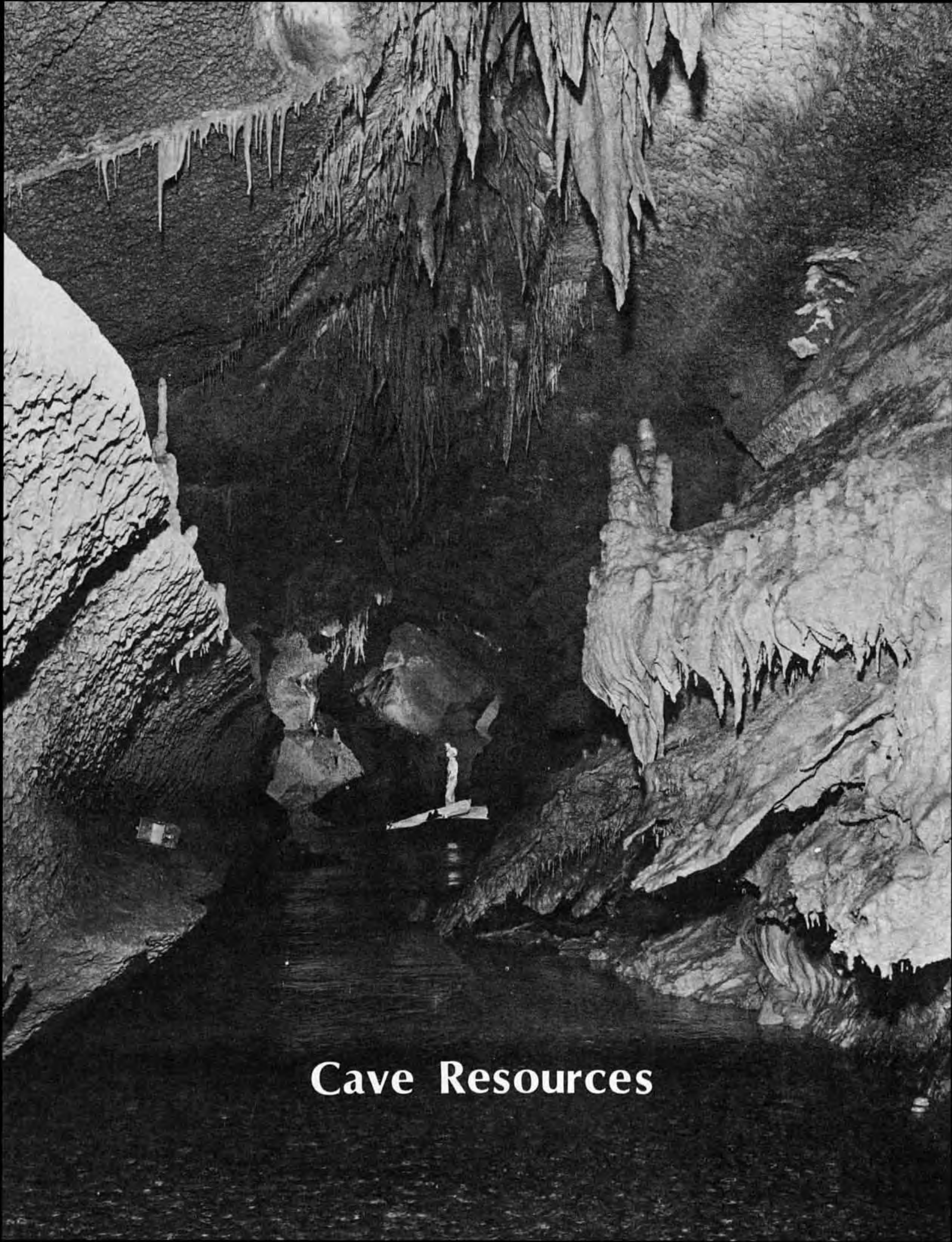

Cave Resources

Paleontology

Arthur H. Harris*

Paleontology is the study of organisms of times past. Anything that gives us direct information about such organisms is fair game for study. Frozen carcasses of mammoths, a lava mold of an overwhelmed rhinoceros, the preserved fecal droppings of the Shasta Ground Sloth, and preserved footprints of extinct jaguars are a few of the more esoteric items paleontologists have studied. More commonly, plant fragments, seeds, pollen, bones and teeth are available. The geologist normally assumes a considerable age before he'll recognize an item as fossil, but for our purposes here, all recognizable prehistoric evidence of past life will be considered fossils.

The study of fossil remains may be from several viewpoints, singly or in combination. Fossils frequently are used to date deposits and, thus, events relatable to the deposition. Biologists traditionally have used fossils to reconstruct the evolutionary lines of individual species or other taxonomic groups and also to reveal past geographic distributions. Now, fossil assemblages are being used more and more frequently as a basis for reconstruction of past environments. Because of the interrelationships of animals, vegetation, geomorphic features, and climate, such studies give information on a number of environmental factors.

Preservation of even the hardest organic remains normally requires protection soon after death from the elements and from biological decomposers such as bacteria. Most fossils surviving to the present were deposited in marine waters. In nonmarine habitats, most preservation has occurred in freshwater situations associated with lakes, marshes, and streams. Caves are one of the few other natural features where deposition is common and where preservation can be expected. Few cave regions have been examined systematically for fossils, but certainly many —and perhaps most—caves harbor some fossil materials.

Cave environments normally offer some physical protection against the sun, wind, rain, and biotic elements; in addition, deposition of cave breakdown, flowstone, and in-wash from the surface often result in protection by burial. Often cave fills are either continuously saturated with water or are perennially dry, both features tending to protect and preserve organic remains.

Were caves merely equivalent to open sites, little importance would attach to them due to their relative rarity. To the contrary, however, there are features of caves that make them unique among fossil sites. Caves open to the surface are possible in areas where erosion rather than deposition is the dominant geological process. Under such conditions, a cave may be the *only* source of fossils for a region.

There are other differences from open sites. Dry caves often preserve substances virtually unknown elsewhere, and although conditions of dryness tend to be somewhat limited timewise, hair, hide, and sinews well over 10,000 years old are known, as is sloth dung dating to more than 40,000 years ago. Dryness also may preserve materials which are ideal for C_{14} dating, whereas open sites more often lack such. In some types of cave fills, stratigraphic sequences are simpler than in most open sites (but, conversely, some cave deposits are confoundingly complex).

Despite the advantages of possible occurrence where no other fossils occur, despite the possible advantages in dating, and despite the possibilities of preservation of kinds of structures unknown from open sites, the biggest value of cave fossil biotas lies in their differences in makeup from those in open sites. In large part, open sites sample biological communities immediately associated in space with the place of deposition. Thus marsh, lakeside, and riverine communities tend to be well represented, as are animals from other communities who visit these areas (e.g., grassland grazers entering a valley for watering). Elements not in the above categories tend to be represented only by broken and waterworn fragments washed in from adjacent communities; and more distant communities seldom are represented at all. Small animals, if present, tend to be spread through large amounts of matrix, and only the more prominent elements of large mammals are easily seen and collected. Plant pollen and spores may or may not be preserved.

In contrast, caves often have representatives of: 1) Cave inhabitants, including arthropods, bats, small and large carnivores, rodents, and birds nesting or sheltering in the twilight zone of the entrance area. 2) Inhabitants of surrounding communities. Plant and animal debris commonly washes in from the immediate vicinity of the cave, and somewhat more distant communities may be represented, as in open sites. 3) Air-carried pollen and spores. When preserved, the regional vegetation is represented in greater or lesser accuracy. 4) Carnivores, raptors, and scavengers, who often utilize caves as dens and roosts. Not only do they leave their own bones, but many also drag in parts of prey animals to their young or for their own leisurely consumption. Often more importantly, owls and some other raptors and some scavengering birds regurgitate at their roosts the undigested fur and bones of their prey. Thus added to the representation of the surrounding community are animals from more distant areas, the distance limited only by the home ranges of the creatures based at the cave. (Migrating stop-offs may increase even that range.) Unfortunately, knowledge of the distances involved is poor at present, but tentative data indicate most material comes from within a few kilometers of the roost, with a *practical* limit of about 32 km.

Caves, then, often represent a larger segment of a contemporary biota than do open sites, though the concomitant disadvantage of having separate communities intermixed in the fill makes study difficult.

The addition of material from owl pellets and the like does more than increase the diameter of geographic representation. It also provides a different *type* of sample from most open sites, for large numbers of small animals usually are present and often these represent forms rare at open sites. For example, other than aquatic and shore forms, birds tend to be scarce in open sites, but well represented in the fill of caves visited by raptors. Larger animals may be seriously underrepresented, but many caves also are excellent pitfall traps, well suited for collecting large animals.

In short, fossil cave faunas often give data obtainable in no

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other way and from no other place.

Among the limitations of caves as sites for fossils, the distribution in space and time deserve mention. In terms of caves per square mile, caves are extremely rare in North America and elsewhere. In terms of caves per million year period of past time, things are even grimmer. I know of no figures, but certainly the vast majority of known cave fossil sites were deposited during or since the Pleistocene Epoch—indeed during or after the Wisconsin Age of that epoch, say the last 100,000 years or so. Older cave fills are known, but extraordinarily rare, for the most part having either been removed by erosion or more deeply buried or obliterated by deposition.

For the cave manager, the next questions are, "Where are cave fossils apt to be found and how are they recognized?"

There is no rule of thumb that will locate all fossils. Lost or sick animals may wander far from entrances or other logical places and bats may have roosted almost anywhere. In general, however, fossil sites are in the vicinity of present and past entrances and in places where the drainage or gravity could carry material from entrance areas. Any present day entrance into a cave is suspect (even if only modern bones are present, these are important for the light they shed on deposition patterns of the past). Likewise, evidences of ancient, now closed entrances should be sought. Particularly, fill of color or other character different from normal cave breakdown should be examined, although leaching or flowstone deposition may obliterate such characters in time. Boulder-clogged lateral or overhead fissures often represent old entrances. And, of course, bone or other organic materials on the surface are a giveaway.

A potential site should be carefully inspected for bone fragments, shells, seeds or other plant debris on the surface. Many such items are small, to less than 1 mm. Even most experienced spelunkers will crawl unseeing again and again over slopes littered with small bones and bone fragments. Unless a conscious effort is made to look for evidence of fossils, only the larger and more spectacular items will attract the attention—and most fossil sites lack such attractions. Keep in mind that mud and dirt are excellent camouflagers; washing of suspicious pieces may be necessary.

If after inspection of this type nothing is found, most fossil materials lying within the fill itself will not be damaged by occasional passage across the surface. If, however, a suspect site will have heavy traffic (enough to notably disturb the surface) or if the area must be torn up by trail building or other potentially harmful activity, a more extensive test should be made.

One or more test pits or trenches into the area where the disturbances will occur should be carried to a depth well below the expected zone of disturbance. In very dry, powdery cave fill, dry screening (with mesh no larger than that of window screen and preferably smaller) may be efficient, but wet-screening usually is called for. Damp fill from the test should be allowed to dry thoroughly and divided into workable subsamples. Each such subsample should be placed into a screen-bottomed container (large soil-testing sieves work well). Fill the container with water, continually adding enough to keep a free water surface (or lower into another container full of water) and agitate gently until the matrix is thoroughly wetted, without allowing water to overflow the sides. Generally the matrix will hold enough water to allow inspection of the water surface for seeds, snail shells, or even small bones that may have floated to the surface. If present, collect them (a small artist's brush will work) and save for inspection by specialists. Then slowly wet-screen the fill through the mesh, removing larger rocks as necessary. When the materials are free of silt and mud, inspect carefully for bone, tooth, shell and plant fragments. If none is visible, spread out to dry and then reinspect.

If all samples prove negative, you have checked out the area sufficiently to go ahead with construction (or whatever) with a clear conscience (but still keep an eye open during construction for the occasional single, rare specimen or for localized lenses, strata, or facies missed by the tests). If *any* sample is positive, steps should be taken to prevent damage to the area until its value can be assessed by a qualified paleontologist.

Damage prevention may be accomplished by rerouting traffic or construction until the importance of the area can be ascertained. A less preferable alternative is to protect the surface by planking or by at least several inches of clean fill laid down over the deposit. The fill positively must have no organic matter and be easily recognizable as different from the fossiliferous fill. If there is any chance of the fill infiltrating into the deposit by way of crevices, etc., this method should not be used. The least desirable positive action that can be taken (but better than none) is to instruct those passing through the area to take as great care as possible to avoid disturbance. Where construction is planned, there is no acceptable way it can be undertaken before assessment unless it can be rendered harmless by changes in design or execution.

If, after proper assessment, you find yourself with a fossil site of any scientific or educational worth, your ethically acceptable choices are preservation or salvage. Remember, fossil sites are nonrenewable resources!

Preservation may be attained by avoidance, fencing, burial, or display. Avoidance is self-explanatory, but usually achievable only if cave access is controllable. Fencing or gating the cave entrance allows controlled access to the cave and thus, in theory, allows for avoidance; in practice, people may be drawn to the fossiliferous area by curiosity and (sometimes) avarice. The actual site may be fenceable, but often is not. Burial is described previously, but should not be practiced unless clean fill is obtainable—use of other fill may introduce different aged fossils or other contaminants—and unless there is no danger of infiltration into the fossiliferous layers. Records of all actions taken should be preserved and available to later administrators and researchers. Display is a possibility in some cases. Partial excavation (by trained personnel) followed by proper interpretative effects may be highly educational to the layman.

Only when funds are available to undertake a scientifically acceptable recovery project should salvage take precedence over preservation. However, if preservation is impossible or *really* impractical (not merely inconvenient), salvage becomes necessary regardless of resources. As used here, salvage means any method of recovery, and thus may run through a continuum ranging from picking up fossils in front of a bulldozer blade (or the cave equivalent) to a maximum effort-multidisciplinary study. In all but the greatest emergencies, salvage should utilize trained paleontologists to insure maximum data and specimen survival. Position in vertical and horizontal space, orientation of individual specimens, presence of man-related materials (artifacts, fire-cracked rocks, artifact manufacturing debris, exogenous rock, certain plant debris, etc.), state of preservation, association of elements, nature of the matrix, and other features can be of vital importance to interpretation, and generally must be determined by experts. In addition, trained personnel have the experience to recover specimens with a minimum of damage and to recognize obscure specimens. Only in bona fide emergencies should untrained personnel excavate without prior consultation and go-ahead from the paleontologist.

To summarize, many and perhaps most caves contain fossil material. As cave managers, it is your ethical duty to protect these unique and nonrenewable resources to the greatest possible extent. If protection is impossible, then you are responsible for initiation of properly undertaken salvage operations.

Cultural Resources

Ann Loose*

I would like to begin this paper with a quotation from Karl Butzer's *environment and Archaeology*, which explains, at least in part, why cultural resources are included in this symposium on cave management.

"Caves were first discovered for science by archaeologists and despite the enthusiasm of amateur cave explorers, caves and archaeology remain almost synonomous in the public mind." (Butzer, 1964:197)

Archeologists first *discovered* caves for science because they are students of man's past and man has used caves and left evidence of his presence in caves since earliest prehistory. Caves have served as sheltering places, storage areas and burial locations. Caves are still used as homes in parts of Spain today, and because of their even environmental character are used for storage of items such as food. The catacombs under the city of Rome have been used for burials for thousands of years and today still contain the mummified remains of individuals who died many years ago. Man has also used caves for religious purposes throughout his history, and even today caves are looked on as having a mystic and religious quality in many places. Many of the religious temples in India are based around a cave and here in the Southwest the Pueblos believe caves are entrances to the underworld and are, therefore, of a sacred nature.

Archeologists are also interested in caves because of qualities inherent in the cave itself. The cave is not subject to the sudden changes in climate and to the erosional cycle on the land surface. Because of this, many materials are preserved in a cave environment that are not preserved outside of the cave. This is especially true of dry caves. The Southwest contains many examples of dry caves whose preservative qualities have allowed archeologists to discover information about aspects of culture not preserved elsewhere. Vegetable materials decay easily when exposed to the elements and without cave sites we would have little information about cultural remains consisting of vegetable materials. In noncave sites the archeologist can expect little beyond the preservation of stone, ceramic and, possibly, adobe materials. Caves, through preservation, provide information about basketry, sandals, weaving techniques, and clothing; wooden implements such as bows, throwing sticks, and arrow shafts; vegetable foods such as seed, husks, and cobs. Cave sites allow us to fill in a number of the blanks which remain after the excavation of noncave sites. Another source of information is in the form of fecal samples which can be found in many cave sites. Analysis of these can reveal the diet of the prehistoric inhabitants of the cave. At Salts Cave, Kentucky, (Watson and Yarnell, 1966:842) such analysis revealed that the Indians were eating at least 17 different plant foods, as well as ingesting charcoal, fish scales, bone, fur and feather fragments, insect parts, rock fragments and sand. Maize was conspicuous by its absence.

Another result of the cave environment is the preservation of human burials as mummies. Much more can be learned from a mummified burial than one in which all has decayed but the bones. This is especially true in those areas where grave goods were placed with the burial. The Pueblo tradition of burying the dead in rock crevices and caves has led to mummification and preservation of mummies with clothing and other material items intact. Tissue studies can contain genetic information of interest to the physical anthropologist. Salts Cave has yielded a number of mummies which give information about the Indians who used the cave. Paraphernalia preserved with one indicated he was a "shaman" collecting crystals for ritual purposes.

A cave need not be dry for preservation to be greater than in the outside environment. The constant cave climate has a great preservative effect. The cave paintings of the Pleistocene inhabitants of Europe are familiar to all of us, but perhaps we are not all familiar with one of the reasons for their preservation. The damp conditions of the cave and the protection from climatic variation preserved these paintings in close to their original condition. The paint in some instances was still wet. When access and visitation to some of these caves increased, it became evident that a change in climate within the cave was destructive. The paintings began to dry out and the colors to fade. It became necessary to install climatic control doors to maintain the humidity and stabilize the paintings.

A wet cave can also serve to preserve archeological materials by sealing them in. At Sandia Cave the age and validity of the Sandia artifacts was based somewhat on the belief that the flowstone sheet above the Sandia artifact layer had sealed them off and prevented mixing and filtering down of artifacts of a later age. Although there is some debate as to whether or not the flowstone sheet did indeed cover the entire cave floor, the reasoning behind this assumption is valid.

Caves are also of interest to archeologists for nonhuman material they might contain which can be related back to archeological problems. Archeologists are interested in data on past environmental conditions, flora and faunal assemblages. Caves often preserve evidences of these past conditions when they have disappeared from the noncave environment. Again, this is due to the constant cave environment and the excellent preservative qualities present. Cave sediments have been used to reconstruct prehistoric climates and for dating purposes. Sediments within a cave may in some cases be more complete than surface deposits. Since preservation of vegetative remains appears to be better within a cave, the pollen sequence within the cave environment may be more complete and give a better climatic picture than samples collected from a noncave environment.

Faunal remains have also contributed to archeological knowledge by demonstrating the existence of a particular animal and man at the same time. Gypsum Cave, in Nevada, gave evidence that man and sloth had coexisted and demonstrated the antiquity of man in Nevada. Data from Burnet Cave in the Guadalupe Mountains of New Mexico demonstrated that the climate in the area had once been similar to that of the present northern United States and that the pine remnants in the Guadalupe Mountains were vestiges of a Pleistocene environment.

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It might help at this point to show just how important cave sites have been to the archeologist in the last 100 years.

Neanderthal man, the first fossil human to arouse the interest of both the scientific and nonscientific world, was found in a small limestone cave near the village of Neader on the Dussel River. Later researches have discovered the remains of these early humans in many caves throughout Europe. The caves supplied the first information that Neanderthal man buried his dead and placed grave goods with them. An altar of cave bear bones preserved in a cave led scientists to postulate that Neanderthal man was capable of abstract thought. Based on noncave remains, Neanderthal was considered subhuman. Evidences preserved in cave sites have led to acceptance of Neanderthal as a variety of man.

The discovery of Australopithecus, the earliest of the "early men" is also connected with caves. It was from a limestone quarry in South Africa that the first fossil skull of Australopithecus was recovered by Raymond Dart.

These skulls had been preserved in a cave within the quarry which had been sealed and was later exposed by the mining activities. Again evidences from cave sites were instrumental in convincing scientists that Australopithecus was ancestral to modern man.

Homo Erectus, the successor to Australopithecus in the fossil record is also associated with caves. The caves of Chou Kou Tien near Peking, provided much information about Homo Erectus and recovery included parts of more than 40 individuals, evidence of cannibalism and the use of fire.

Much of the evidence available about Pleistocene man in Europe comes from caves. Archeological materials demonstrate a way of life based on the hunting of large game animals, many of whom are extinct today. The art preserved in so many of the caves indicates a preoccupation with these animals and with the successful hunt. It is notable that cave art is often located well within the cave itself, as if the cave location was regarded as having some significance in a ritual sense.

Caves are also a source of information for archeologists in the United States and many of the most important time sequences come from cave sites; for example, Lovelock Cave, Nevada; Ventana Cave, Arizona; Gypsum Cave, Nevada; Sandia Cave, New Mexico; and Modoc Rock Shelter. Many of these so called cave sites are actually shelters and overhangs, but many others are true caves. Most caves with which archeologists have been working contain evidences of human habitation within a short distance of the entrance and seldom beyond the twilight zone. These caves are usually those that were used for shelter and storage. Honest Injun Cave in the Guadalupe Mountains is an example of such a cave. Cultural remains are limited to the first room which is lighted by sun filtering in through the small entrance. The cave was apparently inhabited and used as a shelter from the elements for a number of years. We do encounter another utilization of these cave sites which is typified by Salts Cave, Kentucky, and Feather Cave here in New Mexico. In both these caves the Indians went beyond the first room and explored and utilized other areas of the cave. In Feather the main room was found to be a repository of all sorts of vegetable remains, including large numbers of sandals and reeds. It was not for some years after the initial excavation of the cave that a small, very tight lead was found which led into another room. It was discovered that the Indians had traversed this tight crawl with reed torches and drawn a number of pictographs on the walls of this small inner chamber. Dr. Ellis has postulated this as a religious chamber symbolizing the underworld. In Salts Cave the utilization was also apparently, at least partly, of a ritual nature, with the Indians wandering through the cave in search of cathartic mineral deposits used in religious ceremonies.

Another aspect deals with potential conflicts. Cultural resources do not include just archeological sites. Historic materials and sites are also a part of cultural resources and many caves have a historic component—a historic figure may have sheltered there, bandits used it as a headquarters, or an early explorer left his initials within the cave. These are historic events and are of significance to the historian. However, we encounter as we progress through time to the present, the problem of deciding when vandalism (something originally felt to be detracting) becomes history. This can be illustrated perhaps by using an example from Fort Stanton Cave in New Mexico.

Early military expeditions left their names in a number of places within the cave and these are considered to be of historic interest today and are preserved. However, if someone placed his initials within the cave today, he would be a vandal. There is at present no solution to this problem, but it is mentioned here in passing as a management consideration and as a means of leading into a discussion of the effects of archeology on the cave. To my knowledge no studies have been published dealing with the effects of an archeological excavation on the cave resource. However, I think we can assume that the initial occupation and use of the cave by man did disrupt the ecosystem and damage or at least change the cave environment. Some of the things that the archeologist looks for in his investigations are the results of man's influence on the cave environment (i.e. smoke blackened wall, areas of organic deposits, etc.).

When the archaeologist sets out to excavate a cave site, he will also disrupt the cave ecosystem. He will bring in light, disturb the soil deposits, perhaps damage formations. If the cave is dusty, he will bring in respirators and possibly set up a dust and air control system as was done in Feather Cave in the 1950s. Insect and animal life within the cave will be disturbed.

The manager of the cave resource is also faced with a series of conflicts arising out of the archeological nature of some of the cave resources. There will be conflicts between the desires of the archeologist to excavate the cave and others desires to preserve the cave ecosystem. There might also be conflicts between the desire of the archeologists to have the site preserved untouched and the desire of cavers to have access to the cave for recreational purposes. The question may arise as to whether excavation of the cave may or may not be considered a form of vandalism.

These questions cannot be answered here, but this symposium and others like it may eventually offer answers.

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Mineralogy

Carol A. Hill*

ABSTRACT

A "speleothem" is a secondary mineral that forms in caves. Most speleothems are composed of carbonate minerals, but other speleothems may be composed of sulfate, halide, hydroxide, nitrate, oxide, phosphate or silicate minerals. Better known types of speleothems are stalactites, stalagmites, columns, helictites, flowstone, draperies and cave flowers. Cave minerals are usually found in limestone or gypsum caves, but they also occur in lava tubes or cavities in ore bodies.

Cave minerals are a primary cave resource that attracts visitors to caves. The abundance, massiveness, exceptional beauty or unusualness of speleothem types are major factors that influence the popularity of a cave. Cave managers can emphasize the type of speleothem resource a cave contains by proper lighting of speleothems and by educational cave tours.

A main function of a cave manager is protection of speleothems from vandalism and environmental alteration. Protection of speleothems is essential for visitor enjoyment as well as for the in situ scientific value of a speleothem. Protection can be maintained by a selective permit system, cave gating, patrolling of caves, or by keeping cave locations secret. The future condition of speleothems as a major cave resource depends on the enforcement of strict protection policies today.

Cave *formations*, or speleothems as they are more properly called, are secondary minerals formed in caves. The term *formation* should be reserved for primary bedrock strata. Three types of caves contain cave minerals: caves composed of limestone or gypsum (sedimentary rocks); lava tubes composed of basalts; and mine caves which are pockets or cavities in ore bodies. Most speleothems are composed of the mineral calcium carbonate ($CaCO_3$) but other speleothems may be composed of sulfates, halides, hydroxides, nitrates, oxides, phosphates or silicate minerals. Better known types of speleothems are stalactites, stalagmites, columns, helictites, flowstone, draperies and cave flowers. For a complete list of speleothem types and their origin, see the book *Cave Minerals*.**

Cave management problems with regards to speleothems fall into the following general categories:

1. Appraisal of speleothem resources;
2. Protection of speleothems;
3. Exhibition of speleothems in cave tours.

APPRAISAL OF SPELEOTHEM RESOURCES

"How valuable is my cave as a public attraction?" is a basic question every cave manager asks, be it a private owner or a governmental agency. Generally this depends on a combination of the quantity and quality of the speleothems a cave contains and the proximity of the cave to population centers or major highways. Some of the speleothem features that visitors especially seem to enjoy are the abundance of massive speleothems, a variety of different types of speleothems, colorfulness of speleothems or unusualness of speleothems with regards to beauty, shape, rarity, delicacy or crystal texture. A cave manager can determine the speleothem assets of his cave by visiting and comparing his cave with other commercial caves or by contacting a qualified speleologist or caving group for information.

WHY PROTECT SPELEOTHEMS

The main reason for protecting speleothems is to ensure future visitor enjoyment of caves. Just as trees are a part of an outdoor wilderness experience, speleothems are a part of underground wilderness enjoyment—only it takes a lot longer for speleothems to grow than for a forest of trees to grow. Another reason for protecting speleothems is that some speleothems may be considered endangered species. Unique conditions of temperature, moisture, overlying bedrock and drainage patterns combine to form the rare speleothems. These speleothems may not exist anywhere else in the world. A third reason for protecting speleothems is for their scientific value. Speleologists need to examine speleothems *in situ* in much the same manner that archeologists need to look at undisturbed artifacts.

DESTRUCTION OF SPELEOTHEMS

The first type of speleothem destruction that usually comes to mind is overt vandalism, i.e. the selling of speleothems for profit. Another type of vandalism is the defacing of speleothems by spray painting or gouging names and other graffiti on a speleothem's surface. But there are other forms of vandalism that even may be done with good intentions. One of these is collecting by rockhounds. Certainly there is a place for limited collecting of speleothems for museums such as the Smithsonian and similar institutions. But in most cases rockhound collecting of speleothems is a matter of an individual robbing many people of what is rightfully everyones to enjoy. Rockhound collecting in mine caves (i.e. those caves that form within ore bodies) is especially prevalent and should be controlled before all of these most unusual cave minerals are stripped from their natural surroundings. Unintentional vandalism is sometimes committed by careless cavers or an indiscriminent scientific collector. Another form of unintentional

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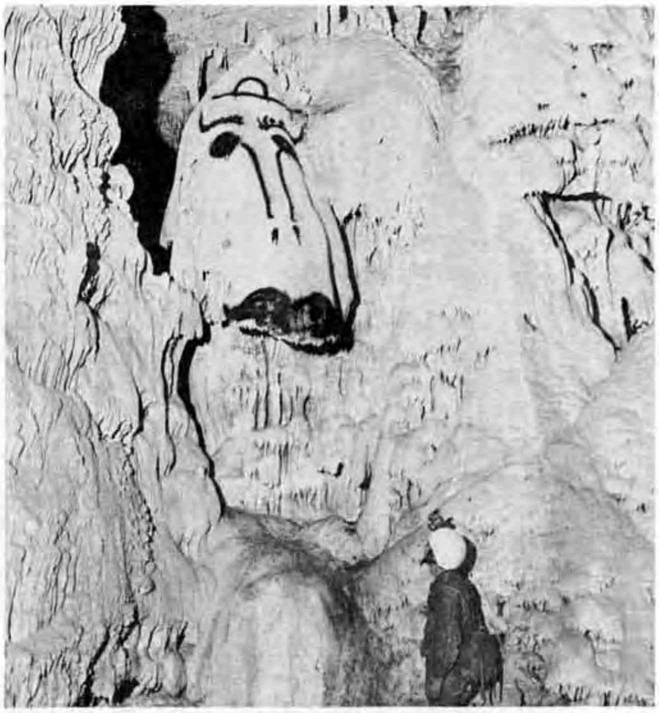
** Hill, C.A., *Cave Minerals*, to be published in 1976 by the National Speleological Society.



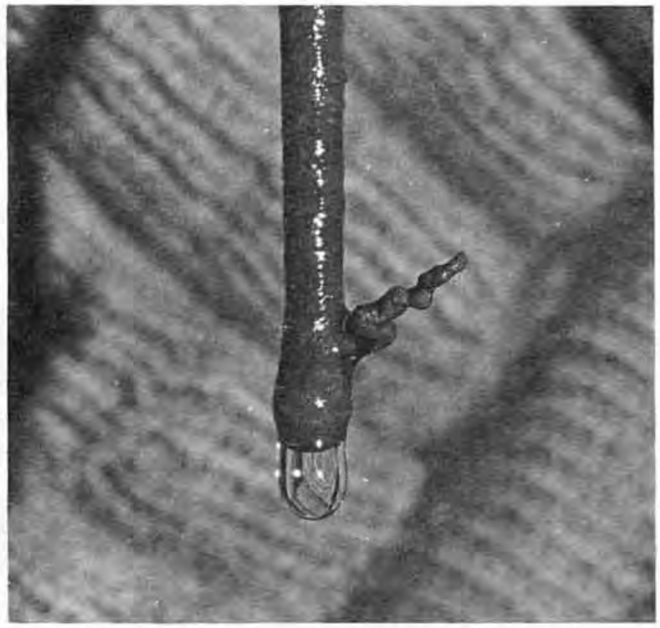
Vandalism by spray paint in Hidden Cave, Lincoln National Forest, New Mexico—*Photo by Charlie and Jo Larson.*

Speleothems being sold (with other minerals) in Arizona. *Photo by Rich Frith.*

vandalism concerns the environmental alteration of a cave by addition of lights, heat, or visitors to a cave, or alteration of surface drainage or cave air patterns. This usually results in a drying up or dessication of speleothems, algae-covered speleothem surfaces, or gray, smoke-covered exteriors of speleothems. The natural crystalline luster and beauty of the speleothem is altered.

HOW TO PROTECT YOUR SPELEOTHEMS

The best way to protect your speleothems is to maintain tight control of all your caves. Either gate and patrol your caves or, if control is not possible, maintain secrecy



Lava soda straw and helictite in Gremlin Lava Cave, Oregon. *Photo by Charlie and Jo Larson.*

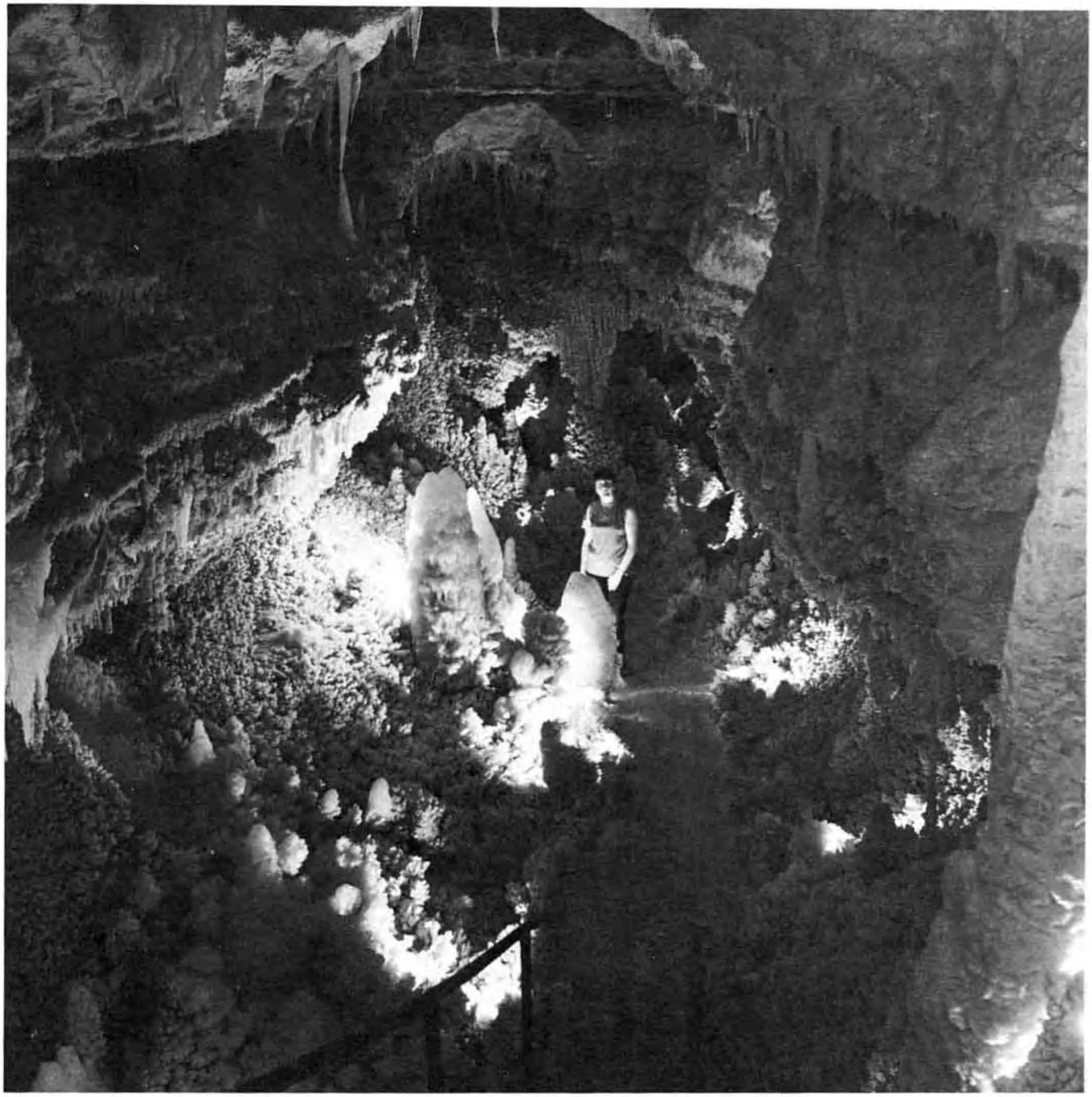
concerning the location and existance of the cave. Rockhounds should be refused admittance to your caves. Scientific collectors should be expected to send you written reports of their findings and should have plans to publish their findings in a reputable, well-read journal. Do not maintain a general policy of issuing permits to all applicants to your caves—know who you are giving permits to. Be sure that you know how you are environmentally affecting your cave—initiate cave climatic studies and act on the recommendations of such studies. Do not allow your visitors to smoke in your cave. Be active in environmental fights against dams that will flood caves and other environmental destructiveness to caves.

HOW TO BEST PRESENT YOUR SPELEOTHEMS TO THE PUBLIC

Proper lighting is of utmost importance when displaying your speleothems to the public, and there are experts in this field that can be of assistance to cave managers. In general, colored lighting should not be used to display speleothems, although when used minimally, colored lights in privately owned caves may add to visitor enjoyment. However, this type of unnaturalness should be avoided in national agency caves where the directive on these lands is to show visitors environments uncontaminated by commercialism. Algae-covered surfaces of speleothems should be periodically cleaned and rimstone pools should be cleaned of trash. Cave tours should be limited in size, be factual and educational, and should contain a minimum of "see the owl in that formation" type of comments. Give your visitors a simple, but factually correct, explanation of how speleothems grow. Plan your tours to minimize or eliminate speleothem damage by visitors. Warn visitors of the penalties for destroying cave minerals and place guards at exceptionally fragile or close-to-the-touch areas.

By protecting your cave now you will ensure future generations the enjoyment of your speleothems.

Ice speleothems in Jot Dean Cave, Shasta National Forest, California. *Photo by Charlie and Jo Larson.*



Use of attractive lighting in Caverns of Sonora, Texas. *Photo by Charlie and Jo Larson.*

A Review of Cave Geology and Hydrology

John W. Hess*

ABSTRACT

Caves are a reflection of their geologic, hydrologic, and chemical environments. They are truncated segments of larger conduits of carbonate drainage systems. The major requirements for solutional development of cavities are: the presence of a soluble material, the presence of an incipient permeability, a source of undersaturated water, and a hydraulic gradient. As the geologic, hydraulic and chemical environments vary from region to region so will the details of cave development vary. Stratigraphy, lithology, and structure are important geologic parameters determining the type and extent of primary and secondary porosity and permeability, location of recharge and discharge regions, and flow conditions within the aquifer. Inputs into the carbonate aquifer are smaller diffuse flow tributaries, larger vertical flow tributaries, and sinking streams. Outputs from the aquifer are usually from springs. They are classified into regional and local springs or as diffuse flow and conduit flow springs. The cave system makes up part of the flow system between the inputs and outputs. It is made up of three basic components; horizontal trunk conduits, vertical shafts, and minor linking and drain passages.

INTRODUCTION

There are many different types of caves depending on rock type and process of formation. This paper will be restricted to discussions of caves formed by solution in carbonate rocks; limestone and dolomite. Caves are a reflection of their geologic, hydrologic, and chemical environment. They are truncated segments of the larger conduits of karst drainage systems which could be up to thousands of square kilometre in area. Some are now active drainage conduits, others have been abandoned as base level changed and are now useful in interpretation of past flow conditions and patterns. Therefore, when one talks about cave geology and hydrology, one must think in terms of large systems. The same point of view is necessary in terms of cave management. Generally because of geologic and hydrologic conditions, it is not enough to just manage the cave itself, the surface and subsurface must be considered together.

The major requirements for solutional development of cavities are: the presence of a soluble material, the presence of an incipient permeability, a source of undersaturated water, and a hydraulic gradient. Chemical quality of the water determines the rate and locations of solution and precipitation within the carbonate aquifer system. The hydrogeologic setting including the geologic parameters of lithology, stratigraphy, and structure provides the boundary conditions determining the flow characteristics of the aquifer, regions of recharge and discharge, and nature of porosity and permeability. The physical hydrology of a region is an analysis of the hydrogeologic setting. Recharge available to enter a hydrologic system is determined by climatological parameters. The outputs can be measured as stream and spring flow and from well data.

Carbonate aquifers, and their associated caves, are widely distributed throughout the United States. According to McGuinness (1963) and the maps of Davis and LeGrand (1972), carbonate rocks occupy some 15 to 20 percent of the land surface. As the geologic, hydrologic, and chemical environments vary from region to region, so will the details of cave development vary. It is, therefore, impossible to assign a particular theory of cave origin to all situations. The various theories of cave origin will not be discussed here. The reader is referred to Sweeting (1973) and Herak and Stringfield (1972) for discussions concerning the development of cave origin theories and additional references on the subject.

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CHEMISTRY OF CARBONATE WATERS

The process of cave formation in carbonate terrains involves mainly the chemical solution and removal of calcite and dolomite. In its simplest form, we have a heterogeneous equilibrium between a solid phase (limestone and dolomite), a liquid phase (containing mainly ionic species and supporting a variety of homogeneous equilibria), and a gas phase (usually air with the only active component being carbon dioxide). The components of the chemical system are illustrated in Table 1.

Table 1
Components of the Chemical System in Carbonate Rocks

Solid Phase	Liquid Phase		Gas Phase
$CaCO_3$	Ca^{2+}	H_2O	CO_2
$CaMg(CO_3)_2$	Mg^{2+}	$(CO_2)_{aq}$	
	H^+	H_2CO_3	
		HCO_3^-	
		CO_3^{2-}	

Chemical Equilibria

For the rest of the discussion only calcite will be used. In pure water, calcite being an ionic salt, dissociates into its constitute ions.

$$CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$$

The reaction is described by the solubility product constant (brackets indicate activities).

$$Kcip = [Ca^{2+}][CO_3^{2-}] = 10^{-8.47}\ (25°C)$$

The solution of carbon dioxide takes place in two steps. First is the transport of CO_2 from the gas phase into (CO_2) in solution. The dissolved CO_2 then reacts with the water to form carbonic acid. The two reactions are usually considered together.

$$CO_{2(g)} \rightleftharpoons CO_{2(ag)}$$
$$CO_{2(ag)} \rightleftharpoons H_2CO_3$$

The carbonic acid species dissociates in solution to form the bicarbonate ion which in turn dissociates to form the carbonate ion. In the pH and ionic strength range of most natural carbonate waters, the bicarbonate ion is the dominent species.

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$
$$K_1 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]} = 10^{-6.35}\ (25°C)$$
$$HCO_3^- \rightleftharpoons CO_3^{2-} + H^+$$
$$K_2 = \frac{[CO_3^{2-}][H^+]}{[HCO_3^-]} = 10^{-3.33}\ (25°C)$$

The whole chemical process can be added up as follows:

$$CaCO_3 + CO_2 + H_2O \rightleftharpoons Ca^{2+} + 2HCO_3^-$$

Non-Equilibrium

An important aspect of the carbonate chemistry is its degree of saturate with respect to the mineral calcite. It can be calculated by:

$$\text{Ion Activity Product Calcite (IAPc)} = [Ca^{2+}][CO_3^{2-}]$$
$$\text{Log Saturation Index Calcite (SIc)} = \log(IAPc/Kcip)$$

SI's that are negative indicate undersaturated waters and those that are positive indicate super saturated waters.

Another useful parameter that can be calculated is the theoretical CO_2 pressure (Pco_2).

$$Pco_2 = [H^+][HCO_3^-]/(Kco_2 K_1)$$

HYDROGEOLOGY OF CARBONATE TERRAINS

Stratigraphy, lithology and structure are important in determining the type and extent of carbonate aquifers and caves. They determine the extent of primary, secondary and tertiary (caves) porosity and permeability. Overviews of the hydrogeology of carbonate terrains are presented by Burdon and Papakis (1963) and Stringfield and LeGrand (1969). White (1969) discusses the effects of structural and stratigraphic control on carbonate aquifer systems and cave development in areas of low to moderate relief. The hydrogeology of carbonate aquifers in folded and faulted rocks is discussed by Parizek, et al. (1971).

Lithologic controls on carbonate aquifers and cavern development have been discussed by Parizek, et al. (1971), Rauch and White (1970), DesMarais (1971), Morehouse (1969), and White (1969). On the microscopic scale, best cavity development occurs in micrite rocks while less occurs in sparry carbonates. In addition the higher the percent of quartz or feldspar, the less solutional development occurs. Solutional activity will be enhanced by the purity of the bulk rock and small grain size. These lithologic parameters along with depositional conditions determine the primary porosity and permeability of the rock.

The relationship of the soluble rocks to non-soluble rocks, or the stratigraphy of the region is important in determining the flow conditions and the location of recharge and discharge regions as discussed below.

Structural controls include the presence of joints, fracture zones, fault zones, bedding planes, stratigraphic dip, and folding. These determine the secondary porosity and permeability of the carbonate rocks as well as recharge and discharge zones. The location and extent of the primary and secondary porosity and permeability together determine the initial flow paths within the carbonate aquifer and the type of cave development.

The lithologic, stratigraphic and structural conditions are combined in the following discussion drawn mainly from White (1969) who divided carbonate aquifers into three main types. Table 2 (White, 1969) summarizes the discussion for carbonate aquifers in regions of low to moderate relief. The first type is the diffuse flow aquifer developed in thick carbonates of unfavorable lithology. They have a high primary porosity such as a shaly limestone or a coarsely crystalline dolomite, an example would be the Silurian dolomite aquifer of the Chicago, Illinois region. In this type the water table is well defined and Darcey's law is obeyed or nearly so. Cavities are widened joints or bedding planes and true caves are rare, small and poorly integrated. When the aquifer is exposed the associated karst landforms are subdued and discharge is through many small springs and seeps.

The second type is the free flow aquifer. This is then subdivided into four subtypes: perched-open, perched-capped, deep-open, and deep-capped. This type of aquifer in general has its flow paths localized by solution into well integrated systems of conduits. Flow is determined by hydrostatic head, hydraulic characteristics of the conduits and the volume of recharge. Gradients are typically low and discharge takes place through a few large springs. Aquifer thickness may be limited by impervious beds either above or below the main carbonate sequence and various combinations of capping or perching beds give rise to the four subtypes.

In perched free flow aquifers the ground water is forced into shallower flow paths and storage is apt to be small. Free-air-surface streams are often found in caves flowing on the perching beds. Cave passages are longer and better integrated and recharging water is quickly drained out since large conduits have little resistance to support much hydrostatic head. If the aquifer is open the caves formed tend to have a short channel morphology, carry a heavy sediment load and have sink inputs. If the aquifer is capped the caves formed tend to be long integrated conduits with vertical shaft inputs and have lateral flow under the capping rocks.

In deep-open free flow aquifers the soluble rocks extend from the surface to a depth below base level. Most of the recharge from surface runoff drains into sink holes and large sediment loads are carried. The caves formed in this type aquifer are apt to be short truncated fragments due to collapse, surface erosion, or sediment chokes. The main water-carrying conduits are apparently at, or somewhat below the regional base level.

In deep-capped free flow aquifers recharge may be lateral

Table 2. Types of Carbonate Aquifer Systems in Regions of Low to Moderate Relief (From White, 1969)

Flow Type	*Hydrological Control*	*Associated Cave Type*
I. DIFFUSE FLOW	GROSS LITHOLOGY Shaley limestones; crystalline dolomites; high primary porosity.	Caves rare, small, have irregular patterns.
II. FREE FLOW	THICK, MASSIVE SOLUBLE ROCKS	Integrated conduit cave systems.
A. PERCHED	Karst system underlain by impervious rocks near or above base level.	Cave streams perched – often have free air surface.
1. Open	Soluble rocks extend upward to level surface.	Sinkhole inputs; heavy sediment load; short channel morphology caves.
2. Capped	Aquifer overlain by impervious rock.	Vertical shaft inputs; lateral flow under capping beds; long integrated caves.
B. DEEP	Karst system extends to considerable depth below base level.	Flow is through submerged conduits.
1. Open	Soluble rocks extend to land surface.	Short tubular abandoned caves likely to be sediment-choked.
2. Capped	Aquifer overlain by impervious rocks.	Long, integrated conduits under caprock. Active level of system inundated.
III. CONFINED FLOW	STRUCTURAL AND STRATIGRAPHIC CONTROLS	
A. ARTESIAN	Impervious beds which force flows below regional base level.	Inclined 3-D network caves.
B. SANDWICH	Thin beds of soluble rock between impervious beds.	Horizontal 2-D network caves.

from sinking streams on adjacent clastic rocks or vertical flow through shafts carrying water from overlying ridges or plateaus to the base level of the main aquifer unit. However, recharge is limited to the periphery of the capped area. Flow is largely lateral and the water table gradient remains low in spite of surface irregularieties.

The third type is the confined flow aquifers which is divided into two subtypes: artesian aquifers and sandwich aquifers. The artesian aquifer is capped and tilted or folded in such a way as to force water to flow at depth under considerable hydrostatic head. The size of the solutional openings offer little friction and, thus, little head loss. Flow is slower than in free flow aquifers due to longer flow paths and discharge into overlying rocks of lower permeability. As a result, many more joints are dissolved and flow is, thereby, not concentrated in a few master conduits. Thus, three-dimensional network caves are formed with passages sloping parallel to the confining bed.

The sandwich aquifers are perched and capped and the soluble unit is usually less than 12 metre thick. The flow is retarded by a lack of concentrated recharge and, thus, channelization does not take place. Rather, solution occurs along many available joints and forms a dense two-dimensional network pattern of cave passages.

Structural controls act in two ways. Folding and faulting in a drainage basin determines the position of the aquifer with respect to recharge and discharge area as well as the orientation of the drainage system. In the folded and faulted Appalachians (Parizek, et al., 1971) carbonate basins tend to be localized because the carbonates outcrop in long narrow bands.

Joints, fracture zones, fault zones and bedding planes provide secondary porosity and permeability within the carbonate aquifer thus acting as initial flow routes within the aquifer. These zones are solutionally enlarged to form the caves: tertiary permeability. The effects of the joints beddings, and fractures vary with the other geologic and hydrologic factors. See Deike (1969) for a discussion of their effect on Appalachians caves where jointing appears to be important and Deike (1967) for a look at the Mammoth Cave region where joint control is less apparent.

PHYSICAL HYDROLOGY AND THE CARBONATE DRAINAGE SYSTEM

The initial source of water to the carbonate aquifer as for any other aquifer system is precipitation. Some of this water is lost through evapotranspiration. The remaining water enters the ground-water system through three possible routes (White and Poulston, 1969). Smaller tributaries derive their diffuse flow from the bottoms of sinkholes and from cracks and crevices in the carbonate surface. They are not directly observable, so details are unknown. Larger tributaries are characterized by vertically flowing waters. Non-carbonate rocks overlying the carbonate sequence act as perching layers forming perched aquifers or surface streams. These recharge the underlying carbonate aquifer at concentrated points via vertical shafts (Brucker, et al., 1972). The third major route is the sinking streams often originating on non-carbonate rocks bordering the carbonate aquifer. The streams sink upon reaching the carbonate contact forming a concentrated recharge point. Such points form an interface between the surface and underground drainage nets.

The output of the carbonate drainage system is in the form of spring discharge. Springs can be classified into local and regional springs depending on their catchment area and relationship to the regional carbonate flow system. Local springs have relatively low discharges and usually a single small catchment area. Regional springs have relatively high discharge from large drainage areas which may include several different types of catchments.

Springs can also be classified into diffuse and conduit springs (Shuster and White, 1971) according to their discharge and chemical varibility which is an indication of the type of carbonate aquifer system that is discharging at the spring. An aquifer with a well integrated conduit system will be discharged at a conduit spring. An aquifer with most of the water movement along joints and bedding plans will discharge at a diffuse flow spring.

In between the recharge points and the discharge points lies the carbonate aquifer system of which the cave system is an integral part. Looking at just the cave system, there are three basic components to the system. The major one is the horizontal trunk conduit which moves the water between the points of recharge and discharge. The second is the vertical shafts which move water vertically from overlying aquifers and surface catchments down to near base level. The third component is the minor linking and drain passages which bring water from various components together to form the major trunks conduits.

Water movement within carbonate aquifers is very rapid. It can be measured in metre per hour rather than metre per year which is more typical for other aquifer types.

SUMMARY

An example of how the geologic, hydrologic, and chemical environments interact is provided by the Central Kentucky Karst aquifer systems (Hess, 1974). It also demonstrates potential cave management problems. For example, Mammoth Cave National Park encompasses only a small portion of the entire hydrologic system. Because of this, water pollution from outside the park is a real possibility.

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Resource Potential of Submerged Caves and Suggested Procedures for Safe Exploration and Study

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One aspect of cave resource management which is often overlooked, or is at least often misunderstood, is that of managing resources in submerged caves. Many caves in the United States are either entirely underwater or have underwater components to them. These *wet* caves often have their own biological systems and occasionally contain paleontological and archaeological resources of great value. This paper examines the nature of the various resources of submerged caves and discusses the specialized diving techniques and procedures which are necessary to permit safe exploration and scientific study of this unique environment.

NATURAL RESOURCES IN SUBMERGED CAVES

There is a wide range of natural resources in submerged caves ranging from geological formations to fragile, well-balanced biotic communities. Dripstone formations which developed in the cavern during a dry stage in the cave's history will sometimes be present many meters underwater. When these occur in a submerged cave they can be of great value in helping to understand regional variations in groundwater level over time and may even contribute to the study of eustatic sea-level changes.

Perhaps the most intriguing of the natural resources found in caves are the biological or *living* resources. Submerged caves provide a very controlled, stable activity area with specific selective pressures on any organisms that inhabit it. The cave environment is also valuable in the study of life systems for what it doesn't provide and that is a closed biotic community. The life in caves must ultimately rely on lifelines to the world of light ouside, much as cave divers depend on *lifelines* of nylon and Plexiglas. Confronting living things in a place antithetical to life, forces the scientist to fill in the gaps in these lines of communication to the outside and challenges them to demonstrate how the life cycle of these animals is completed.

Energy is at the base of all life-cycles and this energy is totally dependent, in the final analysis, on sunlight. The only organisms capable of capturing and storing this energy are green plants; thus all animal life ultimately points back to the sun for its sustenance, from the herbivore to the larger carnivore that eats the smaller carnivore to the scavengers that eat the leftovers to the microorganisms that decompose what the scavengers miss. How, then, does a cave support a complicated life system when the prime mover (sunlight) is not present. True, there are some bacteria capable of metabolizing and creating energy in the absence of light but these exist in quantities much lower than needed to support higher life, so where is the source of energy? The answer is that cave communities are dependent on intrusion from the outside to maintain them. A dry cave depends on the nighttime excursions of some members of its community. Bats or crickets, for example, will leave a cave and gorge themselves during the night and when they return, contribute their nitrogen-rich wastes to the cave floor. Flatworms, isopods and beetles thrive on this guano only to later become the prey of crayfish. Cave fish at the top of this food pyramid live off many of the same things that the crayfish does and most importantly they live off of the crayfish. Another important basic source of nutrient-rich material in caves, and the one most important for most wet caves without accompanying dry sections, is wash-in from rains, high water, or as in the case of spring-syphon systems, river water itself. Rotted leaves, insects, animal droppings and their associated bacteria and fungus growths are, in this manner, spread through the cave.

What types of animals are likely to inhabit caves above and below the water line? One of the prime ingredients is a low metabolic rate. The cave is an extremely sparse and rigorous environment for any life form that is totally relegated to it and *cave dwellers* or troglobitic animals are almost exclusively those that can operate on comparatively small amounts of nourishment and that can exist with minimum expenditures of energy. True cave dwellers, as a matter-of-fact, extend only up through the amphibian level on the evolutionary scale, including the blind salamander. Even reptiles seldom venture past the twilight zone even though the constant temperature and often high humidity of caves would seem to be inviting. Besides low metabolism, small size also seems to be selected for in troglobitic species though this has exceptions in some arthropods.

Besides occasional amphibians and some members of the terrestrial insect world, the only other class of animals that meet these prerequisites for cave life are fish and other forms of aquatic life. Crayfish and true fish also provide some of the best examples of the effects on a species as a whole when it selects for a cave existence. Charles Mohr in the book he coauthored with Thomas Poulson, *Life of the Cave*, recounts a journey along a subterranean stream collecting crayfish which dramatically illustrated the adaptive sequences in the species evolutionary past. As Mohr started down the passage still in the full light of day he found only a surface variety of nontroglobitic crayfish. Well into the twilight zone an occasional troglobitic variety would appear. They were characterized by a lack of pigment and degenerated eyes. By the time he was deep into the cave the ordinary crayfish were absent completely and only the troglobites remained. When the far end of the tunnel and a new twilight zone was reached the process reversed itself. Now this leaves the observer with some nagging questions. Why did the sighted surface variety not extend all the way through the cave and why did natural selection favor blindness and lack of pigment in cave species? The answer to these questions provides insight into the nature of the adaptive responses of all cave species including the widely reported blind cave fish and various terresttial cave dwellers including the blind salamander.

Though it is hard to imagine that sight could ever be a

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negative attribute, it is selected against time and again in the case of caverniculous species. This illustrates a basic evolutionary law that not only harmful but useless traits of species will be eliminated over time. A fish or crayfish that cannot see, but has eyes, is using part of his precious energy resources to maintain a structure that has no survival value. This energy could be utilized to support other sensory systems such as tactile and lateral line sensors which are much more useful in the eternal night of the cave. Nontroglobitic species are consequently no match for the true cave dwellers who, besides having developed specialized sensory structures and new behavior patterns, have conserved their energy waste to the point of even eliminating the process of maintaining pigment in their skin.

The creatures that one is liable to encounter in the basins of the sinks and springs are numerous and are usually representative of the surrounding open water stream and lake life. The twilight zones of many Florida caves abound with brim, catfish, mudfish, bass, and eels and some cave entrances are covered by legions of fresh water snails. Thus far, true cave fish have not been recorded as far south as Florida, but they are present in the aquifer systems farther North in Kentucky, Missouri, etc.

It should be noted by cave resource managers that the balance of submerged cave communities is extremely fragile and easily stressed. There is no doubt of their great scientific value in terms of studying evolution of adaptive patterns and various other life sciences problems but their study should be limited as much as possible to passive observations. Collection of geological or biological specimens should definitely be minimal and highly selective.

ARCHEOLOGICAL AND PALEONTOLOGICAL RESOURCES OF SUBMERGED CAVES

There are several possible ways for cultural and faunal remains to end up in a submerged cave. In some cases, the materials are accidentally deposited as when a ceramic container is lost while obtaining water or an individual or animal falls into the sink and drowns. Artifactual material may also be found in wet caves and sinks as the result of the area being used as a refuse pit or as a place for ritual offerings. There may also be a secondary deposition wherein items which were in a nearby area or in the basin of a sinkhole are washed in as a result of heavy flooding. Perhaps one of the most intriguing of these possibilities is realized in a situation where the materials are deposited during a dry phase in the history of the cave or sink. This last possibility should be examined in more detail. Geomorphologists have been cognizant for a good while that the holocene, or *recent* period in geological terms, witnessed a significant raising of the relative world-wide sea level. There is continuing controversy over the extent of this rise and the patterns of this increase, i.e., was it gradual and consistent, or were there sporadic increases and decreases with the increases being of greater overall magnitude. There is little disagreement, however, that 10,000 years ago the level of the sea was at least 15 meters, and some feel 60 meters to 100 meters, lower than today. This effect manifests itself in specific areas in accordance with local uplift and subsidence factors.

It has now become obvious that a good portion of the pieces to the scientific puzzle regarding the reconstruction of subsistence and settlement patterns of paleo- and archaic-man in the New World is now underwater. Consider, for instance, that a 45-foot difference in mean sea-level would put the Florida eastern coastline many miles out into the Gulf. A good deal, if not most, of the material vestiges of maritime cultural activity in the New World would now be miles offshore. How does all of this relate to submerged caves? If we extend the effects of this phenomenon of eustatic sea-level change inland, we note a curious thing. The piezometric levels or *ground water levels* are also going to be affected in all areas adjacent to points where there has been a significant change in the sea level stand. The limestone karst features in which we find most of our submerged caves in this country are, therefore, going to have been significantly affected in terms of the level sought by their hydrostatic heads. Consequently, we find that the water level in many sinkholes in Florida and other states was considerably lower during immediate post-pleistocene times. Many sinks and their associated solution caverns were therefore dry or, at least, had decreased water levels during a period when early man would have been prone to utilize them for shelter and other functions.

The potential for paleolithic and archaic man sites in submerged sinks and caves now becomes obvious. What is also intriguing, is that the artifactual material, and even more importantly, the context of the artifactual material found in underwater caves, is likely to be in a very excellent state of preservation. In most cases, the material remains of man's activity have not been subjected to thousands of years of the trampling of feet as they would be in a land context. They have also been, until recently, much less accessible to the depredations of *pothunters* or modern day vandals. In addition, unlike the material that is found in marine or reservoir environments, cave remains are not subjected to wave action or shifting currents. There is still much to be learned about the effects of inundation of archeological sites (Jewell, Lenihan, Carrell, Ruppe, and Green, etc.) but the unique underwater environment presented by certain submerged caves presents an archeological situation of extraordinary promise. Besides the direct evidence relating to human activity patterns in prehistory, there is also found in submerged caves and sinkholes, an excellent situation for gleaning information on paleo-ecology, or in other words, the nature of the environment that prehistoric man had to interact with. It is impossible to try to understand man and his behaviorial patterns in a vacuum. Recent archeological investigations in submerged sinks have produced extremely valuable evidence that will help reconstruct the climatic

An NACD surveyor passing over a bed of faunal remains in a Florida sinkhole. Note extra light and mouthpiece. *Photo by Dave Fisk.*

variables that prehistoric man had to contend with in the Old and New Worlds.

Some of the first archeological finds in submerged caves were the result of skin diving. Intrepid early cavers braved the cold, dark waters presented by *sumps*, or points in a cave conduit where the passageway is cut off by the ceiling descending to meet the water surface. The sump diving efforts of Norbert Casteret demonstrated dramatically how important could be the archeological finds in water-filled caverns. In 1922, Casteret *forced* a series of two sumps in a cave at Montespan and discovered an air-filled room which contained a series of pictographs and ceremonial statues which were 20,000 years old. His cave-diving gear consisted of some matches and a candle stuck in his bathing cap. Even the footprints of some of the early men and cave bears were found preserved and superimposed over each other in various parts of the cavern.

Hard-hat diving techniques were also used in early explorations of karst-type features in the Old and New Worlds. Perhaps the most famous of these efforts took place at the cenote of Chichen Itza. Edward Thompson dived the sacred well from 1904 to 1907 and proved that John Lloyd Stephen's theories on the archeological potential of the sinkhole were well-founded. The recovery techniques used were crude in terms of any archeological rigor, but few archeologists in 1906 would have dreamed of attempting to apply the scientific controls of terrestial archeology to the depth of a water-filled pit. Human remains and artifacts of great value for reconstructing the ritual aspects of Mayan life were found in great abundance in exceptionally good states of preservation.

In 1930, hardhat divers discovered large amounts of extinct pleistocene faunal remains in Wakulla Springs, Florida. This was followed in later years by investigations of the springs by scuba divers who reported much in the way of cultural and paleontological items in the basin and cave area (Olsen, 1955). At one point during these later investigations of the springs, an entire mastodon skeleton was removed by divers. In 1953, two divers entered the cavern at Silver springs, Florida, and discovered another significant archeological site. In the early 1960s John Goggin conducted underwater investigations at Warm Mineral Springs, Devil's Den, and Jughole in the Ichetucknee River (Goggin, 1960, Gluckman, 1967).

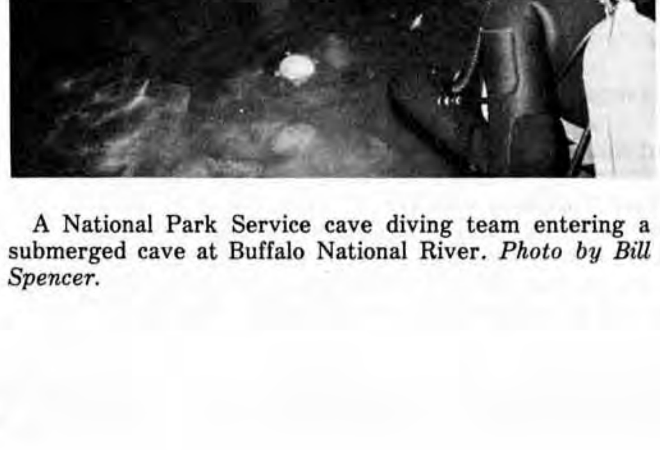
The most recent archeological efforts in submerged caves and sinks in this country have centered in Florida. The interface of archeologists and other scientists with the American cave diving community has also tended to focus on investigations in the Florida karst. As early as the 1955 scuba explorations in Wakulla Springs mentioned above, cave divers from Florida State University worked under the supervision of archeologist, Stanley Olsen. The first formal relationship developed during the 1972 investigation at Little Salt and Warm Mineral Springs. Carl Clausen, who was the state underwater archeologist, utilized National Association for Cave Diving (NACD) personnel as safety divers. Bob Friedman of NACD was Project Diving Officer (Friedman, 1973). Earlier this year (1975), a renewed, intensive program of research under the direction of W.A. Cockrell, present Florida State Underwater Archeologist, was initiated, and the formal relationship between the scientific community and the NACD was broadened and solidified. The combination of research diving motivation with the disciplined, highly innovative approach of the American cave-diving community has resulted in techniques and procedures which are well worth examining.

SURVEY AND MAPPING

Surveying for underwater cave locations is, by its nature, a multidisciplinary pursuit. It involves archeologists, geologists, computer specialists, cartographers, paleontologists, and remote sensing specialists. Through the special contributions of each of these fields, survey methods are being developed to isolate high probability areas for cave sites. A series of overlays are produced of the area to be surveyed based upon either a county map or quad map. The overlays depict the possible variables which can be examined before actual field survey. The known archaic and paleo sites from past land surveys listed in the Master Site Files of state archeological offices are plotted to show concentrations, especially around water sources. The land archaeological surveyors have also become more aware of sinks and springs in the course of their work. Recently, during a land site survey of Jefferson County, Florida, (Frymon, 1975) the ratio of sinks to sites approached a 1:1 correlation. The nature and size of each site is taken into consideration when plotting the site location overlay. Areas of high geologic potential for springs are plotted as a second overlay, also on this series, known remains of fossil pleistocene fauna locations are marked.

A geologic map of high incidence spring and sink locations is plotted over the base map, with areas of local drainage, high ground contours, and chert outcroppings denoted. Computer maps have been made to give additional insight into distribution of land sites in an area on a county-wide basis. Sinks with high archeological potential are listed and inquiry is made into the files of NACD which currently contains over a thousand sinks, springs, and caves which have been dived by its members, to see whether specific data is recorded before actual field work begins.

It is the field of remote sensing which offers archeologists some of the most exciting possibilities. Aerial photography has been used in the past for initial location of sites. New film types, such as high resolution black and white, infrared and blue insensitive, have been in use for some time now and offer good data for the archeologist. Satellite and high-altitude photographs offer a general view of water source patternings not otherwise available. The most recent remote sensing tool adopted by archeologists attempting to pinpoint spring and sink cave locations is the



A National Park Service cave diving team entering a submerged cave at Buffalo National River. *Photo by Bill Spencer.*

thermal scanner. This aerial device can be set to pick up a specific temperature range, e.g. 4°C to 28°C. The scanner picks up all variations of temperature in this range and prints the results using the total range of black and white film, which looks very much like a black and white negative. Standard aerials can be made at the same time so precise locations can be checked.

The laboratory analysis of these thermal scanner prints is done by utilizing an electronic scanning micro-densitometer. This modular package consists of a standard television vidicon camera with zoom lens and monitor with edge enhancement and delayed signal circuit capability. The signal from the monitor is fed to a data color control panel and a gamma control panel to a color monitor. The system uses 32 colors to portray the shades of gray produced in the thermal scanner print as different colors representing the temperature range for quantative analysis. Colors may be added and subtracted by pushing the appropriate button of the color control panel to give desired information.

Members of the Florida Department of Transportation have used this system for the location of cave openings and voids near current and planned roadways (Griepentrog, 1972, Kuyper and Schlobohm, 1972). A slightly different application has been used by remote sensing specialists to locate sink activity. There is thought to be a direct relationship between plant moisture status and sink activity. This moisture stressed vegetation can be picked up on the thermal scanner (Williams, 1972) and aids in locations of possible sinks.

When a high potential area is pinpointed the next phase is the on-site survey. The diving techniques and equipment innovations coupled with intensive training courses which have come out of the cave diving community, particularly the National Association for Cave Diving, have been fundamental in allowing safe examinations and eventual excavations of these archeological sites. Proficiency in line management, silt techniques, special dive equipment handling, and rescue techniques must be mastered by the cave-diving archeologist before initial work can begin.

Some of the specialized equipment that cave-diving archeologists must become familiar with are sophisticated lighting systems, Plexiglas line reels, special air-cylinder manifolds which allow the use of two separate regulators (Benjamin-type conversion) and line clips which indicate the direction out from side passages and offshoot lines. Usually these items are not procured commercially but are purchased from small shops or individual cave divers who have hand tooled these critical items of equipment.

It is necessary to map the cave accurately before the recording of scientific data can take place. Methods of cave mapping may be found in *Mapping Underwater Caves* (Exley, Friedman, 1973). New mapping equipment is currently being devised particularly the use of hand-held sonar units. Sub-bottom profiles with remote heads may, for example, prove useful for probing cave sediments.

EXCAVATION

Archeological excavation techniques must be specially adapted for use in the cave environs. Airlifts, dredges, air and water jets must be constructed to remove the silt and sediments without destroying visibility. Fragile samples are removed in clear Plexiglas boxes that are sealed underwater affording protection from site of removal to the laboratory where they can be studied.

A device which holds particular promise for recording data is the underwater TV. This diver-held unit with hard-line communication to the surface gives a permanent record and allows nondiving or non cave diving scientists a chance to observe the material *in situ* and offers them the capability to pick the most important samples and observe the excavation first hand. The underwater TV has recently proved successful in the project at Warm Mineral Springs, under the direction of W.A. Cockrell during which a recording was made of the main hot water outlet cave of the spring at a depth of 240 feet.

Special problems attend using excavational equipment such as air lifts in submerged caves. Any activity which stirs up silt in a cave is creating a hazard to the divers and causing problems in recording and photography. While the effects of silting and bottom disturbance can be annoying in an open water site, they are much more magnified in an enclosed space and can make finding ones way out of a cave difficult even with the use of a guideline. In some cave configurations the problems can be mitigated by directing the outflow of the air lift into the outflow of the cave, assuming that is not the direction the team must go to exit.

Standard photographic recording of sites in underwater caves puts the same demands on a photographer as does night photography in an open water site with fine organic or clay silt. Much attention must be given to light fall off and to flashback caused by light reflecting off of suspended particulate matter in the water.

Future underwater archeological efforts in submerged caves will be directed towards solving several significant archeological problems. First, in the Southeast, what specifically was the nature of prehistoric man's utilization of sinkholes and caves? If the climate in Florida was indeed cooler and dryer, as recent research seems to indicate, did this create ecological pressures which forced differential patterns of use? Second, were the sinks and caves used only for subsistence oriented activities, i.e., as sources of water, sources of fresh-water mussels and snails, or were they the scene of ceremonial activities? Is there, for instance, a carryover in some way, of the use of sinkholes as sacrificial wells as in the case of the cenotes of the Yucatan? Evidence grows that there were considerable influences from Meso-American cultures on North American peoples during the formative period. It would be interesting to determine if these unique geological formations triggered a ritualistic response from North American cultures similar to those of their Southern counterparts.

There is some indication that the sinkholes may have been used as sources for flint. Chert can be found in the form of nodules in the limestone outcroppings of sinkholes, and it has been hypothesized that prehistoric man utilized the sinkholes for this purpose in Florida. Another focus of archeological studies in submerged caves will be directed towards shedding light on the interrelated question of pleistocene extinctions and early man interactions with megafauna in the Southeast. Although, it has been firmly established that early man in the Southwestern United States hunted mammoth and other large pleistocene mammals, this has not been proved in the Southeast. It is known that human artifacts and the remains of megafauna lie side by side in the submerged cave at Wakulla Springs, Florida, but as yet, the nature of their association is questionable. The answer to the question of whether the mysterious, rapid extinction of the great mammals in Florida was the result of overkill on the part of man, or devolved from some natural sequence of events may well be found at the bottom of a Florida cave.

In Kentucky, the full story of man's prehistoric and historic utilization of Mammoth Cave cannot be understood until the submerged sections are explored by cave divers. The same holds true for many other parts of the country. Archeologists and cave resource managers are both becoming aware of the fact that caves do not stop at the air-water interface and that to fully understand and assess a cave's potential in terms of natural and cultural values, it will be necessary to penetrate their underwater components. Associated with this increased interest in submerged caves will hopefully be an increased awareness of their fragile nature. Conservation of cave resources should be uppermost in the minds of those who deal with caves dry or wet. Biotic systems in caves are unique and easily upset. The archeological resources to be found in caves are also unique in that they can tell us of a range of human activity which is impossible to learn about elsewhere. Like the natural resources in caves, the archeological values are easily disturbed, but unlike plant or animal species, they are non-regenerative.

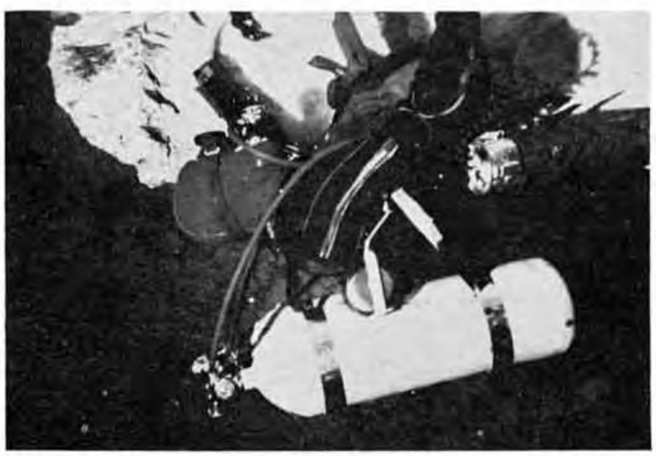
PROCEDURES FOR SAFE EXPLORATION AND STUDY

Cave diving should not be viewed as an advanced form of sport diving. It is a discipline unto itself demanding a period of intense training and a much longer period of gradual, controlled accumulation of experience before a person can be considered a competent cave diver. Combining a research orientation to what is already a very demanding type of diving results in an extremely serious undertaking. What then comprises the highly specialized equipment needs and training prerequisites necessary to engage in research cave diving?

The submerged cave researcher must have as a minimum, the following specialized gear.

1. A powerful primary lighting system—This should include high-intensity bulbs and an adequate power source to support them. Sealed beam bulbs or quartz Iodide bulbs in conjunction with nickle-cadmium battery packs are most commonly used by cave divers.
2. At least one secondary light—Most commercially made dive lights are acceptable though some flashlight type units which turn on by screwing the head down cannot be turned on at depths much in excess of a hundred feet.
3. Sufficient air supply—Doubles are best but this is really relative. Knowing the limits of one's air supply, whatever it may be, and limiting one's activities accordingly are of essential importance here.
4. Well made reel—A Plexiglas reel with built-in buoyancy chamber and strong nylon line is best. *Warning*—do not try to salvage the line if the reel jams; tie it off, cut the line and exit immediately. If the line cannot be detached from the reel, leave them both after securing.
5. Proper buoyancy device—CO_2 cartrige life vests are not advisable. A large capacity buoyancy compensator is needed.
6. Sharp knife—It is wise to keep a razor sharp knife which is used for no other purpose (such as a prying tool) but to cut the line in case of hopeless entanglement.
7. Octopus rig or double manifold—A regulator with two second stages is not a fancy frill in cave diving but a necessity. In an emergency, the long periods of horizontal buddy-breathing which one must undergo before reaching the entrance of most caves makes this a must. A superior system, however, if one can obtain it, is the double or *ideal* manifold which permits the use of two separate regulators with both having access to the entire air supply. This allows the diver to turn off a regulator free flowing from a first stage lead and still have an entire life support system at his disposal.
8. Submersible pressure guage—J-valves are not advised for cave diving. The only acceptable constant reserve system is a pony tank with a separate regulator and then only if it is *not* figured into the dive plan as available air for the penetration, but rather as an auxiliary in addition to any air possibly needed for the dive.
9. Two depth guages—(a) An oil-filled guage which operates on a linear rate of change for determining maximum depth and, (b) a capillary guage which, due to Boyle's Law, gives better shallow readings during decompression stops.
10. Watch—At least two in any dive party.
11. Set of Submersible Decompression Tables—In cave diving you must be prepared to decompress whether you intend to do so or not. Resolving problems deep inside the cave can cause longer bottom times than intended in the dive plan.

Now the second element—What comprises adequate cave diving training? In addition to a basic course and a considerable amount of general diving experience, a specialized course in cave diving is absolutely essential. These are usually extremely long in duration (often 100—200 hours in length) with the rationale being that a whole new psychological set is mandatory in this unique situation. Certain motor skills such as the strong leg thrusts stressed in open water diving are deemphasized in cave diving—the main attention being given to developing slow, deliberate, precise movements in the water. Control of buoyancy and the horizontal attitude of the body is particularly important. Techniques for operating the reel, for backing up the reelman, for following the line, for keeping out of silt, for dealing with entanglement, for dealing with light failure, for emergency communication are some of many specialized skills that must be mastered.



Demonstration of "Flywalking Technique" used for moving over silt-laden bottom in a high current. *Photo by Larry Murphy.*

But all of this is still not enough if a basic attitude of almost over-deliberateness and over-caution is not instilled in a cave diver. He must be constantly alert to the pressure in his tanks and be able to accurately determine if he has an adequate amount of air to return both himself and his buddy to the surface under emergency conditions from any point in their dive. Cave diving instructors often demand of their students instant feedback to within a hundred pounds of

The author in a tight area in a Buffalo National River cave.

their air pressure without being allowed to look at their guages. Air consumption can vary critically from one day to the next even in the same individuals in the same caves. Because of a large number of physiological variables, the close monitoring of one's air supply cannot be overemphasized.

Prospective cave divers should once again be warned that although adequate equipment is essential, it is not enough! Long time open water diving experience is, of course, helpful but cannot be immediately negotiated into cave diving expertise. Cave diving is safe only when undertaken by specially trained and equipped individuals exercising extreme care and good judgement.

Some portion of the section of this paper dealing with archeological and paleontological resources in submerged caves have been excerpted from a paper entitled *Cave Diving and Archeology* presented by Dan Lenihan and Larry Murphy at the Seventh International Conference on Underwater Education in Miami, 1975.

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Rare and Endangered Cave Animals

H.E. McReynolds*

ABSTRACT

The opinions of a non-speleobiologist may be more important for their external frame-of-reference than for any specific knowledge of rare and endangered cave animals. The cave community, despite its low diversity of species, is generally considered a relatively stable fauna and flora. This stability is often attributed to the climatic constancy of the cave environment. It appears that low diversity may be tenuously counterbalanced against this beneficial climatic constancy. If this be true, there is little buffering of the community organization, and any additional stresses might produce disproportionate effects.

In the immedicate future, management of these animals will be severely protectionistic, with State and Federal laws, agency regulations, and restrictive permit procedures delimiting take of these threatened species. The author feels that several cave-associated animals should be immediately raised to threatened or endangered status. Methods of determining whether a threatened species occurs on agency lands are discussed. Regulatory and mechanical controls of human disturbance are considered. Increased restrictions on scientific collections are visualized.

INTRODUCTION

In 1968, as advisor on fisheries problems, I was requested to inspect several Ozark streams on the Mark Twain National Forest in Missouri. During this inspection trip, Thomas Aley—at that time Forest hydrologist—also took me through three caves. He pointed out the lack of management of caves by land-holding agencies. My subsequent studies of this situation convinced me that Aley's opinion was well-founded—caves actually were overlooked in Federal land management programs.

This oversight probably resulted more from a lack of expertise rather than any intentional insensitivity to the problem. Even the cave authorities whom I contacted provided only cursory management direction for the cave as a *unit* (i.e., as a complete ecosystem). There was a rapidly expanding autecologic knowledge of narrow taxa of the cave biota (species, genera, families) but few holistic (cave community) studies of sufficient depth to give good guidance in ecosystem management of caves. This symposium is long overdue, and I congratulate its organizers for their perception and fulfillment of this need.

HISTORY OF CAVE STUDIES

As a novice and interloper in the field of biospeleology, let me briefly review the impressions I have garnered from readings on the history of cave studies.

American cave studies appear to have lagged nearly a half century behind earlier European studies (Pfeiffer, 1961; Grund, 1903), with most American studies dealing with cave geology or faunal taxonomy. In America, in the late 1800s and early 1900s, Smith, Putnam, Packard, Hay, Underwood, Eigenmann, Dekay, Benedict, etc., were discussing new species of troglobites. With the possible exception of Eigenmann's classic studies of eye degeneration in cavernicoles, there were few examples of experimental, ecological or physiological studies of cave animals before 1950. Much of the interest during the first half of the 20th century concentrated on the geohydrogenesis of caves. The controversy of cave origin, with Davis and Bretz proposing a vadose origin and Garner and Mallott countering with a phreatic beginning, occupied the attention of cave authorities for several decades (Poulson). (Ironically, many speleologists now favor a third alternative, Swinnerton's flood-water zone theory.)

Collection of biological data on *cavernicoles* (cave animals) accelerated from 1950 to about 1965. Most of these studies were still narrow taxa investigations. Some studies purporting to be ecosystem analyses were actually parallel autecologic studies (i.e., although they included the entire fauna of a cave, they were really concurrent life history studies of a series of animals). They did not consider the complex interrelationship of energy flows and nutrient exchange between the species. Only in the last decade have I seen the beginnings of comprehensive studies based on community organization and interactions. In the not-very-knowledgeable opinion of an outsider, this is what I see as the present state of speleobiology—just recently moving into definitive ecosystem studies, despite the fact that the relatively simplistic cave ecosystem should be one of the least complicated for comprehensive studies.

THREATENED CAVE ANIMALS

Although I was assigned a title of *Rare and Endangered Species*, I am taking the liberty of redefining this topic as *Threatened Cave Animals*. I am extending this subject to cover two categories of animals: *endangered* or *threatened* species officially designated under the Endangered Species Conservation Act of 1973, and a second category called *unique species* by the Forest Service.

Beyond the obvious need for preservation of threatened species (i.e., those on the official list of threatened wildlife of the United States), the Forest Service has some concern for other species which unfortunately may be imminent candidates for the abyss of extinction. We need to evaluate these species more thoroughly and monitor their populational changes more closely. These *unique species* may be on state endangered species lists, may be regionally depleted, or may be on the periphery of their range. As we learn more

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about them, some may become candidates for the official list, and others will be found to be in a relatively safe status.

On the official list, I note one amphibian, and one mammal that are cave-associated species. (Under the term *cave-associated*, I am including trogloxenes, troglophiles, and troglobites.) These species on the official list are the Texas blind salamander (*Typhlomolge rathbuni*) and the Indiana bat (*Myotis sodalis*). In addition to these officially-designated animals, the Eastern Region of the Forest Service would add several cave-associated *unique species* for which we extend special management considerations. These include four amblyopsid fishes, the troglobites *Amblyopsis rosae*, *Amblyopsis spelaea* and *Typhlicthys subterraneus*, and the troglophile *Chologaster agassizi*. We also consider the gray bat (*Myotis grisescens*), the Ozark big-eared bat (*Plecotus townsendii ingens*, and the Virginia big-eared bat (*Plecotus townsendii virginianus*) as unique species. We have funded contract studies of all of these unique species (except the Ozark big-eared bat) as well as three surveys for the endangered Indiana bat. If one considers the wood rat (*Neotoma*) a trogloxene, then this unique species should also be mentioned. We have funded wood rat studies by Southern Illinois University and Purdue University.

THE PROBLEMS WITH THREATENED CAVE SPECIES

Earlier in the symposium, Dr. Thomas Poulson, and others, pointed out some of the biological difficulties encountered by cave organisms. I will not reiterate except to say that I feel that the cave ecosystem rivals the Alpine or Arctic tundra, and the low desert as the harshest of environments for animal life. This is particularly true if one evaluates ecosystems on the basis of productivity (i.e., on the animal biomass produced). The deep cave ecosystem shares with bathypelagic oceans and soil communities the inability to directly convert solar energy to chemical energy (i.e., the absence of photosynthetic producers). It is basically an energy *import* ecosystem as are the deep water zones.

If these impressions of mine are correct—and I wouldn't wager on it—they leave me with a perplexing problem. My interpretation of the concept of diversity is that stability is positively tied to a large number of species. As the number of species decreases, populations become more unstable, with more frequent and intense cyclic effects. If this is true as many studies indicate (perhaps none more impressively than those of Russian ecologists monitoring the plowing of the virgin grasslands of the Steppes), why is the cave ecosystem considered a stable environment *despite* sparse fauna and flora that it sustains? I read that this is primarily due to the climatic constancy and low competition of the cave ecosystem which make it relatively easy for the specialized cave inhabitants. I can accept this for highly-adapted cave organisms, *despite* the paucity of species, *only* if I concurrently assume a tenuous balance which teeters on the brink of doom.

What bothers me about this situation is this: if the beneficial effects of climatic constancy and low competition are delicately counterbalanced against the detrimental effects of a low diversity index, what happens when an additional outside stress is applied to the system? What happens when an organochlorine insecticide, from surface sprayings for insect control, appears in cave waters? We know from the lower Mississippi experiences (Ferguson, *et al.*, 1964) that fish *can* develop a considerable resistance to these chlorinated hydrocarbons. However, this resistance developed gradually over a period of time, in populations of species of high numbers, where escape refugia may have been available. Even if *Amblyopsis* or *Orconectes* survives these toxic chemicals, what of the sublethal effects on *reproduction* that we have observed in other aquatic organisms?

Suppose the control agent was one from the other major insecticide group, the organophosphates. What effect would the stimulatory nutrient, phosphorus—one of the metabolites of these insecticides—have on the cave system? Would the temporary infusion of this often-limiting nutrient into cave environs lead to increased populations which would become catastrophically competitive when the increased nutrient level had dissipated?

While the phosphorus import from insecticides is likely to be transient, the same nutrient can become a *chronic* addition from detergent pollution. What effects would a temporally extended enrichment have on cave fauna? Perhaps equally important are the pathogens (bacteria and viruses) that may be attached to the detergent molecule. In caves, where pathogenicity is relatively low, one would surmise that natural immunities and resistance also would be low. The significance of synthetic detergents as vehicles to transport bacteria, viruses, or other biological pollutants greater distances than they might normally travel in ground water has been an area of concern. In this vein, Nichols and Koepp, (1961) although disputed by others, maintained that the presence of ABS-type detergent was a better indicator of possible intestinal viral contamination of drinking water than was the presence of coliform organisms. We know from the Columbian period exchange of pox for the "French Disease" what havoc can be wrought in previously unexposed populations. Soil column experiments (Glotzbecker and Novello, 1975) with sanitary landfill leachate, seeded with 100,000 polioviruses, have indicated the persistence of viral pathogens. After 30 days, 35,000 poliovirus still survived.

Other potential contaminants of caves to watch for are heavy metals (copper, zinc, cadmium, nickel, vanadium, etc.) due to an increasing use of the soil filter for sewage sludge disposal. In addition to naturally-occurring radioactive materials in the lithosphere, what about radiation fall-out from nuclear plants or weapons tests? Also, in view of a potential for higher levels of atmospheric strontium, would cave mineralogical processes, particularly deposition of calcitic minerals, be upset, since it appears that the rarer aragonite is deposited rather than the more common calcite when strontium is present?

I am not suggesting that speleobiologists will be more frequently encountering syphilitic *Stygonectes*, polio-crippled *Typhlotriton*, or copper-clad asellids. I am merely implying that deleterious materials of one sort or another—and the vehicles to transport them to and in ground water—seem to be increasing. As an outsider, I do not see the potential effects of these allochthonous substances as, on the whole, *beneficial* to the cave fauna or flora.

In spite of the potential catastrophic effects of the previously-discussed environmental contaminants, I see the greatest danger to rare cave species as coming directly from another contaminant—the rapidly-proliferating human animal. The number of intrusions into the Stygian realm is accelerating dramatically, as both amateur cavers and cave scientists are increasing rapidly in numbers. I have no way of knowing how many human bodies it takes to release enough heat or carbon dioxide to surpass the tolerance limit for a particular cave "critter." I do not know at what point seemingly infinitesimal changes in microclimate or microhabitat may become significant—insidiously at first, I suppose, at sublethal levels. I *have* been told by bat experts that mere disturbance of these animals in their hibernacula, with the attendance energy cost of their avoidance activities, may be enough to preclude their surviving the hibernation period. The human disturbance factor will, I suspect, make 90 percent of all vertebrate troglobites endangered species by 1990, if extreme restrictions are not instituted.

How, then, does a land-holding agency assume its responsibilities for the cave ecosystem in general, and the threatened cavernicoles in particular? Federal agencies are directed to protect those animals which are threatened. First—and this may be so obvious that it is overlooked—agencies must determine whether or not the particular threatened species is *present* on their lands. All the federal agencies sponsoring this symposium have wildlife and fisheries biologists, so this would appear to be no great problem. It generally is not, until one gets into the area of cave animals. Experts on cave fauna are a rarity in both state and federal agencies. Actually, they may be more often found in groundwater or mineral sections of state or federal geological surveys than in wildlife or fisheries agencies.

Agency biologists are generally not academically equipped for, nor experienced in, assessment of cavernicoles. On the other hand, no administrator wants to face the embarrassment of spending $50,000 to protect a species which is ultimately shown to be *absent* there. Who, then, is to tell us whether or not we have any cave animals to protect? Probably the expertise must come from outside the group, but where? I can only give you examples of two somewhat different approaches used by two regions of the Forest Service.

Both the Southern and Eastern Regions turned to academia for help with their threatened species responsibilities, but each chose a somewhat different approach. The Southern Region contracted with a single individual to make the assessment by *major taxa* of the presence or absence of threatened species on the National Forests of the Southern Region (13 or 14 states). The Southern Region contracted with one individual to do the endangered bird surveys, another individual to do the mammals, and a third individual to survey the reptiles and amphibians. They found the fishes more difficult to handle by a single contract and finally ended with about six separate contracts for evaluating the endangered fishes.

We in the Eastern Region of the Forest Service elected to fund contract surveys with a number of university experts on *specific animals*. For instance, we contracted Drs. Russell Mumford, John Whitaker, and John Hall to do our Indiana bat surveys in Indiana, Illinois, and West Virginia, respectively. We funded wood rat surveys in Indiana and Illinois (Mumford and Klimstra); Eagle studies in Minnesota and Michigan (Frenzel and Mattsson); Sandhill Crane studies in Michigan (Reilly); Kirtland's Warbler studies in Michigan (FWS and Michigan DNR); spring cavefish studies in Illinois (Welsh); northern cavefish surveys in Indiana (Welsh and Keith); and several others.

Each of these approaches has its advantages. Administratively it is easier to work with a single individual under a single contract and receive a report of singularly consistent nature as the Southern Region has done for most orders of animals. The Eastern Region approach perhaps bought more expertise on the particular species under study, at the expense of more difficult administration and more variability in the quality of the final reports. I would add, however, that of 12 or 15 studies, only one was below our expectations.

After an agency is in some manner assured that a threatened species *is* a resident of agency lands, how do you protect it? First, the habitat of the species on agency lands should be defined, and the agency's land management operations within that area examined to see if adequate protection is, or can be, provided. If there are conflicts between the management of threatened wildlife and the management of other natural resources, attempts should be made to resolve these.

Keep in mind three things concerning the Endangered Species Conservation Act: (1) it is a congressional directive to protect these endangered animals; (2) its authority (for federal agencies, at least) is further strengthened by internal directives, and (3) it is firmly protectionistic. On the latter point, some agencies which consider themselves *working* resource managers find the term *preservationist* distasteful. Make no mistake—this Act is presently preservation legislation! John Gottschalk, Executive Secretary of the International Fish, Game, and Conservation Commissioners and former director of the Fish and Wildlife Service has stated: "We have finally come to realize that most species that are threatened with extinction have become so because of man. Our own demands on the environment have caused changes in their habitat with which they are unable to cope. The problem of endangered species cannot be separated from the overriding problem of broad environmental deterioration."

If Dr. Gottschalk is correct in his surmisal that most animals become endangered by man-related activities, let's see if this applies equally to cave animals. In the 1973 Redbook, *Reasons for Decline* are given for each threatened species. There are six cave-associated species on this unofficial list. Some of the reasons for decline of these species are as follows:

Ozark cavefish: "No data. There is a danger of overcollecting."

Shasta Salamander: "...It is also in danger through decimation of the populations by both amateur and professional biologists, due to its rarity."

Texas Blind Salamander: "Capping of wells, draining of underground water sources; heavy overcollection of a very restricted population by amateur biologists and by professional dealers in rare animals."

Indiana bat: "...roosts being disturbed by increasing number of spelunkers and others seeking recreation. Disturbance during bat banding programs. Colonies frequently raided for laboratory experimental animals."

Virginia big-eared bat: "...this species is very intolerant to human disturbance."

Ozark big-eared bat: "...The species is intolerant of human disturbance; disturbance causes the bats to abandon favored roosts."

I am intrigued by the Redbook's remarks concerning the Ozark big-eared bat. The last sentence of this summarization is the ultimate in sardonic pessimism. "This race is known only from occasional specimens found in caves, never more than four at a time. All records probably represent stragglers. Surely there must be a nursery colony somewhere in an Ozark cave. *So long as it remains unknown to man, this race will probably persist.*" (Italics mine)

If human activities are the most immediate danger to these animals, how do we control these activities? Two types of controls have been used, regulatory control and mechanical control. Regulatory controls would include agency regulations, state or federal laws, and/or permits for entry or collection. Where the mere presence of humans has a serious adverse effect on cave animals, mechanical exclusion of humans may be necessary. This may entail cave gating, at the least, or sealing of the cave by concrete or steel as an intermediate protective step. No one, as far as I know, has yet proposed the creation of inaccessible refugia by massive rock breakdown from extensive blasting with explosives. Before using any of these mechanical controls, one must consider whether the means for mechanical control will interfere with the life processes of the animal being protected, and, further, should consider its (the control's) effect on other inhabitants of the cave of concern.

The question of permits is a sticky one. Who should receive one, and which applications should be rejected? For those animals on the official national list, the Act directs the U.S. Fish and Wildlife Service (FWS) to make decisions on permit applications. Applications for permits are sent to that agency's Division of Enforcement, which refers them to the Office of Endangered Species. The permit application must explain the study proposal in great detail.

On the basis of the potential impact on the study species, the permit will be issued or rejected. For example, the Fish and Wildlife Service would be more likely to issue permits requiring no handling of the animal (photographing of endangered species). Intermediate would be mark-and-release studies, in which there is minimal handling of the animal which is released unharmed. Studies requiring the taking, retention, and/or killing of endangered animals would be critically reviewed, and the situation thoroughly analyzed.

As an example of considerations that might be made by the Office of Endangered Species, let's imagine that two collection and retention applications are received for two fish species, the woundfin and the watercress darter. The woundfin, restricted to the lower Virgin River in Utah, is faced with extinction by the construction of a dam. The FWS would probably allow the taking of unrestricted numbers of this species since it is likely to be eliminated anyway. Conversely, it is questionable if approval would be given for the taking of *any* specimens of the watercress darter, known only from a single Alabama spring.

As I mentioned previously, only two cave-associated animals are on the official list. (The gray bat, *Myotis grisescens*, would now have been added to the list except for a procedural oversight in the candidate proposal system.) I must agree with Harvey (1975) that the Ozark and Virginia subspecies of the big-eared bat should be added to the official list. My personal opinion is that two cavefishes (*Amblyopsis rosae* and *Speoplatyrhinus poulsoni*) should be assigned endangered status, and three other amblyopsids should be considered threatened: *Amblyopsis spelaea*, *Typhlichthys subterraneus*, and *Chologaster agassizi*.

The entire extent of my knowledge of cave amphibians is the ability to occasionally spell *salamander* correctly. I leave the assessment of this group to the speleoherpetologists. A number of troglobitic invertebrates are in various stages of consideration for threatened or endangered status.

The point of all the foregoing is that within 3 or 4 years most cave-associated vertebrates and a significant number of invertebrates may be accorded official status as endangered or threatened. For land managers, this will greatly increase the areal need for both surficial and subterranean considerations of caves in land use planning and operations. Agency biologists must become more knowledgeable of, and more involved in, management of all threatened animals, including cave species as well as epigean forms. Agencies with endangered species present (or likely present) on the lands that they administer should welcome, rather than resist, inclusion on the Recovery Team appointed for that species. Although agency biologists often consider themselves of low proficiency with some endangered animals, this makes it even more imperative that representatives of the land-management agencies be included on the team. First, they need the opportunity to learn more about the particular species from specialists on the Recovery Team. Secondly, since management of public lands is involved, the agency biologist must equip himself to translate the impact of endangered species management to other land managers within his organization.

Agency biologists need to be involved in the selection and official designation of *critical habitat*, which will be the focal area of recovery plans. These critical habitat areas may be eligible for special acquisition funding (Land and Water Conservation Fund) and this may affect our acquisition priorities. A Recovery Team for an endangered cave animal needs to draw from protean expertise and philosophy—the cave scientist, the agency biologist, the recreational caver and perhaps even from the surface land manager.

I predict that there will be increasing grumbles about not being able to spray pest-infested forests or rangeland "because of some damned cave bug that nobody ever sees—or wouldn't know what it was if they did!"

I will also predict that land managers will counter our objections to practices detrimental to cave animals, with references to the human disturbance impact by spelunkers and speleobiologists themselves. We must very carefully regulate our cave intrustions (where threatened species are concerned) to obviate this objection and its attendant threat. For populations in which decimation is significantly linked to human disturbance, we must accept stricter regulations of our collecting and intrusive activities. I feel we must expect closer scrutiny of our scientific investigations of caves. Land managers will increasingly be referring investigative proposals to a panel of experts who will determine the validity and need of the particular investigation. If we are to forestall the deleterious practices of surface land use, we—the cave people—must not be, or even *appear* to be, the greatest transgressor.

Although I am an aquatic biologist by vocation, under a pseudonymn I pursue an avocation of writing and poetry. In conclusion, humor me while I summarize my thoughts in rhyme.

Your Challenge

This is a time for apprehension
For all who dig the Stygian scene.
We wonder what the future holds
And what increased cave usage will mean.

With increasing incursions into caves,
Can we still preserve this fragile zone?
Surely we must have the caver's help;
Speleobiologists can't do the job alone.

We who walk in darkness must protect the cave;
Perhaps, then, the public will do the same.
We must regulate *ourselves* as well as others;
Only then can we, too, avoid blame.

We must protect the Indiana bat
Which Man seems destined to extirpate,
Unless its "evil" image we can
Somehow—someway—negate.

Others, too, in the same vein
Face extinction's all-final tomb;
Ingens, inermis, and *poulsoni*
Also totter on the brink of doom.

This symposium must make the public understand
That protective management is the only way—
That the ecosystem of this unique midnight land
Depends also on our management of the lands of day.

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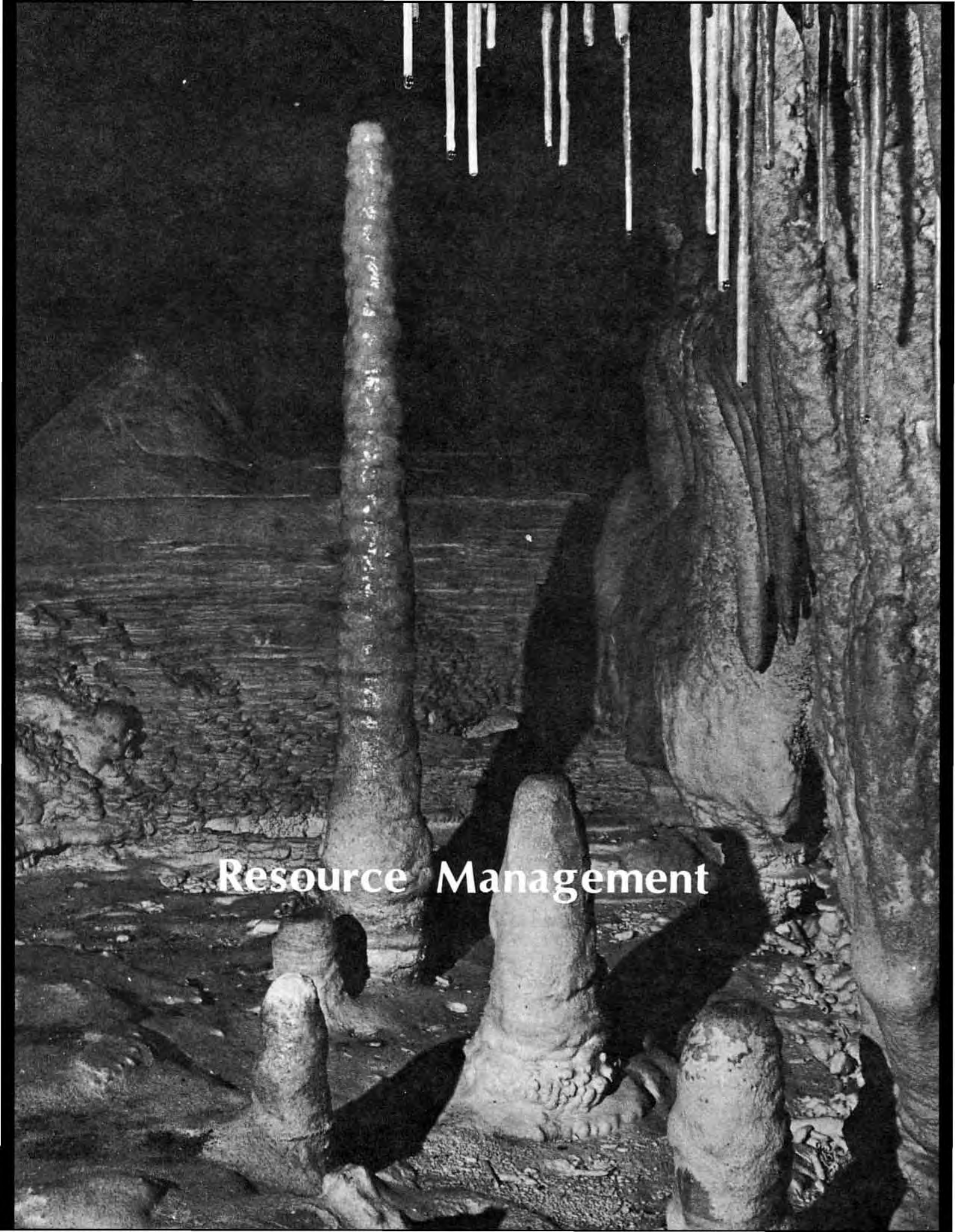
Resource Management

Hydrology and Surface Management

Thomas Aley*

In cave landscapes, the surface and the subsurface are integrally and intimately connected. What happens on the surface affects the subsurface; similarly, what happens in the subsurface affects the surface. It is imperative that we recognize and remember this relationship of the surface and the subsurface. We should also recognize that not all of our cave management problems are related to the control of cave visitors.

Although we have called this a cave management symposium, in reality we are talking about land management of soluble rock terrains. Caves are one feature of soluble rock terrains. There are other features which are also important. The vital point, however, is that you cannot protect and manage the caves without protecting and managing the land in which they lie.

I have a book written by Anton Lubke entitled *The World of Caves*, another by Robert Stenuit and Marc Jasinski entitled *Caves and the Marvellous World Beneath Us*, and a third by Alfred Bogli and Herbert Frank, *Radiant Darkness—The Wonderful World of Caves*. I believe the titles are poorly chosen, for there is no *world of caves* or *world beneath us*. Caves are a component of the world in which we live; they do not exist in a separate world of their own. The idea that caves are somehow separate from the surface world has led to the construction of parking lots immediately above beautifully decorated caves shown to the public. These parking lots have interferred with the quantity and quality of water forming the speleothems.

We tend to view the landscape as a two-dimensional system; the dimensions are length and width. Land is measured in square feet or acres. This system may be fine for the county recorder of deeds; it is not adequate as a conceptual model for the land manager concerned with land management in soluble rock terrains.
terrains.

To properly understand and manage the land, we need to have some vertical dimensions in our conceptual model. Boxes, for example, have three dimensions: length, width, and height or depth. In the case of a box, height and depth are considered to be identical dimensions; the only difference is where you happen to be standing with respect to the box.

The land is different than a box, because dimensions of height and depth are distinctly different. We walk on the surface of the land (at least most of the time). Up consists of air and trees; down consists of soil, rock, and caves. Dealing with the land, there is more difference between up and down than there is between length and width; it seems only fair that if dimensions are allowable for length and width, that dimensions should also be allowable for up and down. Finally, with any natural system everything changes with time. Time is thus a fifth dimension.

Land management in soluble rock terrains should be built on the concept of a five-dimensional matrix. The utility of this concept is that the subsurface would always be considered in land management because it is one of the dimensions upon which the system is built. This recognition of the subsurface, plus the recognition that the subsurface is not a uniform medium any more than any of the other dimensions are uniform, could lead to a substantially better perception of the land and its functioning.

There is an axiom in sociology which maintains that what is perceived is real, for it has real consequences. If we perceive the land as a two-dimensional system, we are doomed to continual errors such as the parking lots atop the caves; what is perceived has real consequences. I believe the five-dimensional matrix provides for a far better perception of the land, and will thus result in beneficial consequences.

Let me use an example from the Ozark Underground Laboratory, in southern Missouri, which I believe will help convince you of the utility of the five-dimensional matrix. The surface in the vicinity of Tumbling Creek Cave is hill and valley land with a local relief of about 150 feet. Bear Cave Hollow is a surface stream which drains several square miles; there is water flow in the surface stream only during and immediately after major rain storms. The reason Bear Cave Hollow does not have perennial flow is that water is pirated from the surface stream into Tumbling Creek, the cave stream.

Tumbling Creek flows roughly parallel to Bear Cave Hollow; Tumbling Creek, however, is flowing beneath Cave Ridge. Tumbling Creek is about 25 feet lower in elevation than Bear Cave Hollow.

If we view the land in the vicinity of the Ozark Underground Laboratory as a five-dimensional matrix, we quickly recognize that the hydrologic valley for this piece of landscape is Tumbling Creek, the underground stream which flows beneath the surface ridge. Water flows out of the channel of Bear Cave Hollow and into Tumbling Creek; hydrologically, this surface valley is not really a valley, but is more properly a ridge or at least an upland area.

There are many surface valleys in the Ozarks which are similar to Bear Cave Hollow. Millions of dollars have been spent in the Ozarks trying to build lakes in these surface valleys (which in the five-dimensional system are not really valleys). These lakes typcially fail. This is a startling occurrence for the two-dimensional land manager. As for us five-dimensional-matrix people, we are not surprised at all; who in his right mind would try and build a lake on a ridge or upland? Lakes have to built in hydrologic valleys.

You cannot protect and manage the caves without protecting and managing the land in which they lie; the surface and the subsurface are intimately and integrally connected. I want to give a few examples from the Ozarks which demonstrate the close relationship of the subsurface to the surface. My concern here is with the impact of surface activities on the subsurface; subsurface activities also affect the surface, but that is outside the topic I wish to discuss today.

Much of my work involves consulting and contract studies on water contamination and pollution problems in soluble rock lands, so most of my examples relate to water pollution problems. One of the greatest problems we have in the

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Ozarks is the disposal of domestic sewage; septic tank systems are commonly used, but seldom provide effective treatment for the wastes.

Sequiota Spring discharges from a cave system in Springfield, Missouri. The spring was once a state park and state fish hatchery; the cave was used as a tourist attraction and boat tours were run about a quarter mile up the underground stream. Then came the urban expansion of Springfield, with the attendent use of septic tank systems.

Today, Sequiota Spring is a city park. The invertebrate fauna of the spring is now typified by bloodworms, *Tubifex*, and similar pollution tolerant organisms; the clean water organisms found at the spring when it was a fish hatchery are gone. The nauseating aroma of sewage permeates the cave through which the underground stream runs; it literally smells like a sewer. The utility of the cave was destroyed by poor land use on the surface.

A different sort of problem occurred at Blanchard Springs Caverns, Stone County, Arkansas. This problem, however, has a happier ending. In the early stages of development at Blanchard, the U.S. Forest Service paved a parking lot updip of the cave. To dispose of runoff from the parking lot, artificial recharge beds were constructed beneath the parking lot.

In 1971 I conducted groundwater tracing work to determine if water from the parking area was entering Blanchard Springs Caverns. I was able to show that it took less than a day for some of the water to travel the several hundred feet from the parking area to the cave. Water running off parking lots is frequently of very poor quality, and could have damaging impacts on the cave and cave speleothems.

As a result of the tracing work, the artificial recharge beds were sealed, and the parking lot runoff water was diverted to an area remote from the cave. The moral of the story is that the surface and the subsurface are intimately tied together, and management of the cave is affected by activities on the surface. The problem could have been avoided if this principle had been recognized before the parking lot was built.

The parking lot problem at Blanchard Springs Caverns had a very beneficial impact on land management planning in the vicinity of the Caverns. Initial development plans called for construction of a large motel complex and a large, compact campground near the cave. After the parking lot problem was discovered, the impacts of the additional developments on the cave system were considered in detail. Both the motel and the campground presented distinct hazards to the water quality of the cave system, and neither was built.

At the Ozark Underground Laboratory I have found a different example showing the close relationship of the surface and the subsurface. To date, we have found about 100 species of animals living in the cave. The base of the food chain in the cave is bat guano. The 150,000 bats which live in the cave during the summer eat about 1,000 pounds of bugs a night; the residue from these bugs provides the bat guano which fuels the ecosystem.

Within the cave, the top animal on the food chain is the Ozark blind salamander (*Typhlotriton spelaeus*). Apparently, however, the salamanders occassionally are prey for raccoons which travel up to several thousand feet into the cave.

We could argue that the bottom of the food chain in the cave is comprised of the surface bugs eaten by the bats, and that the top of the food chain in the cave is the raccoon. If this is the case, then both the bottom and the top of the cave food chain are surface animals. This very nicely shows the intimate relationship between the surface and subsurface.

Those who are involved in land management in soluble rock terrains must consider the subsurface as they plan their activities and make their decisions. Agency personnel must learn to evaluate the impacts of surface activities on the subsurface. Such evaluations are often difficult and require expertise which is scarce both inside and outside of the agencies. Still, if the agencies are to truly be land management agencies (rather than cattle management agencies, timber management agencies, or tourist management agencies), then management of the subsurface must begin.

Management of Biological Resources in Caves

Thomas L. Poulson*

ABSTRACT

Research in caves is important for intrinsic academic reasons, for establishing management baselines, and for providing input into interpretive programs. Research should be encouraged and supported financially. There is the need within caves for untouched areas and for areas that can be manipulated to evaluate the effects of high intensity use and management techniques. Finally, there should be more use of research to update and to lend the excitement of ongoing discovery to interpretive programs.

Caves depend on the surface for food input and management of cave ecosystems must include surface habitat protection. The cave ecosystems require uninterrupted and unmodified flow of water-carried organic matter by diffuse and direct hydrological input. Management must also allow the unmodified migrations of facultative cave animals because they are important food importers, especially at natural entrances. There are different subcommunities associated with different kinds of food input, which includes pack rat nest litter, pack rat fecal dumps, cave cricket guano, cave cricket eggs, bat guano, leached litter and soil from shafts and streams, and backflooded organic silt from rivers.

Aquatic ecosystems are more sensitive to disturbance than are terrestrial cave ecosystems. Aquatic habitats are more restricted in number and area and localized water input makes them more vulnerable to pollutants. Aquatic species are more vulnerable and rebound more slowly because they live 10 to 30 times as long as terrestrial species, have a very low reproductive potential, and breed at infrequent intervals.

Bats are especially sensitive, even to human disturbance as slight as travel past their hibernating or nursery roosts. Bats may use up their hibernating fat reserves before winter's end as a result of even infrequent arousal by humans or as a result of any modification of the microclimate of their hibernating site. Continued disturbance can cause bats to abandon a cave. Disturbance during either summer or winter is critical since only a few caves have suitable microclimates for the more colonial bat species. Finally, insectivorous diets, long life, and long migrations make them sensitive to biological amplification of pesticides.

Applications for permits to collect or study cave organisms should address a uniform set of guidelines as well as specifics for local situations. There should be a panel to evaluate applications. The panel should be comprised of some regular members to assure uniform evaluation and also local experts. All applications should include statements of the need to do a study in caves, relation of the proposal to past or ongoing research, and impact on the species, community, and ecosystem on a short and long term. Additional local constraints will arise from specific management problems and the mission and scope of the agency involved. Collection of rare species and study of fragile and/or unique subcommunities and ecosystems require more restrictive conditions. For example, there should be multiple use of specimens(e.g. observations on live behavior before preservation for anatomical studies) and involvement of experts from different disciplines and with different approaches.

Most of the management ideas presented here have relevance to disciplines other than biology and to natural areas other than caves.

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THE IMPORTANCE OF SCIENTIFIC RESEARCH

The protection afforded in federal, state, or commercial caves is needed for long-term ecological studies that utilize caves as models for other more complex and more economically important ecosystems. It is potentially possible in all caves to know the biology and the interactions of all the component species of a community. With negligible importance of primary producers, caves become a model for more important detrital based systems like litter and soil. The litter-soil system is little understood because of need for indirect methods of study and vast numbers of poorly known species but it is very important because the soil organisms control the rates or inorganic nutrient recycling and thus productivity.

Studies in caves can monitor and manipulate rates and kinds of organic input to give insight into the *rules* that govern community structure and function. In terrestrial systems the organisms are small (0.001 to 10 mg), so they may be studied behaviorally and physiologically under natural cave conditions in the laboratory. Because they do not hide, the larger species can also be observed in natural habitats. Being blind they demonstrate normal behavior when viewed under dim lights. Being small, one can duplicate their natural habitat and do some detailed observations in the laboratory. Long-term protection is critical for observational studies that bridge 5 to 10 generations of the organisms in a subcommunity. Such studies are rarely done in any community but we desperately need such data. In the terrestrial communities of the Mammoth Cave area we have followed several subcommunities for from 6 to 15 years and find great changes in population densities in some cases and changes in community composition in other cases. Some of these observations are in the most stable areas physiochemically and are thought to reflect long cycles in food input, either natural (rhaphidophorine crickets) or man-caused (frequency and extent of backflooding from a surface master stream—Green River). More knowledge of such fluctuations is important both for management and ecological theory.

Long-term protection is also needed for manipulative research which is aimed at testing multiple hypotheses generated by observational studies. In studies of an entire subcommunity it is generally easier to manipulate by increasing some factor and observing the changes in species composition and community behavior. An example is a study using additions of meat, manure, and leaves to an area. This approach is aimed at finding what favors simple communities with a few dominant species as contrasted to complex communities with many species and no dominance. To study interactions of species within a subcommunity, one sets up subsets or microcosms of the whole subcommunity using enclosures so that a certain species can be temporarily removed or excluded. An example is a study on the percent of cricket eggs consumed by a beetle. These field studies of predation show that the laboratory estimates of metabolic cost of beetle foraging are a reasonable estimate of costs in nature.

One emergent property of communities arises from coevolution between interacting species. Such coevolution is likely only in stable-predictable communities where species can *count on* interacting. Among competitors, coevolution may result in narrower niches and, thus, may reduce competition. It is difficult to prove this a posteriori since alone-versus-together experiments may show no competitive release if coevolution has resulted in habitat specialization. On the other hand, prey-predator coevolution is easier to document. The interaction of rhapidophorine crickets with carabid beetle predators is especially well studied and a number of its properties have coevolved independently in at least three prey-predator pairs. This convergent evolution is of interest because it may give a handle on functional properties of communities common to separate ecosystems.

Surely the best known aspect of cave life is the extreme regressive reduction and simplification of vision and pigment systems, to the point where many species appear white and eyeless. The progressive changes are of equal interest but less studied. These adaptations include increases in sense organ number and brain computer capacity, attenuation of appendages, foraging and bioenergetic efficiency, and reproductive risk spreading by having few large eggs laid infrequently over a long life span. Some theories of cave adaptation consider that the loss and gain are intimately related. Thus, reorganization of a species' genetic structure occurs after sudden isolation in caves. However, sudden isolation may be rare, for example with near instantaneous stream capture by an underground drainage. More often, terrestrial organisms seem to adapt gradually near entrances with less food than outside but considerably more than if they were suddenly isolated in caves with no access to entrance or surface habitats. Future electrophoretic analyses of enzyme polymorphism will give insight into the presence or absence of genetic bottlenecks postulated during sudden isolation from surface ancestors. It would be serendipity if agricultural cultivation and/or clearing in sinkhole plain areas did the analogue of interglacial warming and drying in causing extinction of surface populations and so restricting troglophiles to deeper caves. This would allow us to study the initial phases of cave adaptation first hand. It is more likely, however, that such changes will cause loss of important sources of food inport into caves and loss of subcommunities that depend on that import. Therefore it would be wise for the Park Service to buy a piece of sinkhole plain (sinking creek land) now. This could preserve some caves for biological study and the interpretation of regional hydrology.

Management for Research

It is no accident that almost all of the long and short term ecological studies in caves take place in federal, state, or commercial caves: protection by controlled access is the key. Note that I am not talking about research aimed at solving explicit management problems since this need is obvious. I am talking about basic research and contend that it will become an increasingly important use of preserved ecosystems as we develop, destroy, or drastically modify remaining natural areas. As the numbers of natural areas diminish we must have a more formal zoning of caves and the overlying areas upon which the cave ecosystem depends. We will need both unmodified areas for long-term baseline observation and simple experiments (analogous to wilderness zoning) and areas reserved for more complicated manipulative experiments. The wilderness-baseline areas should be varied enough for experiments that suggest multiple hypotheses for explaining the phenomenon under study. For community level studies, the tests of these hypotheses depend on manipulative experiments in the cave. This would include such things as additions of food, in order to test theories concerning the relation of productivity to community structure.

RESEARCH FOR INTERPRETATION AND MANAGEMENT

Research results are often used to update interpretive programs but *ongoing* research is not used often enough to lend excitement of the unknown and discovery to interpretive talks, exhibits, nature trails, and publications: To implement this goal requires greater effort, both by the researcher and the manager/interpreter. In addition to supplying technical publications to manager/interpreters, researchers should institute a section of their annual report, (required by some agencies) devoted to describing new findings and suggesting how they might be incorporated in the interpretive program (The Cave Research Foundation is starting such a section in their Annual Report). The interpreter must also be willing to make an increased effort by reading the technical literature.

It would be unfortunate if the admitted need for resource management scientists, to coordinate research on public lands, precluded an important one-to-one interaction of the interpreter and interpretee. I say interpretee, rather than researcher, to emphasize the value of interpreting research methodology and the unanswered questions. This shows the dynamic aspects of discovery in science. Science presently enjoys a better image with the public than in some recent times, but its image can be further improved by better understanding of how the process of science works. By scientific process I mean the sequence of observations, multiple hypotheses, experiments to falsify some hypotheses, results of experiments feedback to create new and modified hypotheses, and so on. One effective way to interpret the scientific method would be by exhibiting replicates of experimental setups and/or photographic essays in static exhibits, perhaps with slide-tape programs. Other methods are less effective. Occasional public lectures by the scientists are inefficient because they reach only a minority of visitors. Researcher involvement with training sessions for guides is more effective, and should be encouraged, but gives uneven results compared to exhibits.

Free contribution of time and expertise to interpretive and management programs presents a dilemna to the basic researcher. Clearly, the researcher gains long-term insurance of research continuity and protection especially in public or private areas which have security and patrol staffs. However, the manager/interpreter potentially gains more than the researcher in the bargain and so should budget for consulting fees and basic research support as a matter of course. When budgets are cut it may seem expedient to eliminate budget line items for research but consider the long-term gains of basic research as baselines for management and as input to interpretive programs. Researchers in a natural area usually provide continuity because they remain longer than the managers and interpreters. This means that the researchers will want to help, even if no monetary support is present. In these tight times for research funding, remember that the funds for interpretive and managerial advice are coming from the researchers pocket; certainly this is the case for the nongovernment researchers at this symposium.

It should go without saying that research is necessary to provide a management baseline against which to assess the effects of inadvertant disturbance and the effectiveness of deliberate management. Whenever possible, biological surveys should be done, at a community level of investigation, before specific areas are modified. This is in addition to baseline studies that continue at areas *like* those being managed.

Zoning should be by specific category of area and not assigned for each individual area. With knowledge of the local geology and hydrology for any cave region, it is possible to categorize the biological communities, mineralogy, microclimate, hydrology etc. for areas *before they are discovered* by relating potential cave passage types to the surface features. This saves time for the manager and allows identification of management problems and solutions for each kind of passage. For example, the Cave Research foundation has identified hydrological-mineralogical zones for Mammoth Cave National Park and I will indicate how these relate to biological zones in the next section.

SURFACE MANAGEMENT CONSIDERATIONS

Food Input

Caves depend on the surface because autotrophic production is negligible and so management of cave ecosystems everywhere have a common need for surface habitat protection. Basically this means uninterrupted and unmodified movement of water and migrating animals that feed outside and seek the cave for shelter and reproduction. My own work suggests that the biological diversity of a cave depends largely on the number of kinds of food input and the number of locations where each kind of input is to be found.

Each kind of food input has a different terrestrial subcommunity of organisms. Some species are unique to a subcommunity having coevolved and others broadly overlap across subcommunities but with their center of abundance associated with one food input type. Aquatic ecosystems have less distinct subcommunities because they include large species that eat a variety of foods at different ages and so there is less specialization on food type. I will give examples of terrestrial subcommunities in the Interior Lowland region but ecologists believe that there are common principles that allow some prediction of subcommunity structure across cave regions. One such principle is that a food payoff/risk ratio controls subcommunity complexity. High payoff (many calories *available* per gram per time per area) and high risk (high variability and low predictability of food renewal over time and space) favor simple subcommunities. For example, carrion, resulting from an animal falling into a cave, has a high payoff/high risk whereas water-leached leaves and twigs washed down vertical shafts have a low payoff/low risk. Generally high payoff/high risk foods seem to be associated with simple subcommunities where a few short-lived opportunists dominate. Low payoff/low risk foods are associated with complex subcommunities where there are many species of long-lived efficiency *experts* and the short-lived species present do not show dominance. This has definite implications for unnatural kinds of input by man.

Man's input into caves, inadvertant or not, tends to be of the high payoff/high risk category and so favors a few opportunistic species that may not even be part of natural cave subcommunities. Species in natural subcommunities may have coevolved and so there will not be as much dominance in natural food inputs of high payoff/high risk. Man-caused high payoff/high risk organic input includes such items as septic leakage, sewage, garbage, and agricultural erosion.

Hydrologic Input

There are three major kinds of hydrologic input which are important biologically: diffuse flow, concentrated stream input, and backflooding. Each input has a different management problem.

Diffuse flow is associated with carbonate speleothems and has very little organic matter. Parking lots, campgrounds, and even low intensity surface use modify this input. There are only small surface species of protozoa associated with the ceiling drips. In the drip pools below there is a community with bacteria, protozoa, and flatworms, with occasional amphipods and isopods. In these situations there is no particulate organic matter. The flatworms may estivate as the pools dry in some seasons and smaller species of amphipods and isopods may recolonize the pools, as they fill again, by movement through groundwater that feeds ceiling drips.

Concentrated stream input is a two-edged sword; if a sinking stream floods intensely then there is much food but organisms cannot persist. In Mammoth Cave National Park, food input into vertical shafts is low but steady. The perennial nature of this input has been threatened by use in dry years of all the spring output that feeds these shafts. Both the most diverse aquatic and stream-associated terrestrial subcommunities depend on the perennial low input from active vertical shafts and the occasional more major leaf-litter input from older vertical shafts away from the caprock. The terrestrial subcommunity is best developed where the occasional 5-to-15-year floods deposit the leached twigs and leaves, from sinkholes over the older shafts, as a mud-debris veneer on walls and ceiling of the stream passage. This is the terrestrial subcommunity of lowest payoff and risk because there is little food value in leached twigs but they last a long time. There are 12 to 15 species, mostly predators, including: 3 species of carabid beetles, a phalangid, a webworm (fly larva), a rhagidid mite, a millipede, a bristletail, a scavenger beetle, the cave *cricket*, and 2 to 3 collembola. The confluence of several vertical shaft drains in an area forms a master drain which contains the upstream aquatic community of the region. This community includes a small cave fish (*Typhlichthys*), a crayfish, an amphipod, an isopod, a flatworm, and the base of the foodweb which is poorly known—copepods, protozoa and bacteria.

An example of the third kind of hydrologic input is *backflooding* from Green River, the local master surface stream of Mammoth Cave National Park. Obviously any river pollution, organic or otherwise, affects the quality of this input. The spring-winter backfloods cause input of low-organic-content silt into the cave where terrestrial subcommunities persist at the higher flood zones 40 to 60 feet above base level, which is about the height of past 10 to 20 year summer floods. These rare summer floods are caused by hurricane effects and have now been stopped by upstream dams on Green River. These summer floods bring in richer organic matter than winter floods, because there are blooms of plankton in the river during the summer. Such blooms may be even more important to the aquatic big stream shrimp pools, than to the terrestrial community. Further back from the shrimp pools, at the edge of the severe flood zone, is the crayfish and large cave fish (*Amblyopsis*) community.

Biological Input

There are three major kinds of biological input into caves. Bat guano and carrion, cricket guano and eggs, and pack rat nest litter and feces. Organisms which provide this input feed outside of caves and use caves for shelter and reproduction.

Bats that have summer roosts in caves contribute guano and carrion (dead young bats) which are the basis of different subcommunities. The succession of fungi on bat guano seems to favor subcommunities dominated by mites and flies with pseudoscropions as the major predator. In a big bat cave one can test the importance of different payoff/risk functions on the same food type by looking at guano piles of different sizes (ages) with different rates and patterns of renewal.

Rhaphidophorine *crickets* roost near cave entrances when foraging outside at night from late spring through early fall; in late fall they go deep into the cave to mate and lay eggs. One subcommunity is based on their guano near entrances and the other on their eggs deep in the cave.

In loose sand or silt areas, deep in the cave, carabid beetles prey on the cricket eggs and their feces form the base of a food web composed of small arthropods. These include two collembolans, three mites, and a bristletail among the nonpredators and a pseudoscorpion and mite as predators. This is perhaps the commonest terrestrial subcommunity in the Flint-Mammoth cave system and so is one for which we are accumulating long-term data.

At suitable entrances, with no or little cold-dry air input in winter, the thin veneer of guano from large cricket roosts stays moist and supports a subcommunity of small species. The fresh feces attract occasional scavenger beetle larvae but are monopolized by a collembolan which reproduces prodigiously (as many as 150/turd) and is fed upon by occasional carabid beetles and fungus gnat larvae. The more stable part of this subcommunity includes a Sminthurid collembolan which is preyed on by a pseudoscorpion. There is a snail, a millipede, and a mite that are associated with the old guano and are found in no other subcommunity. This part of the subcommunity is not found at every cricket roost since it depends, apparently, on a large population of crickets *and* the correct entrance microclimate. At such places there may be populations of a larger troglophilic predator (e.g. spider) that eats adult crickets.

In the forested areas of central Kentucky, every cave entrance has at least one cave rat (*Neotoma*) whose activities support two subcommunities. There is a leaf-litter subcommunity, associated with the nest and food cache area, and a fecal subcommunity, associated with the separate fecal dump area. Both of these subcommunities have added complexity caused by microsuccession. The microsuccession is caused by heterogeneity of the material and by seasonal cycles of input. Leaf and fecal input increase especially in fall with food storage, nest building and fattening of the rats. In addition, spatial complexity is added since there is always some new and old leaf litter and fecal matter at any one point in time.

The leaf-litter subcommunity, which can also be supported by gravity input at cave entrances, is a simplified version of forest leaf litter. Among predators it includes two species of carabid and two staphylinid beetles, two centipedes, a phalangid, a pseudoscorpion, a mite, and a spider. The non-predators include three or four species of collembola, two or three mites, two flies, a scavenger beetle, and a millipede. These species are partially separated by successional stage, moisture, and density of the litter.

The *Neotoma* fecal dump subcommunity has higher payoff and risk than litter, and so a simpler structure. Depending on microsuccessional age and moisture, either a fly larva or a collembolan are the dominant grazers while the dominant predator remains a large species of staphylinid beetle inside the pile, with occasional fungus gnat larvae as surface predators. In addition, there is a mite component with an

A Cave Cricket (*Ceuthophilus sp*) Photographed in a New Mexico Cave. *Photo by Pete Lindsley.*

early and late saprovore and a rhagidid predator. The mites may depend on the fungi which show their own microsuccession on the feces.

Management of Terrestrial Entrances

Natural entrances with a moist-cool microclimate year around will have multiple subcommunities and so should not be developed as people entrances. Even mere enlargement of entrances can modify microclimate and gating, for security and protection, should allow unimpeded flow of air and movement of cave organisms. Aside from biological interest, it is often more economical to develop an artificial entrance that leads directly to tour areas. In so doing absolute air locks are a necessity to prevent microclimate changes, especially drying, which can harm speleothems and cave organisms. One exception to the air lock, however, is with old artificial entrances that have been abandoned so long that entrance subcommunities have developed or bats have come to use the cave entrance as a hibernating site.

Natural entrances with forest or native vegetation outside them are of special interest because they allow study of interactions between surface and cave communities. Here I refer to surface organisms in the same functional niches or *guilds*, as the cave forms and not the winter hibernating *guests*. In addition to the forest floor analogues of the cave subcommunities, there are species of spiders and flies that seem to occur only at entrances and damp limestone overhangs. The species involved are predictable and these may form a subcommunity that is based on microclimate rather than food type, as in caves.

Aquatic Entrances

Both sinking and emerging streams are of interest because there are gradients of decreasing food and light along which facultative cave species decrease and related obligate species increase. This natural experiment gives insight into two alternate explanations: competition and the specialization to high versus low food supply. Sometimes the inflowing streams carry flood debris with such force that no cave organisms can live in the immediate area; this makes inflowing of less value as a natural experiment compared to outflowing streams.

AQUATIC ECOSYSTEMS ESPECIALLY VULNERABLE

Compared to terrestrial cave subcommunities, there are few examples of an aquatic subcommunity in a given cave or cave region; thus, man-caused modification or loss of one of these subcommunity *islands* may be serious. With few islands, there is lowered likelihood of regaining species lost due to random events or disturbance. Pollution can exacerbate such problems.

Cave stream communities are especially vulnerable to pollution. The watershed for a vertical shaft complex may be large enough to concentrate any pollutants to a small point at the shaft. Conversely the local pollution in one vertical shaft area may be spread through the entire base level of the cave if there is a large Green River flood which backfloods into the cave. When the Green River rises 30 to 60 feet, this head forces water miles upstream in the cave across dry season drainage divides. Furthermore, cave stream drainage divides do not correspond to surface drainage divides and, thus, it is not easy to predict where pollution will go or where it is coming from.

The most spectacular members of aquatic cave ecosystems—fish, salamanders and crayfish—are long-lived species which grow slowly, mature late, breed infrequently, and have a very low reproductive potential. These characteristics are adaptations to a low food supply and organic pollution will favor short-lived opportunists and simplify the community. The long lives and low reproductive potential mean slow or no recovery from even one-time physical disturbance or collecting. Mark-recapture growth studies suggest that some of the cavefish live to 20 years and some of the crayfish from 50 to 60 years! There are always missing age classes and most age classes have only a few individuals. The species are always super efficient bioenergetically. In short, all of this suggests a precarious existence under natural conditions. Thus, any unnatural conditions, such as human disturbance, could be the proverbial *straw that breaks the camel's back*.

Being a top-level and long-lived predator intensifies the problem of biological amplification of pollutants along food chains. We have no evidence yet for such effects in caves, but increased concentration with age is a problem especially in long-lived fish. There is clear evidence of reproductive system upset in birds (the thin-egg-shell syndrome). Fish, are also vertebrates and so share many aspects of reproductive physiology with birds.

BATS

Cave bats and bat guano ecosystems are a special management problem. The reasons for this are covered in detail in the National Speleological Society Bulletin (Volume 34, Number 2, pages 33-47) which deals exclusively with bats (see also "The Protection of Threatened Cave Bats" elsewhere in these *Proceedings*). Suffice it to say that cave bats require special microclimates for summer nursery colonies and for winter hibernation, any human activity at either time can be sufficient to kill bats or make the colony leave the cave, often permanently. In summer nursery colonies, one can avoid the problem by making few visits restricted to the night hours when the adults are out feeding. In winter *any* visit could cause excessive depletion of hibernating fat reserves; therefore, hibernating sites in caves should be completely *off limits*. The reason is that awakening from and returning to hibernation over a several hour period uses as much fat energy as staying in hibernation 2 to 3 weeks! In conclusion, each species requires a particular microclimate combination of wind, moisture, and temperature, especially in winter hibernating sites. These sites are colder, drier, and windier than entrances that have good terrestrial cave communities so one should not try to encourage other cave organisms by gating entrances to improve the microclimate because it will ruin the microclimate for bats.

PERMIT SYSTEMS

Permit applications to undertake research studies or to collect must be addressed to some overall guidelines and an overview panel should conduct the initial evaluation of the applications. In addition to addressing each of the problem areas identified earlier in this paper, there are other general questions that should be addressed by each applicant for a permit:

1. Could it be done better outside of caves?
2. Does it build on previous studies done in caves *and* in in the general discipline involved (e.g. does the applicant show familiarity with the literature)?
3. Has such a study been done before locally, elsewhere, in less detail or with a different approach?
4. Does it overlap or complement ongoing studies by others?

For fair evaluation of such an application I believe we need a panel of three to five scientists, each with cave-related knowledge cutting across at least three of the following fields:

1. Biology, especially ecology and evolution;
2. Microbiology;
3. Geology, especially karst geomorphology and hydrology;
4. Microclimatology;
5. Paleontology;
6. Mineralogy;
7. Archeology and Cultural History.

In karst studies this is not a pie-in-the-sky requirement! The above scheme covers a need not met by scientists who apply for research funds to National Science Foundation, etc. (where the ideas and methodology are the prime review targets). However, it may be characterized as necessary but not sufficient. To make it sufficient requires meeting local constraints as well.

Passing the proceeding general guidelines insures scientific worth and specific local requirements should usually be a matter of friendly negotiation rather than grounds for denial of the application (unless we are considering rare ecosystems or endangered species as discussed later). A two person local panel would include the local manager/interpreter and a scientist familiar with local problems for the project in question. There may be legal enabling act constraints or mission and scope constraints for the manager/interpreter's agency and there will be local problems with carrying out the research that must be resolved with the local scientific panelist.

Further restrictions are required when dealing with rare or unique systems and species although meeting these restrictions would make *any* study more valuable scientifically. In general I mean multiple approaches to study and multiple kinds of data collected. Different approaches and methodologies, especially by different experts, gives insights not gained by one investigator.

For manipulative study of ecosystems, a permit applicant must also address questions such as the extent of baseline studies required, the time required for the area to return to baseline after manipulation, and localization of the manipulative effect. The type of application review will of course depend on the number of areas like the one under study and the vulnerability of the system (e.g. aquatic versus terrestrial *or* terrestrial cricket-beetle area versus terrestrial bat guano system).

The most severe restrictions of all fall on collection of specimens when species are rare, endangered, long-lived, or important key components of a subcommunity or ecosystem. In general, prospective collectors must show that the specimens are not already available in museums, or from biologists studying the species, and cannot be collected in nonprotected areas. If a potential collector can satisfy all these questions, then the following additional guidelines should be addressed:

1. That collections are to be made in areas where only edges of a population are accessible because large populations should be reserved for ecological study;
2. That numbers to be collected must be justified in terms of the study and the rarity and vulnerability of the species;
3. That specimens must be studied by multiple approaches and shared by a variety of investigators.

To enlarge on point 3, one might start with live organisms, and conduct studies of behavior and physiology before preserving the specimen for various anatomical studies. If reproductive cycles or food studies are important, then the specimens must be preserved at the time of collection. In such cases partitioning of the specimen, to allow optimum preservation for different studies by different experts, may be advisable. To summarize, multiple use by multiple experts with multiple approaches is the keynote requirement.

As a matter of course, denials of permits must present the reasons related to either the scientific guidelines or local management restrictions. Suggestions for improvement and resubmittal may be made when the application shows scientific merit but is deficient in meeting management requirements.

Collections

In general, local reference collections of single specimens are good but should be kept only if there is time and budget to maintain them! Carefully curated collections help to shortstop requests for collecting permits by visiting scientists. If the specimens are identified by experts, then the reference collection performs an additional value for ecologists that are doing bona fide research but do not have taxonomic expertise with all of the groups being studied. In addition to the reference collection per se, all organisms that die during live exhibition should be preserved with place and date of collection plus date of death. For many anatomical studies such specimens are perfectly acceptable.

Reference Files and Libraries

Libraries should serve both the visiting scientist and the manager/interpreter. This means having multiple copies of the most general cave reference books and single copies of technical books, journal publications (regular subscription), published technical reports, and theses completed at the site. Copies of slides and topics of talks given to lay audiences by researchers at a site are particularly useful to the interpretive staff. Such copies are also helpful to a researcher interested in starting work in an area.

Reference files should be maintained for unpublished material. Researchers might consider separating reports into confidential material for closed files and material available to qualified investigators in an open research file. Generally speaking, the closed file includes correspondence about and reviews of research projects, copies of grant requests, and summary data. For the open file to be useful, in coordinating research in an area, it should include correspondence about identification of specimens and location of natural areas, annual reports of the investigators, and outlines of ongoing research projects.

Wilderness Cave Management

Robert Stitt*

THE CAVE AS WILDERNESS

In 1964 Congress passed the Wilderness Act,[1] which set aside vast areas of lands in the United States as part of the National Wilderness Preservation System (NWPS) for the purpose of preserving for the people of the United States an enduring supply of wilderness for their enjoyment and so that the experience of this wild state would not fade from human memory. Today, more than ten years later, a review process has been substantially completed, and many hundreds of thousands of acres have been or are being added to the NWPS. Significantly, however, no caves and very few lands containing caves have been added to the System.

When the Wilderness Act was passed, it was estimated that approximately 1000 caves were included in lands then considered eligible for inclusion in the NWPS.[2] The completion of the Review process, continued exploration and cave discoveries may have doubled that number by now. But no lands have been added to the System specifically for the cave values they contain. All lands have been added based upon their surface values.

Caves represent one of the best and, perhaps, last wilderness resources that we have in the world today. The underground world is truly the last frontier. Below the surface are vast areas untouched by human feet. These areas represent the most pristine wilderness that we have, for most surface areas have been walked upon or viewed by humans; but there are underground areas that have never been viewed by human eyes, let alone walked upon.

The Wilderness Act and the NWPS represent a legal definition of wilderness; inclusion in the NWPS is a valuable management tool to assure that the goals of management are aimed at preserving the wilderness state. However, a wilderness is still a wilderness, even if not included in the NWPS, and particularly in the case of caves, underground wilderness can be preserved and maintained by certain management techniques and procedures, even though the area is not presently included in the NWPS. In fact, it is the position of many cave conservationists that all caves should be administered as though they were wilderness, unless they have been specifically dedicated to a nonwilderness use, such as developed recreation, tourism, or industrial purposes. In that way the maximum utilization of the resource can be obtained, since development can destroy the wilderness character of the cave and in many cases render it unfit for wilderness type recreation.

The cave environment is fragile, and can easily be destroyed by simple acts. Once destroyed, it can in most cases never again be returned to its original, wilderness state. The cave environment essentially represents a closed system, with few inputs and few outputs. It, thus, is a unique laboratory for the study of ecology and other environmental problems. Caves have several values to the public: for recreation, both wilderness type and developed; for scientific research, and as a management baseline for the management of other caves. Every day thousands of people visit over 200 developed caves in the United States. Several hundred thousand people, about 5000 of them members of the National Speleological Society, enjoy wilderness-type cave exploration. The field of speleology is growing, as a scientific discipline, and there are an increasing number of institutions devoted to cave and karst research in the world today. The value of caves is increasingly being recognized by the public and by land managers. But just as use of caves is increasing, so is the damage and destruction caused by human intrusions upon the cave environment.

It is ironic that some of the same features of the cave environment that attract the attention of the public are also destroyed by that public as they take home souvenirs, touch formations leaving oily fingerprints, or leave their trash and litter in the cave. But just as certain features of the cave environment make it susceptible to such problems (its dark and hidden nature encourages vandalism; a sense of wonder leads one to touch; and our out-of-sight, out-of-mind approach to waste disposal makes caves a natural disposal point for all manner of things) other features make it relatively easy to manage—if one only goes about it right. For example, a gate at the entrance can restrict traffic into the cave, and effectively provide protection.

WHAT IS UNDERGROUND WILDERNESS?

Many papers have set forth the concept of underground wilderness,[3] and I will not go into the subject in depth here, nor present in detail the arguments favoring the inclusion of subsurface lands in the NWPS, since the Department of the Interior has recently, after a long battle by conservationists, accepted the legality of the underground wilderness concept.[4] But in order to discuss management problems in the underground wilderness environment, it is necessary to define underground wilderness.

Wilderness has been defined in many ways. The following definitions are pertinent to the discussion of underground wilderness:

- Wilderness is land untouched by man;
- Wilderness is land where the effects of man's activities are substantially unnoticeable;
- Wilderness is land that gives the psychological feeling of being remote from the activities of man.[5]

All three of these definitions are perhaps met nowhere better than in the underground wilderness environment.

The inclusion of the subsurface as well as the surface of the earth in the legal definition of land is clearly established in American law. Likewise, the division of land by boundaries in a vertical as well as horizontal plane is clearly established through countless court decisions and common legal practice.[6]

Underground wilderness is a logical extension of the concept of wilderness as defined in the Wilderness act, and embodied in the definitions listed previously. Only the concept of vertical boundaries can be considered new to wilderness land planners—and that concept is gaining increasing acceptance. It remains only to put it into practice.

If certain precautions are taken in managing the surface lands, there is no reason why underground wilderness

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cannot exist under surface lands which are not of wilderness character. But there are differences in the nature of surface and underground wilderness which are important to consider in planning for management of the spelean resources. For example, underground wilderness is less accessible than surface wilderness, In many cases, it cannot be entered at all. In most cases, entrance is gained through a small number of point sources (entrances), which may be at widely scattered locations. In contrast, the surface wilderness is enterable at all points on its periphery, and can be entered from the sky above. The large perimeter of surface wilderness necessitates a buffer zone, to shield the wilderness from human influences. This buffer zone is not necessary to protect underground wilderness.

The decreased accessibility of the underground wilderness has both advantages and disadvantages from the management standpoint. For example, it is usually easy to control access to the cave environment through installation of a gate, or gates, at the entrances. But at the same time the difficulty of access makes it hard for land planners, scientists, environmental analysts, and others to reach the cave environment to monitor it for pollution, degradation, or vandalism. Special training may be necessary for management personnel. In some cases, access to the underground wilderness environment may be limited by endurance factors; in others by the size of the passage or the simple technical expertise necessary to do a 1000-foot free rappel. These factors mean that in some cases it may be impossible to directly monitor the wilderness; often managers may have to rely upon the reporting of cave users to determine the effects of usage.

A second difference between underground and surface wilderness is the higher fragility and non-renewability of the underground environment. If the spelean environment is damaged through over-use or improper-use, vandalism, pollution, or lack of management, in most cases it will never recover; at best it will recover very slowly. Damage to most features of the surface environment is self-repairing (in the case of biological features) or difficult to effect (in the case of most geological features). Cave formations, once damaged, will rarely regenerate, and in those particular instances where the correct combination of factors prevails, repair will be slow.

In a separate paper, presently in preparation for the *NSS Bulletin*, I have identified and described briefly more than 75 human impacts upon cave systems.[7] While many of these impacts will not occur in individual caves, and, hopefully, should not be found in the wilderness environment, sound underground wilderness management planning must consider all of these factors, and be ever alert for them. These generally include external effects such as air and water pollution, surface and underground construction, and improper land use; as well as internal effects arising from visitation, lighting systems, etc.

The goal of underground wilderness management should be to maintain the cave environment in a natural state, with human effects substantially unnoticable. Since any use probably causes some damage, it will be necessary to accept some gradual degradation. With proper management it should be possible to keep damage at acceptable levels, allow use under controlled circumstances, and still maintain the wilderness character of the cave environment.

MANAGEMENT METHODS FOR UNDERGROUND WILDERNESS

Access Control. The most effective method of access control is inclusion of the cave in a surface wilderness area. This assures that users will have to surmount the barrier of self-propelled travel to reach the cave—this should eliminate most casual users and most vandals. However, as backcountry use becomes more popular in a cave area, it is likely that additional precautions will be necessary to assure protection of the caves. Some of these precautions can be incorporated into surface management planning: trails can be routed away from cave areas; issuers of use permits can require special permits for caving activities; and descriptive materials can de-emphasize caves. But in many, if not most, cases further management techniques will be required.

The most useful management tool within the cave is probably the gate. For several reasons, the gate is not a universal panacea—but a properly installed gate, especially in a wilderness area, can provide a high degree of protection. Continued maintenance of the gate, and patrolling at frequent intervals, is necessary to assure its success. In general, gates should probably be placed just within the entrance of wilderness caves to minimize aesthetic impact upon both the surface and spelean environments. A gate is most effective when coupled with a use permit system.[8]

Signs placed strategically, as well as cave registers, descriptive materials passed out when issuing permits and the presences of personnel may also be useful in channelling traffic and educating the public.

Permanent closure of caves is a technique often considered by well-meaning persons who do not wish to follow more complicated methods of cave management. However, this management device should be considered only as a final resort, since it can upset the cave ecosystem, deny access to everyone, and prove a costly alternative should the decision be made to reverse the process and allow access again.

Developments within wilderness. The Wilderness Act permits certain developments within wilderness areas which are compatible with the purposes of wilderness and which are necessary for maintainence of the wilderness values. On the surface, trails, simple shelters, signs, and corrals, for example, are permitted; as are water control projects. In the cave environment, more care must be taken to assure that cave features are not damaged, but this should not preclude the establishment of simple marked trails (or routes), the installation of minimal climbing aids, or the use of cave registers, removable signs and direction markers. Since part of the wilderness caving experience is its self-propelled nature, permanent ladders, stairways, and built-up walkways would not be allowed in the wilderness environment. A rule of thumb for wilderness developments, as those on the surface, should be that they are substantially unnoticeable.

Education of the cave user. An important tool for minimizing management problems in underground wilderness areas is education of cave users before they enter the caves. The National Speleological Society, for example, attempts to educate its members about cave conservation and safety, and it is hoped that most members of the Society are responsible users of wilderness cave resources. But the NSS probably includes only ten percent (at most) of the cavers within the U.S. As caving becomes more popular it is likely that the influence of the NSS will decrease in the caving community (although the Society is presently actively engaged on several fronts in attempting to remedy that problem). Thus, education of users at the point of use, or slightly before use, is probably the most effective approach for most cave users.

Several techniques have been used. Material handed out when permits are issued may be disregarded by the cave user, but should have some impact in the long run. Signs placed in the cave environment, or near the entrance, may have some effect. The NSS is presently moving into high gear with a cave register program designed to determine who is caving, as well as provide names and addresses of cave users to whom educational materials can be sent. The NSS is starting a new publication aimed at educating nonmember cavers about cave conservation, techniques and safety, and speleology. Tentatively entitled *Caving*, it is planned to start publication in January 1976. Copies of selected issues will be made available to land owners, management agencies, and others who are in a position to educate cave users.

Scientific Responsibility. In this era of ecological consciousness on the part of laymen as well as the scientific community, it should be unnecessary to mention the need for professional, selective, and minimal scientific collecting —but in the field of speleology there are so many amateur scientists at work that it is necessary. All scientific work in wilderness caves should be conducted by permit, and permit issuing agencies should be selective and cautious in issuing permits.

SOME SPECIFIC PROBLEMS

Endangered and threatened species, vandalism, and speleothem mining are some specific facets of wilderness cave management which deserve separate consideration. Most of these topics will be covered elsewhere in the symposium, but I would like to touch on their relationship to wilderness management.

Endangered Species. It is the opinion of many scientists that about 10 percent of all species of animal life on earth are endangered at the present time. It may well be that in the spelean world, the percentage is even higher. The reasons for this lie in the unique and fragile nature of the cave environment. Many cave species have been collected, or probably exist, only in a single cave. If that cave is endangered, then the species that inhabit it may be endangered. For this reason, maintaining caves in the wilderness state can be a valuable tool for the protection of endangered species. Even if a cave cannot be included in the NWPS, a wilderness management philosophy should be applied to help preserve the life within it.

Vandalism. Prevention of vandalism must, of course, be an important part of wilderness cave management. But wilderness designation can also be a tool used to prevent vandalism. Inclusion of a cave in a surface wilderness area can limit access and reduce the influx of casual vandals. Just calling a cave *wilderness* may influence users to treat it better. And certainly the methods used to manage it as wilderness should reduce vandalism in the long run.

Speleothem mining. As long as a market exists for cave formations, there will be those who strip caves of their formations for sale to tourists and others for souvenirs and collections. Present efforts of the NSS have been aimed at drying up the market by using moral persuasion to stop the sales, as well as providing more protection for the caves that are as yet unvandalized. Secrecy has been used by many cavers in an attempt to keep knowledge of locations away from vandals. But wilderness can also be a valuable tool in preventing mining. Inclusion of caves in surface wilderness areas can limit vehicular access and make caves less attractive for illegal mining activities. Wilderness management techniques can reduce the accessibility of caves and increase recognition of vandals. And finally, if the public learns to appreciate caves in their natural, wilderness state, perhaps they will be less willing to buy dried-out speleothems, but instead will be content with visiting the caves and taking home photographs.

LEGAL PROTECTION

Legal protection of cave features will on the whole be discussed elsewhere,[9] but here I would like to comment on the need for further wilderness legislation to assure that caves are included in the NWPS. Even though the legality of including caves, and underground wilderness, in the NWPS has been accepted by the National Park Service, to date no caves have been included except as part of a broader, more comprehensive wilderness, which was mainly added to the NWPS because of its surface values. Quite clearly, it would be desirable for Federal Agencies to review all of their lands containing caves for eligibility for the NWPS. This process could be carried out over a period of years, and should not interfere with the continued management of cave resources by the various agencies. In fact, it might be a valuable impetus to the agencies to develop cave management programs for the continued protection of the caves.

CONCLUSION

I would like to conclude with a personal thought about the direction our cave management planning seems to be taking. There is a tendency on the part of land planners to insist that they cannot plan for management unless they have completely inventoried the resource involved, and know it completely. In the case of caves, however, this may be a self-defeating attitude. There is no reason why we need to have completely measured, studied, and trekked over a wilderness area—in fact, if we do not know it completely, it would seem to remain a higher quality wilderness. Caves, by their very nature, may never be completely known. That is what makes them such an intriguing wilderness resource, and contributes to the wilderness experience.

Dr. Arthur Palmer and Margaret Palmer recently summarized the contrasting attitudes of British and Yugoslavian cavers they encountered on a trip to Europe. The British cavers they compared to American cavers, and (by our standards) declared them to be the best in the world, with their push attitudes and the constant desire to make new discoveries.[10]

> *The British team was curious why the Yugoslavs didn't expend more effort at making new discoveries but were content to explore new caves at a leisurely pace and one at a time. The response of the local cavers can be paraphrased as follows: "Caves are a finite resource, and a new discovery is something to be savored; if all the discoveries are made now, there will be none left for our children and grandchildren to discover."*

The Palmers close by asking *Which is the more mature attitude?* as do I.

NOTES

[1] Wilderness Act of 1964, 78 Stat. 890 (1964), 16 U.S.C. 1131 *et seq.* (1965).

[2] Schmidt, Victor A., in *Hearings of the House Interior and Insular Affairs Committee on H.R. 9070*, May 23, 1963.

[3] The list of these works is too long for inclusion here. However, the best of the studies on underground wilderness

include: National Speleological Society, *A Wilderness Proposal for Mammoth Cave National Park, Kentucky*, Vienna, Va: National Speleological Society, 1967; Davidson, J.K. and Bishop, W.P., *Wilderness Resources in Mammoth Cave National Park: A Regional Approach*, Columbus, Ohio: Cave Research Foundation, 1971; and Stitt, R.R. and Bishop, W.P., "Underground Wilderness in the Guadalupe Escarpment: A Concept Applied," *Bulletin of the National Speleological Society*, 34(3):77-88, 1972.

[4] Reed, Nathaniel, Letter to Robert R. Stitt, May 12, 1975.

[5] Davidson and Bishop, p. 23.

[6] Stitt, Robert R., "Legal Brief: Law and Sound Policy Require the National Park Service and the Secretary of the Interior to Review the Underground Portions of Mammoth Cave National Park as to their Suitability for Wilderness under the Wilderness Act of 1964," unpublished paper, June 25, 1974. (Submitted as part of the Hearing Record for the Mammoth Cave National Park Wilderness Hearings, May 27, 1974.)

[7] Stitt, Robert R., "Human Impact on Caves", a manuscript in preparation for the *NSS Bulletin*.

[8] Hunt, Geoffrey, and Stitt, R.R., *Cave Gating, A Handbook*. Huntsville, Al.: National Speleological Society Committee on Conservation, 1975.

[9] Stitt, R.R., "State Cave Protection Laws and Their Enforcement," elsewhere in these proceedings.

[10] Palmer, Arthur, and Palmer, Margaret, "Caving in Yugoslavia," *California Caver*, 26: 82 (September 1975).

The Protection of Threatened Cave Bats

Charles E. Mohr*

ABSTRACT

Since 1966 some protection has been given by the Federal Endangered Species Act to nongame species of wildlife whose survival is in jeopardy. Representatives of cave ecosystems are included, bats being by far the most prominent and abundant. Organized cavers and loosely affiliated bat research specialists have recently taken steps to reduce and eliminate disturbances to bats in caves. Increasingly strict interpretation and enforcement of regulations affecting Endangered and Threatened Fauna have placed new responsibility on federal and state land managing agencies. Cave management procedures in particular require more information on ecosystem diversity and dynamics than is presently available. Surveys of endangered and threatened cave-dwelling bats have already been launched by federal agencies represented in this symposium. Some of the findings are reported here and guidelines for further investigations are considered.

The deliberations of this First National Cave Management Symposium establish a solid plateau from which significant, far-reaching results may be confidently predicted. We are ready to move forward because:

(a) National legislation has provided a legal basis for protection of cave assets, including Endangered Species of cave fauna.
(b) Federal agencies have recognized and accepted responsibility for enforcement.
(c) Scientific data is providing a sound basis for management procedures.
(d) Some recovery plan proposals for endangered species are ready for implementation.

Concern for the preservation of the biological, archeological, and mineralogical contents of caves has long existed, but scattered legislative action failed to provide much protection.

As long ago as 1952, the National Speleological Society cautioned its members against disturbing hibernating bats and reported the apparent disappearance of the Indiana bat, *Myotis sodalis*, from New England and Pennsylvania (Mohr, 1952, 1953).

In 1966 Congress passed the first Endangered Species Act. The U.S. Fish and Wildlife Service (1966) listed two bats: the Hawaiian hoary bat, *Lasiurus cinereus semotus*, and the Indiana bat, *Myotis sodalis*, whose entire population gathers in a few caves to spend the winter.

At the Philadelphia meeting of the American Association for the Advancement of Science in 1971, the National Speleological Society conducted a symposium on cave bats. In a paper on threatened species, Mohr (1972) summarized the findings of University of Arizona biologists (Cockrum, 1969, and Reidinger, 1972) which strongly implicated the widespread use of agricultural pesticides in the well-documented, drastic decline of nursery populations of cave-dwelling free-tailed bats, *Tadarida brasiliensis mexicana* between 1952 and 1969. The opinion was expressed that *Tadarida*, despite its abundance was a threatened species.

In the same paper the findings of two surveys were reported. An NSS survey revealed that most grottos and regional groups were aware of the apparently harmful effect of spelunking disturbances and were willing to curtail visits to bat caves. Seventy-three university-based bat banders, responding to a questionaire from the U.S. Fish and Wildlife Service, agreed that banding activity sometimes had serious effects on bats. They reported collectively that 22 of the 40 North American species appeared to be declining (Jones, 1971).

At the Third Annual North American Bat Research Symposium in San Diego in November 1972, resolutions were adopted, (1) urging the U.S. Fish & Wildlife Service to halt banding projects, (2) recommending that the NSS suspend caving trips to key bat caves, and (3) advising universities to drastically reduce entry into bat caves for university-related research purposes.

MEASURES TAKEN TO PROTECT BATS

The U.S. Fish and Wildlife Service established a moratorium on the issuance of bat bands on June 13, 1973.

In the most critical eastern cave area, in and surrounding West Virginia's Germany Valley Karst Area, an NSS moratorium on visits to bat caves was declared. On the basis of preliminary data provided by John S. Hall and others, ten caves in Virginia and West Virginia were declared off limits during a specified hibernating period. When later surveys showed that several former colonies of *Myotis sodalis* were no longer present, these caves were removed from the restricted list. Designation of the Germany Valley Karst Area by the U.S. Department of the Interior as a Natural Landmark has strengthened cave and bat protection.

Observation and monitoring techniques have been refined so that important studies have been carried out with a minimum of disturbance to the bats. An improved Constantine or harp trap has been developed (Tuttle, 1974a, 1974c) and is being used effectively outside caves or in the entrance. Ultrasonic detectors have been used to locate and count unseen flying bats (Fenton, 1970b). Photography permits population estimates (Humphrey, 1971) and chemiluminescent tagging makes possible the observation of the foraging behavior of individual bats (Buchler, 1975).

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Early efforts by the NSS to establish a professional relationship with federal land-managing agencies were often rebuffed. In 1957 the Cave Research Foundation was established as a non-profit corporation in Kentucky, to (1) promote research and exploration in caves, (2) aid in cave conservation, and (3) improve the interpretation of caves to the public. Increasingly important agreements followed, culminating recently in a 20-year research agreement with the National Park Service.

In the vast, federally managed areas in the Southwest, cave exploration was sporadic, and in some areas was forbidden by agency officials prior to 1966. Founding of the Guadalupe Cave Survey in that year and its merger with CRF in 1972 has made possible numerous officially approved research projects (CRF Personnel Manual, 1975) for Carlsbad Caverns and Guadalupe Mountains National Parks, Lincoln National Forest, on Bureau of Land Management holdings, as well as in Edgewood Caverns, privately owned. The survey data has been stored and manipulated in the computers of the University of New Mexico, Albuquerque.

These steps taken to protect cave bat populations were essentially voluntary actions by involved and concerned bat research workers and the organized cavers. The endangered species concept established by the 1966 legislation doubtless served as part of the motivation but it was hardly compelling.

The situation changed drastically, however, with the passage of the Endangered Species Act of 1973. All previous statutes were strengthened and federal agencies and the states became directly involved in enforcement of the act. Federal funding for endangered species programs to be administered by the states was indicated, and while to date no appropriations have been made, many state and regional programs are under way. All affected federal agencies seem to have begun to develop programs. A number of them are reported here.

According to the latest information (U.S. Fish and Wildlife Service, 1974), the new law seeks "...to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions..." in which the United States has pledged its support for the conservation of wild flora and fauna worldwide.

Some important changes are as follows:

(1) The law establishes two categories of endangerment: (a) *Endangered species* are those species in danger of extinction throughout all or a significant portion of their range and (b) *Threatened species* are those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range; thus, under the new Act there will be two published lists—*Endangered* and *Threatened*;

(2) Separate listings for *Native* and *Foreign* species no longer will be used.

(3) The term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct, and the Act outlaws *taking* of an endangered species.

Officially, the Fish and Wildlife Service of the Department of the Interior, through the Office of Endangered Species and International Activities designates species in danger of extinction and periodically publishes additions to the list, or regulations for their protection, in the *Federal Register*.

ADDITIONAL CATEGORIES

Several additional categories are considered important by some land management agencies. For example, the U.S. Forest Service (1975a, 1975b) recently contracted for regional surveys of threatened species, specifying some different degrees of endangerment. The status of different species has also been evaluated in light of categories defined in the 1973 edition of the Redbook, a voluminous publication of the U.S. Department of the Interior.

Peripheral—a species or subspecies which is at the edge of its natural range on a National Forest or Grassland and where special attention is necessary to assure survival there.

Unique—a species which is typical of a particular limited area but not generally present elsewhere, or a species that is particularly interesting because of the niche it occupies, or because of its peculiar characteristics.

Status Undetermined—a species or subspecies that has been suggested as possibly endangered or threatened with extinction, but about which there is insufficient information to determine its true status. More information is needed.

For a good many years it has been apparent that more information is needed about cave bats. Until quite recently, it has been widely, but erroneously, assumed that if disturbance forced a bat population to move from its accustomed wintering site it could use almost any other cave. This.supposed adaptability was thought to apply also to species such as *Myotis velifer* and *M. grisescens* that in summer occupy maternity or nursery caves.

Population studies begun in the 1950s (Twente, 1955; Hall, 1962; Henshaw, 1972) have clearly demonstrated that each species has so narrow an optimum range of tolerable temperature and moisture parameters both for hibernation and nursery sites that there is little overlapping of microclimates chosen by other species. In addition, we now know that only very limited portions of some caves maintain the stable temperature and humidity which bats need.

If individual bats occupy microclimates not within their species preferance range they expend energy (stored as fat) at a rate so wasteful that their energy resources may be exhausted before winter ends and insects are again flying. This is especially true of yearling bats which enter hibernation with less fat reserves than adults.

Constantine (1967a) at Carlsbad Caverns in the 1950s noted considerable temperature differences in caves of the region. During the breeding season free tail males roosted in the coldest caves; females settled in the warmest caves, where high temperatures favored rapid digestion of food and development of the young. Marginally cool caves could be occupied successfully for nursery sites only if populations were enormous enough to raise the air temperature noticeably and if the configuration of the cave assured the retention of the warmed air.

If cave microclimates can be affected by the body temperature and activity of millions of bats, or by the accumulation of fresh guano and the accompanying chemical reactions (Poulson, 1972) it is not surprising that the presence of human visitors can cause serious alterations. When the public was permitted to explore a bat cave in a Florida State Park in the mid 1960s, heat from human bodies and gas lanterns raised ambient temperature above the tolerable limit for the hibernating bats and evidently accounted for the departure of the bats (Tuttle, personal communication). When visitation was stopped, the cave temperature slowly returned to normal and the bats repopulated the cave in following winters. Through the years the NSS has encouraged cave gating. It is now recognized, however, that permanent changes in cave temperature have sometimes resulted from gates placed at the entrance or at restricted passageways within.

A new NSS publication, *Cave Gating* (Hunt and Stitt, 1975) presents a diversity of gate designs, including gates designed to permit access of bats to hibernating chambers within the cave—involving just a few passages—as well as daily passage during summer if the cave is a nursery site.

There is good reason for concern that some of the gates in use at *Myotis grisescens* nursery caves impede the daily flights. Opportunities to monitor flights, such as by the bats occupying Thomas Aley's Ozark Underground Laboratory, should be taken to provide baseline information needed to protect bat populations elsewhere.

Even when the passage of bats is not impeded, changes in air circulation resulting from seemingly minor narrowing of passageways occasioned by the installation of gates can result in a disasterous rise in temperature in passages undisturbed by human visitors. At Fourth Chute Cave, Quebec, the largest colony of *Myotis leibii* in eastern United States was driven out by blocking the circulation of cold air (Mohr, 1972) and at Coach Cave, Kentucky, construction of a gift shop over an air shaft has resulted in the hibernaculum of the gray bat, *Myotis grisescens*, becoming too warm (Humphrey, 1975). It is clear that much greater attention must be paid to the affect of structural changes on microclimates within caves.

The role of bats in maintaining cave ecosystems is becoming more widely appreciated (Horst, 1972; Poulson, 1972). Major groups of cave fauna may be adversely affected by even a minor decrease of bats in a nursery cave, particularly for forms which depend directly on fresh bat guano. Less is known about aquatic food webs, but concern has recently surfaced with the realization that bats apparently have abandoned Alabama's uniquely rich fauna preserve, Shelta Cave, beneath the NSS headquarters in Huntsville.

Bats were shut out of Ezell's Cave, in San Marcos, Texas, when that cave was totally closed in the early 1960s to prevent collectors from exterminating its unique aquatic life. Recent inquiry reveals that the bats have not returned, but undetermined yet apparently adequate energy input elsewhere in that extensive cave ecosystem accounts for the continued existence of the rich invertebrate fauna and the remarkable blind salamander, *Typhlomolge (Eurycea) rathbuni*. The cave was added to the U.S. Department of the Interior's register of Natural Landmarks in November 1975.

Since bats are essential to the ecosystem in many caves of biological significance, the broad exercise of cave management expertise requires some information that only bat experts can provide.

More than 20 Ph.D. dissertations on various phases of bat research have been published in the last ten years. Most of them involved years of field study and the use of sophisticated techniques for collecting and evaluating data. Much of the information already gathered and published applies to or is applicable to caves within the jurisdiction of land management agencies represented here. Sources of information and expertise can be found in the list of References.

As the presentations in this symposium prove, many NSS members possess and utilize professional skills useful in cave management. The aid of many other experienced, conscientious cave explorers in each region can be enlisted for the extensive explorations needed to accurately assess the presence and distribution of caves and other Karst features, and the occurrence of populations of cave animals.

When scouting reports indicate the presence of bats, the services of a bat research specialist should be engaged. As already noted, determination of the season or seasons when caves are occupied by bats is important. Conservation conscious as most organized cavers/spelunkers are, they are increasingly apprehensive that they are being excluded from many of their favorite caves—particularly from many of the deep caves which have become immensely popular with *vertical cavers*. Certainly they want to know at what season a cave is free of bats and therefore should be accessible to cavers. The regulatory agency can make reasonable decisions on entry to bat caves only on the basis of a knowledgeable recommendation by a bat specialist. Some species of bats can be identified only by examination of the teeth or the skulls (Barbour and Davis, 1969).

GUIDELINES ARE BEING DEVELOPED

Fortunately, some regional or statewide surveys of cave bat populations have already been made or are underway (Findley, 1973; Greenhall, 1973; Hall, 1975; Harvey, 1975; Humphrey, 1975; Humphrey and Tuttle, 1975; Mumford, 1975; Tuttle, 1975a; and Whitaker, 1975). In addition the *Recovery Plan for the Indiana Bat* (U.S. Fish and Wildlife Service, 1975) identifies caves with critical bat populations. From a management standpoint the following broad generalizations may be helpful. Bats may use caves in one or more of these three ways:

For hibernation—with wide variations, from September 15 to May 1—about 20 of 40 North American species over-winter in caves.

For nursery sites—almost exclusively pregnant females, from about May 1; and after June 15, by bat mothers and young until mid-August. The species are primarily *Tadarida* and *Myotis velifer* in the West, and *Plecotus townsendii* and *Myotis grisescens* in the Southeast and Central States. In many cases nursery caves are located far from the hibernacula, sometimes involving exhausting flights of hundreds of miles, making the security of the distant cave extremely critical (Tuttle, 1974b).

An additional use of caves by bats has been widely recognized only since the 1960s. In spring, and again in late summer, far more bats can be seen *swarming* around certain cave entrances—and often entering briefly—than occupy them during hibernation. The purpose of this swarming or *staging* is unknown but the caves may be as important to bats as certain wildlife refuges are for migrating waterfowl. It may aid juvenile bats to make suitable selection from among a variety of caves they *sample* and it probably is needed to provide the adults opportunities to mate before going into hibernation. Even non-cave species—*tree bats*—join the swarming assemblages.

Travel routes and distances flown are unknown for most species but 15 years of banding gray bats, *Myotis grisescens*, has provided Merlin D. Tuttle (1974b) with an impressive volume of data on travels, longevity (many reach 15 years of age), growth, feeding strategy, microclimate needs, and threats to survival. Much that he has learned about this species is useful in designing protective measures for other cave species.

Severe penalties can be imposed for interference with officially listed Endangered Species—such as *Myotis sodalis* and *M. grisescens*. Even experts cannot carry on studies without an explicitly worded permit from the Office of

Endangered Species. This applies also to federal agencies contracting for faunal studies within their jurisdiction.

NEW INTERPRETATIONS OF THE LAW

At the Fish and Wildlife Service, Division of Law Enforcement, I learned that successful prosecution of violations of the Endangered Species Act—in the Federal Courts—probably will have to be based on expert testimony by a qualified biologist, establishing positive identification of the specimen as an Endangered Species, and testimony as to the nature of the offense: *taking, harming,* or *harassing*. The September 26, 1975, issue (Part II) of the *Federal Register* contains two extremely important regulations: The first states that the "similarity of appearance" of several different species (in this situation, alligators) making it difficult for law-enforcement personnel to determine the species with certainty, would be grounds for granting endangered species protection to rare and common alike. If this new regulation is applied to bats (and it can be under the Act), it is possible that most bat species might be protected by the Act—certainly a good many species look very much alike.

Second, according to the notice cited above:

Harass in the definition of *take* in the Act means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering.

Harm in the definition of *take* in the Act means an act or omission which actually injures or kills wildlife, including acts which annoy it to such an extent as to significantly disrupt essential behavioral patterns, which include, but are not limited to, breeding, feeding or sheltering; significant environmental modification or degradation which has such effects is included within the meaning of *harm*.

DOES CAVING DISTURB BATS?

Some cavers, chapfing under the NSS moratorium on visits to specified bat caves, have argued that they were sufficiently aware of the presence of bats to be able to quickly but quietly pass by them and do their exploring without the bats' knowledge. In other cases, known bat roosts are located in remote sections of caves and could be barred from access by cavers while permitting travel elsewhere.

According to a recent unpublished study of the impact of sound on hibernating bats, even the quiet tread of cavers over rocky cave surfaces has a highly disturbing effect on hibernating bats. A more generally recognized effect of even minimal disturbance—sound, lights, and especially heat from lanterns—is the onset of arousal which inevitably continues to complete arousal and flight.

In northern Ontario, Fenton (1970a) studied hibernating little brown bats, *Myotis lucifugus*, Renfrew Mine. He weighed bats at the beginning and end of the 1965-66 and 1966-67 seasons and determined that both males and females lost weight at the rate of 0.013 grams per day, dropping 2.5 grams during a 193-day period—a loss of 25 percent of the October body weight. Similar losses were recorded from more northern hibernacula and from ones farther to the south.

Young bats have less time to accumulate fat, and they go into hibernation weighing about half a gram less than adults. Such weight differences may account for lower survival rates of juvenile bats, according to Fenton and others. Fenton tabulated loss of weight by banded bats which had been disturbed at least three times and found that they weighed significantly less than those disturbed only once.

By the end of the winter energy reserves may be insufficient to meet the demands of the first feeding forays, when emerging insects may be scattered and scarce, or the bats may be too weak to make long flights to their summer territories.

Since weight loss of this degree occurs in a notably successful and adaptable species such as *M. lucifugus*—evidently somewhat tolerant of disturbance—it may well be a serious factor with *M. sodalis* (Henshaw, 1972), possibly instrumental in its disappearance in the Northeast following the first wave of cavers and bat banders, prior to 1950. According to Hall (1975b) *M. sodalis* is so intolerant of disturbance that the banding of an entire hibernating colony has been followed by total disappearance of the bats.

The recently completed *Recovery Plan* for the Indiana bat by a team of wildlife and bat experts (U.S. Fish & Wildlife Service, 1975) predicts recovery for the species but does not indicate how caves in the Northeast and Pennsylvania might be repopulated. Attempts to transfer bat populations from houses and tunnels in Pennsylvania (Mohr, 1942) were totally unsuccessful and recent evidence of the extreme *loyalty—philopatry*—of bats to their accustomed caves (Tuttle, 1974b) leaves little hope for reestablishing deserted hibernating sites.

The need for determining the feasibility or possibility of rescuing populations doomed by cave destruction or inundation is urgent. Long scheduled construction already underway is about to drive bat colonies out of Blanchard Springs Caverns, the Forest Service's preeminent cave attraction in Arkansas.

In Missouri, a single dam will flood scores of caves, including important bat caves. In order to assemble the data needed to prepare an acceptable Environmental Impact Statement, the Army Corps of Engineers is financing an investigation by the University of Missouri, with the cooperation of the U.S. Fish and Wildlife Service and the Missouri Conservation Commission. The 18-month study headed by Richard K. LaVal is entitled *An Ecological Survey of the Myotine Bat Populations to be Affected by the Construction of Meramec Park Lake in Crawford County, Missouri*. Six species of *Myotis* are being studied.

Underway since July 1975, the survey team plans to visit more than 100 caves, banding a sampling of not more than 10 percent of the bats that can be netted outside hibernating caves. Only observations involving a minimum of disturbance will be carried on. At present, there are no plans to attempt to move any colonies. Five major *Myotis sodalis* hibernating colonies and two major *M. grisescens* nursery caves are in the study area.

THE NEED FOR INTERPRETATION

Most of the studies already authorized by the agencies represented in this symposium recognize the problems of public relations and the need for improving the bat's image. Public awareness of the importance of bats in the ecosystem can be improved through interpretive literature, visitor center displays, and trailside (or cave tour) talks. An agency's role in the protection of endangered or threatened species of bats can be the basis for an admission of pride in its program. Incidentally, since contact with the public is not limited to interpretive personnel it is important that the entire staff be well informed about bats.

This awareness should encompass another aspect of visitor relations—the agency's responsibility to advise, calmly, that along with *not* feeding the bears and deer, that no one should ever pick up or touch a bat, since along with most mammals, bats are capable of transmitting rabies. In the unlikely event of a bat bite, it is imperative that the bat be captured with caution, and delivered to a public health laboratory for a swift, routine examination for rabies (the fluorescent antibody test). An unpleasant 21-shot series of duck embryo antirabies vaccine injections is unavoidable unless the biting animal is tested for rabies, and proved negative. It should be noted that bats are now second to skunks as carriers of rabies. Foxes are third.

Incidentally, airborne rabies virus (Constantine, 1967b) is considered a hazard only in huge maternity colonies such as the one in Frio Cave in Texas, where entrance during summer is barred because of two human rabies deaths there.

With the exception of the Ozark Underground Laboratory in Missouri, the presence of rare fauna in a privately owned cave has not generated much enthusiasm for guaranteeing its protection. The first non-governmental organization to exhibit concern for biologically important caves has been the Nature Conservancy. It owns Ezell's Cave in Texas and several bat caves in Illinois. It advanced funds to the NSS for the purchase of Shelta Cave. Recently it completed a report for the U.S. Department of the Interior (Humke, 1975) on the preservation of significant ecosystems.

Among the recommendations in the Nature Conservancy report is a proposal to Congress to establish an interagency commission—A National Ecological Reserve Board—and a Nationwide Ecological Reserve System consisting of protected natural areas representing the full spectrum of biological communities, ecosystems, features, habitat, and form. The proposed legislation now being drafted would establish a National Registry of Ecological Reserves to record and describe areas and sites of national, state, and local significance. Caves, of course, are recognized as significant, and as possessing peculiar preservation problems.

In conclusion, it can be said that the deep concern for bats arising from the studies of federal, university, and speleology associated individuals over a 40-year period has gained for bats strong protection under the Endangered Species Act of 1973. It seems probable that all species of bats will benefit though only two from the continental United States are listed. It appears that increasingly significant studies, carried on within the constraints of the Act and supported in some degree by that legislation, will further enlarge our understanding and appreciation of these unique airborne animals. There can be little doubt that the participating agencies in this symposium are dedicated to implementing many of the proposals to the limit of their resources.

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Status of Endangered Bats in the Blanchard Springs Caverns Area

Michael J. Harvey*

Blanchard Springs Caverns, located in the Sylamore Ranger District of the Ozark National Forest in North-Central Arkansas, is being developed by the United States Forest Service as a tourist attraction. Construction was begun in 1963. One tour route has been completed and the cave was opened to the public in July 1973. An additional tour route is currently under construction. This present development includes the area near the natural entrance where a large majority of the bat population hibernates. Present and future human disturbance will quite likely cause the bat population to abandon the cavern.

Five species of cave bats have been reported from the cavern. They are: *Myotis sodalis*, Indiana bat; *Myotis grisescens*, gray bat; *Myotis keenii*, Keen's bat; *Pipistrellus subflavus*, eastern pipistrelle; and *Eptesicus fuscus*, big brown bat. Two of these bats are considered to be endangered (in danger of extinction throughout all or a significant portion of their range). The Indiana bat is on the United States list of endangered fauna and the gray bat will be added to the list in the near future.

A few Indiana bats hibernate in Blanchard Springs Caverns. Their number has never been estimated to be more than 200, and during the past 5 years we have observed only a few individuals. Gray bats inhabit the cavern during both summer and winter. The summer population, primarily males, numbers a few thousand. According to my records the largest number present in summer was estimated to be 10,000 on 26 June 1971. Usually, however, there are less than 5000 gray bats present at any one time during the summer. We have no evidence that the cave has ever been used as a maternity site. The winter hibernating colony consists of both sexes (approximately 40 percent females) and numbers 4000 to 5000.

Several small Indiana bat hibernating colonies exist in caves within a few kilometers of Blanchard Springs Caverns; hopefully, Indiana bats driven from the cavern will take refuge in these caves or in caves elsewhere. It is also possible that the Blanchard Springs Caverns gray bat population may survive by moving to other caves. A large gray bat hibernating colony, which we recently estimated to number over 175,000 individuals, is located in a cave on Ozark National Forest land, only 32 km from Blanchard Springs Caverns. The Forest Service has recently (1975) gated the cave to protect the colony. In addition, a large summer maternity colony of an estimated 150,000 gray bats is now afforded protection at the Ozark Underground Laboratory in southern Missouri. We have several records of movements of banded individuals between the two large colonies, which are located 60 km apart. Thus, a large hibernating colony and a large maternity colony of gray bats are now afforded protection in the southern Ozark region.

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Algae Control and Removal from Cave Formations

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ABSTRACT

Blanchard Springs Caverns, a new Forest Service development in North Central Arkansas, has experienced a significant problem of algae growth resulting from the introduction of a highly developed lighting system. Several alternative solutions to algae control have been considered and tested with varying degrees of success and feasability. These include chemical control, steam cleaning, light modifications and other methods. Although combinations of these temporarily meet the need, better alternatives are sought.

THE PROBLEM

At Blanchard Springs Caverns, a new Forest Service development in North Central Arkansas, controlling unwanted algae growth on formations is a major problem. Blanchard Springs Caverns is a living, unspoiled and wet cave system with an extensive array of cave features ranging from the large and massive to the small and intricate. An elaborate and high quality lighting system is used to artistically display the cave features. The lighting enhances a wide range of natural colors existing in the cave. The wet cave features (high humidity) coupled with the extensive lighting system has caused the emergence of the *green monster*. This unsightly growth is amplified at Blanchard because of the cave's highly decorated and virgin appearance.

Plant growth in Blanchard, resulting from the introduction of lights, is not limited to algae but includes 18 species of algae, Bryophytes (mosses) and Pteridophytes (ferns). For my purposes, I will refer to all the green plant growth simply as algae.

The relentless growth of these plants is an environmental problem that will probably continue as long as the cave is lighted and moisture is present. We are open all year, 7 days per week and have a lighting system that remains on 8 to 12 hours of every day.

During the 10-year development of Blanchard Caverns, algae growth did not receive much concern. It was generally assumed that the growth could easily be eliminated once development was complete and the Caverns were readied for opening. An unforeseen problem was the deep penetration of algae growth into the cracks and crevices of some formations making it almost impossible to remove. Also, continuing formation growth *sealed in* some of the green growth. A way was needed to remove present growth and, hopefully, eliminate or retard future growth.

ALTERNATIVE SOLUTIONS CONSIDERED

Over a period of years several methods of algae removal have been explored and tested. Removal by chemical solution, steam cleaning, shading and screening lights, installing light switches and decreasing lamp wattage are methods considered or tried with varying degrees of success.

Chemical Solutions

The possibility of using chemical solutions was researched in 1972 by Tom Aley who at that time was a Forest Service Hydrologist. Tom contacted Dr. Paul Redfearn, Professor of Life Sciences at Southwest Mo. State College and together they helped identify types of algae present and considered algaecides which might successfully eliminate the unwanted growth. A solution of copper sulfate and water (0.25 ppm) is considered normal formula in common applications. Later findings indicated that a higher concentration would be needed because of the basic alkaline water conditions at Blanchard. This solution was finally rejected because of its slow bio-degradable qualities and the potential damage to formation growth. Later the environmental statement required for development concluded that chemicals of any type might alter or destroy part of the environment and be dangerous to fauna in the cave. Consequently, we rejected the use of any type of algaecides.

Another process that we have been testing on a small remote test area for the past 18 months uses sodium hypochorite—5 percent (Chlorox or Purex) applied with a hand-held mist applicator. We have exposed this small test area to a light mist (not enough to run) of the solution. The plant growth was apparently killed within 30 minutes of application and thus far no apparent damage has occurred tc the formation. the mist was applied at cave temperature (58°) to reduce the possibility of excessive heat acting upon the solution in an adverse way. Chlorine applied in this manner changes quickly into gas and disipates. We are continuing to monitor the test area for possible harm to formations, soil, water and fauna. Preliminary indications are that there will be no ill effects. There is some question whether extensive use may cause an obnoxious odor to visitors. Further study is needed.

Steam Cleaning

In 1972 Tom Aley and Don Williams, Forest Service Geologist and engineer, considered the possibility of eliminating algae growth by the use of heat, i.e., cooking it. Equipment was used to test hot steam or water applications. Initially, the test results looked good. However, further monitoring of the test area indicated only partial success. The hot water applications destroyed the surface algae but was unable to penetrate into the cracks and crevices completely eliminating the growth. Preliminary testing of the hot water applications revealed that water temperatures

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literally blasted the colorful crust coverings off the formations. The wide differences of temperatures (400°f hot steam applied to 58° cave formations) plus the water trapped between the outer crust and the calcite crystaline formation apparently caused the damage. Further testing at temperatures just below boiling (210°F) was found to be the least destructive. Even at this temperature, extreme care and a thorough knowledge of individual formations have to be used. Although the hot water bath is not the total answer to algae control, it is the method now being used at Blanchard.

Equipment we use is a Hotsy Model 500 High Pressure Hot Water Cleaning Machine. We use a 75 ft. hose to eliminate frequent movement of the equipment. The manufacturer is Slifer, a subsiderary of Kanco Tech Inc., 5035 E. 39th Ave., Denver, Colorado, 80207. Cost of equipment including water hose is about $950.00. The machine pumps require a 120 volt power source plus deisel fuel for heating. We use a water source from the cave, collected in a 750 gal. tank remotely located in the cave system.

Light Modifications

Lighting modifications are being used to help reduce algae growth. Most rapid growth occurs in areas exposed to clear and frosted flood lamps. Decreasing amounts of growth occur respectively from blue-white, yellow and amber lights. Little or no growth apears under blue lamps. Also, we have found that by partially shading our lamps and decreasing wattage ratings we can reduce algae growth. This can usually be accomplished without sacrificing the beauty of formations.

We shade lights by setting a rock directly in front of the lamp and casting a partial shadow on the formation. In a few cases where deep penetrations of algae occur we have completely removed direct lighting. In other places we have installed switches so guides can turn lights on momentarily to show special features and then leave them in darkness until the next tour. Blanchard is arranged in such a manner that the large rooms must be continually lighted while tours are in the cave. One of our most recent modifications of lighting uses a clear plastic screen called UV-100 Clear, a commercial product made by General Solar Corporation. This process is designed to screen out ultraviolet light rays and thus retards plant growth. Preliminary tests have been partially successful but, as yet, are inconclusive. Installation of film material on the light fixture has caused some problems. If it is placed too close, heat will cause melting, especially on lamps of 100 watts and above. We will modify our lamp fixtures if current tests of this process prove successful.

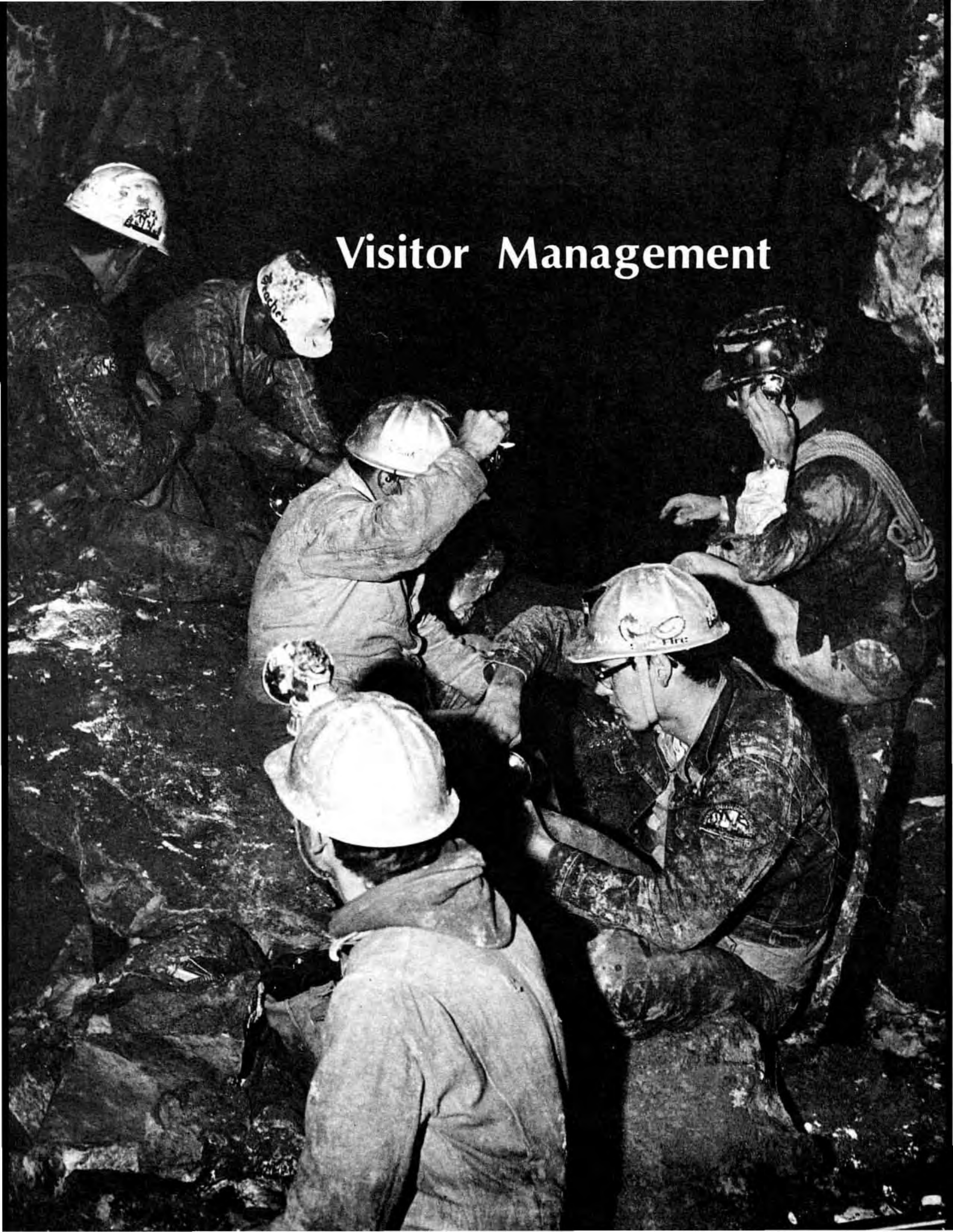
All of these methods are only partial solutions to the problem. At Blanchard we use a combination of processes and procedures. Algae control continues to be a problem. Studies now being made at Blanchard show promise and might lead to acceptable techniques for algae control in the future. This is a problem common to many of us. We should work together to find more answers.

ADDENDUM

January 15, 1976

Since the symposium, we have contracted with Tom Aley of the Ozark Underground Laboratory to research these methods. By far the most effective and apparently harmless method of control on these moss and algaes is the mist application of 5 percent chlorine (Purex or Chlorox)—applied to local areas of speleothems with a hand held applicator. This method is by far the most economic way too, using only 1/5 the manpower and materials and eliminates the pollution problem of operating a diesel fired steam or hot water bath machine in the cave environment. We hope to soon be granted permission to apply this method of control throughout Blanchard Caverns.

Visitor Management



Interpretation at Mammoth Cave

Steven Q. Smith*

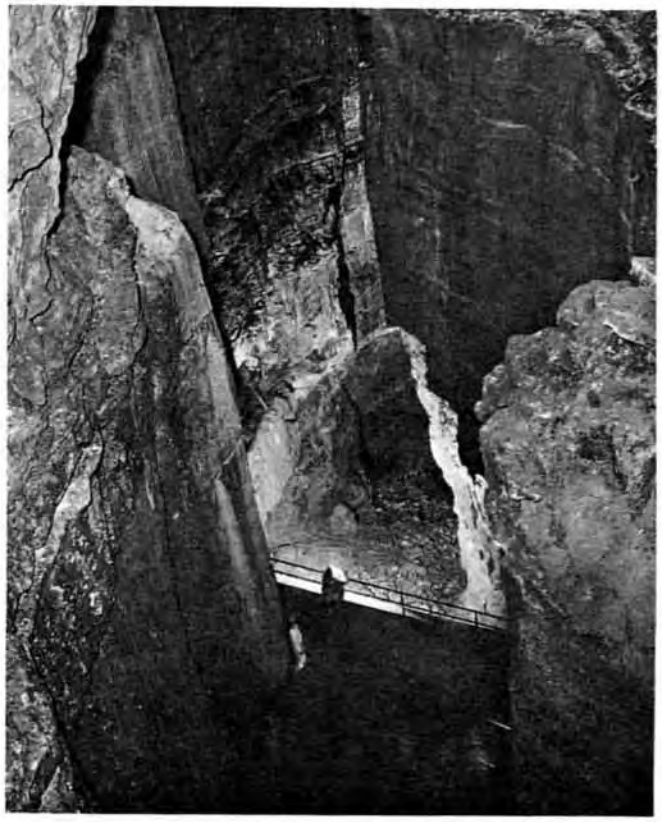
My presentation today will be centered around the operations at Mammoth Cave. Most of you involved in cave management are working under increasingly tighter manpower and financial constraints, as are we at Mammoth Cave. This is a fact of life even though our 1975 cave visitation, as of the end of August, was 533,000, a 7 percent increase over the same period of time last calendar year (total 1974 cave visitation was 590,000). Besides manpower restrictions and increased visitor demands, there are other influences that must be taken into consideration in operating an interpretive program. For instance, a number of our cave tours begin some distance away from the visitor center thus requiring the participants to be bused for a fee by a concessionaire. Any change in the number of tours offered or a decrease in tour size has a direct impact upon the concessionaire's profits. The impact of changes upon the local community must also be taken into account, for there are a number of private show caves just outside the park which schedule cave activities during the hours Mammoth Cave is not operating. Of course, there are a number of motels, restaurants, and amusement parks that are also affected by any changes we may make in our interpretive operation, particularly in those activities that tend to keep visitors in the area over a longer period of time.

To make the interpretive resource available and meaningful to the visitor, there are a number of items that must be considered.

We must encourage an active research program. Research data is not only important for the information that it provides to the interpreter (which he needs to continually review and use in updating his message) but extremely important in compiling a list of unique natural and historical resources. Without such a list of significant resources, area development would be chaotic and would often do irreversible damage.

Hopefully, improvements made in visitor safety at the cave are based upon such sound research. Each improvement, of course, detracts from the natural beauty of the cave. Some improvements, such as lighting, have introduced a new cave environment involving algae, mosses and ferns—a nagging problem in the lighted, wet, *active* sections of Mammoth Cave.

A number of supporting facilities and services are also necessary both underground and on the surface. In Mammoth Cave, where tours may last up to 8 hours, restrooms with running water and associated sewage pump stations are located in three different areas of the cave. An underground dining room, which can accommodate 500 visitors, and an associated supply elevator, is also located in the cave. In addition, four man-made entrances were built to make sections of the cave more readily accessible. A number of surface facilities may also be required, depending upon the distance from communities where such services are available: these may include a visitor Contact Station, Campground, Motel and Restaurant, and associated parking lots. Our facilities at Mammoth Cave were developed before environmental impact statements were required and without much consideration as to what impact parking lot runoff, turf fertilization, sewage, and the removal of water from the cave system would have upon the cave below.



A dome-pit in Mammoth Cave. *Photo by Charlie and Jo Larson.*

A pre-tour information system is under development to alleviate some of the confusion caused by the maze of outside cave related establishments and to provide information on the number and variety of tours departing from our congested visitor center. This system will also provide safety information on cave temperatures, proper footgear, etc., so that the visitor can choose the tour which best fits his physical ability. We have been experimenting with local radio spot announcements and are currently toying with the idea of developing TV spot announcements for distribution to local and distant stations to reach those potential visitors staying in the many area motels. We experimented this past summer with portable contact stations placed in key locations in the visitor center parking lots, again to alleviate confusion in the visitor center. The visitor center provides orientation and information as well as exhibits, tour ticket sales, and a point of dispersal to the various cave tours offered. The problem we are currently facing is providing these services in the proper order—orientation, information, ticket sales and dispersal.

In our interpretive efforts, we must strive to provide a

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variety of activities to meet the diversified needs of the visitor. Some of these activities may deviate from the primary resource of the area the visitor is coming to see—the cave, and of course are generally the first activities to be dropped as the financial constraints tighten and cause interpretive efforts to refocus on the cave.

Surface activities, walks, demonstrations, and evening programs are attended primarily by those visitors spending an evening or more within the park. Although removed from the cave itself, surface activities should relate to the cave. This might be done through interpreting surface topographical features that relate to the development of the subsurface or through cave-related human history messages such as how the cave guides farmed the land to supplement their guide income. Since most of our visitors spend less than one-half day in the park and are here to view the cave, the majority of our manpower is assigned to the cave.

Consideration must be given to providing a separate cave activity for children. As stated by Freeman Tildon in his book, *Interpreting our Heritage*, as one of the six principles of interpretation, *Interpretation addressed to children should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best it will require a separate program.* At Mammoth Cave we have been developing a tour called *Trog* (for ages 8 to 12) which involves surface activities which relate surface features to the cave, and includes subsurface activities centered around the themes of adaptation and the inter-dependence of cave fauna. On the other hand, we cannot overlook the senior citizen. Most of our cave tours at Mammoth Cave are either too strenuous or too considering introducing an easy slow-paced *Golden Age Tour*. There also is an increasing demand for handicapped tours. Access to cave interpretation must be made available to everyone.

Consideration should be given towards providing specialized programs presented by researchers carrying out projects in the park or those with cave-related specialized knowledge to satisfy the visitor who desires more detailed information. This could be one of the steps towards environmental reform mentioned by William Brown in his publication *Islands of Hope*.

With limited manpower, how then can we handle visitor demands for increased service? Consideration could be given towards increasing the number of tours available which of course would require an increase in the number of tours conducted by the existing guide force; this could cause a decrease in employee morale and eventually to labor problems. Also, as mentioned earlier, surface activities could be decreased funneling personnel back to the cave. Another possibility could be using volunteers to take on some interpretive activities which would free more guides for cave interpretation. One could consider increasing the number of visitors per tour which could not only lead to a decrease in the quality of interpretation but could also lead to labor problems.

A solution to the pressure brought on by increased visitor demands is a semi-self guided cave tour. This activity has been used at Mammoth Cave during peak periods of visitation; however, we find it still requires the use of 9 to 13 guides for the interpretation and protection of the features. Interpretive signs and booklets are also used to supplement the stationed guides. Our guides revolve from station to station and are required to present interpretive talks at a publicized time at each station. Another option used at Carlsbad Caverns National Park is the use of an audio transmission system supplemented by roving guides. According to research conducted by Ben Mahaffey and described in a publication titled *Relative Effectiveness and Visitor Preference of Three Audio-Visual Media for Interpretation of an Historic Area*, the most effective audio-visual media was the message recorder (audio over visual).

Obvious problems associated with operating a semi-self guiding system are: the need to gate side passages which detracts from the natural setting of the cave, an increase in vandalism, and the problem of rounding up large numbers of visitors during power outages.

Since a cave attraction concentrates visitor use, particularly a cave with one or two entrances, the number of tours offered might not be limited by manpower, but rather by the carrying capacity of the cave itself. Fortunately, or unfortunately, we do not have that problem at Mammoth Cave for we have a variety of cave options all stemming from privately developed caves which were taken over by the federal government when the park was established.

Over the years (160 years at Mammoth Cave) the interpretive technique has changed from *Stories and Entertainment* to environmental themes dealing with relationships and processes.

New interpretive thrusts are adding to more cave interpretation innovation. For instance, the recent thrust towards living history has led us to return to the past, to develop costumed tours showing how the cave was interpreted before electricity (using kerosene lanterns and torches). Next season we plan to add a Bicentennial costumed tour centering around the tour routes, and stories told when the cave first became an attraction in the early 1800s.

The need to acquaint the visitor with the *whole* of the cave has led us to develop cave tours which include discussions on surface features (natural and historical) and how they relate to the cave system while in route on busses to the cave.

There is currently an increasing demand particularly by the young visitor (late teen to early 20s) for adventure tours which offer a physical feeling for the cave as well as the feeling of adventure—pitting oneself against the challenging aspect of nature. We have strived to fulfill this need through the introduction of a six-hour wild cave tour involving squeezing and crawling. We provide the equipment.

Cave interpretation is no different from surface interpretation in general objectives and interpretive techniques; however, it has its own peculiarities such as the concentration of large numbers of visitors in a small area and the need for obvious intrusions (lights, gates and restrooms) for the health and safety of the visitor. Keeping such peculiarities in mind, I think we should direct our interpretive efforts towards:

- Better informing the visitor about the various attractions and hazards associated with the cave tours, before they arrive.
- Providing the proper sequence of tour services at the visitor center.
- Presenting environmental messages that deal with relationships and processes.
- Providing innovative cave related activities for all ages and abilities.

Electronic Interpretive System at Carlsbad Caverns National Park

Robert W. Peters*

A guided tour with three guides and a thousand visitors is not much of a guided tour. This was the situation at Carlsbad Caverns, in 1972, when the park stopped having guided tours and went to a self-guiding system. Visitors now go through the cave on their own and at their own speed. Guides are stationed or circulate throughout the caverns to provide interpretation and protection. They talk to individuals and small groups as they meet them. At this time, severe personnel limitations make it difficult to have enough guides or technicians to provide more than very minimum interpretation and protection.

To help overcome this manpower deficiency and to provide an individualized interpretive system available to persons throughout the cave, we installed an electronic interpretive system. This provides each visitor with an individual listening device to receive interpretive messages, safety warnings, and explanations of regulations as he walks through the cave. This electronic interpretive system became operational a year ago, after a 6-month installation period. As a visitor walks through the Caverns, a small hand-held receiver provides frequent messages. The messages are given in English at an adult level, in English at a level small children can understand, or in Spanish. Selection is made with a switch on the receiver. As the visitor walks through the cave he receives messages at 43 areas located throughout the cave. The three different versions are being broadcast simultaneously and continuously in each of the 43 areas or listening zones.

These messages are fed from a single transmitter located in the visitor center and operating on three frequencies. The signals are transmitted through a coaxial cable to each listening zone. At each listening zone, a small wire is laid along both sides of the trail to form a continuous loop from the end of the coaxial cable. The loops are up to a couple hundred feet long. When a visitor in this loop holds his radio receiver to his ear, it will operate. (A mercury switch in the receiver turns it on when it is held in an upright position.) Meanwhile, back at the transmitter, thirty-three 4-track tapes are running continuously. Each tape is a continuous loop which broadcasts four messages simultaneously.

The National Park Service has a contract with Telesonic Systems, Inc., of New Jersey, to provide this service. In other words, to help overcome severe manpower deficiencies we have contracted for a major part of our interpretation. This contract provides for the installation, operation and maintenance of the system. The contractor distributes and retrieves the radio receivers. Telesonic has several full-time employees on site to accomplish this.

It costs the National Park Service about 12 cents per visitor to provide this service. There is no additional charge to the visitor for use of the receiver.

We don't claim that this system is better than a small guided tour, but reasonably sized guided tours were eliminated, as an option available to us, many years ago.

DISADVANTAGES

In my opinion, the biggest disadvantage to an electronic system is that many visitors become engrossed in listening and forget to look at the cave. Perhaps there are too many listening zones, although total listening time for a full 3-hour tour is only about 30 minutes.

The system sacrifices personal contact which probably would be more effective, though not in all cases. It makes it more difficult for guides to talk to visitors when they meet them. This means the guides have to work a little harder at it. Some guides also have expressed some resentment of the system and think it's taking away their job.

The passing out and retrieving of the radio receivers in the visitor center adds another element of confusion and delay and hampers the efficient movement of a large number of people.

ADVANTAGES

We feel the advantages of the electronic interpretive system greatly outweigh the disadvantages, in our circumstances.

First, this system actually provides more information to the visitor than could be provided either by guided tours or self-guided tours. Much more detail is available to the visitor. Notice, I said *available*. Visitors who do not want to carry the receiver, do not have to. A visitor with the receiver can quietly walk and look; when he wants to learn something about the cave, all he has to do is hold the receiver to his ear. Even if visitors use the system only part of the time, it's worth it.

Most visitors seem to like the system.

This system provides an efficient and effective means of informing most visitors of safety precautions and regulations.

Another very important consideration is that the system complements the self-guiding tour system which is the only possible way to accommodate the large number of visitors at Carlsbad Caverns during the summer.

CONCLUSION

The electronic interpretive system at Carlsbad Caverns does not completely fill our interpretive needs, but it goes a long way. It does an exceptional job of providing interpretation to a large number of persons on an individual basis. It is an especially effective means of providing high quality interpretation while under severe manpower limitations or personnel ceilings.

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Caves, Cows and Carrying Capacity

Thomas Aley*

I have several points to make today on the problem of determining the carrying capacity for caves. My first point concerns the concept of carrying capacity. I, frankly, do not feel that *carrying capacity* is the proper term for trying to come to grips with the question of how many people should be permitted in a cave.

The term *carrying capacity*, as well as the rationale that a carrying capacity exists, is derived from range management. In range management, carrying capacity is measured in cows per acre (or in the west, acres per cow). By analogy, in cave management, carrying capacity would be cavers per cave.

Carrying capacity is the division between utilization and exploitation, or between utilization and damage to nonrenewable resources. Carrying capacity is a concept for dealing with the utilization of renewable resources in those cases where utilization can occur without damage to nonrenewable resources. In the case of range management, grass is renewable, but the soil on which it grows is nonrenewable. The carrying capacity concept insures that the cows eat all the grass possible without damaging the soil.

Caves contain both renewable and nonrenewable resources. Use of caves does not necessarily first deplete the renewable resources and then, with heavier rates of use, damage the nonrenewable resources. In the case of caves, damage to nonrenewable resources can be substantial even when utilization of the renewable resources is very light. The vandal breaking soda-straw stalactites is destroying non-renewable resources.

There are two important distinctions between carrying capacity as applied to cows and cavers. First, damage to nonrenewable resources in caves can and will occur even if the carrying capacity is not exceeded. In contrast, cows utilize the renewable resources before damaging the nonrenewable resources.

The second distinction relates to the effect damage of the nonrenewable resources has on carrying capacity. In range management, if you damage the nonrenewable resource, the carrying capacity of the site is decreased. In cave management, if you damage nonrenewable resources, the carrying capacity of the cave may be increased. As an example, suppose we had a cave with beautiful and easily broken soda-straw stalactites. The presence of these speleothems would dictate a low carrying capacity for the cave. However, once the stalactites were destroyed by carelessness or vandalism, the carrying capacity of the cave would be increased.

In the example, the quality of the experience would of course be decreased by the loss of the stalactites. Still, it is important that we recognize that as a result of this loss the rate of use of the cave (which is carrying capacity) would be increased by the damage to nonrenewable resources.

The longer we delay effective cave protection and management, the more damage will occur to nonrenewable resources. As a consequence of this damage, the carrying capacity of the caves for cavers will increase. Such a relationship can be a strong deterrent to effective cave protection and management.

I believe the concept of carrying capacity does not fit the situation of cave management. It is important that we recognize that cavers and cows are not closely similar users of the public lands. Still, regardless of whether we use the term *carrying capacity* or some other semantic fabrication, we are still faced with the problem of determining how many people can go in a particular cave and at what rate.

The second major point I wish to make is that the rate and total quantity of visitation should be determined by the physical nature of the cave system plus the characteristics of the user-group. I believe there is a distinct tendency to determine carrying capacity based almost solely upon the characteristics of the user group. As a result, when demand increases the typical land manager may well conclude that carrying capacity can be increased with only a small loss in unit quality.

I believe caves are rather like telephone booths; both have carrying capacities. I firmly believe that the carrying capacity of a phone booth is one person. Merely because some college fraternity was able to get 18 people in one telephone booth during the height of the telephone booth stuffing craze does not negate the fact that the carrying capacity of a telephone booth is one person.

Similarly, the physical features of a cave may well dictate a carrying capacity substantially lower than that indicated by the user group. Although others will undoubtedly disagree, I believe that Carlsbad Caverns is a good analog to the telephone booth invaded by the fraternity. The user group at Carlsbad has been interpreted as saying that they don't care how it is done, they just want to all get in the cave whenever they come. As a result, thousands of cave visitors daily march through the cave with radio receivers held to their ears to receive recorded messages in English or Spanish; children get a broadcast of their own in childrenese. The result is like a science fiction scene where everyone is in perpetual contact with The Voice, and where we only listen and never speak. There are too many people in the phone booth. It is irrelevant whether they are all satisfied or not; they are exceeding the carrying capacity of the phone booth.

If we are to realistically determine carrying capacities we need a good understanding of cave features, and a good understanding of the impacts of use upon these features. Land management agencies seldom have this type of expertise. Similarly, those who have cave expertise typically lack experience in land management.

If carrying capacities are to be determined in part by the physical features of the cave, a logical first step is to determine which features are most sensitive to damage. If we can determine this, then the carrying capacity of physical features of the cave is equal to the carrying capacity of the most sensitive feature. I think this sort of approach is realistic; it is also an approach compatable with the academic training of the foresters and range managers who are so prevalent within the land management agencies.

The concept of the limiting factor is one of the prime

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silvicultural principals taught in forestry schools. The concept, basically, is that although there are many factors which *can* affect tree growth, in any given situation there are seldom more than one or two factors which limit the growth.

If we were to apply the concept of the limiting factor to cave management, I believe we could generally dispense with detailed inventory and classification schemes. Many caves, at least at this point in time, probably have carrying capacities greater than existing use. Rather than dilute our limited funds and efforts in attempting to manage all caves, we should instead concentrate on those caves which have important limiting factors. These are the caves which are most sensitive to damage and are most in need of protection and management.

To summarize, the concept of carrying capacity is not well suited to cave management. This is because carrying capacity is a concept developed for renewable resources; many cave resources are nonrenewable.

The rate and total quantity of visitation should be determined both by the physical features of the cave and the characteristics of the user group. I believe we have been preoccupied with the characteristics of the user group and have made the unwarranted tacid assumption that caves are for cavers. Caves, like trees, are resources. Trees are not made for boards; neither are caves made for cavers.

The concept of the limiting factor could provide a useful approach in cave management on the public lands. We could also call this the concept that the squeaky wheel gets the oil. The first step in cave management is to determine where the squeaky wheels are. After this is determined, management can either seek to oil the wheel (which may often be impossible in cave management) or at least minimize the wear and tear on the wheel.

Comments on Carrying Capacity

Roger W. Brucker*

Carrying capacity appears to be one of the most important subjects raised at this Symposium, based on the comments in response to the Panel's presentations. From those comments and others, one might ask two questions aimed at clarifying the problem: Does carrying capacity as a concept result from an objective *after-the-fact* analysis of the effects on cave usage? Is the concept of carrying capacity useful in constructing a decision making system?

I propose that for maximum utility, the concept of carrying capacity ought to be structured into a decision making system to guide management into wise choices when the problem is complex rather than simple.

We have heard carrying capacity described in terms of conflicts, *trade-offs* such as use versus abuse, protection versus access, etc. Whatever else they provide in insight, they do rest heavily on semantics and politics (one person's use is another's abuse).

It has also been suggested that carrying capacity might be assessed in terms of limits or weak-link constraints, such as the maximum elevator capacity of 1100 visitors per hour at Carlsbad Caverns. Such constraints obviously do have a role in decision making about cave carrying capacity.

It has been said that carrying capacity criteria are always arbitrary, as indeed all standards are arbitrary. There is nothing wrong with arbitrariness *if* the manager is prudent in setting up monitoring to feedback the results of arbitrary policy, and *if* the manager is willing to accept new information.

To help pull together some of the good ideas and handle the rest, I propose consideration of a carrying capacity decision making system based on the work of Irwin Bross.** The system is a box model into which data is put and recommendations come out. Inside the box are the following sub-systems:

1. An alternative probability system.
2. A value system,
3. A decision criterion system.

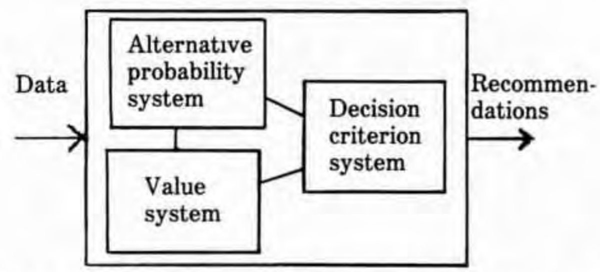
The alternative probability system contains a list of possible constraints and outcomes, together with their associated probabilities.

The value system lists values by priority from the most valuable to the least valuable. Such ordering of priorities usually must come out of discussion by interested persons and experts.

The decision criterion in the simplest case says that you choose the best alternative based on your purpose. It becomes clear that *purpose* is the key to how the system works. To use this carrying capacity decision maker in your own situation, you fill in the model in the manner suggested by the annotated example.

CARRYING CAPACITY DECISION MAKER MODEL

The *Alternative probability system* contains a listing of factors such as visitor demand, staffing resources, budgets, other constraints, and other alternatives with their probabilities.



The *Value system* contains a listing of values in order of importance for your situation, such as visitor solitude, visual remoteness, minimized physical trampling, speleothem breakage, contamination, energy relationships, safety, education values, etc.

Choose the best alternative based on your purpose. (Hint: list your purpose first.)

The most frequent source of poor decision making is likely to be inadequate or changed purpose. Too few alternatives and an insufficient listing of values can create problems also.

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** Bross, Irwin. *Design for Decision.* Free Press; New York, 1965.

Some Thoughts on the *Carrying Capacities* of Developed Caves

Philip F. Van Cleave*

The American Heritage Dictionary of the English Language defines the noun *cave* as *a hollow beneath the earth's surface, often having an opening in the side of a hill or cliff.*

I strongly suspect that the participants in this symposium would require a bit more refinement of definition. One caver-expressed definition adds the qualification that such a hollow beneath the earth's surface extend to a point at which a portion of the cave exists in permanent total darkness. This definition could accept one of two caves of identical size and configuration wholly upon the basis of the one having light absorptive walls, ceiling, and floor, while rejecting its twin with somewhat more reflective walls, etc.

I believe that the caves with which we are concerned will usually, if not invariably exhibit to some degree a *cave climate* with a more uniform year-round temperature and relative humidity than that characterizing the land surface above. At least, I hope that this is the case, for I'm going to barge headlong into my further lines of thought with that as a basic premise.

My second major premise consists of my own arbitrary definition for the term *carrying capacity* as it relates to cave resources. The maximum number of persons who, in a given time-frame, can beneficially utilize the specified cave resources without causing irreparable adverse impact upon those resources. If we start our considerations with a *virgin* cave, we can cover almost all truly objectively based carrying capacities: Zero!

Since we are dealing with a resource that is truly an unrenewable resource it is obvious that there is no way that we can manage a cave for public use under adherance to such a restrictive carrying capacity. Yet, I think it will help to approach the matter of practical carrying capacity if we keep in mind that, in practice, *carrying capacity* has to be created rather than established on the purely objective basis.

The creation of carrying capacity should certainly be preceeded by a great deal of management thought about the purpose or purposes which can best be served by the specific cave under consideration. Can it become all things to all people interested in caves? Possibly, though I don't know of a cave that has so far fulfilled such a broad purpose.

From here on, most decisions are bound to be made on purely subjective judgments, and these are best formulated by a team approach.

How much physical damage are we prepared to accept in the process of developing the cave to fulfill its determined purposes or functions?

Have we identified all of the special preservation needs, such as the presence of rare, endangered or endemic cave biota, or cave features whose fragility or rarity impose need for especially critical consideration? In this regard, keep in mind that significant alteration of the cave climate will have adverse effect upon the totality of the cave resources.

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How can we create a maximum carrying capacity which will still offer an individual the opportunity to enjoy the cave resources without undue sociological or psychological pressures caused by either too much or too little human presence?

How can we offer effective interpretation to the determined maximum of visitors without violating the rights of the person who wishes to be left alone with his own thoughts?

Have we recognized the inherent hazards to the visitor so that we can provide or create an acceptable level of safety for the spectrum of cave users we anticipate?

To this point, we have been working towards the creation of *the maximum* carrying capacity which should ideally be synonymous with the *optimum capacity*, from both viewpoints of resource preservation and visitor enjoyment.

Beyond this point, development will consist almost wholly of construction, and it is at this stage that management must constantly keep on top of the development of design load factors which translate our decisions into the physical plant intended to carry out our carefully thought-out requirements to meet the needs. Too often, the design load for cave facility development ends up as a finished product in conflict with the intended carrying capacities. This might be called *designers' over kill.*

If all turns out to our satisfaction we have now concluded the phase of development which I call *hardening the resource* to minimize the degradation of cave resources under use at the determined capacities, and this concludes this chapter.

While we've been discussing means of arriving at acceptable maximum carrying capacities, most of our cave resources are already being exposed to over-capacity pressures, at least during peak periods of visitor use. Probably no cave has yet been physically developed to a level that assures preservation at determined carrying capacity without augmentation by adequate staffing standards.

I suspect that, by and large, this is the area in which the managers of caves under federal or state control are most frequently plagued to the point of exasperation.

In my career with the National Park Service, I have worked in only one *Cave Park*, Carlsbad Caverns. However, I have had the good fortune to work in non-cave areas that had quite comparable problems based on the preservation of unrenewable resources: Petrified Forest National Park, Mesa Verde National Park, and Wupatki National Monument.

The protection of archeological resources and petrified wood, like the preservation of cave values require recognition of determined minimum staffing levels to prevent vandalism, theft, and unthinking damage by the public. Such minimum staffing levels have to be adhered to as rigidly as determined carrying capacities. If staffing levels fall below that minimum either new compensating carrying capacities must go into effect or public use must be curtailed to bring protection staff capabilities back into balance with carrying capacity. This is undoubtedly one of the most difficult decisions for a manager to make, for it will inevitably produce both political and public *heat*.

If your cave is operating near, at, or above determined carrying capacity, there are, of course, a number of ways by which management can cope with the problem, including some that are indirect, and possibly sneaky. One category of these have been called *built-in frictions.** Most of these are best considered during the development of the adjunct facilities which supplement the cave resources in visitor use. Some consist of *not* doing all that you might think necessary to serve to *convenience* (as opposed to needs) of the public. In many cases this amounts to providing lower *carrying capacities* to noncave facilities such as parking areas. In another instance the distance to be walked from the nearest parking area to reach the cave can be dictated to serve this purpose, or the trail designed to use something less than the easiest route. Increasing the entrance or user fee may be a valid means toward the same end.

The more effective ways are probably those established early in the history of the cave's public use, such as a rigidly adhered-to permit or *reservation only* system.

* Maitland S. Sharpe, "The National Parks and Young America"; Chapter 16, p. 206 in *National Parks for the Future,* The Conservation Foundation, Washington, D.C., 1972.

Probably the most efficient and least used indirect methods especially adapted to caves under governmental management is that of management re-educating itself away from the too common attitude that *more is inevitably better* when it comes to the matter of visitors. With our increasing population and more rapidly increasing demand for recreation, the enlightened manager will reduce to a minimum the press release emissions which promote and encourage increased visitation to facilities taxed to, or beyond, optimum levels for either resource preservation or visitor enjoyment.

Carlsbad Caverns has hosted very nearly 20 million visitors in the 52 years of its history as a National Park Service area. With the advantage of hindsight we don't hesitate to say that the carrying capacity of Carlsbad Caverns operating under guided trips only, had been exceeded by 1952, at which time annual visitation first passed the half-million mark, and daily cavern use in August of that year averaged 2,985 persons.

By various means of increasing the carrying capacity, and changing to a system of non-guided visitor use within the cave, it seems possible that, given adequate man-power to protect the resources, a *built-in* carrying capacity may create *the ultimate carrying capacity* for Carlsbad Caverns. The 4 elevators which exit all people from the cave have a capacity of 1,100 persons per hour, objectively determined and enforced by law.

Proposed NSS Caver Classification Program*

Steve Knutson**

INTRODUCTION

At the request of federal agencies, especially Lincoln National Forest, New Mexico, the National Speleological Society has authorized development of a caver classification program to aid such agencies in managing access to their caves. This is being carried out as a subcommittee of the Safety & Techniques Committee under Donna Mroczkowski in coordination with the Conservation Committee under Rob Stitt.

The program proposes to classify NSS cavers who are willing and/or wish to cave on federal land. Presentation of proof of such classification should then facilitate entry to appropriate caves on the land of agencies utilizing the classification system. Classification will be made with regard to technical ability and (hopefully) conservation awareness. For this to become a national program, a standardized educational and testing procedure must be prepared enabling even isolated cavers to qualify. NSS cavers will obviously have an advantage in dealing with agencies using this program. It is assumed that most government agencies can be persuaded to use it since it will certainly ease their management burden.

For NSS cavers who reject such classification on principle, it is also proposed that a testing procedure be included which would allow agencies to do their own classification of cavers. It would seem that such is necessary anyway, to allow the agencies to provide access to non-NSS cavers. The actual testing available will depend on having the necessary personnel and funding, however, and it will undoubtedly result that it will be advantageous to be classified.

MANAGEMENT OF CAVES ON PUBLIC LAND

It seems to be accepted that agencies managing caves will find it necessary to pursue the following. An inventory of the caves is made. The caves are classified with regard to hazards and contents. The NSS system of caver classification is examined with an eye to local cave conditions and applied appropriately. Finally, a testing program is set up for non-NSS and nonclassified NSS cavers.

CAVER CLASSIFICATION

For the present, it is suggested that classification be kept simple and the following classes are proposed: A. Novice; B. Experienced; C. Vertical I; D. Vertical II. There will of course be variation in the experience, ability and leadership qualities of cavers in any given category. It must fall upon the managing agency to accept this and compensate as much as possible through local testing, observation and acquaintance. In the following descriptions each class will assume the requirements of the previous. All classes will require proper caving equipment of an ordinary sort (lights, clothing, etc.).

Novice: All cavers who have insufficient experience to qualify for any other category.

Experienced: Any caver who has experienced crawlways less than 2 feet in height; difficult scrambling (any caving in which the hands must be used for balance or support, but not in crawling); and has a reasonable amount of other caving experience.

Vertical I: Any caver who can demonstrate personal equipment in good order and an accepted technique allowing descent and ascent of a single rope; physical fitness to ascend 100 feet of rope using a personal system; knowledge of safe rappel and ability to rappel on personal gear; ability to rig a rope for pit work; and use of a belay for protection of an exposed but easy lead (no pitons or bolts for protection).

Vertical II: Any caver who has qualified for Vertical I and who has experienced or can demonstrate the following: Pits or practice descents and ascents of 200 feet or more using personal equipment; Practice or experience involving changeover from rappel to ascent, vice versa, and from one rope to another; and experience in leader climbing (rockclimbing) using a belay and pitons, bolts or chocks for protection.

TESTING

The testing program can be carried on at functions of internal organizations, at conventions or at any other time by individuals so authorized. Obviously, an initial group of testers spread nationwide is needed to get the program underway.

The same or similar testing will presumably have to be used by agencies experiencing access requests from non-NSS cavers. If so, it should be available to NSS cavers not willing to submit to the classification scheme.

Novice—No testing, obviously.

Experienced—The testing could be done in an artificial situation, like crawling in culverts and scrambling at a rock climbing practice area. Citing experience in caves known to be of sufficient difficulty will do for already experienced cavers. If actual caving experience is used as a future test in any locality, caves should be selected which will not suffer from the added traffic.

Vertical I

1. Inspection of personal equipment for ascent and descent:
   a. All slings and harnesses made of 1-inch tubular nylon (or heavier) and either tied or sewn.
   b. Ascent gear of either Mitchell, Inchworm (Texas), Gibbs (ropewalker or floating cam) or

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* Editor's note: the program described in this paper has not yet been adopted or approved by the National Speleological Society.

** NSS Caver Classification Committee, 505 Roosevelt Street, Oregon City, OR 97045.

knot (preferably Ascender or RBS) systems.

   c. Descent gear including either rack, carabiner-brake bars, or figure 8 ring, and slings or harness sufficient for the system used.

2. Demonstration of use of the gear:
   a. Ascent of 100 feet—Can be a pulley-fed system. Must use own gear.
   b. Descent of at least 30 feet (to experience exposure) using personal rappel gear.
3. Demonstration of rigging a pit.
4. Demonstration of proper belay technique. This would include proper situation of the belay, proper technique, and proper anchoring of the belayer.

Vertical II—must demonstrate a 200 foot ascent and descent and various change-overs. Must either demonstrate or cite experience in proper leader climbing.

Caver Classification and the Forest Service

Owen T. Jamison*

To set the scene for what comes later in this paper, I will start by giving you a little background on the Forest Service of today. Some of the material I will cover is basic and many of you already know some of it.

The Forest Service is composed of three arms: The arm of Research does forest and rangeland research but, as far as I know, no cave research (probably should be). The second arm is State and Private Forestry, which deals primarily with private landowners through State foresters. The third arm is the National Forest System of which I am affiliated, as well as most of the other Forest Service people here. The National Forest System consists of 187 million acres and 155 National Forests well scattered over the States.

We have been in public land management for 70 years and the basic philosophy during that time has been to protect and manage the resources, whatever they are. For the well established uses, we have developed detailed policy and guidelines. When something comes up that has not been definitely covered by guidelines and policy, we fall back on our standing policy of protecting and managing the resources. I think, at this point, that caving or caves pretty well come under this policy.

The National Forests are managed for multiple products and services: water, timber, fish and wildlife, range and outdoor recreation. Caves come under outdoor recreation or recreation management.

To help you better understand our decentralized organization I will quickly run through it. We have four line officer levels including the Chief in Washington who sets basic policy and guidelines and the Regional Forester, one of whom is located here in Albuquerque (Federal Bldg., 517 Gold Ave., SW, Albuquerque, NM 87102). The Regional Forester further amplifies the policy within the area he administers, in this case, Arizona and New Mexico. The third level is the Forest Supervisor. The fourth level is the District Ranger. Each level is decentralized and has much room for independent action. If we have national guidelines, then that independent action has to be within those guidelines. Where we do not have guidelines, each decentralized level has the authority to do many things on their own.

To help you understand our situation, I also need to talk about funds. During the past several years, our finances have increased about the same as the rate of inflation. Although we have more funds, we are not in any better position than we were several years ago. Our duties have seemed to increase tremendously, and we have not been able to get funds up to where they should be. We have taken on many new jobs in the past few years jobs like preparation of NEPA environmental statements and endangered species management. On things like this when financing does not follow the needed action, we have to try to squeeze them into the existing base. When you do that you cut something else.

Personnel staffing is just about the same as it was several years ago, except that we have actually taken reductions here. We have personnel ceilings and every once in awhile we have to make reductions. Therefore, we are not able to furnish all the staffing that the land managers need.

I will say again that when we add something new, we have to squeeze something out, and this is just about the way it goes. It could be that this will change, but it does not look too promising now with budget cuts being proposed. We are now working on the Resource Planning Act which is a new law that tells us to make an assessment of what we have and what we need and make our recommendations to Congress through the President. We now have that in draft form. It is available at Forest Supervisor and District Ranger offices. It is out for public comment and I believe October 15 is the cut-off date for comment. If any of you wish to make comments on our programs, now is a good time because we are trying to find out, and Congress will need to know, what the public thinks when they start considering our recommendations.

To get into caves a little, I admit that I know very little about them. I have never been into a wild cave except to just stick my head in a very small one or something like this, but I have been through several commercial caves including Blanchard Springs Caverns in Arkansas. In the 187 million acre National Forest System, we have many caves, but I don't know how many. We have dry caves in the southwest, humid caves in the midwest and east, and wet caves in Florida. I have swum in the Florida caves while I was Assistant Forest Supervisor in Florida.

We are operating under the policy of protection and management of cave resources but this policy is complicated greatly by short funds. Some units have been able to move out better than others in cave management—that is a product of personal interest and the ability to squeeze something else to work caves in.

To get into caver qualifications, I am new on that too, but I will give you some basic things that we believe in. As many of you know, for many years—probably most of the 70 years that there has been a National Forest System—the Forest Service has been involved with hazardous sports of many kinds. Rock climbing has been mentioned earlier and there has been river floating, wilderness travel, hang gliding, caving, and many others. We have a long-standing Forest Service policy that we should protect the public from others to the extent possible, but we are not able to protect the individual from his own acts. There are some exceptions to this. If we have an area that is causing many deaths or accidents, we would probably attempt to close it, or if the trouble is caused by an unnatural hazard we would probably try to modify it. An example of this is where people were diving off the eroded vertical banks in a reservoir in Utah recently. Kids were killing and mangling themselves horribly and warning signs did no good. After the hazard was known and we knew what was coming, we went in and blasted those vertical banks that erosion had caused on the man-made lake.

We have recently been working on a policy for hang gliding, a sport that is fairly new to us and is presenting some management problems. We have not published this yet, but basically what we are thinking is to protect the

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public from the people who are using hang gliders. that would mean keeping hang gliders out of heavily used areas where they might land in concentrations of people and keeping them away from hazardous highways where they might distract the attention of drivers. However, we cannot really protect the hang glider pilots from themselves. I understand that a hang glider association has a licensing system for the pilots. We would support and endorse such action.

In hang gliding, we want to protect the resource also. One of the ways of doing this is to exclude hang gliding from wilderness areas. You might say "Why? They are not motorized or anything like that." However, the Wilderness Act prohibits mechanical travel and hang gliding is mechanized travel, of a sort. They may be removed before we finalize the policy, but that is what we are thinking, and our authority is to protect the wilderness environment.

We encourage involved associations to develop and administer qualification programs and we think that it will be helpful in our management. I do not think, for the many reasons that I went through, that we can really become involved in caver qualification testing. We simply do not have the funds or personnel. As far as the safety of the individual is concerned, we do not think it is really our job to protect a caver from himself. Any efforts in this area would reduce funds somewhere else, and it would probably be funds used for the cave protection and management that we are doing now. I know that our present efforts are not nearly enough, but if we did move into caver qualifications then there would be less funds for protection and management. Of course, caver qualification efforts might aid the overall protection and management job, but it would take away from what we are able to do now.

In cave classification, when we write policy, I feel that it will be mostly on value and with permits issued accordingly, as I understand we are doing now on the Lincoln National Forest. This is about as far as I will get into permits because we did have good discussions on that this morning.

Comments on Caver Classification

Donald G. Davis*

I am not really against caver qualification in the sense that I am not at all against caver training, and I feel that the NSS could and should develop a more organized training program for the up-to-date techniques and difficult forms of caving. Where I differ with the other speakers is on classification and testing. I feel that one of the main reasons that cavers go caving in the first place is to get away from regimentation and formalization of various sorts that people have all too much of in their everyday lives in modern society. I really don't believe that cavers are going to widely accept a new power structure in their own society if this would be involved in administering such a thing.

If Allen Hinds or someone else from Lincoln National Forest is here, could you explain why you originally asked us to develop a caver classification program?

Allan Hinds: I think the basic philosophy behind our request pursuing this is the additional tool to enable us in trying to match a caver to the cave. The problem of managers is that we have several people coming for permits to the caves but we have virtually no way to determine whether the individual or group can safely tour the cave.

Donald Davis: There are parallel situations in government agencies especially in the climbing areas such as Yosemite, Devils Tower, and Rocky Mountain, and it has been traditional in these places for the Park Service or Forest Service to have someone on their staff who is knowledgeable in the field, and when someone comes to them and says "I want to climb Devils Tower," they ask them: "What groups do you belong to? How do you climb and what experience have you had? Show me your equipment." In general it seems that this has worked satisfactorily for those situations, and the reason I asked Allen Hinds to explain was to get an idea as to why he felt that the same kind of thing wouldn't work with cavers.

Allan Hinds: I would like to respond as to why that same thing wouldn't work. What we are dealing with is if you climbed Devil's Tower and don't use the right equipment, that's one thing. What we are talking about here is an irreplaceable resource that is being damaged, and that's totally different. If we are going to protect a cave, we need control, and if we are going to control, we need some kind of regulations.

Donald Davis: The system outlined by Knutson dealt mainly, it seemed to me, with safety and techniques rather than protecting the cave. I haven't fully thought out the implications of separating the contents of the caves and the care of them from the techniques for exploring them, so I don't think I'll go into that.

Caver Classification has been tried in the past by the NSS. There was a program under Rane Curl's leadership in the early 1960's. (Rane Curl was for several years president of the Society, and a well regarded president.) He told me that his Qualified Caver-Qualified Leader program had "islands of support in a sea of opposition" and it collapsed when he left the country temporarily. I didn't go into detail with him as to why he thought it had so much opposition. My own surmise is that cavers are pretty individualist in their attitude toward people's control over their behavior, expecially within their own group.

I see the real problem with the qualifications system in the NSS as the necessity, if we do institute a program of training, to be able to do it without a new power structure within the Society where one caver is given authority over other cavers to say you are or you are not qualified to do this and that. It's one of those things that looks like it's a good idea on paper if you can do it, but as a realist I wonder if we really can expect to be able to do it. Because of this sort of difficulty, I think if we can do anything as a Society to assist the agencies in determining who should go in caves, that probably rather than creating a system of numerical classification for cavers, we should act first of all as a training agency in both techniques and conservation. We can offer this sort of thing to cavers and hope that they'll accept this and benefit by it, but the actual assessment of who gets to go should be done by the personnel of the agency. Stan Ulfeldt has a very interesting paper by Keith Britton on the English experience on management of caves, and I'll quote from him. "Cavers are easily and intensely motivated by actions that offend against their feelings of justice and established rights. Discipline is much more easily accepted if externally imposed. Regulation from other cavers is accepted only if those in control exhibit self-discipline equal to or greater than that which they ask of others."

Aside from instituting training programs, the NSS should be freely available to agencies as advisor on proper techniques and conservation practices. It is my feeling that some of the agencies now are having trouble simply because they don't themselves have people who are knowledgeable in caving, and they really don't know what to think when somebody tries to tell them about their attitudes and qualifications. We should develop explicit standards as to how people should behave in caves, and give these to agencies who administer caves.

There is enough difference of opinion among informed cavers about good techniques, that I feel that the agencies should not expect too specific a statement as to the exact techniques that should be used. I don't think one should say how many ropes should be used in a cave, but they should expect that the cavers have seriously considered what they are doing, have been exposed to the various ideas on these things, and have made a mature decision.

Another difficulty in classification for cavers is that you just can't classify things like the physical condition of the caver at the time he is going caving. People may be a bit sick, may not have slept well, or have partied too much. On the other hand, they may be in top shape. This is something no classification can tell. Classification can't tell how well you are going to be working with the other members of the party, which is probably 50 percent of safe vertical caving. Not just what you know, but who you are with and how well you mesh. It's all subtle and complex, and I think trying to reduce it to letters and numbers that tell whether someone is a good vertical caver or a good conservationist is possibly going to be more misleading than helpful for the person trying to determine who is qualified.

I might emphasize again that caving parties, not individual cavers, are the units of difficult caving, and I don't

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know any possible way to classify the subtle relationships in a caving party.

I hope that in making these remarks I have articulated what I think are the negative aspects of trying to go too far into such a bureaucratic program. I don't think this precludes considerable advances in the way the NSS has been handling training, or the way in which agencies can get a better idea as to who they should let into the cave and who they should not.

National Park Service Permit Systems

Tom Ela*

There are at least two good reasons for permit systems in the areas of the National Park System for users of backcountry, and this includes mountain climbing, boating, and cave entry. First, it assures protection of the resource. The permit tells who is using the resource, what the park requires of the user, and what the user may do. Limits are definitely imposed and are spelled out. Cave party size is limited to a number that can be overseen by a guide assigned to the trip or what the resource can stand.

Secondly, protection of the user is assured to some degree. If an accident occurs, there is a better chance for prompt rescue action.

Using Carlsbad Caverns as an example of need for a permit, we must first go back to see how we got that way.

Years ago, there was little exploration done beyond what was known by the early cavers. Destruction of features occurred in spite of the fact that most persons connected with managing the Caverns had deep respect for the vast chambers and the large formations. As the main cave was developed, however, damage inevitably became apparent. Construction and maintenance of trails, blasting of elevator shafts, lunchroom and restroom installations, hiding of lights and power cables all took toll of the mighty cave and managers tried to check the degradation there. Some remote portions had been considered for public use and unrefined rough trails had been laid out which approached some extremely fragile, unique, or rare speleothems. Employees and special guests were allowed on occasion to see these places. This proved to be a mistake; and over the years, more damage occurred and rarities such as cave pearls *walked* away.

Now management has decreed that certain parts will be closed to any entry except for scientific study that will benefit science and management. Employees as well as other cavers must make application to visit the remote off-beat areas. Permission is given to small groups only if it is shown that scientific or educational benefit, either for the public or the Service, will derive. Applications must be submitted at least one day before a trip is proposed so that proper considerations may be made for what is at stake.

Parties are limited to twelve persons including trip leaders, as a general rule, and many rooms and passages may be visited only in groups up to six, including the trip leader.

These stringent controls assure less impact on delicate features and can offer a regeneration of resources where that is possible. It is too late to start such a program when viewed in retrospect; but, even at this time, much additional damage will be minimized. We cannot fault our early managers for their lack of foresight and the macro and micro damage done in the zeal to exhibit the wonders to the public eye. We are now perhaps wiser and can only take the drastic action indicated by research to halt further destruction and warping of the ecology.

The Service can expect general cooperation from the users only when all of them are convinced that the controls are necessary to protect the environment and features we all prize so highly. When that utopian situation arrives, the controls will no longer be needed for anything but personal protection. Even that will be minimal.

Symposiums like this should help to show that the *Bureaucratic Government* is run by human beings who are responsive to the pressures of people. Some pressures, unstated but present through sheer people numbers, necessitate restraints. Others from special interests modify the mode and degree of control and the judgment of the manager, plus her personal prejudices, rounds out the picture. Contrary to some concepts of management, the Service is not antagonistic to visitor demands but sympathetic while resolving to save what is entrusted to that Service for preservation.

The restrictions on cave entry without permit is in keeping with NPS controls on backcountry users, mountain climbers, and boaters. Until a better form of communication between management and user is found which will be effective in protecting both environment and the visitor, we must expect to put up with the present system. It is a nuisance to the person wanting to enjoy the park resources, and it is no easier for the manager and will be kept as simple as possible. An example of the application, which becomes the permit when approved, is shown in Figure 1.

I have mentioned before the Service authority under the *Code of Federal Regulations*. In case you would like to have a copy of some of the pertinent sections of Title 36, these are shown in Figure 2.

* SW Region, National Park Service, Box 728, Santa Fe, New Mexico 87501.

Carlsbad Caverns and Guadalupe Mountains National Parks
Carlsbad, New Mexico 88220

APPLICATION TO ENTER UNDEVELOPED CAVE

Permission is requested to enter the following cave or undeveloped cavern area in Carlsbad Caverns National Park: ______________________________ ______________________________ for the purpose of exploration, mapping and/or collection of scientific data, under criteria set forth in Section 7.47 of Chapter 1, Title 36 of the Code of Federal Regulations.

The following individuals will be members of the group included in this request, and additions or substitutions will not be made without prior approval of the National Park Service official approving this application:

Name	Age	Name and Address of Person to be Notified in Case of Emergency
(1)______________________________	___	______________________________ ______________________________
(2)______________________________	___	______________________________ ______________________________
(3)______________________________	___	______________________________ ______________________________
(4)______________________________	___	______________________________ ______________________________
(5)______________________________	___	______________________________ ______________________________
(6)______________________________	___	______________________________ ______________________________

On trips into areas where larger groups are permitted, attach a separate sheet with the additional names. However, do not exceed limits which have been established for the area being applied for, as applications exceeding the limits will be denied.

The following equipment will be used on the trip:

Item:	Quantity:
____	________
____	________
____	________
____	________

Government owned caving equipment will be used only after obtaining permission from the responsible National Park Service employee to whom it is assigned. The group leader will assume responsibility for the proper use and care of the equipment and see that it is returned to appropriate storage areas in good, clean, working order immediately following the trip. Emergency or rescue equipment will not be used on regular trips.

Figure 1. Sample Application/Permit Form.

The party will enter the cavern area applied for at approximately _______ a.m. or p.m. on ___________________, 19___, and plans to leave the cavern at approximately _________(a.m. or p.m.) on ______________, 19___.

The group will be directed by and subject to the complete authority of ______________________________who will accompany the group at all times and assume full responsibility for actions of the group.

It is understood that those making the trip are doing so at their own risk and of their own initiative and that the National Park Service will not be held liable for any personal injury, damage or death resulting from the trip into, stay within, or return from the above described areas, and that all persons included in this application are bound by its terms and limitations.

No rock, mineral formation, stalactites, stalagmites, phenomenon of crystallization, or other natural, historical, or archeological specimen of any kind shall be damaged or removed from the cave. All equipment, supplies and other materials taken into the cave by said party will also be removed from the cave at the completion of the trip.

It is further agreed that a full report of the trip will be made to the Park Superintendent within 60 days of the trip, including such items as descriptions of new discoveries, maps, scientific data gathered or other observations of interest resulting from the cave trip.

It is also agreed that there will be no publicity regarding the name or location of any park caves without permission from the Park Superintendent and fully understood that this application, when approved, covers only one cave trip on the date and to the place or places indicated above, and that subsequent trips will require a new application.

Requested by: ______________________________
(Signature)
Address: ______________________________

____
(Signature)
Address: ______________________________

____
(Signature)
Address: ______________________________

APPROVED____DISAPPROVED____

____
(Signature)

____
(Name)

Address: ______________________________

____
(Signature)

____
(Title)

Address: ______________________________

____
(Signature)

____
(Date)

Address: ______________________________

§ 7.47 **Carlsbad Caverns National Park.**

(a) *Cave entry*—(1) *Closed areas.* With the exception of the regular trips into Carlsbad Caverns under the guidance or supervision of employees of the National Park Service, no person shall enter any cave or undeveloped part or passageway of any cave without a written permit from the Superintendent.

(2) *Permits.* The Superintendent may issue written permits for cave entry without escort only to persons engaged in scientific or educational investigations. The Superintendent shall approve issuance of a permit provided:

(i) That the investigation planned will have demonstrable value to the National Park Service in its management or understanding of park resources, and

(ii) That the permit applicant is adequately equipped and experienced so as to ensure the protection and preservation of park resources.

(3) *Solo exploration.* Solo exploration or investigation is not permitted in any cave or undeveloped part or passageway of any cave within the park.

(46 Stat. 279; 16 U.S.C. 407a) [34 FR 8356, May 30, 1969]

§ 2.6 **Closing of areas.**

The Superintendent may establish a reasonable schedule of visiting hours for all or portions of a park area and close or restrict the public use of all or any portion of a park area, when necessary for the protection of the area or the safety and welfare of persons or property by the posting of appropriate signs indicating the extent and scope of closure. All persons shall observe and abide by the officially posted signs designating closed areas and visiting hours.

§ 2.20 **Preservation of public property, natural features, curiosities, and resources.**

(a) In natural and historical areas:

(1) The possession, destruction, injury, defacement, removal or disturbance in any manner of any building, sign, equipment, monument, statue, marker, or other structure, or of any animal or plant matter and direct or indirect products thereof, including but not limited to petrified wood, flower, cone or other fruit, egg, nest, or nesting site, or of any soil, rock, mineral formation, phenomenon of crystallization, artifact, relic, historic or prehistoric feature, or of any other public property of any kind, is prohibited, except as otherwise provided in this section or in special regulations for a park area.

(2) The gathering or possession for personal consumption or use, of only such fruits and berries as the Superintendent may designate is permitted. All such fruits and berries shall be picked only by hand. The gathering or collecting of such objects for the purpose of sale is prohibited.

(3) The possession or use of any mineral or metal detecting device is prohibited: *Provided,* That possession of such a device within a motor vehicle is permitted if the device is broken down or packed in such a way as to prevent its use while in the park areas: *Provided further,* That the provisions of this section shall not apply to (i) fathometers, radar equipment and electronic equipment used primarily for the navigation and safe operation of boats and aircraft, and (ii) mineral or metal detecting devices used in pursuit of authorized mining activities.

(b) In recreational areas:

(1) The intentional or wanton destruction, defacement or removal of any natural feature or nonrenewable natural resource is prohibited.

(2) The intentional or wanton possession, destruction, injury, defacement, removal, or disturbance in any manner of any public building, sign, equipment, monument, marker, or other structure, or of any relic, artifact, ruin, or historic or prehistoric feature or of any other similar public property is prohibited.

(3) Gathering or collecting for personal use, reasonable quantities of natural products of a renewable nature, including, but not limited to, seashells, fruits, berries, driftwood, and marine deposits of natural origin is permitted. The gathering or collecting of such products for the purpose of sale is prohibited.

(4) The destroying, digging, removing, or possessing of any tree, shrub, or other plant is prohibited.

(5) The gathering or collecting of small quantities of pebbles or small rocks by hand for personal use is permitted. The collection of such objects for the purpose of sale is prohibited.

(6) The possession or use of any mineral or metal detecting device is prohibited: *Provided,* That possession of such a device within a motor vehicle is permitted if the device is broken down or packed in such a way as to prevent its use while in the park areas: *Provided further,* That the provisions of this section shall not apply to (i) fathometers, radar equipment and electronic equipment used primarily for the navigation and safe operation of boats and aircraft, and (ii) mineral or metal detecting devices used in pursuit of authorized mining activities.

(c) Damaging or molesting crops or livestock is prohibited.

(d) Taking canes, umbrellas, sticks, or similar objects into caves or caverns is prohibited, except by permission of the Superintendent.

(e) The tossing, throwing, or rolling of rocks or other materials inside caves or caverns, into valleys or canyons or down hills and mountains is prohibited.

[31 F.R. 16651, Dec. 29, 1966, as amended at 34 F.R. 14170, Sept. 9, 1969]

NOTE: Regulations concerning archeological ruins and objects are found in 43 CFR 3.

Figure 2. Sections of the "Code of Federal Regulations" Pertaining to Caves.

The Wilderness Permit System Used in California

Carl Westrate*

In tracing the development and use of the Wilderness Permit system in California, I hope it may provide some guidelines applicable to development of a caving permit system when and where needed.

The Wilderness Permit System concept started in California, in 1969, with managers expressing a need to control numbers of people using Wilderness. In 1970 the Region obtained information and help from Region 9 about the permit system used in the Boundary Waters Canoe Area since 1966. From this advice, we hoped to avoid problems and pitfalls experienced in Region 9. One such troublesome item was issuance of multi-day trip and seasonal permits.

The Regional Forester established an in-house committee to develop the format and rules for use on a Regional basis in California. An Ad-Hoc Committee was established with representatives from private user groups, commercial users, and other State and Federal governmental agencies.

By February 1971 we were ready to announce the coming program which was to start on May 1.

The following objectives were established early in the process and the permit was designed to meet these objectives.

1. To provide an educational contact between the user and manager in an effort to influence the user's behavior and use pattern.
2. To collect user data to aid decision making in management plans.
3. To gain public acceptance of a permit system which might be later used to control use where needed.

Adverse public comment was received after the news releases and before the system was in use. Comments could be attributed to a lack of understanding for problems being experienced by managers of wilderness, a feeling that the concept was a further invasion of the user's freedom, and undue emphasis on the permit being used as a regulation tool.

The adverse comments diminished after the system got underway, in June 1971. By the end of the first season there was generally public support for the system. At the end of the first season an extensive review was conducted by the in-house committee and the Ad-Hoc committee. the only real problem that emerged was availability of the permits to users. Key to future administration was making the permits available, yet providing for issuance at the ground level to provide the manager-user contact.

The permit was made mandatory by a Regional Forester public notice at the start for all areas in the Region. The public notice established that entry without a permit was a citeable offense for enforcement purposes.

Permits were made available by mail or in person upon application to the Forest or District offices on which the area was located. Permits had to be issued for each entry or planned trip with no provision for multiple trips or exemption for day users.

Computer programs were developed and tested on five wildernesses using the 1971 data. The data was summarized to provide origin of visitors by County and State, persons present on each day, length of stay variation and groups size variation. Other programs were developed for use upon request. All of the coded information is stored on magnetic tape by year and can be retrieved when needed.

Permit format has changed over the years. The present format was adopted for optional service-wide use in 1974. The data gathered on the permit has been kept simple, yet it provides information that can be used by most managers. Attempts to expand the permit to be a questionnaire and meet everyone's informational needs have been resisted. If the permit becomes too complicated, it will lose effectiveness as a contact between manager and user.

The following information is presently obtained from the permits:

1. Name and address. (The zip code is the only coded item for data processing and is retrievable in future years.)
2. The Wilderness or Primitive Area to be visited.
3. Starting and ending dates of the trip.
4. Location of entry.
5. Location of exit.
6. Method of travel.
7. Number of people in group.
8. Number of pack and saddle stock.
9. Number of water craft or other craft. This item is used in the Boundary Waters Canoe Area only.
10. The travel zones to be visited. (Travel zones are areas mapped and coded to provide user information on specific areas.)
11. The nights camped in each travel zone.

In 1974, we processed 120,000 permits for the Forest Service and Park Service. In 1974 the California Region designed the permit for optical character reading because of mounting punching costs and lack of key punching facilities in-house. The Park Service permits had to be key punched in 1974 at a cost of 8 cents a card (this was through the Federal Women's Prison). The rising cost was a shock to finances so the Park Service adopted the same permit (OCR) for use in 1975.

PERMIT AVAILABILITY

Permits are available at Forest Service offices by mail or in person. Permits can be obtained only from Forest Service offices serving the particular Wildernes or Primitive Area. Use of cooperators in issuing the permit is held to an absolute minimum as it does not give the manager-user contact desired.

Some issuing offices will accept permit applications by phone to better serve the user where it may be inconvenient to obtain it in person due to distance or time of entering the area. Many Ranger Districts change office hours to accomodate the user.

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INFORMATION FOR PLANNING AND RESEARCH

The mandatory permit provides information of use patterns, travel routes, campsites, etc., useful in making decisions with some foundation rather than a *best guess*. The permits provide a source of contact for sampling visitors by mail. The names and addresses are only provided to approved research projects and where Office of Management and Budget approval has been received for the questionnaire to be used.

PUBLIC CONTACT

The permit provides a more efficient contact with the user than previously available through trail registers and office informational services. Each area has supplemental information and rules that are attached to the permit. Through this contact we try and communicate to the user not only rules, regulations, and desirable behavior, but information to enhance the user's visit. The permit contains the rules that are applicable throughout the Region.

COMPLIANCE

Compliance in obtaining a permit prior to entry has ranged from 30 to 95 percent. Several factors come into play in compliance rates: type of user (day or overnight), availability of permits, and proximity to heavily populated areas.

ENFORCEMENT

Enforcement in areas that have not established user number controls is generally limited to citing second offenders. On the first offense the user may be requested to cut his trip short and depart or may receive a warning notice and allowed to continue.

For areas having capacity or trailhead quotas, a citation is issued on a first offense that can range from $10 to $25 bail.

REGULATION OF USE

Regulation of use (capacity controls) have been approved for individual units only upon completion of the management plan and demonstrated need to use the permit in this manner. User numbers are presently being controlled on the San Gorgonio, San Jacinto, and portions of the John Muir Wildernesses. Before moving into these controls the Forests were deeply involved in public involvement and news media contacts. In all cases, these controls have been supported by the news mèdia (national broadcasts in the case of Mt. Whitney trail) and public. Part of the success might be that these areas were so heavily overused that the public could do nothing but support measures to eliminate such gross overuse and attendant problems (sewage, litter, etc.). However, I would like to believe that the Forests did their homework and supported their case to the public.

In the case of the Mt. Whitney trail, we found out some rather interesting items. Permits for the Mt. Whitney trail are limited to 75 persons staying overnight per day (uncontrolled use exceeded 300 per day on heavy use days). Essentially the District has a reservation system with people making application for entry on a certain day. Application can be made by mail, in person, or phone. The Ranger Station is the only office issuing permits for the Mt. Whitney trail and thus maintains reservations day-by-day. Early in the game the District discovered that they were getting 40 percent no-shows. When this fact was known, it was made mandatory that users holding a reservation pick up the permit in person on date of entry by noon. If not picked up by noon, the capacity was released to persons waiting to enter first come-first serve. In most cases, the District was able to accommodate the drop in visitor or divert the use to another trail. District costs for the first season of operation were estimated to be $8000 which was mainly in clerical and entrance station manning.

APPLICATIONS TO CAVE MANAGEMENT

I see several relationships that apply to caving permits.

1. A mandatory permit can make the user accountable for their actions.
2. The mandatory permit can be used to determine the people problems in caving for an area. (How many people are caving, where do they come from).
3. The permit can serve as a contact in building a caving ethic. It can provide the inexperienced user information on acceptable use and behavior.
4. Permits must be readily available to the user; otherwise, compliance will go down and enforcement needed will increase.
5. I can see that many caves would be closed to entry for scientific reasons or until an inventory can be made of the resource. Entry to such caves would be by a special-use permit or cooperative agreement only upon acceptance of a designed research or exploratory project. This would be outside the mandatory permit for caving use of caves (recreation).

Wilderness Permit

U.S. Department of Agriculture — Forest Service

When signed, this single-visit permit authorizes:

Name

Address

City State Zip

1 2 3 4 5

To visit

6 7 8

and to build campfires in accordance with applicable regulations.

Give best estimate of start and finish dates . . . . From Mo./Day 9 10 11 12 Through Mo./Day 13 14 15 16

Location of entry 17 18

Location of exit 19 20

Primary method of travel 21 22

Number of people in group 23 24

Number of pack and saddle stock 25 26

Number of water craft or other craft 27 28

List all zones to be traversed, in sequence of travel, even if no nights will be spent in one or more zones.

TRAVEL ZONE (SEE MAP)

29 30 33 34 37 38 41 42 45 46 49 50 53 54 57 58 61 62 65 66

NIGHTS CAMPED BY ZONE

31 32 35 36 39 40 43 44 47 48 51 52 55 56 59 60 63 64 67 68

Remarks:

I agree to abide by all laws, rules, and regulations which apply to this area. I will do my best to see that everyone in my group does likewise.

(Date) (Visitor's signature)

(Date) (Issuing Officer's signature)

The visitor must have this permit in possession during the Wilderness visit.

OMB (40-R3857) R5-2300-32 REV. 1/75

Visitor receives yellow copy.

Original white copy to Forest Supervisor or Park Headquarters.

Pink copy to Ranger District where the trip starts.

Wilderness Permit Used in California

Permit Systems in Use at the Roswell District, Bureau of Land Management

Charles Godfrey*

The Roswell District of the Bureau of Land Management is currently using a permit system that is set up specifically for caves. The permits are required on gated caves within the district only. We have identified some 100 caves; and until the end of this month, we had only nine of them gated. After the end of this month, we will have approximately 22 of them gated and several of them fenced. Anytime we go in and gate a new cave or construct some kind of a physical access barrier at the cave, that cave falls into the permit system.

Permits are currently only being issued out of the district office. When the permit system was initially set up in the district, provisions were made for these permits to be made available through some non-Bureau personnel, and also provisions were made for the permits to be made available by a telephone request as well as through the mail or in person through the office. We have modified this so that the permits are presently available only either in person at the office or through the mail. The problems that rendered the decision to change the system in this way were primarily based on the feeling that there was some inconsistency and possibly favoritism in the issuance of permits by a telephone request. Not everyone who is interested in visiting caves on the Roswell District was aware that permits were available by telephone; also the issuing officer was hard put to really determine very much about the prospective visitor from a telephone contact.

The permit contains some standard release terminology, and it is required that each member of the caving party sign the permit and place his address on the face of the permit. There is also a standard stipulation included on the permit against removing or damaging speleothems. In addition to this, there is space on the permit for specific stipulations or requirements that may be necessary to protect any particularly valuable resource in a given cave.

Party size restrictions have been placed on one cave; and access to one cave and to portions of two others has been restricted to scientific research groups.

Some of the problems that we have encountered, based on the availability of permits, have been that cave visitors are fairly mobile—they will cross from one portion of a State clear to the other side, they will cross State boundaries to visit any given cave. Without a standardized permit procedure and information on cave permits available at all of our district offices, people are frequently not aware until they arrive at a cave that a permit is required. We can understand their frustration after driving 400 miles to arrive at a gated cave and see a little sign that says you have to drive another 80 to 100 miles to get a permit.

Another problem, particularly in the Roswell District, has been the variation in the procedures and requirements for permits between the three primary Federal land managing agencies in that area. Within the Bureau there is currently only one other permit system set up that I am aware of that is designed specifically for caves, and that is in the Worland, Wyoming, district. They have executed a cooperative agreement with the National Park Service in that area to issue permits for one cave in their district. I understand this has alleviated some of the problems that we have experienced in Roswell because the Park Service office is considerably closer to the actual cave than is the district office.

We are currently in the process of not only trying to standardize the permit system for caves throughout the Bureau, but also to rework this system hoping that it may be the one to be standardized. We have also been working with the other two Federal agencies within the area in attempting to finalize a cooperative agreement to standardize such things as permit procedures as well as inventory and free exchange of data that is collected through permit systems.

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Physical Controls for Visitor Management

Cal Welbourn*

Any device or structure which is used to withold or restrain a person from a cave, or a portion of a cave, is a physical control. This could include trails with hand rails and glass panels in developed caves, to fences and gates in undeveloped caves, as well as undeveloped portions of developed caves.

The pros and cons of cave gating have been widely discussed among cavers for some time and it is not my purpose to discuss the ideology of cave gating. Many cave managers view gating as a management tool to control access to their caves. Their reasons for cave gating are usually reduction of potential hazards to the public and/or to protect the nonrenewable cave resource. In a great many cases, the only way a government agency can fund a cave gating program is through the hazard-reduction policy.

The pattern of increased traffic and simultaneous increase in vandalism (both intentional and unintentional) and littering has been observed in many caves across the country. In Fort Stanton, a popular New Mexico cave, the traffic and vandalism in the 1960s increased to the point where the Bureau of Land Management placed a fence around the entrance. Three years later the traffic and vandalism continued to increase until a larger and more expensive gate had to be installed in the entrance.

This paper is not intended to discuss actual construction or the various types of gates, but to discuss some of the considerations that should be made before a cave gating program is begun. Information on cave gate types and construction can be obtained in *Cave Gating, A Handbook* published by the National Speleological Society.

The one factor that is often overlooked in planning a cave gate is the cave community. This is because the community is not readily visable and will vary throughout the year. Before any cave gating project is undertaken, a thorough study of cave fauna and microclimate should be required. From this data the location and design of the gate can be determined. The location of the gate should be such that the natural entrance is disturbed as little as possible and air and water flow remain as natural as possible. The actual cave gate design should take into consideration the natural movements of cave animals, especially bats and other vertebrates. Too often in the past, caves have been gated when some of the vertebrate fauna was absent and no provision was left for their return. The design of gates to allow passage of vertebrates requires an opening of a size equal to that of the cave inhabitants. A horizontal opening of 4 inches by 18 inches or 6 inches by 12 inches will allow most bats to pass. If the cave has a bat colony of several thousands of bats, the problems multiply since they will not readily fly through grid type openings. Other vertebrates that may move in and out of a cave range in size from mice to porcupines and they all must be considered. It has been pointed out that vertebrates, especially bats, add significantly to the flow of organic material into the cave. In the Southwest porcupines are an important link in the ecosystem of some caves. The elimination of the vertebrates from a cave community by gating could have significant long term effects on the structure of the cave community.

Other considerations, in addition to the cave environment, are the location, types and numbers of gates. The location of a gate should consider ease of construction (and destruction), patrol and maintenance. A cave gate near the entrance is easy to build and patrol, as well as being easier to destroy and more likely to be vandalized. An interior gate would be harder to build and patrol, but the destruction and vandalism of such a gate is less likely. Wherever possible, natural barriers should be used to maximize the effectiveness of the gate, and there should perhaps be multiple gates in areas with heavy traffic, delicate areas, or hazardous conditions. The interior gates are usually secondary to an entrance gate, and the location and number of interior gates will depend on the manager's goals.

Consideration in the design areas brings up two philosophies of cave gate design. These are the impregnable gate and the weak-link gate. The impregnable gate would be designed to withstand the most determined vandal, but is usually harmful to the cave environment. The weak-link gate is designed with the belief that a determined vandal will get in if he or she wants to. To minimize the damage to the gate, a weak link is designed into the gate, usually the lock. This way a vandal will be likely to only destroy the lock to get in rather than destroy the entire gate. Another consideration is that the door size in the gate should be large enough to allow a Stokes litter and other rescue equipment to be taken into the cave if necessary.

In conclusion, a cave gate will not solve management problems but is an effective tool to be used in conjunction with a good system for issuing permits to qualified persons who desire entry, regular patrol of the gate, and prosecution of persons found vandalizing the gate. A successful gate should keep people out and provide for easy passage of cave fauna, without disturbing the natural drainage and air flow in the cave.

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Electronic Surveillance of Caves

Dean R. Jackson*

Cave gating, no matter how well done, protects a cave only against the honest and less determined intruder. Any cave gate can be opened and/or circumvented. If a cave is to be totally protected, an alarm system which announces an intrusion is needed. The technology is available, all industry needs is the demand to go into production.

Several basic types of systems are possible. Among them are the light emitting diode (LED) (infrared) and the *Proximity*. The proximity can be based on RF (radio signals), capacitance or ultrasonics. Each of these is capable of guarding a *volume*. That is, the detection device cannot be approached in some way so as not to trigger it, as in the familiar photo electric eye. The above mentioned devices do not have a *blind side* so to speak. This allows the system to be tamper and vandal proof. Tampering will set off the alarm signal.

In choosing a system for use in caves, several factors need to be considered. As this is electronics equipment, power considerations are important. The equipment can run from batteries, which eventually run down and need replacement, and/or charging. The batteries can be set up in combination with a bank of solar cells which provide the recharge. The power drain of the systems being discussed here is very low. Three months of operation using Nicad batteries without recharge should be possible.

One possible system would consist of one master unit in a central location that every 24 hours, (or any other time period specified) would scan all of the sites being protected. The master would transmit an interrogation signal to each site. The site then responds with any information it has stored. An important feature here is the checking of the system. If a site does not respond to the interrogation, it is then known that the site needs to be checked for malfunction of the equipment. If the site does respond, it's saying, *I'm ok, you're ok*. Current state allocated frequencies would be used.

In this type of system, the site detects information as it occurs, and records it for later transmission. Information may be in terms of an intrusion, in which case it can tell the time, location, and number of intruders. It is also possible for the system to differentiate between wildlife and human intruders. This capability suggests possible simultaneous use for wildlife studies. Some types of equipment could even tell the size, weight, color and body temperature of the intruder in addition to the number of intruders. Sensors can also be added to monitor the cave environment, and/or the outside environment. Temperature, humidity, the presence of pollutants, CO_2 content and average number of hours of sunlight are among the possibilities. With environment and wildlife monitoring possible, agencies might share both use and cost of equipment.

The major purpose behind recording information and transmitting information only when interrogated by the master control is for verifying system operation. It also conserves battery power.

In the case of a major intrusion, that is, an intrusion into the cave's interior by man, immediate notification might be wanted. This can be provided for by using two detectors, one at the perimeter, and one inside the cave. By coupling the two detectors, a major intrusion is indicated when both detectors are triggered. The major alarm would then be transmitted immediately to the controlling agency.

PROS AND CONS

Options: Infrared, Proximity, or Combination of both.

If a surveillance system is too complex it may have too many possible problems and be unreliable.

Two systems which are independent of one another, but interlocked provide a cross-check. A sort of fail-safe system.

A cheap system will be more expensive in the long run. Maintenance cost can quickly overtake initial system cost if the original design is inadequate. Systems should be built to NASA standards.

An Infrared system can provide number, size, color and density of an intruder. In other words, it can differentiate between man and wildlife. It is unaffected by rain, snow, dust and light. It does require higher power than other systems. Solar cells would eliminate this as a problem. Power requirements are approximately 60mw at 12V for continuous operation. A 60 amphere-hour battery would not be appreciably drained over a 3-month operating period. With solar cells, only an annual check would be needed. A capacitive system requires very little power drain, but works over a limited area. Capacitive systems can defect motion and can describe size and speed. Power drain is approximately 6mw. RF and ultrasonic devices also have high power drain, higher than infrared. A capacitive unit is less expensive than infrared. A combination of infrared and capacitive could be used, Infrared for the cave perimeter and Capacitive for the cave interior. The transmitter also has a high power drain, but its duty cycle is very short. Once again, Nicad batteries coupled with solar cells should provide a very long life system. A yearly maintenance check should be adequate. This system is similar to the ones used in satellites. Recording and storing information requires high power, but only for short periods of time. The master control in these systems is actually a minicomputer or microprocessor.

When a decision is made that a system is wanted, cost, of course, becomes a consideration. The cost of the base station is proportional to the number of caves it monitors. The more information desired, the higher the cost of the unit. All units can be reprogrammed economically. The system cannot, therefore, become outdated.

Cost for the system, in ballpark figures, might be as low as $5000 per satellite with as many as 20 ordered. This does not include the master control, or base station. The base station could run anywhere from $15,000 to $60,000 depending on what specifications were required.

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State Cave Protection Laws and Their Enforcement

Robert R. Stitt*

INTRODUCTION

Caves represent a unique and valuable resource for scientific research, wilderness recreation, and public enjoyment. Yet the future use of caves for these purposes is threatened by a variety of factors, including over-use, improper use, increasing urbanization, public works projects, vandalism, and other products of modern civilization. Over the past one hundred years, with improved public knowledge of caves, and a subsequent increase in recreational cave exploration, there has been an increasing recognition by cave explorers, speleologists, and commercial cave owners that specific statutory protection was required to provide adequate protection for the cave resources. This paper examines existing and proposed state laws applicable to the protection of cave resources and how they have been enforced, and discusses more effective approaches that could be taken in future cave protection laws. Because of space limitations this discussion is limited to state laws and regulations specifically applying to caves and their contents.

STATE LAWS

Existing state laws are described in Table 1, and proposed laws in Table 2. Such laws or proposed laws generally have sections outlawing some or all of the following: breaking or otherwise harming cave formations; killing or harming life found in caves; polluting or littering, or otherwise altering the natural condition of a cave; breaking and entering a gated cave; and selling speleothems taken from a cave. In addition, some states have specifically protected archeological materials found in caves. State laws, existing or proposed, usually do not abridge the rights of the cave owner in any way, therefore overcoming any constitutional problems associated with the taking clause of the Fifth Amendment.[1]

Early cave laws were probably passed at the behest of commercial cave owners, who wished to obtain police protection for the resource they were exhibiting to the public. These laws were found in the western states, which relied upon tourism as a major economic resource even in the nineteenth century, and it is obvious that the early statutes were drafted in such a way as to protect the commercial caves exhibited to the public, without infringing upon the right to remove formations from other caves to sell to the tourists.[2] In fact, the laws may have been passed in response to particular acts of vandalism, as an attempt to assure that vandalism did not reoccur, since they generally relate *only* to vandalism and do not provide protection for those cave resources of secondary importance to a commercial cave owner.

The first comprehensive cave law drafted by conservationists was that of Virginia (see Cave Laws of Virginia and West Virginia at the end of this article), which was passed in 1966 after intensive lobbying by members of the Virginia chapters of the National Speleological Society. The Virginia law, which broadened protection to include cave life and anti-pollution clauses, became the model for laws passed in the late 1960s in several other states. Wyoming specifically included caves in a burglary statute in 1973. A Texas law, modelled on the Virginia law, and passed in 1967, was repealed in 1973 and replaced by a streamlined criminal mischief law, which applies in general to all types of criminal mischief. An Arizona law, based on the Virginia law, was passed in 1974.

Several states currently have laws in various stages of passage through their legislatures. The New York, Pennsylvania, and Ohio bills are modelled after the Virginia law, while other proposed laws are either drafted specifically for a particular state (Missouri) or modelled after the more comprehensive Alabama bill, which not only provides for protection of cave resources, but also for regulation of commercial caves. The West Virginia bill, while not including regulation, is modelled after the protection sections of the Alabama bill.[3]

ENFORCEMENT OF STATE LAWS

In spite of the existence of cave protection laws in several states, there is considerable question as to whether they are effective because there is little evidence that they have been enforced. Although federal regulations are usually enforced in National Parks, other agencies have had less success at enforcement because of the general nature of the regulations. State laws can usually only be enforced at the behest of the property owner, who may or may not have the inclination to go through the hassle involved. Because convictions under cave protection laws, if they occur, are usually cut and dried, there are few appeals, so cases do not get into the more widely available court records. Thus information on the amount of enforcement is difficult to obtain. A nationwide plea in the pages of the NSS NEWS brought only a half-dozen responses, and it has not yet been possible to verify the cases brought to the writer's attention. Thus there are only two documented cases which can be considered here.

Louise Power mentions a Texas case in 1970, in which five individuals were convicted of violating the Texas cave protection law in the County Court in Williamson County, Texas, and sentenced to 30 days in jail, which was probated for six months if they paid restitution of $1000 to be divided between them. They had originally been indicted for burglary, but the cave owners (who had been instrumental in the passage of the Texas law) recommended prosecution as cave vandals.[4]

Max Evans describes an Ohio case in 1972, in which criminal charges (not specified) were filed against a vandal. However, in spite of what should have been an air-tight case, the vandal was acquitted by a jury, probably because of an inexperienced prosecutor's inability to prove malicious intent.[5] According to Evans, the judge who tried this case later said that a conviction would have been more likely

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Table 1. State Cave Protection Laws

State	Citation	Date Enacted	Fine	Sentence	Features Included *: Break or Harm Formations.	Kill or Harm Plants or Animals.	Litter or Pollute	Break or Enter	Comments
Colorado	Colo. Rev. Stat. 1963 40-18-14	Before 1883	$500	90 days	X			X	Provided, that copy of law is posted near the cave entrance.
Wyoming	W.S.A. 1957 6-229	1909	$100	60 days	X				Includes hot springs and their formations.
South Dakota	S.D. Compiled Laws 1967 22-34-9	1939	misdemeanor		X				Mutilation, or removal or carving initials.
Indiana	Ann. Ind. Stat. 1967, 10-4530	1947	$50-500	10 da.-6 mo.	X				
Kentucky	K.R.S. 433.870	1948	$100	30 days	X				Applies to caves exhibited to public only.
Virginia	Code of Va. 18.1-175.1	1966	$500	12 mo.	X	X	X	X	
Oklahoma	O.S.A. 21-1789 21-1790	1967	$500	1 year	X	X	X	X	Specifically includes public lands. Lists species of fauna specifically protected. Two exemptions: guano mining, killing predatory animals.
Tennessee	Tenn., Code Ann. 39-4535	1967	$10-1000	1 year	X	X	X	X	Error in law in statute book; a line left out omits littering and confuses things.
Texas	Vernon's Tex. Code Ann. Title 17, Art. 1350	1967	$500	12 mo.	X	X		X	Repealed 1973
Wyoming	W.S.A. 1957 6-130	1973	$500	1 year				X	Caves specifically included in general burglary statute.
Texas	Tex. Pen. Code 28.03	1973			X				General criminal mischief law. Sentence and fine vary with amount of damage.
Arizona		1974	$500	12 mo.	X	X	X	X	

Table 2. Proposed State Cave Protection Laws

State	Citation	Date Enacted	Fine	Sentence	Features Included: Break or Harm Formations.	Kill or Harm Plants or Animals.	Litter or Pollute	Break or Enter	Comments
New York	63132	1974	$500	12 mo.	X	X	X	X	Archeological artifacts protected, expands speleothem definition to include mud formations.
Alabama	??	1973/74	same as malicious vandalism	*	X	X	X	X	Establishes State Speleo. Comm. to regulate commercial caves and enforce law. Includes archeology.
West Virginia	HB 1144	1974 1975	varies w/offense	*	X	X	X	X	Similar to Alabama, but better written. Includes provision for collecting permit. (Did not pass, 74).
Pennsylvania	HB 518	1973	3rd Deg. Misdemeanor		X	X	X	X	Failed in 1973 after amended to outlaw fornication and adultery (everywhere)
Ohio	No information available—believed to be similar to Virginia statute.								
Missouri	H.R. 1708	1974	$1000	12 mo.	X	X	X	X	Includes archeological materials and provision for collecting permit.

* Alabama and West Virginia have the only proposed state laws which prohibit the sale of cave formations.

under a specific cave protection statute.[6]

Difficulties with enforcement and obtaining convictions include the problem of proving intent, in the case of general malicious mischief laws of proving value of the property damaged, and in fact, even of proving the ownership of the speleothems. Specific statutes affording protection to caves and cave formations usually do not require proof of malice, but only of intent to commit the act. The question of property ownership is more difficult in some cases, since when a cave extends outside of the surface land boundaries which are ordinarily used to divide land, part of it may in fact belong to someone else. In the hands of a clever lawyer this information could lead to questioning of the right of the entrance owner to bring charges, or even to the claim that the permission of the owner had been given. The problem is compounded by the difficulty of precise surveying underground, and the reluctance on the part of cave owners to allow such a survey for fear that it might prove that they didn't own all of their cave, and might have to share profits with another. At the very minimum, such difficulties could lead to unnecessary expense connected with the proper prosecution of a case. However, it is estimated that such circumstances are met only in a small proportion of cave vandalism cases.

There are more important reasons why cave protection statutes are not enforced. Since caves are often isolated from civilization and lie underground hidden from common view, there is great difficulty associated with catching vandals and proving the commission of a crime. There is a natural reluctance on the part of land owners, cavers, and law enforcement officials to get involved. Making an arrest while the crime is being committed is probably an impossibility outside of a national park, unless a cave owner also happens to be a law enforcement official. Since cave protection laws do not deal with possession of cave formations, once the vandal has left the cave there is little that can be done, unless the act of vandalism has been witnessed. Names written on walls could have been forged. A calcite crystal could have come from anywhere in a cave, or from any of several caves. A general lack of recognition on the part of the public and of law enforcement officials of the gravity of cave vandalism has resulted in an indifference towards the problem and a general lack of enforcement of the law.

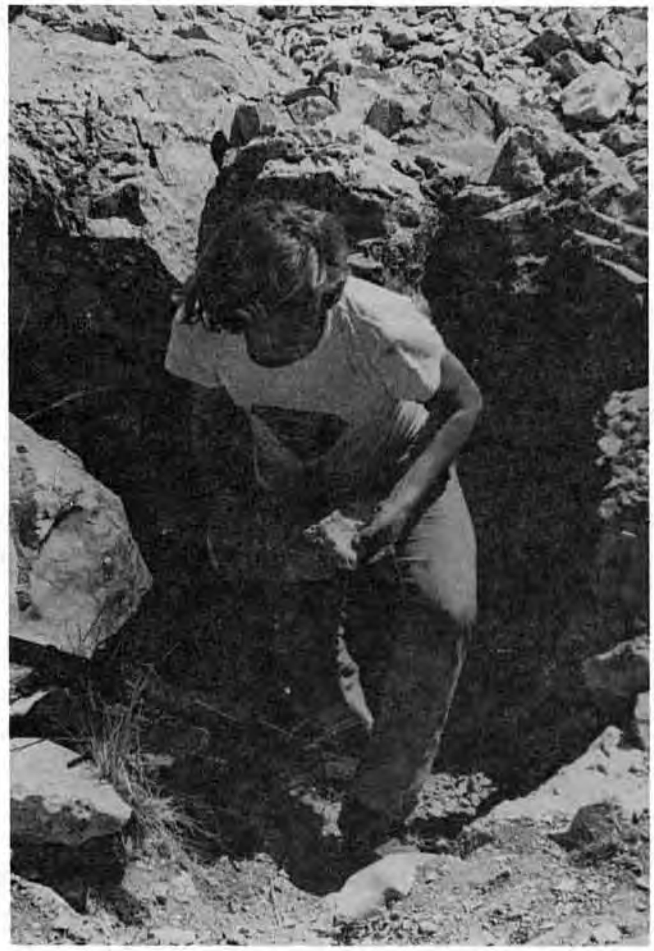
Because cave protection laws have rarely been enforced, it has been argued that they are of little value. Although no study has been made of the true effectiveness of such laws, it is probable that they do have a high deterrent effect. Of course, the laws affect only law-abiding citizens—many vandals would not obey them in any case, unless they had been previously caught and punished. When coupled with a public education program and wide circulation of the law among cavers and the general public, there should be a decrease in vandalism, especially among rockhounds, wilderness- and outdoors-people, and hunters. Those persons not reachable by cave protection laws and an education program are probably not reachable by any means.

NEED FOR NEW LEGISLATION

All cave protection laws now on the books have their origin in the concept of private property and its protection. As such, the laws do not really protect the resource—they protect the landowner—and if the landowner does not choose to be protected (or as in many cases is the one from whom the resource must be protected) then there is no recourse through the existing law. There is some glimmer of hope in the law of malicious mischief, for in some jurisdictions the mischief may be directed against "the rights ... of the public in general.[7] However, there is no history of presumption in this country that cave resources are deserving of public protection, nor any presumption that the public might even care about caves. Joseph Sax suggests that there is a need in this country to enable citizens to watch over the public trust through intervention in the courts.[8] Recent environmental protection laws passed by Congress have recognized more and more the rights of the public to a decent environment. As caves are increasingly threatened by the side-effects of technological civilization, there will be an increasing need for recognition of the public right to enjoy them for recreational and other purposes in an unimpaired state.

The major deficiency in existing laws is that they do not deal effectively with the speleothem sales problem. As long as some citizens are able to remove formations from caves and sell them to others legally, there will always be a market for them, and some people will be stripping caves of formations. Since the supply of caves, and thus cave formations, is limited, the day will come when formations have been removed from most known, unprotected caves. A law outlawing speleothem sales would not stop such pressure on the resource entirely (many speleothems are illegally mined now), but it would eventually dry up the market and would reduce the pressure on the resource.

Such a law would have its problems. Without a precedent of public trust law to back it up, it would probably not be accepted by the courts, since it would represent a taking of the owner's property, without compensation. The most similar law currently enacted is the Endangered Species Act, and this might be a good model for a speleothem sales law to follow. Such legislation would probably have to be federal, since it would be easy to circumvent state laws by exportation of speleothems to other states. Currently many of the speleothems being sold are of Mexican origin. An alternate approach to such a law could merely outlaw interstate transportation, but again that would meet constitutional problems, and might be difficult to enforce, lacking a strong public demand for enforcement.



A vandal photographed while removing a formation from an Arizona cave for sale at a nearby gas station. *Photo by Richard Frith.*

The existing laws have other deficiencies. One problem is that of mines which have intersected cave passages. This is quite common in the western U.S. The question is: is such passage a cave? Would it be protected by a cave protection law? Although the ultimate answer would be up to the courts, the writer's opinion is that the current legal definitions of a cave could be interpreted to include the mine passage as part of the cave, since the natural origin of the cave, and especially the entrance, is not necessary. In any case, current definitions do not require an entrance, and thus even undiscovered caves are protected by anti-pollution legislation.

Fines and sentences imposed by many of the laws are low, having been imposed many years ago, and losing in value to inflation. The minimum fine should probably be $500, with a maximum set at $2000 for maximum deterrent effect.

There is a need for the development of a model state law. For many years the Virginia law has been the model, but the improvements made by Alabama and West Virginia have demonstrated some of the deficiencies of that law. The West Virginia bill is probably the best one now written, and it could be recommended as a future model for state laws. It represents a streamlined and more functional version of the Alabama bill, which could be cumbersome in operation, and would probably cost the state money to administer.

Efforts to obtain cave protection legislation have been haphazard in the past, relying mainly upon local efforts initiated by local cavers or cave owners. There is a need for a nationwide coordinated effort to obtain adequate legislation in all states which have significant numbers of caves. The states can be classified as follows:

1. Those states already having an adequate cave protection law (Virginia, Oklahoma, and Tennessee).
2. Those states having a law on the books which is not adequate (Colorado, Wyoming, South Dakota, Indiana and Kentucky).
3. Those states where a law is currently being proposed (Arizona, New York, Alabama, West Virginia, Pennsylvania, Ohio, and Missouri).
4. Those states with no law which have significant caves worthy of protection (18 and Puerto Rico).
5. Those states having no significant caves worthy of protection (North Dakota, Kansas, Nebraska, and Delaware).

The chances of success in some states with low populations, little organized caving, or few commercial caves are small. Thus there are eight states in addition to those with existing inadequate laws where action should be concentrated for the most effectiveness. These include Arkansas, California, Florida, Georgia, Hawaii, Idaho, Montana, and New Mexico.

In this paper the writer has tried to acquaint the reader with the cave protection statutes of the U.S., both existing and proposed, and to determine their effectiveness as resource protection laws. It is hoped that the information included here will be of use to those persons working in enforcing such laws, both to citizens and to law enforcement personnel and prosecutors, and to those working to obtain new laws. One of the problems in enforcement has been the lack of information on the part of the public and the caving community as to how cave protection laws can be enforced. Thus cavers have stood idly by while cave vandals have not. There is evidence mounting that caving may be undergoing an increase in popularity[9]—and the passage and enforcement of strong cave protection laws is one way in which some of the effects of this explosion may be mitigated. In fact, an increase in public interest in caves might have some positive benefits, since it might result in an increased interest in cave protection, and the passage and enforcement of improved cave protection laws.

NOTES

[1]U.S. Constitution, Amendment V, preventing taking of property without just compensation. There is a judicial and legislative trend towards a broader interpretation in this area. In Cox v. Colossal Caverns, 219 Ky. 612, 276 S.W. 543, Court of Appeals of Kentucky, 1925, the court found that when cave rights were severed from surface rights a cave owner had a right to preserve a cave, but not to destroy it, since that would affect the surface owner's rights. In the case of endangered species legislation, the right of the state to protect the resource is considered to override individual property rights.

[2]For example, the clause in the Colorado law requiring the posting of a copy of the law near the cave if it's to be protected in effect makes the law useless except for protection of commercial caves, since in the absence of a caretaker any would-be vandal could merely tear down the sign and return the next day.

[3]Because of space limitations, only the Virginia law and the West Virginia bill are included in this paper. For the text of all existing and proposed laws, see Louise Power, *A Handbook on Cave Legislation,* NSS Conservation Committee, 1972. Revised Edition, 1974.

[4]Power, *Handbook*, p. 3.

[5]Max Evans, "Damage at Ohio Caverns," *Down Under*, Vol. VIII, No. 1, March, 1973, p. 13.

[6]Max Evans, personal letter.

[7]54 C.J.S. 937.

[8]Joseph L. Sax, *Defending the Environment: A Handbook for Citizen Action,* (New York: Vintage, 1972) Chapter 7, pp. 158-174.

[9]Dickey, Fred, *Report of the Caver Proliferation Committee of the National Speleological Society*, 1974. (Unpublished Manuscript).

CAVE LAWS OF VIRGINIA AND WEST VIRGINIA

Virginia

Code of Virginia, No. 18.1-175.1.

(a) It shall be unlawful for any person, without the prior permission of the owner, to willfully or knowingly break, break off, crack, carve upon, write or otherwise mark upon, or in any manner destroy, mutilate, injure, deface, mar or harm any natural material found in any cave or cavern, such as stalactites, stalagmites, helictites, anthodites, gypsum flowers or needles, flowstone, draperies, columns, or other similar crystalline mineral formations or otherwise; to kill, harm or disturb plant or animal life found therein; to discard litter or refuse therein, or otherwise disturb or alter the natural condition of such cave or cavern; or to break, force, tamper with, remove, or otherwise disturb a lock, gate, door or other structure or obstruction designed to prevent entrance to a cave or cavern, without the permission of the owner thereof, whether or not entrance is gained.

(b) Any violation of this section shall be punished by a fine not exceeding five hundred dollars or confinement in jail not exceeding twelve months in the discretion of the jury or the court trying the case without a jury.

West Virginia Bill

CBD914. HB: 1144. N. 1974

A BILL to amend chapter twenty of the code of West Virginia, one thousand nine hundred thirty-one, as amended, by adding thereto a new article, designated article nine, relating to the protection of caves within the state of West Virginia.

Be it enacted by the Legislature of West Virginia

That chapter twenty of the code of West Virginia, one thousand nine hundred thirty-one, as amended, be amended by adding thereto a new article, designated article nine, to read as follows:

ARTICLE 9. CAVE PROTECTION ACT.

#20-9-1. *Definitions*.

Unless the context in which used clearly requires a different meaning, as used in this act:

(a) "Cave" means any naturally occurring subterranean cavity. The word "cave" includes or is synonymous with cavern, pit, pothole, well, sinkhole and grotto.

(b) "Commercial cave" means any cave with improved trails and lighting utilized by the owner for the purpose of exhibition to the general public as a profit or nonprofit enterprise, wherein a fee is collected for entry.

(c) "Gate" means any structure or device located to limit or prohibit access or entry to any cave.

(d) "Person or persons" means any individual(s), partnership(s), firm(s), association(s), trust(s) or corporation(s).

(e) "Speleothem" means a natural mineral formation or deposit occurring in a cave. This includes or is synonymous with stalagmites, stalactites, helectites, anthodites, gypsum flowers, needles, angel's hair, soda straws, draperies, bacon, cave pearls, popcorn (coral), rimstone dams, columns, palettes, flowstone, et cetera. Speleothems are commonly composed of calcite, epsomite, gypsum, aragonite, celestite and other similar minerals.

(f) "Owner" means a person who owns title to land where a cave is located, including a person who owns title to a leasehold estate in such land.

#20-9-2. *Vandalism; penalties.*

It shall be unlawful for any person, without express, prior, written permission of the owner, to willfully or knowingly:

(a) Break, break-off, crack, carve upon, write, burn or otherwise mark upon, remove, or in any manner destroy, disturb, deface, mar or harm the surfaces of any cave or any natural material therein, including speleothems;

(b) Disturb or alter in any manner the natural condition of any cave;

(c) Break, force, tamper with or otherwise disturb a lock, gate, dor or other obstruction designed to control or prevent access to any cave, even though entrance thereto may not be gained.

Any person violating a provision of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred fifty dollars nor more than five hundred dollars, and in addition thereto, may be imprisoned in the county jail for not less than ten days nor more than six months.

#20-9-3. *Sale of speleothems unlawful; penalties.*

It shall be unlawful to sell or offer for sale any speleothems in this state, or to export them for sale outside the state. A person who shall violate any of the provisions of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred fifty dollars nor more than five hundred dollars and in addition thereto, may be imprisoned in the county jail for not less than ten days nor more than six months.

#20-9-4. *Biological policy; penalties for violation.*

It shall be unlawful to remove, kill, harm or disturb any plant or animal life found within any cave: *Provided*, that scientific collecting permits may be obtained from the director as provided in section fifty, article two of this chapter. Gates employed at the entrance or at any point within any cave shall be of open construction to allow free and unimpeded passage of air, insects, bats and aquatic fauna. A person who shall violate any provision of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than two hundred dollars nor more than five hundred dollars and in addition thereto, may be imprisoned in the county jail for not less than fifteen days nor more than six months.

#20-9-5. *Pollution unlawful; penalties.*

It shall be unlawful to store, dump, dispose of or otherwise place in caves or dolines, any chemicals, refuse, dead animals, sewage, trash, garbage or other materials. A person who shall violate any provision of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred dollars. A person who shall violate any provision of this section shall, for the second offense, be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than four hundred dollars. A person who shall violate any provision of this section shall, for the third or any subsequent offense, be guilty of a felony, and, upon conviction thereof, shall be punished by imprisonment in the penitentiary for not less than one year.

#20-9-6. *Archeology; permits for excavation; how obtained; prohibitions; penalties.*

(a) No person shall excavate, remove, destroy, injure or deface any historic or prehistoric ruins, burial grounds, archeological or paleontological site including saltpeter workings, relics or inscriptions, fossilized footprints, bones or any other such features which may be found in any cave.

(b) Notwithstanding the provisions of subsection (a) of this section, a permit to excavate or remove archeological, paleontological, prehistoric and historic features may be obtained from the chairman of the West Virginia antiquities commission. Such permit shall be issued for a period of two years and may be renewed at expiration. It shall not be transferable but this shall not preclude persons from working under the direct supervision of the person holding the permit.

A person applying for such a permit must:

(1) Provide a detailed statement to the West Virginia antiquities commission giving the reasons and objectives for excavation or removal and the benefits expected to be obtained from the contemplated work.

(2) Agree to provide data and results of any completed excavation, study or collection at the first of each calendar year.

(3) Obtain the additional prior written permission of the director of natural resources if the site of the proposed excavation is on state-owned lands and prior written permission of the owner if the site of such proposed excavation is on privately owned land.

(4) Agree to carry the permit while exercising the privileges granted.

A person who shall violate any provision of subsection (a) of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred dollars nor more than five hundred dollars, and in addition thereto, in the discretion of the court, may be imprisoned in the county jail for not less than ten days nor more than six months. A person who violates any of the provisions of subsection (b) of this section shall be guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than one hundred dollars nor more than five hundred dollars, and the permit herein authorized shall be revoked.

#20-9-7. *Liability of owners and agents.*

(a) Neither the owner of a cave nor his authorized agents acting within the scope of their authority shall be liable for injuries sustained by any person using such features for recreational or scientific purpose if the prior consent of the owner has been obtained and if no charge has been made for the use of such features.

(b) An owner of a commercial cave shall not be liable for an injury sustained by a spectator who has paid to view the cave, unless such injury is sustained as a result of such owner's negligence in connection with the providing and maintaining of trails, stairs, electrical wires or other modifications, and such negligence is the proximate cause of the injury.

NOTE: This bill is the "West Virginia Cave Protection Act" and its purpose is to preserve caves throughout the state by making certain acts unlawful and providing penalties therefore.

This is a new article.

Legislation and Liability of the Bureau of Land Management and the National Park Service

Gayle E. Manges *

As Field Solicitor for the Department of the Interior in Santa Fe, legal services are provided to the Regional Director of the Southwest Region of the National Park Service, the State Director of the Bureau of Land Management (New Mexico), and other agencies. The Park Service region includes Arkansas, Louisiana, Texas, Oklahoma, New Mexico, and the Navajo Reservation in Arizona and New Mexico. The BLM Area includes New Mexico, Oklahoma, and certain acquired interests in Texas. These are my only client agencies pertinent to this discussion concerning proposed legislation and management of caves.

The National Park Service is the Interior agency with the greatest control over caves within its areas. This control is by virtue of its enabling legislation which provides that the Director of the Park Service can promulgate rules and regulations governing Park Service areas. A violation of these rules and regulations is a crime. This provides law enforcement foundation and is one reason why Park Service areas are more intently managed than many other areas.

There are three specific Park Service statutes providing for criminal penalties for violations of regulations promulgated or issued under those statutes. One refers to National Parks and provides for fines of $500 or six months in jail, or both, plus court costs for violation of any regulation promulgated under that statute.

Violations of regulations pertaining to National Monuments and certain other areas transferred some years ago from the War Department are punishable by fines of not more than $100 and not more than three months in jail, or both.

In certain other areas such as Historic Areas, violations of regulations are punishable by fines not to exceed $500 plus court costs.

The Land and Water Conservation Fund Act is of some assistance to the Park Service for protection purposes as well as the Antiquities Act. Other acts also apply.

The regulations under the Antiquities Act in the Interior Department are set forth in Volume 1 of Title 43 of the Code of Federal Regulations. The Park Service has broadened the coverage of the Antiquities Act by virtue of regulations under its Organic Act of 1916 set forth in Title 36 of the Code of Federal Regulations. In Section 2.20 of Title 36 of the Code of Federal Regulations, preservation and protection of public property, natural features, curiosities, and resources are included. In natural and historic areas, regulations protect even such items as flowers and pine cones.

Several years ago, my family was visiting the Tetons on a Park Service guided nature tour. The Park is a natural area. About twenty-five were in the group. One elderly lady was busily collecting pine cones and depositing them in her handbag. After collecting about six cones, the Park Service Naturalist looked at her and said "Lady, you're violating the law." She was shocked when told she could not even collect sample cones in a natural area of the Park Service. The Naturalist was courteous but firm and explained the result if all or a substantial number of visitors collected such usually, common objects as pine cones. In a few months or years, nothing would be left to interpret.

Park Service regulations specifically include caves. In Section 2.20 of Title 36 of the Code of Federal Regulations, the possession, destruction, injury, defacement, removal or disturbance in any manner of rocks, mineral formations, and "phenomenon of crystallization" in natural and historic areas is prohibited. The Park Service regulations are broad but are the type of coverage that, in my opinion, is necessary if you are going to protect a "natural phenomenon of crystallization," mineral or rock formation.

In recreation areas we have a regulation that includes the intentional wanton destruction, defacement and removal of a natural feature of a nonrenewable resource. A regulation encompasses the tossing or throwing of rocks or other minerals inside "caves or caverns" or into valleys and canyons.

Although the regulations lay the foundation for an effective protection program, such regulations are not sufficient by themselves. It does no good to have a regulation if you cannot enforce it. You have to have a means of protection. Probably the most important are trained personnel and funds. The necessary legislation that the Park Service and also the Forest Service have is arrest authority. Park Service Rangers are uniformed, therefore known to the public, have authority to make arrests, and receive considerable training in law enforcement. So, you have a compact bundle. Laws, regulations with criminal provisions, a law enforcement branch, arrest authority, and sufficient personnel and funding to carry out the function of preservation and protection.

Do you have any questions concerning caves managed by the Park Service?

Q. When you come into an area, say a mountain, can you close that mountain and not let anybody on it?

A. Yes, under certain conditions because of safety and protection of the area.

Q. Can you totally restrict it?

A. Yes. It can be closed because of sound reasons.

Q. Is this reasonable? Will it stand up in court?

A. It is up to the Superintendent to provide for the safety of the visitors and the protection of the area.

Q. Are there any regulations available, or is the Park Service concerned with regulating the air space above the National Parks, or is it up to the FAA?

A. The authority for the Park Service to regulate air space above a Park Service Area is questionable. I have no answer at this time. We have had problems such as at Mt. Rushmore, and I should not be surprised to see an effort

* Field Solicitor, Department of the Interior, Santa Fe, New Mexico.

made to protect the air space. I am of the opinion that the Park Service could do so by regulation. Apparently others disagree with or question this. Problems with low flying aircraft and helicopters exist at Grand Canyon, at least in my personal opinion, from a backpacker's standpoint. At Grand Canyon we have worked in cooperation with the FAA to put ceilings over such areas. The FAA seems reluctant to place such a ceiling; however, this could be an effective way of controlling the air space.

Now, let us go on. I suggested that the Interior agency with greater problems than the Park Service is the Bureau of Land Management. We have talked about enabling legislation for the Park Service. In my opinion, legislation is necessary for the BLM to acquire effective control over caves on public domain. The BLM manages considerably more land than the Park Service or other agencies and problems exist. This was recognized by the Public Land Law Review Commission when they recommended that an Organic Act be enacted for the BLM. A brief background might be helpful. Prior to the BLM, in general the General Land Office and the Grazing Service managed the public domain. They were combined to form the BLM. In consolidating, no legislation was enacted. Therefore, the BLM today relies upon many, varied Acts such as the Mining Laws of 1872, the Mineral Leasing Act of 1920, the Taylor Grazing Act of 1934, and many others.

We have problems with protecting caves on public lands. You are probably fully aware of that. As stated, one reason is because the BLM does not have a general statute authorizing it to promulgate rules and regulations with criminal and law enforcement provisions attached to that statute. There is one possible exception we will discuss later. Employees of BLM do not have arrest authority. They have no more authority to make an arrest than does John Doe on the street. Because of this, Bureau employees are in a precarious position trying to enforce such acts as the Antiquities Act which is one of the Acts they must enforce.

The Taylor Grazing Act charges the Secretary to preserve land an its resources from destruction or unnecessary injury. The Act requires protection of resources but whether this includes caves may be debated. The Act that might give BLM a means of enforcement is a proviso in Section 2 of the Taylor Grazing Act that any willful violation of the Act or of rules and regulations thereunder "after notice thereof" can result in a fine of $500. Rules and regulations under that section with criminal provisions attached have never been issued. This has been discussed with associates and we know of no case where the BLM implemented the criminal provision of the Taylor Grazing Act. It is doubtful that it can be implemented in its present form.

The Public Land Law Review Commission recommended that an Organic Act be established for the Bureau and that is still sitting in Washington. However, as of today, it has not reached the bill stage. One proposal includes law enforcement provisos. But these proposals are not firm and it would be premature to even discuss them.

Now, if at this point anyone or group believes that protection of caves on public lands is of importance, and I assume that is one reason we are here, then that person or group should take any available opportunity to give input into the legislation. If caves on public land deserve and require protection, I would strongly urge those interested to make their opinions known at the legislative level, so that when the Organic Act is passed it will provide that necessary rules can be issued under the Act containing criminal provisions that will authorize the BLM to take an active, effective means in protecting those caves requiring protection.

We do not have a rule or regulation protecting caves on public lands so how can a person be in violation of a law by entering a cave? How about cavers? Do they have a right to enter a cave on public land? And with the question you are going to find arguments on both sides but I believe such a right of entry does exist.

What is the difference between collecting items from a cave and rockhounding? Does the public not have a right to rockhound on public land? We have never taken the position that they do not. We have acted but only when they conduct a commercial operation or operate a quarry without authority.

Does the BLM have the duty to preserve those resources of value such as caves? Is it not an inherent power in the Secretary of the Interior to preserve those resources of value on public lands or a part of the public domain? But when you must rely upon the "inherent power of the Secretary" you are not on the strongest grounds. In my opinion, if a cave or caves are resources requiring preservation and protection, such resources should be protected by statute and regulation and a means acquired to protect them.

The BLM might rely upon State law to protect caves. All public land to my knowledge is under only proprietary jurisdiction of the United States. Very briefly, that means that although Federal statutes and BLM rules and regulations apply to the public land, the State law also applies to the extent it does not conflict with a Federal law or regulation. This means that a crime under New Mexico law occurring on public land is enforceable by filing charges by you or by my agency as a local crime in local courts. This type of jurisdiction differs from Federal exclusive jurisdiction such as Big Bend National Park in Texas. With exclusive jurisdiction, generally, only Federal law applies but again with exceptions. However, public land is under proprietary jurisdiction so State law may provide a means to prosecute those destroying natural resources on public land. The general criminal trespass in New Mexico has been held to not apply to Federal public property. There is a specific criminal trespass for knowingly entering or remaining on any "public" property knowing that the property is not open to the public. But unfortunately, this refers only to property of the State or its subdivision and would not include Federal land. This was recently enacted by the State legislature as a result of the holding as to the general trespass act and demonstrations at university campuses.

Considering Federal law in the Federal Tenth Judicial Circuit, there is a policy that the United States Attorneys do not prosecute for theft of Government property unless the Government property is by stamp or insignia designated "Property of the United States Government." That puts the BLM in an awkward position when a person removes a stalactite, stalagmite, or formation from a cave. Is it Government property or should it be handled the same as rockhounding? It is not clear.

As suggested above, I have advised the BLM that the mere entering of a cave on public land is not in itself a criminal trespass. It was suggested to the Roswell District to construct gates across the entrances if that is what has to be done to protect the caves. They should post the gate as government property requiring visitors to obtain a permit to enter from the District Manager. This should assist in controlling the public's right to use the cave. If the gate is vandalized or destroyed and one enters the cave, they have destroyed something marked, Government property. We

can enforce that or at least attempt to do so. That is a roundabout way to protect a valuable resource such as a cave but that is what the BLM has been advised to do. Thank you.

Legislation and Liability of the Forest Service

Demetrie Augustinos *

I'm with the Office of the General Counsel, and we provide legal counsel and representation to the U.S. Forest Service. In fact, the Forest Service is our major client. Region 3 of the Forest Service comprises the States of Arizona, New Mexico, and parts of Oklahoma and Texas.

In researching the question of the Forest Service' legislative authority to administer and govern caves, I was unable to locate any specific statutes dealing with caves in the National Forests. Therefore, the Forest Service must rely on the enabling act, or the Organic Act, which organized the Department of Agriculture. And also upon those statutes which are found in Title 16 of the United States Code, Section 471 to 583, plus the regulations that were promulgated pursuant to those statutes which are contained in Title 36 of the Code of Federal Regulations. In fact, the Forest Service' regulations are contained in the same volume as are the regulations of the National Park Service.

I think Mr. Manges has covered the general questions pretty thoroughly, and I would join in what he said although each agency has its own specific regulations. Now the Forest Service does have regulations in 36 CFR which provide for the protection of property and the protection of the land within the National Forests, and violations of these regulations can result in criminal prosecutions before the United States Magistrate. Just for example, Section 261.4 of Title 36, subsection d. prohibits the mutilating, defacing, or destroying of objects of natural beauty or of scenic value on such lands. The Forest Service also has the authority to regulate the occupancy and use of National Forest lands. This authority is pretty broad. The Forest Service has the authority to close an area to protect it. If they do decide to close an area, they must post notices; they must give notice to the public that the area has been closed. If someone violates that notice, they are subject to criminal prosecution before the United States Magistrate.

Prosecutions of this nature usually result in the payment of a fine. I can think of a couple of instances where people went to jail, but I think this is pretty rare. Mostly, violations are punishable by fine.

As far as legislation goes, I think the Forest Service has ample authority to govern and to administer caves which are located on National Forest land. There isn't really much more that I can say about this which wouldn't be repetitive of some of the things that Mr. Manges said.

I was also asked to speak on the topic of liability. This liability, I assume, would be against the United States Government, acting through the Forest Service, for injuries to property or life or limb on a National Forest. In regard to caving operations, I can only think of two possible grounds of liability against the United States; and that would be under the Federal Tort Claims Act, which makes the United States liable for any injuries caused to persons or property by the negligence of an employee of the United States, of an agency who is acting in the scope of his employment. Generally, what we are talking about is negligence, and the Federal Courts have held that questions of negligence will be under the Federal Tort Claims Act, will be decided according to the cases and laws of the particular State where the injury occurred. My office here in Albuquerque has the authority to determine whether to allow or disallow claims brought against the Forest Service up to $5,000. Any claim beyond $5,000 has to be decided in Washington. So whenever a claim of less than $5,000 comes to me, or any other attorney in our office, we look at the facts of the particular situation, and determine if the injury is caused by the negligence of an employee of the U.S. Forest Service. Since the laws of the State apply, in New Mexico a defense to negligence is a finding of contributory negligence, or the failure to use due care on the part of the person who was injured. We would be looking into that.

Now the Forest Service, as a land owner, would be subject to the law as part of this Federal Tort Claims Act, of making the premises safe or warning those people coming to the National Forest as invitee. Again, if a person were to be injured while engaged in caving, we would have to look at the particular circumstances to see whether the Forest Service may or may not have had a duty to warn people of any defects or any dangers in the cave area that they were using in their activities. Then we would have to determine whether the Forest Service was negligent. If we determine that, then we usually advise the Forest Service to make payment. If we disallow a claim, we normally advise the injured party of our decision, and if they are dissatisfied with that decision, then we advise them that they may bring suit within 6 months in Federal District Court. How a court would hold is anybody's guess.

The only other possible basis I could think of liability against the Government would be a contractual basis. There the jurisdiction, I would think, would be with the court claims, and jurisdiction then would depend on the amount of the claim. I think this kind of liability against the Forest Service would be pretty remote.

* General Counsel, Southwestern Region, Forest Service, 517 Gold Ave., SW, Albuquerque, NM 87101.

Cave Research Foundation Joint Venture Agreement

Extracted from "The Cave Research Foundation Personnel Manual*

EDITOR'S NOTE: This is an example of a "third party" permit system in which the agency enters into an agreement with the second party (Cave Research Foundation in this case). The second party in turn executes a joint venture agreement with the third party—a joint venturer. An accountability or responsibility chain is thus set up which reduces agency administrative work without diluting agency control.

3.3. The Joint Venture Agreement

For the mutual protection of the National Park Service, the Cave Research Foundation, and all Foundation personnel, each participant must sign a Joint Venture Agreement with the Foundation. The text of this agreement is on the following page.

A secondary purpose of the agreement is stated in paragraph 2 which discusses releasing information. The purpose of this rule is to maintain a proper perspective regarding the Foundation's scientific, educational, and conservation goals and accomplishments. Further, the Foundation's agreement with the National Park Service provides a joint relasing procedure for news. The National Park Service has specific public information policies, and because we are working under their auspices, it is often in our mutual best interest to release newsworthy items in accordance with their procedures.

Also, we want information about CRF's findings to be accurate. Rumors of Foundation discoveries can travel very fast and are often incorrect. The hectic schedule at the Park sometimes means that no one is fully aware of events except the expedition leader. Even his views and impressions may change after a few weeks of study and reflection. To help maintain accuracy the rule on information release states that no joint venturer may publish letters, articles, or photographs of any sort concerning CRF, its discoveries, or its projects, without the approval of the CRF directors. Discussions concerning recent discoveries and happenings with persons outside CRF should also be circumspect.

The publicity rule does not apply to the publication of strictly scientific findings or photographs in recognized scientific journals, though the CRF directors do request that they be informed beforehand of the intent to publish and be provided with at least 20 reprints of each article.

The Joint Venture Agreement can be terminated by either the Foundation or the individual joint venturer. On the part of the Foundation, termination may result from some change in the situation of the venturer, such as infrequent participation in the expeditions. Of course, violation of the terms of the Joint Venture Agreement, the policies outlined in this Personnel Manual, or violations of National Park Service regulations may also be the cause for termination. It is a confirmation of the effectiveness of our selection procedures that *very* few joint venturers have had to be terminated because of violations.

3.4. Personnel Information

You are asked to supply various biographical and medical information as part of your Joint Venture Agreement. Some of the biographical information is incorporated into a list of participants submitted to the National Park Service each year. Medical information is kept in a first aid card file at the CRF facilities. It includes the joint venturer's name, blood type, answers to the two medical questions on the Joint Venture Agreement, and the name, address, and telephone number of a person to contact in case of emergency. (See Section 14.5 for details on the first aid information file.) It is imperative that each person keep the Foundation informed of the name, address, and particularly the telephone number of the person to be contacted in case of injury or death. The person named should be aware of your designation.

Each joint venturer bears the responsibility for keeping his personnel officer informed of changes in his own personnel information, as well. A major problem in keeping our records current is the mobility of many Americans. Too many envelopes return undeliverable from each personnel mailing. The result is extra expense for CRF and delayed newsletters, schedules, and reprints for the intended recipients. By not sending the personnel officer your address change you leave him with the impression you no longer care to receive CRF mailings.

Principal CRF researchers often identify joint venture personnel interested in and qualified for participation in their projects from data supplied on the JV information sheet.

* Freeman, John P. (Ed.) *Cave Research Foundation Personnel Manual*. Columbus, OH; Cave Research Foundation, 1975, pp. 10-13. © Cave Research Foundation 1975. Reprinted by permission.

SAMPLE

JOINT VENTURE AGREEMENT

THIS AGREEMENT is made and entered into this _____ day of ____________________, 19_____, by and between ________________________________, hereinafter called Venturer, the Cave Research Foundation, hereinafter called the Foundation, and other members of the joint venture who execute like agreements.

WHEREAS, the Venturer desires to enter into a joint venture agreement with the Foundation and others, and to cooperate with them for the purpose of scientifically studying the extensive cave systems of the world and of encouraging and assisting technical data collection concerning caves for the enrichment of human knowledge and the advancement of science:

NOW, THEREFORE, the Venturer, in consideration of the mutual promises of the joint venturers and in consideration of being permitted to participate in the scientific studies of the Foundation; and of being granted access to the premises exclusively leased or otherwise available to the Foundation, agrees as follows:

1. To abide by the rules and regulations of the Foundation and to accept the leadership of any expedition leader appointed by the Foundation, or jointly selected by the Foundation and other Venturers, while on Foundation expeditions conducted on Federal or other lands.

2. Venturer further accepts the Foundation as the exclusive agency to release news and publicity which the Venturer may make while on expeditions with other members of the joint venture either on Federal lands or on Foundation leased lands.

3. Venturer agrees to show evidence of coverage by hospitalization or accident and health insurance and to keep same in force while participating in the joint venture.

4. Venturer hereby acknowledges the inherent danger of underground exploration and research and assumes any and all risks arising out of the joint venture; and further, hereby agrees to waive any and all claims for personal injury which he might have against the Foundation and other members of the joint venture by reason of its activities.

5. This agreement may be terminated by the Venturer or the Cave Research Foundation, by written notice. In the event of termination by either party or parties, the Venturer agrees that the promises and covenants made by him in paragraphs 2, 3, and 4 shall remain in force for a period of two years from the date of termination.

6. Should the venturer be a minor, his parents and/or legal guardians shall join with him in executing this agreement.

Intending to be legally bound hereby, the parties have hereunto set their hands and seals.

____

Venturer

Witness:

____

Cave Research Foundation

____

by________________________________

(revised, June 1973)

British Caving Experience Relating to Conservation and Cave Management Practices

Keith Britton*

Pre 1930

Cave exploration and investigation was carried out by little more than a handful of individuals and was essentially limited to entry into only obvious, easy entrances. However massive damage was caused, the worst due to ignorance of modern archeological techniques. They left churned into useless confusion more than nine-tenths of the cave sediments in the British Isles which show traces of early man. Speleothems were removed by the poor for sale and by others for souvenirs.

1930-1940

In the decade preceding WW-II, the number of regular cave explorers rose sharply as did their technical competence. For the first time, difficult caves were exposed to human traffic and previously unknown ones sought out. While there were a number of clubs whose members explored caves, the age of the club dedicated to cave exploration had not yet arrived, and for all practical purposes, the British Speleological Association (BSA) contained in its membership a near monopoly of the serious British cavers. This association was national in scope and, like the NSS in America, a loose federation of individuals and otherwise autonomous groups. Exploration was carried out primarily in a sporting vein, but due to the high individual competence, the small number involved, the teaching of a sense of a sense of responsibility to novices and the high experienced/novice ratio, astonishingly little damage to caves occurred.

1945-1950

Those cavers who survived the war had available cheap and splendid surplus equipment making possible the exploration of caves of hitherto impregnable severity. Wire and aluminum ladders replaced hemp and wood, nylon became the universal rope, and waterproof exposure suits drew the teeth from waterfalls and canals. Even greater was the impact of a surge of novices from the demobilized troops.

Initially all went well. With so much new ground reachable, the newcomers had room to spread. The BSA maintained a position of overwhelming dominance though it no longer held a near monopoly.

As the dreams of the pioneers proved attainable, there appeared to be dawning a golden age. Then came the discovery of the Lancaster/Easegill system. A few trips revealed enormous passages decorated with a richness unparalleled in the rest of the country, and then, suddenly, the cave was closed by a gate. An individual, leader of a faction of the BSA, had concluded an access agreement with the landowner designed to exclude the original discoverers. This action shattered the unity of the BSA and generated feuds and bitterness which persist in speleo-politics to this day. Dynamite removed the gate, and it was replaced. With the discovery of Easegill Caverns, a new way was found to enter the system. It was blasted shut, later reopened. The dissidents left the BSA and formed a series of new caving clubs, collectively stronger than and implacably hostile to the BSA. *No gates and free access* was their philosophy. Both sides in the controversy came, however, to the realization that in the Lancaster/Easegill system there existed sights unique in the country, and extraordinary care was taken to preserve the speleothems, hundreds of feet of tape was used to mark the edges of the pathways. White Scar, almost the only cave of comparable decoration and importance, was found; closed; then reopened as a show cave with access to the further reaches limited to the BSA faction.

1950-1960

The diminished size and stature of the BSA, and particularly its personalities, ensured that the bulk of the newcomers to the sport joined the clubs. The older clubs soon could not cope and new clubs appeared. For the first time, caves were being extensively studied though largely with a view to finding more caves. For the first time, the wear and tear of heavy traffic became noticeable underground, as did litter. In the older clubs the experienced/novice ratio remained high, but in the newer clubs, since they were largely formed by those unable to obtain membership in an existing club, the ratio was lower. The conservation message was limited to *Don't break the speleothems*, but was effectively transmitted though the newcomers exhibited neither the skill nor the care of their predecessors.

Improved and cheaper transportation was bringing from the cities increasing numbers who would treat caving as a sport, remain involved for about two years and drop out to be replaced in their turn. Thus, while the conservation message was listened to and heard, the continuity was being eroded and an increasing percentage never would spend the time to achieve the competence of the older cavers nor remain active long enough to pass through the years of juvenile comparative irresponsibility. Improved equipment particularly rubber soled boots, masked this loss of average ability, and novices were apparently able to duplicate the feats of the older cavers with ease, bringing heavy traffic to even the remoter areas of the popular and drier caves.

Speleothems remained comparatively protected, but in almost universal ignorance the bulk of the nation's mud deposits and cave biology was being trampled and lost. Nor could this tide have been stemmed by gating or access restriction so intense remained the feelings generated by the actions of the BSA. Growth continued in a spirit of sturdy independence or destructive anarchy, depending on the point of view, with the very separateness of the clubs contributing new, though friendlier, rivalries.

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* The author started caving in England in 1959 and eventually became a member of the Northern Pennine Club. Most of his experience has been in the Yorkshire area and North Wales and he has been involved in the cave rescue organization in both areas. He has been in the U.S. since 1971.

1960-1965

By 1960, there were few speleothems remaining unstained in popular caves, and the tattered tapes in Easegill Caverns were more reminders of lost beauty than useful guides. And yet deliberate vandalism remained unknown. Paths had just got wider, carelss muddy hands stretched further. Scientific study had begun to show its importance. The Cave Research Group published its *Transactions*, and the first appreciation of the importance of scientific conservation led to the formation of the Pengelly Trust.

Although pollen was soon to be recovered from cave muds for the first time, the importance of such deposits remained little understood. The mushrooming of clubs had continued and the first queues formed at cave entrances. Relations with landowners had been friendly, but their goodwill was constantly being eroded by the bad manners, ignorance and thoughtlessness of the newer cavers.

After a series of incidents, the Lancaster/Easegill system was again closed—this time to all. Denied their Mecca, the older clubs met and took stock. The landowners' position was that with so many cavers they simply could not handle the administrative and policing problems involved: giving permission to enter the caves; restricting the cavers to paths; repairing broken walls and other damage, etc. The clubs, accepting the necessity of controls, formed the Council of Northern Caving Clubs (CNCC) so as to offer the landowners a package whereby the cavers handled the administration, maintained paths, stiles and cave gates, did their own policing and received, in return, access to the caves. The scheme was tried and proved a success. So much so that other landlords were quick to notice and approach CNCC to conclude similar agreements.

In short order, therefore, CNCC found itself in the anomalous position of being the largest cave access controller in the country. Too many cavers remembered the old free days for the system to be liked by many but the landlords, but it was accepted because it worked. It granted access to any responsible group on a first come first served basis, and only irresponsible behavior was grounds for refusal. The problem was the same in other areas, but mostly individual clubs gated caves after obtaining leases, generating much ill feeling by the arbitrariness of their access policies.

1965-70

With the accession to power of a Labour (left wing) government in Westminster, the scene had been set for a period of change and experiment in many areas. The creation of a Ministry of Sport brought intense government pressure for each sport to organize itself such that it had an accepted *national voice*. This the BSA bid to be, but though its evil genius had fortunately died, the suspicion lingered that his soul marched on in its policies. Its enemies remained implacable. As an interim measure and spurred on by continual incidents regional councils were formed patterned on CNCC.

Caves were closed by angry landowners; gated by clubs and individuals. The gates dynamited and even booby-trapped by explosives. The first cases of deliberate vandalism occurred; famous speleothems in Lancaster/Easegill being smashed and safety equipment being removed from the Mendips as *unnecessary*. Closure of most of the British coal mines brought a flood of cheap, reliable, electric lighting sets, and rubber wet suits became common. A novice on his first cave trip could be, and not infrequently was, taken to places which were the limit of possibility not only a decade before. The combination of new equipment and cheap transportation flooded the popular caves, and the relentless attrition of irreplaceable deposits continued.

Out of this mess appeared the first real conservation consciousness and the first real workable conservation/management system for a club controlled cave—an invention from South Wales. Briefly, the club controlled the access and administration, denied access to no responsible group (except during periods of scientific study) but insisted that one of its members accompany each group. The Pengelly Trust started the long delayed, and in most cases too late, scientific conservation, closing a cave to all but scientists. An ominous new factor appeared in the first use of caves as an adventure training resource. The first school parties were to be found underground leaving a wake of destruction and litter. The prospect of caves being used as gymnasiums aroused immediate protest, but with the realization that they could not be stopped, the CNCC opted to make the best of a bad job and attempt to guide rather than thwart.

1970—

The *cave adventure* school at Dent proved that cavers and schools can coexist, given that the schools avoid sensitive terrain at all times and popular caves on weekends. It is also being realized that the students of such schools receive a much sounder and more comprehensive grounding in understanding of caves and particularly conservation needs and methods than do new members of even the oder and more responsible clubs. Parties from ordinary schools, youth groups and the like proved to be a different matter. No single definable class of cave user caused as much damage per head. Only time will tell whether the difference is inherent or merely reflects the high quality of the Dent staff.

Discoveries in the further reaches of a show cave in South Wales tested the *guide system* and demonstrated that a show cave can coexist with wild caving in regions beyond the public section whilst still protecting speleothems in the further regions. White Scar show cave continues to exhibit undamaged speleothems to the public which would unquestionably no longer exist had the cave been accessable to cavers for the last quarter century—but the cavers, long excluded, have entered elsewhere and explore now in a spirit of defiance.

In another cave of the 1940's long since worn out by sheer traffic, there exists a grotto which I shall call the Treasure Chest, though that is not its name. Reputed to contain some of the finest speleothems ever discovered in Great Britain, it remains intact—because its location has never been known to more than a handful, and they have guarded its location well, sealing and camouflaging the entrance after each of a very few visits. In the entire country, no cave now exists which has a man-sized entrance and undisturbed biology or sediments, and the bitter fruit of the early gatings ensures that the preservation of the caves which remain to be discovered will be difficult or impossible in the scientific sense.

OBSERVATIONS REGARDING THE PROCEEDING

Improvements in equipment and the socio-economic conditions in the country determine the type and extent of pressures on caves.

The numbers of cavers primarily interested in *sport* are overwhelmingly greater than those otherwise motivated.

Only the physical separation of cavers and delicate materials, speleothems or other deposits, preserves them intact. This has been achieved by secrecy, total closure or use as a show cave. Biological preservation has proven impossible and this situation is partly a result of conservation efforts being limited to: *Don't break the speleothems.*

In the presence of cavers, caves are degraded. Only the rate may be affected by management or conservation policies. So far the South Wales *Guide System* is the only known method of drastically retarding the process. Education regarding conservation and the maintenance of high experienced-to-novice ratios in caving parties help out, but both fail in times of rapid expansion in the sport.

Successful protection of caves has been invariably associated with the actions of a handful of determined and strongly motivated individuals. In many cases these actions, while often successful for the single cave concerned, have generated reactions throughout the bulk of the caving community which have mitigated very greatly against successful conservation efforts elsewhere.

There are even fewer vandals in caves than active conservationists. The remainder of the cavers—overwhelmingly greater in numbers—may be described as being ignorant, thoughtless and careless but basically well disposed to conservation. While certainly selfish in most of their actions, they are willing to be persuaded to accept a certain measure of self sacrifice if convinced of its dire necessity to avoid total exclusion from caves or the reasonableness of the arguments of conservation minded groups or individuals of stature. They are easily and intensely motivated by actions which offend against their feelings of justice or established rights. Discipline is much more easily accepted if externally imposed; regulation from other cavers is accepted only when those in control exhibit self discipline equal to or greater than that which they ask of others.

The gating of caves is essential to their preservation but, except where the caving community has been persuaded to accept as reasonable the closure of a cave as a show cave or for valid scientific reasons, such gating is likely to prove ultimately destructive unless a method is adopted to allow equitable, though not necessarily uncontrolled, access.

School and youth group parties damage caves.

CONCLUSIONS AS APPLIED TO THE UNITED STATES

Direct comparison with the conditions in the United States is difficult, mainly because of the extreme homogeneity of Britain compared to the U.S. and the vastly greater distances involved here. British caves are very similar in type, have temperatures varying over a five degree range and are considered large if they contain more than two miles or so of passage. While there are geographically distinct regions, excluding Scotland and Ireland, 250 miles covers their extremities and none are more than a short drive from a major city. Communications between cavers are therefore very good despite their numbers, which probably exceed those of American cavers by a factor of between five and ten.

There is little discernable difference between American and British cavers and they will probably react similarly in similar situations. Thus it seems reasonable to expect that, over a period of time, the great bulk of American caves will be gutted of everything fragile by sport caving but that the period of time may be markedly extended if leadership of stature is available. Currently the NSS, with its stance of moralizing on conservation without matching activity, does not seem likely to provide it. The selfishness of the average NSS member appears the same as that of his British counterpart and this is not likely to change unless the leadership offered demonstrates a willingness to contribute much more than its share of time, trouble and money to the common good. Similarly, if the NSS as a group is to influence the non-NSS cavers, they will only do so positively if they behave in like fashion—and the fact is evident. Only unpopular actions are effective in preserving caves and unpopular actions succeed only when the prevailing climate of opinion renders them acceptable, which is not yet the case in this country. Nor for that matter does the NSS appear capable of taking resolute action or directing its course with the necessary wisdom, though one likes to think that will change.

The democracy of the NSS is the proof against the sort of troubles which afflicted the BSA and it seems unlikely to lose its preeminence—on a national scale. On a regional or local scale it is possible that this may not be true.

Conservation of caves, particularly in the scientific or biological senses, may prove to be possible by the National Park Service but there is presently no other organization capable of, or willing to take on this role.

America has in its favor the remoteness of many caves, a much more favorable legal situation regarding trespass, an accepted *national voice* to negotiate at government or State level and a presently small number of cavers per cave. *Adventure groups* are likely to be more prominent and much more difficult to control. Particularly with poor communications, a rapid increase in the number using caves is more likely to produce an uncontrollable situation. Present policies of discouragement will not succeed in stopping a trend caused by socio-economic changes and will ultimately both erode the NSS dominance and generate groups resistant to NSS influence. The most beneficial course of action for the NSS at present would seem to be to vigorously pursue access control for caves and the gathering of experience in their management. Even the development of a model lease/access agreement with a landowner is not legally straightforward, the handling of the paperwork can be onerous and the decisions as to the giving of access permission require experience and tact. Much remains undamaged as yet but unless America finds solutions which eluded the British it will not stay that way.

Safety and Rescue

Physical Hazards in Caves

Richard L. Breisch*

ABSTRACT

SCUBA diving is the most dangerous activity in caves. Other major hazards include drowning, falls, falling rocks, becoming lost, hypothermia and fire. An example of a cave with a particularly poor safety record is given. The "typical cave accident victim" is described.

DROWNING

Some people might suspect that it is hard to identify the one greatest hazard in cave exploration. It is not. As shown in the table, the greatest hazard is scuba diving in caves. In Florida alone, there were at least 135 fatalities in caves between 1960 and 1974 for an average of 9 deaths per year. The number of deaths has increased significantly in the last several years.

Fatal Caving Accidents in North America[1]

Year	Scuba Diving	Other Drownings	General	Vertical
1967	12		6[2]	1
1968	8	1	1	1
1969	9	1[3]	1	
1970	7			
1971	6	2		2
1972	18			2
1973	16[4]	3	2	
1974	≥23			
1975[5]	≥1	3	1	2
Total	≥100	10	11	8

(1) Based on *American Caving Accidents* and information from the National Association for Cave Diving.
(2) Three boys missing but their bodies were never found.
(3) One boy washed out to sea from the mouth of a sea cave in Acadia National Park, Maine. His body was never recovered. This accident was not reported in *ACA*.
(4) One fatality in California. This is the only scuba diving fatality listed here which did not occur in Florida.
(5) 1975 data covers January through August only.

Some of the reasons why cave diving is so dangerous include: (1) It requires considerably more experience to dive in a dark cave than in open water. (2) Much more high quality equipment is required for cave diving. (3) One cannot go directly up to the surface if trouble develops. (4) Time is very limited. (5) It is easy to stir up silt and thus lose one's way if a lifeline is not used. (6) A person who panics often causes his companions to die with him.

Most cave diving in the U.S. is done in Florida. There are few caves on federal land which require scuba gear to enter.

One notable example of such a cave on federal land is Devil's Hole, which is controlled by Death Valley National Monument. However, many caves contain deep bodies of water which can only be explored by diving. Federal agencies which control the access to caves should set up extremely stringent requirements before a permit for cave diving is granted. The National Association for Cave Diving** has developed many suggestions and guidelines concerning cave diving.

Since scuba diving in caves is an activity which is practiced by only a few people, predominantly in Florida, we shall turn our attention to accidents other than those occurring to scuba divers. Even neglecting deaths to scuba divers, drowning is still a major hazard. These drownings can be divided into two categories, those cases where the victim entered the water voluntarily and those where he entered accidentally such as when the cave flooded.

On 26 November 1971 a group of about 15 Explorer Scouts from Houston were exploring la Gruta de Carrizal in Mexico. One boy attempted to push a *siphon* (a water termination of a cave passage) by holding his breath and swimming through in hopes of reaching the air-filled passage on the other side. A few minutes later another boy tried the same thing. Both drowned because they were inexperienced and had underestimated the dangers.

The following summer another group of cavers tried pushing a siphon in Sótano de la Tinaja, also in Mexico. Because of their greater experience, the fellow who did the diving was belayed with a rope tied around his waist. He wore a diving mask but no scuba gear. After swimming about 17 feet he surfaced in a pocket of air. He took several breaths and passed out. The pocket probably contained very little oxygen and most likely a high concentration of methane. The caver's companions saw his flashlight falling and quickly pulled him back to the surface. He was revived with mouth-to-mouth resuscitation. As far as I know, of all the accidents involving people diving in caves, this is the only one in which the victim did not drown.

There have been several cases of people drowning when the cave they were exploring suddenly flooded. The worst case in U.S. history, and also the most recent, occurred when three college freshmen drowned in Salamander Cave, Indiana, on 22 February 1975. All were novices who ignored the warnings of experienced cavers a short time before the tragedy.

Multiple deaths due to drowning are not unusual. In Europe, six cavers drowned in each of two separate

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** 2900 N.W. 29th Avenue, Gainesville, Florida 32601 accidents. Since 1967 there have been two other deaths due to rapid flooding of U.S. caves, as well as several very close calls. Such accidents could occur wherever sinkholes drain large areas.

OTHER HAZARDS

If a noncaver were asked about potential cave hazards, he would probably mention dangers such as bad air, cave-ins, falling into pits and losing one's way. Let's look at each of these in an attempt to evaluate the actual hazard.

As mentioned previously, bad air does occur in caves; however it is not nearly as common in caves as in mines. In many mines insufficient oxygen caused by restricted air circulation, the mining operations and the type of rock. Probably less than one percent of the caves have air conditions which could be considered hazardous. These are often associated with decaying organic matter in stagnant pools of water. Also, caves with thermal springs often contain high levels of carbon dioxide and hydrogen sulfide. Such caves have been found in Yellowstone National Park. At one time a park naturalist at Yellowstone would make weekly trips to the caves to remove the bodies of small birds which had been killed by the gases. This cave is no longer shown to the public. Although cavers and land management officials should be aware of the existence of caves with naturally occurring bad air, it is a relatively minor hazard.

Cave-ins and rocks falling from the ceiling and walls of the cave are almost always induced by the cavers present. This hazard is greatest during the first few trips to a new cave or a new section of a well-known cave. Since 1967 there have been at least 15 incidents of injuries due to falling rocks in caves. In roughly one third of the cases, the victim himself dislodged the rocks, but usually the person who knocked a rock loose escaped injury.

Falling into pits is one of the greatest dangers in caving. About six cases per year are reported to the NSS. Of these, about two thirds of the time, the victim was unroped. Equipment failure and the loss of control during rappel make up essentially the rest of the reasons. During the last 4 years there have been an unusually large number of injuries due to the failure of ladders found in caves. Besides the falls, there are an average of two groups each year who have to be rescued because they entered a cave without sufficient thought given to being able to get out. The most notorious example of this in recent times was David Nott, who along with two others, rappelled some 800 feet into a pit in Venezuela and remained trapped for 5 days. After being rescued, he had the gall to write a book about his assinine adventure.

Becoming lost in a cave remains a great hazard for novices. Every year there are several examples of search teams having to look for people who are long overdue. Many times the victims left no word about where they were going. Experienced cavers are almost never reported lost. This is probably because the more experienced cavers are more observant of the cave's features and also are able to conduct methodical investigations of the cave passages should they become bewildered. An alternative explanation is that experienced cavers seldom admit to having been lost.

There are two cave hazards which are probably not as obvious as those discussed above. The risks associated with each have been underestimated by many people. One of these hazards, hypothermia, has been discussed in another paper at this symposium.

The other hazard which has been played down in the past is *fire*. Fire? What is there to burn in a cave? First of all, fire does not have to burn a person in order to injure him. People have died of asphyxiation in caves. Fire can also cause panic. In Arizona, several people built a fire in a large room of a cave. Later a man who returned from exploring a side passage became confused in the smoke and fell 25 feet to his death.

Actually many combustible items have been introduced into caves, either naturally or by man. The only injury I ever received in a cave was when I dropped a torch and ignited a pile of highly-combustible tumbleweeds while trying to determine the depth of a new pit.

The carbide used in most lamps makes acetylene when water is added. Numerous people have received minor burns from accumulations of acetylene when it was ignited accidentally. In one case it was set off when an electronic strobe was flashed by an amateur cave photographer.

Petroleum products have caused several major accidents. There are cases of young boys becoming burned when they used kerosene lamps for caving. A more serious accident occurred when gasoline leaked from a service station's storage tanks into the cave below. This was accidentally ignited by a group of Boy Scouts exploring the cave. One of the rescuers died of asphyxiation. In another case, a tank truck driver flushed his tank into a sinkhole along a New Mexico highway. A couple later decided to explore the cave using an open flame for light. The resulting explosion killed the man.

Poisonous gases are sometimes inadvertently introduced in caves by the explorers. On 29 July 1967, four men entered a Virginia quarry cave which had been broken into by dynamite blasting only 3 days before. After 70 feet they

Cavers learning vertical techniques on the surface. Rapeller in the foreground should be wearing a helmet.

noted the air had become *foul* and decided to leave. Two of the men never made it to fresh air and safety. The poisonous fumes probably were due to incomplete combustion of the explosives.

HAZARDOUS CAVES

The hazards to cave exploring vary widely with the cave and the geographical area. No one cave has all the dangers described here. Each cave in unique with its own set of problems. Technical difficulty is not the only factor influencing cave safety. Location and ease of access may have more to do with the accident rate than the difficulty of the cave.

An example of a cave which has had many accidents is Dead Deer Cave near San Antonio, Texas. The cave contains two pits with depths of 60 and 50 feet. Although the cave is not unusually hazardous for experienced cavers, it has often been visited by inexperienced, but adventurous high school students. The cave is on private land.

On 10 January 1968, five inexperienced boys entered the cave and descended the first pit. Three descended the second pit, but could not climb out hand-over-hand. They were rescued by the Alamo Grotto of the NSS. On 31 December 1972, three out of seven boys who entered could not climb out and had to be rescued. Less than two months later, on 24 February 1973, two boys entered. One of the boys fell 50 feet when he was unable to climb out hand-over-hand. By now the cave was well-known to local newsmen and a television camera crew was able to cover the rescue. Unfortunately the location was given to the television viewing audience and this led to another incident the very next weekend when two more people had to be rescued. As a result, several Texas cavers installed a gate made out of steel and concrete. This gate halted the accidents at the cave for two years.

On 31 May 1975, the owner of the cave noted that someone had pried loose the gate. The cavers who were called in to investigate found two 16-year-old boys in the cave. The one boy was at the bottom of the pit lying half-submerged in a pool of water. He had a broken leg and a broken jaw. The other boy was dead, hanging in a mass of tangled ropes. The rescue of the injured student took almost 12 hours. The fatality in Dead Deer Cave was not enough to halt the accidents. Less than a month later another teenager became trapped in the cave and had to be rescued.

So within 8 years, this cave has had six accidents involving 12 victims including the one fatality. Because the cave is well-known locally, it is popular among high school students. The past accidents probably enhance the glamour of a sneak visit to the cave. The metal gate and the enforcement of trespassing laws have not eliminated the accidents.

THE "TYPICAL CAVE ACCIDENT VICTIM"

Through cave accident statistics compiled by the Safety and Techniques Committee of the National Speleological Society, a picture of the *typical cave accident victim* is beginning to emerge. Based on the accidents between 1967 and 1973, as reported in *American Caving Accidents*, the typical victim is a male between the ages of 15 and 25. In fact 90 per cent of the victims were male. This is probably due to both the high percentage of the people who cave being male and many men being more likely to take greater risks than would the average woman. Of the victims for which we have data, 72% were between 15 and 25 years old, 65% were not affiliated with any caving group, and 68% had little or no previous caving experience.

Accidents occur throughout the year but the late summer months have a slightly lower rate. As might be expected, 70% of all caving accidents happen on the weekend, with Friday being the next most likely day. This statistic should be noted by those people connected with rescue teams since some team members may be harder to contact on weekends.

SUMMARY

A knowledge of the type of caving accidents which have occurred in the past should provide cavers and land managers with a better understanding of the dangers involved in caving. A person who is aware of the dangers hopefully will be less likely to become a victim himself.

Diseases Associated With Caves

Eileen Craigle*

ABSTRACT

When one mentions diseases in a caving environment, two major ones come to mind, rabies and histoplasmosis. Infectious diseases are not a common threat in most caves. However, the ones that can occur are often highly dramatic and fatal. Generally, the presence of bats, rodents, and certain insects in a cave can signify a projected major problem.

Distinctly associated but less serious incidents are prevalent in nearly every caving experience. These can develop into a principle problem if a cave visitor is not in excellent health and in good physical and mental condition.

INTRODUCTION

My caving career began in late 1969. It generally takes a novice caver many hours and several miles of passageway before one masters the arts of rock climbing in diminished lighting, wearing the proper clothing, carrying the correct equipment, relighting a carbide lamp in the dark, and finding your way back out of a cave. Things we cavers generally term as *cave sense*.

Until the technical aspects are fairly well mastered, one is usually oblivious to the actual environment and ecology of a cave system. I'm sure I fell into this group. For, by the end of the year, I squeezed through many a passage half filled with not-too-healthy water and mud; descended a pit with an enormous natural behive a little more than an arms' reach away; spent 16 hours in a cave heavily populated with bats; coughed through 6 hours of a dusty, rodent visited cave; experienced numerous cuts and scratches on my hands and arms; and waded calf-deep in semi-liquid bat guano and bird droppings. It was a wonder to me then, and more a miracle to me now, that I didn't acquire some hideous mixture of vermin.

As gruesome as it may seem, in all honesty, cavers are actually fairly safe from disease in the cave environment. Many of their problems arise on the way to and from the cave, and from other than infectious disease. Most disease would seem to occur within the first few hundred feet of the cave, the entrance and twilight zone offering access to many rodents and insects. However, the few diseases that can occur are highly dramatic and often fatal. When the subject arises, we immediately think of rabies and histoplasmosis.

RABIES

Rabies is an acute, almost always fatal, viral infection of the nervous system. It primarily affects non-human carnivores, but transmission to man is possible through the bite of an infected animal. The manifestation of the disease in man varies slightly from the course in animals. The incubation period may vary from one to three months. The development of the clinical disease usually follows a specific course. With the completion of a prodromal phase of from 2 to 4 days of nonspecific symptoms, the disease may take one of two phases. The excitative phase may begin gradually and persist to death. In this course there is an increasing anxiety, apprehension, and an impending sense of doom. Muscular tone is affected, and cranial nerve malfunctions usually occur in the eye. At this time there can be effects on the heart and respiratory centers. Hydrophobia exhibits itself as an indirect result of painful, spasmodic contractions of the muscles of swallowing and respiration. The second phase the disease may follow is one of paralysis. The flaccid paralysis becomes general and progressive. Stupor becomes coma, and death follows vascular collapse.

Rabies occurs world-wide in wildlife with no true reservoir host. However, members of the weasel-skunk (*Mustelidae*) and vivvet-ferret (*Viverriadae*) families are most often the source. In 1973, according to the National Communicable Disease Center, 3698 cases of rabies were confirmed in the United States. This was 729 fewer than the previous year and 4 percent below the average for the preceding 5 year level. The animals most frequently infected were skunks (50 percent), foxes (13 percent), bats (12 percent), cattle (10 percent), dogs (5 percent), cats (4 percent), and raccoons (3 percent). Generally, the occurrence in domesticated animals parallels the migrating, cyclic epidemic in nature. Though rabies is down in domesticated animals, it is interesting to note that the occurrence in bats is up 15 percent over the preceding 5 year level, with California having the largest number of cases (141) for the fourth consecutive year.

Vampire-bat transmitted rabies was first identified by Carini in Brazil in 1911. There are reports as early as 1526 reporting *venomous bites of vampire bats* in the Americas. Vampire bat rabies was identified by lab test in man in 1931, by Hurst and Pawan in Trinidad. When, in 1921, rabies was reported in a fruit-feeding bat in Brazil, rabies was soon reported in other countries in other nonhematophagus (non-blood drinking) bats.

It wasn't until 1953 that bat rabies was discovered in the United States. The problem wasn't new, but, an increasing awareness brought more indications of bat rabies to the health services. The numbers increased from 8 in 1953 to 504 in 1972. To date, rabies has been identified in 26 of the 40 bat species in the United States. Rabies deaths in humans have been attributed to insectivorous bats since 1951, with 6 in the United States. Four followed bat bites, and 2 after exposure to airborn virus in a heavily populated bat cave (Frio Cave) in Texas in 1955 and 1959. It is estimated that 30,000 people are treated annually in the U.S. for possible rabies contact.

Bats frequently bite each other, biting is more frequent in colonial species than in migratory species according to Dr. Denny Constantine. He (Constantine) reports that less than 1 percent of resident bats and 2 to 3 percent of migratory bats are rabid. The development of the disease in bats can be prolonged, and there is evidence of survival in some. Rabies signs in colonial bats tends to be of a paralytic nature, as opposed to the excitive course of migratory bats. In heavily populated bat caves of certain species, atmospheric

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conditions contribute to the survival and transport of the rabies virus in urine droplets and bat guano. Insectivorous bats are not as threatening as vampire bats because they do not seek out and bite man. Nevertheless, a direct hazard to man has been established.

Prevention seems to be the key word in the control of bat rabies. There are some criteria we can follow in order to sustain this principle. Cavers or visitors to heavily populated bat caves are placing themselves in a precarious and extremely dangerous position. A first bit of advice is to stay out, if you are not protected. A pre-exposure vaccination course is available to high risk groups, cavers included. Never handle sick or dead bats. Lastly, if you are bitten, scrubbing and thorough cleansing of the wound with an antiseptic solution seems to be of considerable value, before treatment can be taken. Within the last year, the post-exposure series of 14 injections of vaccine has been increased to 23. Education and prevention seem a better course than what may follow if you do develop the disease. You may not be as lucky as 7 year old Matt, who has been the only human to survive the clinical disease of rabies.

HISTOPLASMOSIS

Histoplasmosis is a systemic fungus infection that varies in severity. It is acquired by the inhalation of spores of the organism *Histoplasma capsulatum*, which grows as a mold in soil and a yeast in animal and human tissue. Through infection is common, there is generally either no detectable illness, or only mild respiratory symptoms. However, the progressive type of the disease, a disseminated form, has been reported 90 percent fatal. The prognosis of the disease is entirely dependent on the intensity of the exposure. Histoplasmosis is endemic to certain areas of the United States, specifically the Mississippi-Missouri-Ohio River valleys where 80 percent of the population have been infected, as indicated by positive histoplasmin skin test.

The fungus was first isolated from the soil in 1949 by Emmons, indicating that bird droppings and bat feces provide an optimum environment for growth and sustinance. Because of the bacteria-poor intestines of bats, survival of the organisms is further aided in this species. In 1962 Shacklette isolated the organism from naturally infected bats. Since then numerous studies have been done on bats and guano in several areas of the Southeast and Southwest. Infection rates differed between species, and it was suggested that environment was probably more significant than type of bat. Nevertheless, the studies conclude that there is a significant problem for susceptible cavers who enter bat caves favoring the growth of Histoplasmosis.

The only practical method of control seems to be the avoidance of caves and areas harboring infected soil. Warnings should be made to individuals who are not skin-test positive.

OTHER RELATED HEALTH PROBLEMS

There are many more infectious diseases that can and have been contracted by man on his visits to caves. Most are concerned with the presence of bats or rodents who, in a direct or indirect manner, play a role in the transmission of organisms.

Though not as dramatic, there are numerous other related health problems associated with caving, of which I will just mention here. The most significant to me is hypothermia, which will be covered at another time. Most cave environments, and often long periods of inactivity seem to magnify the hypothermic situation. Minor injuries and common skin infections from scratches and abrasions are also commonplace. Exhaustion is possible. Hypoxia (lack of an adequate amount of oxygen in the air) and noxious gasses can present problems. With middle aged and older individuals not in prime condition, we can also include heart attacks. Allergic reactions of the skin and respiratory tract to certain particles or substances in the cave air or soil can be threatening. Bites from snakes, spiders, and insects are other health indications. And, the mere presence of certain insects such as fleas, mites, ticks and mosquitoes can be a nuisance.

Something as simple as food poisoning from improperly prepared foodstuffs can compound discomfort on a cave visit. *Susceptible* has so often been a key word in relation to health. I cannot impress enough, the importance of top physical and mental health for cavers and cave visitors.

MANAGEMENT

Management of caves in relation to health problems can prove to be simple or complicated, depending on the specific area or cave. I'll propose three general areas of concern with specifics in each area. These include (1) survey of the caves' projected problems; (2) specific measures and controls; and (3) education of the public.

Surveying a cave's anticipated problems is dependent on many variables. The number of cave visitors would also indicate the necessity and extensiveness of a study. We are working with not only the physical aspects of layout and presence of water, but also the life and ecology of the cave. More specific would be physical risks, water contributing to drowning and hypothermia, and sustinence or purging of infectious organisms. The presence of bats should greatly magnify your management efforts.

The measures involved would include the actual studies of troglobites and occasional animal visitors. Animal and soil samples, and the data from the survey would indicate the amount of control necessary, if any. One must remember that there is a definite obligation to those individuals performing the studies, in regard to their health and safety. We must keep in mind, at all times, the ecology of a cave system. Man is so often quick in his decision to control the numbers of wildlife rather than to restrain himself.

We hear so often the phrase *to educate the public*. Yet, this is where the crux of management lies. If people can understand the problems and possible projected harm to themselves and the cave system, they will be more willing to accept measures and controls.

SUMMARY

Though there are numerous infectious diseases associated with caving, rabies and histoplasmosis remain the most significant. They are rare, but, extremely anxiety provoking and rabies and the progressive type of histoplasmosis are nearly always fatal. As a rule, the caver or cave visitor, would tend to encounter numerous other health problems on an average trip or visit. Management is based primarily on the data collected, and knowledge associated with caves.

This is why we are all here. Man's curiosity to know, to discover, brings us together. We must seek out information from each other, from so many areas. Information that will help man to conserve that magnificent underground wilderness of the cave.

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Editor's Note: Please contact the author for a valuable study on infectious diseases. We were unable to include her study in this publication because of its length and specialized nature.

Hypothermia

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Death by exposure, freezing to death, hypothermia—all are the same thing. They mean a lowering of the temperature of the inner core of the body; if this temperature is lowered far enough, death follows.

Who is in danger from hypothermia? Anyone who spends much time outdoors is a possible victim. This means hikers and campers, skiers and snowshoers, hunters and fishermen, victims of crash or breakdown, sailors and swimmers, and, of course, climbers and cavers. I suppose some of you reading this will say that cavers have no need to fear hypothermia, but you are wrong. There are recorded deaths due to hypothermia among cavers and hypothermia has been a contributing factor in many accidents; these victims may also have thought they were in no danger from it.

Why is a low body temperature such a serious thing, and how can it cause death? That's not an easy thing to explain, but let's try. Your body is a heat engine, burning food in order to produce the heat needed for all body processes to go on. The process of heat production becomes less efficient when the body core temperature falls below the optimum level of about 99° F. If the temperature falls very much below this level, all body processes begin to slow down. If they slow down too much the body can no longer produce enough heat to raise the body temperature back to its proper level. The heat producing processes slow down still further, even if further loss of heat is prevented, and the eventual result is death.

Let's look at the way your body responds to cold. The first response is to constrict the outermost blood vessels, and then those just under the skin. This constriction reduces the amount of heat transported to the outer layers of the body and therefore reduces the amount of heat lost there. This constriction also reduces the skin temperature, and thereby provides a cooler layer of tissue to act as insulation between the body core and the cold environment. The skin temperature may fall to nearly that of the outside, while the core temperature remains at 99° F. A fall in skin temperature to 50° has the effect of reducing skin sensitivity and pain responses, and also lowering the strength of the muscles located near the surface. This loss is especially apparent in the muscles of the hand. These changes render the hands nearly useless in the performance of any critical or delicate maneuvers. Shivering also starts soon after the constriction of the surface blood vessels takes place. This shivering is a very effective method of heat production, but it is extremely strenuous exercise and may exhaust the victim in a very short time, especially if he is tired already or not in good physical condition. If the exposure to cold continues after the constriction of the surface blood vessels, the body core temperature begins to drop. It is this fall of core temperature which is called hypothermia.

How does the body lose heat? There are basically five ways: radiation, conduction, convection, evaporation, and respiration.

Radiation is the primary mechanism of heat loss in most situations. Most of this heat is radiated from the head, which is heavily supplied with blood and is usually exposed. At 40° F. half of the body's heat production may be lost from the uncovered head; at 5° F. up to three-quarters of the body's entire heat production may be lost from the head alone. Thus the saying, *If your feet are cold, put on your hat.* For this reason, a hat is one of the most important defenses to have against hypothermia.

Conduction is not normally a large mechanism of heat loss. For cavers, however, who are frequently in contact with considerable areas of cold rock, it is probably appreciably greater than for most people. The rock may be only as cold as 50 or 60° F., but this is so much colder than the body that considerable heat may be lost by conduction if little insulation is present between the body and the rock.

Convection is small in still air; however, when there is any appreciable wind, the losses due to convection rise abruptly. Thus we see the wind-chill charts, which show that the chilling effect of any given temperature is doubled by a wind of only three miles per hour. Clearly, the effects of wind must be considered when dressing for the weather. Most caves have a moderate breeze blowing in them at all times; this breeze may become quite a bit stronger in some areas within the cave. One of the very best items to carry for protection against hypothermia is some kind of tightly woven windproof outer garment, such as a windshirt.

Evaporation is the next cause of heat loss to be considered. If you become wet, much of your body heat production will be used to evaporate water, which process will cool you down considerably. In addition, the water will conduct the heat much more rapidly to the outside environment. We all know how cold it feels to step out of a swimming pool, especially if there is any wind blowing; we feel cold even if the air temperature is 90° F. or more. Imagine how much colder you would feel if the air temperature were 50° F. or less! The best protection from heat losses by evaporation is simply not to get wet; whether from runoff, ground water, or perspiration. If you do get wet, you should have emergency dry clothes available to you. In some cases, it is better to take off your clothing, let your body get wet, and then put your dry clothes back on; you will warm up quickly, and your clothes will warm you much better than if they were wet.

Finally, the last mechanism of heat loss is respiration, which is the heat you expend in warming the cold air that you breathe in. In addition, heat is lost in the process of evaporating water in the lungs into this inhaled air. Both the heat and the moisture are lost to you when you exhale. Little can be done to reduce this mode of heat loss, although if the weather is cold enough, tunnel-shaped hoods can provide a significant reduction.

How can you tell if someone is suffering from hypothermia? Let's look at the symptoms which appear as the core temperature falls.

As the body temperature drops below 99° F., the first symptoms are violent shivering and a slight decrease of the ability to perform complex tasks. The next sign of chilling is an increasing difficulty in speaking. Sluggish thinking and some degree of amnesia may appear by the time the core temperature drops to 91° F. The shivering now decreases and is replaced by a considerable degree of muscular

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rigidity. Exposed skin is likely to become blue or puffy, and muscle coordination is affected. The victim appears clumsy; speech becomes blurred; thinking is less clear; but the victim still appears to be aware of his surroundings. As the core temperature drops below 85° F., the victim becomes irrational, pulse and respiration slow down, and the victim drifts into a stupor. The final phases of the cooling are unconsciousness, gradual failure of reflexes, and, usually below 78° F., death.

The above symptoms are not all always present, but the general course of events is usually followed. There is some evidence that the entire series may be hastened and abridged somewhat by lower than normal levels of blood sugar, and by exhaustion or poor physical condition.

Note that by the time the victim is in serious trouble, he is probably unable to do very much to rescue himself, and may not be aware of his danger at all. By the time many people realize they are in trouble, they have lost the ability to get out of their predicament. For example, the victim may by that time be too clumsy to build a fire.

A number of factors help make hypothermia more likely. The wrong clothing or insufficient clothing usually is a major factor. Poor physical condition or exhaustion frequently enters in. Getting wet and being exposed to drafts or breezes are almost invariably causes. If one were to select a typical victim, he would be lightly dressed, tired and wet from heavy exertion, resting for a while in a light or moderate breeze with his head uncovered. Victims under precisely these conditions, with the air temperature between 40 and 50° F., have died in less than two hours from the first noticeable symptoms. Note that in cases of shipwreck in the North Atlantic, where the water temperature was between 31 and 35° F., the survival time ranged from 15 to 30 minutes; this loss of heat was due almost entirely to conduction, and illustrates how little time you may have if you become thoroughly wet. It should be clear by now that knowledge of the symptoms and causes of hypothermia are important to cavers.

To repeat the symptoms:

- Intense shivering
- Loss of coordination
- Difficulty in speaking
- Clumsiness
- Amnesia or unawareness of surroundings
- Muscular rigidity
- Irrationality
- Hallucinations
- Blueness or puffiness of skin
- Dilation of pupils
- Weak or irregular pulse
- Stupor.

What is the first aid for victims of hypothermia? Basically, it is to provide heat to the victim and preserve the heat he has left. Note that it will do no good only to conserve the heat the victim has left; he is unable to survive if that is all that is done. There are a number of cases on record in which the victim was rescued, placed in a sleeping bag, and died while being carried out. The victim's body was unable to bring his temperature up again, so his temperature fell until he died.

How should heat be supplied to the victim? The needed heat may be supplied in any way that is feasible for the rescuers. The Mountain Rescue Council here in Albuquerque uses a vest made of two layers of cloth with a piece of plastic tubing going back and forth between them. This tubing has a hand pump at one end; in use, the victim is placed in the vest, then into a sleeping bag (for insulation), and then warm water is pumped through the vest continuously until the victim's temperature is back to normal. The vest uses about two cups of water, which is easily heated by a small camping stove. Similar devices, called hydraulic sarongs, hypothermia bags, etc., are in use in most areas where hypothermia victims are at all common. If this equipment is unavailable, heat may be supplied to the victim in many other ways. The best is to immerse him in a bathtub filled with water at 110° F.; such items are rather uncommon in caves. Chemical hot packs or hot water bottles may also be used, but great care must be taken with these not to burn the victim. Perhaps the best emergency measure is to place the undressed victim in a prewarmed sleeping bag with an undressed rescuer, who provides life-saving heat for the victim at the price of considerable personal discomfort. Even if the victim and the rescuer are of the opposite sex this can in no way be regarded as fun; indeed, it will probably be necessary to exceed the cold tolerance of more than one rescuer in order to rewarm the victim sufficiently.

In addition, if the victim is conscious, he is given warm liquids and sweets to eat. These can obviously not be used with an unconscious victim. Under no circumstances should the victim be given alcohol or any drinks containing alcohol. It opens the peripheral blood vessels, thereby removing still more heat from the core.

How can you prevent the occurrence of hypothermia? First and chiefly, be aware of the danger. Dress for the worst conditions you expect to encounter, and a little worse still. Avoid getting your clothes wet, and minimize your heat loss whenever possible. Do not use down clothing if there is any possibility of getting wet; down becomes useless when wet. Under these conditions, use Fiberfill II or Polarguard, which are nearly as good as down when dry, and very much better when wet. Clothing made of these materials has the additional advantage that it may be squeezed out and put back on if it becomes soaked. Foam clothing, such as a wet suit, is also useful under wet conditions. Provide yourself with a hat, preferably one that covers the head and neck completely, such as a wool balaclava. Wear wool whenever possible, since wool still provides considerable insulation even when wet. Avoid clothing which is tight fitting, especially at neck, wrists, and ankles, since it impedes the flow of blood, and hastens chilling of head, hands, and feet. In any case, tight fitting clothing prevents maintenance of the air space which is your most effective insulation.

Keep eating sweets and such foods all the time. This helps maintain the level of blood sugar, and thereby provides the body with readily used, immediately available fuel. Be careful that the sweets you get are not for dieters; such foods usually have no real sugar in them and are useless for fuel.

Avoid getting wet; it is better to take off your clothes and get your body wet, then put on your dry clothes again. That way you can get warm; if your clothes get wet, you may need to be rescued.

Avoid wind, and avoid sitting in drafts. If you wish to sit or lie down for a while, try to sit in a place where the wind is at a minimum. Provide yourself with a foam pad or a piece of spare clothing to sit on, thereby minimizing the conductive heat loss to the rock.

Above all, be aware of your own condition and symptoms, and keep alert to the condition of those around you. You may notice that they are in trouble before they do. Don't be ashamed to admit that you are not made of iron; if you are cold, the others probably are, too. Stop and get warm again if that is possible or otherwise head for the entrance.

Keep these dangers in mind, know what to do, and, if needed, do it without hesitation.

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Problems of Cave Rescue

Perry and Betty Denton*

ABSTRACT

*Since prevention is preferable to cure, the requiring of increased skills, knowledge and safety practices should be encouraged in caving. Vehicular access to cave areas encourages proper equipment and simplifies rescue efforts.*** *Helicopters ae not suitable alternatives to vehicular access.*

Many accidents are too serious for amateur rescuers to attempt the rescue. Highly specialized rescue and medical training is required in addition to caving skills. If cross-trained people are not available, the team must be composed of experts from each area of skills. Medical assistance to stabilize the victim's condition is of prime importance, with evacuation secondary.

When law enforcement or government agencies request aid from a rescue unit for an accident victim it is wise to have definite agreements about financial expenses and responsibilities for various phases of the rescue operation. It is also desireable to agree on policies of operation.

Rescuers prefer to interrogate witnesses themselves and be guided to the scene by them. First aid should be rushed to the victim, after which sufficient time should be devoted to planning and arranging the evacuation so that it offers as little strain to the victim and rescuers as possible.

Rescue responsibilities should be divided among several teams, who stay in radio communication to share knowledge, plans and progress.

The first consideration in a discussion of cave rescue is, logically, accident prevention. Many useage control systems contribute to safety by requiring specified minimums of skills, experience and equipment for the entrance to certain caves. It would seem reasonable to expect every member of a caving group to have proper equipment, basic caving knowledge, technical skills in proportion to the known hazards of the cave and basic first aid knowledge, and to expect at least some of the group to have advanced first aid and sufficient knowledge and experience to recognize potential hazards and anticipate and prevent problems. New cavers should gain experience in a ratio no greater than two novices to each experienced caver in a difficult or delicate cave. While it might be possible to list some known hazards for a particular cave, it would be nearly impossible to list everything that could be hazardous to some cavers. Failure to identify as a hazard a condition which contributed to an accident could cause a problem. This becomes a more serious problem in view of the fact that at any time in almost any cave the moving of a key rock could open up additional passages and hazards.

A factor in both accident prevention and rescue success is vehicular access to the cave area.** The closer a vehicle can be taken to the cave vicinity the more likely the cavers are to have with them *all* the proper equipment for safe caving, particularly for vertical caves. A five-mile hike from vehicle to cave tends to reduce equipment to barest minimums, often below safety levels. In rescue efforts vehicular access can be the difference between life and death due to both travel time to and from the cave and ease of equipment supply. The popular idea that a helicopter could be called in for an emergency fails to take into account several facts. There is a time lag of several hours while establishment of need and mission clearance are run through channels. In the case of smaller helicopters, their fuel range slows response time because of the need for frequent refueling, litters can only be carried lashed to the outside which would add to the victim's shock reaction and even small helicopters require a good sized, fairly level cleared area in which to land, which often means landing a considerable distance from the victim. Larger helicopters can be equipped with a hoist so that they don't have to land, but their hover time is limited and hazardous in many areas and being hoisted can also contribute to the victim's shock condition. Helicopters are grounded by high winds and bad weather and may also be unavailable because of other assignments.

No responsible caver would enter any cave without telling someone capable of rescuing him or securing assistance for him, if necessary, which cave he was going to and when he planned to be back. Many take the added precaution for a more dangerous cave of having someone stand by, on the surface, near the entrance. If all cavers were required to show proof of someone capable standing by to check on them if they failed to return on time as part of the process of getting permission to enter a cave it could serve several good purposes: the reminder that they could have an accident should make them more careful; aid would be available sooner if needed and local authorities in areas without formal rescue squads would have some ideas of whom to call on for assistance. However, since some caves are entered without permits being secured, others don't require permits, and some accidents are too serious for inexperienced rescuers to handle, there would remain the need for formally organized rescue units willing to assist anyone in trouble.

The ideal rescue unit is one which is formally organized for rescue with members who are well equipped, extensively

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** Editor's note: Statistics reported in the annual *American Caving Accidents* series indicate that ease of access is a *contributing* rather than a *diminishing* factor in cave accidents. Ease of access tends to attract casual visits by inexperienced people with unsuitable equipment.

trained and practice together regularly, are all accustomed to the same equipment and techniques, are familiar with each other's capabilities and can maintain their own radio communications on a non-public frequency. Vertical rescue training and emergency medical technician level are almost necessities, and obviously, for cave rescue, reasonable caving experience. The average doctor or nurse may not function as well in emergency field situations as people with less medical knowledge but specific emergency management training.

If cross-trained rescue personnel are not available, the most workable team would probably be composed of mostly experienced cavers, plus two emergency medical technicians and several people with vertical rescue training. The cavers would be responsible for getting the EMT's and vertical rescue people in and out of the cave safely and for the actual transport of the victim within the cave, with direction and assistance on techniques and rigging from the rescue people, while the EMT's would be responsible for the care of the victim, stabilizing him for transportation and advising the others of his medical needs. If a cave presents many hazards and sufficient experienced personnel are *not* available to move the victim without undue risk of additional injury to either the victim or the rescuers, efforts should be directed to providing medical care for the victim where he is until sufficient help can be obtained for safe transport. Pain medication and IVs for shock management will often stabilize a patient's condition so that removal from the cave need not be rushed.

Rescue priorities call for first getting emergency medical assistance to the victim so that his condition can be stabilized, then splinting and supporting him properly for transport from the cave, followed by evacuation and transport to a medical facility. Unfortunately, there are many complications to this process.

When one group of cavers agrees to stand by as a safety for another group there is usually a mutual understanding as to reimbursement for incurred expenses and as long as it remains a private situation of reasonably minor proportions there are few complications from outside sources. If law enforcement or government agencies request the assistance of a rescue unit for an accident victim, time is usually critical, the situation is more serious and the accident becomes public knowledge with resultant complications. Therefore it is most expedient that area of responsibility and liability be agreed on prior to an emergency for smooth operation. There should be a definite agreement as to who will be responsible for what expenses if a rescue is necessary. When operating in their own locality many rescuers expect to provide their own food, shelter, equipment and vehicle, with gas and expended equipment being paid for by the requesting agency. When operating in an area outside their usual territory, which often means flying to the accident area, rescuers usually provide only specialized rescue equipment, with all other expenses and needs being met by the requesting agency.

The agency usually assumes the responsibility for keeping access and egress routes free of excess traffic, dealing with landowners, relatives of the victim and spectators, securing extraordinary equipment and general support. The rescuers usually provide specialized rescue equipment and medical and first aid supplies, select any additional rescue volunteers that are needed, and are responsible for the safety and welfare of both victim and rescuers. Agreement will probably have to be reached on each occasion as to the method of transporting the victim to the medical facility and who will release what information to the news media. The exact location of the accident is best kept secret, both to reduce traffic and to reduce the possibility of future similar accidents.

Some general operational guidelines also need to be agreed upon. The general aim should be to save life and limb and alleviate suffering, while preventing further injury to the victim, the rescuers, the cave, the surface area and the access route and to safely evacuate both victim and rescuers from the cave. Fairness and common sense dictate that the safety and welfare of the rescuers comes first, with the victim second. Rescuers serve at their own risk and are responsible for their own safety. *One* person should be designated by the rescue leader to remain on the surface as coordinator, managing all surface rigging, maintaining surface safety, relaying instructions, making equipment requests, etc. Above all, enough time must be taken to do everything correctly—rushing must be avoided. All rigging should be double-checked. Rescue responsibilities should be divided among three teams—the emergency team, the evacuation team and the support team.

When a cave accident is reported there are two important reasons why every effort should be made to keep the reporting person available to the rescuers at an accessable location. This may be difficult, because the reporting person often feels a need to return to the accident scene at once to try to help the victim. An experienced rescue leader will usually want to question the reporting person at length. He needs an opportunity to get his information first hand because he knows what to ask and how to ask it without putting words in the other's mouth, and to minimize the chance for misunderstanding. However, specific situations may make it imperative that the reporting person does return to the scene. In this case complete written instructions for reaching the scene should be left at the reporting point, along with information as to how the trail from the cave entrance to the victim will be marked. The reporting person should then be accompanied back to the scene by someone well enough oriented in the area that he can then return to the reporting point, or another meeting place, and guide the rescuers in. This precaution is needed because the instructions which seem clear in town can become confusing in the field—the biggest tree becomes a choice between the thickest trunk or the tallest one; the prominent rock becomes a choice between the brightly colored one or the large one, etc.

As long as there is a chance that the victim is alive, the most urgent need is to get medical care to him as soon as possible. Therefore a small emergency team of three or four people should depart as soon as possible with caving gear and first aid supplies of at least blankets, a heat source, oxygen, pain medication, blood pressure cuff and stethescope, dressings, splints, IVs, adheisive tape and a radio that will transmit back to town and to the other crews. The type of specialized information to be transmitted can rarely be relayed through people unfamiliar with the equipment and terms without losing validity, which makes direct communication between rescue teams mandatory. Their duties as an emergency team include leaving a well marked trail all the way to the victim, stabilizing his condition, evaluating and treating his injuries, and protecting all present from further injury. They also should evaluate the evacuation problems and communicate any special problems or unusual equipment needs to the evacuation and support teams, as well as prepare the victim for transport.

While some of the practices of an experienced rescue group may seem time consuming, there are good reasons behind them. The rescue equipment used in a cave is dictated by the limiting factors of passage size and configuration, the victim's injuries, and the types of obstacles to be traversed. Thus, if the rescuers are personally unfamiliar with a cave they usually wait for the report of the emergency team before making definite decisions as to technique and equipment to be used. They may, after talking with a witness from the accident scene, decide to rely on his opinion of what is required. However, since wise choices of equipment and technique often depend on the careful weighing of many factors which the average person may not be aware of, no offense should be taken if the rescuers prefer to make their own evaluation.

While collapsable equipment can usually be moved faster and easier in a cave in its collapsed state, time must be taken on the way in to be sure that it will be possible to manipulate the assembled transportation device through the tight spots with the victim in it on the way out. If some areas are too tight for the assembled litter, alternate stabilizing devices (suited for the victim's injuries) can then be arranged ahead of time for those areas. The alternative devices, being smaller and usually somewhat less protective, are generally not suitable for prolonged transportation. Therefore it is very worthwhile to take a collapsed or segmented litter past tight spots where it cannot be used to have it available on the other side where there is room to use it.

In preparing to negotiate a particularly difficult obstacle, if there is any question of clearance or the suitability of the method, it is wise to take the time to test the proposed method of movement on a rescuer before attempting it with the victim. It is also good practice to stop to let the victim rest if the evacuation is long or painful. If there are not enough people in the evacuation team to permit working in relays alternating with rest periods, it is better to stop and rest than to push the rescuers so close to exhaustion that they become careless.

The evacuation team assembles needed rescue equipment and appropriate special equipment required for the location, such as a generator, public address system, walkie talkies, etc., and a radio for direct communication with other teams and in nearby towns. Upon reaching the scene, part of the team starts rigging for any vertical movement of the victim that may be necessary, while the rest of the team enters the cave, most going straight to the victim to begin evacuation, while a few stop along the trail to scout for alternate routes around difficult obstacles and begin rigging for obstacles that cannot be bypassed.

Some members of the support team may remain in a nearby town to be available to secure and deliver any additional equipment that is needed. Others proceed to the staging area to assist in transporting equipment and supplies to the scene, to operate communications equipment and to give general support.

It is not possible to completely plan a rescue in advance, nor is there any practical way to haul enough equipment to an accident site to meet every possible need, as judged by preliminary information. A successful rescue effort depends on well trained, innovative people using common sense and ingenuity to adapt variations of tested techniques to meet unique situations.

Radon in Carlsbad Caverns and Caves of the Surrounding Area

Philip F. Van Cleave*

In 1968, Richard L. Breisch, published a most comprehensive article titled "Natural Radiation in Caves" which appeared in *Southwest Caver*, Volume VII, No. 5 (entire issue). this article, along with its extensive if not exhaustive bibliography, deserved far more concerned attention than it apparently received.

More recently, manuscripts by Dr. Marvin H. Wilkening, of the New Mexico Institute of Mining and Technology, and his graduate students, David Watkins and Jo Bob Trout, have focused attention upon the potential hazards posed by radon gas, and more importantly, its radioactive decay daughters, in caves of this area. It is hoped that these studies will be published in some readily available journal in the near future.

As a result of this recent work, alpha radiation levels are being monitored at Carlsbad Caverns National Park.

The following is adapted from a report by National Park Service Research Ecologist Dr. Gary Ahlstrand to the employees of the park.

$Radon^{222}$ is a radioactive, inert gas. It is an intermediate in the radioactive decay of $uranium^{238}$ to $lead^{206}$. $Radon^{222}$ decays rather rapidly through several intermediate elements, termed *radon daughters*, to $lead^{210}$. Radon gas and the radon daughters are not necessarily in equilibrium within the cave because their concentrations are influenced by such things as changes in atmospheric pressure and air exchange rates.

Radiation levels within the Caverns are not intense enough to pose a health hazard from external exposure. However, alpha particles released during the radioactive decay of radon and its daughters are capable of ionizing or disassociating cells of the epithelial lining of the lungs. This health hazard is in proportion to the cumulative radiation exposure received. Standards have been set for the maximum permissible exposure that workers in uranium mines can experience annually.

Cigarette smoking has been shown to compound the problem with radon daughters in increasing the incidence of lung cancer among miners.

The lungs are normally cleansed of particulate matter, including radon daughters attached to dust particles, by the wave-like action of cilia *little hairs* in the epithelium (tissue lining the lung). Smoking partially paralyzes the cilia, thus inhibiting this action. Therefore, the radioactive particles are present for longer periods of time in the lungs of smokers, and have more time to cause damage to lung cells. Only total abstinence from smoking is effective in restoring the ciliary action, not just restraint while in a radon daughters environment.

For a portion of the year, when circulation of air within the cave is curtailed, radon daughters accumulate and build to levels that would require monitoring under health standards for uranium miners established by the Occupational Safety and Health Administration (OSHA).

It is felt at this time that no health hazard exists from radiation for employees working in the Caverns. We are concerned that the exposure of all employees be kept at a minimum. A radon daughters monitoring program has been established and individual exposure records are being maintained for all Cavern Supply Company and Service personnel employed in the underground portion of Carlsbad Caverns National Park. The study is in its initial stages and there is much to be learned, both through the monitoring program and research. The scope of the research program has not yet been defined.

A major purpose for calling this matter to the attention of this group is to alert all cave managers to the likelihood that radiation levels occurring in their caves may well be higher or lower than those in the Carlsbad Area and some may wish to have at least preliminary investigation commenced at an early date.

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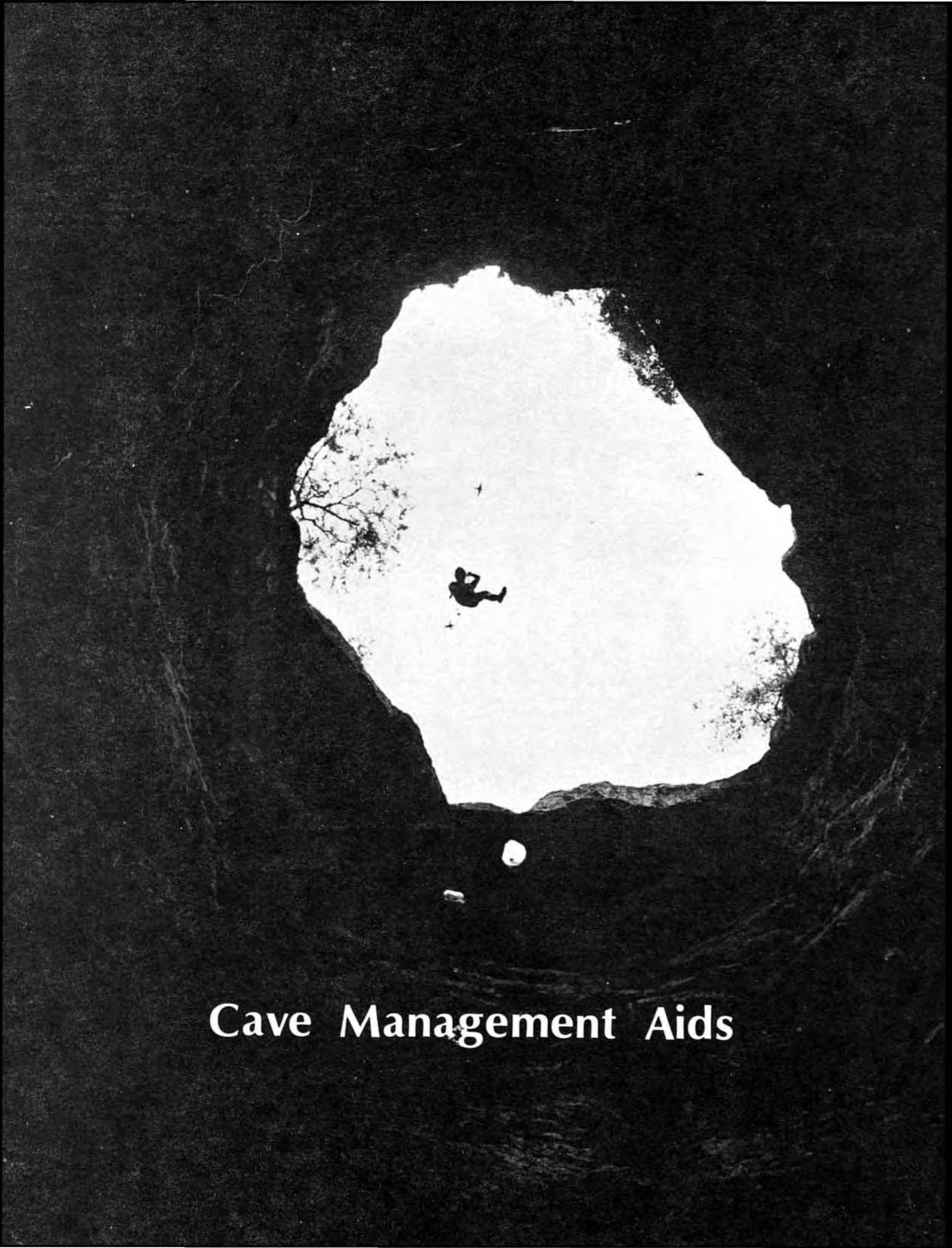

Cave Management Aids

Cave Photography

Charles Larson*

ABSTRACT

Photography is one of speleology's most valuable tools. As a vivid, accurate and viriually permanent record of local cave features it has no peer. An ever-widening range of easy-to-use photographic materials and lighting techniques, judiciously employed, will produce easy-to-understand records of cave features, admirably suited to the purposes of cave research, cave management and recreational use of caves.

Photo by the author.

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Cave Surveying—Basic Techniques and Purposes

John Corcoran III*

Cave surveying is one of the principal tools for determining the physical environment of a cave. As a management tool, surveying can provide the most basic information regarding cave geography which in turn may be used to provide a reference for other types of information by providing a framework to tie other resource-inventory data together.

Surveying is the art or science of determining the relative locations of points with respect to each other. This is usually done by measuring the distances, directions, elevations of discrete points, and frequently relating nearby natural or manmade features to these points.

Cave surveying is usually accomplished by establishing survey stations which are intervisible, measuring their distances, bearings, and elevation differences, then constructing a sketch which relates such features as walls, ceilings, floors, breakdown, speleothems, pools, streams, archeological remains, biota habitats, etc. to the survey points. The information gathered in the cave is then used to construct a map which will be a graphical representation from which one can gain an approximate knowledge of the size, shape, length, depth, etc. of the cave. The information gathered in the cave can be of varying degrees of precision ranging from a sketch constructed from memory in which the dimensions and orientation of the cave are estimated (with care) to a survey using sophisticated devices such as theodolites, precise-levels, and Laser distance meters. The relative precision of the survey stations can be determined at any level from grossly incorrect through relative differences measured in parts per million, or better.

The techniques to be used are determined primarily by the use of the final product. For small caves with no special values or specific needs for accuracy, a sketch map, or compass and pace survey may be adequate, although for some cases, such as geological research, it may be important to have at least a good elevation and entrance location so that the cave can be related to surface or structural features. Most caves are surveyed by the compass-tape traverse method, with varying results depending on techniques used. Using a Brunton compass mounted on a small nonmagnetic tripod, and using a steel tape with reasonable care taken in measurements, the relative locations of the survey stations can be determined to better than 1 percent. In complicated caves where high precision (compass-tape-survey) is required, closed-traverses are used to allow survey errors to be measured and if they are reasonably small without major blunders, the resulting loops can be statistically adjusted (once the closure efforts are known) to give a reduction of that error by proportionately distributing the errors back into the loop points. If higher precision is required (such as a survey intended to locate a remote part of a cave accurately enough to drill an elevator shaft from the surface without missing the cave) then surveying instruments of a higher precision are used. An Engineer's transit and surveyor's Chain can, with care, produce survey accuracy in the neighborhood of 1 part in 5000 or better. For most purposes this is sufficient precision for the construction of elevators, trails, etc. Also in the case where there may be high magnetic interference with a compass, a transit survey can be used as a substitute. If circumstances arise where extreme precision is needed such as geodetic surveys, or where very good elevation control is needed to measure very shallow stream gradients, then a theodolite or precise-level survey may be justified. Additionally, topographic maps can be made of both floor and ceiling to further morphological studies, to determine the approximate volume of the cave, or as an aid in engineering problems such as the construction of commercial facilities.

Other techniques used in cave surveying are the result of research into geophysical prospecting, and similar fields. It is possible to make a map of a cave's location from the surface using gravity, resistivity, siesmic, and other measurements. Inductive-radio transmittors working both in the cave and on the surface can provide another approach. These other methods generally yield only an approximate location, size, and depth, although with development of the respective technologies, it can be expected that these methods will soon be able to compete in accuracy and speed, if not cost, with the traditional compass surveys.

The construction of the cave map itself can vary from the simple to the complex. A traditional method has been the simple use of ruler and protractor (or drafting machine) to plot the data in the survey notes; this method required only that the horizontal distance be calculated from the slope (measured) distance and the vertical angle. A more accurate method of plotting that avoids cumulative plotting errors is coordinate-plotting. In this case the survey data is reduced to Cartesian coordinates and plotted on graph paper. After plotting by some method, the individual survey points are then used as the framework to resketch the cave features, using other information such as the distance measured from the points to the walls and other obvious landmarks to rectify the scale and relationship of details.

The last stage in map production is to produce a master map that is reproducible by some means. This can be anything from the first pencil sketch copied photographically, electrostatically, etc., to inked and mechanically lettered transparencies to be copied via blue-lining, ozalid copying, through reproduction by offset printing or other commercial processes. The choice of reproductive media, final scale, and distribution are governed by the expected use of the map, the cost of reproduction, and even esthetics. The state of the art of cave surveying changes rapidly, and what may seem costly in a technical sense may easily be the most cost-effective method of arriving at a final product. Currently, all the calculations and even the plotting can be accomplished with the aid of a computer, at low cost if computer time is available for the task. If not, even a small pocket calculator can make short work of a small cave. In some cases, small programmable calculators have been used to reduce survey data as it is gathered in the cave, thus

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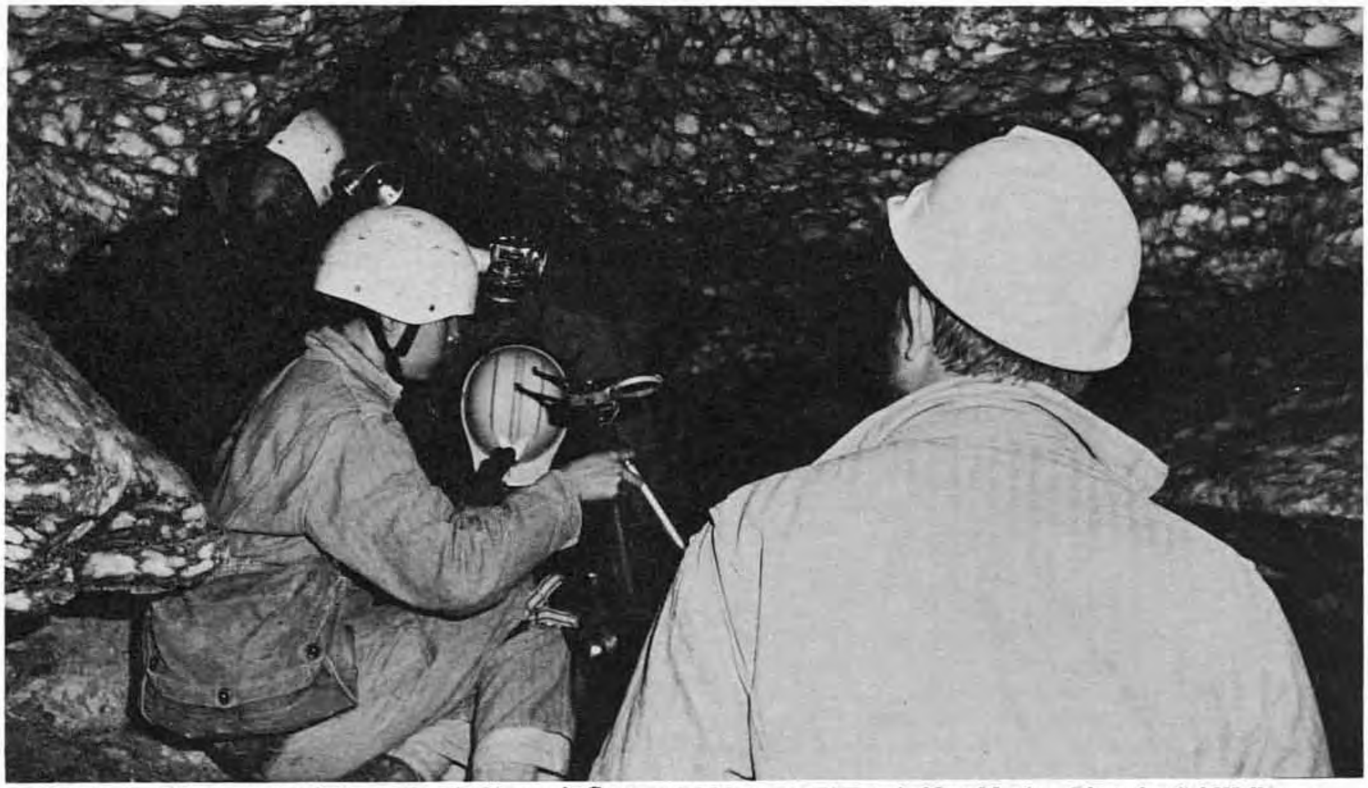

Brunton and tape survey being set up in Harvey's Cave, a BLM-managed cave in New Mexico. *Photo by Cal Welbourn.*

making it possible to detect and correct errors on the spot, saving manhours and speeding completion of projects. In the near future it may be possible to produce, with the aid of computers, true 3-dimensional models of caves, in the physical sense, and psuedo-3-dimensional plots of cave maps including all features using ortho-photo processes in which photographs of caves are used to produce complete pictures and combined with control surveys to produce a map.

Control Surveys and Computer Processing of Cave Surveys

James M. Hardy*

Precise control surveys provide a relationship between caves, surface features and other resources. In addition, control surveys provide a base from which less precise surveys may be started as well as a base which can insure the relative accuracy of less precise surveys. As the value of cave resources increase, it becomes more and more imperative for managers to know exactly where a cave is and what relationship it has to other resources or lands.

Control surveys used to locate caves may be divided into surface and subsurface control surveys. The surface surveyor uses the U.S. Coast and Geodetic Survey (USC&GS) control net to provide a base for the survey; he then brings to the cave a survey system using USC&GS standards and sets two or more reference marks at the cave entrance. Once the surface control net has been established, it remains to bring the control survey to the subsurface. The subsurface control survey is tied into the surface control in the same manner as the surface control was tied into the USC&GS control net. The subsurface control survey is extended into the cave as far as is feasible and from this precise base, brunton and other less precise surveys can be run. The primary objective of the subsurface control survey is to provide a skeleton from which the less precise surveys will be controlled. Occasionally, very large rooms can be surveyed with small control nets. The precision of the subsurface control will not be as good as the surface control because of space and size restriction imposed by the cave passage. The primary restriction is that instrument pointing accuracy suffers on short lines of sight. In addition, short sights increase the number of stations adding additional error.

Obtaining the control survey can be a long process. If the manager is fortunate the surface control already exists near the cave. Even more fortunate is the case where a control survey has already been brought into the cave. More often, no control survey exists near the cave and it has to be brought in. A manager now has two options: do the survey himself or have someone else do the job. The first option requires a theodolite accurate to one second and a precise distance measuring device (most likely electronic) and expert knowledge of control surveying. As this is beyond the reach of most people, the second option is more likely. If the manager hires someone to do the job, he must be careful, as the average surveyor often does not have the necessary expertice. The individual hired must have experience in control surveying. The same options apply to the subsurface control, only more so: few surveyors have experience in surveying caves.

Control surveys are necessary to tie together the relationships between resources such as caves and, in addition, provide a precise base upon which to build the survey required to map a cave.

When processing survey data with computers, the first and foremost consideration is maintaining the precision established by the survey data. One requirement of survey processing is to preserve as much of the original precision and information as possible. Control surveys are so accurate that it is almost a must to use a mathematical adjustment called *least squares*. This method adjusts the data in such a manner that the total adjustment represents the minimum change possible to the data. Ideally, this method is best for all surveys. But it requires considerable computer time. More frequently, less precise surveys are adjusted using methods like the *compass rule* or other similar methods of adjustments. Another consideration is the size of the data input and the resultant data base required to store the results. The programming system must be designed to accept large volumes of data and yet be economical with computer resources and processing time. A method of reduction should be selected based on the analysis of the relative costs involved.

Having considered all the constraints on the programming system, the system analyst then designs the system and provides program output as required. Printed output is a must and is the least expensive type of output. Graphical output is perhaps the easiest to use, yet it has the highest cost. Data base storage is useful when adding to a large survey system, yet it costs more than storing data on tapes or cards. Much depends on the computing system available to the user and the future use of the reduced data.

Computer processing of cave surveys is a natural and efficient way to reduce the large volumes of data generated by the surveys. The multiple outputs and displays available for data from computers allow a better understanding of the cave system. Permanent storage of results and raw data allows easy integration of additional survey information.

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A Practical Method for Cave Radio Survey

Stanley Ulfeldt*

ABSTRACT

A new method of surveying with cave radios has been developed that is efficient enough for routine mapping of any cave. Previously, cave radios were used for location finding by setting up the transmitter underground, zeroing in on the surface point above the transmitter by triangulation, and finding the depth by backing off a measured distance and measuring the dip of the magnetic field.

The method developed by the author uses fixed surface transmitters operating on different frequencies and a single tunable receiver taken into the cave. Transmitters are accurately placed at known locations on the surface alongside the cave. The receiving equipment consists of a small, easily carried, loop with a Brunton compass mounted on it and a transistorized receiver. In practice, the bearing and dip of the magnetic field of each transmitter is measured at each survey station by rotation of the loop until the direction of the null is found. From this data the station's location can be graphically plotted or calculated to coordinates and the map drawn. Initial tests of this method in Lilburns Cave indicate that an accuracy of approximately one percent of the distance from the transmitter can be obtained.

Advantages of this method are: (1) The transmitters can be permanently located and accurately leveled, (2) Only the small receiver is taken into the cave, (3) Only one person is needed to operate the receiver and take the necessary data, and (4) The far end of a newly discovered passage can be accurately located the same day it is discovered.

Previously, cave radios were used for location finding by setting up the transmitter underground, zeroing in on the surface point above the transmitter by triangulation, and finding the depth by backing off a measured distance and measuring the dip of the magnetic field. A map could be made by surveying the points on the surface and subtracting the depth. This method requires considerable time both in the cave setting up the transmitter and on the surface finding it. In rugged or heavily wooded country it is practically impossible to locate the surface point. Consequently, cave radios have only been used to locate specific points where the time and effort were justified, close surveys, location of possible entrances, etc.

The method developed by the author and described in this article uses cave radios for routine mapping. It is roughly the inverse of the present cave radio technique. Several transmitters, operating on different frequencies, are placed at accurately surveyed points on the surface. The receiver, tunable to each transmitter, is taken into the cave. The bearing and dip of the field for each transmitter from each station is measured with a Brunton compass mounted on the receiver loop. The locations of the stations can now be plotted graphically or calculated to coordinates and the map drawn.

The advantages over previous cave radio techniques are (1) Transmitters can be permanently located and acurately leveled, (2) No bushwacking on the surface is required, (3) Only the smaller receiver is taken into the cave, (4) Only one person is needed to operate the receiver and take the necessary data. Compared to tape and compass surveying, over long distances, accuracy is probably better because each station is independently located and not subject to cumulative error as the tape and compass method is. The chief advantage is the freedom allowed to the surveyor. Stations can be as close or as far apart as desired. Forget those fifteen 3-feet shots to get through that twisty spot; just crawl through and make your next station on the other side. The far end of a newly discovered passage can be accurately located the same day it is discovered!

The shape of the magnetic field of a current carrying loop of wire is the same as that of a magnetic dipole (Mixon and Blenz) at distances that are large compared to the diameter of the loop and is shown in Figure 1. This field oscillates (expands from zero to a maximum of one polarity, contracts back to zero, expands to a maximum of the opposite polarity, and contracts back to zero) at the transmitter frequency, 1000 to 2000 Hz. A voltage will be induced in a coil placed in this field if the lines of force cut the coil during their oscillations, case 1 Figure 2. If the coil is rotated so that it is parallel to the lines of force, no lines of force will cut the coil, no voltage will be induced in the coil, case 2 Figure 2. The direction of the field can be found by rotating the loop until no signal is received. This condition is called a null.

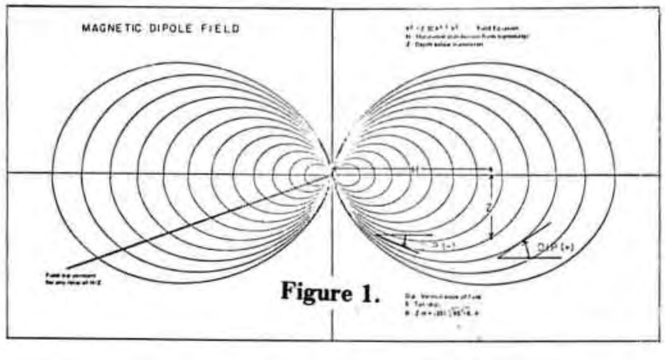

Figure 1.

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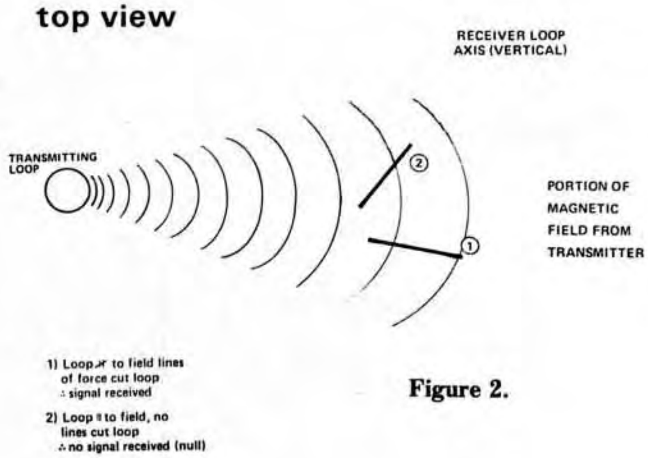

Figure 2.

Operation of the system depends on a knowledge of the shape of the magnetic field of the transmitter. For a level loop the field is composed of closed lines of force oriented in vertical planes radiating outward from the axis of the loop, Figure 2 and 3. The shape of the lines of force in the vertical plane is such that for a given slope, S, (Slope = tan [dip]), dip measured as shown in Figure 1, the ratio, R, of Z/H (Z = depth below transmitter, and H = horizontal distance from transmitter) is given by

(1) $$R = Z/H = (3S \pm \sqrt{9S^2 + 8})/4$$

Equation (1) is needed to calculate the depth below the transmitter knowing the slope, S, of the magnetic field and the distance, H, from the transmitter in the horizontal plane.

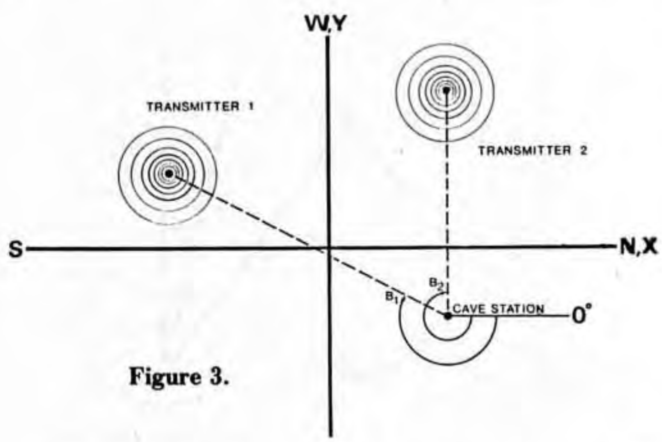

Figure 3.

The location of the station in the horizontal plane can be found by triangulation using two or more transmitters. The compass bearings to each transmitter are found by measuring the direction of the null in the horizontal plane, Figure 1. The location of the transmitters are known from surface surveys. The triangulation can be performed analytically using a computer or graphically on a scaled map. The distance, H, from the transmitter to the survey station can be calculated or measured from the map. The depth of the station can now be calculated from equation 2,

(2) $$D = (R)(H) + Z_t$$

where D equals the depth of station and Z_t is the elevation of the transmitter.

In practice, the system is set up as follows. Transmitters are placed beside the cave system near where the passage to be surveyed is located. It is important that the transmitters are accurately surveyed. The transmitter loops should be made as large as convenient for maximum range. The ones used in Lilburn Cave were two meters in diameter with approximately 200 turns of wire with an effective range of over 1000 feet with the receiver in use at that time. The receiver is tunable to the frequencies of the transmitter loops to enable one to listen to one transmitter at a time. The transmitter frequencies used were 1100 and 1500 Hz. The receiving loop is 0.3 meters in diameter.

The operation of the receiver in the cave is quite simple. The receiver is tuned to the frequency of the first transmitter and the direction of the null in the horizontal plane is found by rotating the loop around the vertical axis. The bearing is taken from the Brunton compass mounted on the loop. The loop is then rotated about a horizontal axis perpendicular to the direction of the previous bearing until the null is found and the dip of the field is measured again using the vertical scale on the Brunton. This procedure is repeated for each of the transmitters in operation at the time. The minimum number of transmitters required is two.

The proceeding information obtained for each station together with the transmitter locations is all that is needed to locate the stations. This can be done graphically using a scaled map or calculated to coordinates using a computer program which accepts the raw data.

Agreement with locations determined by conventional survey methods is quite good, all cases being within the expected accuracy of the conventional survey method. All test points in the Lilburn survey are located on a closed loop from the main entrance to the Meyer entrance. This survey loop contains approximately 2500 feet of underground survey with a closure error of 10.5 feet slope distance.

This technique should solve many of the problems of cave surveyors. Points located with this method are not dependant of previous stations, therefore are not subject to cumulative errors. Survey stations can be located at any desired point in the cave allowing remote areas to be surveyed without starting from the entrance and working inward. Stations can be placed as far apart as desired and the intervening stretches sketched in if a quick survey is desired, thereby allowing the surveyor to make as detailed a map as needed.

Computer Drawn Stereo Three-Dimensional Cave Maps

Stanley Ulfeldt*

One of the main purposes in surveying a cave is to acquire data and present it in some form of a map. If the cave is flat, a plan view on a flat sheet of paper gives an accurare representation. But many caves are three dimensional in development with many overlapping levels. A plan view of this type of cave is quite confusing as it is difficult to distinguish between levels. A side view of the same cave simply transfers the confusion to another plane. The combination of the two helps some but still requires considerable interpretation.

What is needed is a three dimensional map. The technique described in this paper uses a computer to produce stereo three dimensional maps. The three coordinates of a survey station are the distances from the origin or cave entrance in the north-south, east-west and vertical directions. The coordinate values of all stations are calculated by a survey program and stored in the computer and then used to draw the stereo map on a computer-controlled plotter.

The stereo effect depends on the function of binocular vision. The brain determines the distance to a nearby object from the parallax of the viewers eyes. For a distant object the eyes are pointed parallel. For a near object the eyes are rotated inward to superimpose the two images perceived by each eye. The closer the object, the more the rotation inward. (Figure 1.)

A three dimensional visual model can be created by drawing the images seen by each eye on a plane and providing some means of separating these images so that each eye sees only its image. These images, one for each eye, are called stereo-pairs. (Figure 2.)

The images are separated by drawing one in red and the other in green and viewing them through red and green filters. The eye looking through the green filter sees only the red image as black lines and the eye with the red filter sees only the green image, also as black lines.

To get the three dimensional effect the viewer rotates his eyes inward, as if viewing a near object, until images in each eye become superimposed. When this happens the combined image will literally leap off the paper to its proper three dimensional location. This takes some practice because it is necessary to overcome the coordination of the focus of the eyes with their parallax and focus on the drawing.

In practice, the drawing of the stereo-pairs on paper is the job of the computer. It is used to calculate the projections of the survey stations on the plotting plane from the coordinates of each eye's view point, the plotting plane and the stations. (Figure 3.) The projections from each view point are plotted, one in red and the other in green, with lines connecting the points along the survey route. This creates a stereo three dimensional stick figure model of the cave.

The stereo three-dimensional program allows the user to select viewing parameters in the coordinate system used in

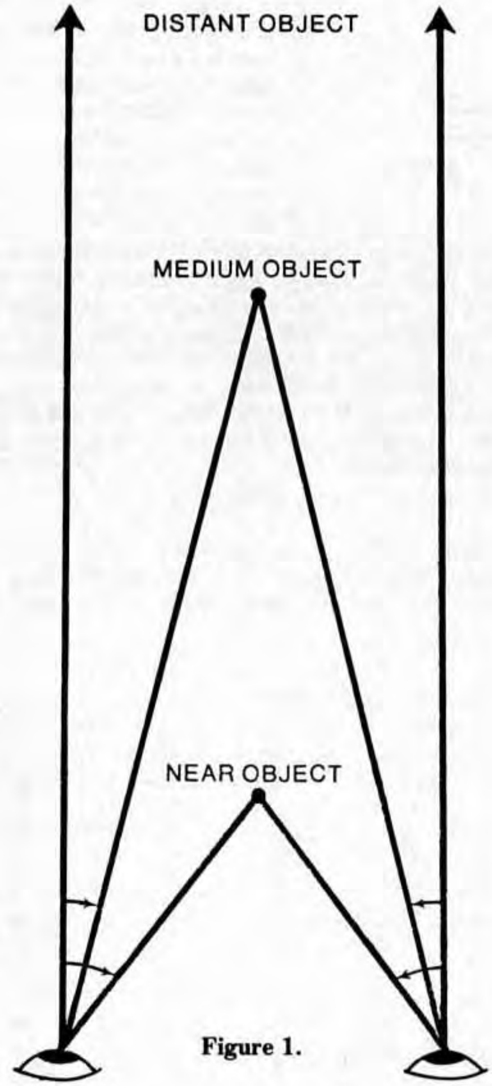

Figure 1.

the survey. To create a specific stereo model it is necessary to select a viewed point, the direction and distance from which to view it, the distance to the plotting plane and the scale of the model.

First, it is necessary to choose a suitable viewed point and viewing direction. This choice depends on the desired view of the cave, top, side or oblique and the shape of the cave. For example, the cave that was used in the initial development of this method of mapping, Lilburn Cave, Kings Canyon National Park, California, is developed in a north-south direction and therefore the best view is in an east-west direction. This allows the plot to fit the paper better and limits the crowding and relief of the map.

Second, the plotting plane should be chosen just behind the cave the allow the viewer to put a transparent scale

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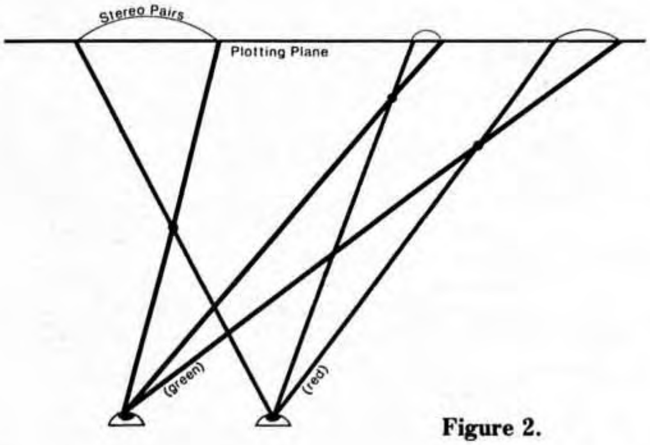

Figure 2.

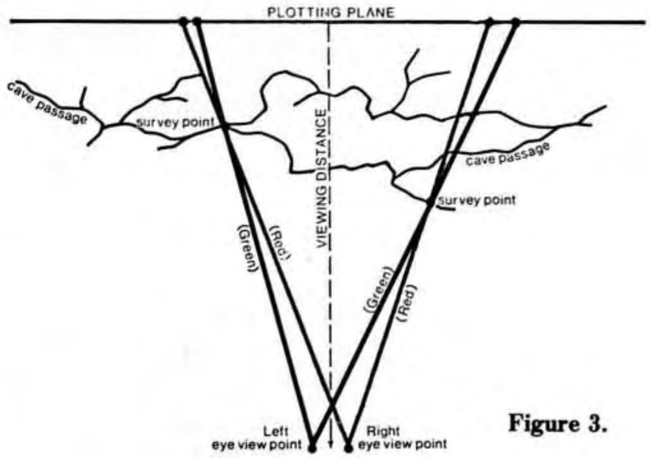

Figure 3.

within the stereo model to measure distances or angles. A viewing distance is selected so that the cave subtends an angle of not more than 90 degrees.

Third, the scale at which the map is to be plotted is set. This is the three dimensional scale of the stereo model and is true for distances in any direction when the plot is viewed from the scaled view point.

The current version of the program draws a stick figure map of the cave which is very useful though not showing the outlines of the passages. It gives a correct picture of the locations of the passages and enables one to easily separate overlapping levels and for example, to see the relationship between the surface and a possible new entrance. With data on the width and height of the passages a tunnel-like stereo model could be produced.

Values, Decision Making and Cave Management

Richard L. Weisbrod*

ABSTRACT

In recent years, management decisions made by public land agencies have come under increasing public scrutiny. The Environmental Impact Report has served as a vehicle for identifying and describing the foreseeable consequences of decision alternatives. Decisions, however, are made on the basis of values as well as facts, and the EIR does not provide mechanisms for identifying values and using them to make decisions.

This paper discusses an approach to decision making known as multi-attribute utility assessment and shows how it can be applied to cave management. The idea behind this approach is simple and has been around for a long time. Decisions are decomposed into their component attributes of value. The attributes are then weighed and each alternative is assessed on the basis of each individual attribute. Finally, the individual attributes are aggregated and the decision is made on the basis of the overall value of each alternative.

Multi-attribute utility assessment is not a panecea. Used wisely, however, it can help decision makers to clarify issues, resolve value conflicts, and arrive at decisions which are justifiable on the basis of explicitly specified values.

INTRODUCTION

With the advent of the National Environmental Policy Act, the management decisions of public land agencies such as the National Forest Service, the National Park Service, and the Bureau of Land Management have come under increasing public scrutiny. These agencies have received a legal mandate to recognize and incorporate the views and values of divergent groups and individuals into the decision process. Agencies, however, quite often find themselves caught between advocates of one proposal or another with little to help them make their decision but the relative noise level and the volume of mail generated by each side.

The Environmental Impact Report (EIR) has assumed a role of major importance in the decision making of most agencies. The original intent of the EIR was to identify and describe in detail the foreseeable consequences of significant decisions. For this reason, the EIR has become a focal point for many of the battles over a plan. Supporters of a plan will attempt to use the EIR to present the strongest possible case for their plan, while saying as little as possible about negative factors and alternative plans. Opponents, on the other hand, will question the adequacy of the EIR and attempt to poke as many holes in the plan as possible.

The EIR is very useful as a vehicle for collecting information about the consequences of various decision alternatives, but this information is not, by itself, sufficient to make the choice between these alternatives. Decisions are and should be made on the basis of values as well as facts. It is not sufficient to know that continued pumping of water in the vicinity of Devils Hole will cause the water level to drop, resulting in the extinction of the Devils Hole Pupfish (*Cyprinodon diabolis*). It is not sufficient to know that a proposal to upgrade a jeep road in Carlsbad Caverns National Park "would make an outstanding scenic drive available to the general public" (National Park Service, 1974) or that this road would "produce the separation of a *de facto* wilderness and destroy the unity of the back country" (National Speleological Society, 1974). Nor is it sufficient to know that a proposed commercial "guide service" in a Sequoia National Forest cave will provide "a needed recreational service to the public" (Fairchild, 1974), but will "more than double the number of people visiting the cave" (Southern California Grotto, 1974).

It is important to know the information contained in the EIRs and a great number of battles will continue to be fought over the accuracy and completeness of this information, but knowing this information is not sufficient to make a decision to accept or reject an alternative. The decision is based on questions like how important is it to continue pumping water versus how important is it that the pupfish survive; how important is it to make an outstanding scenic drive available to the public versus how important is it to preserve the wilderness character of the back country; and how important is it to provide a caving guide service versus how important are the consequences of doubling the visitation rate. It is not sufficient for a decision maker to know the consequences of a decision alternative. Before he or she can make an intelligent decision it is necessary to assess the value of each of these consequences and weigh them against each other.

The battles fought over an EIR are usually based on conflicts over values. Because the EIR contains no mechanisms for resolving value differences, these differences are transformed into arguments over which facts should be included in the report. This paper discusses a mechanism for bringing individual and group values out into the open,

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estimating their magnitude, and integrating them to arrive at a decision.

MULTI-ATTRIBUTE DECISION MODELING

The approach discussed in this paper is known in the jargon of decision analysis (Raiffa, 1968) as *multi-attribute utility assessment.* But don't let this technical sounding name scare you off. The idea behind this approach has been around for a long time and is quite simple. Many of you have probably used it at one time or another. Benjamin Franklin was probably the first to write about the use of this idea in a 1772 letter to his friend Joseph Priestly (in Bigelow, 1887):

> I cannot, for want of sufficient premises, advise you *what* to determine but if you please I will tell you *how* ... My way is to divide half a sheet of paper by a line into two columns; writing over the one *Pro*, and the other *Con*. Then, doing three or four days' consideration, I put down under the different heads short hints of the different motives, that at different times occur to me *for* or *against* the measure. When I have thus got them all together in one view, I endeavor to estimate the respective weights ...[to] find at length where the balance lies ... And, though the weight of reasons cannot be taken with the precision of algebraic quantities, yet, when each is thus considered, separately and comparatively, and the whole matter lies before me, I think I can judge better, and am less liable to make a rash step; and in fact I have found great advantage for this kind of equation, in what may be called *moral* or *prudential algebra* [p. 522].

The essence of Franklin's "prudential algebra" and of multi-attribute utility assessment in general, is the decomposition of a complex decision into its individual value attributes. This is known as dimensional decomposition. Then, rather than trying intuitively to make the decision in a wholistic manner, each decision alternative is evaluated in terms of the attributes and these individual value assessments are algebraically combined to give an overall value for each alternative. Finally, the alternative with the highest value is chosen.

Two hundred years ago, Ben Franklin realized he was "less liable to make a rash step" if he decomposed his decisions. Today, as a result of considerable psychological and decision making research, we understand why dimensional decomposition works. People are very good at perceiving, recognizing patterns in their perceptions, and organizing or coding these patterns into meaningful chunks of information. We are not, however, nearly as good as we would like to think we are at integrating information from diverse sources in order to make judgements (Dawes, 1975). Multi-attribute utility analysis is a model of human decision processes which can aid us in organizing and integrating information relevant to a decision.

There is considerable evidence that decisions based on multi-attribute decision models are superior to intuitive judgements, even when these judgements are made by experts. Dawes (1975) cites a number of examples where external methods existed for verifying the correctness of the decision. These examples include the prediction of college and graduate school success, ultimate psychiatric diagnosis, and the longevity of patients with Hodgkins disease. A checker playing program written by Arthur Samuel (1963) has not lost a game in years. Dawes further argues that multi-attribute decision models will outperform intuitive decision makers in choosing a single alternative even when there is no external criterion of value.

THE SIMPLE MULTI-ATTRIBUTE RATING TECHNIQUE

The technology of multi-attribute utility assessment provides guidelines for coding and integrating value judgements. These guidelines help insure mathematical consistency in decomposing and integrating the multiple attributes. Numerous versions of the technology have appeared in the decision analysis literature (e.g., Fisher, 1972; v. Winterfeldt and Fischer, 1973; Bauer and Wegener, 1975) and, indeed, there are a number of computer programs for performing the required functions (Ulvila, 1975).

The technique described here is based on the Simple Multi-Attribute Rating Technique (SMART) developed by Gardner and Edwards (1975). It was chosen because of its orientation towards "easy communication and use in environments in which time is short and decision-makers are multiple and busy." The SMART approach has been successfully applied to a case study involving California coastal zone land management (Gardner, 1974). The technique described here is essentially identical:

Step 1: Identify and enlist the cooperation of the people or organizations whose values are to be considered. In the case of caves on Federal land, the following might be included: local, state, and Federal agencies and governmental bodies; user groups such as the National Speleological Society, cave research organizations, archeologists, backpacking and hunting clubs; and nearby land owners.

Step 2: Identify the issues to which the decision addresses itself. Values often depend on the purpose for which the evaluation is being made. If the purpose of a management decision is to protect a cave, one set of values might come into play. If the purpose is the protection of people, an entirely different set of values might be involved.

Step 3: Identify the alternatives to be evaluated. There are always at least two alternatives, because the alternative of doing nothing must always be considered. There may, however, be more than two alternatives. Like Ben Franklin's prudential algebra, multi-attribute utility assessment does not tell you what to decide, only how to decide it. Nevertheless, the technique offers some help in choosing alternatives which we will discuss later.

Step 4: Identify the relevant attributes to be evaluated in making the decision. This step is extremely important because it determines which dimensions the decision is decomposed upon. Much of the information needed for this step and for steps 2 and 3, as well, may be derived from a well prepared environmental impact report. It is important that the number of attributes is not too large (see step 5). This can be done by combining several attributes into a more general one or by eliminating less important ones.

For the purpose of discussion, let us consider a hypothetical, but realistic example. Suppose a decision maker for a government agency received a request from the concessionaire of a commercial cave for a permit to conduct wild cave tours in a nearby wild cave. The following are some of the value attributes which might be relevant:

(1) Economic benefits and costs (jobs, revenue, permit fees, adverse effects on other commercial caves, etc.).
(2) Increased public awareness of cave conservation problems.
(3) Increased public demand for wild caving experiences.
(4) Decreased nontour caver access to cave.
(5) Increased control over caver behavior in the cave.
(6) Increased traffic through the cave.

(7) Increased rate of destruction of cave features.
(8) Adverse effects on cave biota.
(9) Increased litter and other forms of pollution.
(10) Environmental impacts on surrounding surface areas.
(11) Increased uncontrolled visitation of the cave and other nearby caves.
(12) Impact of tour control structures on wilderness nature of the cave.
(13) Impact of tour on wilderness experience of non-tour cavers.
(14) Impact on public safety.

The purpose of the above list is to illustrate, not to define, some of the attributes which might be relevant. Nevertheless, it is typical of the kind of list which might be developed as a first pass in Step 4. One of the major problems with this list from the standpoint of dimensional decomposition is that the attributes are not reasonably independent of each other. Attributes number 6, 7, 8, 9, and 10, for example, are closely related. If the traffic goes up, then the other effects are increased also. Economic effects may also be related to the visitation rate.

Using these kinds of considerations, the list can be refined to the following:

(1) Party size.
(2) Number of visitors per year.
(3) Effect on quality of visitor behavior.
(4) Effect on quality of wilderness experience.
(5) Impact on public safety.

Party size, obviously, is not important in itself. Party size is important because of its synergystic impact on the cave. A party of ten cavers, no matter how well behaved, has *more than twice* as much impact on the cave features, biota, litter, etc. as an equally well behaved group of five. Likewise, the total number of visitors per year is important as a measure of cumulative impact on the cave. These two factors, as well as the others, can be decomposed into their component parts, evaluated, and reintegrated using the procedures outlined in Steps 5 through 8, but often this is not necessary.

One final comment on attributes, and we will move on to the next step. Attributes may be purely subjective, partly subjective, or purely objective. It may, for example, be possible to quantify the cumulative effects of cave visitation on the cave environment, if enough data is available. If this is not possible, both objective and subjective factors may be combined to give a partly subjective measure. The National Forest Service (1971) attempt to quantify "wilderness potential" is an example of a partly subjective measure. Finally, a purely subjective measure may be necessary. For example, we may not be able to say anything more than whether a plan will increase, have no effect, or decrease public safety.

Step 5: Assign importance weights to each of the attributes. Here we use a three-stage procedure to determine how important each attribute is in making our decision. The first stage is to rank them in order of importance. One person may, for example, decide that public safety is the least important factor to consider and party size is the most important. Another person may decide that safety is the most important. Thus, different people or groups may give different degrees of importance to each attribute. Conflict is to be expected at this stage. One way to control the degree of conflict is to try a group process first. This helps get all of the arguments out in the open and helps insure that everyone starts with a common data base. The participants then separate and arrive at individual judgements.

The second stage is to assign numeric weights to each of the attributes. Start with the least important attribute and give it a weight of 10. Then assign a weight to the next attribute on the ranked list. Suppose you think it is 2½ times as important. Give it a weight of 25. If the third attribute is twice as important as the second, its value becomes 50. The important thing to remember is that ratios between attribute weights must be preserved! The value of 50 given to the third attribute implies that it is five times more important than the first one, as well as twice as important as the second one. For this reason, it may be necessary to revise the weights as you go along in order to maintain consistency. If two attributes are equally important give them the same weight.

The third stage of attribute weighting is to *normalize* the weights by summing them up, dividing each weight by the sum, and multiplying by 100. This purely mathematical procedure is used to convert the weights to a convenient, zero to one hundred scale.

At this point we can see why it is important not to specify too many attributes in Step 4. The lesser attributes simply become so unimportant that they do not contribute significantly to the final decision. Gardner and Edwards (1975), as a rule of thumb, suggest that eight attributes are plenty and fifteen are too many.

Step 6: Develop value curves for each attribute. These curves will be used to assign measures of worth to each attribute for each decision alternative. One simple, but often sufficient, way to draw these curves is to assign a worth of zero to the lowest plausible value of an attribute and a worth of 100 to the highest plausible value. If less of a particular attribute is better than more of that attribute, reverse the worth numbers. Figure 1 is illustrative. Sometimes, however, this simple straight line approach is not satisfactory. Figures 2 and 3 illustrate other kinds of curves.

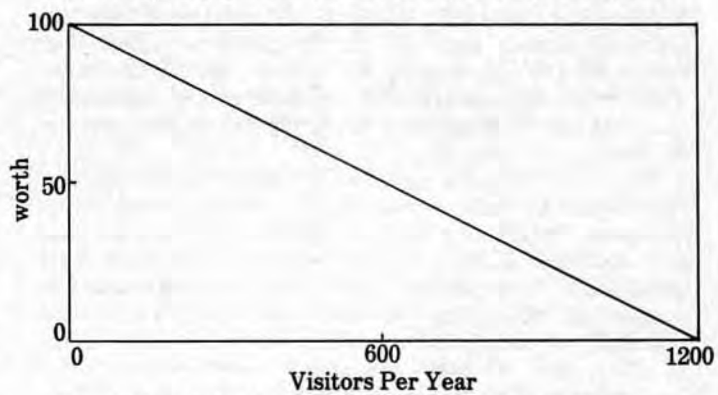

Figure 1. Illustrative Value Curve for Visitors Per Year

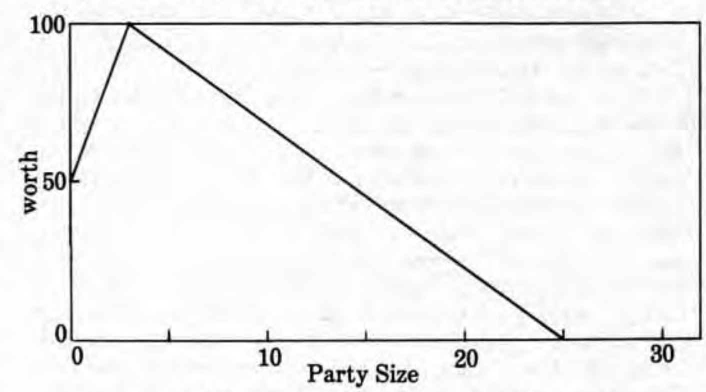

Figure 2. Illustrative Value Curve for Party Size

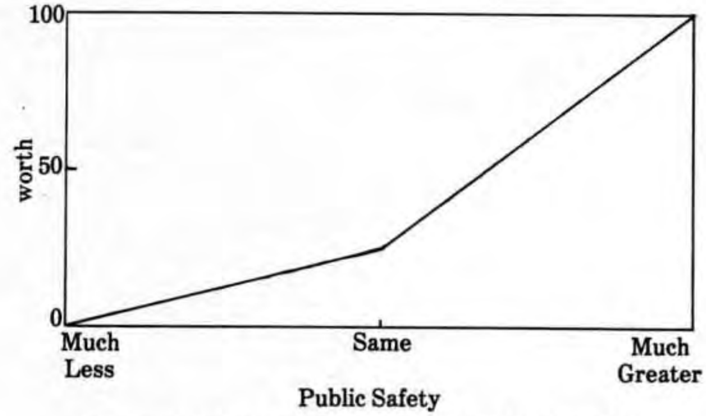

Figure 3. Illustrative Value Curve for Public Safety

Again, it is not necessary that all participants in the decision come to agreement. If, however, the decision is one which must be made repeatedly, it may be worth spending considerable effort to arrive at some sort of consensus. One example might be the decision to grant an entry permit to a party of cavers or a research permit to a speleologist.

Step 7: Locate the consequences of each decision alternative on each value curve. Say our cave has 600 visitors per year and doing nothing will have no effect on the number of visitors per year. Then, from Figure 1 we see that the worth, $u_{1,0}$, of alternative 0 (doing nothing) on dimension 1 (visitors per year) is 50. Suppose, now, that the proposed cave tour (alternative 1) will increase the annual visitation to 1000. The worth on this attribute dimension is then $u_{1,1} = 17$.

Step 8: Calculate the total value of each decision alternative. This purely mathematical step is accomplished by multiplying each value obtained from Step 7 by its corresponding weight from Step 5, and taking the sum for each decision alternative.

Step 9: Decide which alternative to choose. If a single alternative is to be chosen, choose the one with the highest value. If more than one alternative is to be chosen, then choose the set of alternatives which maximizes the total value. A threshold value, such as the value of doing nothing, might be used as a cut-off point.

There are two special cases which should be considered here. The first case is the one which occurs when the consequence of an alternative exceeds some maximum or minimum threshold on a particular attribute. The Devils Hole Pupfish case provides a good example. Suppose that one attribute of value is the water level in the cave. Suppose, further, that a drop of 3 feet would destroy the fish feeding and breeding area. Then all decision alternatives which resulted in a drop of three feet or more would automatically be discarded.

The second special case occurs when there is a budgetary constraint. In this case we can compute the value-to-cost ratio and choose, in decreasing order, as many alternatives as we can until the budget is used up. If there is no budgetary constraint, cost is treated like any other attribute of value.

VALUE CONFLICTS

To this point, we have not concerned ourselves with value conflicts between the participants in the decision. In this section, we will examine some sources of conflict and how they may be resolved.

Conflicts often arise because attention is focused on the decision alternatives rather than the underlying issues. Identifying the attributes of value and assigning weights to them may change this focus. This is illustrated in an example cited by Dawes (1975): Recently there was a great controversy in the city of Denver over the use of *dum-dum* bullets by police. The chief of police and the district attorney took opposite positions in a heated political battle which focused on the bullets, not their attributes. Analysis by a group of decision analysts revealed that the socially important attributes of bullets were (1) stopping ability, (2) potential for serious harm to the victim, and (3) potential for injury to bystanders. The social importance (weight) of each of these attributes was rated by the city council and found to be roughly equal. This was true even for the chief of police and the district attorney. All available bullet types were then rated independently by a number of ballistics experts. A bullet was found with much greater stopping ability than the currently used bullet and no greater probability of harm to the victim or bystander. This bullet spread out on contact, knocking the person over, without penetrating deeply.

The weights assigned to attributes in Step 5 and the values assigned in Steps 6 and 7 are often sources of conflict. In spite of this, Gardner and Edwards (1975) found that the use of the model turned modest disagreement on the basis of wholistic decisions into strong agreement. The reason they suggested for this is that when we make wholistic decisions, we tend to focus on those attributes which most strongly engage our biases. Multi-attribute utility assessment forces us to look at the other attributes as well. Thus, agreement on less controversial attributes tends to reduce the impact of disagreement on controversial ones.

One important aspect of multi-attribute utility assessment is that it focuses attention on values and provides a mechanism for identifying where the conflicts lie. Once we have done this, it may be possible to reduce the degree of conflict through discussion, persuasion, and information exchange. A further benefit of the technique is that, having identified the sources of conflict, it may be possible to go back to Step 3 and devise new alternatives which are mutually agreeable to all parties.

CONCLUSION

Multi-attribute utility assessment is not a panecea. It will not solve the problems of the beleagered decision maker. It does not eliminate the need for wisdom in developing viable decision alternatives and choosing them. Used wisely, however, multi-attribute utility assessment will provide a tool for clarifying the issues and arriving at a decision. In the case of agencies which find themselves in the not uncommon position of promoting a plan on the one hand, and trying to objectively evaluate it on the other hand, it provides a mechanism for separating these two functions and allowing others to participate in the evaluation process. People who have been allowed to effectively participate in a decision are much more likely to accept the result, even if they don't completely agree with it. Agencies will still be criticized for their decisions, but these decisions will now be justifiable on the basis of explicitly specified values, and not just rhetoric.

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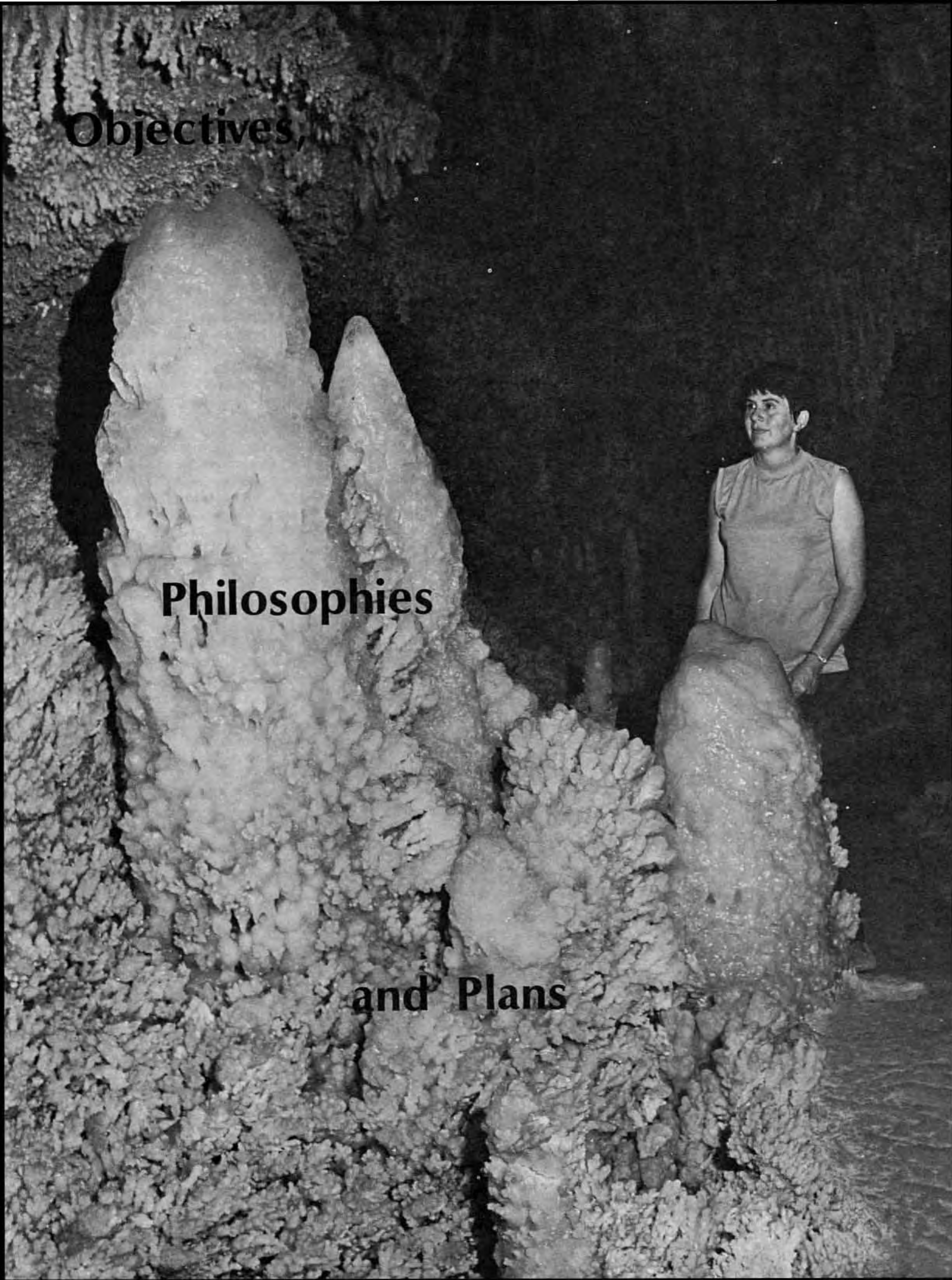
Objectives, Philosophies and Plans



Bureau of Land Management Plans and Programs in the Carlsbad Area

Ann Loose*

The Roswell District of the BLM first became aware of its cave resources in 1966, through a dispute between a sheep rancher and a group of cavers who wished to visit a cave on federal land leased to the rancher. The rancher feared that caver traffic would disrupt his sheep flocks. A compromise was negotiated in which the cavers would refrain from visiting the cave during lambing season and would notify the rancher of their intended visits. Although located outside of the Carlsbad region, this was the beginning of the BLM program in the Carlsbad area. Following awareness of this new resource, the Roswell District began to gather data on the caves under their jurisdiction. The Southwest Region of the NSS was very cooperative and BLM representatives attended many of the regional caver meetings.

The cavers stressed the problems of vandalism and BLM recognized the need to have some idea of cave visitation. A number of caves were designated as in need of protection and these were fenced with chain link fences and posted with information on how to obtain a permit. It was immediately obvious that this was an inadequate system for protecting the resource and steps were taken to begin a gating program. Here again, caver input was extremely important. Gates were designed and installed by the Southwestern Region of the NSS in Dry, Fort Stanton and several other caves. An information system was developed and shared with the other agencies since many of the caves reported to the BLM were not on national resource lands but were in either Lincoln National Forest or Carlsbad Caverns National Park. Professional research was encouraged by BLM as a means of obtaining more information on the resource. Professor Harris' work in Dry Cave and Susan Applegarth's work in Honest Injun are examples of this.

Although information was to some extent being shared, each agency at this time was going on its own direction and BLM was no exception. Work was being directed at obtaining some control over known caves and cavers were being depended upon for much of the relevant information. We had only a part time recreation specialist and were lacking in the necessary manpower to really manage the resource. During this time several briefing trips were made by State Office personnel to Washington in an attempt to obtain funds and personnel. This was partly successful, in that funds for some cave gating were made available.

In 1974 the Roswell District Office obtained a new position for an archeologist and it also became necessary to fill the recreation specialist position due to Don Sawyer's retirement. It was decided to attempt to hire someone with caving experience for one of these positions and I was hired as the archeologist and as a cave program consultant.

In an attempt to obtain more help for the cave program a briefing was presented to the State Office requesting funding and personnel to allow proper management of the cave program. As a result of this briefing arrangements were made for a team of Washington Office personnel to be taken on a tour of some of our cave resources. The team was given a tour of Endless cave with special emphasis on the amount of vandalism which has taken place. Again cooperation from the cavers of the Southwest Region was immense. As a result of this Washington briefing, we were given $50,000 for cave gating. The only drawback was that we had to spend it before the beginning of the new fiscal year. The gates were designed by BLM personnel and the contracts let before the deadline. To date these caves have not been locked and will not be until proper arrangements can be made for publicizing the procedures for obtaining permits to these caves. Another result of the Washington briefing was the go-ahead on this symposium which had been proposed a number of years previous. Originally BLM had thought to sponsor the symposium mainly for BLM personnel, but contacts with cavers and the other agencies indicated an extreme interest in this sort of symposium and a joint NPS USFS and BLM sponsorship was decided upon. Increasing amounts of interest from NSS and CRF led to their inclusion as joint sponsors. This symposium is a visible example of the decision of the three agencies to cooperate whenever possible. A third result of the briefing of Washington personnel was the decision to institute a memorandum of agreement between the three agencies in the Carlsbad area. This agreement merely states that whenever possible, the three agencies will cooperate and attempt to standardize procedures within the Carlsbad area. It is now in Washington for signature.

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Present Cave Management Program and Plan, Lincoln National Forest, Guadalupe Ranger District

Allan Hinds*

The present Cave Program on the Lincoln National Forest consists of locating, identifying, inventorying, classifying, and developing management prescriptions for cave resources located in the Guadalupe Ranger District. The program was started in 1971 to provide a recreational opportunity in undeveloped caves, while protecting caves with significant contents.

Cave locations are important to the land manager to assure that other resource activities do not adversely affect the cave environment. Under our present program, locations are plotted on an overlay which is consulted before activities that could adversely affect caves are undertaken.

Caves are quite often known by more than one name, which causes considerable confusion in the exchange of information. To minimize this problem brass caps are being installed at the entrance of each cave. The official cave name and number are stamped on the face of the 2½-inch-diameter cap.

the inventory process consists of gathering and recording information on 16 elements. The information is coded and recorded on a 5x8 card in a manner than can be programmed by ADP. A more detailed description of the elements are maintained in individual cave files.

Classification is based on two elements, cave contents and the hazards present. A dual system is used, with the content significance being rated from I through V, and the hazards rated A through E. Guidelines have been developed to assist in determining these classifications, however, a considerable amount of value judgement is necessary.

Management prescriptions are based on the dual classification system. Caves are open to visitation without permits if they do not present hazards requiring special skills and if they do not have contents of significant importance.

Permits are required for caves which require specialized equipment or knowledge, such as technical climbing, and for caves which contain objects of significant values. In some cases, gates are installed to protect the cave contents. Other caves may be completely closed to protect their values.

Requirements for obtaining permits vary from cave to cave, primarily based on the hazard classification. These requirements are tied into the difficulty of the cave.

To date, we have information on 93 caves within the district. Data is sufficient on 68 of these and management prescriptions have been developed. The following is a break-down of these prescriptions:

38 do not require a permit to visit.
7 have been gated.
11 additional caves will be gated.

Goliath, a formation in Cottonwood Cave, Lincoln National Forest, Guadalupe Ranger District. A permit is not required to enter this section of the cave. *Photo by Charlie and Jo Larson.*

2 caves can only be entered with Forest Service personnel.
1 cave is closed to all entry.
Visitation to one cave is strongly discouraged because of the hazards.

Our plans for the next two years are to complete installation of brass caps at all known caves, installation of signs at the entrance of caves requiring permits, and completion of data gathering on the other known caves. As funds become available gates will be installed on three or four caves each year.

The management program has been modified in the past and additional changes will be made as new information becomes available.

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Existing Cave-Related Plans and Programs at Carlsbad Caverns National Park

Philip F. Van Cleave*

Existing cave-related programs at Carlsbad Caverns are feeling the increasing pinch of personnel shortage resultant from current economy efforts in the Federal Government. This is especially true in the case of our number one public attraction, Carlsbad Caverns proper where, unless there is a quick turn-around in our ability to fill current job vacancies, public use of Carlsbad Caverns will have to be curtailed.

Present plans are that this can be accomplished mainly through shortening hours of operation rather than drastically changing the scope of visitor programs.

It may prove necessary to revert to guided trips in some of the more fragile portions of the cave during the off season. this would not preclude the continuing public use of the recently installed electronic interpretive system in any way, but would provide better supervision to prevent any increase in resources damage.

It may seem a bit of an anachronism to say that a cave can have too few visitors. Yet, when the carrying capacity for the Caverns has been created through a combination of built-in protections and carefully determined levels of protective staffing throughout the cave, if reduced staffing occurs during the light travel season, we are deprived of one very significant aid to preservation (heavy visitor presence) which is abundantly available during the late spring, summer and early fall.

It is definitely true that a moderate to heavy visitor presence throughout the cave helps to prevent vandalism, simply because few persons will chance an act, which he knows to be forbidden, in the presence of others.

In the near term, and throughout the off-season, trips to New Cave will continue on a week-end only basis with advance reservations required. This *primitive tour* of a minimally developed cave has an enthusiastic reception by a small segment of park visitors during the past two seasons, yet with a limit imposed on party size at 25, the average party size throughout the past two seasons has been only 10 persons.

Non-cave-related interpretive programs (normally reduced or suspended during the off-season) will, if necessary, be curtailed or dropped from the program for the next heavy use season to utilize available personnel in cave protection.

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National Speleological Society Liaison with Federal Agencies

Rane L. Curl*

NSS members have long had a variety of contacts with federal agencies about caves and caving, including discussing management plans, conservation projects, access arrangements, mapping and cave study projects, and cave rescue cooperation. The NSS has generally supported local arrangements; only providing backup resources through various committees and individuals who have special knowledge.

We are now in a period when federal agencies are devoting more time for formulating cave management plans; to setting qualifications and criteria for caving and cave research in *public* caves; and to expanding their roles in cave management, protection and study. It is an opportune time for the NSS to become more *visible* to federal agencies, and in particular to make our collective knowledge in conservation, cave studies and caving techniques and qualifications available to these agencies. In turn, the NSS can make an additional important contribution by acting as a liaison, or *clearing house*, between federal agencies and the speleological community.

Direct contact is now being established between the NSS and federal agencies responsible for cave management. The purposes and goals that are guiding this program include the following:

1. To make the information and expertise resources of the NSS more available to federal agencies for the interpretation and management of caves.
2. To direct inquiries from federal agencies to local NSS members, grottos and regions; or to an appropriate committee, section, survey, study group, project or individual.
3. To publicize agency regulations for cave use via the *NSS NEWS*.
4. To announce and solicit information, comments and recommendations regarding proposed new management plans for caves on public lands.
5. To provide more support and aid for existing projects between federal agencies and NSS members or member groups.
6. To encourage more cooperation with federal agencies in providing them with inventory and evaluation data about caves under their jurisdiction, for their use in making management decisions and, in turn, obtaining new information that such agencies may obtain (subject to all policies of the NSS or other agencies involved concerning the dissemination of cave data).
7. To provide continuity of contact with federal agencies during changes of personnel or activity in NSS internal organizations or other groups.
8. To establish an information base about problems in cave management—and their solutions—to be available to NSS members and federal agencies.

The first step being taken is to provide federal agencies having responsibility for caves additional information about the NSS, its organization, committees, chapters, projects, publications, and other activities, and an expression of our interest in furthering the above objectives. It would be very good if we could also mention and give support to the existing projects and arrangements that now exist between NSS members and these agencies. To do this we need additional information about the name and address of the agency with which cave explorers are working; the name of the primary contact person in that agency; and a short description of both the nature and history of the project or arrangements which are involved.

We believe this program can assist NSS member interests in cave study, protection, use and the development of good management plans for caves on public lands and help federal agencies in carrying out their obligations to protect and manage cave resources.

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New Melones Project Cave Program

Ralph Squire*, Dave Harris, Bob Martin†, and Mike Schaefer‡**

ABSTRACT

New Melones Dam and Reservoir, a large water resource development in California, will provide ready access to over 80 caves in the immediate project area and on adjacent lands. The Corps of Engineers and Bureau of Reclamation are preparing a development and management plan for the caves in the project area, and the Bureau of Land Management is considering a similar plan for the caves on adjacent public domain. Some problems have been overcome and many others are being worked on through the efforts of the National Speleological Society and the newly formed New Melones Cave Committee.

BACKGROUND

The New Melones Project was authorized by the Flood Control Act of 1944. It was modified by the Flood Control Act of 1962 which stated that upon completion of the dam and initial recreation facilities it would become an integral part of the Central Valley Project and be operated by the Bureau of Reclamation. This project provides for flood control, irrigation, and domestic supplies, water quality, recreation, power production, and wildlife preservation.

The Environmental Impact Statement of May 1972 noted that the National Speleological Society reported to the Corps the existence of about 70 caves plus two natural bridges in the project area. The NSS and the Yokut Wilderness Group of the Sierra Club expressed concern and requested preservation of the caves as the lake would provide additional access by the public. Vandalism is presently a problem and could become worse as the lake will make the caves more accessible to many people.

The EIS stated that measures for protection and public use of caves will be included in the master plan. Also, the EIS stated that consideration would be given to relocation of biological specimens in caves located below gross pool.

NEW MELONES CAVE COMMITTEE

Because of the large scale of the project the Corps formed a temporary New Melones Master Planning Section. This group recognized the need for and was instrumental in forming the New Melones Cave Committee composed of four National Speleological Society (NSS) members and an area manager from the Bureau of Land Management (BLM). The NSS members represent recreational, geological, and biological pursuits of caves, and are familiar with the Stanislaus River Canyon caves. The BLM representative administers land which contains numerous caves both adjacent to the project and on land withdrawn by the Corps for project purposes.

The following cave management plans are being considered for inclusion in the Draft Master Plan based upon cave committee recommendations:

A. Additional lands should be purchased to preserve known groups of caves for recreation purposes.

B. Removal of formations in caves below gross pool is not recommended.

C. Caves should be classified as follows:

1. *Recreational*—Considered safe for general public using common sense. Open without restriction.
2. *Interpretational*—Considered safe and open without restriction. Will have self-guided nature trail.
3. *Scientific*—To be gated to protect features and fragile formations for scientific study.
4. *Hazardous*—To be gated so that entry will be only by qualified cavers.

D. Guidelines to enter hazardous caves:

A group with a minimum of three people with one having previous experience should have these items of equipment as requirement for permit:

1. Hardhat with chin strap and attached light source.
2. At least one auxiliary light source.
3. Ropes and other climbing equipment, if necessary.
4. Container for litter and spent carbide.

E. Maximum numbers for groups going into restricted caves have been determined by the cave committee.

F. As many caves probably remain undiscovered, each newly discovered cave will be immediately mapped and classified.

BIOLOGICAL TRANSPLANT OF HARVESTMEN

Tom Briggs, an Associate Entomologist with the California Academy of Sciences, and a member of the Committee, informed the Corps that a species of Harvestmen lived in only two known caves. One of those two caves is on adjacent private lands and was just recently blasted closed and will be quarried soon. The other cave, McLean's Cave, is below the proposed gross pool. Mr. Briggs has started the procedure to declare this species

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endangered. The Corps contracted with him to move the biological specimens to a safe location in a mine shaft located on BLM land inside the future project boundary. An agreement was made with BLM to allow the Corps' use of the mine and then gating it for protection of the specimens. Nine species of invertebrates have been moved and their survival chances are good.

A gate was also placed on McLean's Cave to protect the habitat, but the cave was vandalized shortly thereafter by formation collectors who were not caught.

INTERAGENCY COORDINATION, AGREEMENTS, AND LAW ENFORCEMENT

Various Federal and local agencies are involved in the New Melones reservoir area. They include the Bureau of Land Management, National Forest Service, Corps of Engineers, Bureau of Reclamation, State of California, and the Counties of Tuolumne and Calaveras. In addition, the National Park Service and the California Department of Parks and Recreation are involved in the archeological, historical, and paleontological preservation programs, while the Fish and Wildlife Service and California Department of Fish and Game are involved with the fish and wildlife preservation and propagation programs.

After construction in 1979, the Corps will turn the project over to Reclamation for operation. As this won't be just a *key-handing-over* process, close coordination between these two agencies is essential, especially in the recreation program. The Caves portion of this program is a new area for both our agencies, and that is the reason for our attendance at the Symposium this week.

Recognizing the close proximity of caves on adjacent BLM lands and the New Melones Project lands, it would be realistic and desirable for only one Federal agency to manage the cave area. Reclamation has suggested that BLM take the lead in this responsibility. If BLM is not staffed or funded for this by the completion of the project construction, Reclamation will be ready to assume this responsibility, but only for the caves within the Federal project takeline.

Presently, Reclamation has no policy on caves, but will formulate such as necessary and in cooperation with the Corps' Reservoir Master Plan and the NSS recommendations. We understand the BLM New Mexico State Office and the National Park Service has such a policy, and will investigate these now.

The limitations of any agency administering this natural resource include personnel ceiling, funding, expertise and policing capabilities. Ceiling and funding are provided by administrative and congressional actions. Cave expertise will be Reclamation's or BLM's responsibility, and policing will be a combined effort of Federal, local and private groups. Presently, Reclamation has no law enforcement authority and will rely on the local governments for this need. Safety and rescue operations will be the responsibility of Reclamation and County agencies with volunteer help from NSS and the private sector.

CAVE MANAGEMENT ON BLM LANDS ADJACENT TO THE NEW MELONES PROJECT

To effectively manage the cave resource on BLM lands adjacent to the New Melones Project, it has been proposed that these lands be withdrawn under a protective withdrawal. Further studies will be required to inventory the caves within these lands and to locate and classify these caves. In addition to the protective withdrawal, which will include a Lands, Mineral, and Justification Report, the BLM also anticipates a designation of these lands as a natural area. Simultaneously, the BLM will also be developing a recreation plan for this area and to define some objectives, policies, and guidelines for the utilization of this unique resource.

National Park System Objectives and Philosophies of Cave Management

Richard S. Tousley*

BACKGROUND

The National Park Service has been involved in the management of cave resources since its formation in 1916, some 13 years after Wind Cave National Park was established by act of Congress. We now administer about a dozen park units where subterranean resources are either the principle park feature or a significant secondary one. In terms of overall responsibility, our sister agencies are charged with the protection of a far greater number of caves; but as far as public recognition and visitation are concerned, the National Park Service may share the lead in the field of cave management.

It might be said that the Service's earliest objective was to host the greatest possible number of people in the caves—consistent with the restraints of space, manpower and manageability of the visitor. We were guided by the precepts of our Organic Act—to provide for the use and enjoyment of the resources while preserving them for the benefit of future generations. As is the case with terrestrial features, these inherently conflicting responsibilities have often necessitated value judgments, balance and, sometimes compromise.

Compared to equally well-known surface parks, the visitation to caves has historically been somewhat limited. Only one park, Mammoth Cave, is approaching the mark of 2 million visitors per year. Two others, Carlsbad and Wind Cave, have visitation in excess of one-half million. However, we do not underrate the significance of these figures, for the surface acreages of the cave parks are small—and the underground space for the accommodation of visitors is even more limited. We have long been hard-pressed to serve all cave visitors with the type and quality of experience we would like them to enjoy. The general trend in park visitation, after having slowed and reversed itself in 1973 and 1974, appears to be on the upswing again. This will bring with it renewed pressure to accommodate more visitors each year.

We have wished that the regimentation of visitors was not so necessary—that there were greater opportunities for leisurely visits to the caves. We have also wished that every person could take any cave tour at his own convenience, but this is no longer possible in every park. With the thousands of people visiting certain of the caves each day, we have been forced to make compromises.

Many of the National Park Service's cave management problems are either directly or indirectly related to people. For example:

—I have already alluded to the pressure caused by the sheer numbers of people who wish to visit the caves. This has strained the park staffs who have lived under severe personnel limitations for the past decade—increased responsibility notwithstanding. Even if staffing and funding were not limited, there is a physical limit to the number of visitors who can be guided through any given cave during the course of a day. This leaves us with the alternatives of either opening new routes, where possible and practical, or establishing some type of user limitation. Either alternative may have negative effects.

—The general public must, unfortunately, be closely supervised in the cave environment; both for visitor safety and for the preservation of delicate cave formations. The degree of protection afforded to cave features is probably even greater than that we give to surface features. This is for the simple reason that caves can rarely, if ever, heal themselves—and no amount of money or manpower can repair the damage to cave formations. It would be simplistic to say that damage problems could be totally cured through public education, for this is one area of management where we cannot accept anything less than 100-percent success.

—The mere introduction of man and his conveniences into cave ecosystems has sometimes caused rather severe biological changes. We have also come to understand that the manner in which surface lands are developed may have a pronounced effect on the underlying cave system. Judgments must be made as to how these influences can be mitigated or if indeed a cave system should be developed or opened to the general public.

—There have been conflicts between managers and special user groups—in the case of cave areas, the cavers. This may result from an understandable reluctance on the part of a manager to permit hazardous activities in a park when the character and abilities of applicants are unknown to him. There may also be legitimate reasons why certain types of activities, such as purely recreational caving, should be restricted or prohibited.

—Not all of the Service's people problems are created by the visitor. Occasionally our own people are prone to self-entrapment. Employees who are regularly engaged in interpreting cave resources must always be aware of the pitfalls in leading tours. The repetitive nature of interpretive work, which is a special problem in leading four or five guided trips each day, can easily lead people into bored, disinterested or complacent presentations.

These examples are representative of some of our past management problems and are not meant to be all inclusive. More importantly, they are not intended to reflect any negative attitude of the National Park Service toward cave management. The existence of problems in any form of management can be a positive force. Increasing visitation has caused us to develop new methods of handling people. Ecological problems have provided the catalyst of cave research to better understand the resources. Conflicts with special interest groups have prompted better communications; often with greater appreciation of each other's point of view. Awareness of interpretive problems inherent in cave management has generally led to a high degree of professionalism in interpretive programs.

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OBJECTIVES FOR CAVE MANAGEMENT

The National Park Service's objectives in the management of cave systems parallel those of other National Park System units. Very briefly, they may be stated as follows:

- *To preserve and protect caves and their features for the benefit of future generations.*
- *To admit the general public, in safety and in reasonable numbers, to representative portions of cave systems.*
- *To instill in visitors through interpretive programs an understanding of and appreciation for the underground world.*
- *To provide for the study of subterranean resources, reserving, where appropriate, portions of cave systems for purely scientific purposes.*
- *To assure that each cave area has an approved set of management objectives for the administration, planning, development and use of that area.*

These objectives suggest other considerations that stem from law, custom or policy. The Service has learned, for example, that park planning should often be done on a regional basis—that a particular park may be only a portion of a larger outdoor recreational complex. We have also learned that it is desirable and sometimes necessary to involve the public in the planning and assessment processes. The objectives also imply that the Service will not open all caves to all people and will at times impose limitations on use. There should be a variety of experiences available, ranging from a large tour for the general public to reasonable opportunities for a limited number of serious cavers to total closure—except for scientific purposes. They suggest a proportioning or balancing of conflicting uses, but it is extremely difficult to reach equity between various user interests. Not only are value judgments required in achieving balance, but with a few exceptions, we don't even know the full dimensions of our cave resources.

UNDERGROUND WILDERNESS

Of the more recent influences on cave administration, perhaps the one with the most intriguing future is the Wilderness Act of 1964. There does not seem to be any indication that the Congress thought about the possible effects of the Act on cave systems. Perhaps because of this or because of the acreage language in the bill, our efforts in responding to the requirements of that law were generally directed toward large blocks of surface land. The Service has not been totally oblivious to the directives of the Wilderness Act as they apply to caves, but movement has been somewhat restrained by uncertainties and unresolved questions.

It is apparent that heavily used portions of caves, with their attendant elevators, paved trails, stairways, lighting and other visitor amenities, do not fit any definition of wilderness. The point at which wilderness conditions cease to exist in a cave environment is even less clear than it is on the surface. If we were to follow a strict definition of a wilderness experience, perhaps we would do nothing more than mark underground routes—perhaps not even that.

Probably the greatest deterrent to making wilderness recommendations for cave systems or portions of them is the lack of knowledge for study purposes. Most caves have not been fully explored and, therefore, we know neither the scope of our cave resources nor the real significance of them. Perhaps, then, it is premature to decide which portions of the caves should be reserved in wilderness status.

The National Park Service has not been inactive in nominating cave systems for wilderness classification. The lava tubes at Craters of the Moon and Lava Beds National Monuments were included in wilderness recommendations that have since been enacted into law. Similar recommendations have been made or are contemplated in several other areas. More to the point, Director Everhardt recently instructed us to fully consider submerged lands and underground caverns for possible inclusion in the National Wilderness Preservation System, irrespective of their size or of previous study status.

CAVE MANAGEMENT

The management policies of the National Park Service have been rewritten and they were made available in April of this year. Many parts of those policies apply directly or indirectly to caves, but they are too lengthy to discuss here. However, in the section on Resource Management, caves are cited specifically as follows:

Cave Management

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

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

No surface development above caves will be undertaken which would significantly alter natural cave conditions including subsurface water movements.

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

Like the rest of our policies, this statement sets parameters rather than specifies how every cave area shall be managed. Within those boundaries, planners and managers should tailor the development and management of each cave unit according to individual circumstances—and there is room for innovation, creativity and program growth.

COOPERATIVE ACTIVITIES

Briefly, I would like to mention the communication and cooperation between the National Park Service, cave managers of other agencies and those of you outside of Government who have some special interest in cave management. I believe that this symposium is evidence that all of us have advanced remarkably in these areas during the past few years. Director Everhardt joins me in asking for future interaction between us, for a free and open interchange of ideas, and for your counsel in planning and managing our cave parks.

Bureau of Land Management Objectives and Philosophies

Darrell Lewis*

The Bureau of Land Management is a relatively young federal agency. Briefly, our history traces back to the General Land Office which was formed in 1812 to dispose of the public domain. Another ancestor was the Grazing Service, created in 1934. In 1946, these two agencies were joined to form the Bureau of Land Management. Another significant action was the Classification and Multiple Use Act of 1964 which called for classification for disposal or retention on federal ownership for multiple use management. This Act expired in 1970, but forms the basis for the Bureau's current multiple use program.

The next significant action is before Congress now in the form of a bill that would, if enacted, be an organic act for the Bureau—National Resource Lands Act HR 5441; S-1292.

We are responsible for the management of approximately 451 million acres, 175 million in the lower 48 states and the remainder in Alaska. This amounts to 60 percent of the federally owned land. Of interest to this group is the fact that these lands contain some 50 percent of the Nation's coal (85 percent of the low sulphur coal reserves); 50 percent of the Nation's geothermal sites; more than 60 percent of the Nation's potential oil and gas; 85 percent of the Nation's oil shale. I'm giving you this information to indicate the Bureau's current priorities. In fact, the Bureau's number one priority is energy. Second priority has been given to our range management program.

Okay, where do caves come in and how do they relate to the following Bureau Resource programs?

Forestry	Minerals
Range	Lands and Realty
Watershed	Recreation
Wildlife	

The Division of Recreation has several discrete programs: Recreation, Cultural, Visual Resources (Esthetics) and Natural History—Scientific. The BLM recognizes both recreational and scientific values in caves.

Now within the recreation program we have three designation categories that relate to cave management—Outstanding Natural Areas, Research Natural Areas, and Primitive Areas.

Outstanding Natural Areas are established to preserve scenic values and areas of natural wonder. The preservation of these resources in their natural condition is the primary management objective. There is access on the periphery of these areas and the public is encouraged to walk in. We now have 26 such areas.

Research Natural Areas are established primarily for research and education purposes. Scientists and educators are encouraged to use research natural areas in a manner that is nondestructive and consistent with the purpose for which the area is established. The public may be excluded or restricted where necessary to protect studies or preserve the area.

Primitive Areas are areas which contain pristine wilderness and are managed similar to the wilderness program (NPS, FWS, USFS). Primitive Areas are selected the same as the Wilderness Areas managed by other areas. The ground management philosophy is essentially the same, and the BLM manual paraphrases the wilderness act regarding other uses. The BLM uses the Primitive Area designation to avoid confusion with wilderness areas set up under the Act. It is an administrative designation and is easier to reverse than the act of Congress required to designate a wilderness area. There are 11 areas totaling 234,000 acres under this designation.

As you have heard from several other BLM representatives, we have the beginnings of a cave management program underway. It is a grass roots effort. You have also heard a Bureau policy is being developed by our New Mexico State Office for review by the rest of the Bureau. We expect to send copies of the proceedings of this symposium to each state to bring the importance of caves to the attention of key managers in the Bureau. Our next step will be to document the need for managing specific caves.

As I stated earlier, we recognize both recreational and scientific values in caves. Some of our greatest concerns in each area are as follows:

Scientific

Research	Preservation
— Design	— Unique
— Merit of research	— Outstanding
— Multidiscipline coverage	— Typical

Recreation

Visitor Safety
Resource Protection
Preservation of a Specific Experience (as determined by management objectives)

In terms of priorities, the scientific values come first with recreation use being controlled so that undue damage to scientific values does not result.

Just a couple of closing remarks in reaction to some of the things we have discussed this week:

Wilderness—Caution should be taken in viewing wilderness designation as the panacea of cave management problems. We are concerned about the increased use generated by such a designation.

Another problem that I should point out in reference to several comments made earlier in the week is the need for inventory information. The Bureau is actively developing resource management plans. These result in resource allocation decisions. Inventory of all resources is essential to equal treatment of all values.

All of our discussion on caver qualification has convinced me that it might have merit for one aspect of our concern, visitor safety, but we still need to develop a user accountability system. (I don't think a conservation ethic program can do it alone.) Let me encourage you to make your views known to Bureau land managers.

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National Speleological Society Philosophy and Objectives

Charles Larson*

The National Speleological Society is a national organization of persons with a common interest—caves. It is the only national organization of individuals interested in caves in the world. *Caves* is the one best word to describe the typical member's stake in the organization; single-mindedness is the second best word.

Conceived in 1939, the NSS was incorporated, in Washington, D.C., in 1941 as a non-profit, scientific organization "for the purpose of promoting the science and study of *speleology* throughout the United States."

After 34 years of more or less steady growth, the NSS now numbers about 4800 members, not counting subscribers and other caving organizations. Membership includes virtually all U.S. and many foreign cave scientists, scientists in many other fields, cave owners, libraries, universities other caving groups and a large fraction of the nation's recreational cavers. The majority of NSS members are recreational cavers, most of whom assist—some more, some less—in the study of caves and without whose support and assistance speleology would not be as advanced as it is.

PHILOSOPHY

The NSS philosophy is simple, it believes that caves have distinctive, occasionally peculiar and mostly irreplacable geological, biological and cultural features which cause them to have unique scientific, recreational and scenic values. The NSS believes these values are impaired—if not destroyed—by carelessness and misuse, and that responsible users of caves, since of all people they have the most to lose, should be devoted to insuring the recognition and preservation of such values. It is, therefore, the Society's purpose to promote interest in and advance the science of speleology, the protection of caves and the fellowship of all interested therein.

OBJECTIVES

A primary objective of the NSS is support of the science of cave study—speleology. To that end, the NSS maintains an affiliation with the American Association for the Advancement of Science, encourages research through grants and awards and, through its many membership services, aids and encourages exploration, documentation and publication of scientific knowledge of caves.

Awards, both honorary and financial, are made each year to those members who make singular and appreciable contributions to speleology. The Research Advisory Committee financially assists individuals and groups with specific speleological investigations. An Educational Opportunities Committee maintains a roster of schools and universities offering courses in speleology. Speleological knowledge is accumulated and distributed through the NSS Library, Cave Files, Audio-Visual services, Photo Archives, and bookstore. Regular NSS publications are the *NSS News* and *Bulletin*. Irregular publications include the *Speleo Digest*, *American Caving Accidents* and the *Caving Information Series*.

The furthering of speleology on an international level is carried on through an International Secretary and attendance of NSS representatives at international meetings.

Another primary objective of the NSS is to promote the preservation of irreplaceable, distinctive and occasionally peculiar cave features—and, occasionally, the caves themselves—and to discourage the degradation of caves through misuse, wilfull or otherwise. This devotion casts the Society in a *sharecropper* role, since it neither owns, controls, or represents the owners of a significant percentage of U.S. caves.

Its conservation effort, therefore, relies primarily on persuading cave owners and users that the uniqueness and irreplaceability of caves and their features justify wise use and preservation.

The cave conservation effort is primarily channeled through the Conservation Committee at a national level and locally through sub-committees and task forces. The Conservation Committee seeks out cave conservation problems throughout the U.S., assists local efforts administratively and financially, and encourages such efforts with awards.

In addition, the NSS preaches the gospel of cave science and conservation through its Public Relations, Federal Agencies Liaison and Youth Group Liaison committees.

Still another NSS objective is to encourage the fellowship of cavers. It strives to maintain a community of interest in caves and provides a forum where communication is enhanced. To this end, recruitment is carried out among those already interested in caves. A policy of granting charters to internal organizations (usually called grottos) helps promote fellowship and, at the same time, permits virtually 100 percent local control of local problems. The most effective fellowship inducement is the society-sponsored annual convention where hundreds of cavers and scientists from all over the U.S. meet to present papers, exchange ideas and meet friends in the caving community.

A vigorous Audio-Visual Aids program helps to promote a feeling of kinship. There is no doubt that caving creates a strong bond of fellowship, for the welcome mat is always out when cavers meet in their journeys to caves, conventions and meetings all over the U.S.

Only recently has the NSS become a cave manager. In the past few years the Society has acquired two caves; Shelta Cave in Huntsville, Alabama (a National Landmark) and McFail's Cave in New York. At its October 1975 Board of Governors meeting the Society will consider the acquisition of Knox Cave in New York.

From a cave management standpoint, it is the objective of the NSS to pursue maximization of recreational use of caves, consistent with their preservation and the Society's purposes and maximization of responsibility and ability among those who use caves.

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Agency Objectives and Philosophies—The Cave Research Foundation's Viewpoint

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The Cave Research Foundation was established in 1957 to support scientific research related to caves and karst, to aid in conservation of cave and karst resources, and to assist in the interpretation of caves through education. This carefully delineated charter serves to distinguish objectives of the Cave Research Foundation from other participants of this conference, including federal agencies (whose legislative mandates define general policies and objectives) and the National Speleological Society (an open membership organization encompassing a great diversity of cave-oriented interests). Nevertheless, the Cave Research Foundation's objectives are shared to some extent by every organization participating in this symposium. Though undoubtedly for different reasons, each of us here today is concerned with cave research, cave conservation, and cave interpretation. I believe it is the experience and knowledge accumulated as a private organization during nearly twenty years of undivided attention to these three objectives, that makes the Foundation's views on "Agency Objectives and Philosophies" unique.

Much of our research activity has focussed on cave-bearing lands under jurisdiction of the three principal agencies represented at this meeting (Bureau of Land Management, National Forest Service, and National Park Service). As special users, we neither expect nor desire direct management control regarding the public lands on which we conduct activities. We do, however, strongly believe in wise management of cave-bearing lands and in the past have supported, and also criticized, specific management practices. It seems self-evident that for lands that are to be maintained in a highly natural state, a rational management policy must include a sensitivity to the natural features and processes of those lands. Wise and enlightened management planning accepts and incorporates these natural characteristics. Our past comments regarding management of karst lands have dealt with karst features and processes, because these form the central focus for our research. In fact, we see the single most important role of the Cave Research Foundation in influencing management policy to be the dissemination of karst knowledge. Important methods of dissemination include support of research and research publications, preparation of resource documents, formal comment on proposed actions, and participation in informal dialogue. A novel, and we hope useful, forum is provided by the present conference and the opportunities it creates for discussion of important issues.

There is an interesting dichotomy between the self-view of the scientist and the policy maker. The scientist and the policy maker. The scientist is trained to make hypotheses, to test the hypotheses by experiment, and to revise the original hypotheses when experimental results are in hand. Scientists, therefore, are not bound by past analyses and conclusions (which are usually hypotheses anyway). The decision maker, on the other hand, views this approach as a luxury. He must make decisions on the basis of information available (often fragmentary and sometimes even incorrect), and those decisions (unlike the scientist's hypotheses) are very difficult to alter later on. Organizations such as the Cave Research Foundation can assist the policy maker in this difficult situation in two important ways: by providing information and interpretation on the basis of the most recent findings and analyses, and by pressing managers to alter decisions as dictated by newly developed information. The former is often a smooth interaction between the two parties; the latter interaction, equally important, is often more painful. Implicit in our reasoning, of course, is the conviction that the scientist's responsibility extends beyond the mere development of new data, but also includes interpretation of the data for use by others, including the managers.

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